# Morice TSA

## Documentation of Vegetation Resources Inventory Analysis

***Prepared for:***

**Ministry of Forests, Lands and Natural Resource Operations**
**Forest Analysis and Inventory Branch**
**Victoria, BC**

***Prepared by:***

**Jahraus Consulting Inc.**
**Maple Ridge, BC**

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# EXECUTIVE SUMMARY

The objective of this project was to complete a VRI sample data analysis of selected Phase I inventory attributes to provide an assessment of the accuracy of the inventory in two target populations of interest in the Morice TSA. The analysis was based on current Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) standards. Fifty Phase II ground samples were established in the 2012 field season in each of two target populations: 1) Young Stand Monitoring (YSM) stands between 15 and 50 years of age (in 2011), and 2) Volume Audit stands 51 years and older (in 2011) in the Vegetated Treed portion of the landbase.

Lodgepole pine stands in the Morice TSA have been significantly impacted by the Mountain Pine Beetle (MPB) infestation. Since the majority of the Phase I photo acquisition in this TSA pre-dates the MPB infestation, the Ministry's BCMPB mortality algorithm was used to adjust the lodgepole pine trees/ha and volume/ha in the Phase I inventory to reflect losses due to MPB.

The analysis focused on seven inventory attributes: age, height, basal area/ha at 7.5cm+ dbh (BA), trees/ha at 7.5cm+ dbh (TPH), Lorey height (LH), volume/ha net dwb at 12.5cm+ dbh and site index (SI). The ratio of the weighted mean Phase II ground value to the weighted mean Phase I inventory value was computed for each attribute. A ratio greater than 1.0 suggests that, on average, the Phase I inventory is *under*estimating an attribute, based on the Phase II ground sample information. Similarly, a ratio less than 1.0 suggests that, on average, the Phase I inventory is *over*estimating the value of an attribute. The resulting VRI analysis ratios, and their associated sampling errors, are shown for each attribute, by stratum, in Table 1.

***Table 1:*** Ratio of means (Phase II Ground/Phase I inventory) for seven attributes, by stratum, for the target populations in the Morice TSA. Shaded cells indicate small sample size.

| | | ***Ratio of weighted means (with 95% sampling error shown as % of the ratio)*** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***Stratum*** | ***n*** | ***Age (years)*** | ***Height (m)*** | ***Basal area @7.5cm+ ($m^2$/ha)*** | ***Trees/ha @7.5cm+*** | ***Lorey height @7.5cm+ (m)*** | ***Volume net dwb @12.5cm+ ($m^3$/ha)*** | ***SI (m)*** |
| YSM (Immature) | 50 | 1.175 (±15.4%) | 1.270 (±10.7%) | 4.825 (±38.5%) | 0.869 (±41.4%) | 1.107 (±12.8%) | 7.995 (±74.1%) | 1.108 (±7.5%) |
| Volume Audit (Mature) | | | | | | | | |
| Balsam | 19 | 0.902 (±14.1%) | 0.943 (±12.0%) | 1.517 (±26.2%) | 1.884 (±20.2%) | 1.042 (±15.3%) | 1.695 (±37.8%) | 0.994 (±23.6%) |
| Pine | 17 | 0.923 (±12.3%) | 0.962 (±8.0%) | 0.644 (±30.5%) | 1.297 (±34.4%) | 0.980 (±13.0%) | 1.018 (±43.5%) | 1.030 (±19.2%) |
| Spruce | 11 | 0.776 (±31.3%) | 0.839 (±21.4%) | 0.792 (±31.1%) | 1.169 (±31.3%) | 0.897 (±17.1%) | 0.831 (±34.8%) | 1.142 (±24.6%) |
| Other (decid) | 3 | 0.881 (±25.1%) | 1.134 (±6.3%) | *0.803 (±41.3%)* | *0.707 (±13.0%)* | *1.205 (±19.7%)* | 1.272 (±54.7%) | 1.300 (±8.2%) |
| *Subtotal* | *50* | *0.878 (±9.5%)* | *0.934 (±6.8%)* | *1.003 (±17.1%)* | *1.469 (±18.5%)* | *0.994 (±8.3%)* | *1.249 (±23.6%)* | *1.054 (±13.3%)* |

The Volume Audit sample suggests that the Phase I volume is underestimated by 25%. *However, this result must be interpreted with caution.* The sampling error associated with this estimate is very high (±24%) and does not meet the target sampling error level of ±15%.

With the exception of the Pine leading stratum, trends in basal area bias are reflected in the trends in volume bias. The Phase I volume/ha and trees/ha in VRIMS have been adjusted for pine mortality using the BCMPB algorithm. However, the BCMPB model does not adjust Phase I basal area. As a result, the observed Phase I basal area overestimation in the Pine leading stratum is likely due to a significant dead pine component. Phase I age and, to a lesser degree, height in the mature stratum is generally overestimated.

Inference for the YSM stratum is limited since many of the stands in this sample have not yet achieved the thresholds required for VDYP7 to produce a basal area or volume estimate. Phase I ages and heights in this stratum appear to be underestimated. Leading species identification was good with 78% of the samples having the same leading species in the Phase I and Phase II.

Based on the inventory analysis in Morice TSA, the following recommendations and observations are made:

- Inference for the Volume Audit (mature) target population is limited because of high variability and low confidence in the estimates. To reduce the sampling error for volume, it is recommended that additional samples be established in this target population.
- The sample suggests that the BCMPB volume adjustment for MPB mortality is performing adequately. However, sampling error, particularly in the Pine leading stratum is high and additional samples may strengthen this inference.
- An examination of whole stem volumes, particularly in the Balsam leading stratum, may provide a better understanding of the contribution of loss factor bias to model-related volume bias.
- Alternative approaches and/or improvements to Phase I basal area estimation should be investigated, particularly in the Balsam leading stratum.
- Analysis procedures tailored specifically for the unique inventory characteristics of younger stands (i.e. stands less than 30 years of age) should be developed for future data analysis of these types of ground samples.
- A uniform extract process from the LRDW that would include all the Phase I attributes required for the VRI sample data analysis and be limited to the set of polygons that have been matched to the Phase II ground samples (e.g. merged based on cluster id and feature id) should be developed for future VRI sample data analyses.
- This report is a technical document intended to provide complete details of the analysis. However, it is also recommended that a template for communicating these results in a uniform, succinct format suitable for wider distribution be developed.

# ACKNOWLEDGEMENTS

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# 1. INTRODUCTION

## 1.1 Background

Details of the ground sampling planning for the Morice TSA are available in the document "*Morice Timber Supply Area – TSA 20: Vegetation Resources Inventory Project Implementation Plan for Volume Audit Sampling, Young Stand Monitoring and Net Volume Adjustment Factor Sampling*" (Nona Phillips Forestry Consulting 2012b) available from the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO).

## 1.2 Description of the Target Population Area

The Morice TSA is located in the northwestern part of British Columbia and is situated along the western edge of the province's Interior Plateau. It extends from the north end of Babine Lake in the north to Ootsa and Whitesail Lakes in the south. The topography in the TSA is gently rolling in the north and east, becoming mountainous in the southwest. The SBS biogeoclimatic zone predominates, followed by ESSF and some CWH. The area also includes minor percentages of MH, BAFA and CMA.

The main trees species are lodgepole pine (Pl), subalpine fir (balsam or Bl) and spruce (Sx, Sw and Sb). More than two-thirds of the forests in the TSA are mature and old, age class 6 and older (Timberline 2007). The TSA has been impacted heavily by the Mountain Pine Beetle (MPB) infestation (FAIB 2007).

Table 1, excerpted from the "*Morice TSA Sample Selection Report*" (Nona Phillips Forestry Consulting 2012a), provides a summary of the landbase in the Morice TSA.

***Table 1:*** Morice TSA Landbase Summary, indicating net-downs.

| *Land Classification* | *Area (ha)* | *% of TSA* |
|---|---|---|
| **Total TSA Area** | **1,501,703** | **100.0%** |
| **Net-downs** | **171,707** | **11.4%** |
| Parks | 134,899 | 9.0% |
| Private | 34,740 | 2.3% |
| Indian Reserve | 2,068 | 0.1% |
| **Net Area** | **1,329,996** | **88.6%** |
| Non-Vegetated | 291,212 | 19.4% |
| Vegetated | 1,038,784 | 69.2% |
| Non-Treed | 180,432 | 12.0% |
| Treed | 858,352 | 57.2% |

An overview map of the Morice TSA is provided in Figure 1.

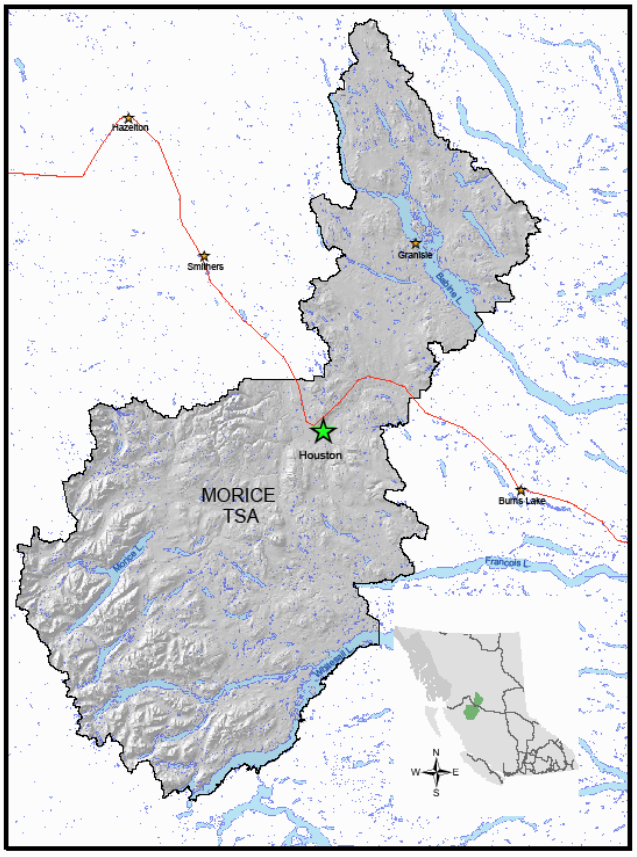


***Figure 1:*** Map of the Morice TSA (FAIB 2007).

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

1. Young Stand Monitoring (YSM): stands between 15 and 50 years of age (in 2011), *not* restricted to Vegetated Treed (VT) polygons
2. Volume Audit: stands 51 years and older (in 2011) in the Vegetated Treed portion of the landbase

The area distributions by inventory leading species in each of these two populations of interest are provided in Tables 2 and 3 (Nona Phillips Forestry Consulting 2012b).

***Table 2:*** Morice TSA population of interest for Young Stand Monitoring, by leading species.

| *Inventory Leading Species* | *Area (ha)* | *% of YSM population* |
|---|---|---|
| Lodgepole pine (PL) | 51,152 | 71% |
| Spruce (S) | 17,232 | 24% |
| Balsam (B) | 2,566 | 3% |
| Cottonwood (AC) | 1,146 | 2% |
| Birch (EP) | 6 | <1% |
| Fir (FD) | 4 | <1% |
| Cedar (CW) | 1 | <1% |
| **total** | **72,107** | **100%** |

***Table 3:*** Morice TSA population of interest for Volume Audit, by leading species.

| *Inventory Leading Species* | *Area (ha)* | *% of Volume Audit population* |
|---|---|---|
| Balsam (B) | 295,723 | 37% |
| Lodgepole pine (PL) | 268,645 | 34% |
| Spruce (S) | 176,907 | 22% |
| Cottonwood (AC) | 38,045 | 5% |
| Hemlock (H) | 9,076 | 1% |
| Birch (EP) | 341 | <1% |
| **total** | **788,737** | **100%** |

### 1.3 Scope and Objectives

The objective of this project was to provide a VDYP7-based VRI sample data analysis for the Morice TSA, based on current Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) standards (FAIB 2011). The analysis was to be carried out for the 50 Volume Audit (mature) Phase II samples and the 50 Young Stand Monitoring (Immature) samples that were both established in the 2012 field season.

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

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

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

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

## 2. METHODS

### 2.1 Overview of VRI Sample Data Analysis

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

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

These ratios of means, which are developed from the relationship between the Phase II ground sample values and the Phase I photo-interpreted inventory values for the set of polygons that comprised the VRI Phase II

ground sample, form the basis of the inventory assessment. The sampling errors for these ratios can be used to interpret the risk and uncertainty associated with the sampling process.

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

- Age of the first species,
- Height of the first species,
- Basal area at 7.5cm+ dbh utilization (BA7.5),
- Trees per hectare at 7.5cm+ dbh utilization (TPH7.5),
- Lorey height[1] (LH) at 7.5cm+ dbh utilization (LH7.5),
- Volume net top, stump (CU), decay, waste and breakage at 12.5cm+ dbh utilization, and
- Site index.

## 2.2 Populations for Analysis

The VPIP for the Morice TSA identified two separate target populations of interest for the analysis:

1. Young Stand Monitoring (YSM): stands between 15 and 50 years of age (in 2011), *not* restricted to Vegetated Treed (VT) polygons (referred to interchangeably as "immature" or YSM in this document)
2. Volume Audit: stands 51 years and older (in 2011) in the Vegetated Treed portion of the landbase (also referred to as "mature" in this document)

The total area of the YSM population of interest was about 72,000 ha whereas the total area of the Volume Audit population of interest was approximately 789,000 ha (see Tables 2 and 3 in Section 1.2 for details).

Each of these target populations was analyzed separately and the YSM or immature sample results are shown as a separate "stratum" in the tables that follow.

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

For the Volume Audit sample selection, pre-stratification was carried out based on leading species. Further sub-stratification, by volume classes, was also applied in the sample selection to ensure adequate representation of the samples across the target population. Samples were selected with Probability Proportional to Size With Replacement (PPSWR).

The population for the YSM portion of the project was not pre-stratified and the sample selection was grid-based[2]. Fifty YSM samples were selected from the total population area of 72,107 hectares, resulting in each sample representing 1442 hectares.

Sampling weights were determined from area information presented in the *"Morice TSA Sample Selection Report"* (Nona Phillips Forestry Consulting 2012a). The weights, as calculated in Table 4 below, were applied in the analysis.

[1] Lorey height is mean height, weighted by tree basal area. This height measure is generally more stable than unweighted mean height and is an important input attribute in the VDYP7 yield prediction model.

[2] Refer to the sample selection report (Nona Phillips Forestry Consulting 2012a) for details.

***Table 4:*** Sample weights for the inventory analysis of the Morice TSA.

| *Stratum* | *Sub-stratum (volume class)* | *Area (ha)* | *Area %* | *n* | *Weight (number of hectares represented by each sample) = A/n* |
|---|---|---|---|---|---|
| Balsam leading | 1 | 93,255 | 31.5% | 6 | 15543 |
| | 2 | 95,553 | 32.3% | 6 | 15926 |
| | 3 | 106,915 | 36.2% | 7 | 15274 |
| | total | **295,723** | **100.0%** | **19** | |
| Pine leading | 1 | 83,791 | 31.2% | 5 | 16758 |
| | 2 | 104,346 | 38.8% | 7 | 14907 |
| | 3 | 80,508 | 30.0% | 5 | 16102 |
| | total | **268,645** | **100.0%** | **17** | |
| Spruce leading | 1 | 49,687 | 28.1% | 3 | 16562 |
| | 2 | 59,768 | 33.8% | 4 | 14942 |
| | 3 | 67,452 | 38.1% | 4 | 16863 |
| | total | **176,907** | **100.0%** | **11** | |
| Other spp leading | 1 | 14,769 | 31.1% | 1 | 14769 |
| | 2 | 14,926 | 31.5% | 1 | 14926 |
| | 3 | 17,767 | 37.4% | 1 | 17767 |
| | total | **47,462** | **100.0%** | **3** | |
| Volume Audit Total | | **788,737** | | **50** | |
| Yound Stand Monitoring Total | | **72,107** | | **50** | 1442 |

The geographic distribution of the samples in both target populations is shown in Figure 2, which has been reproduced from the sample selection report.

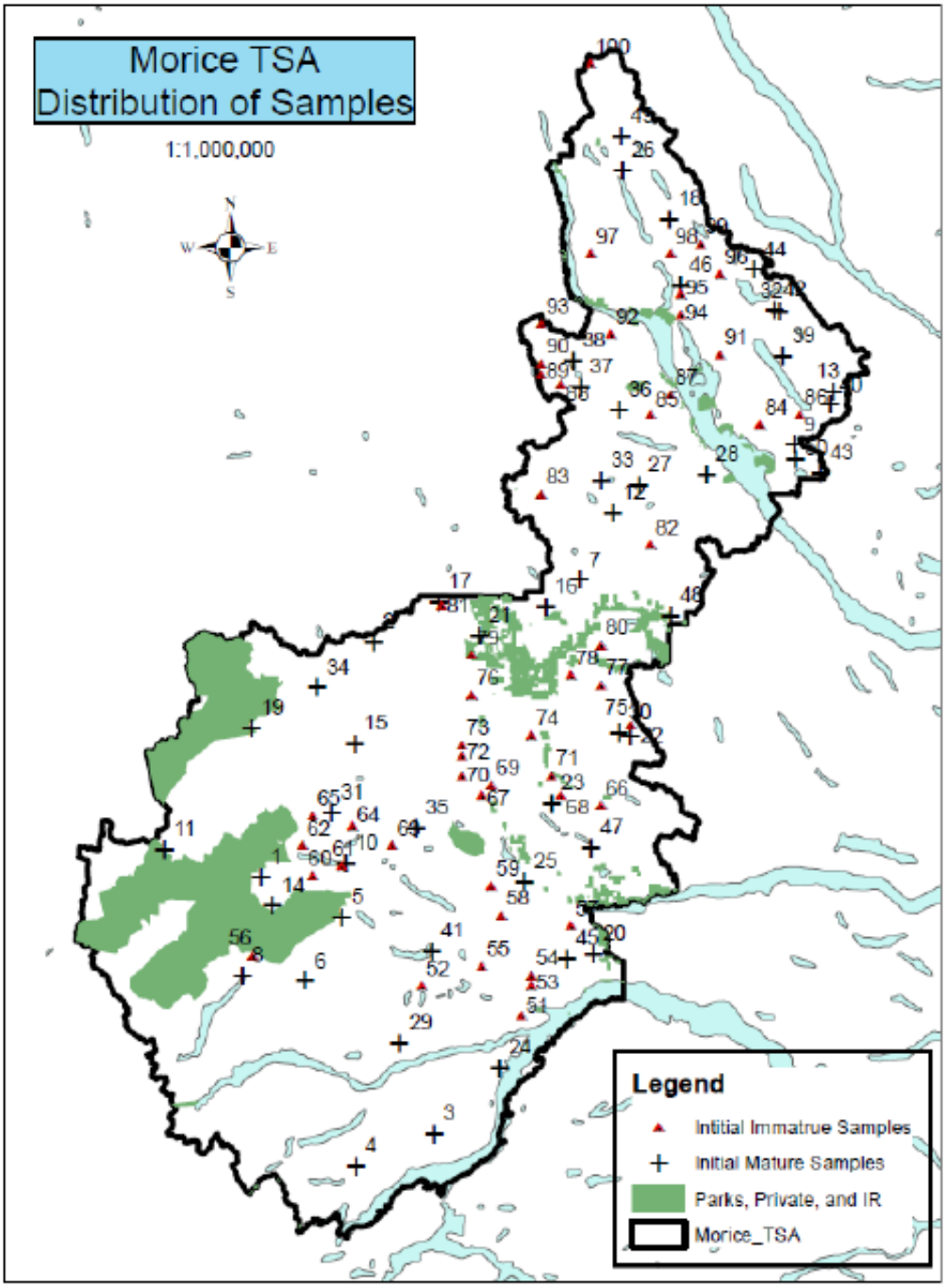


**Figure 2:** Map of the distribution of YSM (immature) and Volume Audit (mature) samples in the Morice TSA (Nona Phillips Forestry Consulting 2012a).

## 2.4 Data Sources

### *2.4.1 Phase I photo-interpreted inventory data*

VRIMS inventory data from the LRDW, projected to 2012, was provided by Marc Rousseau (MFLNRO). Since ground sampling was also completed in 2012, values on this file for age, height and volume were used directly in the analysis. However, values for Lorey height (LH) at the 7.5cm+ dbh utilization were not provided on the VRIMS file. Hence VDYP7 Console version 7.7a.33 was used (in conjunction with input values and reference year) to obtain projected values for this attribute.

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

The inventory for this management unit is relatively old. Table 5 shows the population area distribution by reference year (year of photo-interpretation) of the VT portion of the Morice TSA greater than 15 years of age. Nearly 60% of the area was photo-interpreted in either 1991 or 1992.

***Table 5:*** Morice TSA VT greater than 15 years of age, area distribution by inventory reference year.

| *Reference year (photo-interpretation) by decade* | *% of Area* |
|---|---|
| 1953 - 1959 | 2.0% |
| 1960 – 1969 | 4.4% |
| 1970 – 1979 | 16.1% |
| 1980 – 1989 | 1.9% |
| 1990 – 1999 | 74.1% |
| 2000 – 2012 | 1.6% |
| **total** | **100%** |

Table 6 shows the distribution of samples (both Volume Audit and YSM) by reference year. More than 2/3 of the samples used in this analysis had reference years pre-dating 1992.

***Table 6:*** Volume Audit and YSM samples in the Morice TSA, distribution of samples by inventory reference year.

| *Reference year (photo-interpretation) by decade* | *Number of Volume Audit samples* | *Number of YSM samples* |
|---|---|---|
| Pre-1980 | 6 | 1 |
| 1980 – 1984 | 0 | 2 |
| 1985 – 1989 | 0 | 3 |
| 1990 - 1994 | 42 | 23 |
| 1995 – 1999 | 2 | 16 |
| 2000 – 2012 | 0 | 5 |
| **total** | **50** | **50** |

The majority of the sample polygons (85%) recorded an F-type inventory standard[3]. This means that basal area and trees/ha would have been generated in the FIPSTART module of VDYP7 since no photo-interpreted values for these attributes would have been available.

The Phase I inventory attributes used in the analysis are shown in Appendix A.

[3] Six samples indicated a V-type inventory standard and 9 samples indicated an incomplete or non-standard (i.e. I-type) inventory type.

### 2.4.2 Phase II ground sample data

The "*Morice TSA VRI Sample Selection Report*" (Nona Phillips Forestry Consulting Ltd. 2012a) details the selection of the Phase II samples that were established in the Morice TSA. The Phase II data were compiled by MFLNRO and included application of the most up-to-date regional NVAF values. This Phase II compiled data file was provided by Bob Krahn (MFLNRO).

The compiled data were provided under project number 0201. The Phase II site index (SI) value for each sample was computed as the average site index (SI) of the T, L, X and O trees on the "trees_h" file. Site index is computed by the compiler using SINDEX and is provided for each tree where possible.

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

### 2.4.3 Data issues related to the statistical adjustment

Scatterplots comparing the Phase I and Phase II attributes were examined for potential outliers. Large differences between the ground sample and photo-based estimates, particularly for basal area, tree/ha and volume, were noted for a number of samples. Potential outliers were examined in detail by MFLNRO staff. Details of the findings of this investigation are provided in Appendix C.

For two samples, the ground sample IPC was located close to a polygon boundary and it was determined that the incorrect Phase I polygon data had been provided[4]. The correct polygon identifiers and corresponding attribute data were subsequently obtained.

Sample #40 showed particularly large differences between the Phase I and II attribute values. It was determined by MFLNRO staff that this was likely due to a Phase I photo-typing error. Because of the influence of this sample on the attribute means and ratios of means, a supplementary set of results that excluded this sample are provided in Appendix D (see Section 3.1).

### 2.4.4 Height and Age data matching

The data matching used to determine the appropriate Phase I and II heights and ages upon which to base the comparison ratios followed the same basic approach outlined in the MFLRNO procedures and standards document.

For each VRI sample polygon, the Phase II ground sample data were matched with the corresponding Phase I inventory data for the same polygon. The ground heights and ages used in the analysis were based on the average values for the T, L, X & O trees[5] for the ground leading species (by basal area at 4cm + dbh utilization) on the ground. The objective in the matching process was to choose an inventory height and age (i.e. for either the leading or second species) so that the ground and inventory species "matched".

If a leading species match could not be made at the sp0[6] 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.

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[4] The location for sample #18 was originally specified as polygon 619. The correct polygon was 618. The location for sample #46 was originally specified as polygon 224. The correct polygon was 603.

[5] T or "top height" tree is the largest DBH in 0.01 ha plot, regardless of species; L or "leading species" tree is the largest DBH in 0.01 ha plot, of leading species. T trees are selected and measured at the IPC only whereas L trees are selected at the IPC and all auxiliary plots. If a suitable (age or height) leading species sample tree is not found in any given plot in a cluster, a "replacement" tree will be selected. An "O" tree is the closest suitable (for height and age) tree of the leading species to the 5.64m radius plot center. An "X" tree is the closest suitable tree of the leading species outside of the 5.64m radius plot but within a maximum 25m radius of plot centre. For further details, refer to the MFLNRO document "VRI Ground Sampling Procedures Version 4.8, May 2008, Amendment # 1: Modifications to the Leading Species Site Tree Selection Procedures", April, 2009.

[6] sp0 refers to the 16 major species codes and is roughly equivalent to the genus level.

Of the 100 samples used in the analysis, 70% indicated a match between the Phase I inventory leading species and the Phase II ground leading species at 4cm+ dbh utilization. A further 3 samples were matched based on the inventory secondary species. Note that there were 12 samples where the inventory secondary species matched the ground leading species but where no Phase I height or age data were available for the secondary species. It was possible, however, to match these samples on a conifer-to-conifer or deciduous-to-deciduous basis. Thirteen additional samples were also matched on the same (i.e. Case 3) basis. Two samples could not be matched and were therefore excluded from the development of the age and height comparison ratios. Both of these samples (#78 and #92) were in the YSM stratum.

#### *2.4.5 Site Index*

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

As a result, 27 samples were not included in the SI comparison. Among the Volume Audit samples, the samples that were excluded were comprised of 2 Balsam stratum samples, 9 Pine stratum samples, 5 Spruce stratum samples and 1 sample in the Other stratum. Ten among the YSM samples were also excluded from the site index comparison. The large number of excluded samples for the SI comparison may be further justification for the establishment of additional plots in the Morice TSA, especially given the significant mid-term timber supply issues in this management unit.

### 2.5 Analysis of Dead Pine

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

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

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

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

## 3. RESULTS AND DISCUSSION

### 3.1 Attribute bias

As a way to compare the Phase I inventory attribute values with the Phase II ground sample values, ratios of the weighted mean Phase II ground sample attribute over the corresponding weighted mean Phase I inventory attribute were computed. The ratios of means were calculated for each of the seven key attributes identified in Section 2.1. The analysis stratification for the Volume Audit population was based on Phase I inventory leading species. The samples from the YSM population were not post-stratified. The means and their ratios are shown in Tables 7 & 8 respectively[7].

