
Fort St. James Forest District Vegetation Resources Inventory Statistical Adjustment

Prepared by

Wenli Xu

For

Sam Otukol

(DRAFT)

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EXECUTIVE SUMMARY

Timberline Natural Resource Group recently completed a VDYP6 VRI statistical adjustment analysis of the Prince George TSA. The analysis was done separately for each of the three forest districts within the TSA: Prince George, Vanderhoof and Fort St. James.

The objective of this project was to provide a VDYP7 adjustment for the Fort St. James Forest District of the Prince George TSA which followed the same approach as the Timberline VDYP6 adjustment for this unit. Hence analysis strata, sampling weights, target population, compiled VRI Phase II data, etc. were provided by Timberline.

This adjustment was to be carried out according to the interim procedures for a VDYP7 adjustment which allows for adjustment of age, height, basal area/ha at 7.5cm+ dbh utilization, trees/ha at 7.5cm+ dbh utilization and volume/ha net dw2 at 12.5cm+ dbh utilization.

Because of the heavy MPB infestation in this area and how MPB mortality is dealt with in a timber supply context, timber supply staff requested that all dead pine be included in the adjustment. In addition, due to serious decline in balsam (*Abies lasiocarpa*) stands, it was also requested that dead balsam also be incorporated into the adjustment. Hence the basal area/ha, trees/ha, and volume adjustment factors are all based on live (all species) plus dead lodgepole pine plus dead balsam.

The NVAF destructive sampling data for this unit was compiled and NVAF values in five strata were calculated. These NVAF values, shown in Table 1 below, were then applied as a multiplier to the compiled volumes for each species present within a sample.

Table 1: NVAF values applied in the analysis.

<i>Species stratum</i>	<i>NVAF value</i>
Dead	0.944
Live – Immature	1.007
Live – Mature - Balsam	1.065
Live – Mature - Pine	0.993
Live – Mature - Spruce	0.913

The population of interest for this adjustment, was: “All VT polygons, 30 years of age and older as of 2006”. However, it was determined that only about 72% of the VT forest land with age \geq 30 years in 2006 was sampled, so the adjustment was limited to the corresponding population.

The target population was stratified based on the PI proportion in the stand and age class into 3 strata for which individual adjustment factors would be computed:

- Polygons containing less than 31% PI volume and less than 141 years old (Low Risk-Immature)
- Polygons containing less than 31% PI volume and 141 years or older (Low Risk-Mature)
- Polygons containing more than 30% PI volume (High Risk)

The resulting VDYP7 adjustment factors for age, height, basal area and trees per hectare are shown in Table 2.

Table 2: VDYP7 Adjustment Factors for age, height, trees/ha (at 7.5cm+dbh utilization), basal area/ha (at 7.5cm+dbh utilization) and volume/ha (net DW2 at 12.5cm+ dbh utilization). Note that the basal area/ha, trees/ha & volume/ha adjustment factors are based on Phase II per hectare values that include live trees for all species plus dead trees for balsam and dead trees for lodgepole pine.

		VDYP7 Adjustment Factors				
		Stage 1			Stage 2	
Stratum	n	Age	Height	Basal area/ha @7.5cm+dbh	Trees/ha @7.5cm+ dbh	Volume/ha net DW2 @12.5cm+ dbh
PI%≤30% - Immature	32	1.196	1.045	1.338	1.422	1.127
PI%≤30% - Mature	74	0.846	0.988	1.678	2.085	1.105
PI%>30%	38	0.872	0.946	1.162	1.500	0.987

Timber supply analyses are typically done on a net decay, waste and breakage volume basis. Hence, a special unadjusted run of VDYP7 was done to provide unadjusted volumes net decay, waste & breakage so that the estimated volume impact of the VDYP7 adjustment and its associated sampling error could be computed. The estimated volume impacts of the adjustment were computed as ratios of the ground (Phase II) volume to the unadjusted VDYP7 (Phase I) volume, with appropriate sample weights applied. The results, by stratum, are shown in Table 3.

Table 3: Volume Impact of VDYP7 adjustment, by stratum

Volume/ha @12.5cm+ dbh utilization net DWB: Estimated VDYP7 Adjustment Impact					
Stratum	n	Wt'd Mean Phase 2 Vol/ha (LIVE + Dead PL+DeadB)	Wt'd Mean Phase 1 Unadjusted vol/ha	Estimated volume impact ratio	SE % for volume impact (at 95%)
PI%≤30% - Immature	32	182.449	122.995	1.483	24%
PI%≤30% - Mature	74	294.863	171.021	1.724	13%
PI%>30%	38	300.934	286.254	1.051	14%

The stratum “PI%≤30% - Mature” has the biggest effect and its ratio is 1.724 indicating that after adjustment, the VDYP7 volume will increase by about 72%. This appears to be driven largely by the basal area adjustment (Table 3.3). For this stratum in particular, including the dead balsam into the adjustment had a significant effect on the adjustment ratios and hence the volume impact. The volume impact ratio for stratum “PI%>30%” is 1.051, indicating that the adjustment had very little net effect on volume in this stratum.

Overall, the impact of a VDYP7 adjustment was estimated to be 1.413 with a 9.0% sampling error (at the 95% confidence level). This level of sampling error was within the target of ±10%

set in the project VPIP. When the adjustment was applied to the target population, the calculated impact of the adjustment was about 42%, which is quite close to what was expected based on the sample.

The Mountain Pine Beetle infestation is widespread in this unit. In addition, “ongoing outbreaks of western balsam bark beetle and two-cycle spruce budworm over the past decade, coupled with various heart rot diseases common to over-mature sub-alpine fir-leading stands, have contributed to extensive stand mortality and significant loss of merchantable volume”¹ in balsam (*Abies lasiocarpa*) stands. To facilitate the current TSR approach for representing the effect of Mountain Pine Beetle and balsam decline on the inventory and to ensure consistency with that approach, timber supply requested that dead pine and dead balsam volume be included with live volume in the adjustment. Hence the Phase II compiled values for all per hectare-based adjustments (i.e. basal area/ha, trees/ha, volume/ha) included dead balsam and dead pine. The magnitude of the dead component in these stands was significant, particularly for balsam. In mature stands comprised of less than about 30% pine, the samples indicated that dead balsam accounts for over 20% of the total volume for live trees (all species) plus dead balsam and dead pine. *The impact of including dead volume in the analysis should be considered in terms of degradation of volume and value of these stands. A process is currently being developed for dealing with the dead volume component of the inventory in a more systematic and consistent manner.*

¹ “Prince George Timber Supply Area Timber Supply Review: Data Package”, p. 35, Ministry of Forests & Range, Forest Analysis and Inventory Branch. November 2008. 56pp.

