Robson Valley TSA

Documentation of Analysis for Net Volume Adjustment Factor and Vegetation Resources Inventory Statistical Analysis

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EXECUTIVE SUMMARY

The objective of this project was to complete a VRI statistical analysis of selected Phase I inventory attributes for the Robson Valley TSA, based on current Ministry of Forests, Mines & Lands (MFML) standards and incorporating NVAF into the Phase II volume compilation. This analysis will provide an assessment of the accuracy of the Phase I inventory in this management unit.

The VRI Project Implementation Plan (VPIP) in the Robson Valley TSA specified the establishment of 80 Phase II ground samples within the population of interest which was defined as: Vegetated Treed (VT) polygons greater than 29 years of age in the operable area, excluding those falling in private land, Indian Reserves, parks, protected areas and those where the Integrated Plot Centre (IPC) showed the forest to be harvested in a pre-screening process but including Community forests and woodlots (Crown land portion).

These samples were selected proportional to area among each of four strata:

- Stratum 1: Spruce
- Stratum 2: Balsam
- Stratum 3: Douglas Fir - Pine and other minor species (Deciduous)
- Stratum 4: Cedar – Hemlock

An additional 20 samples were selected for the Cedar-Hemlock stratum, for a total of 100 samples selected. However, as a result of budgetary restrictions, only 73 samples were actually established.

The VPIP also specified sampling for Net Volume Adjustment Factor development. The Net Volume Adjustment Factor (NVAF) is an integral component of the VRI since it corrects the compiled Phase II ground sample volumes for hidden decay and for bias in the taper functions. Although 115 trees were planned for destructive sampling, only 60 trees were available for analysis[1].

The final Ministry-approved NVAF values are shown in Table 1. These values were applied as multipliers to individual tree volumes generated by the Phase II VRI compiler. Note that the NVAF stratum and the corresponding NVAF value is assigned at the stratum species level in the VRI compiler.

Table 1: NVAF values for the Robson Valley TSA

Species stratum	*NVAF*	*n*	*Sampling error % (at 95%)*
Dead trees	0.8114	5	29.1
Immature trees[2]	1.0384	5	11.3
Mature B	0.9104	10	7.3
Mature C	0.8625	10	11.8
Mature H	1.0387	10	16.2
Mature S	0.9999	12	12.1
Mature – Other spp.	1.0975	8	4.9

[1] Due to budgetary restrictions, not all of the planned trees could be established.

[2] Sample polygon age of 120 years or less.

The VRI statistical analysis was based on the same four leading species-based strata defined for sample selection (i.e. Balsam; Cedar-Hemlock; Fir, Pine, Other; and Spruce) and focused on six inventory attributes (age, height, basal area/ha at 7.5cm+ dbh, trees/ha at 7.5cm+ dbh, Lorey height, and volume/ha net dwb at 12.5cm+ dbh). The ratio of the mean Phase II ground value to the 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 2.

Table 2: Ratio of means comparisons (and sampling error % at a 95% confidence level) for six attributes, based on the 30+ years of age population of interest in the Robson Valley TSA.

Stratum	n	Ratio of weighted means (with 95% sampling error shown as % of the ratio)					
		Age	Height	Basal area/ha (7.5cm+ dbh)	Trees/ha (7.5cm+ dbh)	Lorey height	Volume/ha (net dwb, 12.5cm+ dbh)
Balsam	18	0.9428 (±13.9%)	1.0227 (±13.8%)	1.1019 (±18.3%)	0.9472 (±25.4%)	1.1806 (±16.2%)	1.2973 (±30.7%)
Cedar, Hemlock	18	0.7447 (±9.9%)	0.9906 (±7.7%)	0.9841 (±18.8%)	0.9719 (±26.0%)	1.0298 (±12.7%)	1.2108 (±18.8%)
Fd, Pl, Other	15	1.0978 (±23.8%)	1.1333 (±16.4%)	1.0209 (±38.2%)	0.7424 (±30.0%)	1.1147 (±18.5%)	1.1989 (±46.5%)
Spruce	21	0.7298 (±12.6%)	0.9288 (±8.5%)	1.1614 (±8.3%)	1.4177 (±21.8%)	0.9196 (±11.8%)	1.1400 (±13.6%)
Overall	69	0.8387 (±8.9%)	1.0000 (±6.7%)	1.0875 (±10.9%)	1.0139 (±13.5%)	1.0429 (±%)8.2	1.1975 (±15.8%)

This analysis suggests that overall average Phase I inventory volumes in the Robson Valley TSA are underestimated by nearly 20%. The sampling error (at the 95% confidence level) associated with this estimate was 15.8% which was considered reasonable given the reduced sample size in this project.

Volume underestimation is consistent among all four leading species strata examined and ranged from a 14% underestimation in the Spruce leading stratum to a nearly 30% volume underestimation in the Balsam leading stratum[3]. However, sampling error for the volume ratios is quite high in some strata (reflecting the variability and the sample size) and hence strata results must be viewed cautiously.

Although photo-interpreted ages in most strata were overestimated, overall photo-estimated height was, on average, unbiased. The vast majority of the Phase I inventory in the Robson Valley TSA is based on the old FIP standard and hence there were virtually no polygons with photo-interpreted basal area and trees/ha. As a result, values for these attributes are generated by a module within VDYP7. It is unknown whether or not photo-estimation of basal area and trees/ha (i.e. if a new VRI-type inventory were implemented) would improve the estimates of these attributes compared with the values that are generated by VDYP7.

It is recommended that further study be done to examine the source of the volume bias (e.g. input attributes, VDYP7 model, taper and loss factor assumptions in VDYP7, etc.).

[3] A discussion paper by Will Smith, focused on volume bias trends in the Mature Cedar stratum, is provided in Appendix H.

ACKNOWLEDGEMENTS

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1. INTRODUCTION

1.1 Background

The Vegetation Resources Inventory Strategic Inventory Plan (VSIP) for the Robson Valley TSA identified the implementation of Vegetation Resources Inventory (VRI) Phase II ground sampling, in conjunction with conducting Net Volume Adjustment Factor (NVAF) destructive sampling, as important VRI activities to support timber supply objectives and inventory data needs in the TSA[4].

The VRI Project Implementation Plan (VPIP)[5] specified details for the implementation of the Phase II VRI ground sampling and the NVAF destructive sampling.

Based on the VPIP recommendations, the sample selection process identified 100 Phase II VRI ground samples in polygons older than 30 years[6] within the operable, vegetated, treed portion of the Robson Valley TSA. Due to budgetary restrictions, only 73 of these samples were established. Sampling was carried out in the 2008/2009 field seasons and destructive sampling of 60 trees for Net Volume Adjustment Factor (NVAF) was completed concurrently.

1.2 Description of the Inventory Unit

The following description of the Robson Valley TSA has been excerpted from the VPIP document[7]:

> *The Robson Valley TSA is located in east central BC between Bowron Lake and Wells Gray Provincial Parks on the west and the Province of Alberta on the east. It comprises approximately 1.46 million hectares of the Headwaters Forest District which is administered from Ministry of Forest and Range office in Clearwater with a field office in McBride. Mount Robson Provincial Park is located in the TSA.*
>
> *The terrain is quite variable. The Rocky Mountain Trench runs through the center of the TSA which is a broad valley bottom. Steep rugged ground is found in the Rocky Mountains to the east and the Cariboo and Monashee Mountains to the west.*
>
> *Of the total area for the TSA, only about 15% is considered available for timber harvesting under current management practices. There are four biogeoclimatic zones in the TSA including Alpine Tundra, Engelmann Spruce-Subalpine Fir, Interior Cedar-Hemlock, and Sub-boreal Spruce. Spruce and balsam leading stands predominate the vegetated treed component of the landbase.*

The location of Robson Valley TSA is illustrated in Figure 1 below[8].

[4] "Robson Valley Timber Supply Area: Vegetation Resources Inventory Strategic Inventory Plan", Nona Phillips Forestry Consulting. March 19, 2007.

[5] "Robson Valley Timber Supply Area: Vegetation Resources Inventory Project Implementation Plan for Ground Sampling and Net Volume Adjustment Factor Sampling", Nona Phillips Forestry Consulting, May 2007.

[6] Details on the population of interest and the sample selection are provided in sections 2.3 and 2.4.

[7] Ibid. 5

[8] Ibid. 5

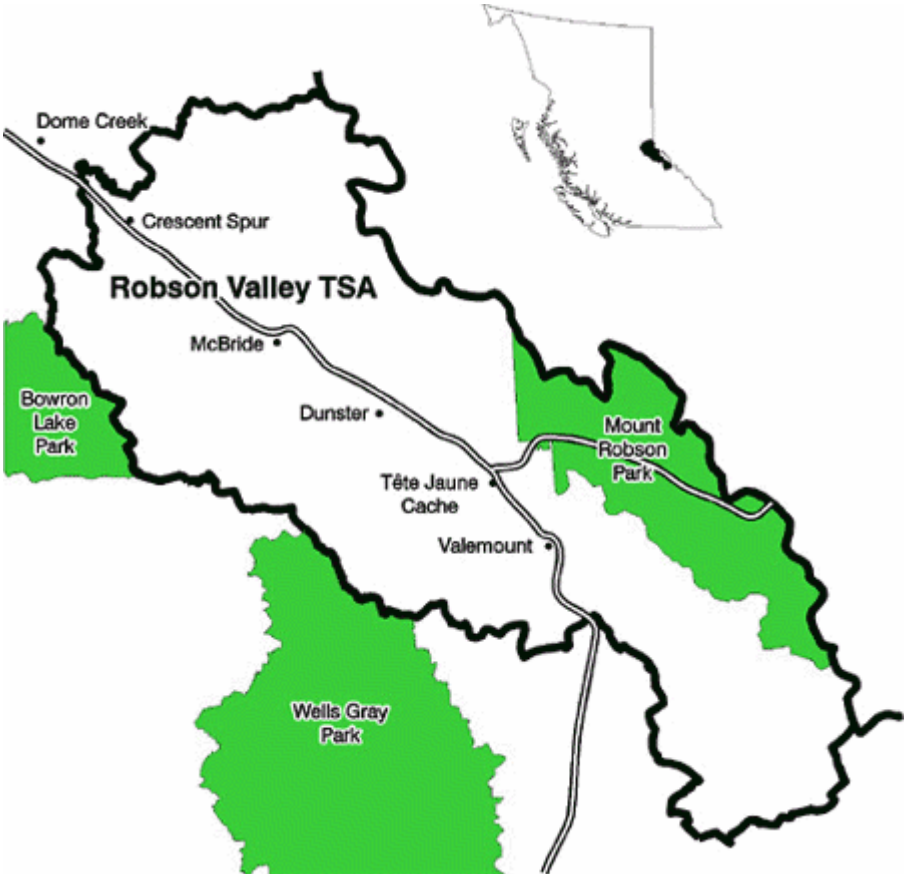

Figure 1: Location of the Robson Valley TSA.

1.3 Scope and Objectives

The objective of this project was to provide a VDYP7-based VRI statistical analysis for the Robson Valley TSA, based on current Ministry of Forests, Mines and Lands (MFML) standards and incorporating NVAF into the Phase II volume compilation.

The Robson Valley TSA VRI statistical analysis was restricted to Vegetated Treed (VT) polygons greater than 30 years of age[9] in the operable landbase. The VRI compilation and the development of statistical ratios of means and sampling errors were carried out in accordance with the recommended MFML procedures as of September 2010. All attribute values were based on live trees only.

2. METHODS

2.1 Overview of NVAF analysis

The Net Volume Adjustment Factor (NVAF) is an integral component of the VRI since it corrects the compiled Phase II ground sample volumes for hidden decay and for bias in the taper functions.

[9] An analysis based on 0+ years of age is provided in Appendix A.

As specified in the VPIP, a total of 115 trees were selected for the determination of NVAF values. However, due to budgetary restrictions, only 60 tees were actually destructively sampled in the field. The 60 NVAF destructively sampled trees were distributed as follows:

- 5 dead trees
- 5 immature trees
- 10 mature balsam
- 12 mature spruce
- 10 mature cedar
- 10 mature hemlock
- 8 mature other species (5 Pl, 3 Fd)

A design-based approach was used to compute sample weights and estimate the NVAF values and the associated sampling error values. NVAF values were computed for a number of alternative strata before the final stratification was chosen, in consultation with Will Smith, Volume and Decay Officer, Forest Analysis & Inventory Branch (FAIB), MFML.

2.2 Overview of VRI Statistical Analysis

The role of the VRI statistical analysis is to evaluate the accuracy of the Phase I photo-interpreted inventory data, using the Phase II ground sample data as the basis for the comparison[10].

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[11]. 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 strata.

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 six 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[12] at 7.5cm+ dbh utilization (LH7.5), and

[10] "VRI Attribute Analysis Procedures and Standards" MFML draft document, September 2010.

[11] The target population is usually pre-stratified prior to sample selection. In some cases, post-stratification may be required at the analysis stage particularly if significant bias trends are observed in the residuals plots of the data. However, post-stratification is generally restricted to subdivision of existing strata Analysis stratification that differs greatly from the original sample selection stratification is usually very inefficient and is not recommended. However, analysis sub-stratification within the original sample selection strata may be used to distinguish important trends if a sufficient number of samples are available. The need for sub-stratification can often be deduced from the plots of residual values.

[12] 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.

- Volume net top, stump (CU), decay, waste and breakage at 12.5cm+ dbh utilization.

2.3 Population for Analysis

The population of interest for the Robson Valley TSA analysis included Vegetated Treed (VT) polygons greater than 29 years of age in the operable area, excluding those falling in private land, Indian Reserves, parks, protected areas and those where the Integrated Plot Centre (IPC) showed the forest to be harvested in a pre-screening process. Community forests and woodlots (Crown land portion) were included[13]. The total area in this population of interest was 426,800 hectares.

The sample selection was actually based on all polygons 0+ years of age. As a result, 4 of the established samples were less than 30 years of age. Although the weighted means and ratios shown in Sections 3.2 are based on the originally intended 29+ years population of interest, corresponding statistics for the 0+ years population are shown in Appendix A. The total area for the 0+ years of age population was 435,897 hectares.

2.4 Phase II Sample Selection Pre-Stratification and Weights

The VPIP originally specified four strata for sample selection, based on leading species. Table 1 below shows the planned and established sample distribution, along with stratum areas. All samples were selected with probability proportional to size with replacement (PPSWR). The sample selection strata were maintained throughout this analysis.

Table 1: Stratum areas and VRI Phase II sample allocation for the Robson Valley TSA

Leading species stratum	*Population area (0+ years)*	*Population area (30+ years)*	*Planned sample allocation*	*Established samples (0+)*	*Established samples (30+)*
Balsam	133,067 (31%)	131,940 (31%)	25	19	18
Cedar, Hemlock	43,626 (10%)	43,151 (10%)	8+20 extra	18	17
Pl, Fd, Other	106,178 (24%)	102,902 (24%)	19	15	14
Spruce	153,026 (35%)	148,807 (35%)	28	21	20

Sampling weights were determined based on the areas and established samples above, in combination with the volume class allocation in each stratum that was also applied at the time of sample selection. The sampling weights were computed as A_h/n_h. For the 29+ years target population, the sample weights are shown in Table 2. Similar information for the 0+ years target population is provided in Appendix A.

Table 2: Sample weights in each stratum and volume class (number of hectares represented by each sample), based on the 30+ years target population in the Robson Valley TSA.

Sampling weights (30+ year population of interest), by stratum				
Volume class	*Balsam*	*Cedar, Hemlock*	*Fd, Pl, Other*	*Spruce*
0	6746	2151	10845	6726
1	5666	2273	6534	7231
2	9758	3297	6283	8262

[13] Ibid. 5

2.5 Data Sources

2.5.1 Phase I photo-interpreted inventory data

The Robson Valley TSA was re-inventoried in 1994-95. Prior to sample selection, the most current update year for the Veg files in the MFML Land & Resource Data Warehouse (LRDW) was 2002[14]. A cut of this file, corresponding to the population of interest (based on operability and ownership), was provided for sample selection[15]. This sample selection file was also used as the source of the Phase I inventory attributes for the analysis[16].

Virtually all of the Phase I inventory data in the Robson Valley TSA is based on the old F-type[17] inventory standard and hence there was no photo-interpreted basal area/ha, tree/ha or second species height and age data available.

For the VRI statistical analysis, the Phase I polygons corresponding to the Phase II ground samples were projected using VDYP7 to either 2008 or 2009 to correspond to the year that ground sampling was completed. The Phase I inventory attributes used in the analysis are provided in Appendix B.

2.5.2 Phase II ground sample data

A total of 73 Phase II ground samples were established in the Robson Valley TSA[18]. The Phase II ground sample data had been loaded and was available in the Ministry's VGIS Oracle database. The raw sample data from this source was provided by the Ministry and was then compiled according to Ministry standards with the NVAF values (see Section 3.1) applied to the volumes.

Of the 73 ground samples available, 4 were in polygons less than 30 years of age and hence were outside of the original population of interest for this analysis (see Section 2.3). The analysis in the body of this report is based on the 69 samples in the original population of interest. However, results based on all 73 samples are provided in Appendix A.

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

2.5.3 Data issues related to the statistical adjustment

As noted previously, 4 Phase II samples were established in polygons less than 30 years of age. Although they were included in the supplementary analysis in Appendix A, they are not part of the results shown in the body of this report.

A number of samples were identified as potential outliers in scatter plots comparing the Phase I and Phase II attributes and, with the help of Ministry staff (Bob Krahn and Matt Makar), these samples were investigated to ensure that the Phase II ground compiled values were reasonable and that there were no errors associated with the matching of the Phase I photo-interpreted values. Details of these findings are provided in the Data Issues Log in Appendix D.

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[14] Ibid. 5

[15] Received from Meridian Mapping on January 31, 2007.

[16] Roughly 75% of the polygons showed a Phase I inventory reference date of 1991. A further 13.5% had reference dates prior to 1991 and the remainder were after 1991.

[17] Old FIP standard as opposed to the current V-type or VRI standard inventory records.

[18] This included 4 samples established in polygons less than 30 years of age.

2.5.4 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 MFML procedures and standards document.

For each VRI sample polygon, the Phase II ground sample data was matched with the corresponding Phase I inventory data for the same polygon. The ground heights and ages used in the analysis were based on the average values for the T, L, S, X & O trees[19] 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". Since nearly the entire Robson Valley TSA inventory is based on the old F-type inventory standard, there were no height and age data for the second species.

If a leading species match could not be made at the sp0[20] 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.

Of the 69 samples used in the analysis, 47 (or 68%) indicated a match between the inventory leading species and the ground leading species at 4cm+ dbh utilization. A further 20 samples were matched based on a conifer-to-conifer or deciduous-to-deciduous basis. Only two samples could not be matched and were therefore excluded from the development of the age and height comparison ratios. However, all samples were used in the analysis of basal area, trees/ha, Lorey height and volume.

3. RESULTS AND DISCUSSION

3.1 NVAF

The strata and final NVAF values are shown in Table 3. These values were applied as multipliers to individual tree volumes generated by the Phase II VRI compiler. Note that the NVAF stratum and the corresponding NVAF value is assigned at the stratum species level in the VRI compiler.

The NVAF values in Table 3 correct for bias associated with hidden decay not represented by the net factoring process and for bias associated with the taper functions used to estimate whole stem and net close utilization (i.e. net top and stump) volume. Scatterplots showing the strata relationships between the actual (destructive sampling) volume and the estimated (compiled volumes with net factoring) volume for the NVAF sample trees are provided in Appendix F. This appendix also shows plots of the residual values (actual volume – NVAF-adjusted volume estimate) as a function of the NVAF-adjusted volume estimate.

The NVAF value for all Mature sample trees combined (n=50) was 0.9785 and had a sampling error of 3.1%. Note, however, that the strata values in Table 3 (and not this combined value) were used to adjust the compiled volumes.

[19] 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; S or "second species" is the largest DBH in 0.01 ha plot, of second species. T and S 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 MFR document "VRI Ground Sampling Procedures Version 4.8, May 2008, Amendment # 1: Modifications to the Leading Species Site Tree Selection Procedures", April, 2009.

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

Table 3: NVAF values for the Robson Valley TSA used to adjust Phase II compiled volumes.