[7] Appendix E shows a similar set of results with Sample #40 excluded (see Section 2.4.3)

***Table 7:*** Sample-estimated weighted means for the Phase I inventory and Phase II ground sample for seven key inventory attributes, for the volume audit (mature) target population in the Morice TSA. Shading indicates small sample size.

| *Attribute* | *Weighted Means* | | | | | |
|---|---|---|---|---|---|---|
| | Immature (YSM samples) | Mature (Volume Audit) Samples | | | | |
| | | *Balsam* | *Pine* | *Spruce* | *Other* | *All mature strata* |
| ***Age (years)*** | | | | | | |
| n | 48 | 19 | 17 | 11 | 3 | 50 |
| Phase II Ground | 35 | 191 | 117 | 131 | 79.1 | 146 |
| Phase I Inventory | 30 | 212 | 127 | 169 | 89.7 | 166 |
| ***Height (m)*** | | | | | | |
| n | 48 | 19 | 17 | 11 | 3 | 50 |
| Phase II Ground | 11.3 | 20.8 | 21.3 | 21.2 | 23.9 | 21.2 |
| Phase I Inventory | 8.9 | 22.1 | 22.1 | 25.3 | 21.0 | 22.7 |
| ***Basal area (m2/ha) at 7.5cm+ dbh*** | | | | | | |
| n | 50 | 19 | 17 | 11 | 3 | 50 |
| Phase II Ground | 19.2 | 46.7 | 22.0 | 23.0 | 26.3 | 31.8 |
| Phase I Inventory | 4.0 | 30.8 | 34.2 | 29.0 | 32.7 | 31.7 |
| ***Trees/ha at 7.5cm+ dbh*** | | | | | | |
| n | 48 | 19 | 17 | 11 | 3 | 50 |
| Phase II Ground | 1422 | 1478 | 871 | 644 | 707 | 1038 |
| Phase I Inventory[8] | 1637 | 785 | 671 | 550 | 1000 | 706 |
| ***Lorey height (m)*** | | | | | | |
| n | 31 | 19 | 17 | 11 | 3 | 50 |
| Phase II Ground | 10.2 | 17.8 | 18.5 | 18.9 | 22.6 | 18.6 |
| Phase I Inventory | 9.2 | 17.1 | 18.8 | 21.1 | 18.8 | 18.7 |
| ***Volume/ha (m3/ha) at 12.5cm+ dbh net dwb*** | | | | | | |
| n | 50 | 19 | 17 | 11 | 3 | 50 |
| Phase II Ground | 49.8 | 290.2 | 133.6 | 164.9 | 195.6 | 203.1 |
| Phase I Inventory[9] | 6.2 | 171.2 | 131.2 | 198.4 | 153.8 | 162.7 |
| ***Site index (m)*** | | | | | | |
| n | 40 | 17 | 8 | 6 | 2 | 33 |
| Phase II Ground | 19.6 | 8.8 | 15.4 | 11.0 | 18.8 | 11.4 |
| Phase I Inventory | 17.7 | 8.8 | 15.0 | 9.6 | 14.4 | 10.8 |

The relationship between the Phase II ground and the Phase I inventory attributes corresponding to each ratio were examined in scatterplots (Appendix F). The ratios of means were also evaluated for potential bias by plotting the "residual" values[10] as a function of the ratio-adjusted (or "estimated") value for each attribute. In addition, the residuals were plotted as a function of unadjusted inventory age as a check for any age-related trends in the ratios. These graphs are also included in Appendix F.

[8] The Phase I trees/ha from VRIMS represent LIVE values (net of dead Pl) after the MPB mortality model has been applied.

[9] Phase I volume has been adjusted using the MPB mortality model hence represents LIVE trees net of dead pine.

[10] A "residual" is computed as *actual minus estimate*. In this case, the actual is the Phase II sample value and the estimate is the ratio-adjusted Phase I value (i.e. Phase I value multiplied by the ratio of means value).

Careful examination of the scatterplots in Appendix F did not suggest any significant bias patterns associated with the ratios of means. However, many of the graphs illustrated a weak relationship between the ground and the inventory attribute values and a high level of variability.

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

| Stratum | n | Ratio of weighted means (with 95% sampling error shown as % of the ratio) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Age (years) | Height (m) | Basal area @7.5cm+ ($m^2$/ha) | Trees/ha @7.5cm+ | Lorey height @7.5cm+ (m) | Volume net dwb @12.5cm+ ($m^3$/ha) | SI (m) |
| YSM (Immature) | 50 | 1.175 (±15.4%) | 1.270 (±10.7%) | 4.825[11] (±38.5%) | 0.869 (±41.4%) | 1.107 (±12.8%) | 7.995[12] (±74.1%) | 1.108 (±7.5%) |
| Volume Audit (Mature) | | | | | | | | |
| Balsam | 19 | 0.902 (±14.1%) | 0.943 (±12.0%) | 1.517 (±26.2%) | 1.884 (±20.2%) | 1.042 (±15.3%) | 1.695 (±37.8%) | 0.994 (±23.6%) |
| Pine | 17 | 0.923 (±12.3%) | 0.962 (±8.0%) | 0.644 (±30.5%) | 1.297 (±34.4%) | 0.980 (±13.0%) | 1.018 (±43.5%) | 1.030 (±19.2%) |
| Spruce | 11 | 0.776 (±31.3%) | 0.839 (±21.4%) | 0.792 (±31.1%) | 1.169 (±31.3%) | 0.897 (±17.1%) | 0.831 (±34.8%) | 1.142 (±24.6%) |
| Other | 3 | 0.881 (±25.1%) | 1.134 (±6.3%) | *0.803 (±41.3%)* | *0.707 (±13.0%)* | *1.205 (±19.7%)* | 1.272 (±54.7%) | 1.300 (±8.2%) |
| *Subtotal* | *50* | *0.878 (±9.5%)* | *0.934 (±6.8%)* | *1.003 (±17.1%)* | *1.469 (±18.5%)* | *0.994 (±8.3%)* | *1.249 (±23.6%)* | *1.054 (±13.3%)* |

The ratios of means in Table 8 can be used to assess the accuracy of selected attributes within the Phase I inventory. Since the ratios are computed as the Phase II value over the Phase I value, *a ratio of means greater than 1 suggests that the Phase I attribute is underestimated*. Similarly, *a ratio of means value less than 1 indicates that the Phase I is overestimating* the attribute value.

The sample size of 3 in the "Other species leading" stratum (all samples were At leading) was too small to allow for any reasonable conclusions.

The sample suggests that, on average, the inventory overestimates age among the three main leading species strata (i.e. Balsam, Pine and Spruce leading) in the mature target population in the Morice TSA, with an average age overestimation of about 14% relative to the average ground age[13] (ratio of means = 0.878).

In the three main mature strata, the sample suggests that height is also overestimated. Average height overestimation appears greatest in the Spruce leading stratum. However, the variability in this stratum (for both age and height) is quite high.

The Volume Audit sample suggests that the Phase I underestimated trees/ha in all three main mature strata. However, strata sampling errors were relatively high for this attribute. Note that the Phase I trees/ha values

[11] Twenty YSM samples had insufficient height for VDYP7 to produce a BA estimate and hence zero values were assumed for this analysis. Similarly, VDYP7 did not generate a Phase I volume for 22 samples. The zero values for these attributes assumed in the analysis had a considerable impact on the ratios.

[12] Ibid. 12

[13] Computed as: ((Ground vol –Inventory vol)/Ground vol) X 100%= (1- (Inventory vol/Ground vol))X100%

reflected in the Table 8 have been adjusted for MPB mortality in the pine component of these polygons. The extent to which the MPB mortality algorithm may be exacerbating the trees/ha underestimation in the inventory is unknown.

Among the three primary mature strata, bias trends in Lorey height were relatively minor. Although the Phase I underestimated site index in the spruce leading stratum, site index bias in the Balsam and Pine strata was relatively low. Note that the SI assessment in the pine and spruce strata is based on only 8 and 6 samples respectively.

Bias in mature basal area/ha is relatively high and is not consistent among the main Volume Audit strata. Note that the sampling errors for the basal area ratios of means are also high. None of the Phase I basal area estimates are adjusted in the MPB mortality algorithm hence the inventory basal area estimates may reflect a component of dead pine. As a result, this might account for some of the observed overestimation of basal area in the Phase I, particularly in the Pine leading stratum.

In the Balsam leading stratum, the Phase I underestimates basal area. This is consistent with trends observed for ESSF samples in the Bulkley TSA. However, it must be noted that the sampling error for the basal area ratio of means in the Balsam stratum is more than 25%.

Trends in basal area bias in the mature Balsam leading and mature Spruce leading strata are mirrored by similar trends in volume/ha bias in these strata. Once again, however, sampling errors in these strata are very high (between 30 and 40%) hence these results must be interpreted with caution.

In all strata, but particularly in the Pine leading stratum[14], results must be interpreted carefully since volume/ha and trees/ha in this stratum are adjusted by the BCMPB mortality algorithm whereas inventory basal area/ha is not changed when this algorithm is applied.

The Phase II ground sample in the Volume Audit target population for the Morice TSA suggests that, on average, Phase I inventory volume is underestimated by about 25%. However, it is important to note that the overall sampling error for the volume bias estimation of 23.6% did not meet the targeted sampling error of 15% specified for the mature population in the VPIP. Hence these results must be interpreted with caution.

Many of the YSM samples did not achieve sufficient height for VDYP7 to produce basal area or volume estimates. Twenty of the samples (40%) had zero Phase I basal area and 22 samples had zero Phase I volume estimates, which may have inflated the ratios of means for these attributes[15]. The sampling errors for these ratios, particularly for volume, are also very high. Note that in the timber supply modeling process, yields for young managed stands are typically estimated using the TIPSY model rather than VDYP7, which was designed for yield estimation in natural stands.

Age, height and site index[16] all appear to be underestimated in the YSM stratum. The site index assessment, based on 40 samples in this stratum, suggests that the calculated Phase I site index is underestimated by about 10% in this stratum. Note that in younger stands (i.e. stands less than 30 years of age), site index cannot be reliably estimated from age and height and hence is generally obtained from other sources (growth intercept equations, silvicultural data, etc.).

[14] The MPB algorithm is applied to the pine component of a stand. The inventory identified a dead pine component volume in 2 out of 10 samples in the Balsam leading stratum, 16 out of 17 samples in the Pine leading stratum and 6 out of 11 samples in the Spruce leading stratum among the Volume Audit (Mature) samples.

[15] For the 20 samples with zero Phase I BA, the mean Phase II BA was 18.2 m2/ha. Similarly, for the 22 samples with zero Phase I volume, the mean Phase II volume was 40.9 m3/ha. Hence the basal area and volume ratios of means in the YSM stratum may appear inflated. However, even when these zero samples are excluded from the ratio calculations for these two attributes, the resulting ratios are still over 3 and 5 for basal area and volume respectively.

[16] This assessment is based on the Phase I site index calculated from age and height.

## 3.2 Model-Related and Attribute-Related Components of Volume Bias

The volume ratios of means, comparing the mean Phase I inventory volume with the mean Phase II ground sample volume, provide an estimate of the total bias in volume estimation for the Volume Audit and YSM populations in the Morice TSA. In the YSM stratum, nearly half (22 out of 50) of the samples were too short for VDYP7 to estimate volumes. For these samples, the VDYP7 volume was set to zero.

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

The results vary widely by stratum, ranging from volume overestimation in the Spruce stratum to volume underestimation in the Balsam leading stratum to very little volume estimation bias in the Pine leading stratum. Over all mature strata, the Phase I appears to underestimate volume by nearly 25%. Note that the sampling error of 23.6% (at 95% confidence) for this estimate did not meet the sampling error target of 15% specified in the VPIP.

In the VRI inventory, estimates of volume for a polygon are generated by the VDYP7 yield model, based on a set of input attributes that are typically photo-estimated. As such, this creates two main sources or two potential underlying causes for the volume bias that we observe when we compare the Phase I inventory volume with the Phase II ground volume. These two underlying causes, which each contribute independently and in an additive fashion to the total volume bias, are:

1. Attribute-related volume bias: bias associated with providing the yield model with incorrect input attributes i.e. biased photo-estimates of inventory attributes for a polygon (e.g. species composition, height, age, basal area, trees/ha).
2. Model-related volume bias: bias associated with poor prediction by the VDYP7 yield model (independent of the input attributes i.e. assuming a correct set of input attributes).

Understanding the cause or source of the volume bias in a management unit may help to focus future efforts for improving volume estimation in the inventory.

Estimates of the relative contribution of each of these bias components to the total inventory volume bias can be obtained by creating a new volume estimate using the polygon attributes from the ground sample (to remove the bias associated with the photo-estimation of these attributes) as inputs to the VDYP7 yield model.

In this manner, the model-related volume bias can be approximated by computing the difference between the ground sample volume and the VDYP7 volume using the ground attributes as input[17]. Attribute-related volume bias can be approximated by computing the difference between the VDYP7 inventory volume (using the photo-estimated attributes as input) and the VDYP7 volume using the ground attributes as input[18]. In each case, either the "model" or the "attributes" are held constant to isolate their respective effects on volume estimation.

The results of the analysis of model-related and attribute-related volume bias in the Morice TSA are shown in Table 9. This analysis was carried out for volume/ha at a 12.5cm+ dbh net dwb utilization.

[17] To estimate model bias, the bias associated with the inputs to VDYP7 is removed by using the ground attributes, which are assumed to be "correct". Since the ground attributes are used as inputs for both volume computations (i.e. VDYP7 and the compiler), any resulting volume differences are then attributed to the "model". That is, the ground sample compiler (which is assumed to be accurate) is compared as directly as possible to the VDYP7 yield prediction model.

[18] To estimate the attribute-related bias component of the total volume bias, the same "model" is used (i.e. VDYP7 in both cases) but volumes using the ground attributes (which are assumed to be accurate) as inputs to VDYP7 are compared to volumes using the photo-estimated attributes as inputs to VDYP7.

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

| Stratum | n | Weighted mean vol/ha net dwb at 12.5cm+ dbh | | | | | |
|---|---|---|---|---|---|---|---|
| | | *Phase II Ground* **A** | *VDYP7 Phase I Inventory (VRIMS with MPB adjustment)* **B** | *VDYP7 volume with Phase II attributes as input (VRISTART)* **C** | *Model-related volume bias* **A-C** | *Attribute-related volume bias* **C-B** | *Total volume bias* **A-B** |
| YSM (Immature) | 50 | 49.8 | 6.2 | 45.9 | 3.9 | 39.7 | 43.6 |
| Volume Audit (Mature) | | | | | | | |
| Balsam | 19 | 290.2 | 171.2 | 223.2 | 67.0 | 52.0 | 119.0 |
| Pine | 17 | 133.6 | 131.2 | 133.0 | 0.6 | 1.8 | 2.4 |
| Spruce | 11 | 164.9 | 198.4 | 146.3 | 18.6 | -52.1 | -33.5 |
| Other | 3 | 195.6 | 153.8 | 168.8 | 26.8 | 15.0 | 41.9 |
| *Subtotal* | *50* | *203.1* | *162.7* | *172.0* | *31.1* | *9.3* | *40.4* |

For the mature (Volume Audit) target population, the difference between the ground volume and inventory volume (Table 9 column A – column B), referred to as the total volume bias, was 40 m3/ha, indicating that, on average, the inventory is underestimating the overall mature volume by about 40 m3/ha or about 20% relative to the ground volume. The model-related component of the volume bias (column A – column C) was +31 m3/ha, and the attribute-related volume bias was +9 m3/ha.

These results are shown diagrammatically in Figure 3.

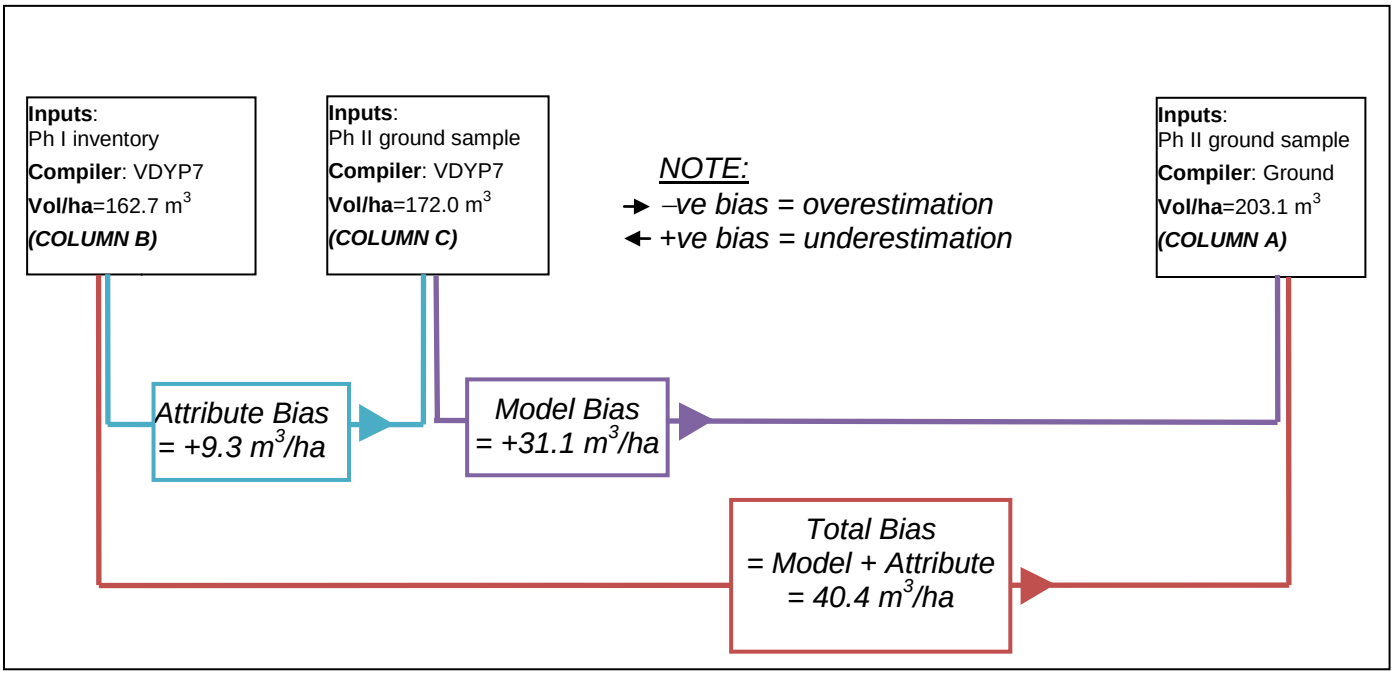


***Figure 3:*** The relationship between the model and attribute-associated components of total volume bias for the mature target population in the Morice TSA (from Table 9). A negative bias indicates overestimation whereas a positive bias indicates underestimation.

The results in Table 9 are presented as ratios of means in Table 10. In Table 10, a model bias ratio greater than one indicates that VDYP7 underestimates volume. An attribute bias ratio less than one indicates that inaccuracies in the Phase I estimates may be associated with an overestimation of volume.

On a leading species stratum basis within the mature target population, the trends varied widely. For Balsam leading, the attribute-related and model-related biases associated with the Phase I inventory volume were both substantial and contributed in similar proportions to the total inventory volume underestimation bias. For Pine leading, the level of total volume bias was quite low, with slightly more attribute-related bias than model-related bias. For Spruce leading, the model contributed to a volume underestimation which mitigated, to a limited degree, the rather large attribute-related volume overestimation.

In all strata, the estimates of model bias had relatively low sampling errors whereas the sampling errors for the attribute bias estimates were quite high.

***Table 10:*** Ratios of mean volumes (12.5cm+ dbh net dwb) representing total, model and attribute bias, with associated sampling error % at a 95% confidence level. Shaded cells represent small sample sizes where results must be interpreted with caution.

| ***Stratum*** | ***n*** | *Ratio of Weighted Mean Volume/ha net dwb at 12.5cm+ dbh (and sampling error at a 95% confidence level)* | | |
|---|---|---|---|---|
| | | ***Total Bias**: Ground/Inventory (Table 9 col A/B)* | ***Model Bias**: Ground/ VDYP7 (ground attributes) (Table 9 col A/C)* | ***Attribute Bias**: VDYP7 (ground attributes) / Inventory (Table 9 col C/B)* |
| YSM (Immature) | 50 | 7.995 (±74.1%) | 1.085 (±4.2%) | 7.371 (±73.0%) |
| Volume Audit (Mature) | | | | |
| Balsam | 19 | 1.695 (±37.8%) | 1.300 (±9.1%) | 1.303 (±34.3%) |
| Pine | 17 | 1.018 (±43.5%) | 1.004 (±8.1%) | 1.014 (±47.1%) |
| Spruce | 11 | 0.831 (±34.8%) | 1.127 (±10.6%) | 0.737 (±40.7%) |
| Other | 3 | 1.272 (±54.7%) | 1.159 (±5.8%) | 1.098 (±49.8%) |
| *Subtotal* | *50* | 1.248 (±23.6%) | 1.181 (±5.1%) | 1.057 (±23.0%) |

Basal area/ha is known to be an important driver of volume in the VDYP7 model. In the mature Balsam and Spruce leading strata, the trends in basal area/ha bias shown in Table 8 are mirrored in the trends in attribute bias shown in Table 10 above.

Note that in the Pine leading stratum, the same interpretation cannot be made. The estimate of Phase I inventory basal area/ha bias in Table 8 (ratio of means = 0.644) does *not* reflect the MPB mortality that *is* taken into account in the Phase I inventory volume estimate. The attribute bias results in Table 10 would suggest that the BCMPB mortality algorithm is producing acceptable results for volume in the Pine leading stratum.

### 3.3 Leading species comparison

Tables 11 and 12 below summarizes the correspondence between the leading species on the Phase I inventory files and the leading species from the Phase II ground sample compilation, for the samples from the immature (YSM) target population. For 78% of the samples (39 out of 50), the inventory and the ground sample had the same leading species. This is a relatively good result compared with findings in other units.

***Table 11:*** Phase II ground vs. Phase I inventory leading species cross-tabulation, for the Immature (YSM) target population in the Morice TSA (cell value expressed as a percent of the row i.e. Phase I total, is shown in brackets).

| *Immature (YSM) samples* | | | | | | |
|---|---|---|---|---|---|---|
| ***Phase I Inventory leading spp*** | ***Phase II Ground leading species at 4cm+ dbh utilization*** | | | | | |
| | ***AT/AC*** | ***B*** | ***PL*** | ***S (Sb/Sw/Sx)*** | ***Total %*** | ***Total count*** |
| ***AT*** | 0 | 0 | 1 (100%) | 0 | 100% | 1 |
| ***B*** | 0 | 2 (100%) | 0 | 0 | 100% | 2 |
| ***PL*** | 3 (8%) | 0 | 29 (81%) | 4 (11%) | 100% | 36 |
| ***S (Sb/Sw/Sx)*** | 0 | 2 (18%) | 1 (9%) | 8 (73%) | 100% | 11 |
| ***Total %*** | 6% | 8% | 62% | 24% | 100% | |
| ***Total count*** | 3 | 4 | 31 | 12 | | 50 |

***Table 12:*** Phase II ground vs. Phase I inventory leading species cross-tabulation, for the Immature (YSM) target population in the Morice TSA (cell value expressed as a percent of the column i.e. Phase II total, is shown in brackets).

| *Immature (YSM) samples* | | | | | | |
|---|---|---|---|---|---|---|
| ***Phase I Inventory leading spp*** | ***Phase II Ground leading species at 4cm+ dbh utilization*** | | | | | |
| | ***AT/AC*** | ***B*** | ***PL*** | ***S (Sb/Sw/Sx)*** | ***Total %*** | ***Total count*** |
| ***AT*** | 0 | 0 | 1 | 0 | 2% | 1 |
| ***B*** | 0 | 2 (50%) | 0 | 0 | 4% | 2 |
| ***PL*** | 3 (100%) | 0 | 29 | 4 (33%) | 72% | 36 |
| ***S (Sb/Sw/Sx)*** | 0 | 2 (50%) | 1 | 8 (67%) | 22% | 11 |
| ***Total %*** | 100% | 100% | 100% | 100% | 100% | |
| ***Total count*** | 3 | 4 | 31 | 12 | | 50 |

Tables 13 and 14 show the corresponding results for samples from the mature (Volume Audit) target population. Here, 62% of the samples (31 out of 50) had the same leading species for both the Phase I inventory and Phase II ground.

In the mature Pine leading stratum, only 35% (6 out of 17 samples) were also leading in Pl in the Phase II ground sample. This is likely due to the fact that although the BCMPB mortality algorithm adjusts TPH and volume to account for dead pine, it does not adjust species composition or basal area.

***Table 13:*** Phase II ground vs. Phase I inventory leading species cross-tabulation, for the Mature (Volume Audit) target population in the Morice TSA (cell value expressed as a percent of the row i.e. Phase I total, is shown in brackets).

| *Mature (Volume Audit) samples* | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Phase I Inventory leading spp*** | ***Phase II Ground leading species at 4cm+ dbh utilization*** | | | | | | |
| | ***AT/AC*** | ***B*** | ***H*** | ***PL*** | ***S (Sb/Sw/Sx)*** | ***Total %*** | ***Total count*** |
| ***AT*** | 2 (67%) | 0 | 0 | 0 | 1 (33%) | 100% | 3 |
| ***B*** | 0 | 17 (90%) | 1 (5%) | 0 | 1 (5%) | 100% | 19 |
| ***H*** | 0 | 0 | 0 | 0 | 0 | 100% | 0 |
| ***PL*** | 2 (12%) | 4 (24%) | 0 | 6 (35%) | 5 (29%) | 100% | 17 |
| ***S (Sb/Sw/Sx)*** | 0 | 3 (27%) | 0 | 2 (18%) | 6 (55%) | 100% | 11 |
| ***Total %*** | 8% | 48% | 2% | 16% | 26% | 100% | |
| ***Total count*** | 4 | 24 | 1 | 8 | 13 | | 50 |

***Table 14:*** Phase II ground vs. Phase I inventory leading species cross-tabulation, for the Mature (Volume Audit) target population in the Morice TSA (cell value expressed as a percent of the column i.e. Phase II total, is shown in brackets).

| *Mature (Volume Audit) samples* | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Phase I Inventory leading spp*** | ***Phase II Ground leading species at 4cm+ dbh utilization*** | | | | | | |
| | ***AT/AC*** | ***B*** | ***H*** | ***PL*** | ***S (Sb/Sw/Sx)*** | ***Total %*** | ***Total count*** |
| ***AT*** | 2 (50%) | 0 | 0 | 0 | 1 (8%) | 6% | 3 |
| ***B*** | 0 | 17 (71%) | 1 (100%) | 0 | 1 (8%) | 38% | 19 |
| ***H*** | 0 | 0 | 0 | 0 | 0 | 0% | 0 |
| ***PL*** | 2 (50%) | 4 (17%) | 0 | 6 (75%) | 5 (38%) | 34% | 17 |
| ***S (Sb/Sw/Sx)*** | 0 | 3 (12%) | 0 | 2 (25%) | 6 (46%) | 22% | 11 |
| ***Total %*** | 100% | 100% | 100% | 100% | 100% | 100% | |
| ***Total count*** | 4 | 24 | 1 | 8 | 13 | | 50 |

## 3.4 Analysis of Dead Pine

With the prevalence of the Mountain Pine Beetle (MPB), the MFLNRO has developed a methodology to estimate and reflect the dead volume proportion in a stand as an inventory attribute. Under this methodology, dead volume (and trees/ha) estimates are produced so long as a minimum 30% dead pine threshold criterion is met.

The Ministry's Phase I estimates of dead pine volume were compared with the Phase II compiled estimates of dead pine. These results for volume/ha are summarized in Table 15.

The BCMPB model is applied in management units where at least 30% of volume in pine leading stands has been killed by MPB. In pine leading stands, the Phase II ground sample suggests that 54% of the volume was represented by dead pine, which justifies the application of the BCMPB model in this unit. In the Morice TSA, the BCMPB model appears to slightly underestimate (45% vs. 54%) the actual level of pine mortality as a percentage of all live volume plus dead pine, based on a comparison with the Phase II data.

Whereas the BCMPB model suggests that, on average for the sample, 52% of the pine in pine leading stands is dead, the Phase II for the same samples indicates a 74% mortality rate in the pine. Given the ramification

for mid-term timber supply, additional sampling in the pine leading sub-stratum of the mature Volume Audit population are recommended in order to confirm these mortality levels.

