TFL 1 VEGETATION RESOURCES INVENTORY ATTRIBUTE ADJUSTMENT

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Prepared for

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1.0 INTRODUCTION

This document describes the methods used to adjust stand ages, heights, site index, and volumes in the TFL 1 inventory data base, using the results of the 1999 and 2000 field seasons' vegetation resources inventory (VRI). The attribute adjustment procedures used are those described in Draft version 4.4 April 2002 of " Vegetation Resources Inventory Attribute Adjustment Procedures ", Ministry of sustainable Resource Management, Terrestrial Information Branch.

2.0 BACKGROUND

During 1999 and 2000, 289 VRI plot clusters were established in productive stands within TFL 1. The 1999 sample included stands between 10 and 110 years old, based on the inventory age. During 1999 and 2000, 150 VRI plot clusters were established in productive stands within TFL 1. Sample selection procedures were described in the Sterling Wood Group Report " TFL 1 Ground Sampling Plan for Second Growth Productivity Estimates ", April 1999. Since then, the area of TFL 1 has been reduced by transferring lands to the Nisgaa' land claim settlement. The number of clusters remaining in TFL 1 are 118.

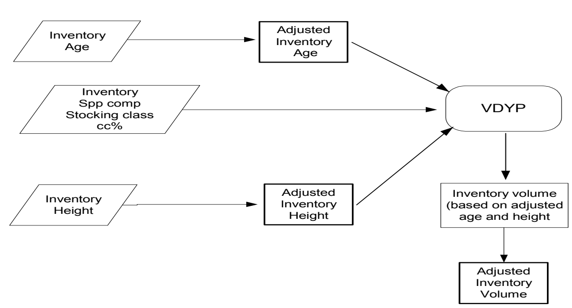
Attribute adjustment is the process of analyzing the relationship between existing estimates and ground sampling data; and then adjusting the estimated data. The adjusted attributes form the interim VRI attribute database.

Attribute adjustment has two objectives:

1. to obtain overall averages and totals for an inventory unit that are statistically unbiased;
2. to adjust the existing or new photo-interpreted estimates to obtain individual polygon values.

Height, age, and volume attributes are continuous variables. Site index calculated from height and age is also a continuous variable. Attribute adjustment of these continuous variables for this project is done by ratio technique. The Fraser Protocol is an interim adjustment process developed by the Ministry of Sustainable Resource Management. Figure 1 outlines this process.

Figure 1: Data and Process Flowchart for the Fraser Protocol



3.0 PROCEDURE

3.1 DATA ASSEMBLY

The inventory data used to determine attribute adjustments were from the original inventory files used in 1999 to determine the VRI sample population. These files were projected to 1999 for age and height comparisons. The original sample population was not pre-stratified, and therefore pre-stratification weights are not required for this data analysis.

The first step was to determine the VRI leading species age and height data to be used to calculate adjustment factors. Leading species is determined by basal area per hectare at the >4.0cm DBH level. The matching of age and height data for each sample is categorized by the following cases as described by the Fraser Protocol:

- Case 1: The Phase II (VRI ground sample) leading species is the same as the Phase I (inventory photo estimated attribute) leading species at the species code level.
- Case 3: The Phase II leading species is the same as the Phase I leading species at the Sp0 code level (genus level, as detailed in Volume 8, Chapter 6 of the Inventory Manual).
- Case 5: The Phase II leading species is matched with Phase I leading species regardless of species, provided that both are hardwood or both are conifer.
- Case 7: None of the above cases apply, and the VRI sample is dropped from the age/height adjustment analysis. These samples, which include the polygons where the Phase II leading species is hardwood and the Phase I leading species is conifer, or vice versa, are considered incompatible for age and height analysis, but are considered useful for volume and basal area attribute analysis.

- The Fraser Protocol also documents criteria for Cases 2, 4, and 6, which do not apply to TFL 1 where inventory data are used. The case is identified for each data match used in the adjustment process, as shown in Appendix 1. For TFL 1, 41% of the samples are case 1; 22% are case 3; 28% are case 5; and 9% are case 7.

For each of the 108 matched samples, the VRI height and age were paired with the existing inventory height and age. For the VRI sample, height was the average height of the T, L and S trees, for the leading species. VRI age was the average age of all T, L and S trees for the leading species.