Species stratum	*NVAF*	*n*	*Sampling error % (at 95%)*
Dead trees	0.8114	5	29.1
Immature trees[21]	1.0384	5	11.3
Mature B	0.9104	10	7.3
Mature C	0.8625	10	11.8
Mature H	1.0387	10	16.2
Mature S	0.9999	12	12.1
Mature – Other spp.	1.0975	8	4.9

3.2 VRI statistical analysis

As a way to compare the Phase I inventory values with the Phase II ground sample values, ratios of the weighted mean[22] 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 six key attributes identified in Section 2.2, for each stratum as well as over all samples. The resulting weighted means are shown in Table 4. The ratios of means, and the sampling error associated with each of these statistics, are provided in Table 5.

The relationship between the Phase II ground and the Phase I inventory attributes corresponding to each ratio were examined in scatterplots (Appendix G). The ratios of means were also evaluated for potential bias by plotting the "residual" values[23] as a function of the 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. These graphs are also included in Appendix G.

[21] Sample polygon age of 120 years or less.

[22] Weights are provided in Table 2.

[23] 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).

Table 4: Sample-estimated weighted means for the Phase I inventory and Phase II ground sample for six key inventory attributes (based on the 30+ years target population in the Robson Valley TSA).

Attribute	*Weighted Means*				
	Balsam	*Cedar, Hemlock*	*Fir, Pine, Other*	*Spruce*	*All strata*
Age (years)					
n	18	17	12	20	67
Phase II Ground	192.5	183.4	100.1	176.8	165.8
Phase I Inventory	204.1	246.2	91.2	242.3	197.7
Height (m)					
n	18	17	12	20	67
Phase II Ground	21.7	26.9	24.2	27.0	24.7
Phase I Inventory	21.2	27.2	21.3	29.1	24.7
Basal area (m2/ha) at 7.5cm+ dbh					
n	18	17	14	20	69
Phase II Ground	34.8	56.5	32.5	43.8	39.6
Phase I Inventory	31.6	57.5	31.8	37.7	36.4
Trees/ha at 7.5cm+ dbh					
n	18	17	14	20	69
Phase II Ground	848.3	775.3	867.0	989.8	894.8
Phase I Inventory	895.6	797.8	1167.8	698.2	882.5
Lorey height (m)					
n	18	17	14	20	69
Phase II Ground	19.8	24.8	21.0	21.5	21.2
Phase I Inventory	16.8	24.1	18.8	23.5	20.3
Volume/ha (m3/ha) at 12.5cm+ dbh net dwb					
n	18	17	14	20	69
Phase II Ground (with NVAF)	222.8	391.3	245.4	330.0	282.7
Phase I Inventory	171.7	323.1	204.7	289.5	236.1

Table 5: Ratio of means comparisons (and sampling error % at a 95% confidence level) for six attributes, based on the 30+ years target population in the Robson Valley TSA.

Leading species Stratum	*n*	*Ratio of weighted means (with 95% sampling error shown as % of the ratio)*					
		Age (years)	*Height (m)*	*Basal area[24] (m^2/ha at 7.5cm+ dbh)*	*Trees/ha[25] (at 7.5cm+ dbh)*	*Lorey height (m)*	*Volume/ha (m^3/ha at 12.5cm+ dbh net dwb)*
Balsam	18	0.9428 (±13.9%)	1.0227 (±13.8%)	1.1019 (±18.3%)	0.9472 (±25.4%)	1.1806 (±16.2%)	1.2973 (±30.7%)
Cedar, Hemlock	18	0.7447 (±9.9%)	0.9906 (±7.7%)	0.9841 (±18.8%)	0.9719 (±26.0%)	1.0298 (±12.7%)	1.2108 (±18.8%)
Fd, Pl, Other	15[26]	1.0978 (±23.8%)	1.1333 (±16.4%)	1.0209 (±38.2%)	0.7424 (±30.0%)	1.1147 (±18.5%)	1.1989 (±46.5%)
Spruce	21	0.7298 (±12.6%)	0.9288 (±8.5%)	1.1614 (±8.3%)	1.4177 (±21.8%)	0.9196 (±11.8%)	1.1400 (±13.6%)
Overall	69	0.8387 (±8.9%)	1.0000 (±6.7%)	1.0875 (±10.9%)	1.0139 (±13.5%)	1.0429 (±%)8.2	1.1975 (±15.8%)

Careful examination of the scatterplots in Appendix G did not suggest any significant bias patterns associated with the ratios of means that would indicate that the relationship was statistically inappropriate. However, some of the graphs illustrated a weak relationship between the ground and the inventory attribute values, particularly for trees/ha.

The ratios of means in Table 5 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 suggests that, on average, the inventory age is overestimated in all strata except the "Fir, Pine & Other species" stratum, where the sample suggest that age is underestimated by about 10%. Overall height estimation in the Robson Valley TSA is relatively unbiased. However, the sample did suggest that height was slightly overestimated in the "Spruce" stratum and was underestimated (by more than 10%) in the "Fir, Pine & Other species" stratum.

Basal area is a major driver of volume in the VDYP7 yield model. In the Robson Valley, where the majority of the TSA does not have a photo-estimated value for basal area, the VDYP7 model itself generates estimates of basal area using a module called FIPSTART. In this analysis, the Phase II ground sample data would suggest that the VDYP7 model underestimates basal area in the Robson Valley TSA in all strata except "Cedar, Hemlock", where the basal area is slightly overestimated. The magnitude of the basal area underestimation ranges from about 2% (in the "Fir, Pine & Other species" stratum) to over 15% (in the "Spruce" stratum).

[24] In the Robson Valley TSA, since it is a F-type inventory, this attribute is derived by VDYP7 rather than being photo-interpreted.

[25] Ibid 24

[26] For age and height, the sample size was n=12 for the ratio development.

The trees/ha attribute is typically underestimated in Phase I photo-inventories because of the difficulty in photo-interpreting this attribute. However, since the Robson Valley TSA was largely an old FIP-type inventory (without photo-interpreted trees/ha), the Phase I values for trees/ha were generated by the VDYP7 model. Overall, there was minimal bias in the inventory values of trees/ha. However, among the strata the sample suggested biases ranging between a 25% overestimation (in the "Fir, Pine & Other species" stratum) and a 40% underestimation (in the "Spruce" stratum).

Lorey height is another significant input for generating volume in the VDYP7 model. Lorey height itself is an attribute that is derived by VDYP7 (i.e. it is not directly photo-interpreted, although it is based on photo-interpreted height). The ground sample suggests that Lorey height is underestimated in all strata except "Spruce" and that the magnitude of the underestimation ranges from 3% in the "Cedar, Hemlock" stratum to 18% in the "Balsam" stratum.

The assessment for volume estimation is discussed separately in Section 3.3.

3.3 Assessment of Phase I inventory volume accuracy

Since volume estimation and yield projection are important components of the VRI inventory, the information in Tables 4 and 5 have been restated in Table 6 to focus the discussion on volume. Timber supply analyses are typically done on a net decay, waste and breakage volume basis. Hence, the volume/ha accuracy assessment and its associated sampling error is computed on this basis. As for the other attribute comparisons (Section 3.2), the ratios of means for volume were computed as ratios of the weighted mean Phase II (ground sample) volume to the weighted mean Phase I (VDYP7) volume. Hence a ratio greater than 1 indicates that the Phase I inventory is underestimating volume. The results, by stratum, are shown below.

Table 6: Assessment of Phase I inventory volume accuracy, based on the Phase II ground sample, by stratum for the 30+ years target population in the Robson Valley TSA.

Assessment of Phase I inventory volume (m^3/ha) estimates @12.5cm+ dbh utilization net DWB					
Stratum	***n***	***Weighted Mean Phase II vol/ha***	***Weighted Mean Phase inventory vol/ha***	***Estimated ratio of means volume comparison***	***Sampling error % for volume ratio (at 95% confidence level)***
Balsam	18	222.8	171.7	1.2973	±30.7%
Cedar, Hemlock	17	391.3	323.1	1.2108	±18.8%
Fd, Pl, Other	14	245.4	204.7	1.1989	±46.5%
Spruce	20	330.0	289.5	1.1400	±13.6%
Overall	69	282.7	236.1	1.1975	±15.8%

The Phase II ground sample suggests that, on average, the VDYP7 volumes in the Robson Valley TSA are consistently underestimated across all strata. The inventory volume underestimation ranges from 14% in the "Spruce" stratum to nearly 30% in the "Balsam" stratum. Overall, inventory volumes in the Robson Valley TSA appear to be underestimated by almost 20%, based on the ground sample information.

A discussion paper providing an interpretation of the volume bias trends in the Mature Cedar stratum was prepared by Will Smith[27] and is presented in Appendix H. It is surmised that much of the volume bias observed in this stratum may be related to the estimation of volume loss due to decay within the VDYP7 yield model.

[27] Volume and Decay Sampling Officer, FAIB, MFML.

3.4 Sampling error

The sampling error estimates in Tables 5 and 6 were computed using the MFML's Excel-based macro tool[28]. These values can provide an indication of the reliability of the sample-based estimated ratios of means. The VPIP document for the Robson Valley TSA targeted a sampling error of 10%. However, this target was based on establishment of all of the 100 samples that were originally planned. Given that only 69 samples[29] were actually established, achieving an overall sampling error for volume of ±15.8% was considered reasonable for this project[30]. The relatively high sampling errors in the "Balsam" and the "Fir, Pine & Other species" strata are related to the small sample sizes and relatively high variability observed in these strata.

4. CONCLUSIONS AND RECOMMENDATIONS

The VDYP7-based VRI statistical analysis for the Robson Valley TSA suggests that, overall, inventory volumes in the population of interest[31] are currently underestimated by nearly 20%. The sampling error for this volume bias estimate was ±15.8% (at the 95% confidence level). Although this level of precision did not meet the target in the original VPIP document, it was considered acceptable given the reduced sample size in this project.

The statistical analysis indicated that the average inventory volumes were consistently underestimated across all strata in the Robson Valley TSA. The sample suggested that the magnitude of the volume underestimation ranged from 14% in Spruce leading polygons to nearly 30% in Balsam leading polygons. However, it should be noted that the sampling error for the volume comparison in the Balsam stratum was relatively high. The Spruce leading stratum comprised the largest proportion of area (35%) in the target population within the TSA. Balsam leading stands were the second largest stratum, representing just over 30% of the area of interest.

Photo-interpretation in balsam stands in the Robson Valley TSA is often difficult due to the growth characteristics of this species and site productivity differences associated with elevation. This may account for some of the high variability between the Phase I and Phase II attributes that was observed in this stratum. In addition, many of the stands in both the Spruce leading and Balsam leading strata were spruce/balsam mixes. In these polygons, incorrect assignment of leading species may have also contributed to volume underestimation in the inventory since balsam leading polygons typically have lower volume than spruce leading polygons.

The vast majority of the Phase I inventory in the Robson Valley TSA is based on the old FIP standard and hence there were virtually no polygons with photo-interpreted basal area and trees/ha. As a result, values for these attributes are generated by a module within VDYP7. In both the Balsam and the Spruce leading strata, the ground sample suggested that VDYP7 underestimated basal area by at least 10%. Since this attribute is a significant driver of volume, it seems likely that this may have contributed to the observed inventory volume underestimation in these strata.

However, even in strata like Cedar and Hemlock leading, where biases associated with input attributes (such as basal area, lorey height, etc.) were relatively minor, significant volume underestimation bias was observed. This suggests possible underlying bias within the volume estimation component of the VDYP7 yield model

[28] "VRI Analysis Workbook 2010-10-29_Test_mod.xlsm" provided by Sam Otukol, MFML.

[29] 69 samples in the 0+ years target population and 73 samples in the 30+ years target population

[30] Based on discussions at the February 2, 2011 conference with the client and MFML staff.

[31] Polygons greater than 29 years of age in the VT, operable portion of the TSA.

itself. Particularly in the case of the Cedar and Hemlock stratum, this may be related to the taper and loss factor assumptions upon which the VDYP7 model was built.

Although photo-interpreted ages in most strata were overestimated, overall photo-estimated height was, on average, unbiased. It is unknown whether or not photo-estimation of basal area and trees/ha (i.e. if a new VRI-type inventory were implemented) would improve the estimates of these attributes compared with the values that are generated by VDYP7.

Based on issues encountered through the statistical analysis in the Robson Valley TSA, the following recommendations for further study are made:

- Examine the difference between photo-interpreted and VDYP7-generated estimates of basal area to determine if photo-interpretation offers any potential for reducing the observed bias related to this attribute.
- Investigate methodology for determining the source of volume estimation bias e.g. to distinguish between:
    - bias in photo-interpretation of determinant attributes;
    - bias in the VDYP7 (FIPSTART/VRISTART) stand description generation (e.g. basal area, Lorey height); and
    - bias in the taper and/or loss factor assumptions integral to VDYP7 volume estimation.

5. APPENDIX A: RESULTS OF ANALYSIS BASED ON ALL SAMPLES (I.E. 0+ YEARS OF AGE)

The body of the report presents results based on the 69 samples that met the criteria for the 30+ years of age population of interest. However, an additional 4 samples were established in polygons that were less than 30 years of age. The inventory age of these samples ranged from 22 to 29 years.

Although there were only minimal changes when these samples were included in the analysis, the full set of results based on all 73 samples in the 0+ years of age target population are presented for reference in the following tables.

Table A-1: Area and sample size by stratum and volume class, for the 0+ years target population in the Robson Valley TSA.

Stratum Area and Established Samples (0+ years)								
Volume class	*Balsam*		*Cedar, Hemlock*		*Fd, Pl, Other*		*Spruce*	
	Area (ha)	*n*	*Area (ha)*	*n*	*Area (ha)*	*n*	*Area (ha)*	*n*
0	34264	6	10628	6	33599	4	42361	7
1	39965	7	16305	7	33379	5	51620	7
2	58839	6	16693	5	39199	6	59045	7
Total	133067	19	43626	17	106178	15	153026	21

Table A-2: Sample weights in each stratum and volume class (number of hectares represented by each sample), based on the 0+ years target population in the Robson Valley TSA.

Sampling weights (0+ years population of interest), by stratum				
Volume class	*Balsam*	*Cedar, Hemlock*	*Fd, Pl, Other*	*Spruce*
0	5711	1771	8400	6052
1	5709	2329	6676	7374
2	9807	3339	6533	8435

Table A-3: Sample-estimated weighted means for the Phase I inventory and Phase II ground sample for 6 inventory attributes (based on the 0+ years target population in the Robson Valley TSA).

Attribute	*Weighted Means*				
	Balsam	***Cedar, Hemlock***	***Fir, Pine, Other***	***Spruce***	***All strata***
Age (years)					
n	19	18	12	21	70
Ground	186.9	178.4	101.2	170.7	162.5
Inventory	199.1	240.0	95.4	234.6	195.4
Height (m)					
n	19	18	12	21	70
Ground	21.3	26.4	24.4	26.3	24.3
Inventory	20.6	26.8	22.0	28.2	24.3
Basal area (m^2/ha) at 7.5cm+ dbh					
n	19	18	15	21	73
Ground	33.9	54.4	31.0	42.2	38.2
Inventory	30.6	56.4	30.9	36.3	35.3
Trees/ha at 7.5cm+ dbh					
n	19	18	15	21	73
Ground	817.8	751.0	872.3	949.0	870.5
Inventory	980.6	801.3	1104.0	713.4	898.9
Lorey height (m)					
n	19	18	15	21	73
Ground	19.4	24.3	20.6	21.0	20.7
Inventory	16.2	23.9	18.7	22.6	19.8
Volume/ha (m^3/ha) at 12.5cm+ dbh net dwb					
n	19	18	15	21	73
Ground (with NVAF)	217.4	375.6	232.5	319.8	272.8
Inventory	167.8	317.6	201.2	280.9	230.6

Table A-4: Ratio of means comparisons (and sampling error % at a 95% confidence level) for six attributes, based on the 0+ years target population in the Robson Valley TSA.

Stratum	*n*	*Ratio of weighted means (with 95% sampling error shown as % of the ratio)*					
		Age	*Height*	*Basal area/ha*	*Trees/ha*	*Lorey height*	*Volume/ha*
Balsam	19	0.9387 (±13.3%)	1.0328 (±13.5%)	1.1092 (±18.5%)	0.8340 (±34.5%)	1.1951 (±16.3%)	1.2954 (±31.1%)
Cedar, Hemlock	18	0.7435 (±9.5%)	0.9840 (±7.8%)	0.9651 (±19.5%)	0.9372 (±26.0%)	1.0157 (±12.9%)	1.1826 (±19.4%)
Fd, Pl, Other	15 [32]	1.0603 (±22.7%)	1.1090 (±14.8%)	1.0061 (±34.4%)	0.7901 (±30.2%)	1.0993 (±15.8%)	1.1553 (±42.3%)
Spruce	21	0.7275 (±12.7%)	0.9321 (±8.6%)	1.1616 (±8.5%)	1.3302 (±24.9%)	0.9265 (±12.1%)	1.1384 (±13.6%)
Overall	73	0.8318 (±8.4%)	0.9981 (±6.3%)	1.0831 (±10.3%)	0.9683 (±15.8%)	1.0439 (±7.9%)	1.1830 (±15.2%)

[32] For age and height in this stratum, the sample size was n=12 for the ratio development. Three samples were excluded in the age & height matching process since the ground and inventory leading species were not either both coniferous or both deciduous.

6. APPENDIX B: PHASE I INVENTORY ATTRIBUTES

SAMPLE	Stratum	Volume class	Sampling weight (based on 30+ population)	Measurement year (for projection)	Reference Year	Inventory standard (F=FIP-type inventory)	Input Age	Input Height	Species Composition	VDYP7 attributes projected to measurement year					
										Age sp1	Height sp1	BA/ha @7.5cm+ dbh	TPH @7.5cm+ dbh	Lorey height @7.5cm+ dbh	Volume/ha net dwb @12.5cm+ dbh
0001	Balsam	0	6,746	2009	1991	F	90	8	BL 80 S 20	108	10.12	14.44	1073.7	8.3	26.4
0002	Balsam	0	6,746	2009	1991	F	90	13	BL 70 S 30	108	15.67	20.2	864.7	13.3	78.5
0004	Balsam	0	6,746	2008	1991	F	160	15	BL 100	177	16.42	30.39	1222.1	11.4	97.5
0005	Balsam	0	6,746	2008	1991	F	110	16	BL 90 S 10	127	18.14	27.62	898.7	14.2	119.1
0007	Balsam	0	6,746	2008	1991	F	180	17	BL 90 S 10	197	18.28	25.46	847.7	13.4	100.7
0009	Balsam	1	5,666	2008	1991	F	180	18	BL 90 S 10	197	19.28	26.9	825.3	14.2	114.5
0010	Balsam	1	5,666	2008	1991	F	200	18	BL 70 S 30	217	19.15	31.24	1061	14.9	140.9
0011	Balsam	1	5,666	2009	1994	F	180	18	BL 85 S 15	195	19.13	32.78	1099.4	14.2	138.5
0013	Balsam	1	5,666	2008	1991	F	200	20	BL 60 S 35 CW 5	217	21.11	29.07	829	17.2	149.7
0014	Balsam	1	5,666	2008	1991	F	220	19	BL 90 S 10	237	20.04	35.14	1024.3	14.8	156
0015	Balsam	1	5,666	2008	1991	F	140	19	BL 80 S 20	157	20.62	35.25	1039.4	16.3	178.3
0017	Balsam	1	5,666	2008	1991	F	200	21	BL 70 S 30	217	22.08	34.85	948.5	17.6	192.2
0018	Balsam	2	9,758	2008	1991	F	230	23	BL 60 S 40	247	23.87	30.31	654.2	20.3	197.4
0019	Balsam	2	9,758	2010	1991	F	200	20	BL 80 S 20	219	21.23	34.88	994.8	16.1	172.4
0020	Balsam	2	9,758	2008	1991	F	200	21	BL 90 S 10	217	22.08	34.53	859.7	16.6	175.8
0022	Balsam	2	9,758	2008	1974	F	200	21	BL 90 S 10	234	23.03	37.65	966.5	16.3	187.2
0023	Balsam	2	9,758	2008	1991	F	240	24	BL 50 S 50	257	24.79	33.51	704.2	21.8	239.2
0025	Balsam	2	9,758	2008	1974	F	222	33.9	BL 65 S 35	256	34.83	44.02	574	30.1	436.7