***Table 15:*** Weighted average volumes/ha (net dwb at 12.5cm+ dbh), by stratum, indicating pine mortality.

| | | ***Weighted mean vol/ha net dwb at 12.5cm+ dbh*** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ***Live – all species A*** | | ***Live – pine only B*** | | ***Dead – pine only C*** | | ***Pine mortality as % of pine C/(B+C)*** | | ***Pine mortality as % of live all + dead Pl C/(A+C)*** | |
| ***Stratum*** | ***n*** | *Ph I* | *Ph II* | *Ph I* | *Ph II* | *Ph I* | *Ph II* | *Ph I* | *Ph II* | *Ph I* | *Ph II* |
| YSM | 50 | 6.2 | 49.8 | 3.4 | 29.9 | 0.7 | 2.0 | 17% | 6% | 10% | 4% |
| Volume Audit | | | | | | | | | | | |
| Balsam | 19 | 171.2 | 290.2 | 0.8 | 4.9 | 8.3 | 6.2 | 91% | 56% | 5% | 2% |
| Pine | 17 | 131.2 | 133.6 | 102.2 | 55.7 | 109.5 | 156.2 | 52% | 74% | 45% | 54% |
| Spruce | 11 | 198.4 | 164.9 | 22.3 | 21.6 | 27.0 | 37.8 | 55% | 64% | 12% | 19% |
| Other | 3 | 153.8 | 195.6 | 2.6 | 28.1 | 3.6 | 88.0 | 58% | 76% | 2% | 31% |
| *Subtotal* | *50* | *162.7* | *203.1* | *40.3* | *27.3* | *46.7* | *69.3* | 54% | 72% | 22% | 25% |

## 3.5 Limitations of the approach

***Attribute definitions in young stands*** – Some of the Phase I attributes for young stands are obtained from silvicultural records and may have different definition and standards of data collection. In particular, although height and age may have been measured in the field, site index for young stands is usually estimated from SIBEC or from the previous stand (Penner 2012).

***Sample unit*** – Whereas in the Phase I the sample unit is the polygon, in the Phase II the sample unit is a single five plot cluster. 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 single five plot cluster may not be as effective in capturing such variability.

***VDYP7*** – VDYP7 is used to project the Phase I attributes to the year of ground sampling. For very young stands, VDYP7 uses a module called VRIYoung which does not estimate the full suite of inventory attributes until the polygon meets the minimum criteria of breast height age ≥ 6 years, dominant height ≥ 6 m and basal area (7.5cm+ dbh) ≥ 2 $m^2$. Hence VDYP7 may not be the most appropriate model for projecting young managed stands (Penner 2012). 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 coniferous leading managed stands.

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

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

# 4. CONCLUSIONS AND RECOMMENDATIONS

The VRI statistical analysis for the mature (Volume Audit) target population in the Morice TSA suggests that the Phase I volume is underestimated by 25%. *However, this result must be interpreted with caution.* The sampling error associated with this estimate is very high (±24%) and does not meet the target sampling error level of ±15%. Additional sampling may improve the precision of the bias estimates.

With the exception of the Pine leading stratum, trends in basal area bias are reflected in the trends in volume bias. The sample suggests that the Phase I underestimates both basal area and volume in the Balsam leading stratum. In the Spruce leading stratum, these attributes appear to be overestimated in the Phase I. Because of high stratum sampling errors, confidence in these bias trends is limited.

Overall in the mature strata, age and to a lesser degree height is generally overestimated in the Phase I inventory. Site index in the mature strata is slightly underestimated. Of all the Phase I attributes that were examined in this analysis, trees/ha showed the highest levels of bias and was consistently underestimated in all of the main leading species strata. In about 62% of the mature samples, the assignment of leading species matched in both the Phase I and Phase II.

Inference for the YSM stratum is limited since many of the stands in this sample have not yet achieved the thresholds required for VDYP7 to produce a basal area or volume estimate. Phase I ages and heights in this stratum appear to be underestimated. Leading species identification was good with 78% of the samples having the same leading species in the Phase I and Phase II.

The Phase I volume/ha and trees/ha attributes in VRIMS have been adjusted for pine mortality using the BCMPB algorithm. However, the BCMPB model does not adjust Phase I basal area. As a result, the observed Phase I basal area overestimation in the Pine leading stratum is likely due to a significant dead pine component. In the Morice TSA, the BCMPB model appears to slightly underestimate (45% vs. 54%) the actual level of pine mortality as a percentage of all live volume plus dead pine, based on a comparison with the Phase II data. Whereas the BCMPB model suggests that, on average for the sample, 52% of the pine in pine leading stands is dead, the Phase II for the same samples indicates a 74% mortality rate in the pine.

Based on the inventory analysis in Morice TSA, the following recommendations and observations are made:

- Inference for the Volume Audit (mature) target population is limited because of high variability and low confidence in the estimates. To reduce the sampling error for volume, it is recommended that additional samples be established in this target population.
- The sample suggests that the BCMPB volume adjustment for MPB mortality is performing adequately. However, sampling error, particularly in the Pine leading stratum is high and additional samples may strengthen this inference.
- An examination of whole stem volumes, particularly in the Balsam leading stratum, may provide a better understanding of the contribution of loss factor bias to model-related volume bias.
- Alternative approaches and/or improvements to Phase I basal area estimation should be investigated, particularly in the Balsam leading stratum.
- Analysis procedures tailored specifically for the unique inventory characteristics of younger stands (i.e. stands less than 30 years of age) should be developed for future data analysis of these types of ground samples.
- A uniform extract process from the LRDW that would include all the Phase I attributes required for the VRI sample data analysis and be limited to the set of polygons that have been matched to the Phase II ground sample (merged based on cluster id and feature id) should be developed for future VRI sample data analyses.

- This report is a technical document intended to provide complete details of the analysis. However, it is also recommended that a template for communicating these results in a uniform, succinct format suitable for wider distribution be developed.

# 5. LITERATURE CITED

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Penner. 2012. TFL 18 Documentation of Vegetation Resources Inventory Statistical Analysis. November 16, 2012. Prepared by Margaret Penner, Forest Analysis Ltd. 14p + app.

Timberline. 2007. Morice Timber Supply Area Vegetation Resources Inventory Strategic Inventory Plan. Prepared by Timberline Natural Resource Group Ltd. March 2007. 20p + app.

# 6. APPENDIX A: PHASE I INVENTORY ATTRIBUTES

Morice TSA sample
data analysis spreads

# 7. APPENDIX B: PHASE II COMPILED GROUND ATTRIBUTES

See embedded spreadsheet in Appendix A.

# 8. APPENDIX C: DATA ISSUES AND POTENTIAL "OUTLIERS"

Data issues and potential sample "outliers" were forwarded to the MFLNRO for further investigation, including examination of air photos. Some of these samples have been identified on the scatterplots in Appendix F. The following comments were provided by Graham Hawkins and Will Smith (MFLNRO).

| ***Sample*** | ***Comments*** |
|---|---|
| 3 | BA difference is probably OK – phase 1 typing in a polygon with quite a bit of variability |
| 5 | BA difference is likely due to it being in a polygon with lots of rock, could also be due to model limitation (very low phase 1 ht and 0 phase 1 BA) |
| 6 | BA difference and phase 1 polygon looks OK – could be due to model limitation (FIPSTART VDYP7?) |
| 8 | BA difference and phase 1 BA may have been typed too low |
| 10 | BA difference and MPB kill noted in this polygon (not contributing to BA) |
| 11 | Age difference may be caused by there being two layers in the polygon |
| 18 | Sample is misplaced and should be in polygon 618 which is balsam stratum and not in polygon 619. This plot is close to the type line but it would stay in balsam.<br>NOTE: *PHASE I ATTRIBUTES FOR POLYGON 618 WERE USED IN THE ANALYSIS.* |
| 46 | Sample is misplaced and belongs in polygon 603 which puts it in the spruce stratum and not in polygon 224. BA difference in this poly which is a mix of mature and immature<br>NOTE: *PHASE I ATTRIBUTES FOR POLYGON 603 WERE USED IN THE ANALYSIS.* |
| 23, 25, 29, 30, 32, 34 & 35 | These samples are in polygons with significant MPB kill which is likely the reason for the large BA anomalies with these plots |
| 37 | BA difference may be due to model limitation (FIPSTART VDYP7?) |
| 40 | Height difference appears to be a phase 1 typing error and the polygon looks immature.<br>NOTE: *THIS SAMPLE REMAINED IN THE ANALYSIS BUT APPENDIX D SHOWS RESULTS WITH THIS SAMPLE EXCLUDED.* |
| 43 | BA difference probably OK as there are small openings in the polygon and the sample may have fallen in some of these 'holes' |
| 45 | BA difference probably OK (same reason as for sample 43) |
| YSM samples | Everything for the YSM samples matches up well for location (save a few UTM points or so) with the exception of sample 79 which fell right on a road and had been moved. I noticed a couple of relatively small shifts in three plots but not huge moves (comparing coordinates in the sample file with those in the Nona sample selection file) but these were pretty minor and wouldn't explain the issues with the outliers. The BA issues could be related to model limitations. The couple of age and height anomalies are likely due to poor typing in the old inventory carried up to present (I recall it's '94 vintage) and those two TPH outliers may be caused by carrying over old RESULTS data in the original inventory with the new ground numbers being OK. |

# 9. APPENDIX D: ATTRIBUTE BIAS RESULTS WITH SAMPLE #40 EXCLUDED

Sample #40 showed particularly large differences between the Phase I and II attribute values. It was determined by MFLNRO staff that this was likely due to a Phase I photo-typing error. This sample was not excluded in the main analysis because it was a valid example of a potential source of bias in the inventory.

However, because of the potential influence of this sample on the attribute means and ratios of means, a supplementary set of results that *excluded* this sample are shown in the Tables that follow.

***Table D-1:*** Sample-estimated weighted means for the Phase I inventory and Phase II ground sample for seven key inventory attributes, for the volume audit (mature) target population in the Morice TSA, with Sample #40 excluded. Impacts of Sample #40 are shown in RED. Shading indicates small sample size.

| Attribute | Weighted Means | | | | | |
|---|---|---|---|---|---|---|
| | Immature (YSM samples) | Mature (Volume Audit) Samples | | | | |
| | | Balsam | Pine | Spruce (sample #40 excluded) | Other | All mature strata |
| ***Age (years)*** | | | | | | |
| n | 48 | 19 | 17 | 10 | 3 | 49 |
| Phase II Ground | 35 | 191 | 117 | 141 | 79.1 | 148 |
| Phase I Inventory | 30 | 212 | 127 | 162 | 89.7 | 164 |
| ***Height (m)*** | | | | | | |
| n | 48 | 19 | 17 | 10 | 3 | 49 |
| Phase II Ground | 11.3 | 20.8 | 21.3 | 22.4 | 23.9 | 21.5 |
| Phase I Inventory | 8.9 | 22.1 | 22.1 | 25.0 | 21.0 | 22.6 |
| ***Basal area (m2/ha) at 7.5cm+ dbh*** | | | | | | |
| n | 50 | 19 | 17 | 10 | 3 | 49 |
| Phase II Ground | 19.2 | 46.7 | 22.0 | 24.0 | 26.3 | 32.1 |
| Phase I Inventory | 4.0 | 30.8 | 34.2 | 29.2 | 32.7 | 31.8 |
| ***Trees/ha at 7.5cm+ dbh*** | | | | | | |
| n | 48 | 19 | 17 | 10 | 3 | 49 |
| Phase II Ground | 1422 | 1478 | 871 | 631 | 707 | 1043 |
| Phase I Inventory [1] | 1637 | 785 | 671 | 559 | 1000 | 711 |
| ***Lorey height (m)*** | | | | | | |
| n | 31 | 19 | 17 | 10 | 3 | 49 |
| Phase II Ground | 10.2 | 17.8 | 18.5 | 19.9 | 22.6 | 18.8 |
| Phase I Inventory | 9.2 | 17.1 | 18.8 | 21.0 | 18.8 | 18.6 |
| ***Volume/ha (m3/ha) at 12.5cm+ dbh net dwb*** | | | | | | |
| n | 50 | 19 | 17 | 10 | 3 | 49 |
| Phase II Ground | 49.8 | 290.2 | 133.6 | 175.0 | 195.6 | 205.9 |
| Phase I Inventory [2] | 6.2 | 171.2 | 131.2 | 200.3 | 153.8 | 162.4 |
| ***Site index (m) [3]*** | | | | | | |
| n | 40 | 17 | 8 | 6 | 2 | 33 |
| Phase II Ground | 19.6 | 8.8 | 15.4 | 11.0 | 18.8 | 11.4 |
| Phase I Inventory | 17.7 | 8.8 | 15.0 | 9.6 | 14.4 | 10.8 |

NOTES:

[1] The Phase I trees/ha from VRIMS represent LIVE values (net of dead Pl) after the MPB mortality model has been applied.

[2] Phase I volume has been adjusted using the MPB mortality model hence represents LIVE trees net of dead pine.

[3] Sample #40 did not have a suitable Phase I and II leading species match for site index comparison hence exclusion of Sample #40 did not affect site index.

***Table D-2:*** Ratio of means comparisons (and sampling error % at a 95% confidence level) for seven attributes, for the target populations in the Morice TSA, with Sample #40 excluded. Impacts of Sample #40 are shown in RED. Shading indicates small sample size.

| Stratum | n | Ratio of weighted means (with 95% sampling error shown as % of the ratio) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Age (years) | Height (m) | Basal area ($m^2$/ha) | Trees/ha | Lorey height (m) | Volume net dwb ($m^3$/ha) | SI (m) |
| YSM (Immature) | 50 | 1.175 (±15.4%) | 1.270 (±10.7%) | 4.017 (±35.9%) | 0.869 (±41.4%) | 1.107 (±12.8%) | 7.995 (±74.1%) | 1.108 (±7.5%) |
| Volume Audit (Mature) | | | | | | | | |
| Balsam | 19 | 0.902 (±14.1%) | 0.943 (±12.0%) | 1.517 (±26.2%) | 1.884 (±20.2%) | 1.042 (±15.3%) | 1.695 (±37.8%) | 0.994 (±23.6%) |
| Pine | 17 | 0.923 (±12.3%) | 0.962 (±8.0%) | 0.644 (±30.5%) | 1.297 (±34.4%) | 0.980 (±13.0%) | 1.018 (±43.5%) | 1.030 (±19.2%) |
| Spruce | 10 | 0.871 (±22.1%) | 0.896 (±17.9%) | 0.822 (±32.7%) | 1.130 (±34.0%) | 0.949 (±13.2%) | 0.874 (±35.9%) | 1.142 (±24.6%) |
| Other | 3 | 0.881 (±25.1%) | 1.134 (±6.3%) | *0.803 (±41.3%)* | *0.707 (±13.0%)* | *1.205 (±19.7%)* | 1.272 (±54.7%) | 1.300 (±8.2%) |
| *Subtotal* | *49* | *0.901 (±8.4%)* | *0.950 (±6.4%)* | *1.012 (±17.2%)* | *1.466 (±18.9%)* | *1.008 (±8.0%)* | *1.268 (±23.7%)* | *1.054 (±13.3%)* |

# 10. 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 matching typology is 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

Of the 100 samples used in the analysis, 70% indicated a match between the Phase I inventory leading species and the Phase II ground leading species at 4cm+ dbh utilization. A further 3 samples were matched based on the inventory secondary species. Note that there were 12 samples where the inventory secondary species matched the ground leading species but where no Phase I height or age data were available for the secondary species (these cases are denoted by 3* in the table below). It was possible, however, to match these samples on a conifer-to-conifer or deciduous-to-deciduous basis. Thirteen additional samples were also matched on the same (i.e. Case 3) basis. Two samples could not be matched and were therefore excluded from the development of the age and height comparison ratios. Both of these samples (#78 and #92) were in the YSM stratum.

***Table E-1:*** Phase I and II heights and ages for ratio comparison

| *SAMPLE* | *Phase II (ground) lead spp @ 4cm+dbh* | *Ph II lead species age (aget_tlxo)* | *Ph II lead species height (ht_tlxo)* | *Number of age trees (n_ag_tlxo)* | *Number of height trees (n_ht_tlxo)* | *Ph I inventory lead SP01* | *Ph I inventory second SP02* | *Case for match* | *Ph I age for match (depending on case; msg if case 5)* | *Ph I ht for match (depending on case; msg if case 5)* |
|---|---|---|---|---|---|---|---|---|---|---|
| 0001 | BL | 202.19 | 14.66 | 5 | 5 | BL | PA | 1 | 201 | 13.5 |
| 0002 | BL | 279.67 | 19.58 | 5 | 5 | B | S | 1 | 240 | 19.6 |
| 0003 | BL | 208.19 | 23.98 | 5 | 5 | BL | | 1 | 181 | 15.8 |
| 0004 | BL | 247.04 | 19.88 | 5 | 5 | BL | HM | 1 | 201 | 13.5 |
| 0005 | BL | 69.3 | 12.02 | 5 | 5 | BL | | 1 | 71 | 10 |
| 0006 | BL | 275.1 | 23.28 | 5 | 5 | BL | | 1 | 271 | 15.1 |
| 0007 | BL | 196.78 | 19.1 | 5 | 5 | B | S | 1 | 241 | 25.1 |
| 0008 | HM | 133.7 | 18.44 | 5 | 5 | B | | 3 | 270 | 25.8 |
| 0009 | BL | 172.5 | 16.34 | 5 | 5 | B | | 1 | 190 | 19.6 |
| 0010 | BL | 182.25 | 10.55 | 4 | 4 | BL | PL | 1 | 81 | 21.1 |
| 0011 | B | 178.65 | 27.53 | 3 | 3 | B | | 1 | 340 | 25.4 |
| 0012 | S | 156.4 | 23.4 | 1 | 1 | B | S | 3 | 201 | 20.5 |
| 0013 | BL | 204.17 | 18.5 | 3 | 3 | BL | SW | 1 | 242 | 27.7 |
| 0014 | BL | 185.68 | 30.3 | 5 | 5 | BL | PL | 1 | 221 | 29 |

| SAMPLE | Phase II (ground) lead spp @ 4cm+dbh | Ph II lead species age (aget_tlxo) | Ph II lead species height (ht_tlxo) | Number of age trees (n_ag_tlxo) | Number of height trees (n_ht_tlxo) | Ph I inventory lead SP01 | Ph I inventory second SP02 | Case for match | Ph I age for match (depending on case; msg if case 5) | Ph I ht for match (depending on case; msg if case 5) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0015 | BL | 185.3 | 21.6 | 5 | 5 | B | S | 1 | 271 | 30.6 |
| 0016 | BL | 191.1 | 22.82 | 5 | 5 | B | S | 1 | 201 | 25.3 |
| 0017 | BL | 231.92 | 24.76 | 5 | 5 | B | S | 1 | 178 | 25.3 |
| 0018 | BL | 160.3 | 18.8 | 5 | 5 | S | BL | 1 | 200 | 25.3 |
| 0019 | BL | 171.21 | 30.62 | 5 | 5 | B | S | 1 | 221 | 31.8 |
| 0020 | SX | 62.83 | 18.3 | 3 | 3 | PL | SW | 2 | 61 | 17.7 |
| 0021 | AT | 84.6 | 23.72 | 5 | 5 | PL | AT | 3* | 121 | 22.5 |
| 0022 | PLI | 41.83 | 10.3 | 3 | 3 | PL | SX | 1 | 57 | 11.2 |
| 0023 | S | 129.1 | 23.18 | 5 | 5 | PL | S | 3* | 121 | 22.5 |
| 0024 | PLI | 66.5 | 17.68 | 5 | 5 | PL |  | 1 | 66 | 18.9 |
| 0025 | PL | 76.7 | 18.96 | 5 | 5 | PL |  | 1 | 86 | 21.9 |
| 0026 | AT | 57 | 20.42 | 5 | 5 | PL | AT | 3* | 88 | 21.1 |
| 0027 | PL | 83.5 | 19.35 | 5 | 6 | PL |  | 1 | 80 | 19 |
| 0028 | S | 76.3 | 24 | 5 | 5 | PL |  | 3 | 80 | 23.2 |
| 0029 | BL | 294.39 | 16.5 | 5 | 5 | PL |  | 3 | 221 | 26.4 |
| 0030 | SX | 191.1 | 17.68 | 5 | 5 | PL | SX | 2 | 198 | 24.1 |
| 0031 | BL | 141.52 | 26.36 | 5 | 5 | PL | BL | 3* | 201 | 24.5 |
| 0032 | PLI | 117.1 | 31.14 | 5 | 5 | PL |  | 1 | 155 | 24.9 |
| 0033 | PL | 116.1 | 24.48 | 5 | 5 | PL | S | 1 | 115 | 22.6 |
| 0034 | BL | 179.7 | 25.6 | 5 | 5 | PL | S | 3 | 161 | 25.8 |
| 0035 | BL | 162 | 19.1 | 4 | 4 | PL |  | 3 | 221 | 24.4 |
| 0036 | S | 126.75 | 25.1 | 4 | 4 | PL | S | 3* | 138 | 26.4 |
| 0037 | S | 150.7 | 23.96 | 5 | 5 | SB | SW | 1 | 116 | 14.2 |
| 0038 | S | 221.3 | 12.82 | 5 | 5 | SB | SW | 1 | 185 | 15.5 |
| 0039 | SB | 158.3 | 17.36 | 5 | 5 | SB | SW | 1 | 135 | 17.1 |
| 0040 | PLI | 20.5 | 8.4 | 1 | 1 | SW | BL | 3 | 242 | 28.4 |
| 0041 | BL | 155.2 | 25.7 | 6 | 5 | S | PL | 3 | 121 | 27.3 |
| 0042 | S | 114.1 | 29.44 | 5 | 5 | S | PL | 1 | 163 | 28 |
| 0043 | SX | 134.33 | 16.38 | 6 | 5 | SW | BL | 1 | 142 | 26.8 |
| 0044 | BL | 140.52 | 29.8 | 5 | 5 | S | B | 3* | 205 | 34.2 |
| 0045 | BL | 113.71 | 24.7 | 5 | 5 | S | PL | 3 | 141 | 30.5 |
| 0046 | PLI | 27.25 | 12.65 | 4 | 4 | S |  | 3 | 130 | 26.8 |
| 0047 | SX | 194.5 | 31.22 | 5 | 5 | SX | PL | 1 | 273 | 29.7 |
| 0048 | AT | 69.59 | 20.84 | 5 | 5 | AT | S | 1 | 71 | 17.5 |
| 0049 | AT | 58.37 | 20.62 | 5 | 5 | AT | PL | 1 | 90 | 19.6 |
| 0050 | SX | 104.31 | 29.08 | 5 | 5 | AT | S | 3* | 105 | 25.2 |
| 0051 | PL | 37.5 | 13.53 | 4 | 4 | PL |  | 1 | 32 | 9.9 |
| 0052 | PL | 30.5 | 10.8 | 4 | 4 | PL | BL | 1 | 24 | 8.2 |
| 0053 | PL | 34 | 13.13 | 4 | 4 | PL |  | 1 | 37 | 11.4 |

| SAMPLE | Phase II (ground) lead spp @ 4cm+dbh | Ph II lead species age (aget_tlxo) | Ph II lead species height (ht_tlxo) | Number of age trees (n_ag_tlxo) | Number of height trees (n_ht_tlxo) | Ph I inventory lead SP01 | Ph I inventory second SP02 | Case for match | Ph I age for match (depending on case; msg if case 5) | Ph I ht for match (depending on case; msg if case 5) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0054 | PL | 35.17 | 9.6 | 3 | 3 | PL | | 1 | 31 | 12.4 |
| 0055 | PL | 30.3 | 10.9 | 5 | 5 | PL | BL | 1 | 24 | 8.2 |
| 0056 | BL | 62.57 | 9.98 | 4 | 4 | B | H | 1 | 51 | 7.7 |
| 0057 | BL | 174.5 | 13.93 | 3 | 3 | BL | S | 1 | 51 | 16.2 |
| 0058 | PL | 26.75 | 10.23 | 4 | 4 | PL | S | 1 | 23 | 9.9 |
| 0059 | SX | 31 | 10.4 | 4 | 4 | S | BL | 1 | 31 | 7 |
| 0060 | SX | 27.5 | 6.83 | 4 | 4 | PL | S | 3* | 24 | 9.3 |
| 0061 | SX | 40.5 | 13 | 4 | 4 | S | PL | 1 | 38 | 6.9 |
| 0062 | PL | 35.1 | 11.9 | 5 | 5 | PL | S | 1 | 39 | 15.3 |
| 0063 | PL | 25.5 | 8.94 | 5 | 5 | PL | S | 1 | 23 | 6.8 |
| 0064 | SX | 37.7 | 14.7 | 5 | 5 | S | PL | 1 | 39 | 7.2 |
| 0065 | SX | 31 | 8.15 | 2 | 2 | PL | S | 3* | 26 | 11.3 |
| 0066 | PLI | 28.5 | 11.2 | 4 | 4 | PL | AT | 1 | 31 | 11.7 |
| 0067 | AT | 20.75 | 9.08 | 4 | 4 | PL | AT | 3* | 22 | 6.5 |
| 0068 | PLI | 25.5 | 7.35 | 2 | 2 | PL | SX | 1 | 28 | 7.1 |
| 0069 | PLI | 25.5 | 11.63 | 3 | 3 | PLI | SX | 1 | 25 | 9.2 |
| 0070 | PL | 23.5 | 10.55 | 4 | 4 | PL | | 1 | 24 | 7.2 |
| 0071 | PLI | 26.75 | 11.78 | 4 | 4 | PL | | 1 | 26 | 7.9 |
| 0072 | PL | 25 | 11.8 | 4 | 4 | PL | | 1 | 24 | 7.2 |
| 0073 | PLI | 24.25 | 10.2 | 4 | 4 | PL | AT | 1 | 23 | 6.8 |
| 0074 | PL | 21.17 | 6.13 | 3 | 3 | PL | S | 1 | 22 | 8.4 |
| 0075 | PLI | 39.7 | 12.18 | 5 | 5 | PL | | 1 | 47 | 5 |
| 0076 | PLI | 24.5 | 11.23 | 4 | 4 | PLI | ACT | 1 | 30 | 13.1 |
| 0077 | PLI | 22.5 | 8.78 | 5 | 5 | PL | S | 1 | 21 | 6.1 |
| 0078 | ACT | 32.17 | 21.43 | 3 | 3 | PL | S | 5 | . | . |
| 0079 | PL | 27.25 | 12.3 | 4 | 4 | PL | AT | 1 | 23 | 8.8 |
| 0080 | PLI | 29.9 | 13.04 | 5 | 5 | AT | PL | 3* | 28 | 12.6 |
| 0081 | PLI | 28 | 11.53 | 4 | 4 | PL | S | 1 | 27 | 8.3 |
| 0082 | S | 37.25 | 12.35 | 4 | 4 | PL | BL | 3 | 35 | 6.8 |
| 0083 | BL | 32.75 | 7.83 | 4 | 4 | S | BL | 3* | 26 | 3.5 |
| 0084 | PL | 26.5 | 10.08 | 4 | 4 | PL | BL | 1 | 34 | 13.6 |
| 0085 | PLI | 31.7 | 11.64 | 5 | 5 | PL | S | 1 | 33 | 10.2 |
| 0086 | SX | 36.75 | 13.63 | 4 | 4 | S | BL | 1 | 34 | 5.6 |
| 0087 | S | 35.5 | 14.06 | 5 | 5 | SX | BL | 1 | 42 | 12.8 |
| 0088 | PLI | 21.75 | 9.73 | 4 | 4 | SX | PLI | 2 | 21 | 8.5 |
| 0089 | S | 27.75 | 12.5 | 4 | 4 | PL | AT | 3 | 24 | 9.3 |
| 0090 | PLI | 25.5 | 10.95 | 4 | 4 | PL | AT | 1 | 24 | 11 |
| 0091 | SX | 34.5 | 12.97 | 3 | 3 | S | AT | 1 | 34 | 8.7 |
| 0092 | AT | 23 | 16.23 | 4 | 4 | PL | | 5 | . | . |

| SAMPLE | Phase II (ground) lead spp @ 4cm+dbh | Ph II lead species age (aget_tlxo) | Ph II lead species height (ht_tlxo) | Number of age trees (n_ag_tlxo) | Number of height trees (n_ht_tlxo) | Ph I inventory lead SP01 | Ph I inventory second SP02 | Case for match | Ph I age for match (depending on case; msg if case 5) | Ph I ht for match (depending on case; msg if case 5) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0093 | S | 39.5 | 8 | 2 | 2 | S | BL | 1 | 25 | 4.6 |
| 0094 | PL | 23.25 | 11.78 | 4 | 4 | PLI | ACT | 1 | 24 | 12.8 |
| 0095 | PL | 22.1 | 9.92 | 5 | 5 | PLI | SX | 1 | 21 | 7.9 |
| 0096 | S | 25.9 | 9.8 | 5 | 5 | S | | 1 | 26 | 5.5 |
| 0097 | BL | 91.91 | 24.6 | 4 | 4 | S | | 3 | 41 | 7.8 |
| 0098 | PLI | 27.3 | 10.96 | 5 | 5 | PL | | 1 | 25 | 10.8 |
| 0099 | PLI | 18.75 | 8.2 | 4 | 4 | PLI | BL | 1 | 18 | 6.4 |
| 0100 | PL | 55 | 17.93 | 4 | 4 | PL | S | 1 | 37 | 7.2 |

# 11. APPENDIX F: SCATTERPLOTS AND RESIDUALS FOR RATIO ANALYSIS

*Immature (YSM) stratum* *(Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value.* **RED** *= samples examined for potential data issues)*

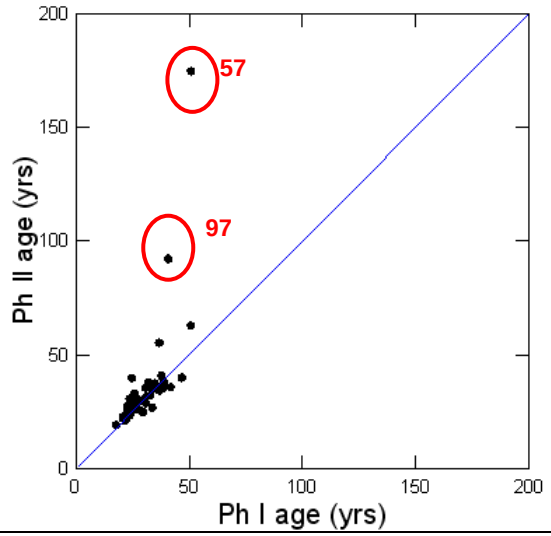


Fig F-1a: Phase II vs. Phase I age. The blue line represents a 1:1 correspondence.