Table of Contents

EXECUTIVE SUMMARY I

1. INTRODUCTION.....5

 1.1 BACKGROUND AND ISSUES 5

 1.2 DESCRIPTION OF THE INVENTORY UNIT 5

 1.3 SCOPE AND OBJECTIVES 6

2. METHODS7

 2.1 OVERVIEW OF NVAF ANALYSIS 7

 2.2 POPULATION FOR ADJUSTMENT 7

 2.2.1 Samples excluded from the analysis (outside of target population)..... 8

 2.3 DATA SOURCES 8

 2.3.1 Phase I photo-interpreted inventory data 8

 2.3.2 Phase II ground sample data 8

 2.3.3 Data matching 8

 2.4 DATA ISSUES RELATED TO THE STATISTICAL ADJUSTMENT (DATA SCREENING)..... 9

 2.5 STRATIFICATION AND WEIGHTS 9

 2.6 OVERVIEW OF STATISTICAL ADJUSTMENT 9

3. RESULTS AND DISCUSSION.....10

 3.1 VDYP7 ADJUSTMENT ANALYSIS 10

 3.1.1 First stage VDYP7 adjustment: Height, age, basal area & trees per hectare 10

 3.1.2 Second stage VDYP7 adjustment: Volume net DW2 at 12.5 cm+ dbh utilization 12

 3.1.3 Volume impact analysis by stratum 12

 3.2 OVERALL ESTIMATED VOLUME IMPACT AND ESTIMATED SAMPLING ERROR 13

 3.3 INVENTORY FILE ADJUSTMENT FOR THE VDYP7 STATISTICAL ADJUSTMENT 14

4. CONCLUSIONS AND RECOMMENDATIONS 14

5. APPENDIX A: DATA ISSUES 16

6. APPENDIX B: INVENTORY AND GROUND ATTRIBUTES USED IN THE ADJUSTMENT 17

7. APPENDIX C: VDYP7 SCATTER PLOTS & RESIDUALS FOR AGE & HEIGHT (STAGE 1 ADJUSTMENT) 18

8. APPENDIX D: VDYP7 SCATTER PLOTS & RESIDUALS FOR BA & TPH (STAGE 1 ADJUSTMENT) 20

9. APPENDIX E: VDYP7 SCATTER PLOTS & RESIDUALS FOR VOLUME (STAGE 2 ADJUSTMENT) 22

10. APPENDIX F: POPULATION DISTRIBUTIONS PRE- AND POST-ADJUSTMENT 23

1. INTRODUCTION

1.1 Background and Issues

Timberline completed the VDYP6 adjustment of the Prince George TSA. The analysis was done separately by forest district: Prince George, Vanderhoof and Fort St. James. A concurrent analysis using VDYP7 was carried out by Ministry of Forests and Range (MRF) staff for the Vanderhoof and Fort St. James Forest Districts and by Churlish Consulting Ltd for the Prince George Forest District. This document details the VDYP7 statistical adjustment analysis completed for the Fort St. James Forest District.

Since Timberline was doing the VDYP6 adjustment for this unit concurrently, all stratum assignments and sample weights were provided by Timberline so that the VDYP6 and VDYP7 analyses would be more readily comparable.

Based on the VPIP, 150 samples were planned. However, only 147 samples were established. Of these, 123 samples were measured in 2006 and 24 samples were measured in 2007. Three samples could not be matched with the stratum assignments for the population and hence were excluded. A total of 144 samples were therefore used for the VDYP7 statistical adjustment analysis.

It was determined that only about 72% of the VT forest land with age \geq 30 years in 2006 was sampled and hence the adjustment was restricted to the corresponding population.

In the course of the analysis, issues and questions arose for some samples. The resolution of these issues or assumptions that were made are summarized in the Data Issues section that follows.

1.2 Description of the Inventory Unit

Fort St. James Forest District is one of three forest districts in the Prince George TSA (Figure 1). The Fort St. James Forest District covers about 3.2 million ha, of which 2.1 million (66%) are Vegetated Treed. Most of the Fort St. James Forest District is located in the Sub-Boreal spruce (SBS) and Engelmann Spruce-Subalpine Fir (ESSF) biogeoclimatic zones.

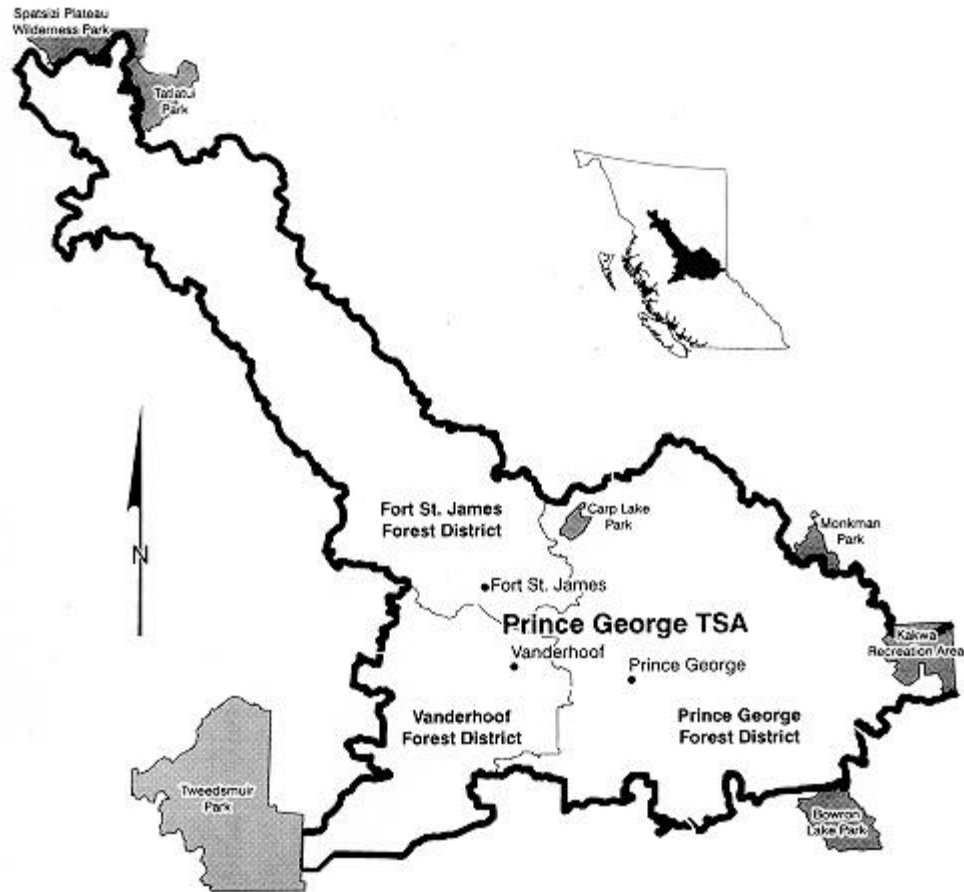


Figure 1: Map of the Prince George TSA showing the Fort St. James District

1.3 Scope and Objectives

The objective of this analysis was to provide a VDYP7 statistical adjustment for the Fort St. James Forest District, following the same set of assumptions (regarding the population of interest, stratification, sampling weights, etc.) used by Timberline for their VDYP6 statistical adjustment for this management unit.

The population of interest for this adjustment, as specified in the VPIP, was: “All VT polygons, 30 years of age and older as of 2006”. However, it was determined that only about 72% of the VT forest land with age ≥ 30 years in 2006 was sampled and therefore it was decided that the adjustment would be restricted to the same population as that which was sampled. The population for adjustment was identified in the population inventory files provided by Timberline.

The sampling error objective was specified as achieving:

“...an overall minimum sampling error of $\pm 10\%$ (at a 95% confidence level)”

2. METHODS

2.1 Overview of NVAF analysis

Timberline completed NVAF destructive sampling in the 2007 field season, compiled this data and provided the NVAF values. The NVAF was applied to the volumes by Gitte Churlish. In November 2008, it was discovered that NVAF values in the original analysis were missing for 5 samples. These values were obtained from Timberline and the NVAFs were reapplied to the volumes in November of 2008. Table 2.1 shows the NVAFs that were applied to the volumes in this analysis.

Table 2.1: NVAF values applied in the analysis.

<i>Species stratum</i>	<i>NVAF value</i>
Dead	0.944
Live – Immature	1.007
Live – Mature - Balsam	1.065
Live – Mature - Pine	0.993
Live – Mature - Spruce	0.913

2.2 Population for Adjustment

Details of the sampling done for this project can be found in the document: “Fort St. James District Vegetation Resources Inventory Project Implementation Plan Version 3.0 (VPIP)”, March 2007, a contract report prepared by Timberline on behalf of Canfor Prince George and the forest licencees in the Prince George TSA.

The population of interest for this adjustment, as specified in the VPIP, was: “All VT polygons, 30 years of age and older as of 2006”. However, it was determined that only about 72% of the VT forest land with age \geq 30 years in 2006 was sampled, so the adjustment was limited to the corresponding population.

The target population was stratified based on the PI proportion in the stand and age class into 3 strata for which individual adjustment factors would be computed:

- Polygons containing less than 31% PI volume and less than 141 years old (Low Risk-Immature)
- Polygons containing less than 31% PI volume and 141 years or older (Low Risk-Mature)
- Polygons containing more than 30% PI volume (High Risk)

Plots were allocated proportionally across all strata (for sample allocation purpose only, each stratum was further subdivided into sub-strata – either age class or volume class – to ensure a representative distribution).