SAMPLE	Stratum	Volume class	Sampling weight (based on 30+ population)	Measurement year (for projection)	Reference Year	Inventory standard (F=FIP-type inventory)	Input Age	Input Height	Species Composition	VDYP7 attributes projected to measurement year					
										Age sp1	Height sp1	BA/ha @7.5cm+ dbh	TPH @7.5cm+ dbh	Lorey height @7.5cm+ dbh	Volume/ha net dwb @12.5cm+ dbh
0026	C H	0	2,151	2010	1990	F	25	2.7	HW 50 S 20 FD 20 PL 10	45	8.03	3.61	408.8	8.8	3.3
0027	C H	0		2009	1992	F	12	1.8	CW 47 AC 21 BL 15 HW 12 S 5	29	10.9	11.01	966.1	13.2	31
0028	C H	0	2,151	2008	1991	F	200	21	CW 40 HW 30 S 20 BL 10	217	22.46	48.35	1022.6	20.7	248.8
0029	C H	0	2,151	2008	1992	F	250	21	HW 95 S 5	266	21.74	43.32	924.7	17.2	167.3
0031	C H	0	2,151	2009	1991	F	240	24	CW 50 HW 30 S 10 BL 10	258	25.33	53.96	739	22.8	264.5
0033	C H	0	2,151	2008	1991	F	160	22	HW 60 S 30 BL 10	177	23.36	49.33	1279.4	19.9	276.9
0035	C H	1	2,273	2009	1991	F	200	24	HW 50 S 30 CW 20	218	25.06	45.63	780.9	21.7	251.5
0037	C H	1	2,273	2009	1991	F	150	23	HW 70 S 20 BL 10	168	24.52	51.1	1272.1	20.4	277.2
0038	C H	1	2,273	2009	1974	F	240	27	HW 50 CW 20 FD 20 S 10	275	28.39	58.06	841.7	24.7	344.5
0039	C H	1	2,273	2009	1994	F	260	27.6	CW 45 BL 30 HW 15 S 10	275	28.62	63.59	827.5	26.2	381.3
0043	C H	1	2,273	2009	1991	F	300	35	CW 50 S 20 BL 10 FD 10 AC 10	318	35.87	73.07	499	34.4	541.8
0045	C H	2	3,297	2009	1991	F	260	25	HW 40 S 30 CW 30	278	25.73	60.12	958.9	22.7	330
0046	C H	2	3,297	2009	1994	F	260	31	HW 80 CW 20	275	31.5	57.27	510.5	27.1	309.3
0047	C H	2	3,297	2009	1991	F	200	27	HW 70 S 20 CW 10	218	27.98	57	897.7	23.6	335.7
0048	C H	2	3,297	2009	1990	F	250	32	CW 70 HW 30	269	33.21	81.78	512.6	29.5	398.2
0051	C H	2	3,297	2009	1974	F	300	35	CW 50 HW 40 FD 5 S 5	335	36.64	82.52	552.6	32.9	479.2
0054	FP_dec	0		2009	1993	F	9	5.1	AT 40 PL 30 CW 20 EP 10	25	11.39	9.41	823.6	10.9	18
0056	FP_dec	0	10,845	2009	1990	F	25	10	PL 75 SE 15 FD 5 BL 5	44	13.34	16.18	1626.1	11.4	28.1
0057	FP_dec	0	10,845	2009	1991	F	20	8	FD 50 S 25 CW 10 BL 10 HW 5	38	13.57	22	1662.1	11.1	51.5
0060	FP_dec	1	6,534	2009	1991	F	90	24	AT 90 PL 5 S 5	108	25.91	31.31	523.9	23.9	178
0061	FP_dec	1	6,534	2009	1995	F	79	18.3	PL 100	93	19.8	28.18	1113.3	17.1	173.2

SAMPLE	Stratum	Volume class	Sampling weight (based on 30+ population)	Measurement year (for projection)	Reference Year	Inventory standard (F=FIP-type inventory)	Input Age	Input Height	Species Composition	VDYP7 attributes projected to measurement year					
										Age sp1	Height sp1	BA/ha @7.5cm+ dbh	TPH @7.5cm+ dbh	Lorey height @7.5cm+ dbh	Volume/ha net dwb @12.5cm+ dbh
0062	FP_dec	1	6,534	2008	1991	F	90	19	PL 80 AT 20	107	20.46	26.83	971.2	18	157.1
0063	FP_dec	1	6,534	2009	1991	F	60	18	PL 90 FD 10	78	20.8	32.6	1358.7	17.9	206.5
0064	FP_dec	1	6,534	2008	1974	F	60	23.6	AT 100	94	29.02	40.08	581.4	26.6	266.4
0067	FP_dec	2	6,283	2009	1991	F	75	20	PL 90 S 10	93	22.05	38.97	1366.2	18.9	278.7
0068	FP_dec	2	6,283	2008	1991	F	110	23	PL 100	127	24.07	27.05	664.7	21.3	220.1
0071	FP_dec	2	6,283	2008	1991	F	90	30	FD 50 PL 40 S 10	107	33.11	43.92	697.1	28.5	453.2
0072	FP_dec	2	6,283	2008	1974	F	152	25.6	PL 57 S 21 BL 20 FD 2	186	26.68	48.22	1093.1	22.3	384.4
0073	Spruce	0		2009	1989	F	2	0.2	S 100	22	2.32		1260		
0074	Spruce	0	6,726	2008	1971	F	200	18	S 60 BL 40	237	21.02	23.38	780.4	14.9	108.8
0075	Spruce	0	6,726	2009	1994	F	146	21	S 57 BL 43	161	22.67	36.65	1064.4	18.2	218.5
0076	Spruce	0	6,726	2008	1971	F	240	21	S 60 BL 40	277	23.59	32.45	875.6	17.4	181.2
0078	Spruce	0	6,726	2008	1994	F	69	22.7	S 50 EP 20 AT 15 FD 10 HW 5	83	26.36	37.59	1139.3	22.2	272.3
0079	Spruce	0	6,726	2008	1991	F	260	24	S 60 BL 40	277	25.09	35.34	765.1	20	228.8
0081	Spruce	0	6,726	2008	1974	F	181	22.2	S 70 BL 30	215	25.08	33.05	878.6	18.3	198.8
0083	Spruce	1	7,231	2008	1991	F	280	26	S 80 BL 20	297	26.98	31.31	555.5	22.1	222.6
0084	Spruce	1	7,231	2009	1991	F	70	22	S 50 PL 20 CW 20 AC 10	88	26.43	43.96	1081.1	21.6	311.8
0085	Spruce	1	7,231	2008	1991	F	260	27	S 70 BL 30	277	27.98	35.04	596.7	22.7	260.6
0086	Spruce	1	7,231	2009	1994	F	300	30	S 60 BL 40	315	30.65	37.43	524.2	24.9	298.1
0087	Spruce	1	7,231	2008	1991	F	270	27	S 90BL 10 0 0 0	287	27.96	34.33	585.6	22.9	259.7
0089	Spruce	1	7,231	2008	1991	F	200	28	S 70 BL 10 PL 10 HW 10	217	29.16	40.4	692.2	23.4	302.7
0090	Spruce	1	7,231	2008	1991	F	220	29	S 70 BL 30	237	30.02	34.17	559.4	24.4	269.2

SAMPLE	Stratum	Volume class	Sampling weight (based on 30+ population)	Measurement year (for projection)	Reference Year	Inventory standard (F=FIP-type inventory)	Input Age	Input Height	Species Composition	VDYP7 attributes projected to measurement year					
										Age sp1	Height sp1	BA/ha @7.5cm+ dbh	TPH @7.5cm+ dbh	Lorey height @7.5cm+ dbh	Volume/ha net dwb @12.5cm+ dbh
0092	Spruce	2	8,262	2008	1991	F	200	30	S 60 BL 40	217	31.06	39.98	645.3	24.8	325.5
0093	Spruce	2	8,262	2008	1991	F	260	30	S 80 BL 20	277	30.82	39.25	571.9	25.5	333.8
0094	Spruce	2	8,262	2009	1971	F	227	29.5	S 70 BL 30	265	31.5	39.06	613.6	24.7	317.9
0095	Spruce	2	8,262	2008	1994	F	280	32	S 90 BL 10	294	32.55	38.38	453.6	27.7	356.1
0097	Spruce	2	8,262	2008	1974	F	350	36	S 80 BL 20	384	36.68	42.4	418.2	31	425.5
0098	Spruce	2	8,262	2008	1995	F	130	30	S 40 HW 30 BL 30	143	31.41	54.89	986.2	24.1	398.7
0100	Spruce	2	8,262	2008	1974	F	228	37.1	S 80 BL 20	262	38.26	38.55	384.9	31.8	388.4
0101	Balsam	0		2009	1990	F	10	1.5	BL 70 S 30	29	2.95		2955		
0135	C H	1	2,273	2009	1991	F	240	24	HW 40 S 30 BL 20 CW 10	258	24.87	51.87	966.8	22.2	334.7
0136	C H	1	2,273	2008	1991	F	240	27	CW 60 SE 30 BL 10	257	28.23	68.34	839.2	25.4	407.4
0155	FP_dec	0	10,845	2009	1991	F	50	14	PL 100	68	17.32	27.27	1616.3	14.6	120.3
0167	FP_dec	2	6,283	2009	1995	F	116	22.6	PL 40 HW 30 FD 20 PW 10	130	23.42	42.87	1316.9	19.8	272.4
0169	FP_dec	2	6,283	2009	1974	F	77	23.9	FD 50 PL 30 S 20	112	30.04	41.7	792.2	25.7	378.4

7. APPENDIX C: PHASE II COMPILED GROUND ATTRIBUTES

SAMPLE	Species composition @4cm+dbh	Basal area/ha @7.5cm+dbh	Trees/ha @7.5cm+dbh	Lorey height @7.5cm+dbh (ht_mean1)	Live Vol/ha with NVAF net dwb (NVL_NWB) @12.5cm+dbh
0001	Bl 64 Se 36	19.8	330	19.4	158.8
0002	Sx 60 Bl 40	25.2	1558	10.5	97.8
0004	Bl 89 Se 11	18	1069	11.0	73.1
0005	Bl 91 Se 09	25.2	1057	14.0	119.9
0007	Bl 79 S 21	28.8	565	19.5	178.2
0009	Bl 76 S 24	43.4	1464	11.6	229.6
0010	Bl 82 S 18	32.4	1578	10.1	165.0
0011	Bl 52 S 48	37.8	600	16.3	265.0
0013	Sx 56 Bl 44	16.2	86	33.3	158.5
0014	Bl 75 S 17 Pa 08	16.8	284	18.1	99.1
0015	Se 56 Bl 44	40.8	772	25.9	291.1
0017	Bl 81 Se 19	46.8	781	23.2	331.3
0018	Bl 73 S 23 Hw 04	30.8	1169	18.3	182.2
0019	Bl 79 Se 21	70.2	1032	21.9	465.1
0020	Bl 64 S 36	45	1086	20.5	275.6
0022	Bl 90 S 10	34.2	366	28.1	262.5
0023	Bl 53 S 47	34.2	713	22.3	244.9
0025	Bl 95 S 05	39.6	707	24.5	254.0
0026	Bl 71 Se 29	19	1145	12.6	108.3
0027	Sx 30 Bl 30 Cw 20 Hw 20	8	460	11.1	32.8
0028	Cw 45 Hw 36 Sx 12 Bl 07	93.6	1724	20.0	617.6
0029	Hw 77 Sx 23	72	655	29.3	547.7
0031	Cw 38 Sx 33 Hw 21 Ac 04 Bl 04	57.6	619	29.9	458.0
0033	Hw 92 Cw 04 Fd 04	57.6	896	25.6	363.3
0035	Cw 43 S 29 Hw 28	33.6	301	30.1	269.1
0037	Hw 92 Sx 04 Bl 04	62.4	750	23.6	410.9
0038	Hw 80 Cw 20	64	723	18.1	426.8
0039	Cw 76 Bl 12 Sw 10 Hw 02	124.8	922	24.9	785.5

SAMPLE	Species composition @4cm+dbh	Basal area/ha @7.5cm+dbh	Trees/ha @7.5cm+dbh	Lorey height @7.5cm+dbh (ht_mean1)	Live Vol/ha with NVAF net dwb (NVL_NWB) @12.5cm+dbh
0043	Cw 64 Sx 21 Bl 15	56	175	36.3	448.3
0045	Hw 64 Bl 23 Sx 13	50.4	612	24.0	402.8
0046	Hw 73 Cw 27	19.8	156	15.5	136.5
0047	Hw 50 Cw 25 Bl 20 Sx 05	64	1483	23.8	417.1
0048	Cw 62 Hw 35 Fd 03	62.4	555	35.2	410.7
0051	Hw 55 Cw 40 Sx 05	48	1050	22.1	312.6
0054	Pl 56 Fd 19 Ep 13 Ac 12	15	1204	12.6	46.5
0056	Pl 88 Fd 12	24	1154	17.0	165.5
0057	Cw 47 Hw 26 Sx 18 Ep 06 Bl 03	61.2	743	24.9	437.1
0060	At 57 Pl 22 Ep 13 Sx 08	27.5	556	26.5	253.2
0061	Pl 86 Sx 14	14	464	18.7	107.9
0062	At 45 Sx 27 Fd 09 Pl 09 Bl 10	11	313	21.2	74.2
0063	Fd 77 Pl 23	42	1003	26.5	315.7
0064	Sx 65 At 23 Ep 08 Bl 04	25	644	18.2	189.7
0067	Pl 80 Sx 20	18	356	20.3	153.1
0068	Pl 100	14	789	13.0	89.5
0071	Fd 69 Pl 17 Bl 10 S 04	52.2	655	29.3	472.6
0072	Pl 67 Bl 20 Se 13	27	428	22.2	234.6
0073	S 99 X 01	0.82167	160	4.0	0.0
0074	Bl 64 Se 36	29.4	886	17.0	177.8
0075	S 62 Bl 38	43.2	1492	17.8	284.1
0076	Bl 75 Se 25	36	1278	14.5	184.1
0078	S 50 Cw 25 Hw 10 Bl 10 Fd 05	36	862	20.3	243.5
0079	Bl 81 Se 19	43.4	2003	13.4	200.4
0081	S 54 Bl 46	46.8	923	19.9	368.0
0083	S 58 Bl 42	34.2	311	30.2	319.1
0084	S 47 Ac 44 Ep 06 Pl 03	57.6	997	22.1	452.1
0085	S 67 Bl 33	37.8	204	28.4	384.9
0086	Bl 65 S 35	43.2	1041	21.8	331.7
0087	Bl 53 Sx 47	40.8	503	24.6	331.6
0089	Sx 52 Bl 44 Hw 04	57.6	1892	24.5	409.7
0090	Se 80 Bl 20	36	1149	15.1	250.9

SAMPLE	Species composition @4cm+dbh	Basal area/ha @7.5cm+dbh	Trees/ha @7.5cm+dbh	Lorey height @7.5cm+dbh (ht_mean1)	Live Vol/ha with NVAF net dwb (NVL_NWB) @12.5cm+dbh
0092	S 71 Bl 29	50.4	912	25.0	384.9
0093	Se 58 Bl 33 Hw 09	57.6	662	28.9	525.6
0094	Bl 67 S 33	36	1378	19.7	210.1
0095	Se 53 Bl 47	32.4	553	10.1	273.6
0097	Bl 69 S 31	48.6	1277	21.9	336.8
0098	Hw 75 Fd 10 Bl 10 Pw 05	48	1329	21.5	294.2
0100	Sx 57 Bl 43	55.2	322	31.3	561.8
0101	Bl 100	2.8	202	6.0	6.9
0135	Bl 36 Hw 27 Se 23 Cw 14	52.8	637	28.2	392.5
0136	Bl 67 Hw 17 Sx 13 Ep 03	41.4	849	23.0	275.7
0155	Pl 100	16	1547	11.8	43.5
0167	Fd 50 Sx 29 Hw 18 Cw 03	91.2	2262	27.3	734.4
0169	Bl 29 Sx 24 Pl 24 Fd 18 Cw 05	30.6	666	23.4	241.9

8. APPENDIX D: DATA ISSUES

Sample #	*Issue*	*Additional ground sample information*	*Resolution/comments? BK=Bob Krahn; MM=Matt Makar*
	Although original population of interest was specified as >29 years, the sample selection included 4 samples <30 years of age (one sample in each stratum). Should these be included or excluded from the analysis?		Use >29 years as main analysis and include 0+ years in appendix (per conference call on Feb 2/11)
1	Balsam stratum. Large difference between Ph II ground and Ph I inventory values for height, age and volume: Height: inventory = 10.1 m; ground = 24.9 m Volume: inventory = 26.4 m^3/ha; ground = 158.8 m^3/ha Age: inventory = 108 yrs; ground = 223 yrs BA: inventory = 14 m^2/ha; ground = 19.8 m^2/ha	6 BL site trees - Age range 165 - 272 Ht range 15.4 - 28.4 Full meas'd & count trees: 11 dead, 7 live. Live dbh range 16.4 - 29.6.	This happens to be a balsam (BL) stand. That in itself means that you can easily get 12 photo interpreters look at the same polygon and all 12 will give you a different estimation of the polygon attributes – simply because of the species BL and the way it grows. Having said this, when looking at the ortho image of this polygon there appears to be a problem with the delineation of the polygon. The upslope portion appears to be shorter and younger than the downslope portion (i.e. next to the 1993 cutblock) of the poly. The interpreter appears to have generalized what looks like two separate types (younger/older) and given it a label that would match the younger portion of the poly. In this case, the sample appears to have landed in the 'older' portion of the poly. Therefore, the ground sample is probably not a good description of the entire polygon. BK
11	Sample selection indicates polygon 217 but ground data indicates 247		Ground GPS shows 217; 247 probably a typo. MM

Sample #	***Issue***	***Additional ground sample information***	***Resolution/comments? BK=Bob Krahn; MM=Matt Makar***
13	Balsam stratum. Large difference between Ph II ground and Ph I inventory values for height and BA: Height: inventory = 21.1 m; ground = 39.05 m BA: inventory = 29 m^2/ha; ground = 16 m^2/ha Age: inventory = 217 yrs; ground = 142 yrs Volume: inventory = 150 m^3/ha; ground = 158.5 m^3/ha Spp comp: inventory = B60 S35 Cw5; ground = S56 B44	2 SP site trees - Age range 140 - 143 Ht range 37.2 - 40.9 Full meas'd & count trees 6 dead, 15 live. Live dbh range 36.5-50.4 SP meas'd avg ht (6 trees) = 34.9	Again the basic comment made for sample 1 holds true here as well, re: the BL species. As for the species SX it should be a bit more predictable. In this case, the polygon/stand has been greatly influenced by avalanche/slide tracks – providing a huge variety of ages, heights and species for this poly. This would probably mean that the [two] species composition would be highly variable using just the ground sample data. Because of this it would be very surprising if the ground sample data would have matched the inventory label. Simply explained, the difference is fully dependent on where the random location – landed. Therefore, the ground sample is probably a good description of the entire polygon. BK
19	Balsam stratum. Large difference between Ph II ground and Ph I inventory values for BA, age and volume: BA: inventory = 34.9 m^2/ha; ground = 70.2 m^2/ha Volume: inventory = 172.4 m^3/ha; ground = 465 m^3/ha Age: inventory = 219 yrs; ground = 112 yrs Height: inventory = 21.2 m; ground = 22.3 m	7 BL site trees - Age range 100 - - 122 Ht range 19.8 - 24.1 Full meas'd & count trees 3 dead, 34 live. Live dbh range 13.8-57.8 BL meas'd avg ht (4 trees) = 21.5	Again the basic comment made for sample 1 holds true here as well, re: the BL species. The ortho shows a relatively young stand, which matches the ground sample age of 112 yrs. In this case, there are a number of tree DBH's greater than 30 cm. The BA is slightly surprising when looking at the ortho. But when taking into account the DBH's it is well within the realm of possibilities to have this calculated BA. Therefore, the ground sample is probably a good description of the entire polygon. BK