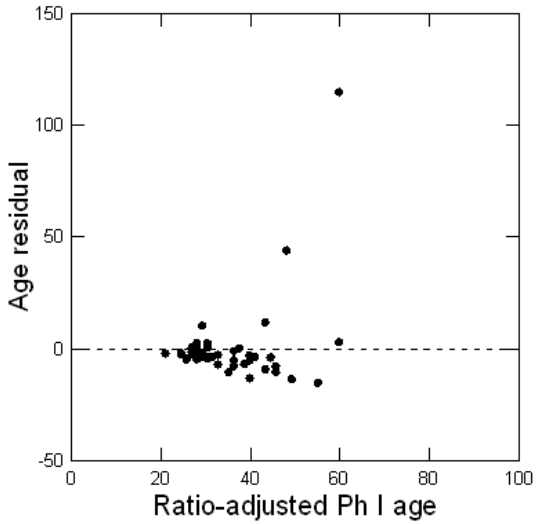


Fig F-1b: Age residuals vs adjusted Phase I inventory age (i.e. R × unadjusted Ph I age).

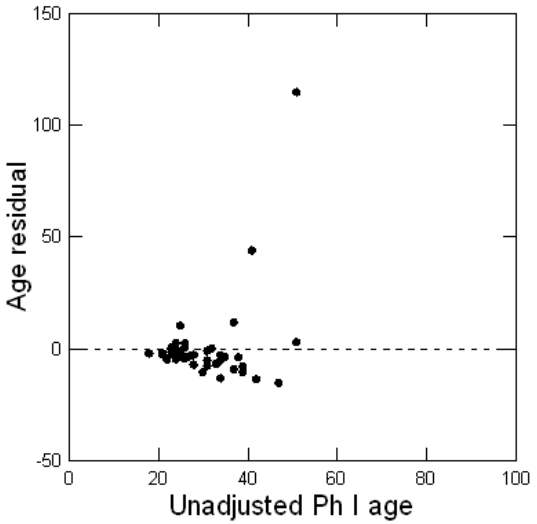


Fig F-1c: Age residuals vs unadjusted Phase I inventory age.

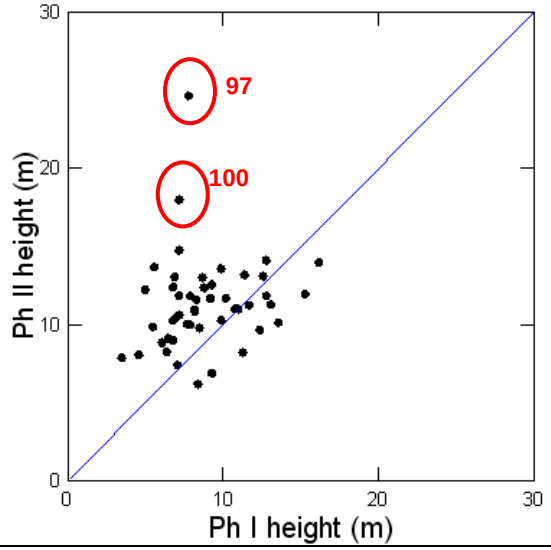


Fig F-2a: Phase II vs. Phase I height. The blue line represents a 1:1 correspondence.

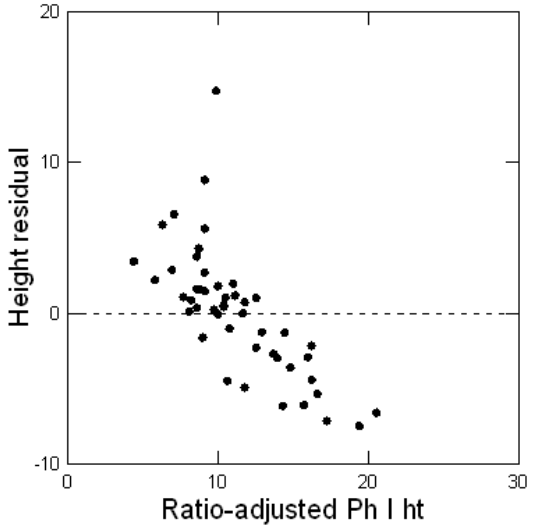


Fig F-2b: Height residuals vs adjusted Phase I inventory height (i.e. R × unadjusted Ph I height).

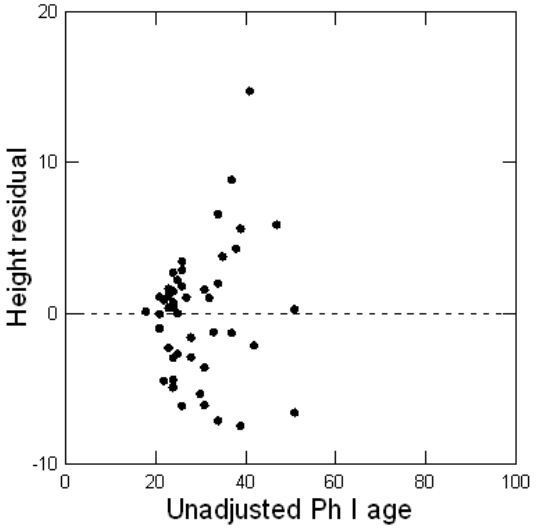


Fig F-2c: Height residuals vs unadjusted Phase I inventory age.

*Immature (YSM) stratum* *(Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value.* **RED** *= samples examined for potential data issues)*

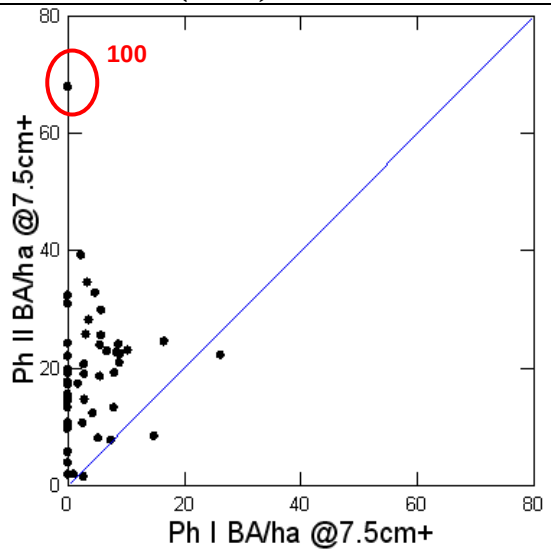


Fig F-3a: Phase II vs. Phase I ba/ha. The blue line represents a 1:1 correspondence.

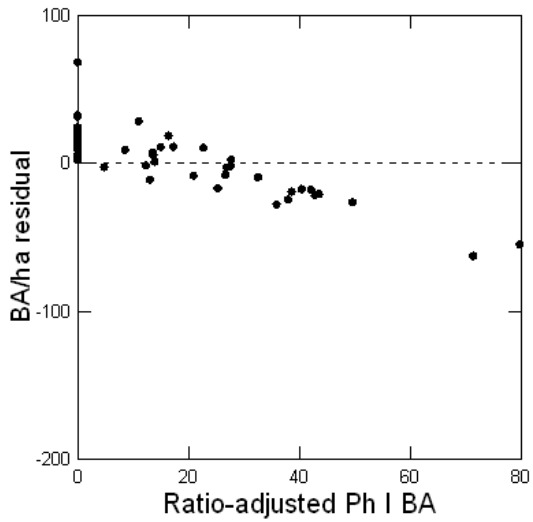


Fig F-3b: Ba/ha residuals vs adjusted Phase I inventory ba/ha (i.e. R × unadjusted Ph I ba/ha).

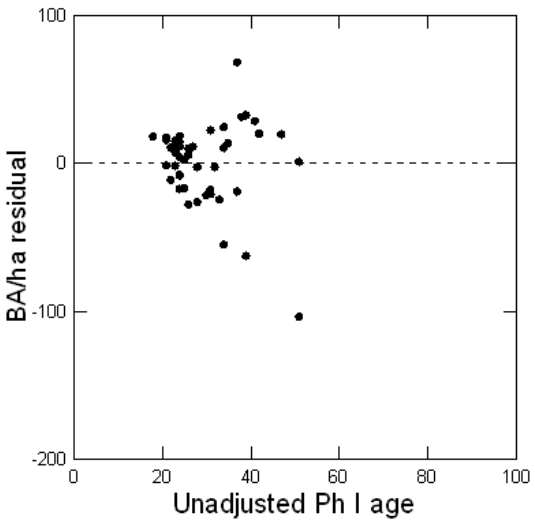


Fig F-3c: Ba/ha residuals vs unadjusted Phase I inventory age.

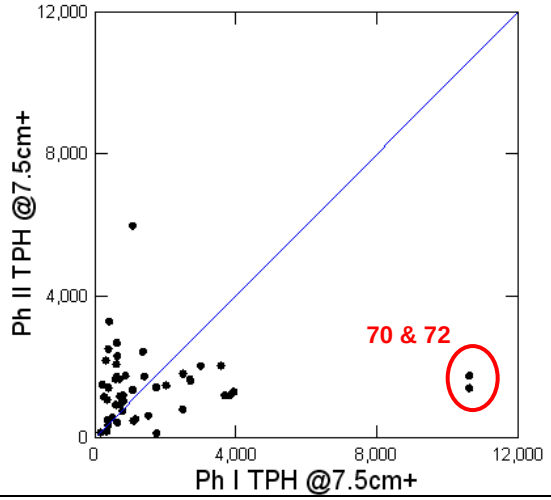


Fig F-4a: Phase II vs. Phase I trees/ha. The blue line represents a 1:1 correspondence.

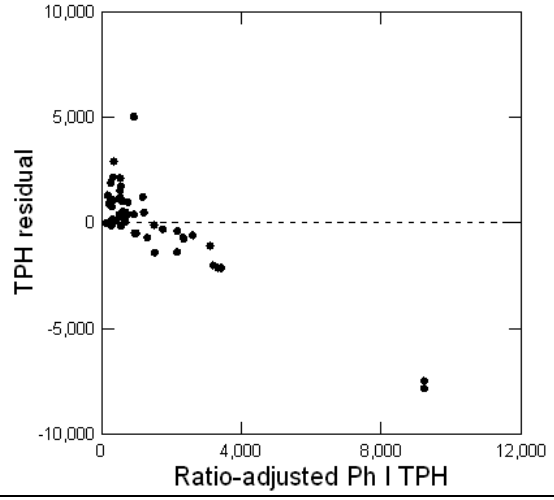


Fig F-4b: Trees/ha residuals vs adjusted Phase I inventory trees /ha (i.e. R × unadjusted Ph I trees /ha).

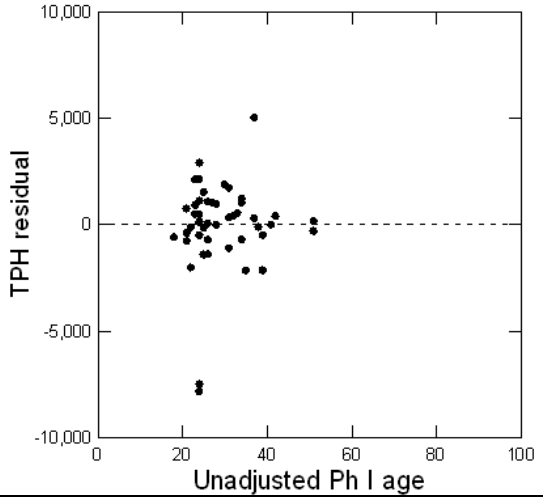


Fig F-4c: Trees /ha residuals vs unadjusted Phase I inventory age.

*Immature (YSM) stratum* *(Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value.* **RED** *= samples examined for potential data issues)*

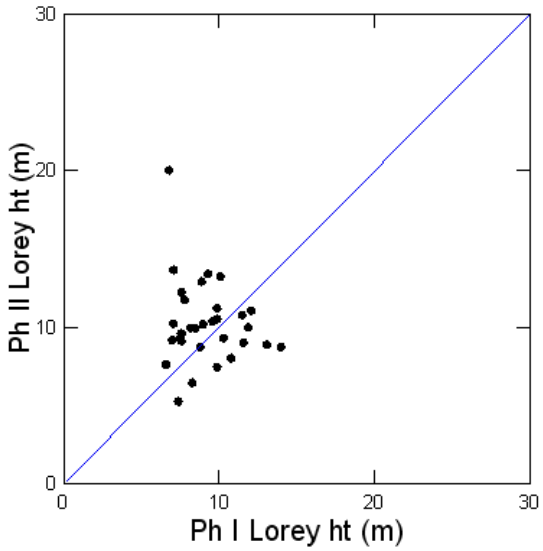


Fig F-5a: Phase II vs. Phase I Lorey height. The blue line represents a 1:1 correspondence.

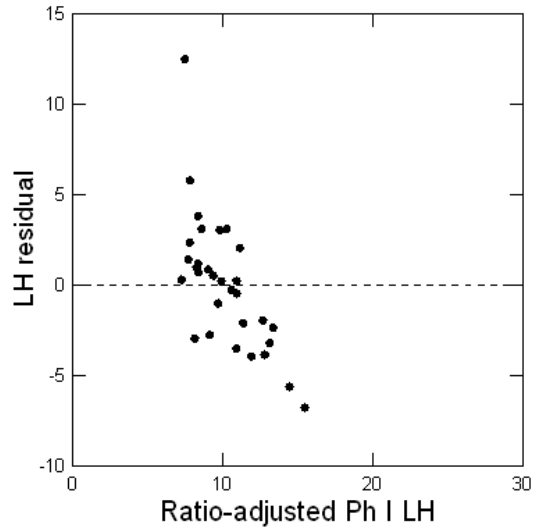


Fig F-5b: Lorey height residuals vs adjusted Phase I inventory Lorey ht (i.e. R × unadjusted Ph I Lorey ht).

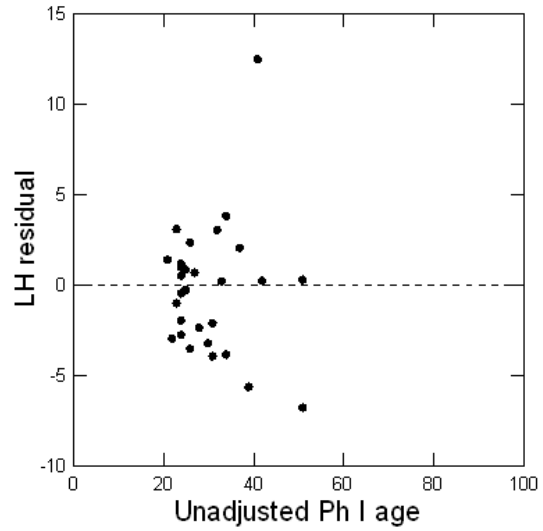


Fig F-5c: Lorey height residuals vs unadjusted Phase I inventory age.

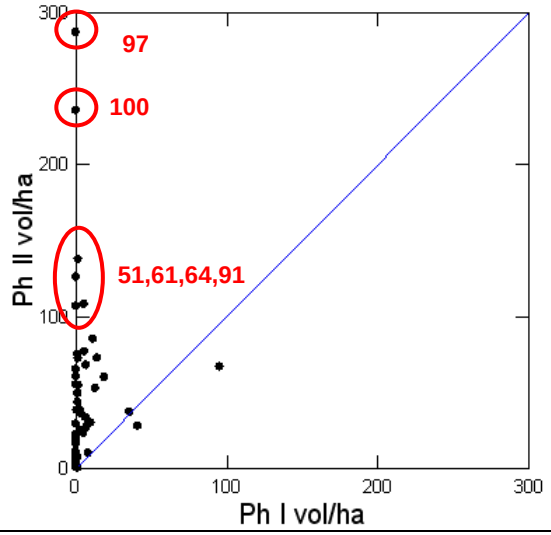


Fig F-6a: Phase II vs. Phase I vol/ha. The blue line represents a 1:1 correspondence.

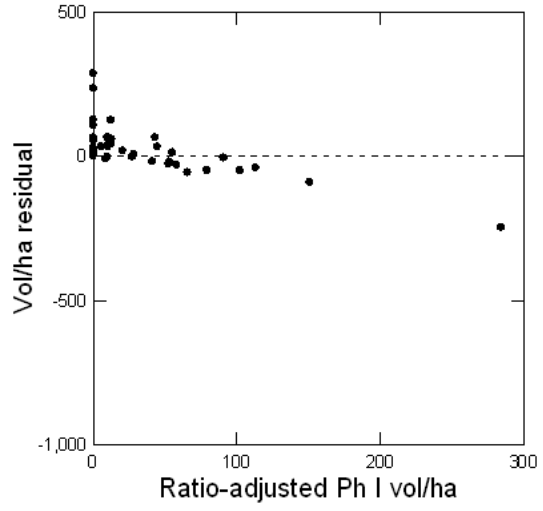


Fig F-6b: Vol/ha residuals vs adjusted Phase I inventory vol/ha (i.e. R × unadjusted Ph I vol/ha).

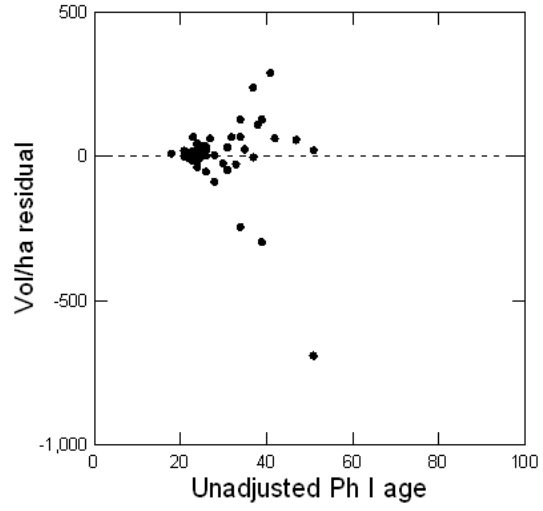


Fig F-6c: Vol/ha residuals vs unadjusted Phase I inventory age.

*Immature (YSM) stratum* *(Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value.* **RED** *= samples examined for potential data issues)*

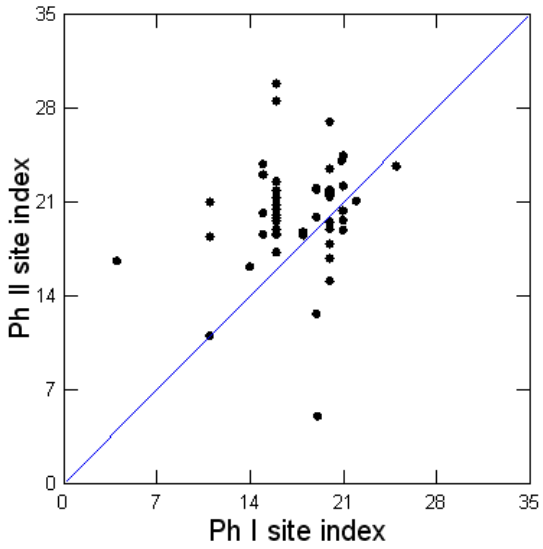


Fig F-7a: Phase II vs. Phase I site index. The blue line represents a 1:1 correspondence.

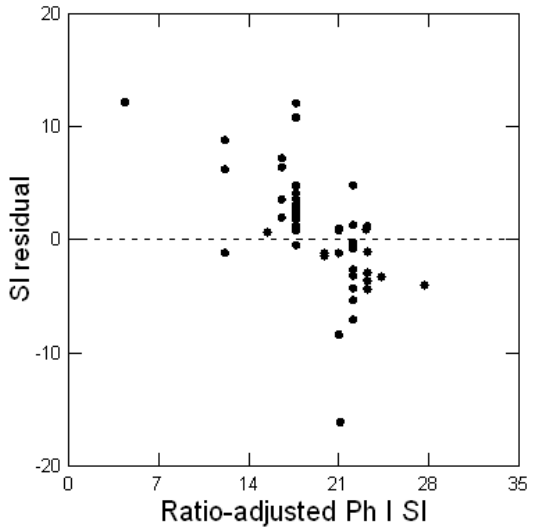


Fig F-7b: Site index residuals vs adjusted Phase I inventory site index (i.e. R × unadjusted Ph I Lorey ht).

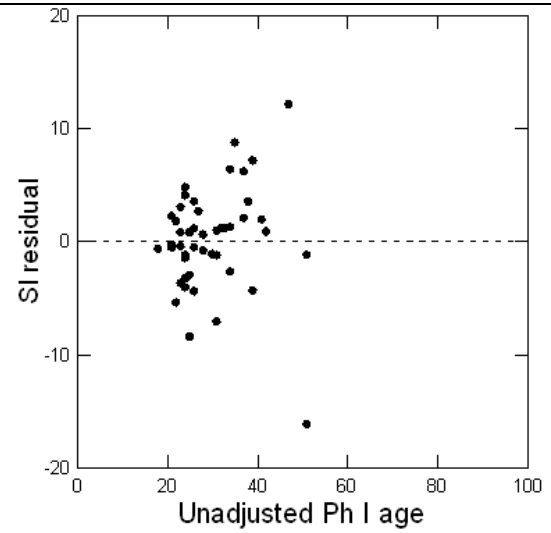


Fig F-7c: Site index residuals vs unadjusted Phase I inventory age.

## *Mature (Volume Audit) Balsam leading stratum* *(Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

**RED** = *samples examined for potential data issues)*

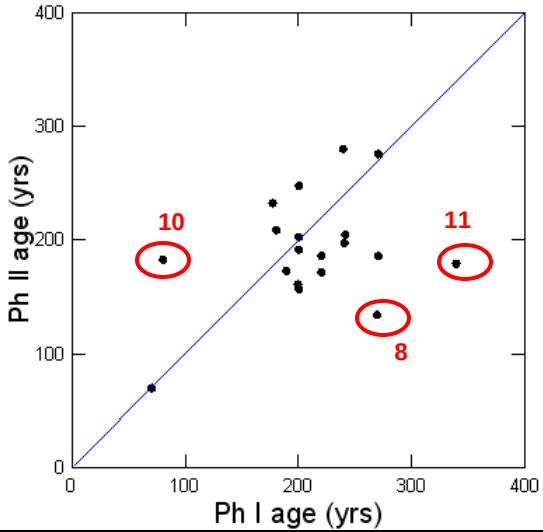


Fig F-8a: Phase II vs. Phase I age. The blue line represents a 1:1 correspondence.

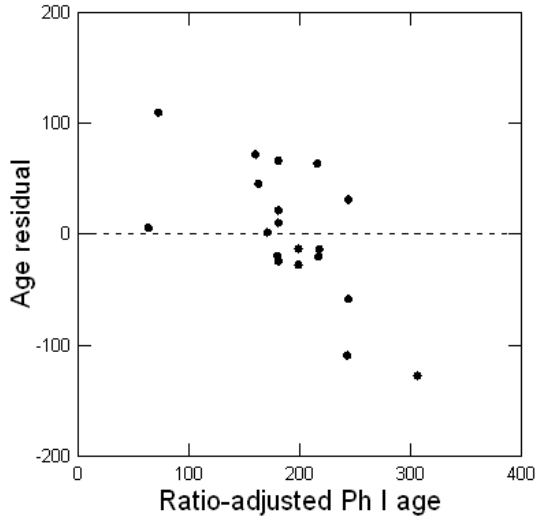


Fig F-8b: Age residuals vs adjusted Phase I inventory age (i.e. R × unadjusted Ph I age).

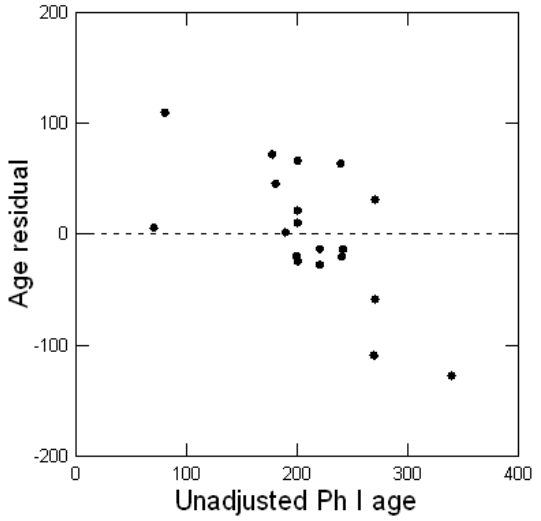


Fig F-8c: Age residuals vs unadjusted Phase I inventory age.