Appendix 1 is a set of tables, by stratum, which identify the VRI and inventory attributes for each matched sample, and the age, height, and volume ratio calculations.

3.2 POST- STRATIFICATION

Post-stratification of the samples was done in an effort to provide more precise adjustment for specific forest types. The strata were determined based on the following criteria:

- biogeoclimatic classification as used in the sample design;

- biological similarity;
- similar relationships in the ratios between VRI and inventory values;
- number of samples available.

Comparison of ratios, plotting of age and height ratios against age and the above criteria resulted in the selection of five strata as shown in Table 1. The five strata account for 12% of the TFL 1 productive land base. The 11 deciduous matched samples were not used in the attribute adjustment process because deciduous leading stands were excluded from the Timber Harvesting Land Base (THLB).

Table 1: TFL 1 Analysis Strata and Sample Distribution

Stratum	BEC Zone	Subzone/ Variant	Leading Species	Age Range (years)	Number of Samples
1	CWH	ws1 vm	deciduous	all	11
2	CWH MH	ws1 ws2 Vm Mm2	conifer	10-30	39
3	CWH MH	ws1 ws2 Vm Mm2	conifer	31-110	41
4	ICH	Mc1 Mc2	conifer	10-30	9
5	ICH	Mc1 Mc2	conifer	31-110	8

3.3 AGE AND HEIGHT ADJUSTMENT RATIO CALCULATIONS

Age and height adjustment factors were calculated for strata 2 - 5 based on the relationship of the ground attribute to the inventory attribute, using the ratio-of-means approach as described in the Fraser Protocol.

The ratios are calculated for height and age as follows:

$$\text{Ratio} = \frac{\text{weighted mean ground sample attribute}}{\text{weighted mean inventory attribute}}$$

Because pre-stratification was not carried out for this population, the mean attributes all have equal weight. Table 2 identifies the age and height ratios obtained for each stratum.

Table 2: TFL 1 Age and Height Adjustment Ratios

Stratum	BEC Zone	Subzone/ Variant	Leading Species/ Age	Mean Ground Age	Mean Inventory Age	Mean Ground Height	Mean Inventory Height	Age Ratio	Height Ratio
2	CWH	ws1 ws2	Conifer 10-30	26.23	22.05	10.22	5.88	1.189	1.736
3	CWH MH	ws1 ws2 Vm Mm2	Conifer 31-110	62.77	55.83	15.99	11.78	1.124	1.357
4	ICH	Mc1 Mc2	Conifer 10-30	31-110	25.77	22.67	9.92	5.5	1.137
5	ICH	Mc1 Mc2	Conifer 31-110	31-110	89.93	21.32	19.65	1.081	1.085

VRI results indicate that inventory heights are significantly underestimated in the 10-30 year range on TFL 1.

3.4 VOLUME RATIO CALCULATIONS

The volume adjustment was done with a two-step process.

1. The adjusted ages and heights for the samples in each of the four strata were used along with the original inventory species composition, crown closure, and stocking class to compute the attribute adjusted inventory volumes using VDYP (VDYP Batch ver. 6.6d). Inventory volumes are net decay, waste and breakage.

2. The volume adjustment ratio for each stratum was then calculated by:

$$\text{Ratio} = \frac{\text{mean ground vol / ha}}{\text{mean "attribute adjusted" inventory vol / ha}}$$

The ground volumes were the VRI compiled volumes defined as volume/hectare live top, stump, cruiser decay, waste and breakage (Vha_dwb) that were updated by the Ministry of Sustainable Resource Management in October 2001. Utilization levels are 12.5 for pine leading stands, and 17.5 for all other conifer species for both ground and attribute adjusted volumes.

For TFL 1, the mean attributes all have a weight of 1 since pre-stratification was not done for the VRI sample. Table 3 shows the volume ratios for the fourTFL 1 strata. These ratios were used in step two to adjust the attribute adjusted inventory volumes derived in the first step of the volume adjustment.