Sample #	*Issue*	*Additional ground sample information*	*Resolution/comments? BK=Bob Krahn; MM=Matt Makar*
25	Balsam stratum. Large difference between Ph II ground and Ph I inventory values for height and volume: Height: inventory = 34.8 m; ground = 23.7 m Volume: inventory = 436.7 m^3/ha; ground = 254 m^3/ha Age: inventory = 256 yrs; ground = 226 yrs BA: inventory = 44 m^2/ha; ground = 39.6 m^2/ha	6 BL site trees - Age range 156 - - 311 Ht range 19.8 - 25.3 Full meas'd & count trees :14 dead, 38 live. Live dbh range 15.6-43.1 BL meas'd avg ht (20 trees) = 21.6	Again the basic comment made for sample 1 holds true here as well, re: the BL species. This poly has a wide variation in the height for the species BL mainly due to the fact this is a large polygon on a steep mountainside. The BL is shorter at the higher elevations within the polygon than at the lower elevations. In this case, the ground sample data is much better at describing the 'entire' polygon attributes than the photo interpreted label. BK
56	Sample selection indicates polygon 880, ground data indicates 33.		Ground GPS shows poly 880. 33 could be from the access point which is in poly **8**33. MM
57	FPDec stratum. Large difference between Ph II ground and Ph I inventory values for age, height, BA and volume: Height: inventory = 13.6 m; ground = 26.7 m BA: inventory = 22 m^2/ha; ground = 61.2 m^2/ha Volume: inventory = 51.5 m^3/ha; ground = 437.1 m^3/ha Age: inventory = 38 yrs; ground = 124 yrs Spp comp: inventory = FD50 S25 CW10 B10 HW5; ground = CW47 HW26 S18 EP6 BL3	5 C site trees - Age range 106.5 - - 139 Ht range 21.8-33 Full meas'd & count trees 4 dead, 38 live. Live dbh range 18.7-100.6 C meas'd avg ht (2 trees) = 21.	This is a two layer stand. It appears possible that the wrong layer was identified as layer 1. Especially when viewing the adjacent polygons and realizing that the dominant layer has very similar heights. Therefore, the ground sample data is probably a good description of the entire polygon. BK It is not so much a two layer stand as it is a polygon that should have been split in two - probably split in half would work. If I remember what I saw correctly, I am thinking that half of the polygon is correctly identified by the inventory label. And the other (lower elevation) half of the poly matches the ground label. Definitely two separate stands lumped together in this poly. BK (21Jan2011)
67	Sample selection indicates polygon 1687, ground indicates 1769.		Ground GPS shows 1687; 1769 is the adjacent polygon where the TP is. MM
155	Sample selection indicates polygon 239, ground indicates 240.		Ground GPS show polygon 239. The 240 is probably from the access point in poly 240. MM

Sample #	***Issue***	***Additional ground sample information***	***Resolution/comments? BK=Bob Krahn; MM=Matt Makar***
167	FPDec stratum. Large difference between Ph II ground and Ph I inventory values for height, BA and volume: Height: inventory = 23.7 m; ground = 34.8 m BA: inventory = 30.9 m^2/ha; ground = 91.2 m^2/ha Volume: inventory = 235.1 m^3/ha; ground = 734.4 m^3/ha Age: inventory = 168 yrs; ground = 130 yrs Spp comp: inventory = PL 100; ground = FD50 SX29 HW18 CW3	5 F site trees - Age range 127-136 Ht range 28.3-39.5 Full meas'd & count trees 4 dead, 31 live. Live dbh range 8.6-51.8 F meas'd avg ht (1 trees) = 35.6	Unable to match the ortho species of "PlHwFd(Pw)" [and by extension the LRDW info] with inventory species information of "Pl"? Is this the correct inventory info...? Please check. BK Polygon mismatch… inventory attributes have been corrected i.e. for correct polygon. GC
28	CH stratum. Large difference between Ph II ground and Ph I inventory values for BA and volume: BA: inventory = 48.4 m^2/ha; ground = 93.6 m^2/ha Volume: inventory = 248.8 m^3/ha; ground = 617.6 m^3/ha Age: inventory = 217 yrs; ground = 143 yrs Height: inventory = 22.5 m; ground = 26.4 m	4 C site trees - Age range 95 - - 190 Ht range 23.9 – 28.2 Full meas'd & count trees 3 dead, 51 live. Live dbh range 4.1-66.7 C meas'd avg ht (17 trees) = 21.7	Ortho confirms ground sample data. The stand is very dense. Plus, using a BAF 12 and obtaining roughly 8 trees per plot on average or better would provide a large BA of between 80 to 95 m^2/ha. Therefore, the ground sample data appears to provide a better description of the entire polygon. Inventory label is under-estimated. BK
29	CH stratum. Large difference between Ph II ground and Ph I inventory values for volume: Volume: inventory = 167.3 m^3/ha; ground = 547.7 m^3/ha Age: inventory = 266 yrs; ground = 194 yrs Height: inventory = 21.7 m; ground = 28.5 m BA: inventory = 43.3 m^2/ha; ground = 72 m^2/ha	5 H site trees - Age range 119-305 Ht range 25.9-32 Full meas'd & count trees 7 dead, 47 live. Live dbh range 15.7-99.8 C meas'd avg ht (22 trees) = 26.4	These are large DBH trees. Plus, the use of a BAF 12 will provide considerable BA and volumes – which the ortho appears to confirm. Therefore, the ground sample data appears to provide a better description of the entire polygon. BK
39	CH stratum. Large difference between Ph II ground and Ph I inventory values for BA & volume: BA: inventory = 63.6 m^2/ha; ground = 124.8 m^2/ha Volume: inventory = 381m^3/ha; ground = 785.5 m^3/ha Age: inventory = 275 yrs; ground = 278 yrs Height: inventory = 28.6 m; ground = 29.9 m	7 C site trees - Age range 160 - - 393 Ht range 13.7-32.5 Full meas'd & count trees 1 dead, 28 live. Live dbh range 13.7-84.8 C meas'd avg ht (6 trees) = 25.8	Ground sample appears to land close to the edge of the target polygon 581. Again these are large DBH trees, large BAF 16 used and very dense stand as seen on the ortho. As well, the ground data appears to make sense. Therefore, the ground sample data appears to provide a good description of the entire polygon. BK

9. 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, S, 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 (does not apply in Robson Valley TSA since no second species height or age data is available for the samples)

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 (does not apply in Robson Valley TSA since no second species height or age data is available for the samples)

Case 5: No match

SAMPLE	*Phase II (ground) lead spp @ 4cm+dbh*	*Ph II lead species age (aget_tlsxo)*	*Ph II lead species height (ht_tlsxo)*	*Number of age trees (n_ag_tlsxo)*	*Number of height trees (n_ht_tlsxo)*	*Ph I inventory lead SP01*	*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	223	24.92	6	5	BL	1	108	10.12
0002	SX	88	18.86	5	5	BL	3	108	15.67
0004	BL	221	13.2	5	1	BL	1	177	16.42
0005	BL	209	19.45	5	4	BL	1	127	18.14
0007	BL	116	15.86	5	5	BL	1	197	18.28
0009	BL	192	17.6	5	4	BL	1	197	19.28
0010	BL	210	15.28	5	4	BL	1	217	19.15
0011	BL	242	19.16	6	5	BL	1	195	19.13
0013	SX	142	39.05	2	2	BL	3	217	21.11
0014	BL	201	17.23	4	4	BL	1	237	20.04
0015	SE	293	24.1	3	3	BL	3	157	20.62
0017	BL	204	26.7	3	1	BL	1	217	22.08
0018	BL	170	19.9	2	2	BL	1	247	23.87
0019	BL	112	22.3	6	5	BL	1	219	21.23
0020	BL	214	19.43	4	4	BL	1	217	22.08
0022	BL	189	26.68	5	5	BL	1	234	23.03
0023	BL	237	24.63	3	3	BL	1	257	24.79

SAMPLE	Phase II (ground) lead spp @ 4cm+dbh	Ph II lead species age (aget_tlsxo)	Ph II lead species height (ht_tlsxo)	Number of age trees (n_ag_tlsxo)	Number of height trees (n_ht_tlsxo)	Ph I inventory lead SP01	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)
0025	BL	226	23.68	5	4	BL	1	256	34.83
0026	BL	48	11.16	5	5	HW	3	45	8.03
0027	SX	36	10.8	5	5	CW	3	29	10.9
0028	CW	143	26.45	4	2	CW	1	217	22.46
0029	HW	194	28.5	5	2	HW	1	266	21.74
0031	CW	189	30.28	5	5	CW	1	258	25.33
0033	HW	244	23.17	5	3	HW	1	177	23.36
0035	CW	241	28.68	4	4	HW	3	218	25.06
0037	HW	129	21.86	6	5	HW	1	168	24.52
0038	HW	231	30.6	5	5	HW	1	275	28.39
0039	CW	278	29.92	6	5	CW	1	275	28.62
0043	cw	206.4228	37.12	5	5	CW	1	318	35.87
0045	HW	148.6465	27.1	5	5	HW	1	278	25.73
0046	HW	194.0983	21.7	3	1	HW	1	275	31.5
0047	HW	151	26.6	5	5	HW	1	218	27.98
0048	CW	176	33.9	5	5	CW	1	269	33.21
0051	HW	189	26.57	4	3	CW	3	335	36.64
0054	PL	27	14.88	5	5	AT	5		
0056	PL	57	23.46	5	5	PL	1	44	13.34
0057	CW	124	26.68	5	5	FD	3	38	13.57
0060	AT	67	27.35	4	4	AT	1	108	25.91
0061	PL	77	23.36	5	5	PL	1	93	19.8
0062	AT	67		2	0	PL	5		
0063	FD	110	22.36	5	5	PL	3	78	20.8
0064	SX	89	25.43	3	3	AT	5		
0067	PL	87	21.38	5	5	PL	1	93	22.05
0068	PL	63	17.63	5	4	PL	1	127	24.07
0071	FD	163	31.12	5	5	FD	1	107	33.11

SAMPLE	Phase II (ground) lead spp @ 4cm+dbh	Ph II lead species age (aget_tlsxo)	Ph II lead species height (ht_tlsxo)	Number of age trees (n_ag_tlsxo)	Number of height trees (n_ht_tlsxo)	Ph I inventory lead SP01	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)
0072	PL	147	23.72	5	5	PL	1	186	26.68
0073	S	22	4.97	6	6	S	1	22	2.32
0074	BL	172	20.47	4	3	S	3	237	21.02
0075	S	197	26.82	5	5	S	1	161	22.67
0076	BL	189	18.08	5	5	S	3	277	23.59
0078	S	80	24.3	3	3	S	1	83	26.36
0079	BL	211	19.87	3	3	S	3	277	25.09
0081	S	211	27.65	2	2	S	1	215	25.08
0083	S	143	30.77	3	3	S	1	297	26.98
0084	S	91	28.48	4	4	S	1	88	26.43
0085	S	138	30.4	2	2	S	1	277	27.98
0086	BL	194	24.96	5	5	S	3	315	30.65
0087	BL	158	25.93	4	3	S	3	287	27.96
0089	SX	233	32.6	5	5	S	1	217	29.16
0090	SE	139	27.3	2	2	S	1	237	30.02
0092	S	159	22.77	3	3	S	1	217	31.06
0093	SE	283	35.7	4	2	S	1	277	30.82
0094	BL	114	18.52	5	5	S	3	265	31.5
0095	SE	248	35.1	2	2	S	1	294	32.55
0097	BL	238	25.28	4	4	S	3	384	36.68
0098	HW	149	26.13	4	4	S	3	143	31.41
0100	SX	171	35.8	2	2	S	1	262	38.26
0101	BL	42	10.02	5	5	BL	1	29	2.95
0135	BL	182	27	5	5	HW	3	258	24.87
0136	BL	194	25.75	3	2	CW	3	257	28.23
0155	PL	91	15.73	5	6	PL	1	68	17.32
0167	FD	130	34.8	5	5	PL	3	130	23.42
0169	BL	108	27.18	4	4	FD	3	112	30.04

Table E-1 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 roughly two-thirds of the samples, the inventory and the ground sample had the same leading species. There were only 3 samples which could not be matched on a coniferous-to-coniferous or a deciduous-to-deciduous basis.

Table E-1: Phase II ground vs. Phase I inventory leading species cross-tabulation, based on the 0+ years target population in the Robson Valley TSA.

Phase I Inventory leading spp	***Phase II Ground leading species at 4cm+ dbh utilization***							
	AT	***BL***	***CW***	***FD***	***HW***	***PL***	***S***	***Total***
AT	1	0	0	0	0	1	1	3
BL	0	16	0	0	0	0	3	19
CW	0	1	5	0	1	0	1	8
FD	0	1	1	1	0	0	0	3
HW	0	2	1	0	7	0	0	10
PL	1	0	0	2	0	6	0	9
S	0	7	0	0	1	0	13	21
Total	2	27	7	3	9	7	18	73

10. APPENDIX F: NVAF SCATTERPLOTS

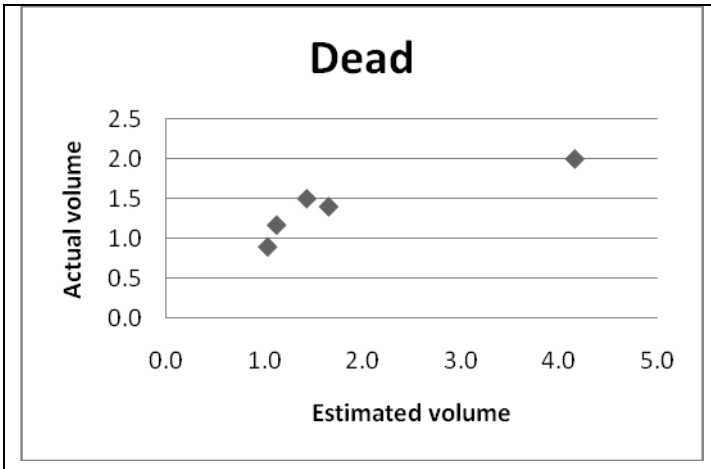

Fig F-1: Actual versus estimated tree volume (m3) in the "dead" stratum.

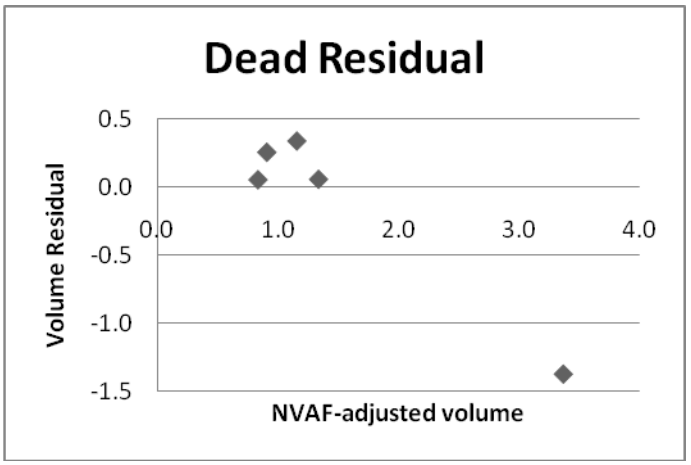

Fig F-2: Residual (actual – NVAF-adjusted) volume vs. adjusted volume in the "dead" stratum.

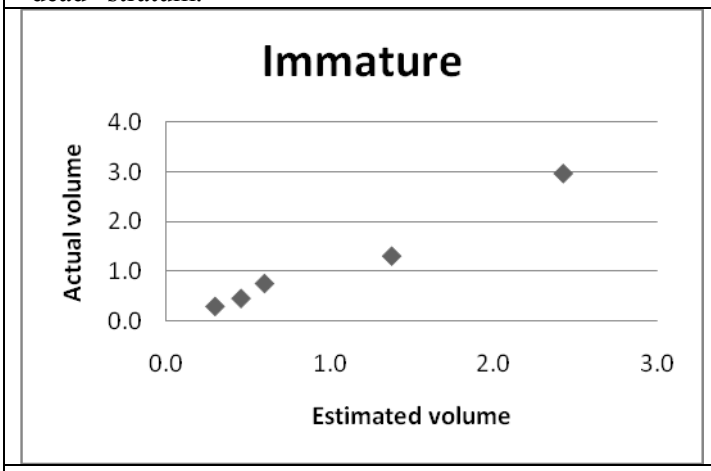

Fig F-3: Actual versus estimated tree volume (m3) in the "immature" stratum.

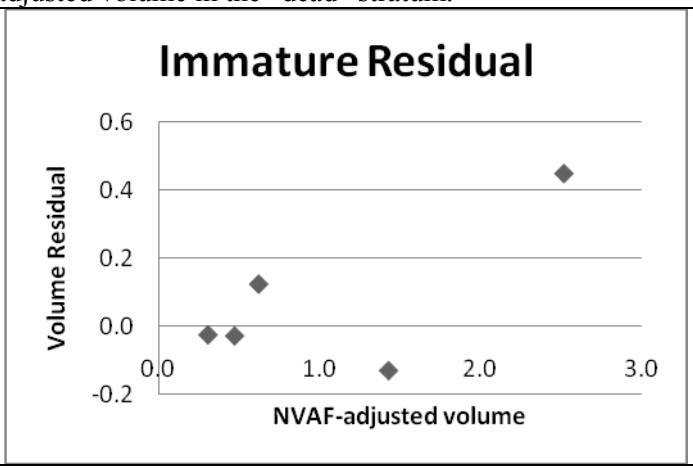

Fig F-4: Residual (actual – NVAF-adjusted) volume vs. adjusted volume in the "immature" stratum.

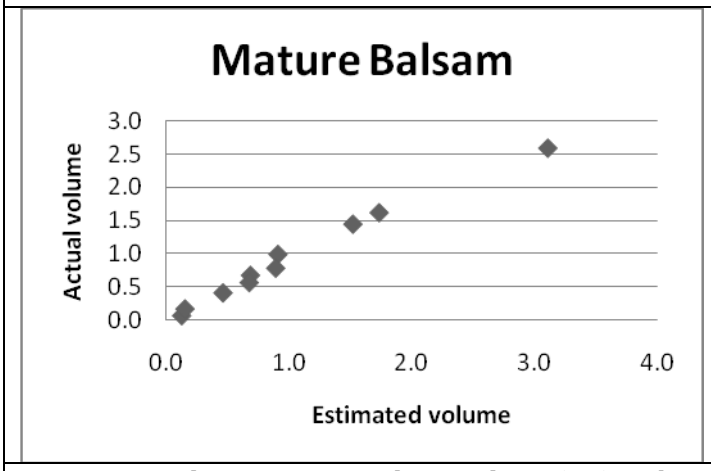

Fig F-5: Actual versus estimated tree volume (m3) in the "mature balsam" stratum.

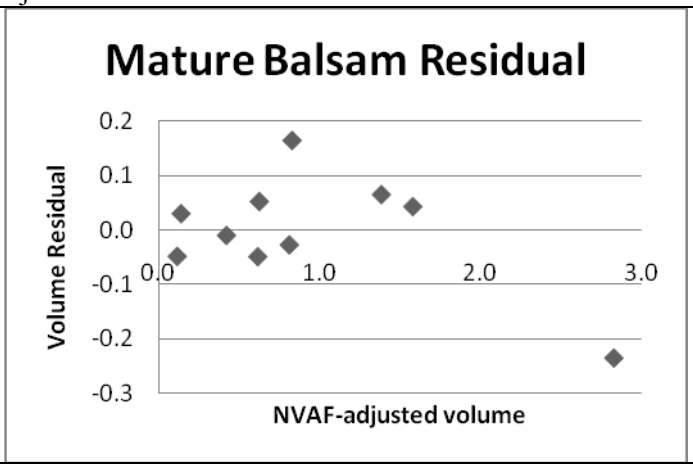

Fig F-6: Residual (actual – NVAF-adjusted) volume vs. adjusted volume in the "mature balsam" stratum.

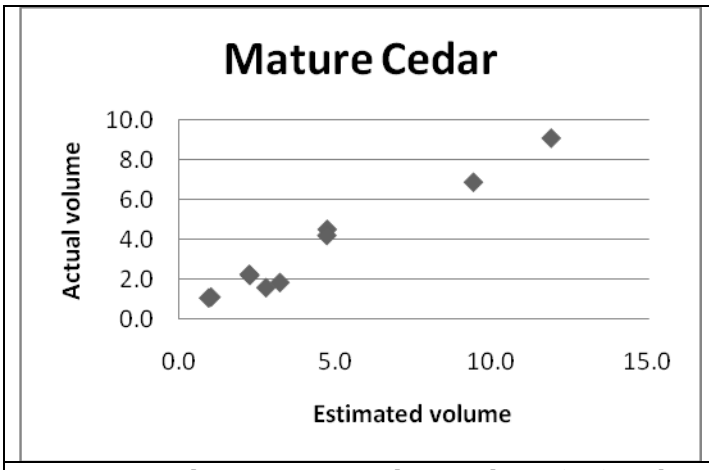

Fig F-7: Actual versus estimated tree volume (m3) in the "mature cedar" stratum.