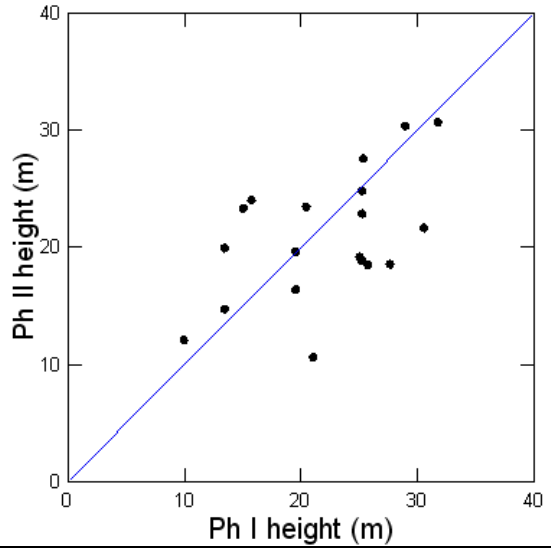


Fig F-9a: Phase II vs. Phase I height. The blue line represents a 1:1 correspondence.

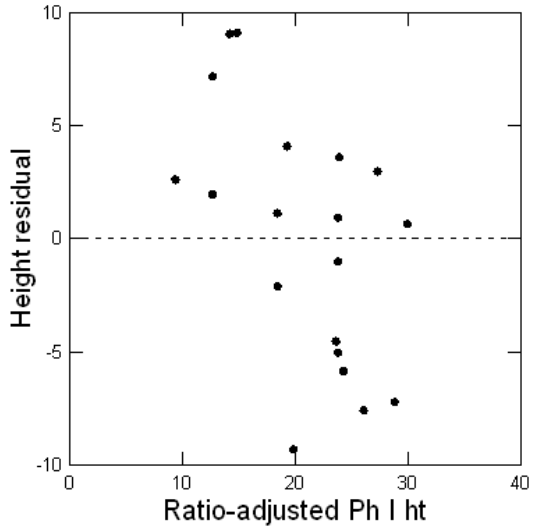


Fig F-9b: Height residuals vs adjusted Phase I inventory height (i.e. R × unadjusted Ph I height).

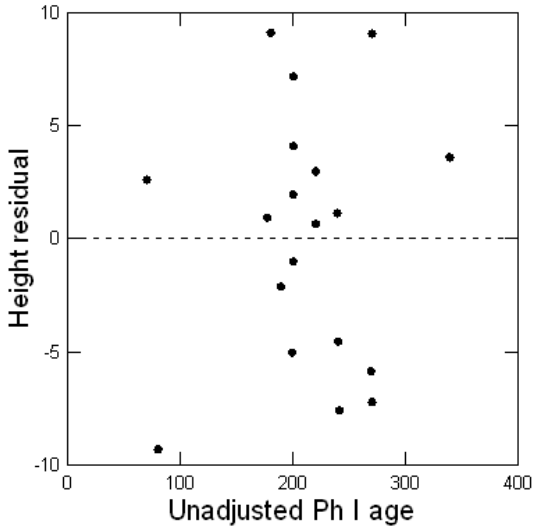


Fig F-9c: Height residuals vs unadjusted Phase I inventory age.

## *Mature (Volume Audit) Balsam leading stratum* *(Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

**RED** = *samples examined for potential data issues)*

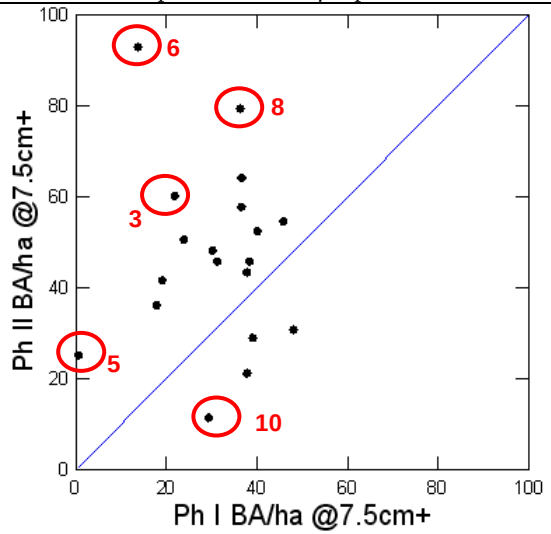


Fig F-10a: Phase II vs. Phase I ba/ha. The blue line represents a 1:1 correspondence.

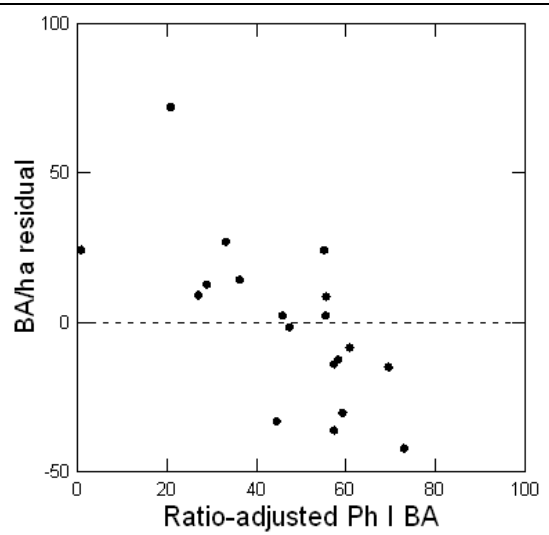


Fig F-10b: Ba/ha residuals vs adjusted Phase I inventory ba/ha (i.e. R × unadjusted Ph I ba/ha).

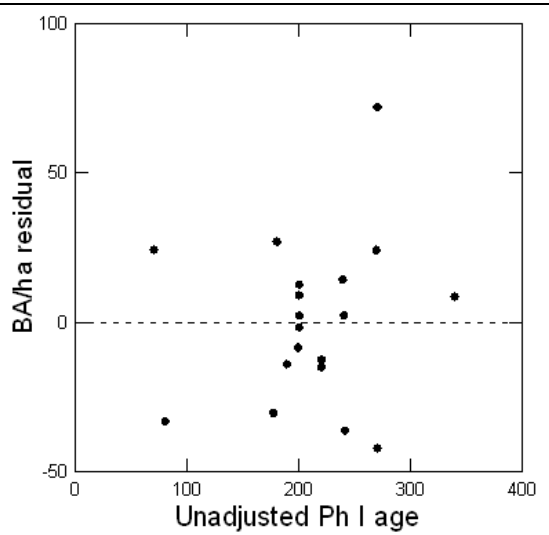


Fig F-10c: Ba/ha residuals vs unadjusted Phase I inventory age.

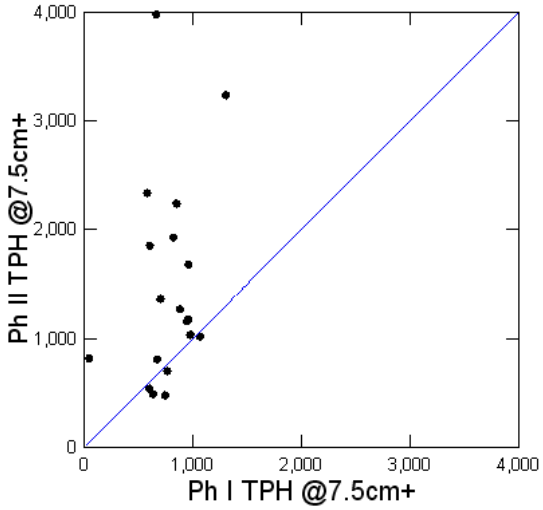


Fig F-11a: Phase II vs. Phase I trees/ha. The blue line represents a 1:1 correspondence.

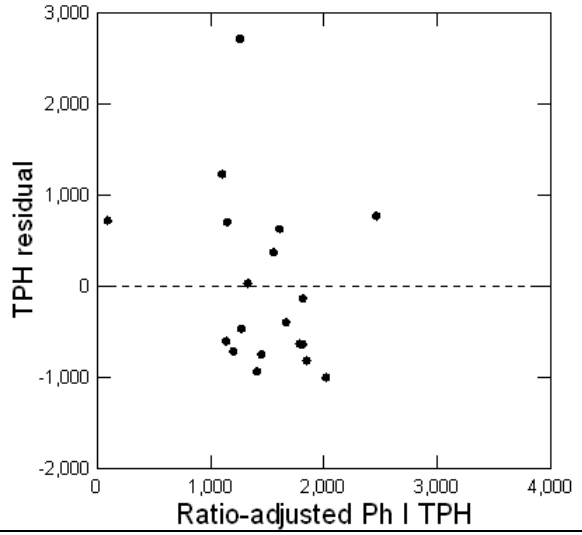


Fig F-11b: Trees/ha residuals vs adjusted Phase I inventory trees /ha (i.e. R × unadjusted Ph I trees /ha).

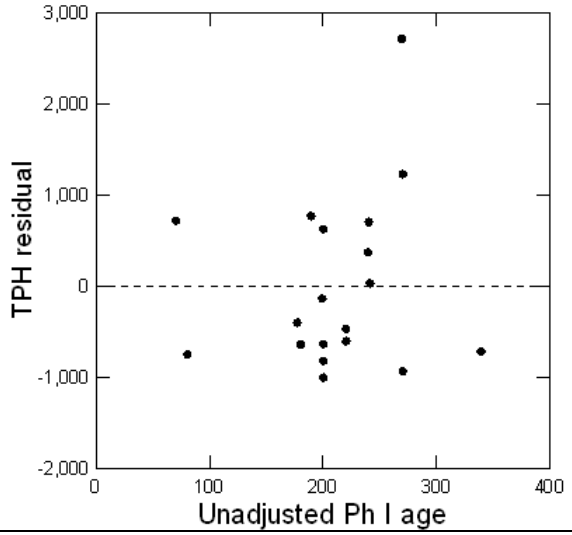


Fig F-11c: Trees /ha residuals vs unadjusted Phase I inventory age.

*Mature (Volume Audit) Balsam leading stratum (Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

**RED** = *samples examined for potential data issues)*

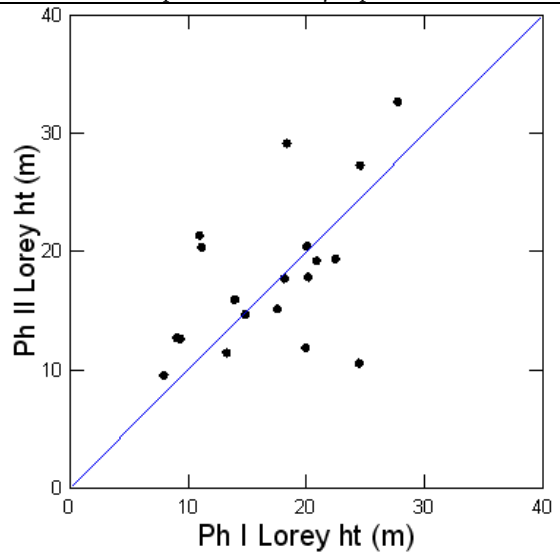


Fig F-12a: Phase II vs. Phase I Lorey height. The blue line represents a 1:1 correspondence.

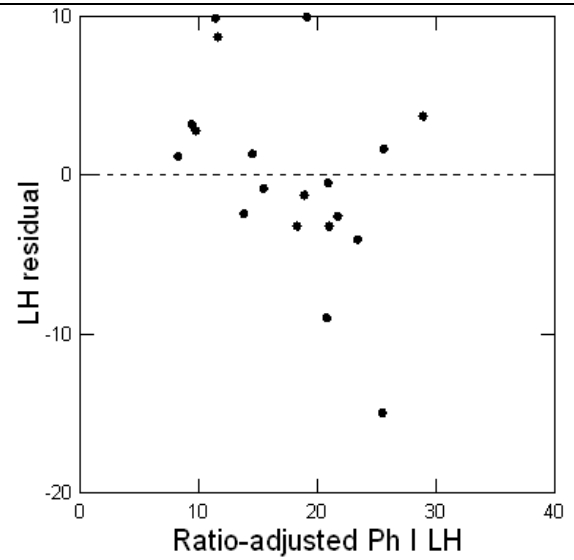


Fig F-12b: Lorey height residuals vs adjusted Phase I inventory Lorey ht (i.e. R × unadjusted Ph I Lorey ht).

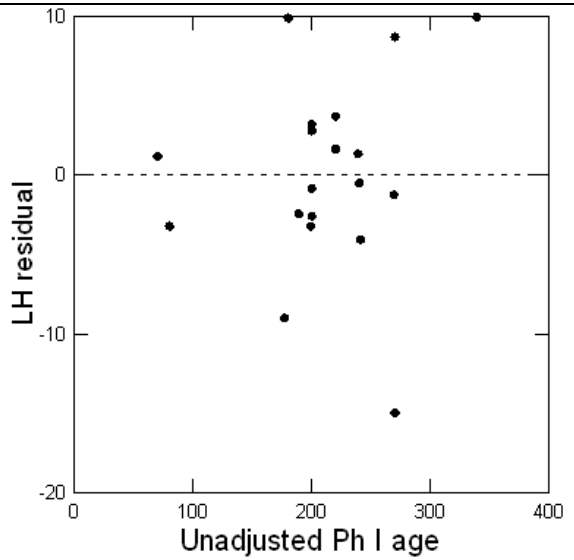


Fig F-12c: Lorey height residuals vs unadjusted Phase I inventory age.

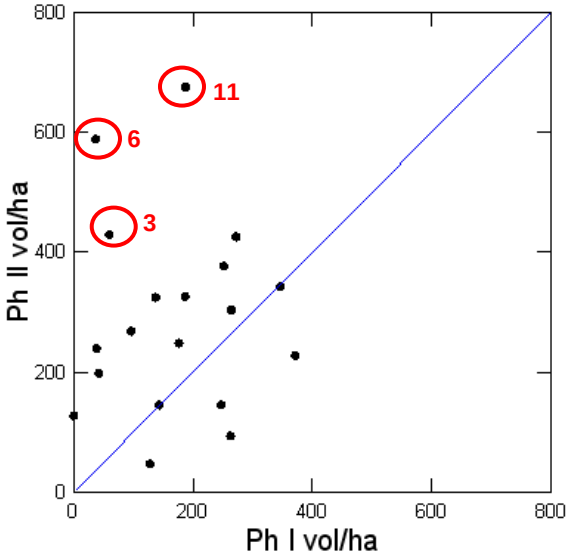


Fig F-13a: Phase II vs. Phase I vol/ha. The blue line represents a 1:1 correspondence.

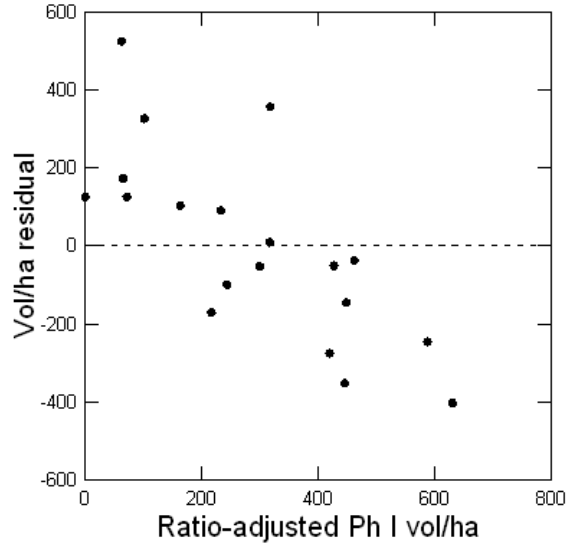


Fig F-13b: Vol/ha residuals vs adjusted Phase I inventory vol/ha (i.e. R × unadjusted Ph I vol/ha).

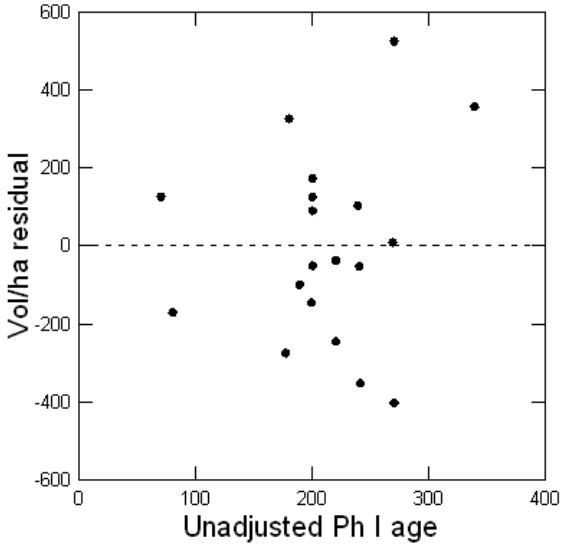


Fig F-13c: Vol/ha residuals vs unadjusted Phase I inventory age.

*Mature (Volume Audit) Balsam leading stratum* *(Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

**RED** = *samples examined for potential data issues)*

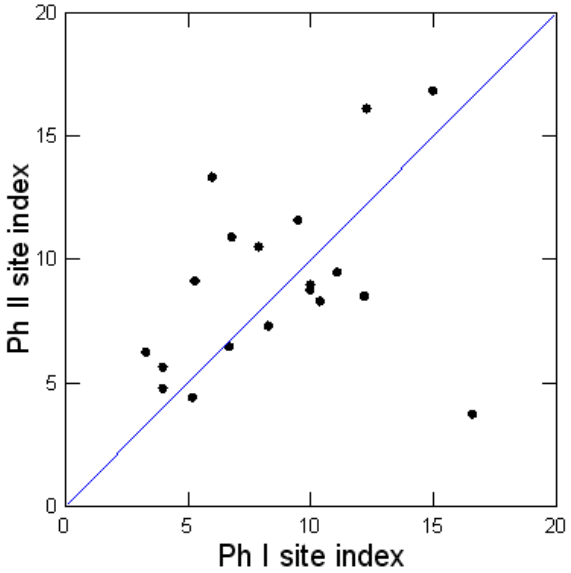


Fig F-14a: Phase II vs. Phase I site index. The blue line represents a 1:1 correspondence.

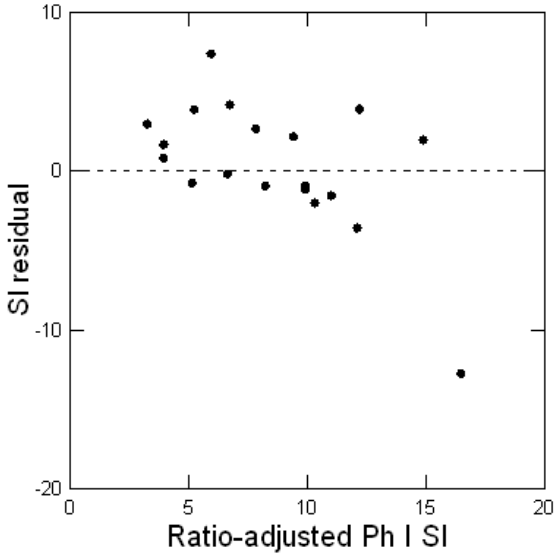


Fig F-14b: Site index residuals vs adjusted Phase I inventory site index (i.e. R × unadjusted Ph I Lorey ht).

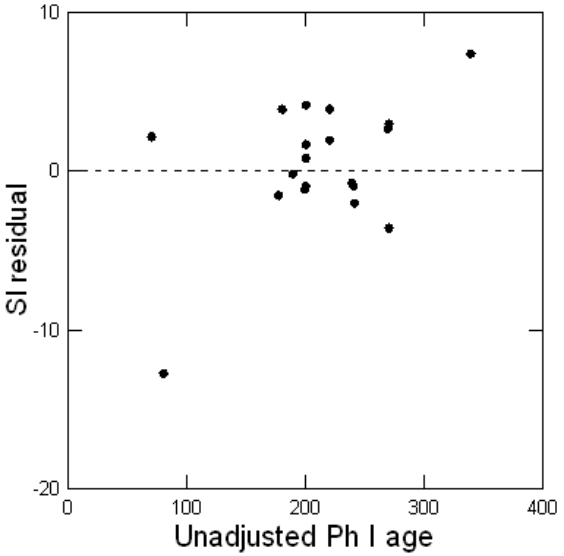


Fig F-14c: Site index residuals vs unadjusted Phase I inventory age.

*Mature (Volume Audit) Pine leading stratum (Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

**RED** = *samples examined for potential data issues)*

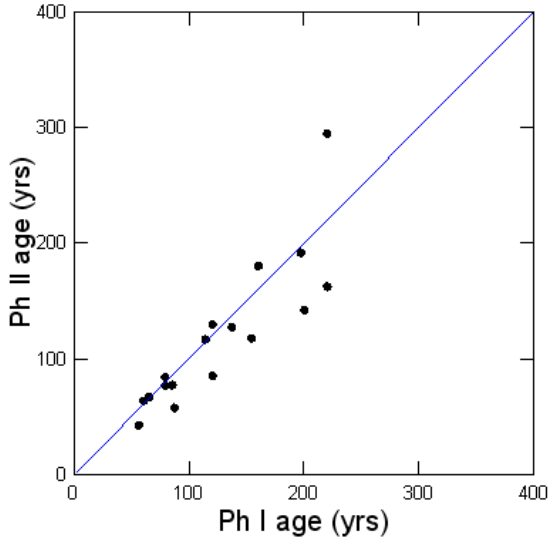


Fig F-15a: Phase II vs. Phase I age. The blue line represents a 1:1 correspondence.

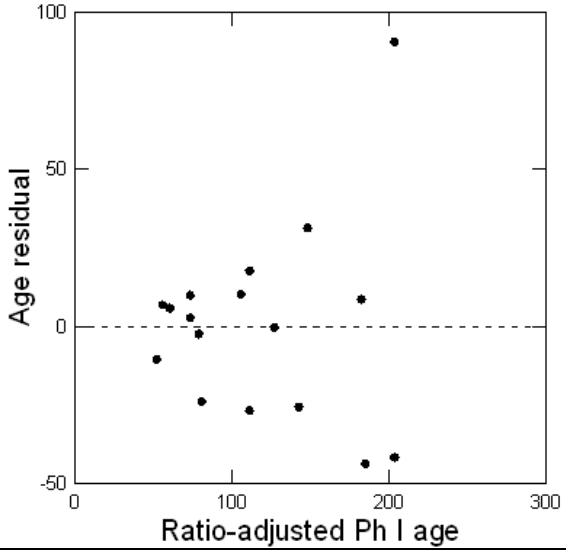


Fig F-15b: Age residuals vs adjusted Phase I inventory age (i.e. R × unadjusted Ph I age).

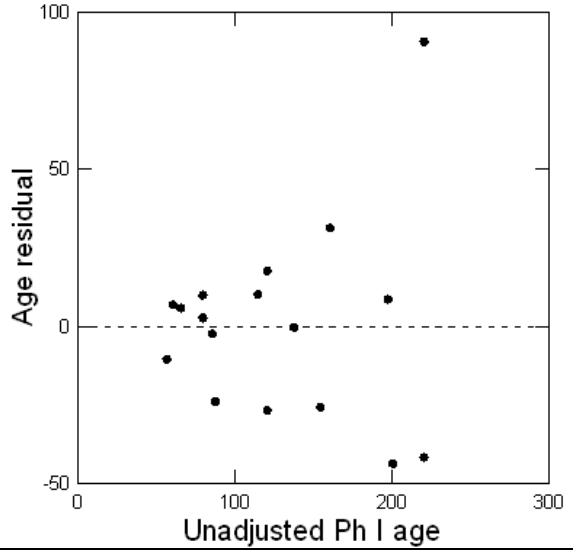


Fig F-15c: Age residuals vs unadjusted Phase I inventory age.

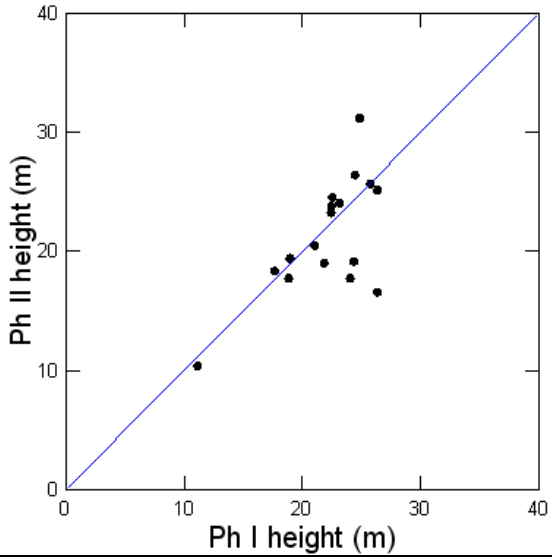


Fig F-16a: Phase II vs. Phase I height. The blue line represents a 1:1 correspondence.

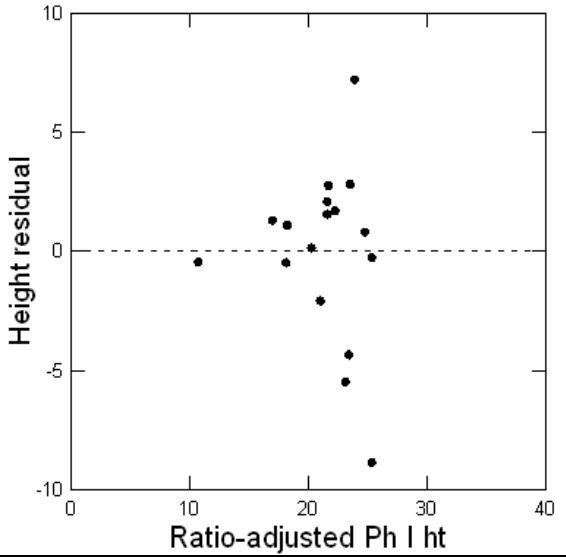


Fig F-16b: Height residuals vs adjusted Phase I inventory height (i.e. R × unadjusted Ph I height).

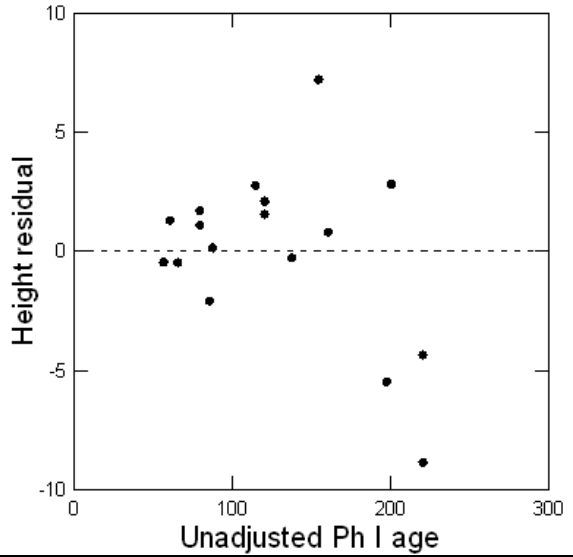


Fig F-16c: Height residuals vs unadjusted Phase I inventory age.

*Mature (Volume Audit) Pine leading stratum (Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

**RED** = *samples examined for potential data issues)*

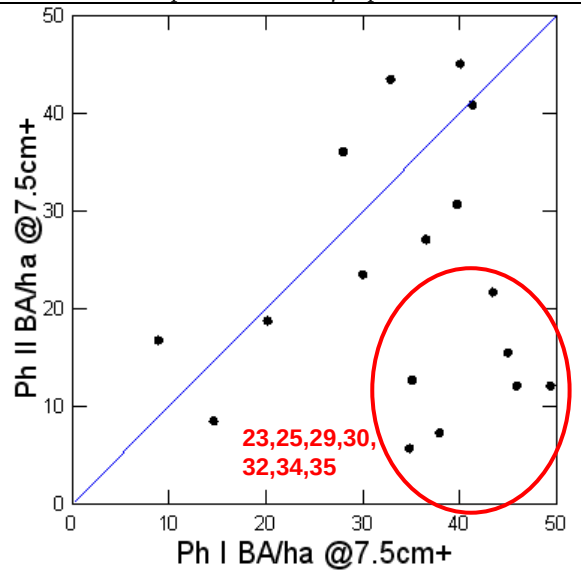


Fig F-17a: Phase II vs. Phase I ba/ha. The blue line represents a 1:1 correspondence.