2.2.1 Samples excluded from the analysis (outside of target population)

The stratum assignments for the population provided by Timberline could not be matched with the Phase I inventory data provided by Tim Salkeld for three samples (sample # 35, 86 and 111). These samples were excluded from the analysis, bringing the total number of samples available to 144.

2.3 Data Sources

Phase I & II data were provided by Tim Salkeld (MFR) and Guillaume Therien (Timberline).

2.3.1 Phase I photo-interpreted inventory data

Phase I inventory attribute data were provided by Tim Salkeld in the files: DJA_VRI.dbf, BasalArea.dbf and DJA_BEC.dbf. All inventory data was projected to either 2006 or 2007 to correspond with the year of ground sampling for each sample.

2.3.2 Phase II ground sample data

All ground sample data of project DJA1 provided directly from Timberline (File location: E:\Adj_PrinceGeorgeTSA\for_Sam_Otukol\FortStJames_Package_2007NOV05). Since the data was not loaded into the Oracle prior to the analysis, it did not go through the usual error checking process. On November 21, 2007 new data was received from Timberline for sample #24 when some errors related to tree heights were discovered.

For timber supply purposes, Barry Snowden proposed to include dead balsam (B) and dead lodgepole pine (PL) in the adjustment ratio calculations, i.e., the compiled ground values of BA, TPH and volume were to include all the live tree values plus dead B and dead PL tree values. Based on this approach, it was assumed that specific modeling techniques would be then used in the course of the timber supply analysis to eliminate the influence of the dead trees as time progressed.

Note that although this approach was used in this analysis, it is suggested that a comparison analysis be done using only live trees for the attribute adjustment and yield projections. The magnitude of the BA, TPH, and volume adjustment factors and the estimated overall volume impact analysis suggested that including the dead B and dead PL in the adjustment process had significant effects on the adjusted population volume.

2.3.3 Data matching

The data matching used to determine the appropriate heights and ages upon which to base the adjustment ratios followed the standard procedures outlined by the MFR. For each VRI sample polygon, the ground sample data was matched with the corresponding inventory data for the same polygon. The ground heights and ages used in the adjustment were based on the average values for the T, S & L trees for the leading species (by basal area at 4cm + dbh utilization) on the ground. The objective in the matching process was to choose an inventory height and age (i.e. for either the leading or second species) so that the ground and inventory species “matched”. If a match could not be made at the sp0 level, conifer-to-conifer matches were allowed. However, conifer-deciduous matches were not considered acceptable. Note that where second species inventory ages and heights were required and were available, these attributes were also projected to the year of ground sampling.

For 109 of the 144 samples (~76%), the inventory leading species matched the ground leading species at 4cm+ dbh utilization. For a further 19 samples, the ground leading species matched the inventory second species. Twelve samples were matched based on conifer-to-conifer or deciduous-to-deciduous. The remaining 4 samples could not be matched and were excluded from the development of the age and height adjustment factors.

There were a number of samples where height and age site tree data was not collected for the leading species at 4cm+ dbh. This resulted in 2 missing values for ground height and 1 missing value for age in the analysis.

2.4 Data issues related to the statistical adjustment (data screening)

Sample #124 had an initial ground stand height of 94.95 m which was later corrected to 30.64 m by Timberline on November 21, 2007. Additional details on data issues encountered and assumption made are provided in Appendix A.

2.5 Stratification and weights

Table 2.2 that follows indicates the analysis strata, along with the sample selection sub-strata and weights as provided by Timberline.

Table 2.2: Stratum assignments and sample weights used in the adjustment analysis.

<i>Analysis Stratum</i>	<i>Sub-stratum</i>	<i>n</i>	<i>Weight</i>
Pl% <=30% Immature	30-80 yrs	7	10297.88
	81-100 yrs	6	8746.1
	101 + yrs	19	9342.952
Pl% <=30% Mature	0-200 m ³ /ha	34	10846.18
	200.1 – 300 m ³ /ha	26	9892.156
	300.1 + m ³ /ha	14	7855.958
Pl% >30%	30-100 yrs	13	8283.303
	101-140 yrs	12	12878.27
	141 + yrs	13	10917.31

2.6 Overview of statistical adjustment

The VDYP7 statistical adjustment process is similar to the VDYP6 process in that it is sequential and involves two stages. However, for VDYP7 additional attributes are adjusted at the first stage: age, height, basal area at 7.5cm+ dbh utilization (BA7.5), and trees per hectare at 7.5cm+ dbh utilization (TPH7.5). Although the process has the flexibility to adjust multiple attributes at the second stage, only volume net decay and waste at the 12.5cm+ dbh utilization will be adjusted at the current time. Within the VDYP7 context, various internal modules of VDYP7 are used to project the polygons,

generate additional attributes, and adjust attributes. Hence the VDYP7 model itself takes a much larger role in the statistical adjustment process than did VDYP6.

3. RESULTS AND DISCUSSION

3.1 VDYP7 Adjustment Analysis

3.1.1 First stage VDYP7 adjustment: Height, age, basal area & trees per hectare

When the samples without a suitable inventory species match and/or no suitable ground ages or heights were considered, there were 136 samples for age and 134 samples for height that were available for the development of the age and height adjustment factors respectively.

Adjustment factors were computed as the ratio of the weighted mean ground i.e. Phase II (ground) value over the weighted mean inventory i.e. Phase I value, using the sample weights provided by Timberline.

The resulting VDYP7 ratio of means adjustment factors for age, height, basal area (BA) and trees per hectare (TPH) are shown in Tables 3.1 to 3.4 respectively. Scatterplots of the Phase I and II relationships for these attributes are provided in Appendices C & D. These tables also show sampling errors (at the 95% confidence level) for the ratio of means adjustment factors.

Table 3.1: Stage 1 VDYP7 Adjustment Factors for age

Age: VDYP7 Adjustment Factors					
Stratum	n	Wt'd Mean Phase 2 Age	Wt'd Mean Phase 1 Age	Ratio of Wt'd Means	SE % at 95%
PI%≤30% - Immature	30	119	100	1.196	16%
PI%≤30% - Mature	70	172	204	0.846	8%
PI%>30%	36	110	126	0.872	8%

Table 3.2: Stage 1 VDYP7 Adjustment Factors for height

Height: VDYP7 Adjustment Factors					
Stratum	n	Wt'd Mean Phase 2 Height	Wt'd Mean Phase 1 Height	Ratio of Wt'd Means	SE % at 95%
PI%≤30% - Immature	31	15.8	15.2	1.045	10%
PI%≤30% - Mature	69	19.0	19.2	0.988	6%
PI%>30%	34	20.7	21.9	0.946	6%

Table 3.3: Stage 1 VDYP7 Adjustment Factors for basal area/ha

<i>Basal Area/ha @7.5cm+ dbh utilization: VDYP7 Adjustment Factors</i>					
Stratum	n	Wt'd Mean Phase 2		Ratio of Wt'd Means	SE % at 95%
		BA/ha (LIVE + Dead PL + Dead B)	Phase 1 BA/ha		
PI%≤30% - Immature	28	31.947	23.873	1.338	18%
PI%≤30% - Mature	73	51.259	30.543	1.678	11%
PI%>30%	38	45.001	38.717	1.162	13%

Table 3.4: Stage 1 VDYP7 Adjustment Factors for trees/ha

<i>Trees/ha @7.5cm+ dbh utilization: VDYP7 Adjustment Factors</i>					
Stratum	n	Wt'd Mean Phase 2 TPH		Ratio of Wt'd Means	SE % at 95%
		(LIVE + Dead PL + Dead B)	Phase 1 TPH		
PI%≤30% - Immature	28	1096.3	771.0	1.422	32%
PI%≤30% - Mature	73	1556.4	746.4	2.085	19%
PI%>30%	38	1530.5	1020.2	1.500	20%

Note that for the BA and TPH adjustment, the Phase 2 ground values included not only live trees but also dead pine and dead balsam, to correspond with the treatment requested by timber supply branch. The BA and TPH ratios based on live trees only (or live trees + dead pine only or live trees + dead balsam only) are provided in Table 3.5 for reference. Note that the age and height adjustment factors are based on live trees only since ages and heights were not collected for dead trees.