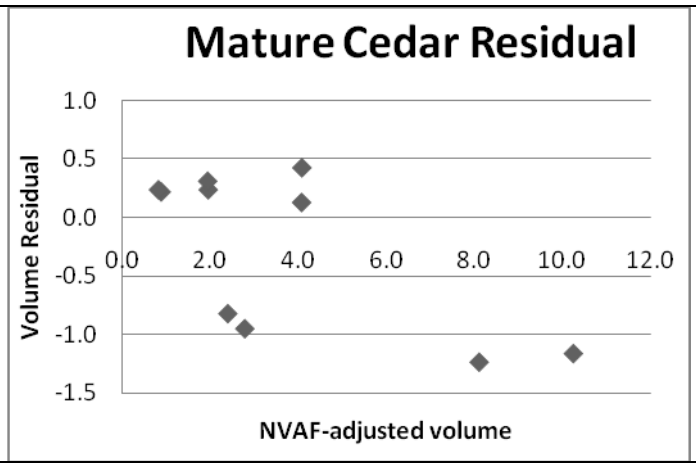

Fig F-8: Residual (actual – NVAF-adjusted) volume vs. adjusted volume in the "mature cedar" stratum.

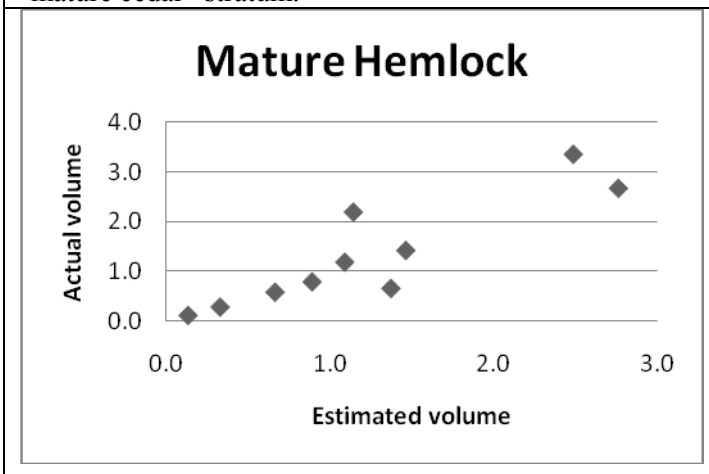

Fig F-9: Actual versus estimated tree volume (m3) in the "mature hemlock" stratum.

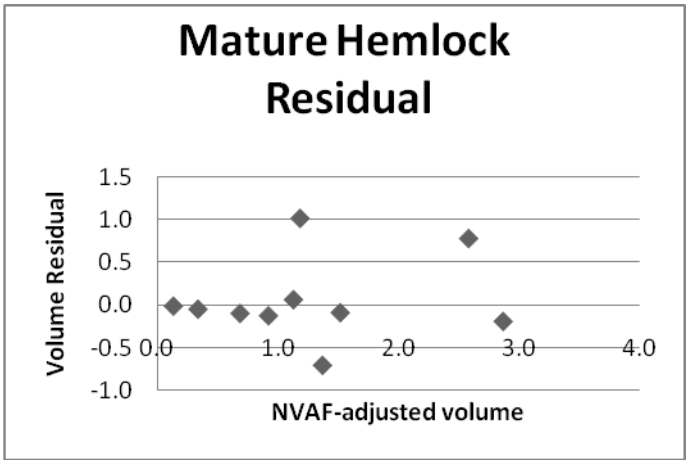

Fig F-10: Residual (actual – NVAF-adjusted) volume vs. adjusted volume in the "mature hemlock" stratum.

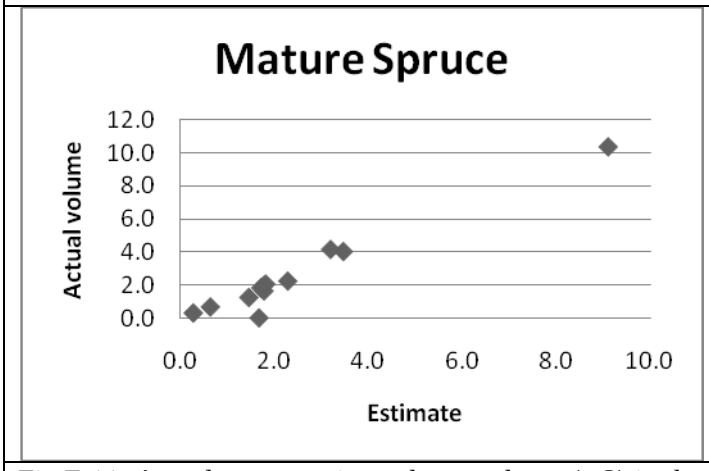

Fig F-11: Actual versus estimated tree volume (m3) in the "mature spruce" stratum.

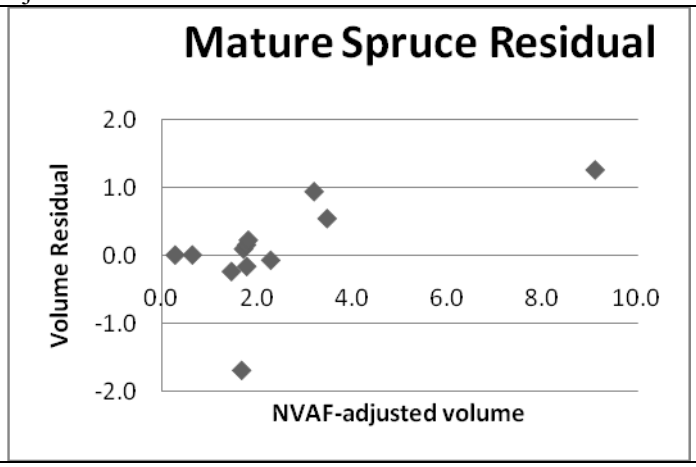

Fig F-12: Residual (actual – NVAF-adjusted) volume vs. adjusted volume in the "mature spruce" stratum.

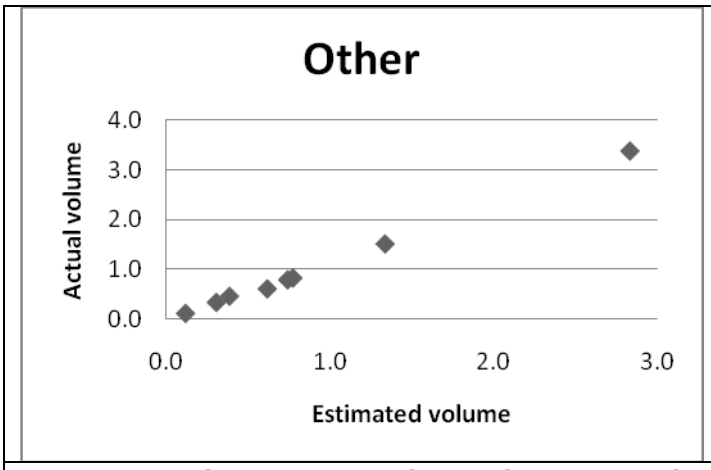

Fig F-13: Actual versus estimated tree volume (m3) in the "mature other" stratum.

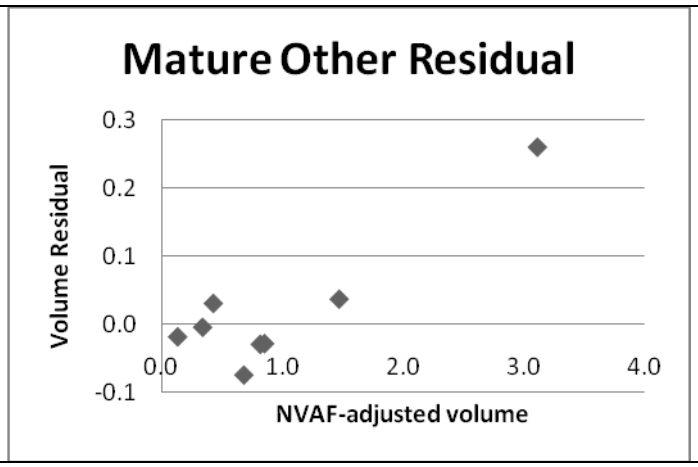

Fig F-14: Residual (actual – NVAF-adjusted) volume vs. adjusted volume in the "mature other" stratum.

11. APPENDIX G: SCATTERPLOTS AND RESIDUALS FOR STATISTICAL ANALYSIS

Balsam stratum

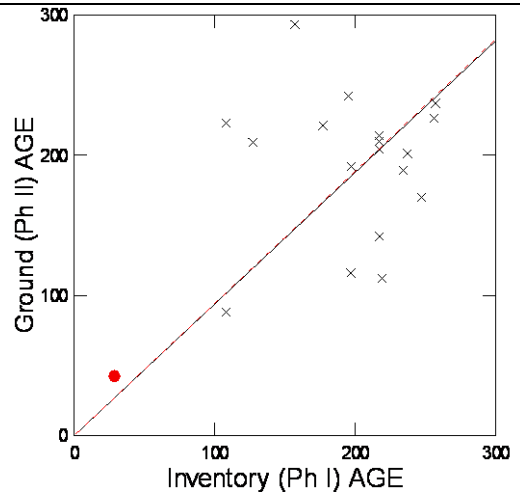

Fig G-1a: Phase II vs. Phase I age. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

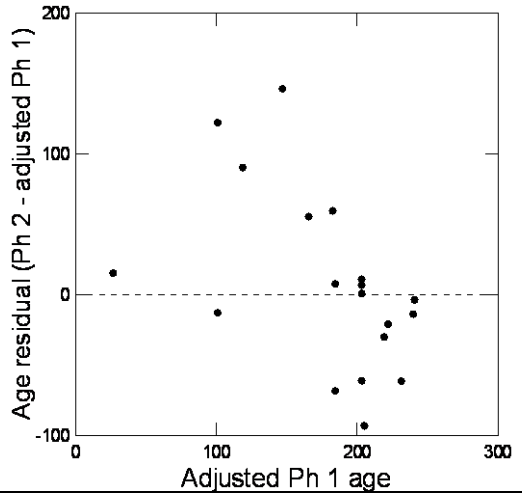

Fig G-1b: Age residuals vs adjusted Phase I inventory age (i.e. R × unadjusted Ph I age).

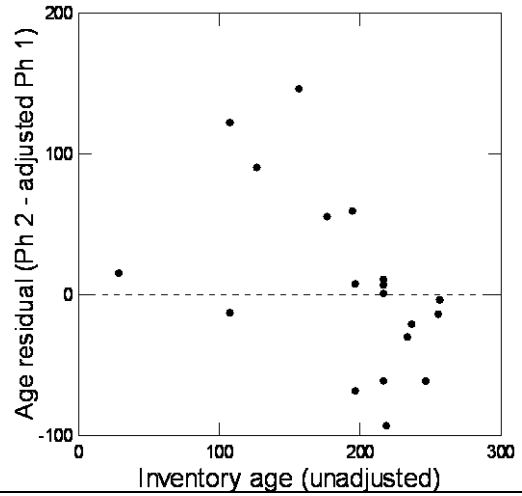

Fig G-1c: Age residuals vs unadjusted Phase I inventory age.

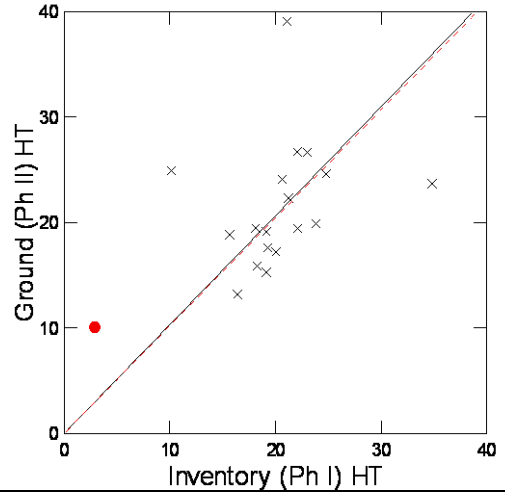

Fig G-2a: Phase II vs. Phase I height. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

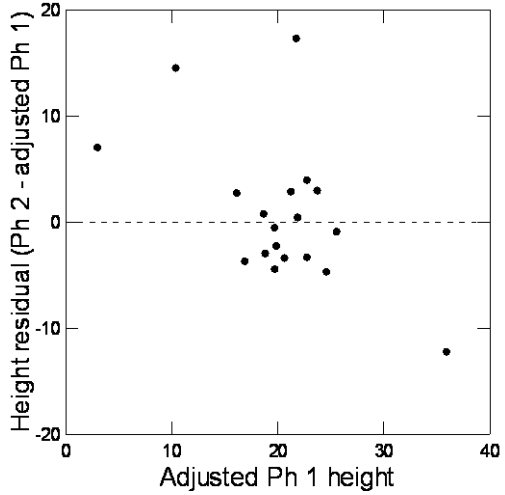

Fig G-2b: Height residuals vs adjusted Phase I inventory height (i.e. R × unadjusted Ph I height).

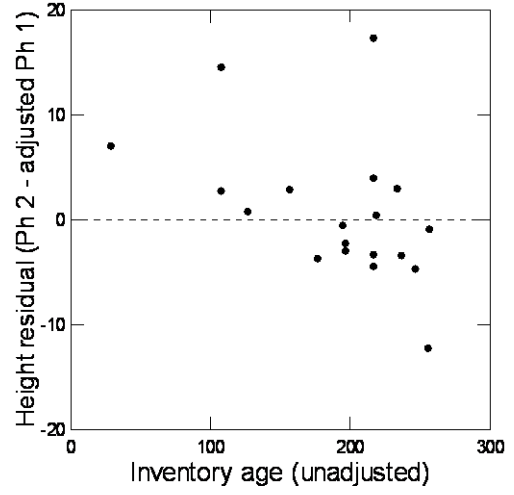

Fig G-2c: Height residuals vs unadjusted Phase I inventory height.

Balsam stratum

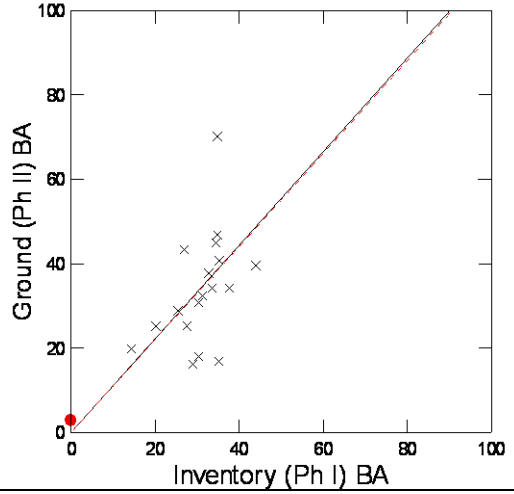

Fig G-3a: Phase II vs. Phase I ba/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

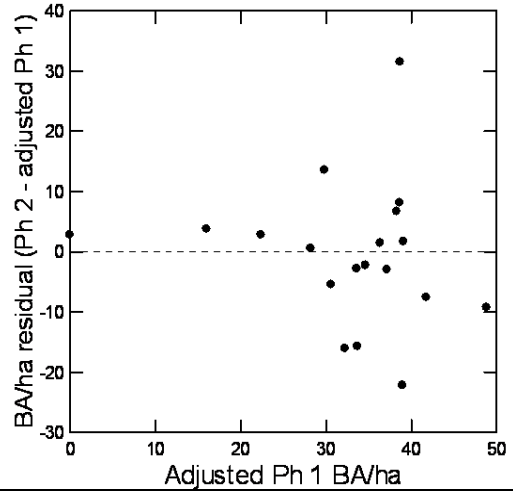

Fig G-3b: Ba/ha residuals vs adjusted Phase I inventory ba/ha (i.e. R × unadjusted Ph I ba/ha).

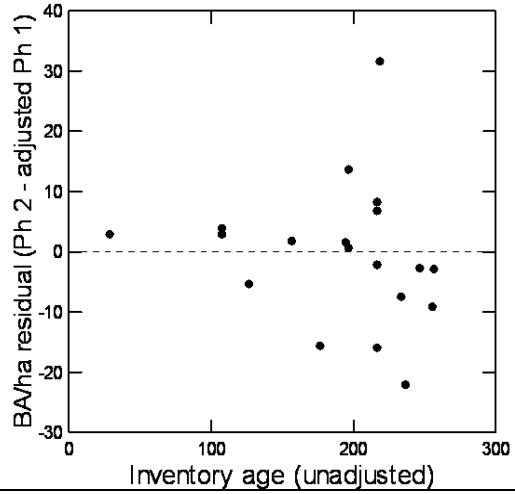

Fig G-3c: Ba/ha residuals vs unadjusted Phase I inventory ba/ha.

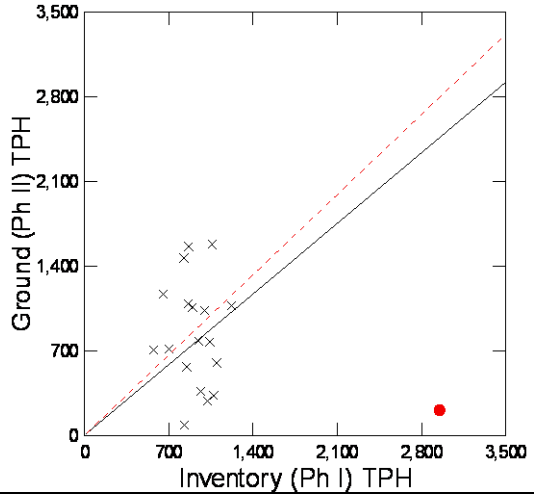

Fig G-4a: Phase II vs. Phase I trees/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

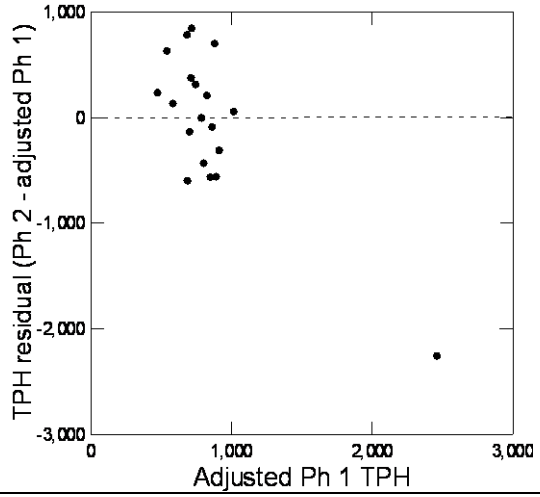

Fig G-4b: Trees/ha residuals vs adjusted Phase I inventory trees /ha (i.e. R × unadjusted Ph I trees /ha).

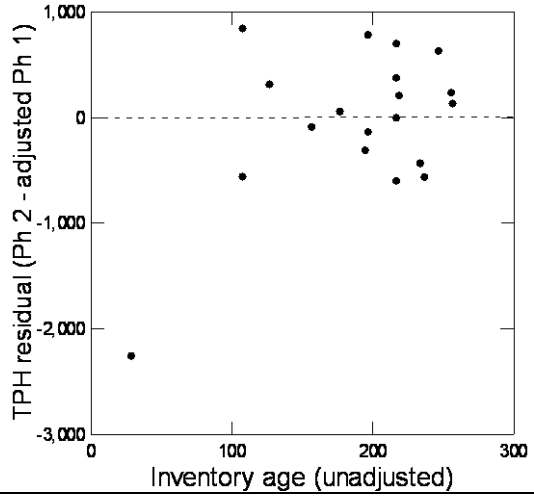

Fig G-4c: Trees /ha residuals vs unadjusted Phase I inventory trees /ha.

Balsam stratum

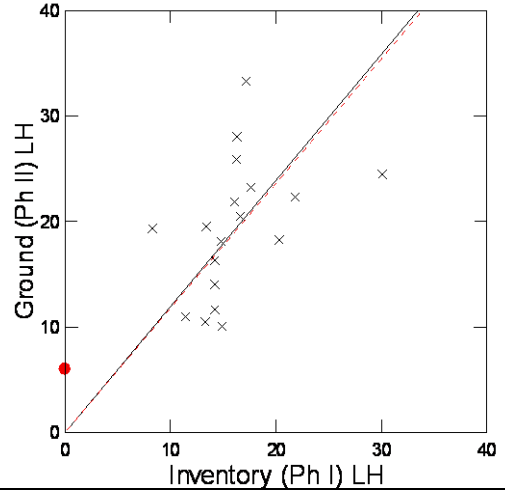

Fig G-5a: Phase II vs. Phase I Lorey height. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

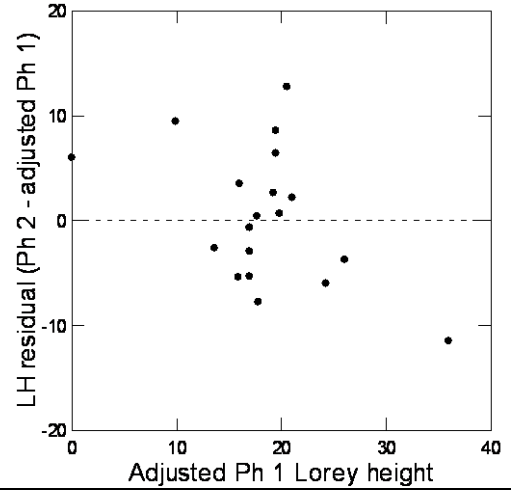

Fig G-5b: Lorey height residuals vs adjusted Phase I inventory Lorey height (i.e. R × unadjusted Ph I Lorey height).