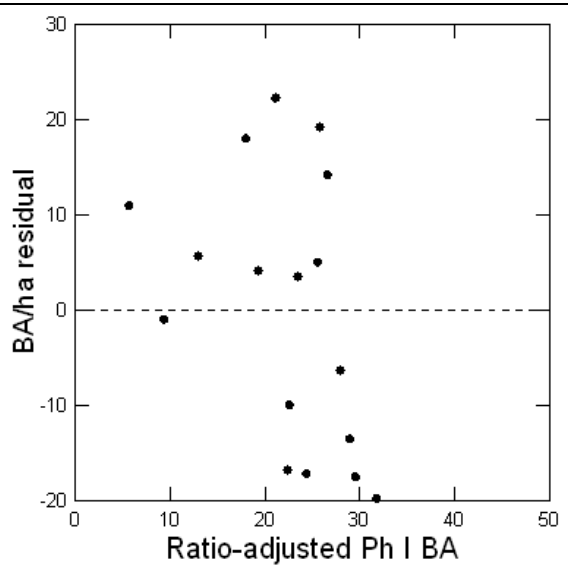


Fig F-17b: Ba/ha residuals vs adjusted Phase I inventory ba/ha (i.e. R × unadjusted Ph I ba/ha).

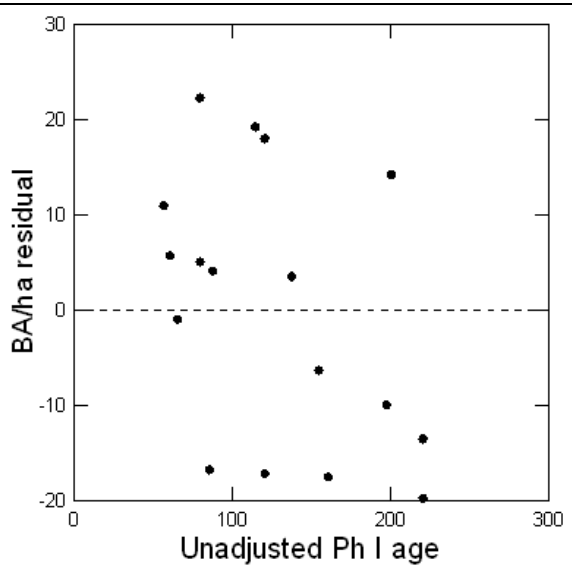


Fig F-17c: Ba/ha residuals vs unadjusted Phase I inventory age.

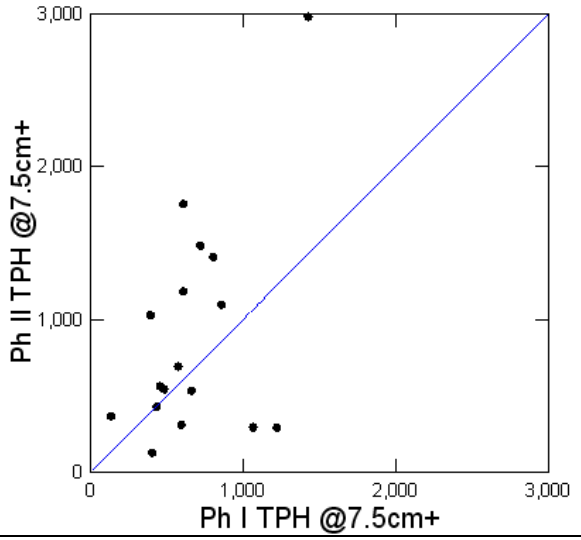


Fig F-18a: Phase II vs. Phase I trees/ha. The blue line represents a 1:1 correspondence.

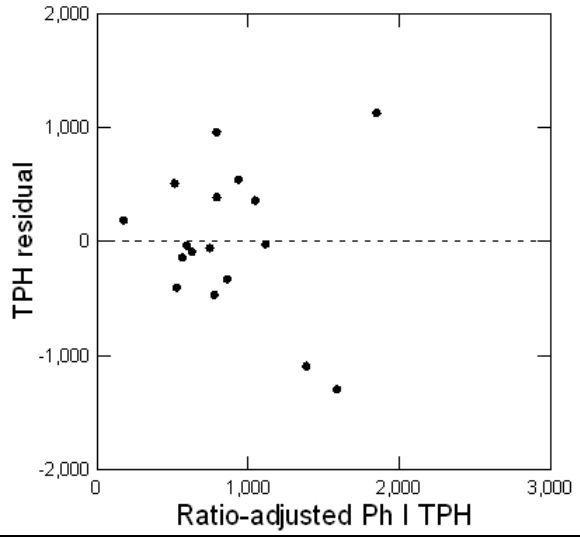


Fig F-18b: Trees/ha residuals vs adjusted Phase I inventory trees /ha (i.e. R × unadjusted Ph I trees /ha).

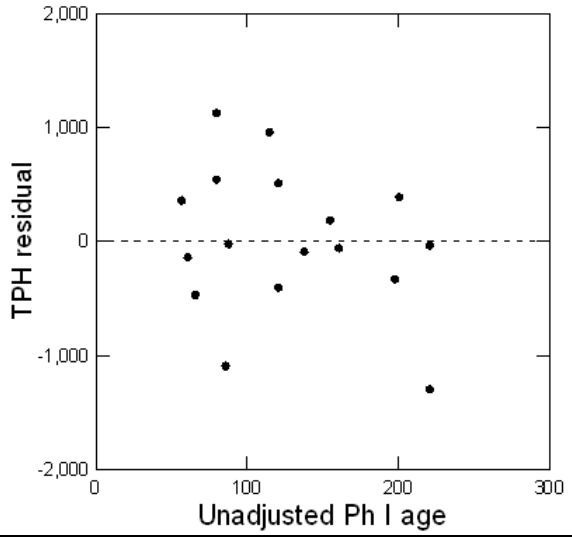


Fig F-18c: Trees /ha residuals vs unadjusted Phase I inventory age.

*Mature (Volume Audit) Pine leading stratum (Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

**RED** = *samples examined for potential data issues)*

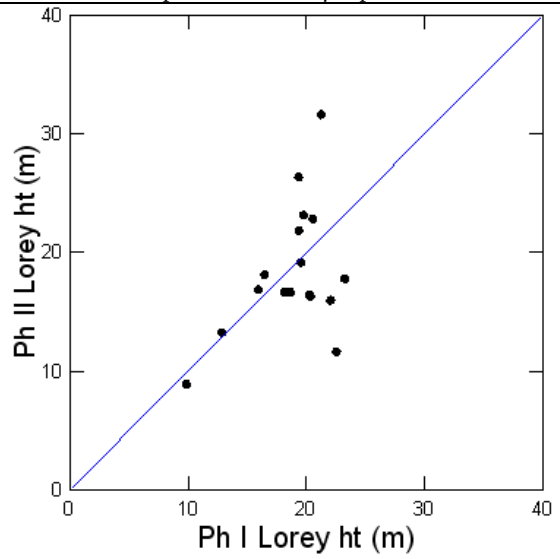


Fig F-19a: Phase II vs. Phase I Lorey height. The blue line represents a 1:1 correspondence.

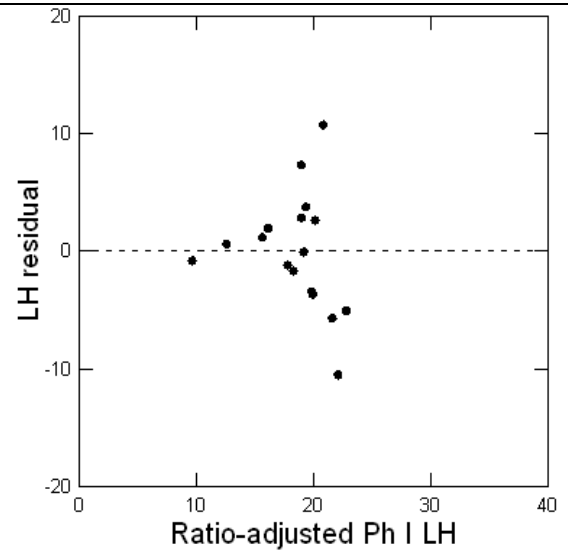


Fig F-19b: Lorey height residuals vs adjusted Phase I inventory Lorey ht (i.e. R × unadjusted Ph I Lorey ht).

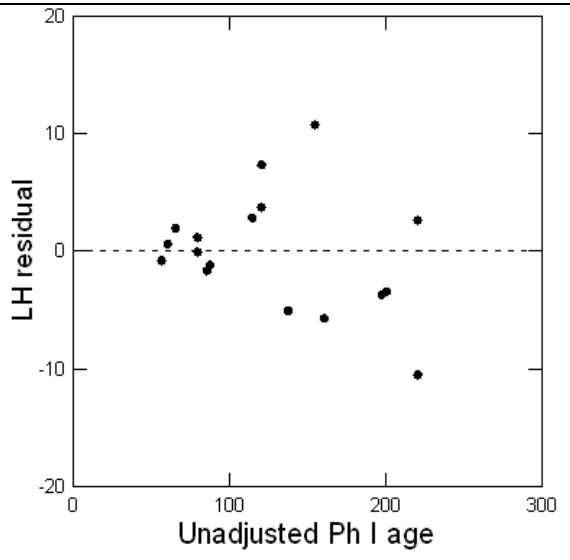


Fig F-19c: Lorey height residuals vs unadjusted Phase I inventory age.

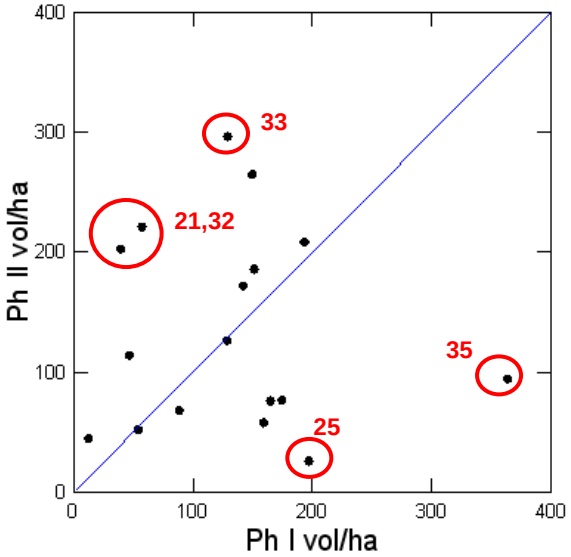


Fig F-20a: Phase II vs. Phase I vol/ha. The blue line represents a 1:1 correspondence.

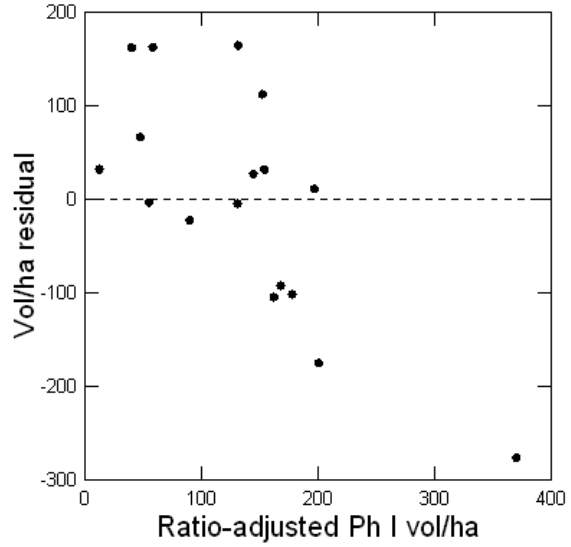


Fig F-20b: Vol/ha residuals vs adjusted Phase I inventory vol/ha (i.e. R × unadjusted Ph I vol/ha).

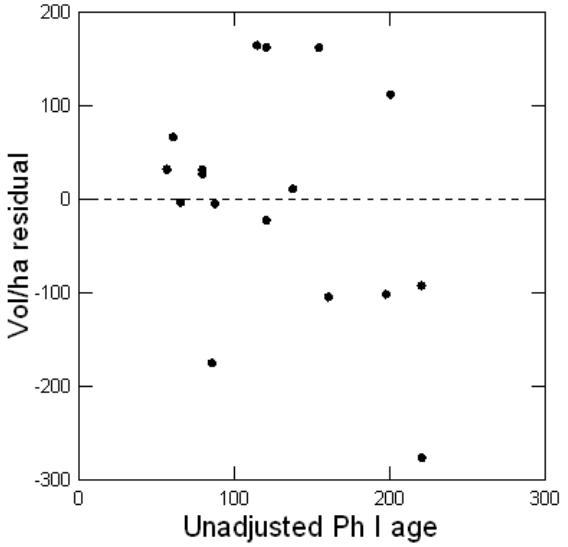


Fig F-20c: Vol/ha residuals vs unadjusted Phase I inventory age.

*Mature (Volume Audit) Pine leading stratum (Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

**RED** = *samples examined for potential data issues)*

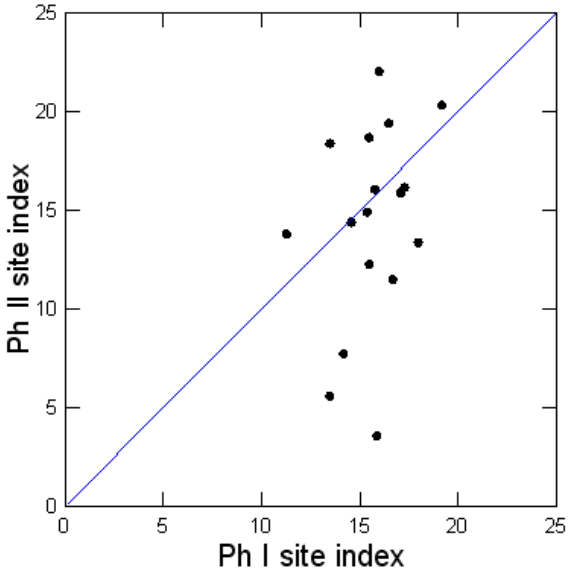


Fig F-21a: Phase II vs. Phase I site index. The blue line represents a 1:1 correspondence.

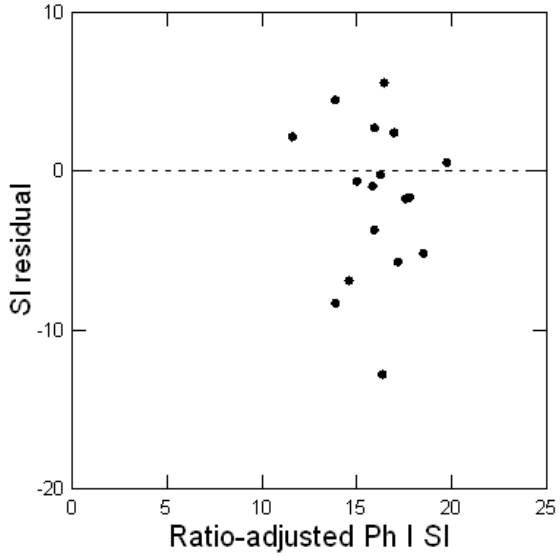


Fig F-21b: Site index residuals vs adjusted Phase I inventory site index (i.e. R × unadjusted Ph I Lorey ht).

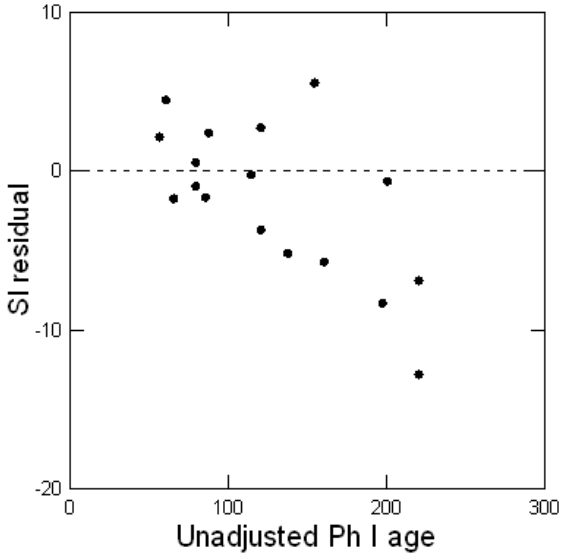


Fig F-21c: Site index residuals vs unadjusted Phase I inventory age.

*Mature (Volume Audit) Spruce leading stratum* *(Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

**RED** = *samples examined for potential data issues)*

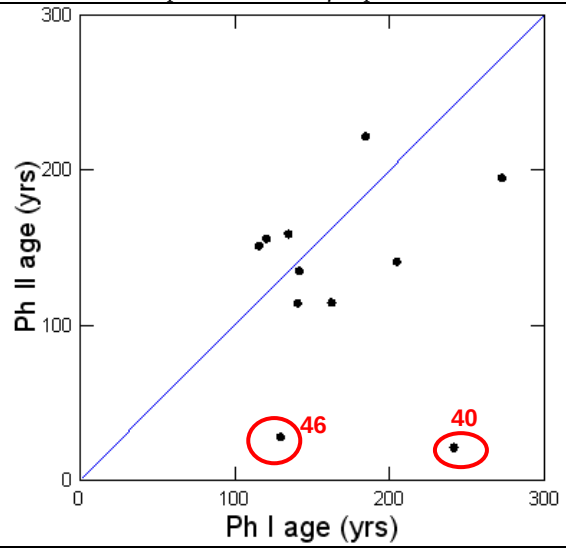


Fig F-22a: Phase II vs. Phase I age. The blue line represents a 1:1 correspondence.

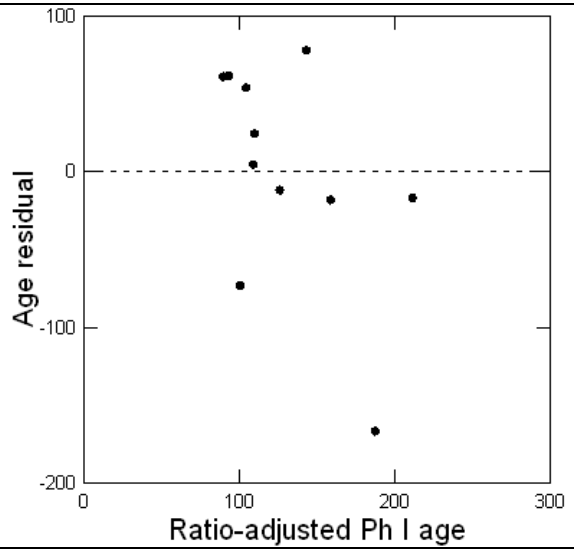


Fig F-22b: Age residuals vs adjusted Phase I inventory age (i.e. R × unadjusted Ph I age).

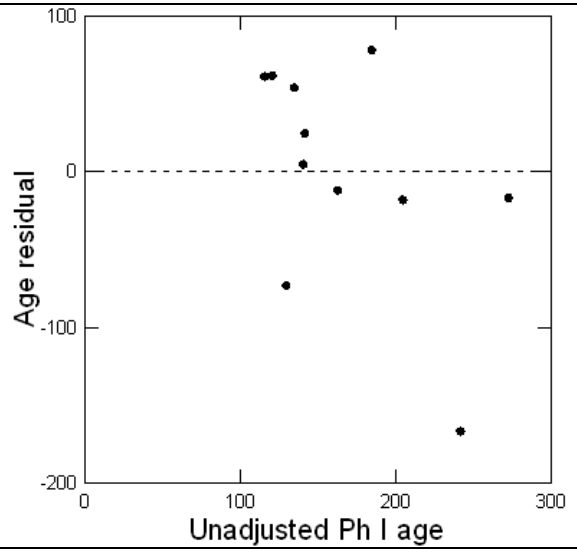


Fig F-22c: Age residuals vs unadjusted Phase I inventory age.

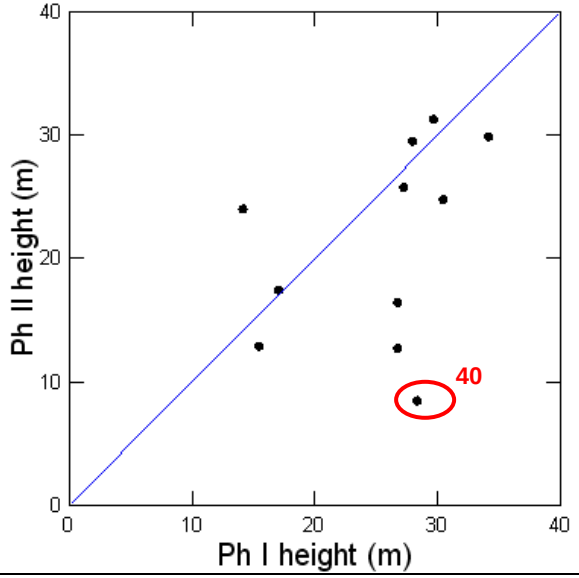


Fig F-23a: Phase II vs. Phase I height. The blue line represents a 1:1 correspondence.

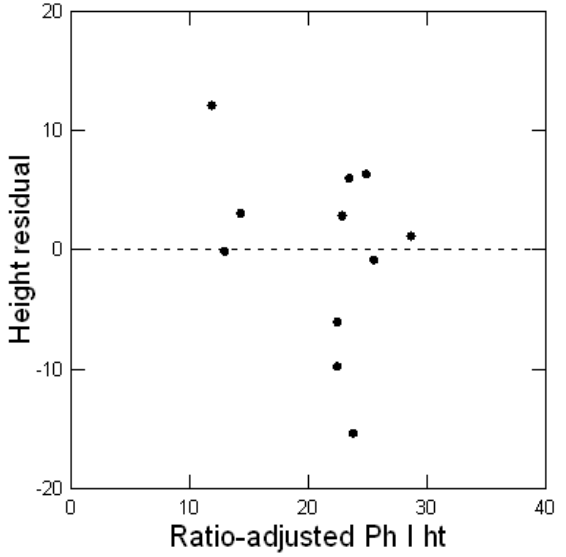


Fig F-23b: Height residuals vs adjusted Phase I inventory height (i.e. R × unadjusted Ph I height).

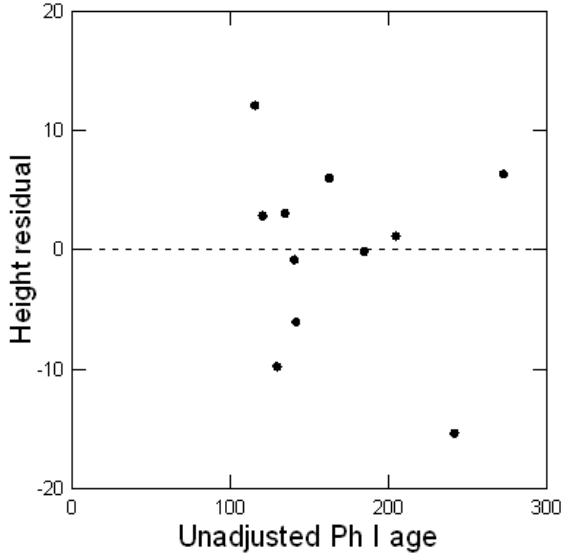


Fig F-23c: Height residuals vs unadjusted Phase I inventory age.

*Mature (Volume Audit) Spruce leading stratum* *(Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

**RED** = *samples examined for potential data issues)*

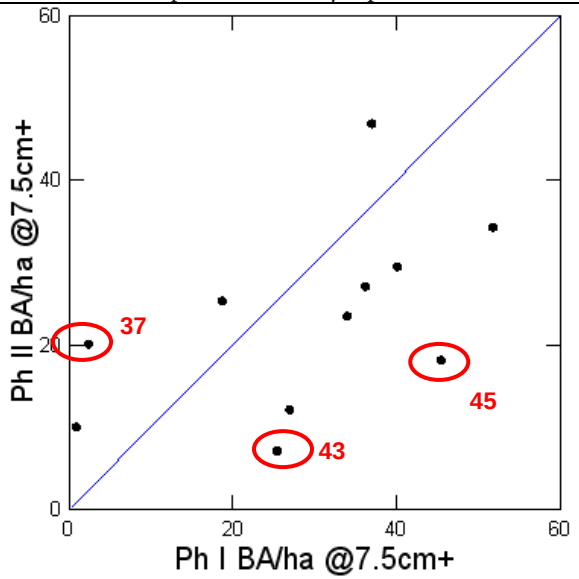


Fig F-24a: Phase II vs. Phase I ba/ha. The blue line represents a 1:1 correspondence.

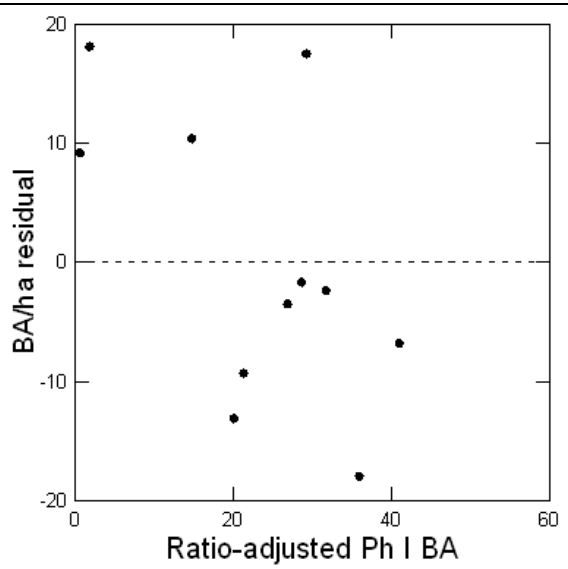


Fig F-24b: Ba/ha residuals vs adjusted Phase I inventory ba/ha (i.e. R × unadjusted Ph I ba/ha).

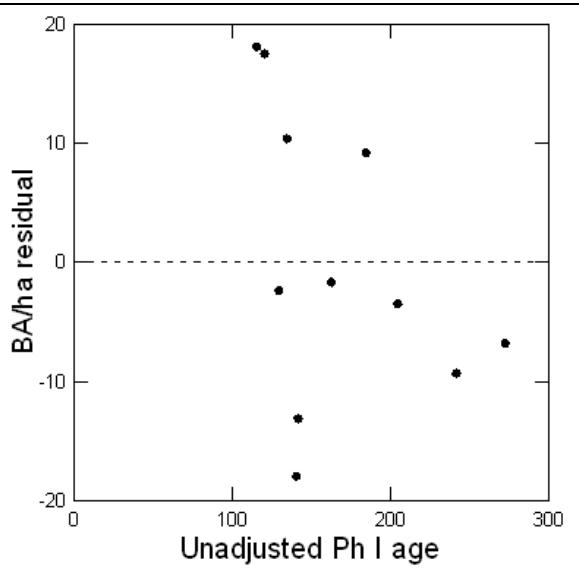


Fig F-24c: Ba/ha residuals vs unadjusted Phase I inventory age.

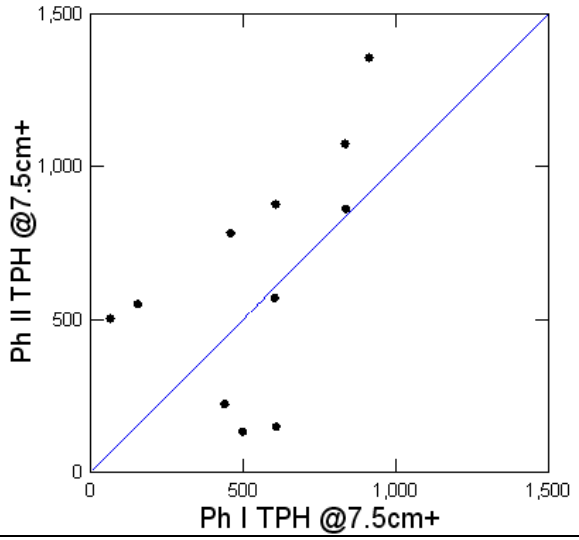


Fig F-25a: Phase II vs. Phase I trees/ha. The blue line represents a 1:1 correspondence.