Table 3: TFL 1 Volume Adjustment Ratios

Stratum	BEC Zone	Subzone/ Variant	Leading Species/Age	Mean Adjusted VDYP Volume/ha	Mean Ground Volume/ha	Volume Ratio
2	CWH	ws1 ws2 Vm	Conifer 10-30	26.898	19.295	1.394
	MH	Mm2				
3	CWH	ws1 ws2 Vm	Conifer 31-110	123.472	157.0	0.786
	MH	Mm2				
4	ICH	Mc1 Mc2	Conifer 10-30	10.933	5.767	1.896
5	ICH	Mc1 Mc2	Conifer 31-110	160.590	238.070	0.674

These VRI results indicate that the attribute adjusted inventory volumes are underestimated for stands younger than 30 years and overestimated for stands between 30 and 110 years.

3.5 Adjustment Evaluation

Residual analysis was used to evaluate potential bias in the attribute adjustments. Scatter plots were produced for each of the strata age, height and volume adjustments as shown in the example in Figure 2. Residual plots for all strata are included in Appendix 3.

The Y axis shows the residual, which is the difference between the ground value and the adjusted inventory value. The X axis shows the adjusted attribute (age, height, or attribute adjusted inventory volume, multiplied by the adjustment ratio).

Figure 2: Age Residuals versus Adjusted Ages, Stratum 3

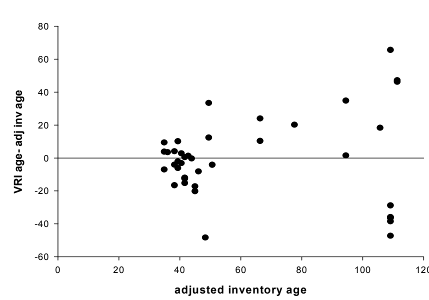
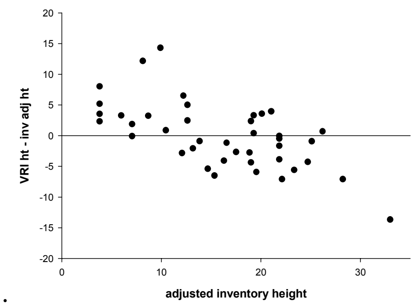


Figure 3 shows the corresponding scatter plot for height.

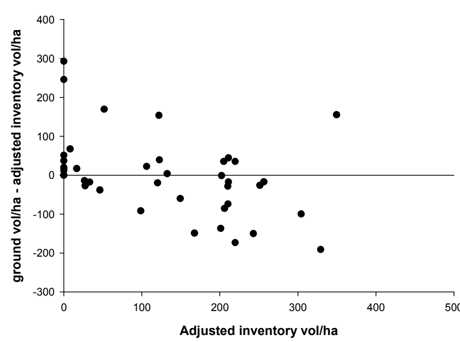
Figure 3: Height Residuals versus Adjusted Heights, Stratum 3



The downward trend in the height residual plot indicates some bias in the adjustment, namely overestimating the height in taller stands and underestimating the height in the shorter stands for this stratum.

Figure 4 shows the volume residual plot that corresponds to the age and height residual plots above. There appears to be little bias in the volume adjustment ratio.

Figure 4: Volume Residuals versus Adjusted Volumes, Stratum 3



4.0 INVENTORY FILE ADJUSTMENT

The TFL 1 inventory FIP file database was updated to 2001. The population to be adjusted was defined as the 2001 database productive landbase aged 10-110 years older that is included in the four described strata.

The productive landbase is defined by npforestdescriptor is null and npforestcode is 0. For TFL 1, 12% of the productive landbase is included in the adjustment. The unadjusted productive land has one or more of the following attributes:

- biogeoclimatic classification was not sampled by the VRI, including AT, ATp, IDFunn, ESSFvc, ESSFvcp, and unclassified;
- stand is less than 10 years old, with inventory age projected to 2001;
- deciduous leading stand;.
- Stand has attributes assigned from a silvicultural survey.