Table 3.5: Ratios calculated based on a Phase 2 value for: a) live trees + dead balsam + dead pine; b) live trees only; c) live trees + dead balsam only; d) live trees + dead pine only.

Phase 2 basis for adjustment	Stratum		
	PI%≤30% - Immature	PI%≤30% - Mature	PI%>30%
Age	1.196	0.846	0.872
Height	1.045	0.988	0.946
a) BA Live+Dead B+Dead PL	1.338	1.678	1.162
b) BA Live only	1.119	1.137	0.833
c) BA Live+Dead B	1.328	1.654	0.882
d) BA Live+Dead PL	1.130	1.162	1.113
a) TPH Live+Dead B+Dead PL	1.422	2.085	1.500
b) TPH Live only	1.239	1.424	1.073
c) TPH Live+Dead B	1.408	2.071	1.174
d) TPH Live+Dead PL	1.253	1.438	1.399

3.1.2 Second stage VDYP7 adjustment: Volume net DW2 at 12.5 cm+ dbh utilization

The adjustment factors for height, age, BA and TPH were input into the VDYP7 model which then produced an expanded output set of inventory attributes. Only one adjustment factor, for volume net decay & waste² at the 12.5cm+dbh utilization level, was directly developed from the available attributes produced by VDYP7 at this stage. The ratios developed for this particular volume were applied to volumes at other utilizations. Although the VDYP7 software has been designed to also accept second stage adjustment factors for other attributes, including Lorey height and basal area at 12.5cm+ dbh, adjustment factors for these additional attributes were not computed at this time.

Table 3.6 below shows the VDYP7 volume adjustment factors by strata for the Fort St. James Forest District population of interest. The ground volumes used to compute the adjustment ratio of means were based on net factored volumes to which the NVAF values had been applied in the compilation. All volumes are net decay and waste² only, at the 12.5cm+ dbh utilization level for all polygons. The Phase II volumes include dead balsam and dead lodgepole pine. Scatterplots showing the volume relationship and the residuals from the adjustment are provided in Appendix E.

The second stage volume adjustment ratios (for net DW2 volume at 12.5 cm+ utilization) and their sampling errors are listed in Table 3.6. All of the other volumes produced by VDYP7 (wsv_075, wsv_125, vcu_125, vd_125 and vdw_125) are adjusted using the the ratio for net DW2 at 12.5 cm+ utilization to ensures consistency among the utilizations. The ratios for lorey_ht075 and BA_12.5 were both set to 1 for the adjustment process. The calculation programs were provided by Gitte Churlish.

Table 3.6: Stage 2 VDYP7 Adjustment Factors

<i>Volume/ha @12.5cm+ dbh utilization net DW2: VDYP7 Adjustment Factors</i>					
Stratum	n	Wt'd Mean	Wt'd Mean	Ratio of Wt'd Means	SE % at 95%
		Phase 2 Vol/ha (LIVE + Dead PL+Dead B)	Phase 1 Attribute- adjusted vol/ha		
PI%≤30% - Immature	32	186.761	165.718	1.127	24%
PI%≤30% - Mature	74	301.990	273.234	1.105	13%
PI%>30%	38	307.655	311.627	0.987	16%

3.1.3 Volume impact analysis by stratum

The weighted adjusted and unadjusted volumes and their impact ratios and sampling errors are provided in Table 3.7 by stratum. The stratum “PI%≤30% - Mature” has the biggest effect and its ratio is 1.724 indicating that after adjustment, the VDYP7 volume will increase by about 72%. This appears to be driven largely by the basal area adjustment (Table 3.3). For this stratum in particular, including the dead balsam into the adjustment had a significant effect on the adjustment ratios and hence the volume impact. The volume impact ratio for stratum “PI%>30%” is 1.051, indicating that

the adjustment had very little net effect on volume in this stratum. Table 3.8 provides more detailed information about the volume impacts of including the dead B and dead PL in the adjustment process. Further analysis may be necessary for dealing with the dead tree issues.

Table 3.7: Volume Impact, by stratum

Volume/ha @12.5cm+ dbh utilization net DWB: Estimated VDYP7 Adjustment Impact					
Stratum	n	Wt'd Mean Phase 2 Vol/ha (LIVE + Dead PL+DeadB)	Wt'd Mean Phase 1 Unadjusted vol/ha	Estimated volume impact ratio	SE % for volume impact (at 95%)
PI%≤30% - Immature	32	182.449	122.995	1.483	24%
PI%≤30% - Mature	74	294.863	171.021	1.724	13%
PI%>30%	38	300.934	286.254	1.051	14%

Table 3.8: Impact of dead balsam and dead lodgepole pine, by stratum

Volume/ha @12.5cm+ dbh utilization net DWB: Estimated VDYP7 Adjustment Impact and Dead Pine and Dead Balsam %										
Stratum	n	Wt'd Mean Phase 2 Vol/ha (LIVE + Dead B+Dead PL)	Wt'd Mean Phase 2 Vol/ha (LIVE only)	Wt'd Mean Phase 2 DEAD B vol/ha	Wt'd Mean Phase 2 DEAD PL vol/ha	Wt'd Mean Phase 1 Unadjusted vol/ha	Estimated volume impact ratio based on LIVE+Dead B+Dead PLvolume	Estimated volume impact ratio based on LIVE only volume	Dead B vol/ha as a % of LIVE+dead B +Dead PL	Dead PL vol/ha as a % of LIVE+dead B +Dead PL
PI%≤30% - Immature	32	182.449	156.054	25.413	0.981	122.995	1.483	1.269	14%	1%
PI%≤30% - Mature	74	294.863	226.674	61.782	6.407	171.021	1.724	1.325	21%	2%
PI%>30%	38	300.934	231.022	4.223	65.688	286.254	1.051	0.807	1%	22%

3.2 Overall estimated volume impact and estimated sampling error

The VPIP for the Fort St. James Forest District specified a target sampling error of ±10% (at a 95% probability level) for total volume for VT polygons in the target population. To provide an indication of the sampling error achieved in the VDYP7 adjustment process, a comparison of the overall estimated adjusted inventory volume and the overall estimated VDYP7 unadjusted sample inventory volume was made. The overall ratio of these values and its standard error were computed using the formula for a separate ratio estimate after a pre-stratified PPSWR sample.

The overall impact of a VDYP7 adjustment was estimated to be 1.413 with a 9.0% sampling error (at the 95% confidence level). This level of sampling error was within the target of $\pm 10\%$ set in the project VPIP.

3.3 Inventory file adjustment for the VDYP7 statistical adjustment

The adjustment was applied to the target population specified by Timberline and the population volume impact was computed. The ratio of adjusted volume to unadjusted volume in the population was 1.421. Impacts on the population by age class and stratum are shown in Appendix F. The actual volume impact on the population was quite close to the estimated impact (1.421 vs. 1.413). Adjusted yield curves were produced for the target population in support of the timber supply analysis for this unit.

Note that Timberline's target population covered only 72% of the population of interest defined for this adjustment analysis. The remaining 28% of the population of interest was not adjusted but yield curves (without an adjustment) were still produced for timber supply purposes.

4. CONCLUSIONS AND RECOMMENDATIONS

The VDYP7 statistical adjustment analysis of the Fort St. James Forest District was completed as an adjunct to the work done by Timberline in their VDYP6 adjustment analysis of this management unit. The target population of interest, stratification, sampling weights, sample status, the compilation of the Phase II ground samples and the NVAF values were all provided by Timberline in correspondence with their VDYP6 analysis.

The VDYP7 analysis of this sample suggests that both age and height are underestimated (by about 20% and 5% respectively) in "PI \leq 30% - Immature" stands. For "PI \leq 30% - Mature" and "PI $>$ 30%" stands, age in particular and height to a lesser degree are both overestimated. The analysis also suggests that basal area/ha is underestimated in all strata but this underestimation is greatest in the "PI \leq 30% - Mature" stratum where the adjustment suggests that there should be over 65% more basal area/ha. Note that the basal area adjustment incorporates dead B and dead PI into the inventory. Including the dead B basal area has a major impact on the basal area adjustment factor, particularly in the "PI \leq 30% - Mature" stratum.