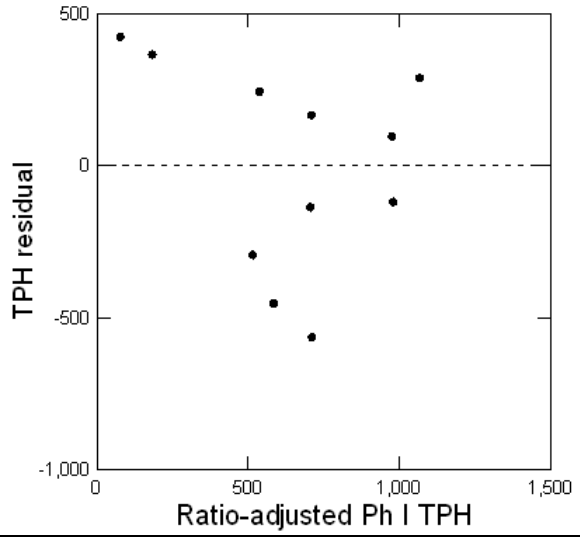


Fig F-25b: Trees/ha residuals vs adjusted Phase I inventory trees /ha (i.e. R × unadjusted Ph I trees /ha).

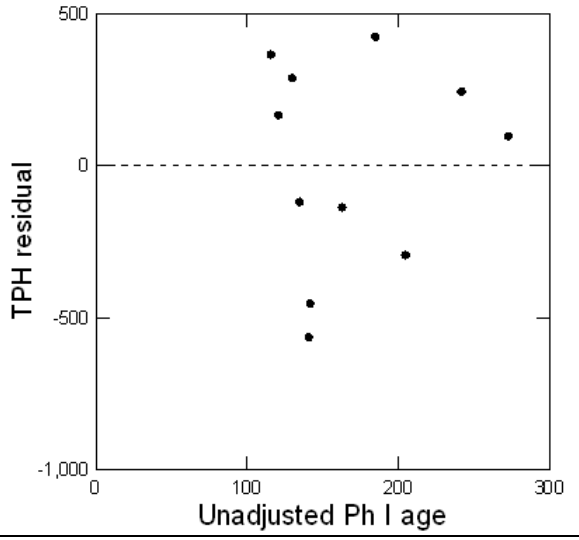


Fig F-25c: Trees /ha residuals vs unadjusted Phase I inventory age.

*Mature (Volume Audit) Spruce leading stratum* *(Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

**RED** = *samples examined for potential data issues)*

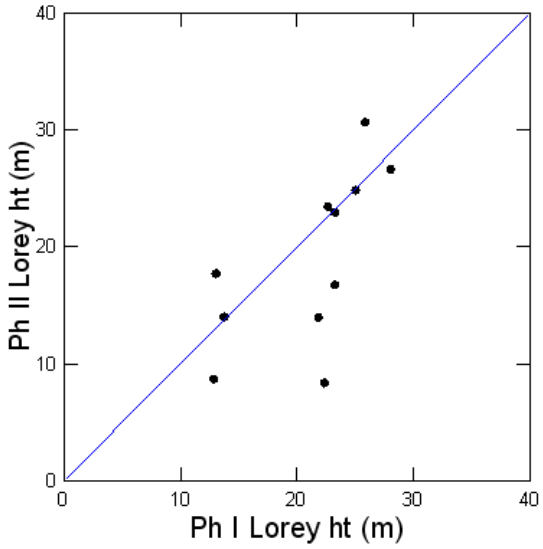


Fig F-26a: Phase II vs. Phase I Lorey height. The blue line represents a 1:1 correspondence.

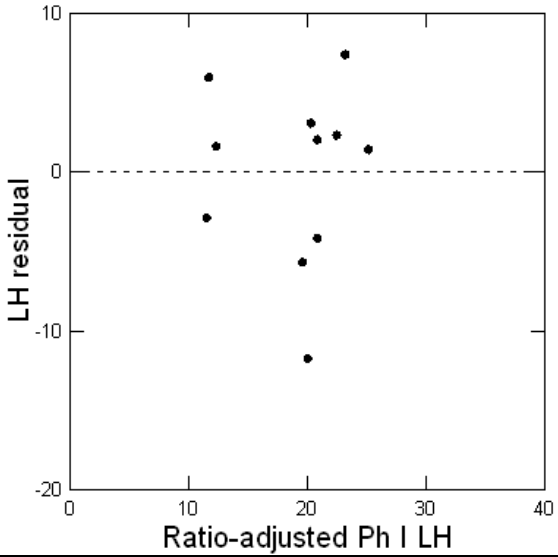


Fig F-26b: Lorey height residuals vs adjusted Phase I inventory Lorey ht (i.e. R × unadjusted Ph I Lorey ht).

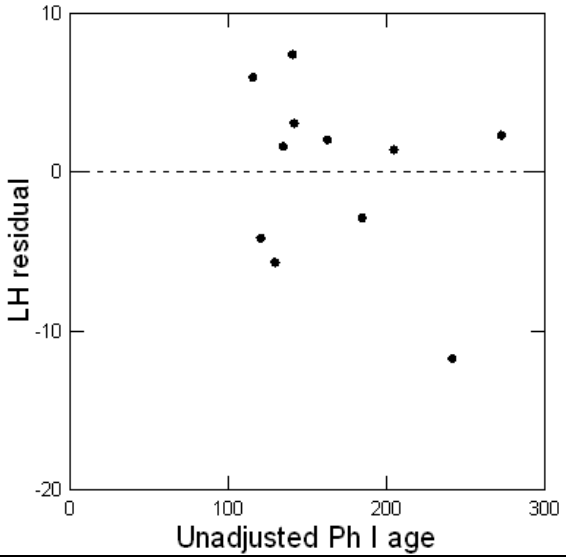


Fig F-26c: Lorey height residuals vs unadjusted Phase I inventory age.

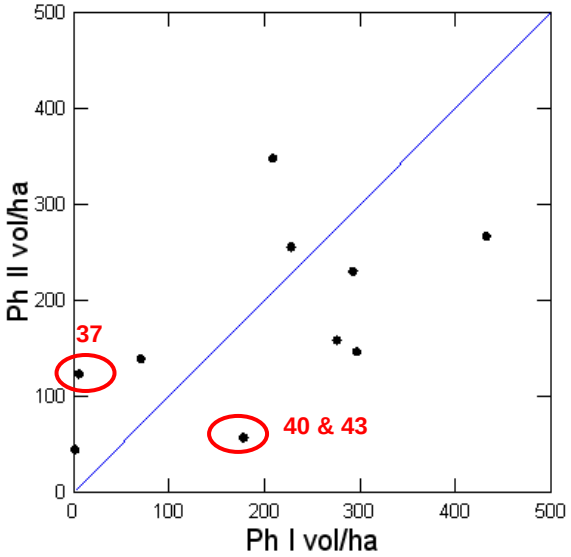


Fig F-27a: Phase II vs. Phase I vol/ha. The blue line represents a 1:1 correspondence.

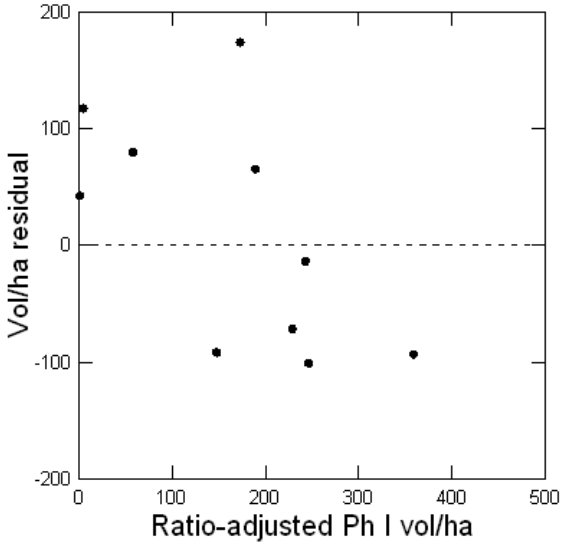


Fig F-27b: Vol/ha residuals vs adjusted Phase I inventory vol/ha (i.e. R × unadjusted Ph I vol/ha).

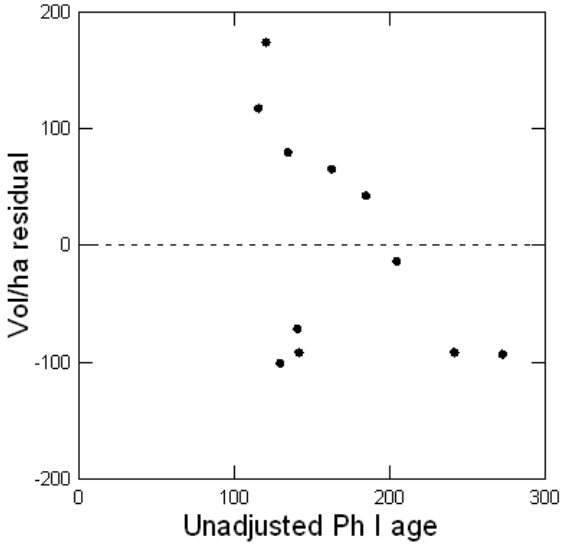


Fig F-27c: Vol/ha residuals vs unadjusted Phase I inventory age.

*Mature (Volume Audit) Spruce leading stratum* *(Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

**RED** = *samples examined for potential data issues)*

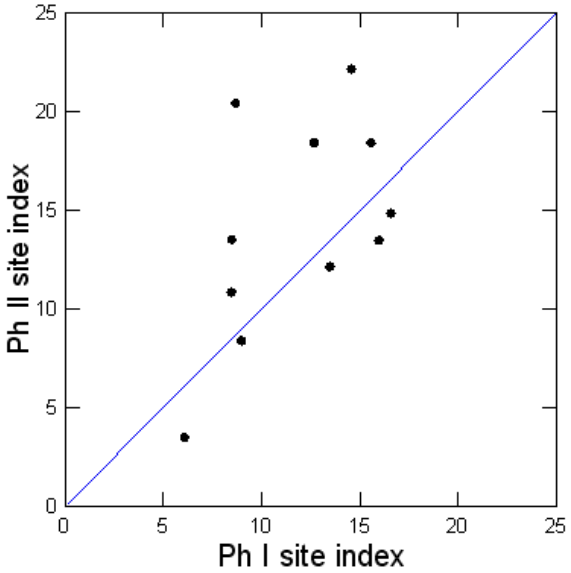


Fig F-28a: Phase II vs. Phase I site index. The blue line represents a 1:1 correspondence.

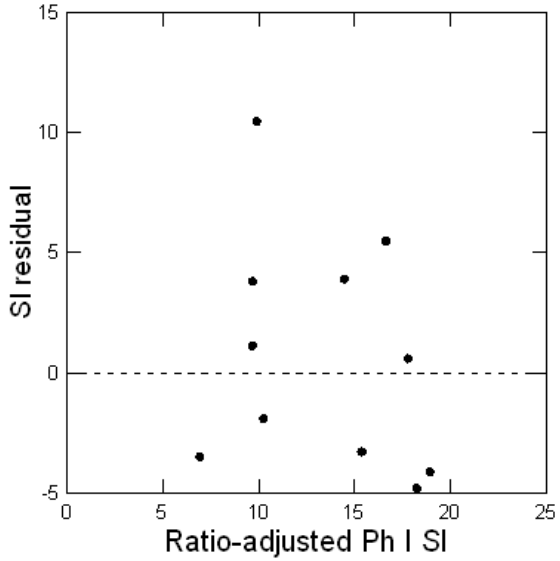


Fig F-28b: Site index residuals vs adjusted Phase I inventory site index (i.e. R × unadjusted Ph I Lorey ht).

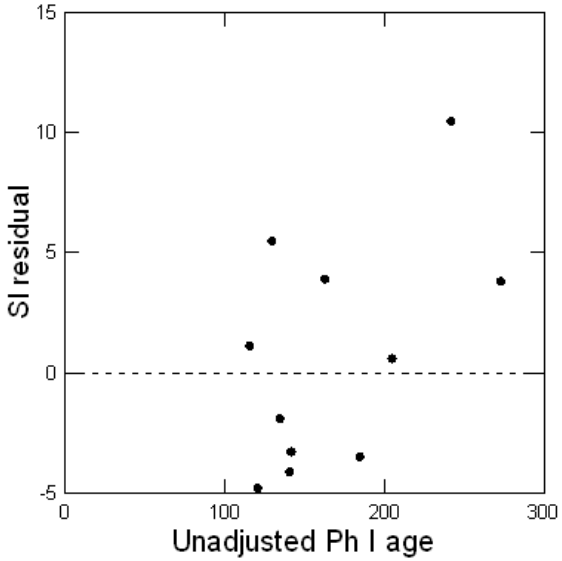


Fig F-28c: Site index residuals vs unadjusted Phase I inventory age.

*Mature (Volume Audit) Other (deciduous) leading stratum* *(Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

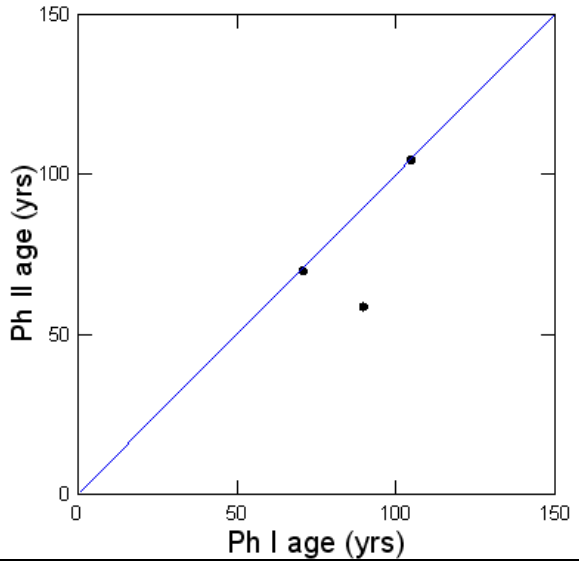


Fig F-29a: Phase II vs. Phase I age. The blue line represents a 1:1 correspondence.

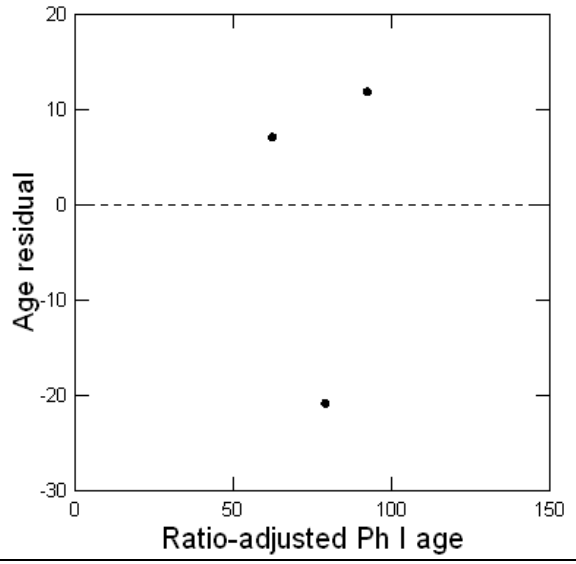


Fig F-29b: Age residuals vs adjusted Phase I inventory age (i.e. R × unadjusted Ph I age).

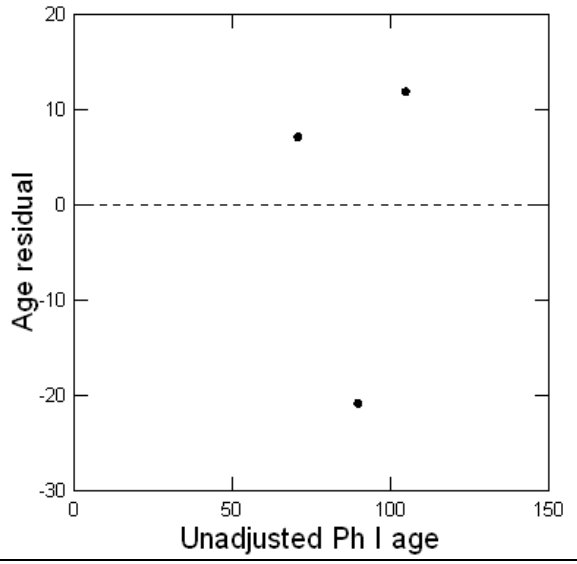


Fig F-29c: Age residuals vs unadjusted Phase I inventory age.

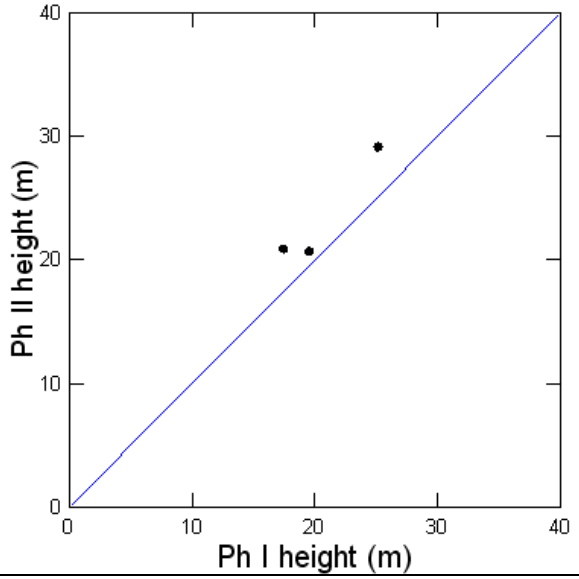


Fig F-30a: Phase II vs. Phase I height. The blue line represents a 1:1 correspondence.

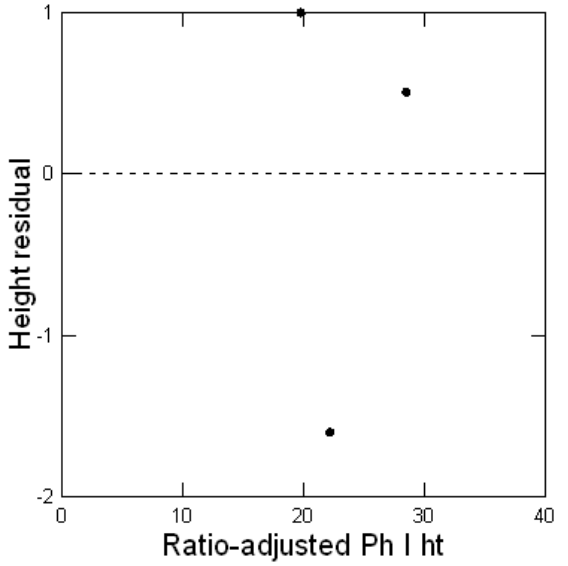


Fig F-30b: Height residuals vs adjusted Phase I inventory height (i.e. R × unadjusted Ph I height).

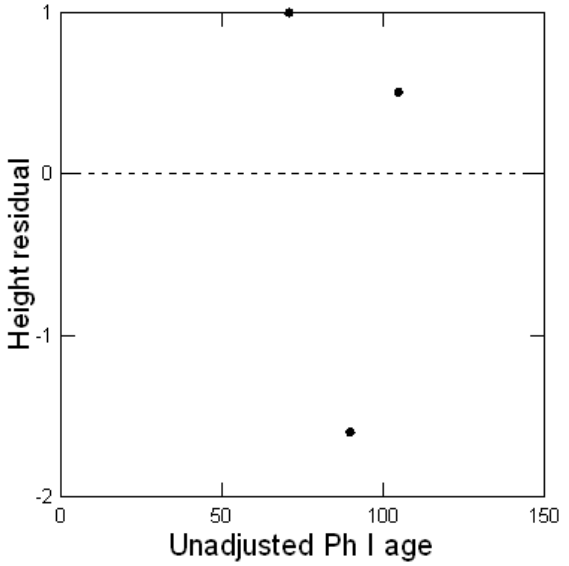


Fig F-30c: Height residuals vs unadjusted Phase I inventory age.

*Mature (Volume Audit) Other (deciduous) leading stratum (Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

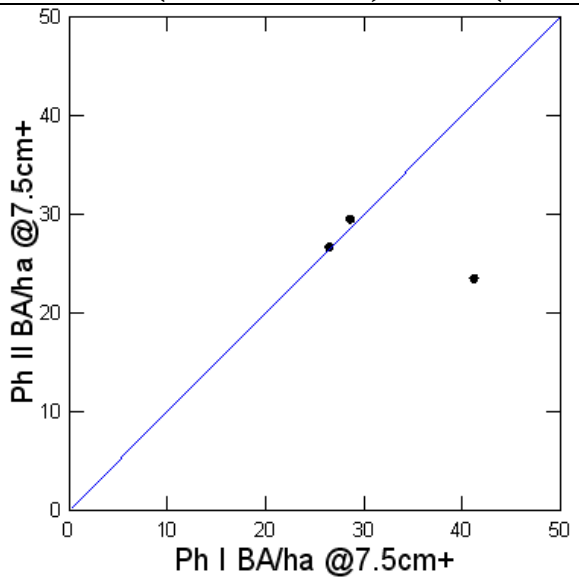


Fig F-31a: Phase II vs. Phase I ba/ha. The blue line represents a 1:1 correspondence.

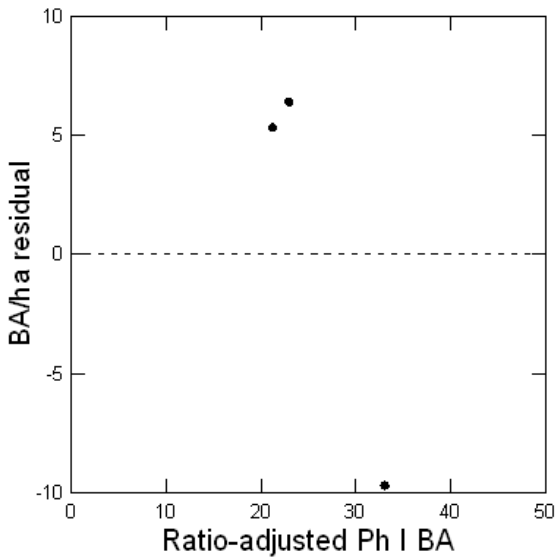


Fig F-31b: Ba/ha residuals vs adjusted Phase I inventory ba/ha (i.e. R × unadjusted Ph I ba/ha).

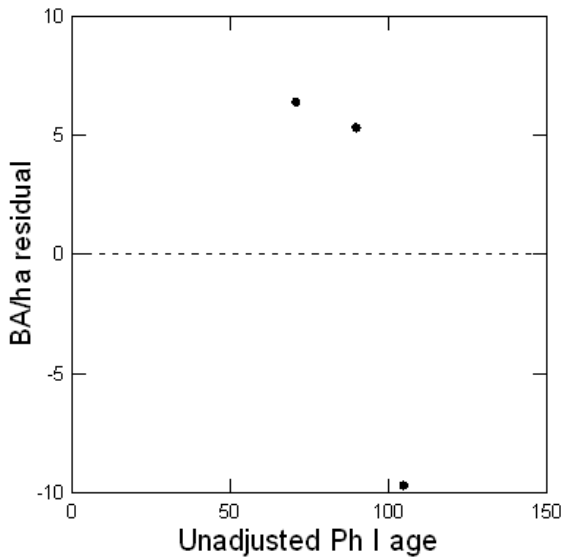


Fig F-31c: Ba/ha residuals vs unadjusted Phase I inventory age.

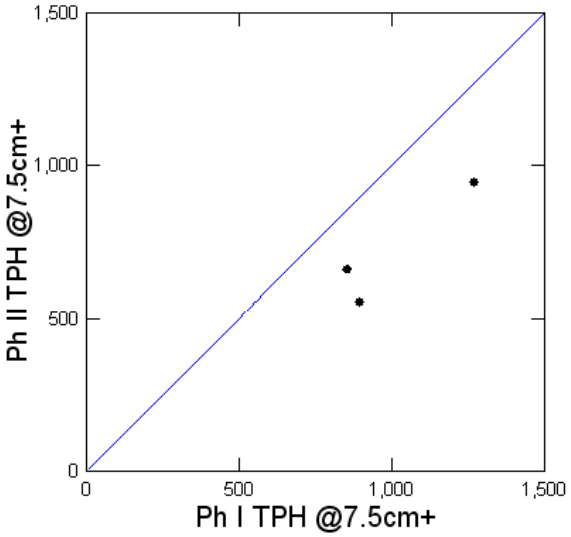


Fig F-32a: Phase II vs. Phase I trees/ha. The blue line represents a 1:1 correspondence.

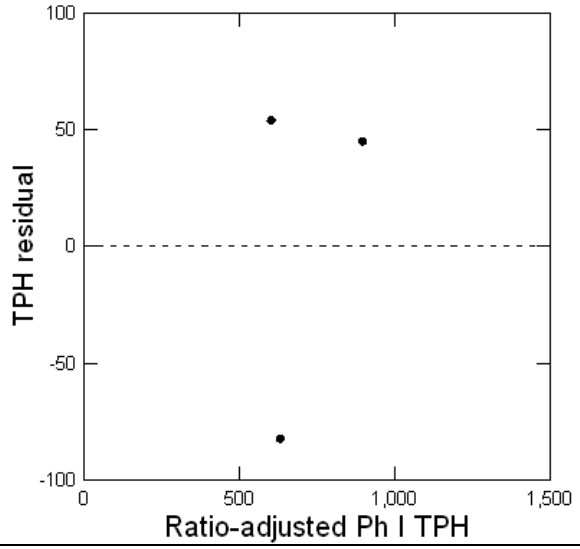


Fig F-32b: Trees/ha residuals vs adjusted Phase I inventory trees /ha (i.e. R × unadjusted Ph I trees /ha).

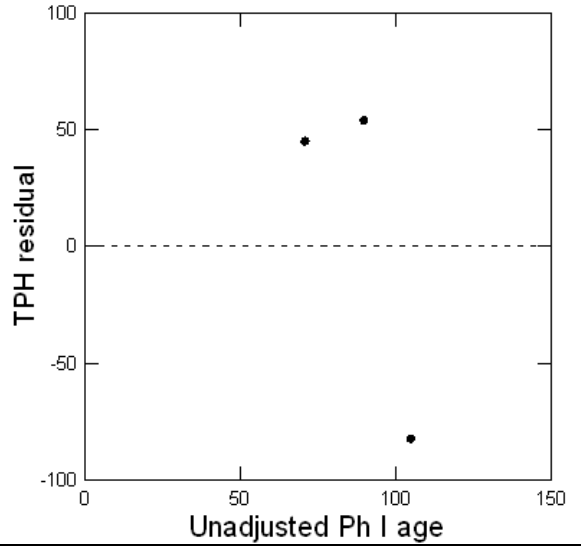


Fig F-32c: Trees /ha residuals vs unadjusted Phase I inventory age.