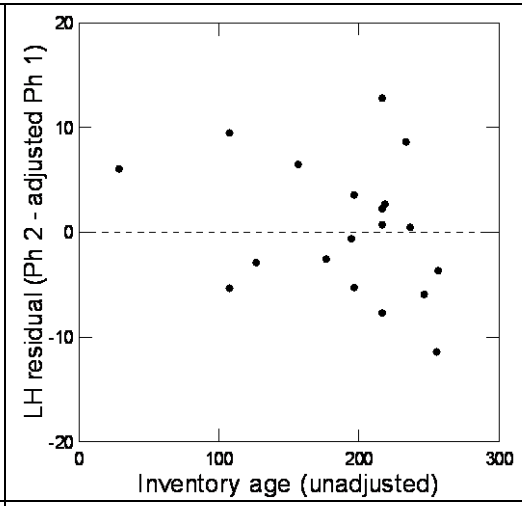

Fig G-5c: Lorey height residuals vs unadjusted Phase I inventory Lorey height.

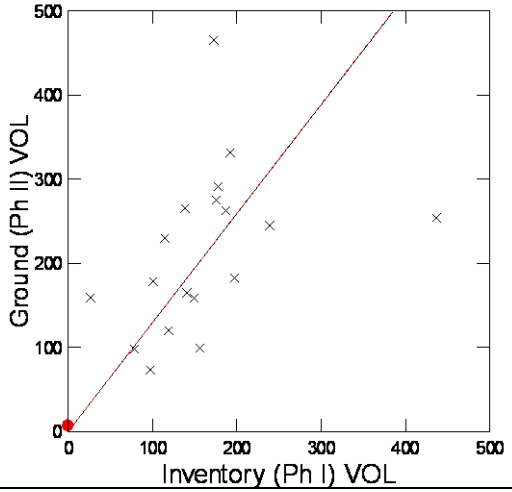

Fig G-6a: Phase II vs. Phase I vol/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

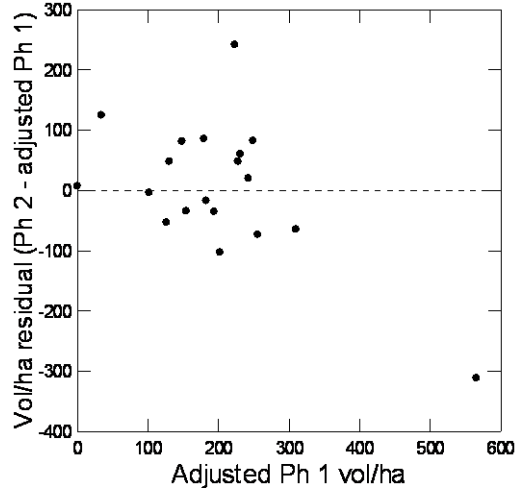

Fig G-6b: Vol/ha residuals vs adjusted Phase I inventory vol/ha (i.e. R × unadjusted Ph I vol/ha).

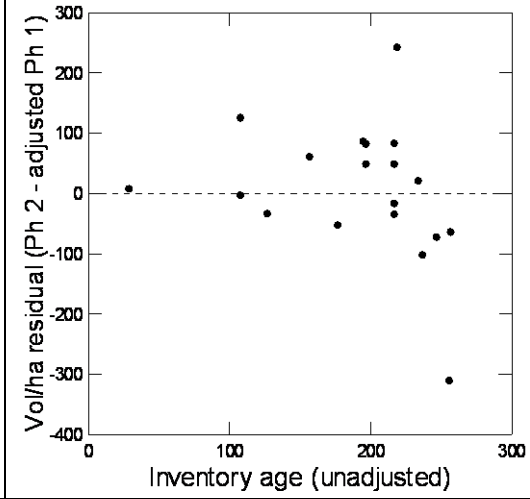

Fig G-6c: Vol/ha residuals vs unadjusted Phase I inventory vol/ha.

Cedar-Hemlock

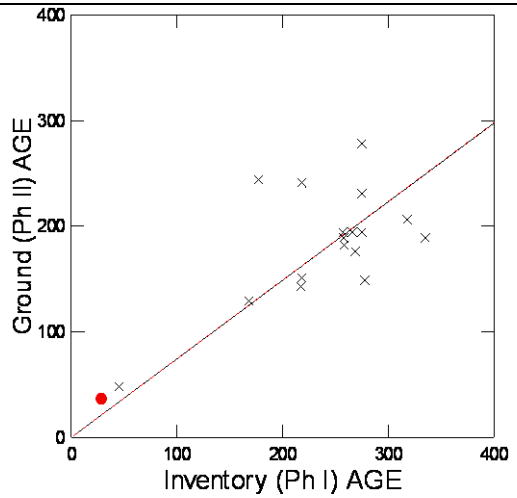

Fig G-7a: Phase II vs. Phase I age. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

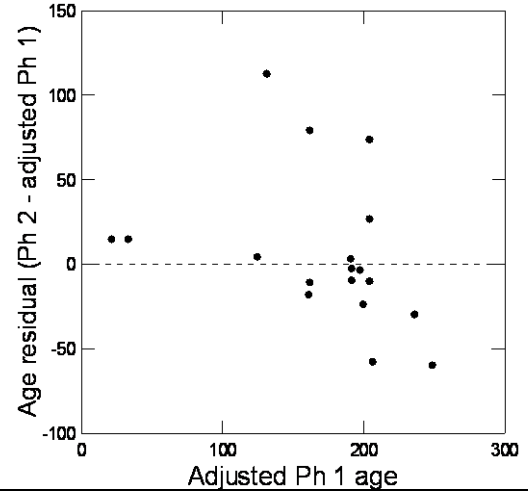

Fig G-7b: Age residuals vs adjusted Phase I inventory age (i.e. R × unadjusted Ph I age).

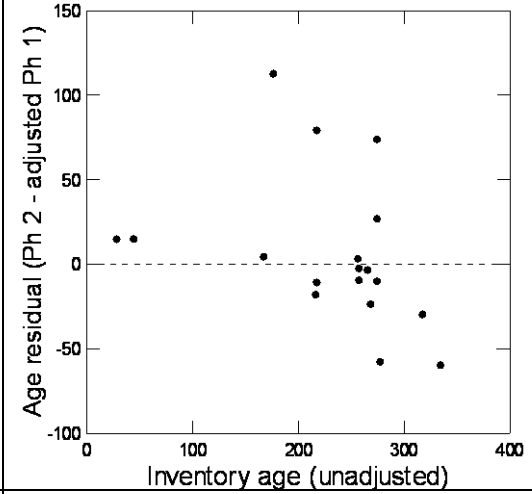

Fig G-7c: Age residuals vs unadjusted Phase I inventory age.

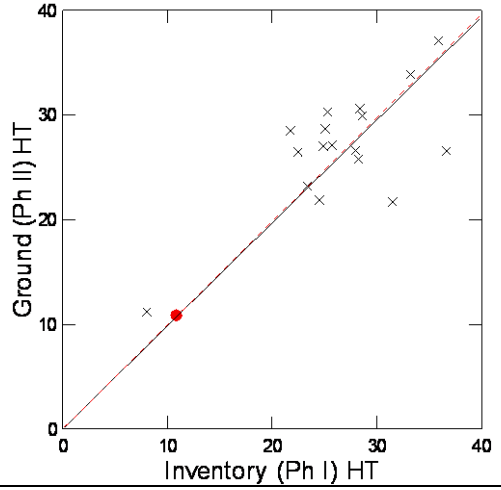

Fig G-8a: Phase II vs. Phase I height. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

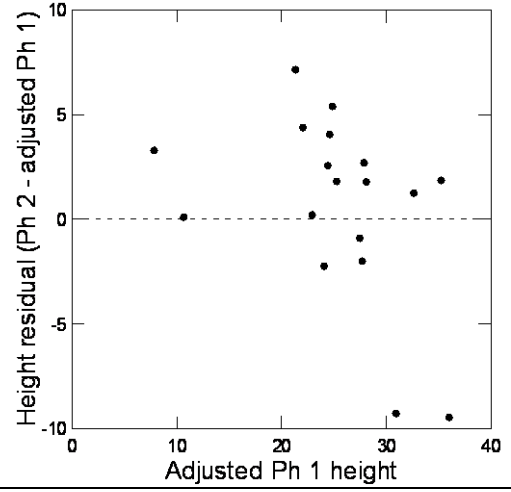

Fig G-8b: Height residuals vs adjusted Phase I inventory height (i.e. R × unadjusted Ph I height).

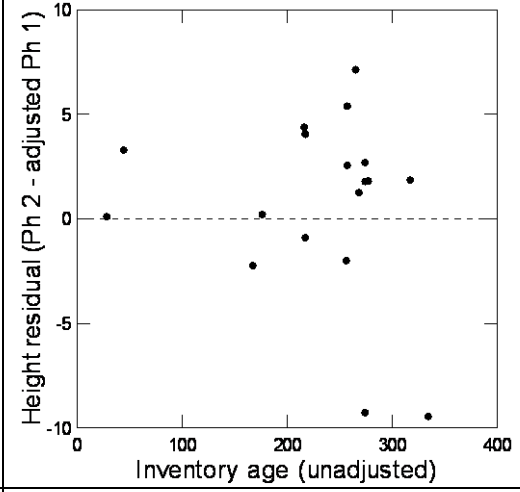

Fig G-8c: Height residuals vs unadjusted Phase I inventory height.

Cedar-Hemlock

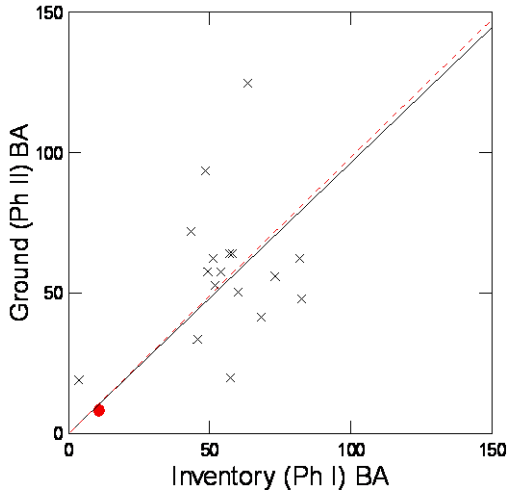

Fig G-9a: Phase II vs. Phase I ba/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

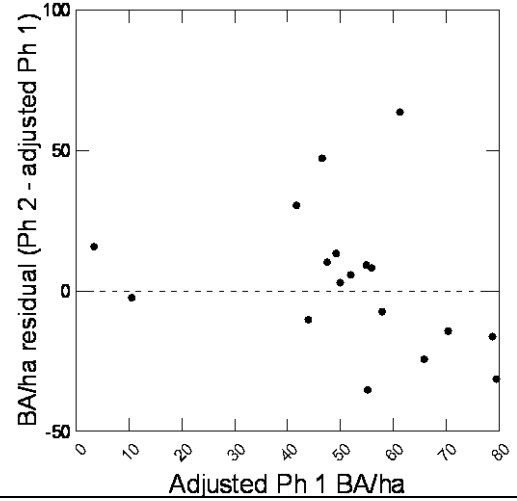

Fig G-9b: Ba/ha residuals vs adjusted Phase I inventory ba/ha (i.e. R × unadjusted Ph I ba/ha).

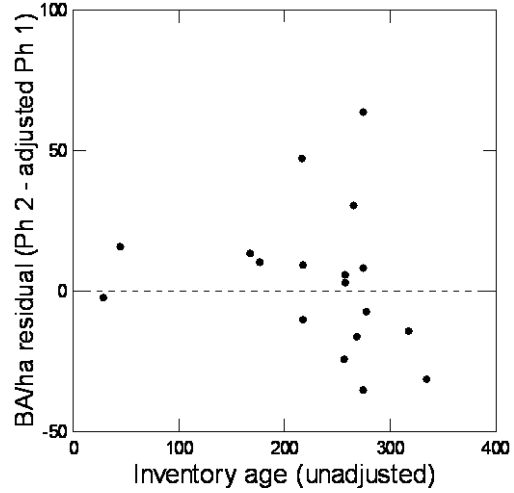

Fig G-9c: Ba/ha residuals vs unadjusted Phase I inventory ba/ha.

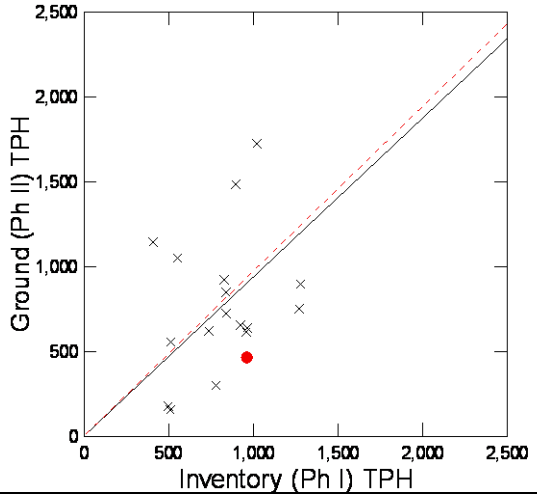

Fig G-10a: Phase II vs. Phase I trees/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

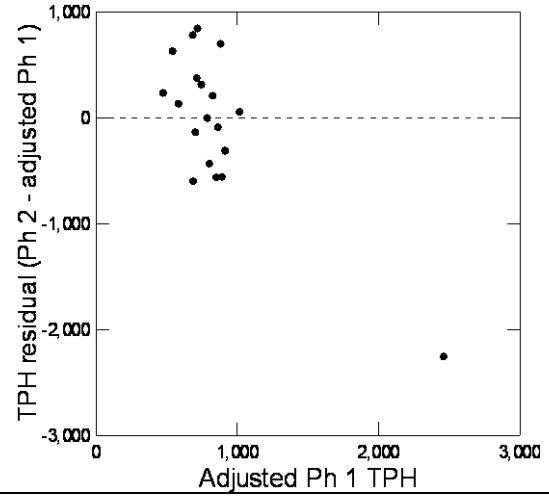

Fig G-10b: Trees/ha residuals vs adjusted Phase I inventory trees /ha (i.e. R × unadjusted Ph I trees /ha).

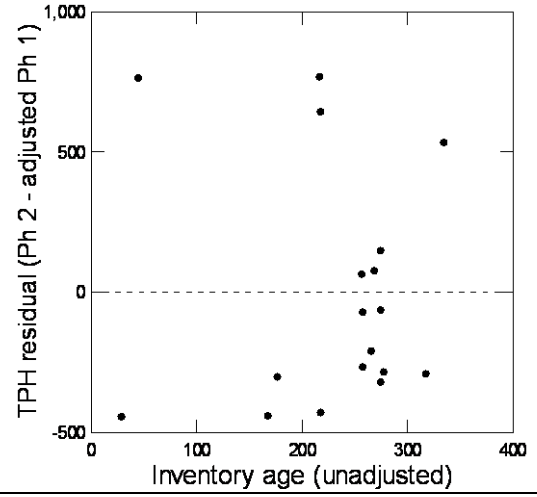

Fig G-10c: Trees /ha residuals vs unadjusted Phase I inventory trees /ha.

Cedar-Hemlock

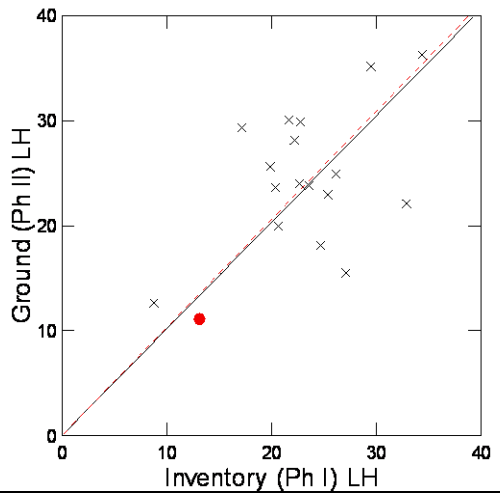

Fig G-11a: Phase II vs. Phase I Lorey height. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

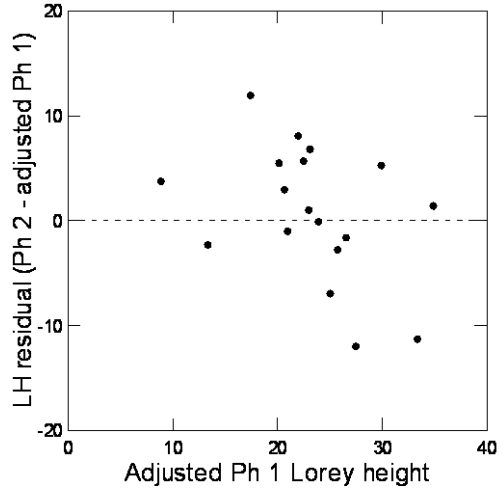

Fig G-11b: Lorey height residuals vs adjusted Phase I inventory Lorey height (i.e. R × unadjusted Ph I Lorey height).

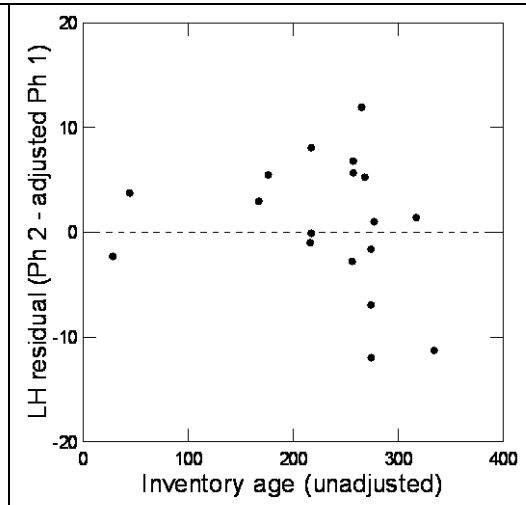

Fig G-11c: Lorey height residuals vs unadjusted Phase I inventory Lorey height.

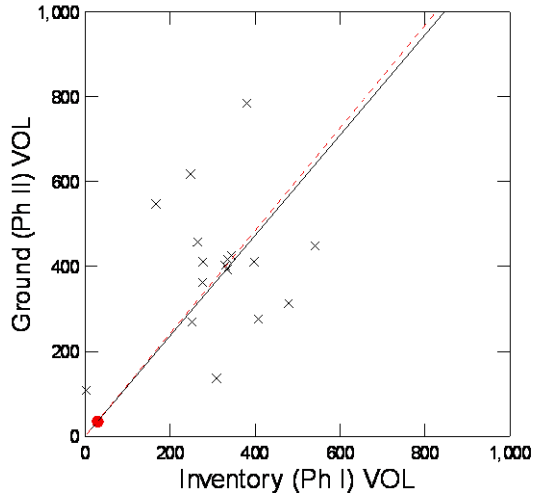

Fig G-12a: Phase II vs. Phase I vol/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

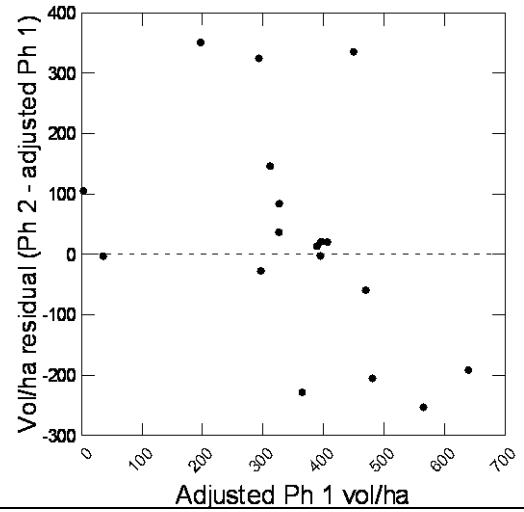

Fig G-12b: Vol/ha residuals vs adjusted Phase I inventory vol/ha (i.e. R × unadjusted Ph I vol/ha).