After the adjustment of age, height, basal area and trees/ha, the VDYP7 still underestimated volume in all strata except for where pine was more than 30% of the stand, as reflected by the Stage 2 volume adjustment factors.

When the scatterplots of the data were examined some potential trends in the residuals plots were observed, particularly for the "PI \leq 30% - Mature" stratum which may have been age-related. *Given the relatively large number of samples in this stratum an investigation of post-stratification alternatives may have been able to address some of the bias trend concerns.* However, since the VDYP7 adjustment was intended to directly follow the VDYP6 work done by Timberline, further post-stratification was outside the scope of this analysis.

The VDYP7 statistical adjustment based on this sample will increase current VDYP7 volume in immature stands with less than or equal to 30% pine by about 48%, on average. For mature stands with a similar pine component, the adjustment will increase the volume by over 70%. Note that this analysis incorporated the dead pine and dead balsam component of the stands into the adjustment of the per hectare attributes (i.e. BA, TPH and volume). For stands with greater than 30% pine, the adjustment is expected to increase volumes by about 5%.

Overall, the adjustment was estimated to increase total VDYP7 volume by about 41%. The sampling error for this estimated adjustment impact was $\pm 9\%$ (at the 95% confidence level) which met the target specified in the VPIP. When the adjustment was applied to the target population, the calculated impact of the adjustment was about 42%, which is quite close to what was expected based on the sample.

The Mountain Pine Beetle infestation is widespread in this unit. In addition, “ongoing outbreaks of western balsam bark beetle and two-cycle spruce budworm over the past decade, coupled with various heart rot diseases common to over-mature sub-alpine fir-leading stands, have contributed to extensive stand mortality and significant loss of merchantable volume”² in balsam (*Abies lasiocarpa*) stands. To facilitate the current TSR approach for representing the effect of Mountain Pine Beetle and balsam decline on the inventory and to ensure consistency with that approach, timber supply requested that dead pine and dead balsam volume be included with live volume in the adjustment. Hence the Phase II compiled values for all per hectare-based adjustments (i.e. basal area/ha, trees/ha, volume/ha) included dead balsam and dead pine. The magnitude of the dead component in these stands was significant, particularly for balsam. In mature stands comprised of less than about 30% pine, the samples indicated that dead balsam accounts for over 20% of the total volume for live trees (all species) plus dead balsam and dead pine. *The impact of including dead volume in the analysis should be considered in terms of degradation of volume and value of these stands. A process is currently being developed for dealing with the dead volume component of the inventory in a more systematic and consistent manner.*

It is also recommended that further analysis be undertaken to investigate the high proportion of dead balsam in the ground samples and to examine the implications of including this volume in the adjustment. It is suggested that a comparison analysis be done using only live trees for the attribute adjustment and yield projections.

² “Prince George Timber Supply Area Timber Supply Review: Data Package”, p. 35, Ministry of Forests & Range, Forest Analysis and Inventory Branch. November 2008. 56pp.

5. APPENDIX A: DATA ISSUES

This table documents questions and responses regarding the Fort St. James Forest District VRI data that were made during the course of the analysis.

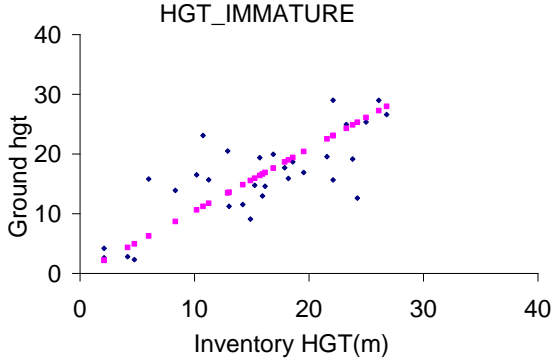
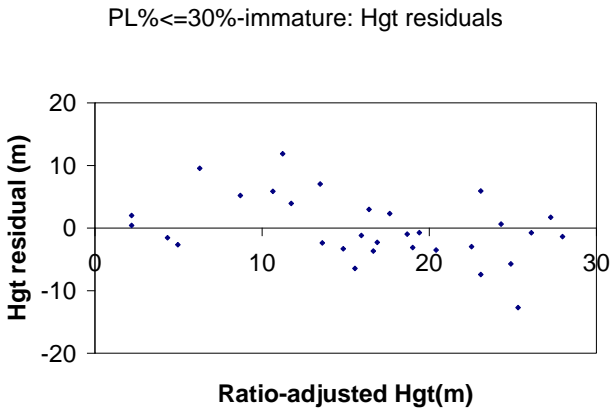
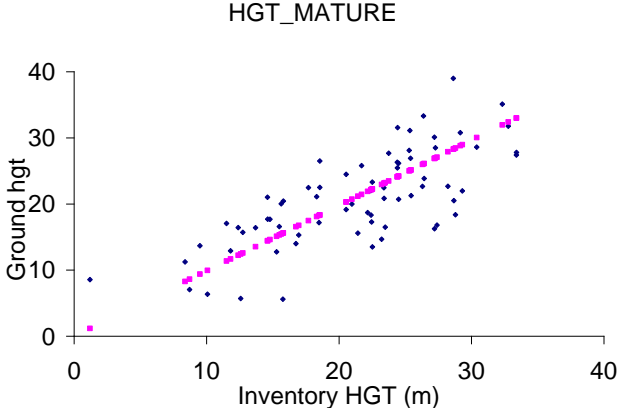
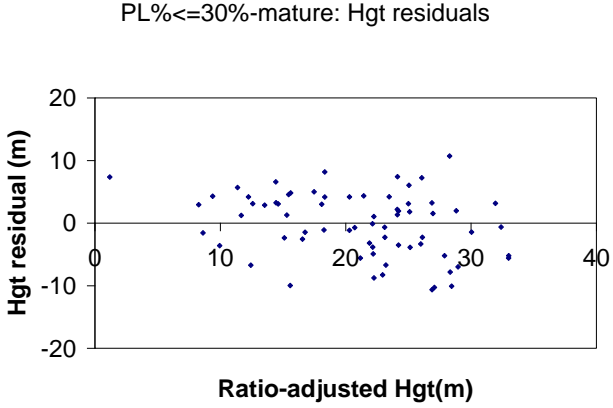
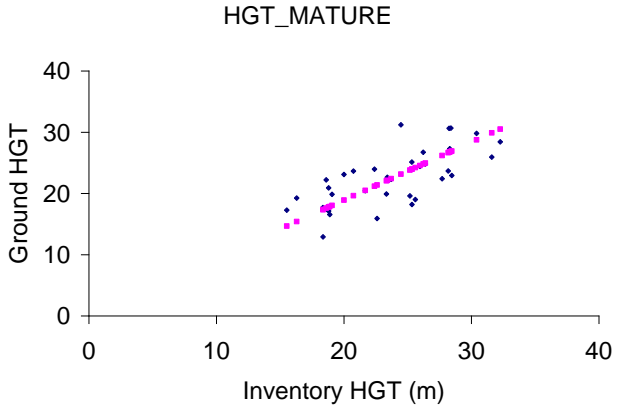
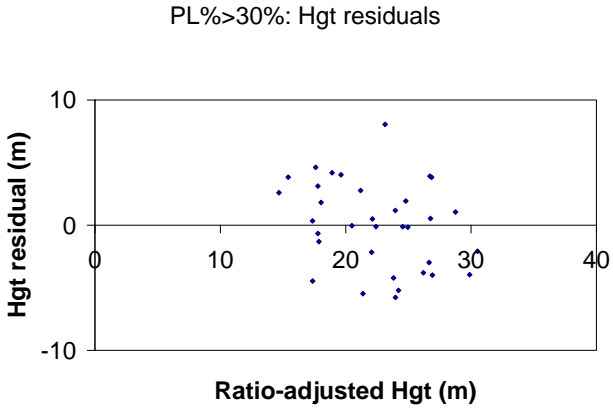
<i>Sample #</i>	<i>Issue</i>	<i>Action/Resolution</i>
155	extra for 128	
154	extra for 133	Weight of 7855.95 used for this analysis (as per Timberline)
156	extra for 56	
153	extra for 66	
152	extra for 77	Weight of 12878.27 used for this analysis (as per Timberline)
151	extra for 8	
154	extra for 133	
77	Harvested, replaced with 152	
66	Harvested, replaced with 153	
133	Harvested, replaced with 154	
56	Harvested, replaced with 156	
80	Harvested, replaced with 157, but 157 is unsafe	
128	replaced with 155	
35	Tim's inventory data issue	Inventory data not available; sample excluded from analysis.
86	Tim's inventory data issue	Inventory data not available; sample excluded from analysis.
111	Tim's inventory data issue	Inventory data not available; sample excluded from analysis.
78	Unsafe	Dropped
139	Unsafe	Dropped
157	Unsafe and VN(Veg, but No tree)	Dropped