*Mature (Volume Audit) Other (deciduous) leading stratum (Note: RESIDUAL = Phase II value – ratio-adjusted Phase I value)*

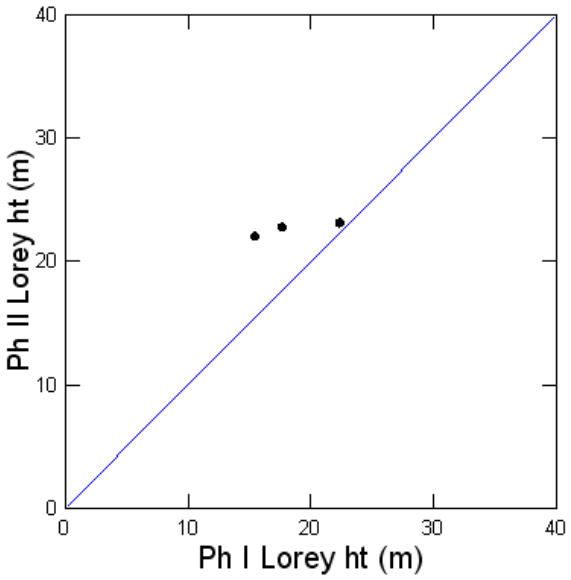


Fig F-33a: Phase II vs. Phase I Lorey height. The blue line represents a 1:1 correspondence.

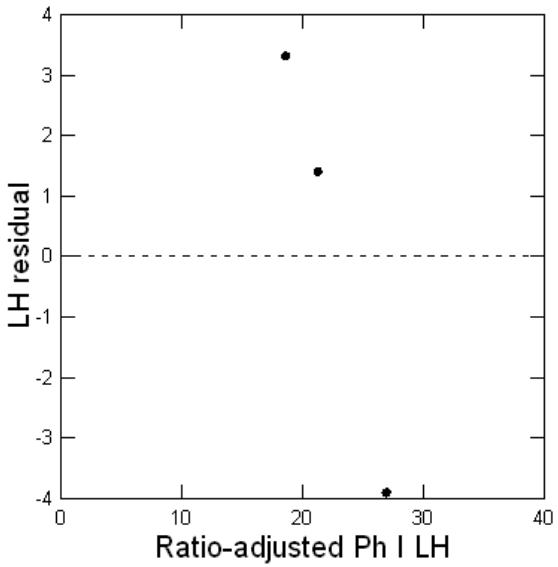


Fig F-33b: Lorey height residuals vs adjusted Phase I inventory Lorey ht (i.e. R × unadjusted Ph I Lorey ht).

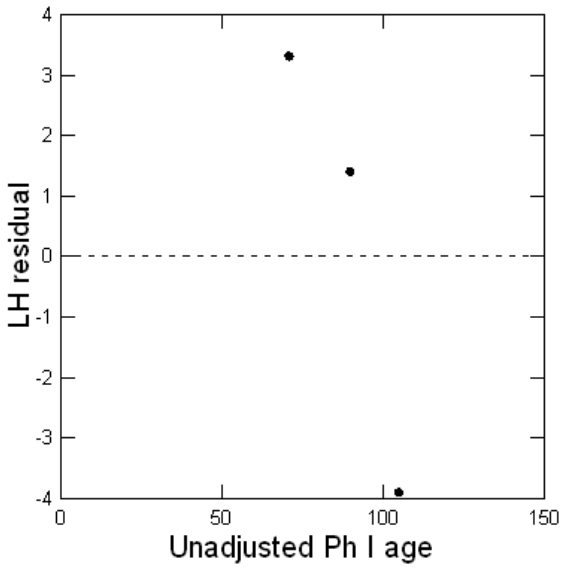


Fig F-33c: Lorey height residuals vs unadjusted Phase I inventory age.

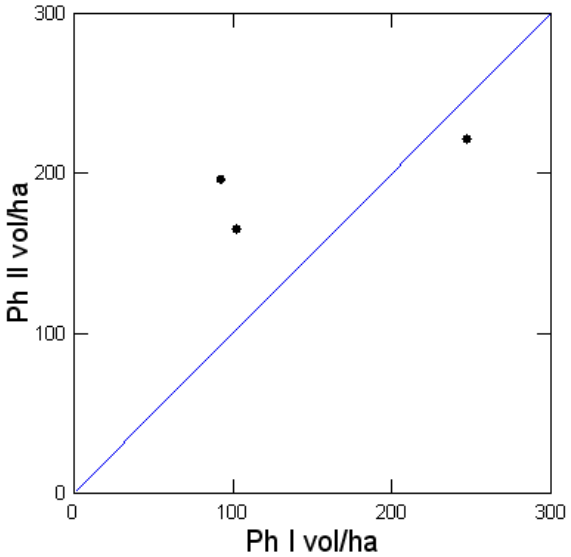


Fig F-34a: Phase II vs. Phase I vol/ha. The blue line represents a 1:1 correspondence.

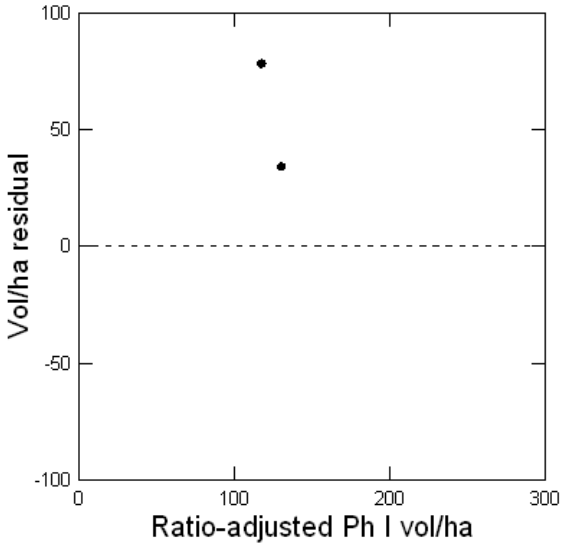


Fig F-34b: Vol/ha residuals vs adjusted Phase I inventory vol/ha (i.e. R × unadjusted Ph I vol/ha).

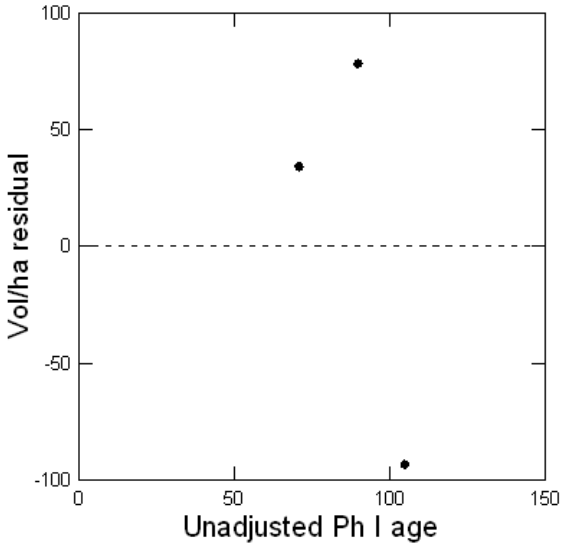


Fig F-34c: Vol/ha residuals vs unadjusted Phase I inventory age.

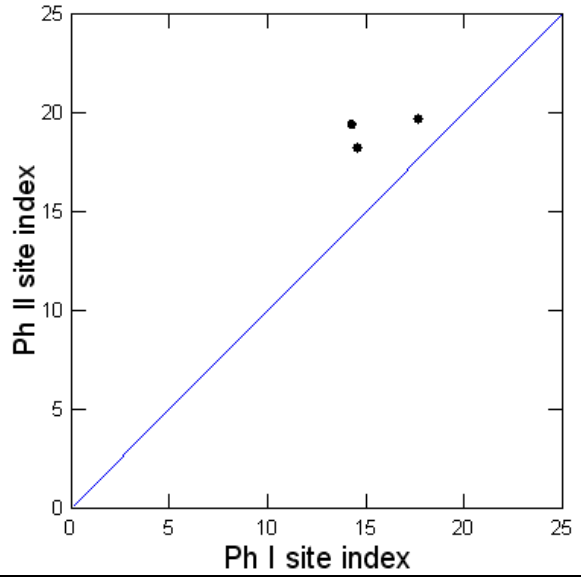


Fig F-35a: Phase II vs. Phase I site index. The blue line represents a 1:1 correspondence.

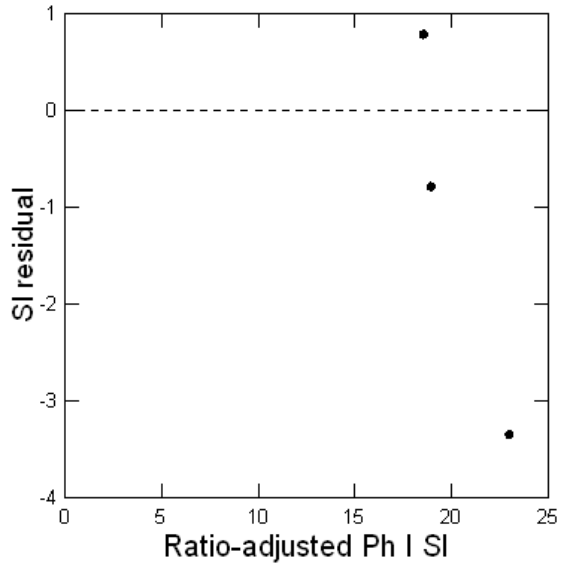


Fig F-35b: Site index residuals vs adjusted Phase I inventory site index (i.e. R × unadjusted Ph I Lorey ht).

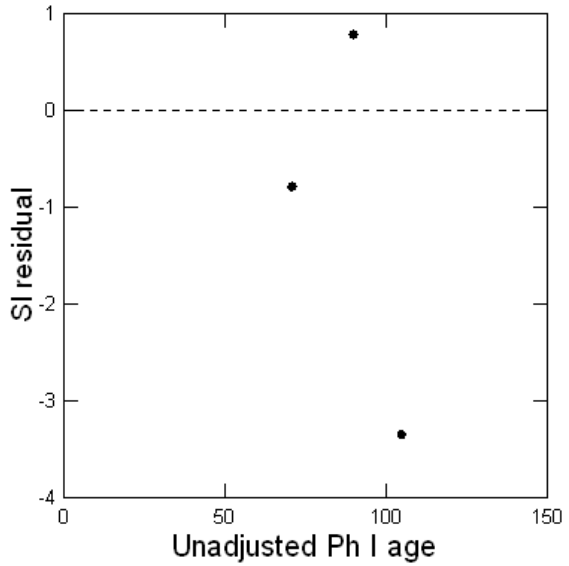


Fig F-35c: Site index residuals vs unadjusted Phase I inventory age.

# 12. APPENDIX G: GRAPHS OF TOTAL VOLUME BIAS, MODEL BIAS & ATTRIBUTE BIAS

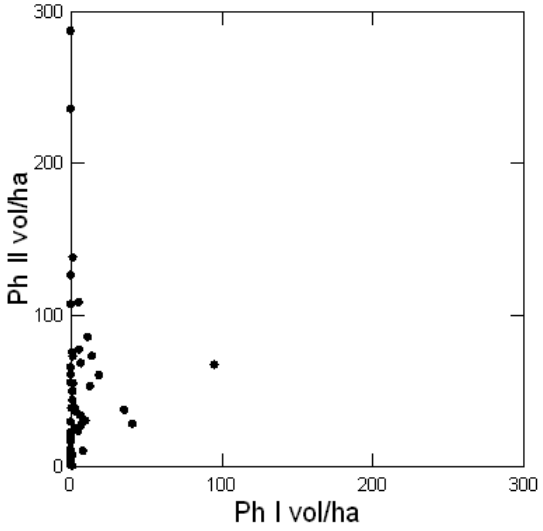


Fig G-1: Immature stratum: ***"total volume bias"*** i.e. Phase II compiled vol/ha vs. VDYP7 Phase I inventory vol/ha.

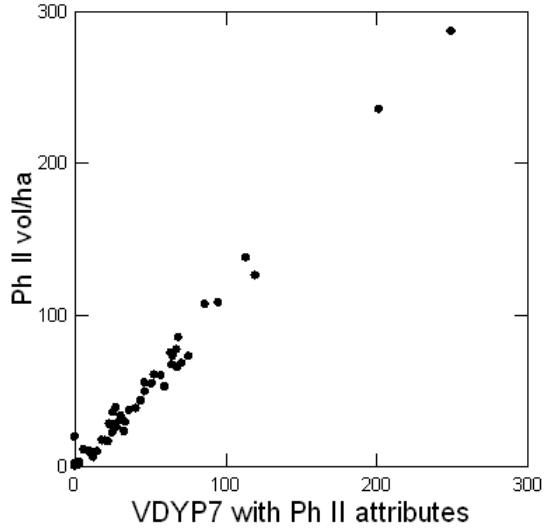


Fig G-2: Immature stratum: ***"model-related volume bias"*** i.e. Phase II compiled ground vol/ha vs. VDYP7 vol/ha based on ground (Ph II) attributes.

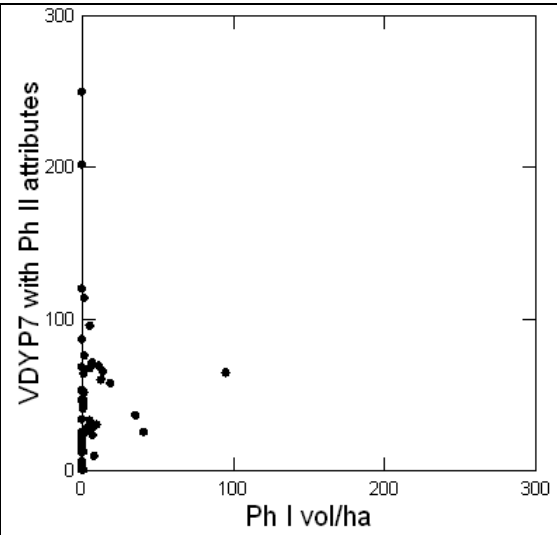


Fig G-3: Immature stratum: ***"attribute-related volume bias"*** i.e. VDYP7 vol/ha based on ground (Ph II) attributes vs. VDYP7 Phase I inventory vol/ha.

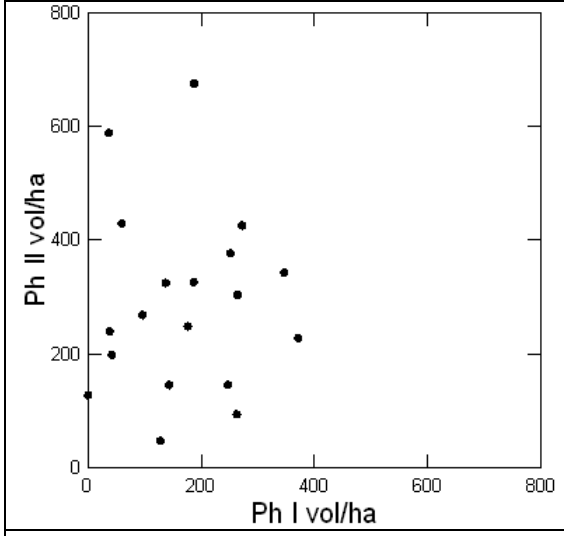


Fig G-4: Mature Balsam stratum: ***"total volume bias"*** i.e. Phase II compiled vol/ha vs. VDYP7 Phase I inventory vol/ha.

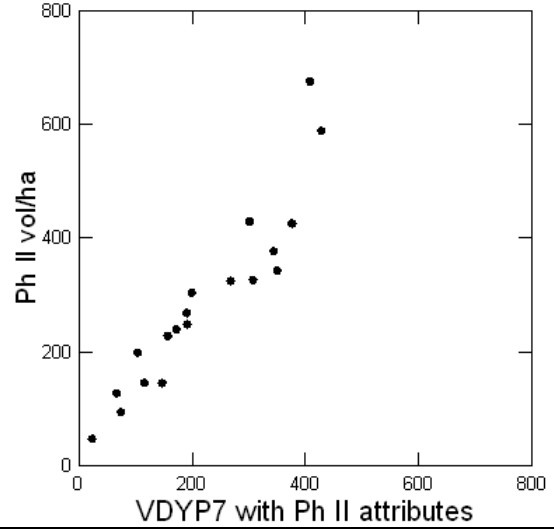


Fig G-5: Mature Balsam stratum: ***"model-related volume bias"*** i.e. Phase II compiled ground vol/ha vs. VDYP7 vol/ha based on ground (Ph II) attributes.

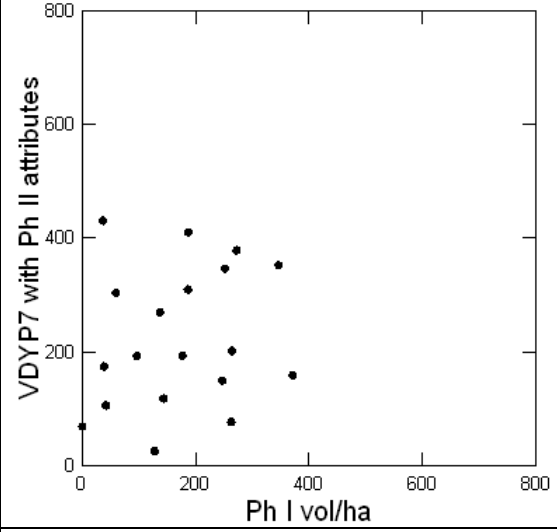


Fig G-6: Mature Balsam ture stratum: ***"attribute-related volume bias"*** i.e. VDYP7 vol/ha based on ground (Ph II) attributes vs. VDYP7 Ph I inventory vol/ha.

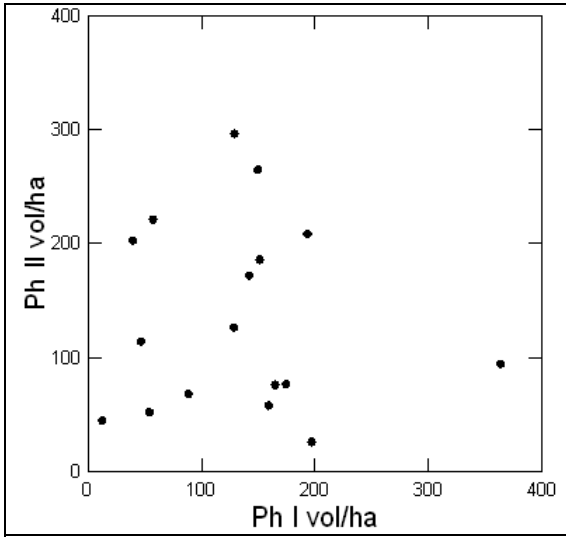


Fig G-7: Mature Pine stratum: ***"total volume bias"*** i.e. Phase II compiled vol/ha vs. VDYP7 Phase I inventory vol/ha.

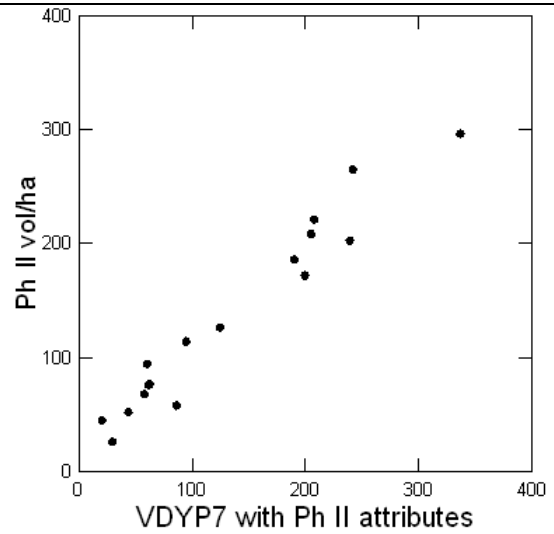


Fig G-8: Mature Pine stratum: ***"model-related volume bias"*** i.e. Phase II compiled ground vol/ha vs. VDYP7 vol/ha based on ground (Ph II) attributes.

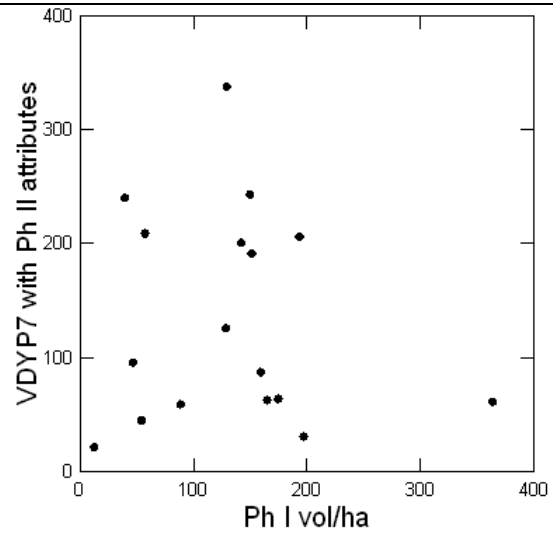


Fig G-9: Mature Pine stratum: ***"attribute-related volume bias"*** i.e. VDYP7 vol/ha based on ground (Ph II) attributes vs. VDYP7 Phase I inventory vol/ha.

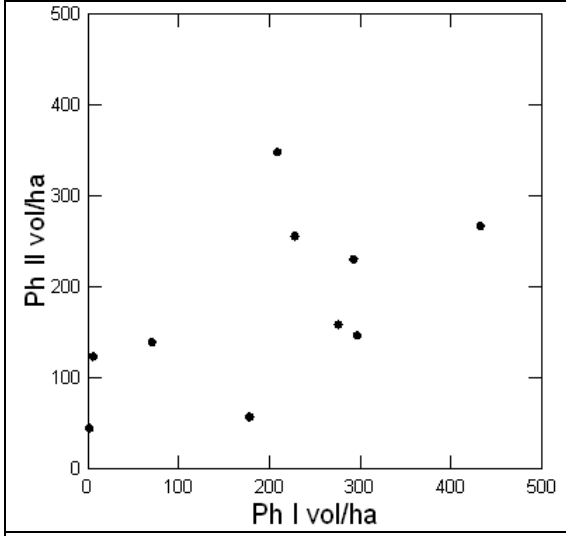


Fig G-10: Mature Spruce stratum: ***"total volume bias"*** i.e. Phase II compiled vol/ha vs. VDYP7 Phase I inventory vol/ha.

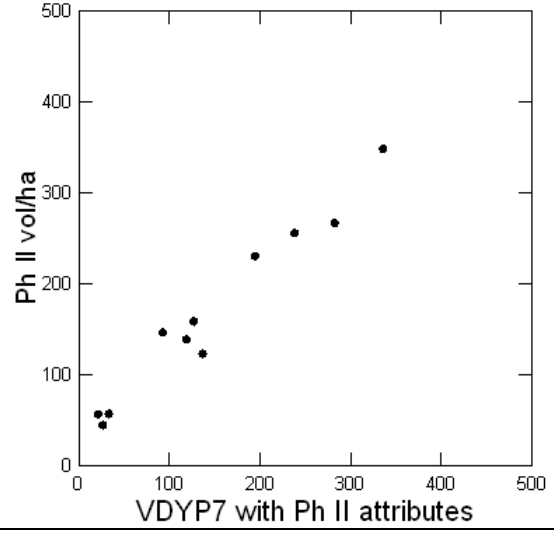


Fig G-11: Mature Spruce stratum: ***"model-related volume bias"*** i.e. Phase II compiled ground vol/ha vs. VDYP7 vol/ha based on ground (Ph II) attributes.

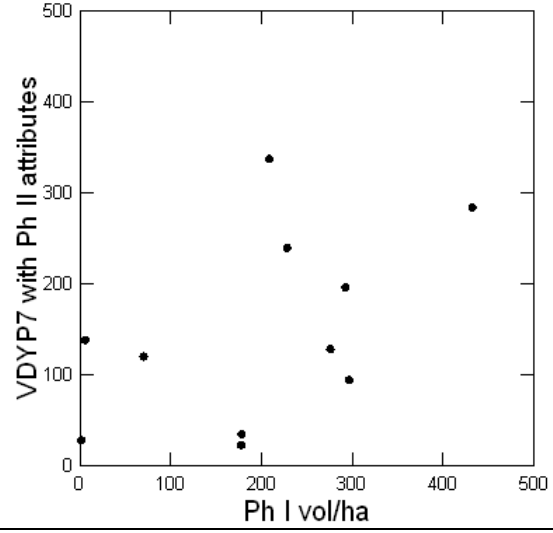


Fig G-12: Mature Spruce stratum: ***"attribute-related volume bias"*** i.e. VDYP7 vol/ha based on ground (Ph II) attributes vs. VDYP7 Phase I inventory vol/ha.

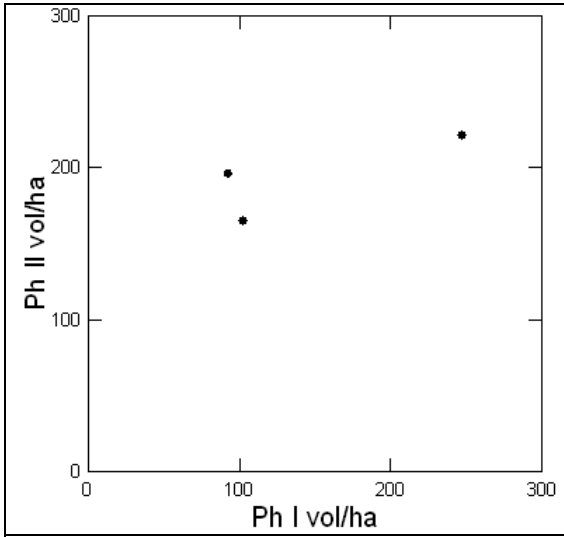


Fig G-13: Mature Other stratum: ***"total volume bias"*** i.e. Phase II compiled vol/ha vs. VDYP7 Phase I inventory vol/ha.

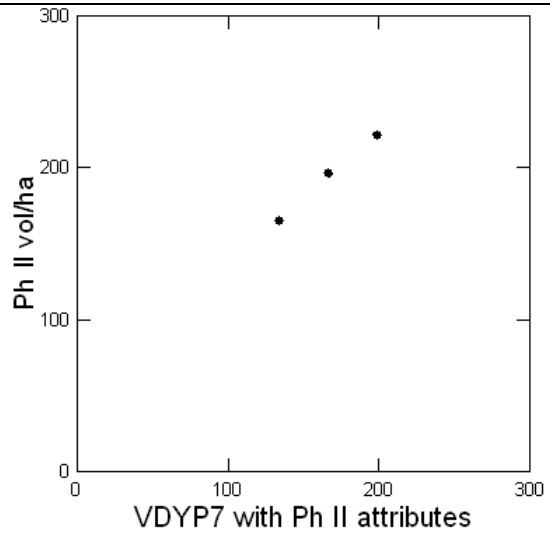


Fig G-14: Mature Other stratum: ***"model-related volume bias"*** i.e. Phase II compiled ground vol/ha vs. VDYP7 vol/ha based on ground (Ph II) attributes.

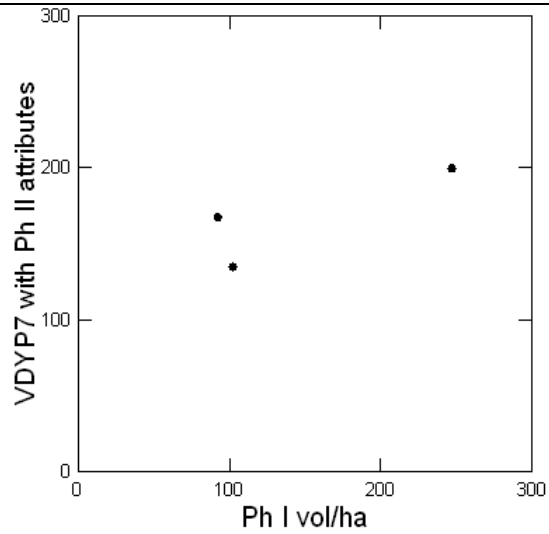


Fig G-15: Mature Other stratum: ***"attribute-related volume bias"*** i.e. VDYP7 vol/ha based on ground (Ph II) attributes vs. VDYP7 Phase I inventory vol/ha.

# 13. APPENDIX H: SAMPLE SELECTION DOCUMENTS

Morice TSA SAMPLE SELECTION REPORT.