The post-stratification strata criteria used in the development of the adjustment factors were applied to the inventory database. The appropriate age and height adjustments, which are the adjustment ratios identified in Table 2, were then applied to each polygon in each stratum as follows:

- adjusted age = age adjustment ratio x inventory age
- adjusted height = height adjustment ratio x inventory height

Using the adjusted ages and heights and existing inventory attributes of species composition, crown closure, and stocking class from the inventory database, the inventory volume for each polygon is calculated using VDYP. These are the attribute adjusted inventory volumes. The volume adjustment ratios identified in Table 3 are then applied to each polygon in each stratum as follows:

- final adjusted volume = volume adjustment ratio x attribute adjusted inventory volume

An adjusted site index was calculated for each polygon from the adjusted height and adjusted age, using VDYP. The interim VRI attribute file includes columns for adjusted age, adjusted height, adjusted site index, and final adjusted volume.

5.0 IMPACT OF VRI ADJUSTMENT ON TFL 1

The following table shows the impact of using the Fraser Protocol for age, height, and volume adjustments for the adjusted portion of TFL 1 in terms of site index and merchantable volume. The pre-adjustment site index and volumes are generated by VDYP using the current inventory ages and heights. Site index and merchantable volumes are area weighted for the pre- and post adjustment comparisons.

Table 4: TFL 1 Site Index and Merchantable Volume Comparisons – Inventory File

Stratum	BEC zone	Subzone/ variant	Leading species/age	Average original SI	Average adjusted SI	Average original volume	Average adjusted volume
2	CWH	ws1 ws2 Vm	Conifer 10-30	17.0	19.3	2.7	54.7
	MH	Mm2					
3	CWH	ws1 ws2 Vm	Conifer 31-110	14.8	17.0	111.1	195.5
	MH	Mm2					
4	ICH	Mc1 Mc2	Conifer 10-30	15.9	18.6	1.2	14.5
5	ICH	Mc1 Mc2	Conifer 31-110	17.2	20.0	240.5	364.7

Note: site index and merchantable volume figures are area weighted

5.1 SAMPLING ERROR STATISTICS

The ground sampling work plans for both the old growth and the second growth Phase II sampling specified a precision target of ±10% for both age and height attributes. The precision expressed as a proportion of the mean is calculated as:

$$E = \frac{t * cv}{\sqrt{n}}$$

where: n = number of samples
t = students + value with 95% probability
cv = standard deviation expressed as proportion of the mean.

The resulting precision is shown in the following table.

	VRI Age	VRI Height
n	97	97
t	1.96	1.96
cv	0.769	0.460
e	15.3%	9.15%

These values show that the resulting sampling precision is 15.3% for age and 9.15% for height.

5.1.2 Overall Volume Impact

Total inventory volumes were calculated for the landbase that falls within the four defined VRI strata. As stated in Section 4.0, this area represents about 12% of the TFL 1 productive landbase. Volumes were calculated using VDYP bat ver. 6.6d, net decay, waste and breakage. Utilization is 12.5cm+ for pine leading stands, and 17.5cm+ for all other conifer species for both ground and inventory volume estimates. The productive forest area in the adjusted strata totals about 28,000 hectares in a total productive land base of 229,379 hectares.

Within these strata, the total original inventory volume is 2,311,325 cubic metres (83 cubic metres per ha). Total adjusted volume, based on volume ratios derived from VRI net factor volumes, is 4,358,914 cubic metres (157 cubic metres per ha). The volume adjustment increases the total volume estimate on the total productive forest land base by 2,047,589 cubic metres.

5.1.3 Summary Statistics

The following calculations were made to compare the overall ground volumes with the overall unadjusted inventory volume, and to determine the standard error for this ratio.

Volume	Combined total volume ratio	95% confidence interval for ratio	Sampling error as % of ratio	n	se
loss factor	1.45	1.222-1.677	9.4%	97	0.137

Dr. Peter Ott's (Ministry of Forests, Research Branch) formulae, taken from the January 2002 Documentation of Analysis for Vegetation Resources Inventory Statistical Adjustment, for the combined overall volume ratio estimates and variance were used as follows:

Notation

n_h – number of samples in h^{th} stratum, $h = 1,2,\ldots,H$

Z_h – area within h^{th} stratum (hectares)

$\hat{y}_{hj}$ – ground volume per hectare of j^{th} observation in h^{th} stratum, $j = 1,2,\ldots,n_h$

x_{hj} – photo-interpreted volume per hectare of j^{th} observation in h^{th} stratum

$\bar{y}_h$ – estimated mean ground volume per hectare in h^{th} stratum $= \frac{1}{n_h}\sum_{j=1}^{n_h}\hat{y}_{hj}$