6. APPENDIX B: INVENTORY AND GROUND ATTRIBUTES USED IN THE ADJUSTMENT

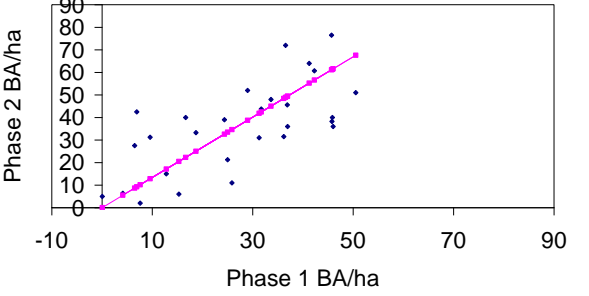
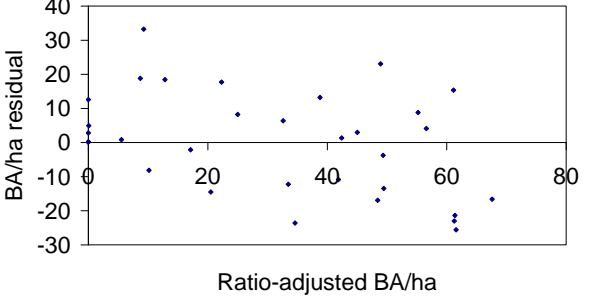
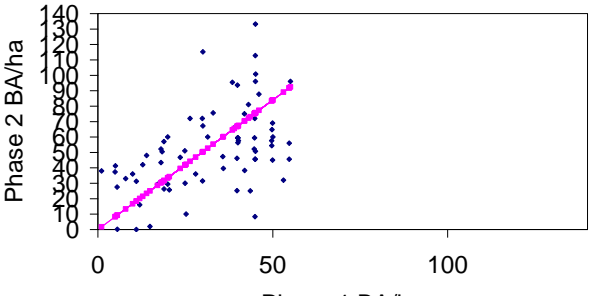
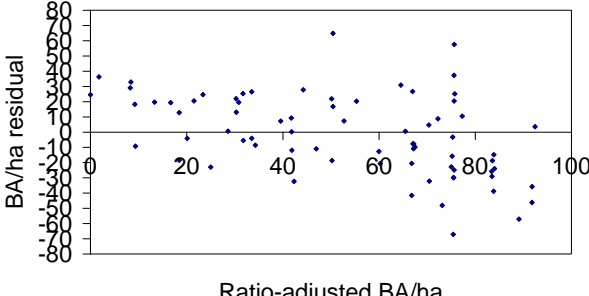
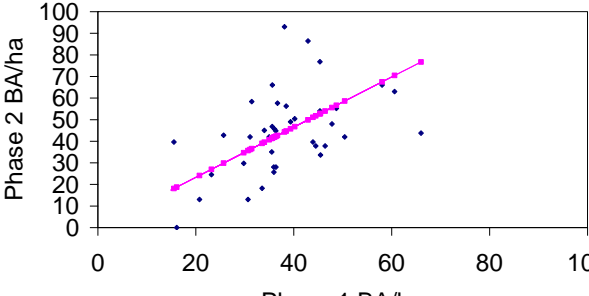
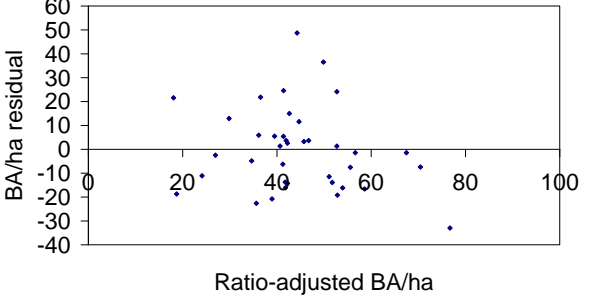
PDF version of spreadsheet to be merged into final PDF of this document

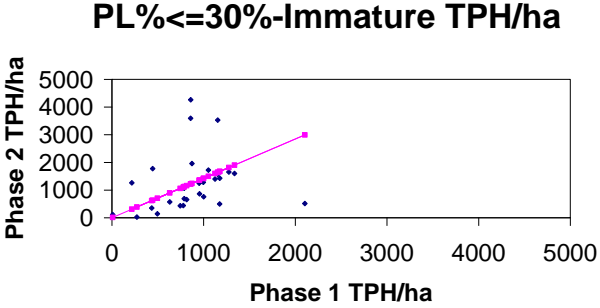
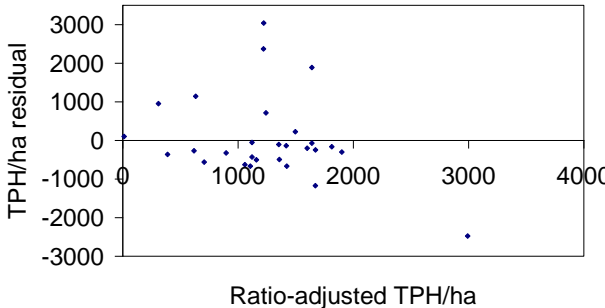
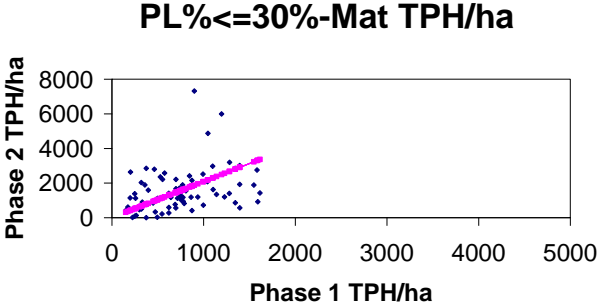
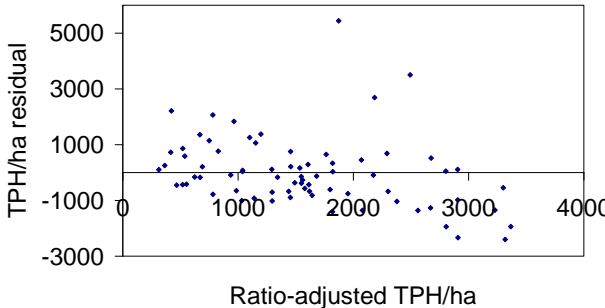
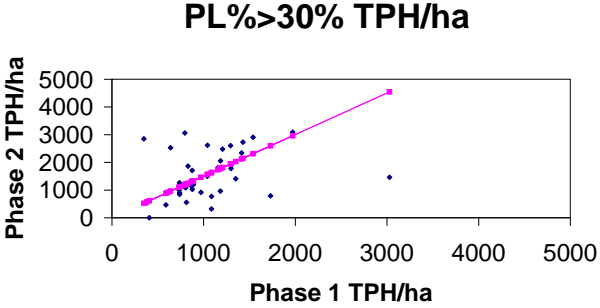
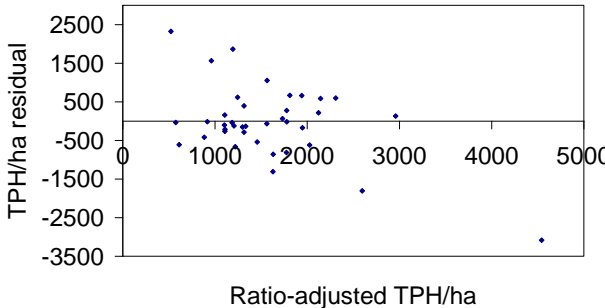
7. APPENDIX C: VDYP7 SCATTER PLOTS & RESIDUALS FOR AGE & HEIGHT (STAGE 1 ADJUSTMENT)