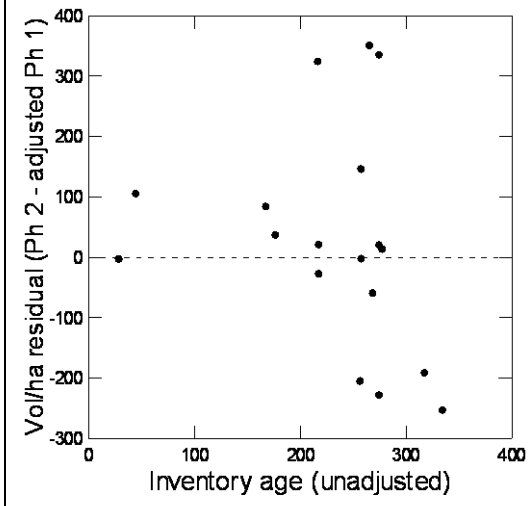

Fig G-12c: Vol/ha residuals vs unadjusted Phase I inventory vol/ha.

Fir, Pine, Deciduous

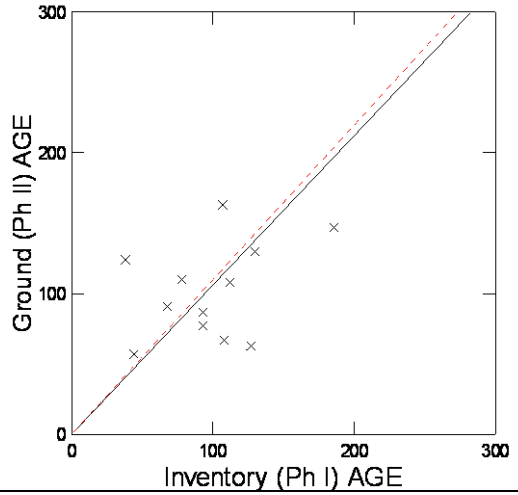

Fig G-13a: Phase II vs. Phase I ba/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

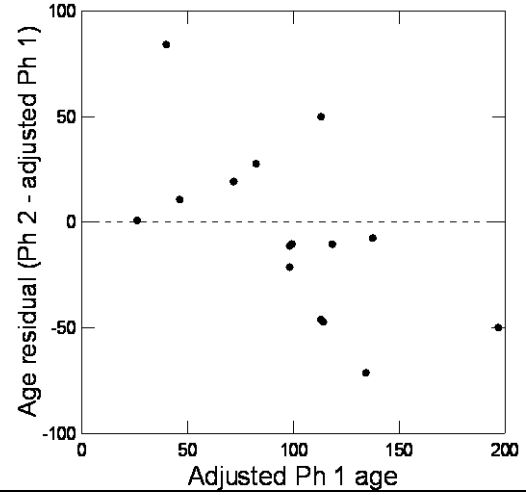

Fig G-13b: Ba/ha residuals vs adjusted Phase I inventory ba/ha (i.e. R × unadjusted Ph I ba/ha).

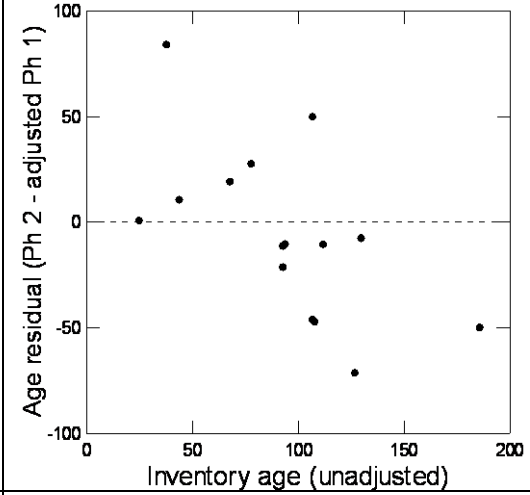

Fig G-13c: Ba/ha residuals vs unadjusted Phase I inventory ba/ha.

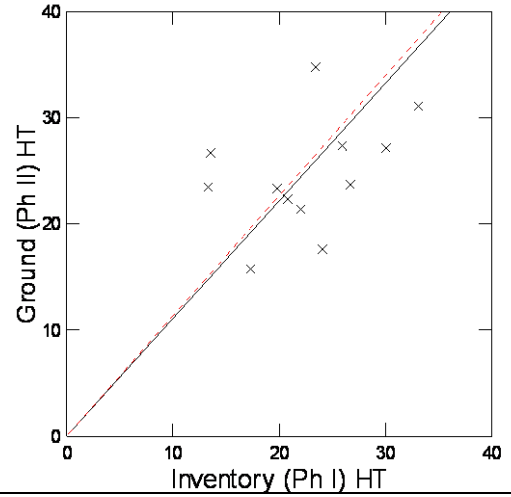

Fig G-14a: Phase II vs. Phase I trees/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

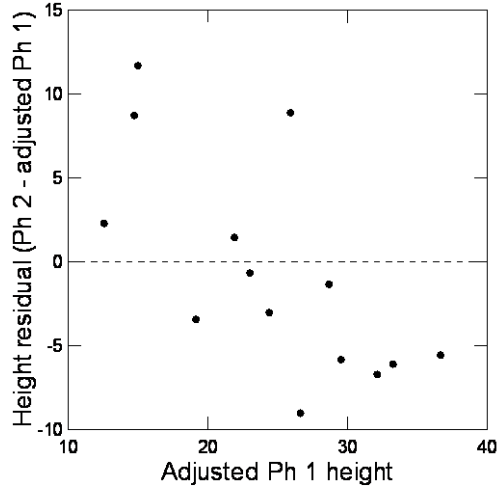

Fig G-14b: Trees/ha residuals vs adjusted Phase I inventory trees /ha (i.e. R × unadjusted Ph I trees /ha).

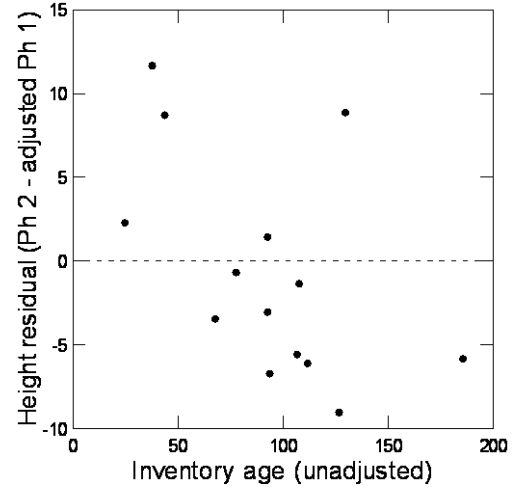

Fig G-14c: Trees /ha residuals vs unadjusted Phase I inventory trees /ha.

Fir, Pine, Deciduous

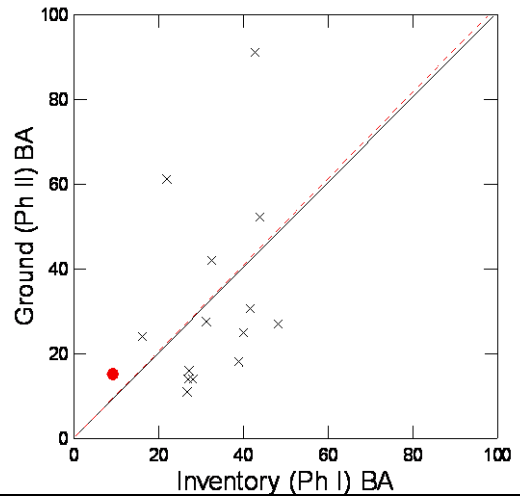

Fig G-15a: Phase II vs. Phase I ba/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

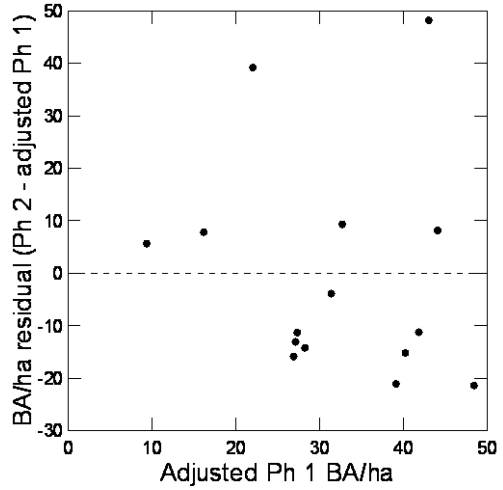

Fig G-15b: Ba/ha residuals vs adjusted Phase I inventory ba/ha (i.e. R × unadjusted Ph I ba/ha).

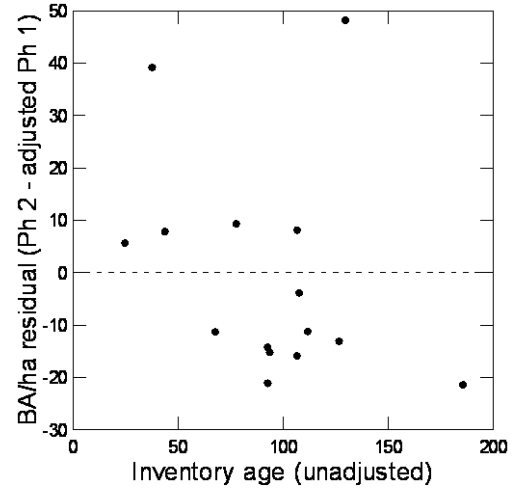

Fig G-15c: Ba/ha residuals vs unadjusted Phase I inventory ba/ha.

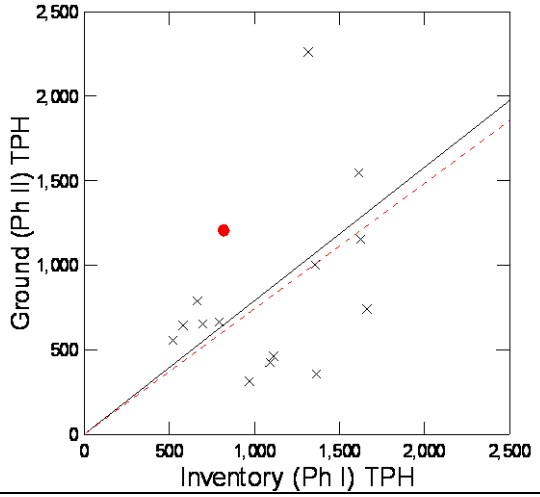

Fig G-16a: Phase II vs. Phase I trees/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

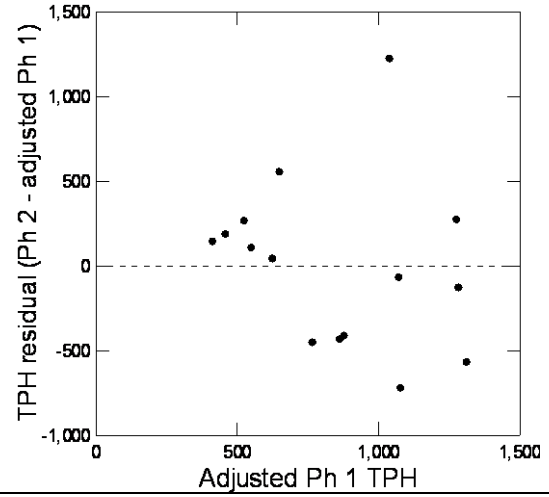

Fig G-16b: Trees/ha residuals vs adjusted Phase I inventory trees /ha (i.e. R × unadjusted Ph I trees /ha).

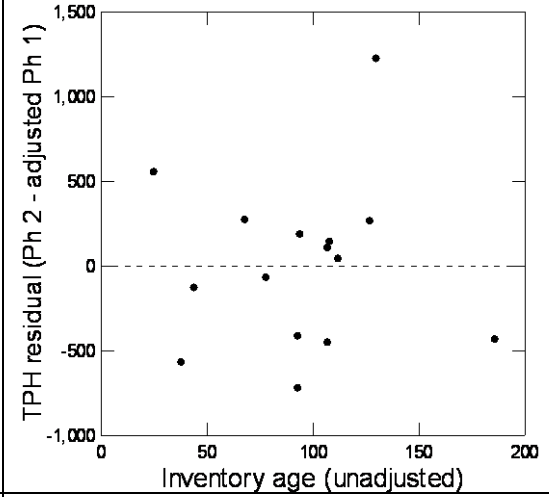

Fig G-16c: Trees /ha residuals vs unadjusted Phase I inventory trees /ha.

Fir, Pine, Deciduous

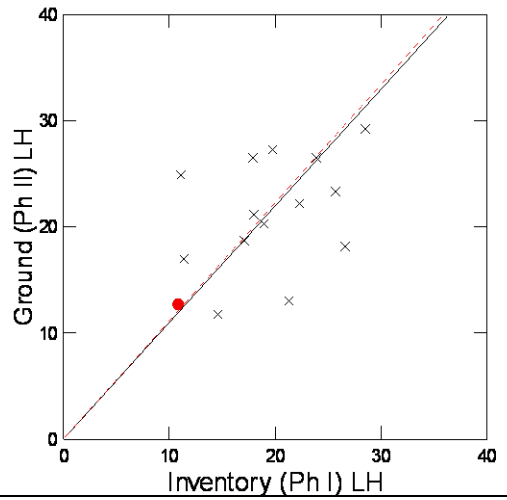

Fig G-17a: Phase II vs. Phase I Lorey height. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

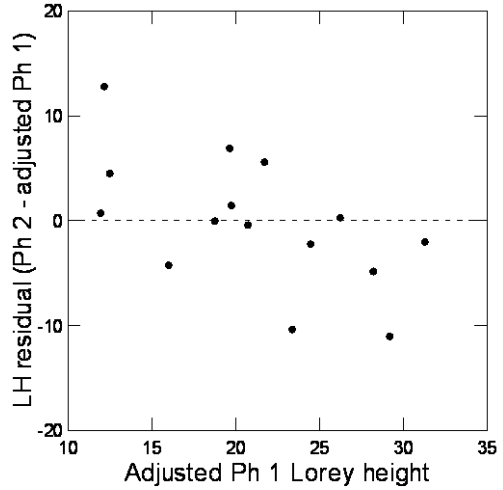

Fig G-17b: Lorey height residuals vs adjusted Phase I inventory Lorey height (i.e. R × unadjusted Ph I Lorey height).

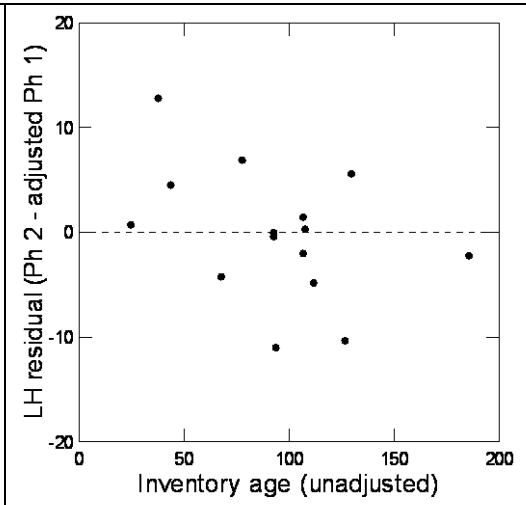

Fig G-17c: Lorey height residuals vs unadjusted Phase I inventory Lorey height.

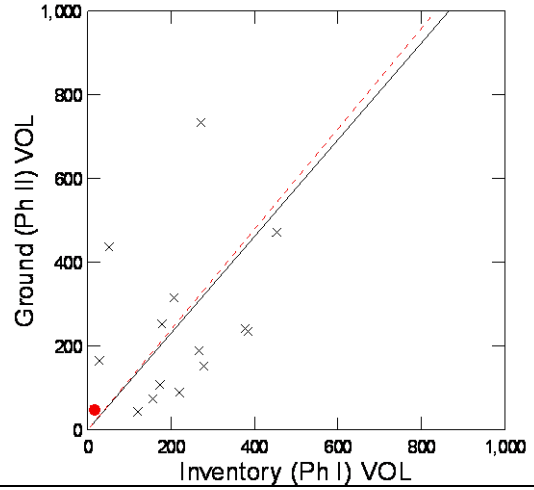

Fig G-18a: Phase II vs. Phase I vol/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

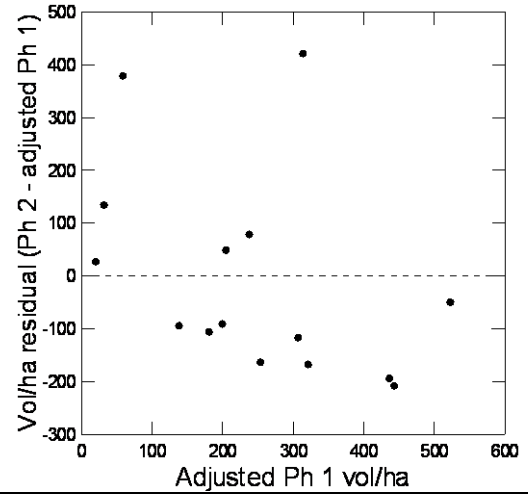

Fig G-18b: Vol/ha residuals vs adjusted Phase I inventory vol/ha (i.e. R × unadjusted Ph I vol/ha).

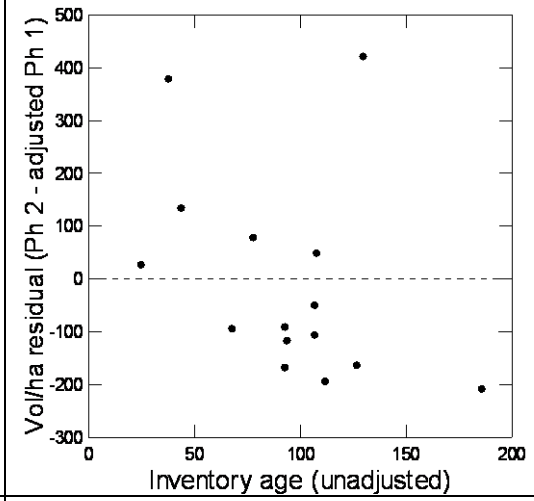

Fig G-18c: Vol/ha residuals vs unadjusted Phase I inventory vol/ha.

Spruce

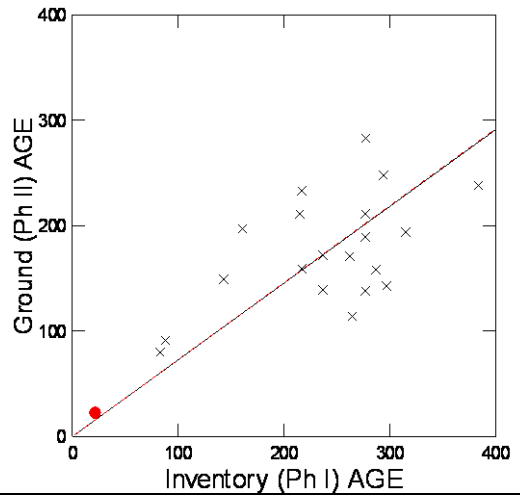

Fig G-19a: Phase II vs. Phase I age. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

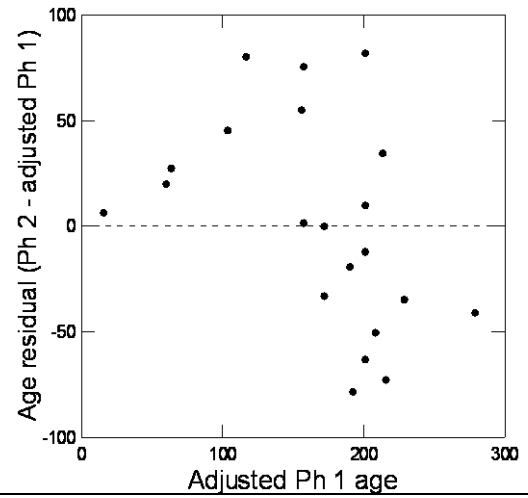

Fig G-19b: Age residuals vs adjusted Phase I inventory age (i.e. R × unadjusted Ph I age).

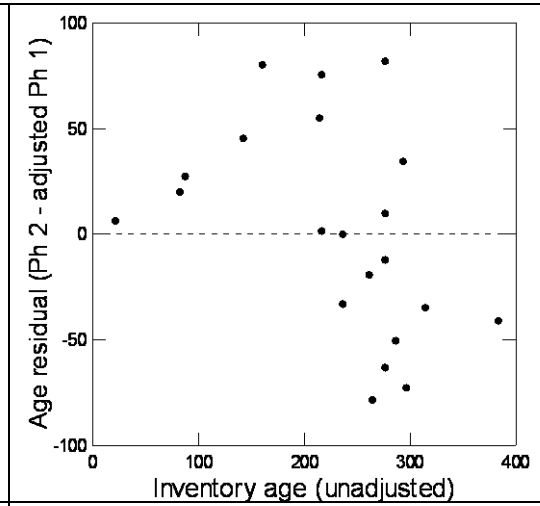

Fig G-19c: Age residuals vs unadjusted Phase I inventory age.