	<p>PL%<=30%-immature: Age residuals</p>
<p>Fig. 1: PL%<=30% - Immature. Phase 1 and Phase 2 age relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 2: PL%<=30% - Immature. Age residuals (Phase 2 age – adjusted Phase 1 age) vs. adjusted Phase 1 age.</p>
<p>Age_mature</p>	<p>PL%<=30%-mature: Age residuals</p>
<p>Fig. 3: PL%<=30% - Mature. Phase 1 and Phase 2 age relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 4: PL%<=30% - Mature. Age residuals (Phase 2 age – adjusted Phase 1 age) vs. adjusted Phase 1 age.</p>
<p>Age_PL>30%</p>	<p>PL%>30%: Age residuals</p>
<p>Fig. 5: PL%>30%. Phase 1 and Phase 2 age relationship. The</p>	<p>Fig. 6: PL%>30%. Age residuals (Phase 2 age – adjusted</p>

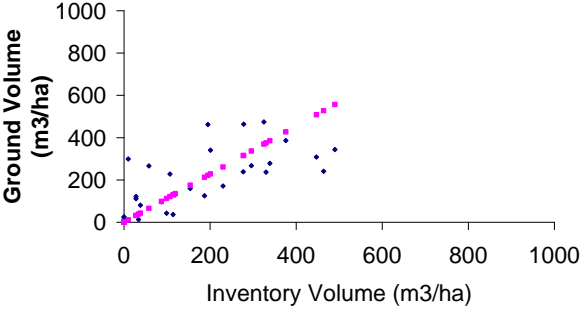
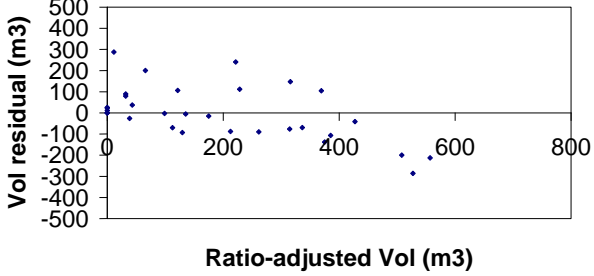
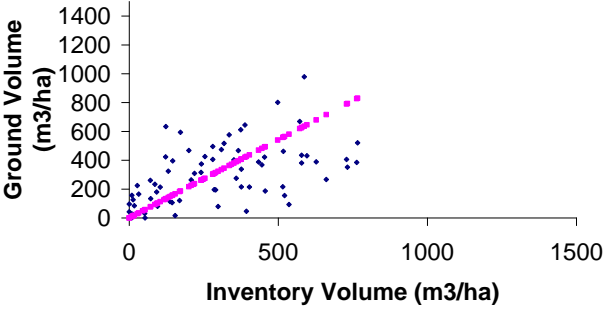
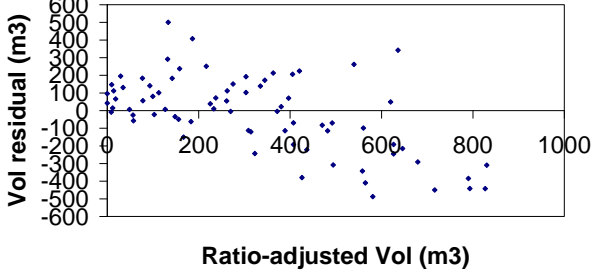
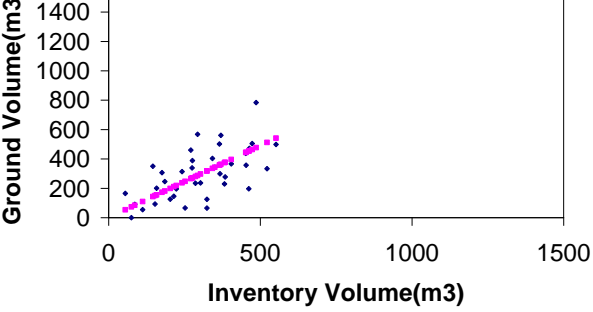
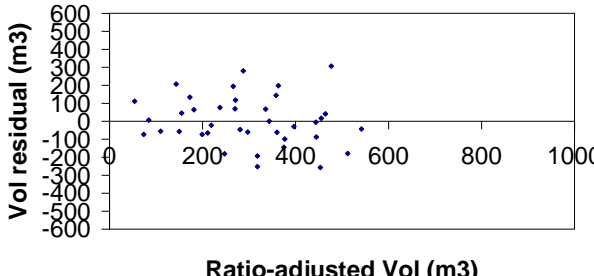
<p>line on the graph corresponds to the adjustment ratio.</p> 	<p>Phase 1 age) vs. adjusted Phase 1 age.</p> 
<p>Fig. 7: $PI\% \leq 30\%$ - Immature. Phase 1 and Phase 2 height relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 8: $PI\% \leq 30\%$ - Immature. Height residuals (Phase 2 height – adjusted Phase 1 height) vs. adjusted Phase 1 height.</p>
	
<p>Fig. 9: $PI\% \leq 30\%$ - Mature. Phase 1 and Phase 2 height relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 10: $PI\% \leq 30\%$ - Mature. Height residuals (Phase 2 height – adjusted Phase 1 height) vs. adjusted Phase 1 height.</p>
	
<p>Fig. 11: $PI\% > 30\%$. Phase 1 and Phase 2 height relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 12: $PI\% > 30\%$. Height residuals (Phase 2 height – adjusted Phase 1 height) vs. adjusted Phase 1 height.</p>

8. APPENDIX D: VDYP7 SCATTER PLOTS & RESIDUALS FOR BA & TPH (STAGE 1 ADJUSTMENT)

<p>PL%<=30%-Immature BA/ha Scatterplot</p> 	<p>PL%<=30%-Immature: BA/ha residuals</p> 
<p>Fig. 1: P1%<=30% - Immature. Phase 1 and Phase 2 basal area/ha (BA) relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 2: P1%<=30% - Immature. Age residuals (Phase 2 BA – adjusted Phase 1 BA) vs. adjusted Phase 1 BA.</p>
<p>PL%<=30%-mature BA/ha Scatterplot</p> 	<p>PL%<=30%-mature: BA/ha residuals</p> 
<p>Fig. 3: P1%<=30% - Mature. Phase 1 and Phase 2 basal area/ha relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 4: P1%<=30% - Mature. Age residuals (Phase 2 BA – adjusted Phase 1 BA) vs. adjusted Phase 1 BA.</p>
<p>PL%>30% BA/ha Scatterplot</p> 	<p>PL%>30%: BA/ha residuals</p> 
<p>Fig. 5: P1%>30%. Phase 1 and Phase 2 basal area/ha relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 6: P1%>30%. Age residuals (Phase 2 BA – adjusted Phase 1 BA) vs. adjusted Phase 1 BA.</p>