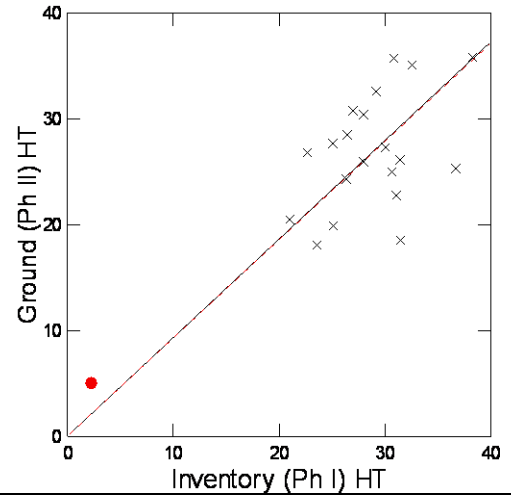

Fig G-20a: Phase II vs. Phase I height. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

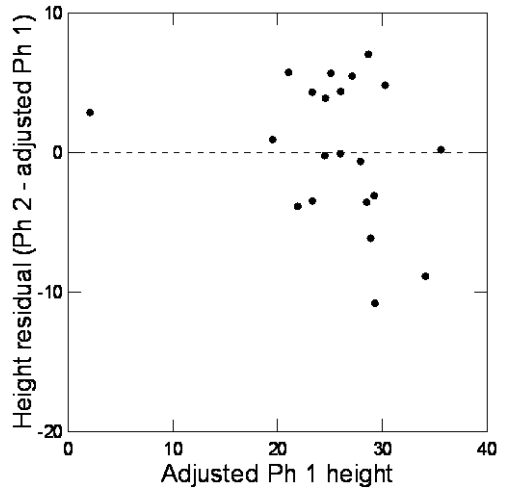

Fig G-20b: Height residuals vs adjusted Phase I inventory height (i.e. R × unadjusted Ph I height).

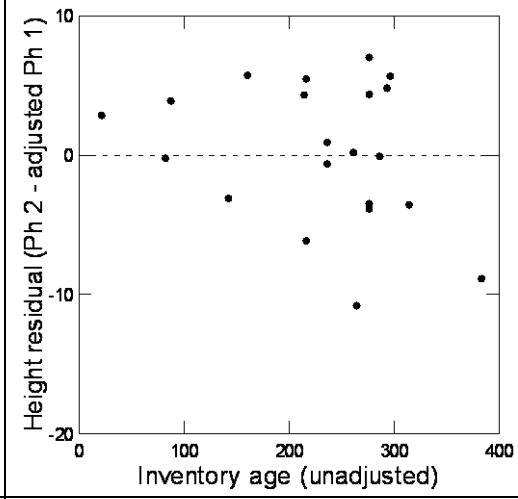

Fig G-20c: Height residuals vs unadjusted Phase I inventory height.

Spruce

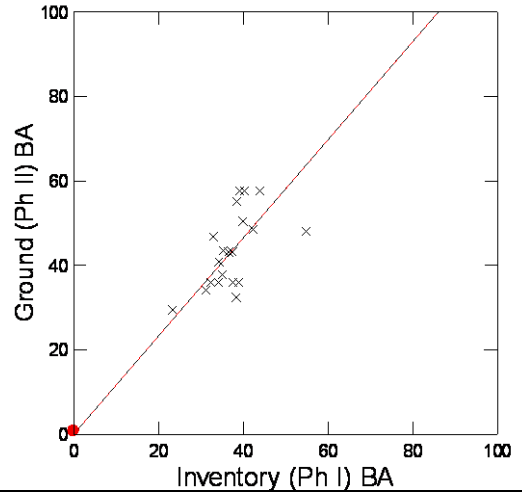

Fig G-21a: Phase II vs. Phase I ba/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

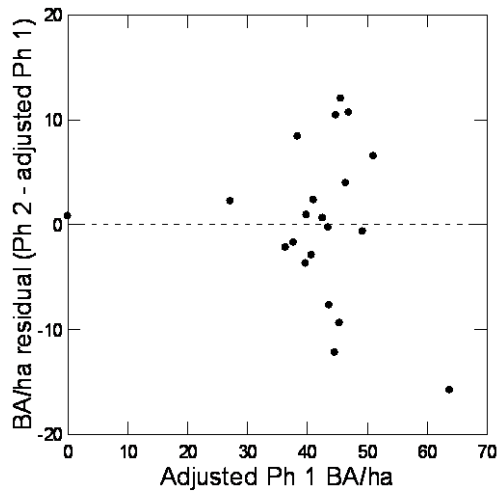

Fig G-21b: Ba/ha residuals vs adjusted Phase I inventory ba/ha (i.e. R × unadjusted Ph I ba/ha).

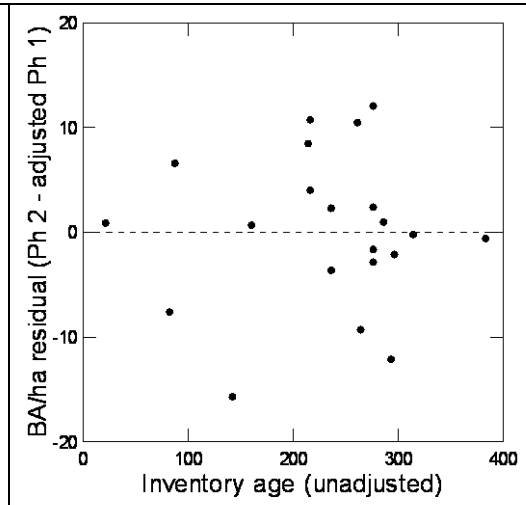

Fig G-21c: Ba/ha residuals vs unadjusted Phase I inventory ba/ha.

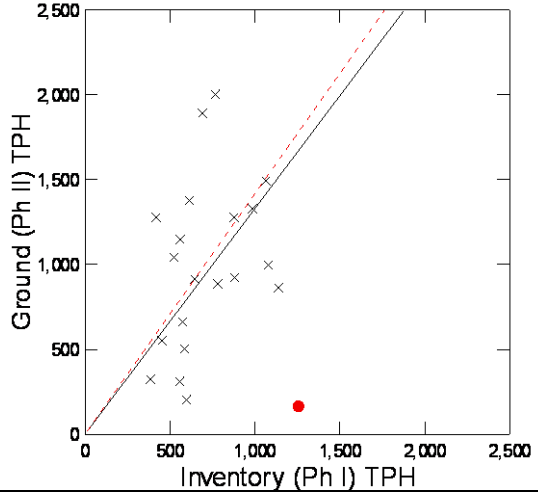

Fig G-22a: Phase II vs. Phase I trees/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

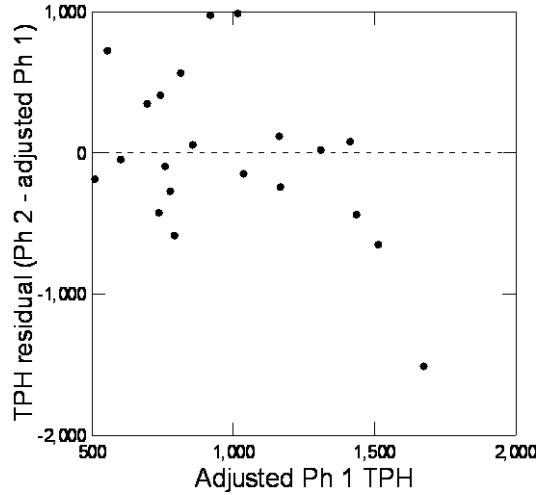

Fig G-22b: Trees/ha residuals vs adjusted Phase I inventory trees /ha (i.e. R × unadjusted Ph I trees /ha).

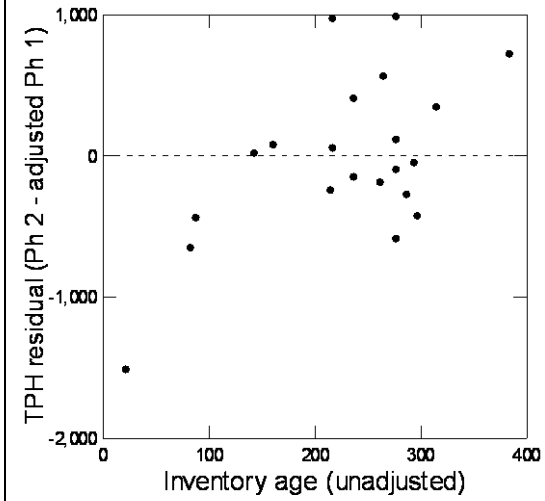

Fig G-22c: Trees /ha residuals vs unadjusted Phase I inventory trees /ha.

Spruce

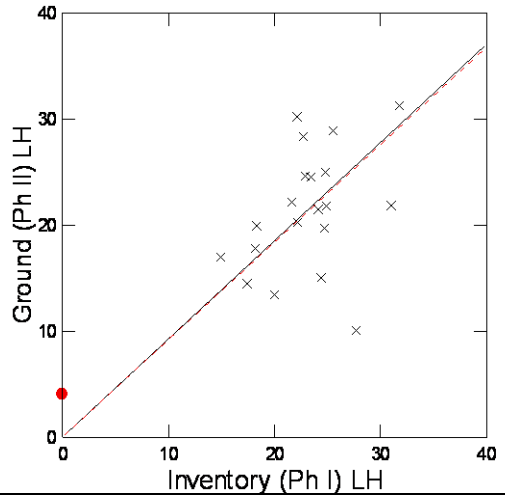

Fig G-23a: Phase II vs. Phase I Lorey height. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

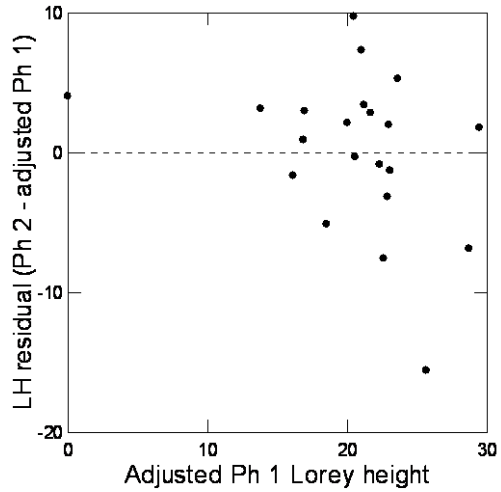

Fig G-23b: Lorey height residuals vs adjusted Phase I inventory Lorey height (i.e. R × unadjusted Ph I Lorey height).

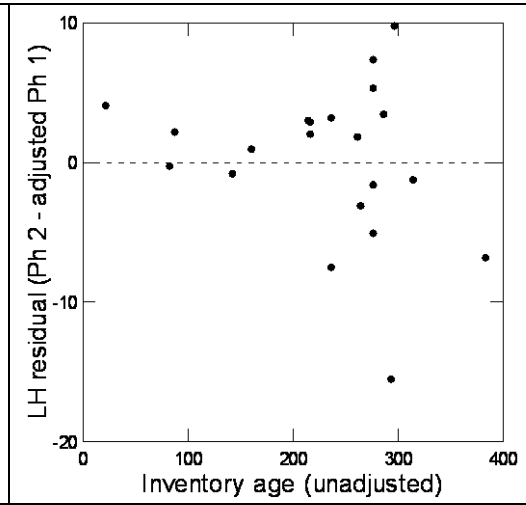

Fig G-23c: Lorey height residuals vs unadjusted Phase I inventory Lorey height.

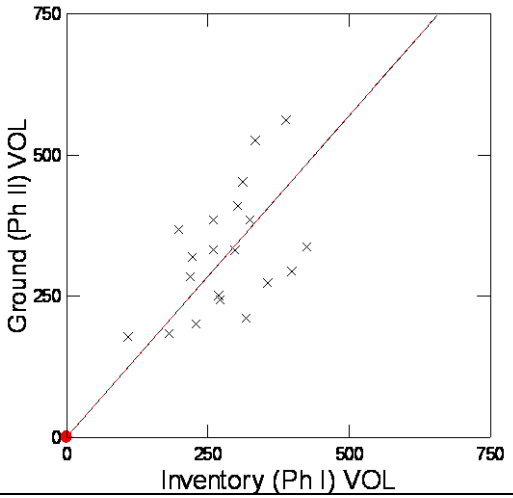

Fig G-24a: Phase II vs. Phase I vol/ha. The black line represents the ratio of means. The ● is a sample <30 yrs of age; the red line is the ratio of means computed *without* this sample.

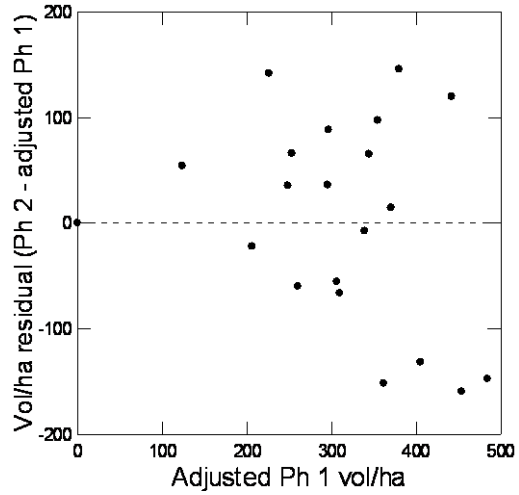

Fig G-24b: Vol/ha residuals vs adjusted Phase I inventory vol/ha (i.e. R × unadjusted Ph I vol/ha).

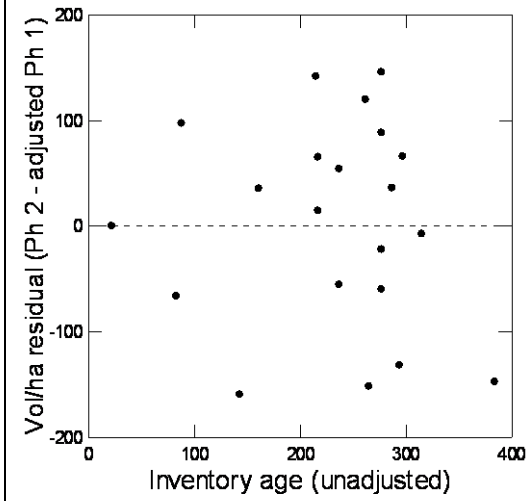

Fig G-24c: Vol/ha residuals vs unadjusted Phase I inventory vol/ha.

12. APPENDIX H: VOLUME TRENDS IN THE MATURE CEDAR STRATUM

An Interpretation of the Mature Cedar Volume Found in the Robson Valley TSA VRI

By Will Smith, FAIB, March 11, 2011

Cedar volumes appear to be rising as a result of the VRI analysis for the Robson Valley TSA. Table 2 of the Robson VRI Statistical Analysis Report shows that volumes estimated by VDYP7 growth and yield model are 21 percent underestimated for cedar leading polygons. Given that the inputs to VDYP7 in the form of polygon inventory attributes appear to be correct, the model remains as the primary source of volume bias.

One source of error within the model is the estimation of volume loss due to decay. Statistical adjustments have been calculated for the ICH vk1 and wk1 (found in the southern portion of the TSA) from randomly selected data and have found an approximate 50% decrease in decay volume. Random sampling, such as the NVAF, has found that the trend of loss factors overstating the decay volume is near universal for mature species, particularly Interior cedar. Various reasons have been proposed to explain this trend and range from:

1. The sample selection of trees for loss factors was non-random and therefore biased and not representative of the population.
2. Uneconomic sound wood was included in the measurement of decay.
3. Stained sound wood, such as the pink or dark brown wood was also included as decay.

Whatever the cause, the loss factor estimation of decay in mature cedar leads to a poor estimate of biomass. Regardless of the accuracy of the estimates, the VRI process adjusts the estimates with ground truth data such as the NVAF to result in volumes closely related to biomass, with small allowances made for Z grade logs and breakage. An important factor to consider is how well decay relates to merchantability. For Interior cedar, percent decay infers merchantability but does not equate to it due to the distribution of sound wood within a tree. Frequently sound wood is present in a non-contiguous form that is either extremely difficult, or impossible to saw into lumber, let alone be extracted in whole log form. The NVAF sample process has recently added a measure of merchantability where the decay and uneconomic sound wood using conventional scaling rules around trim allowance and grade consideration is captured.

A recently collected sample of NVAF trees from several cutting permits in the Revelstoke and N Thompson areas was also scaled in the field, allowing for a relationship between actual and estimated decay and the nonmerchantable NVAF measure. The following graphic shows the relationships between actual and estimated percent decay and nonmerchantable (non-sawable) wood for the Robson area and cutting permit data.

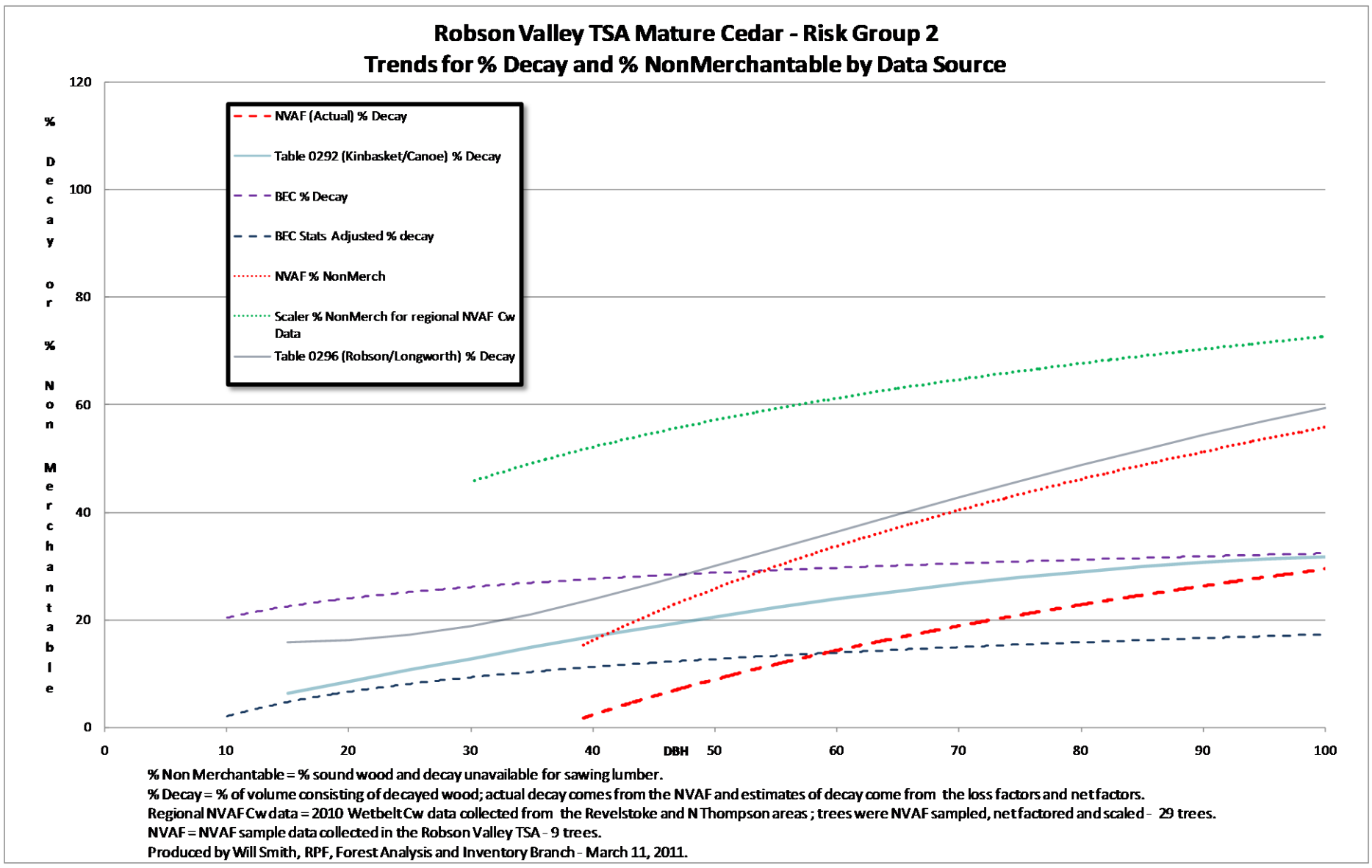

Fig H-1: Trends for % decay and % non-merchantable volume by data source.