 <p>PL%<=30%-Immature TPH/ha</p> <p>Phase 2 TPH/ha</p> <p>Phase 1 TPH/ha</p>	<p>PL%<=30%-Immature: TPH/ha residuals</p>  <p>TPH/ha residual</p> <p>Ratio-adjusted TPH/ha</p>
<p>Fig. 7: P1%<=30% - Immature. Phase 1 and Phase 2 trees/ha (TPH) relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 8: P1%<=30% - Immature. TPH residuals (Phase 2 TPH – adjusted Phase 1 TPH) vs. adjusted Phase 1 TPH.</p>
 <p>PL%<=30%-Mat TPH/ha</p> <p>Phase 2 TPH/ha</p> <p>Phase 1 TPH/ha</p>	<p>PL%<=30%-mature: TPH/ha residuals</p>  <p>TPH/ha residual</p> <p>Ratio-adjusted TPH/ha</p>
<p>Fig. 9: P1%<=30% - Mature. Phase 1 and Phase 2 TPH relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 10: P1%<=30% - Mature. TPH residuals (Phase 2 TPH – adjusted Phase 1 TPH) vs. adjusted Phase 1 TPH.</p>
 <p>PL%>30% TPH/ha</p> <p>Phase 2 TPH/ha</p> <p>Phase 1 TPH/ha</p>	<p>PL%>30%: TPH/ha residuals</p>  <p>TPH/ha residual</p> <p>Ratio-adjusted TPH/ha</p>
<p>Fig. 11: P1%>30%. Phase 1 and Phase 2 TPH relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 12: P1%>30%. TPH residuals (Phase 2 TPH – adjusted Phase 1 TPH) vs. adjusted Phase 1 TPH.</p>

9. APPENDIX E: VDYP7 SCATTER PLOTS & RESIDUALS FOR VOLUME (STAGE 2 ADJUSTMENT)

	
<p>Fig. 1: $PI\% \leq 30\%$ - Immature. Phase 1 and Phase 2 volume relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 2: $PI\% \leq 30\%$ - Immature. Volume residuals (Phase 2 vol/ha – adjusted Phase 1 vol/ha) vs. “attribute-adjusted” Phase 1 vol/ha.</p>
	
<p>Fig. 3: $PI\% \leq 30\%$ - Mature. Phase 1 and Phase 2 volume relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 4: $PI\% \leq 30\%$ - Mature. Volume residuals (Phase 2 vol/ha – adjusted Phase 1 vol/ha) vs. “attribute-adjusted” Phase 1 vol/ha.</p>
	
<p>Fig. 5: $PI\% > 30\%$. Phase 1 and Phase 2 volume relationship. The line on the graph corresponds to the adjustment ratio.</p>	<p>Fig. 6: $PI\% > 30\%$. Volume residuals (Phase 2 vol/ha – adjusted Phase 1 vol/ha) vs. “attribute-adjusted” Phase 1 vol/ha.</p>

10. APPENDIX F: POPULATION DISTRIBUTIONS PRE- AND POST-ADJUSTMENT

Figure 1: Age class distribution of Fort St. James Forest District population of interest, pre- and post-adjustment.

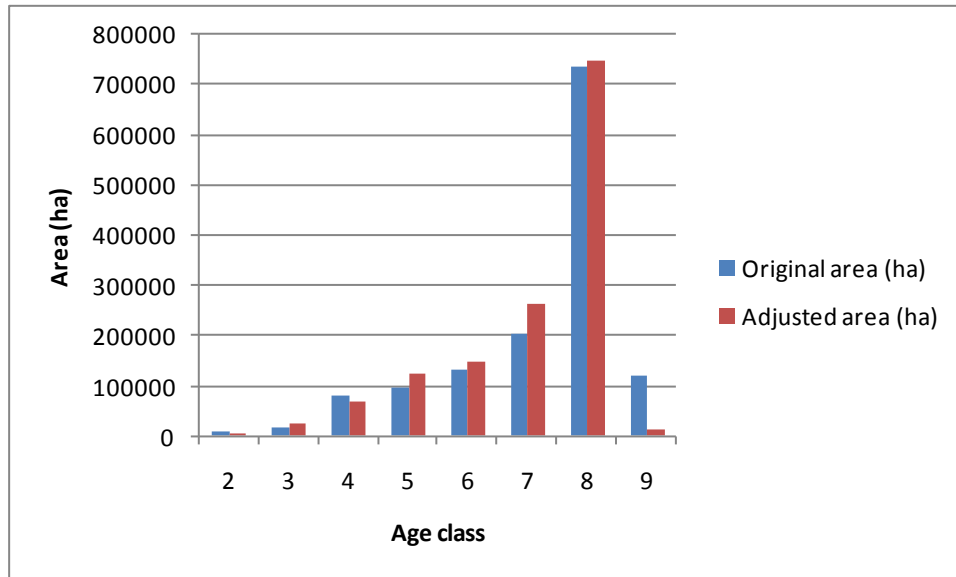


Figure 2: Average vol/ha by age class for population of interest, pre- and post-adjustment.

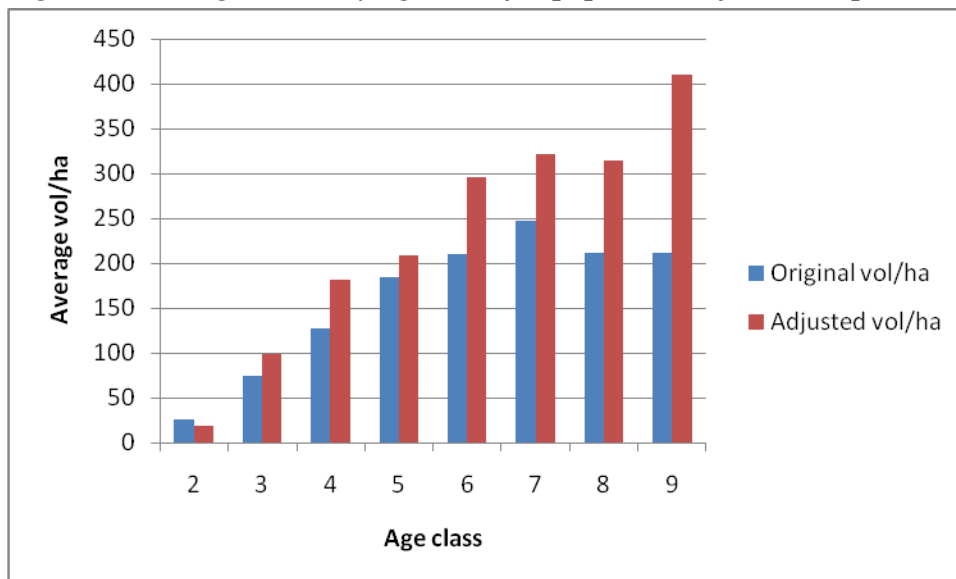


Figure 3: Total volume by age class for population of interest, pre- and post-adjustment.

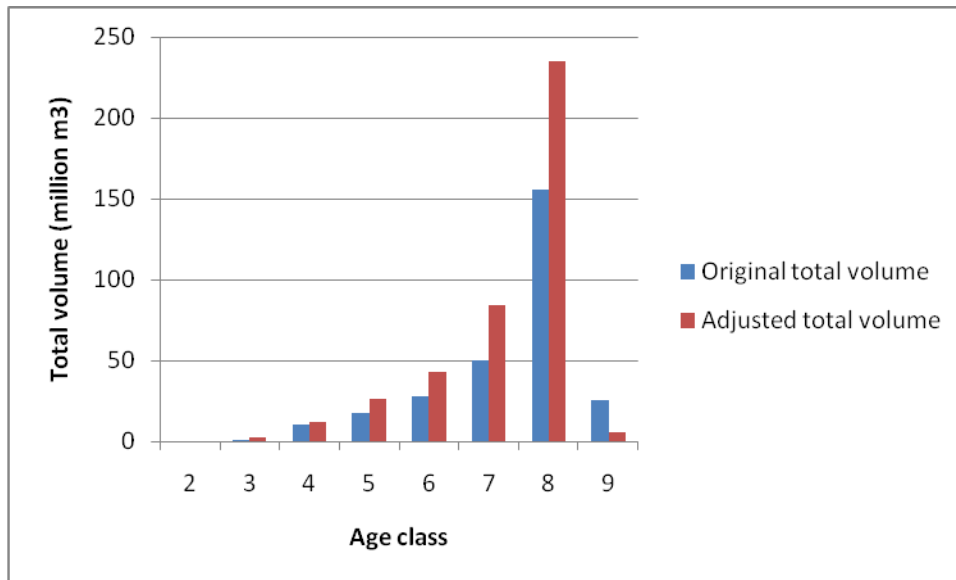


Figure 4: Average vol/ha by stratum for population of interest, pre- and post-adjustment.