$\bar{x}_h$ – estimated mean photo-interpreted volume per hectare in h^{th} stratum $= \frac{1}{n_h}\sum_{j=1}^{n_h}x_{hj}$

$\hat{y}_h$ – estimated total ground volume in h^{th} stratum $= Z_h \cdot \bar{y}_h$

$\hat{x}_h$ – estimated total photo-interpreted volume in h^{th} stratum $= Z_h \cdot \bar{x}_h$

$\hat{y}$ – estimated total ground volume for entire unit $= \sum_{h=1}^{H}\hat{y}_h$

$\hat{x}$ – estimated total photo-interpreted volume for entire unit $= \sum_{h=1}^{H}\hat{x}_h$

X – total photo-interpreted volume of entire population $= \sum_{h=1}^{H}\sum_{j=1}^{N_h}x_{hj}$

Combined Ratio Estimator	Its Standard Error
$\hat{R} = \frac{\hat{y}}{\hat{x}} = \frac{\sum_{h=1}^{H} Z_h \cdot \bar{y}_h}{\sum_{h=1}^{H} Z_h \cdot \bar{x}_h}$	$s.e.(\hat{R}) = \sqrt{\frac{1}{X^2}\sum_{h=1}^{H}\frac{Z_h^2}{n_h}s_h^2}$, where $s_h^2 = \frac{1}{n_h - 1}\sum_{j=1}^{n_h}\left(e_{hj} - \bar{e}_h\right)^2$, $e_{hj} = \hat{y}_{hj} - \hat{R}x_{hj}$, and $\bar{e}_h = \frac{1}{n_h}\sum_{j=1}^{n_h} e_{hj}$

1. ***Combined Total Volume Ratio Estimates***

   For this ratio, ground and inventory volumes are area weighted for the 6 strata, using mean volumes per strata derived from the sampled polygons. Ground volumes used were the new_nwb for net factor volumes and new_dwb for loss factor volumes. The mean inventory volume is the unadjusted, original inventory volume calculated by VDYP, net decay, waste and breakage, for the polygons sampled by the VRI.

   The combined overall volume ratio 1.45 includes strata 2,3,4, and 5.

2. ***Combined Volume Ratio***

   The sampling error of 9.4% of the combined total volume ratio is equivalent to a sampling error of 0.137.

3. ***Confidence Interval***

   The sample size of 97 is large enough to support the use of the normal approximation to calculate the confidence interval for the combined ratio. The 95% confidence interval was calculated from:

$$\hat{R}_c = \pm t_{0.05} S_{\hat{R}_c}$$

   For this sample, $t_{0.05}$ = 1.66 with 90 degrees of freedom and the standard error is 0.

Discussion

Our concerns regarding age and height adjustments are outlined in Section 5.1. Following discussion of these concerns with MSRM staff, the decision was made to adjust site index and volume only, without age or height adjustment. Subsequently, our concerns regarding volume adjustment in strata 1&2, and 3 are outlined in Section 5.1. For these two strata, the adjusted site index was added to the database, and final volume adjustment is based on the original inventory projected age and adjusted site index. The final strata specific volume adjustment ratios were not applied to strata 1 & 2 and 3.

For strata 4 to 7, adjusted site index and final adjusted volumes are added to the database. This included the application of the volume ratios generated from the VRI net factor ground volumes compared to the site index adjusted volumes.

A review of the appropriate volume adjustment ratios must be determined for the timber supply analysis. At some point in the timber supply analysis the MOF will have to choose between the net factor and the loss factor adjustment ratios.

Although the sampling error for the combined volume ratio appears satisfactory, the consultants have noted classification inconsistencies in the inventory that were brought to light by the VRI. The large age and height ratios identified by the VRI adjustment methodology show evidence of inconsistent inventory age and height information. Possible causes are:

- classification procedures in the original inventory;
- mid pointing of height and age classes together with repeated later adjustments;
- updating inventory attributes for young stands from silvicultural surveys;
- the possible presence of residual trees in stands for which there is no silvicultural record available.

If these inconsistencies are not addressed, project results and information derived from inventory height and age attributes may lose credibility in future field checks.

APPENDIX 6-1-1

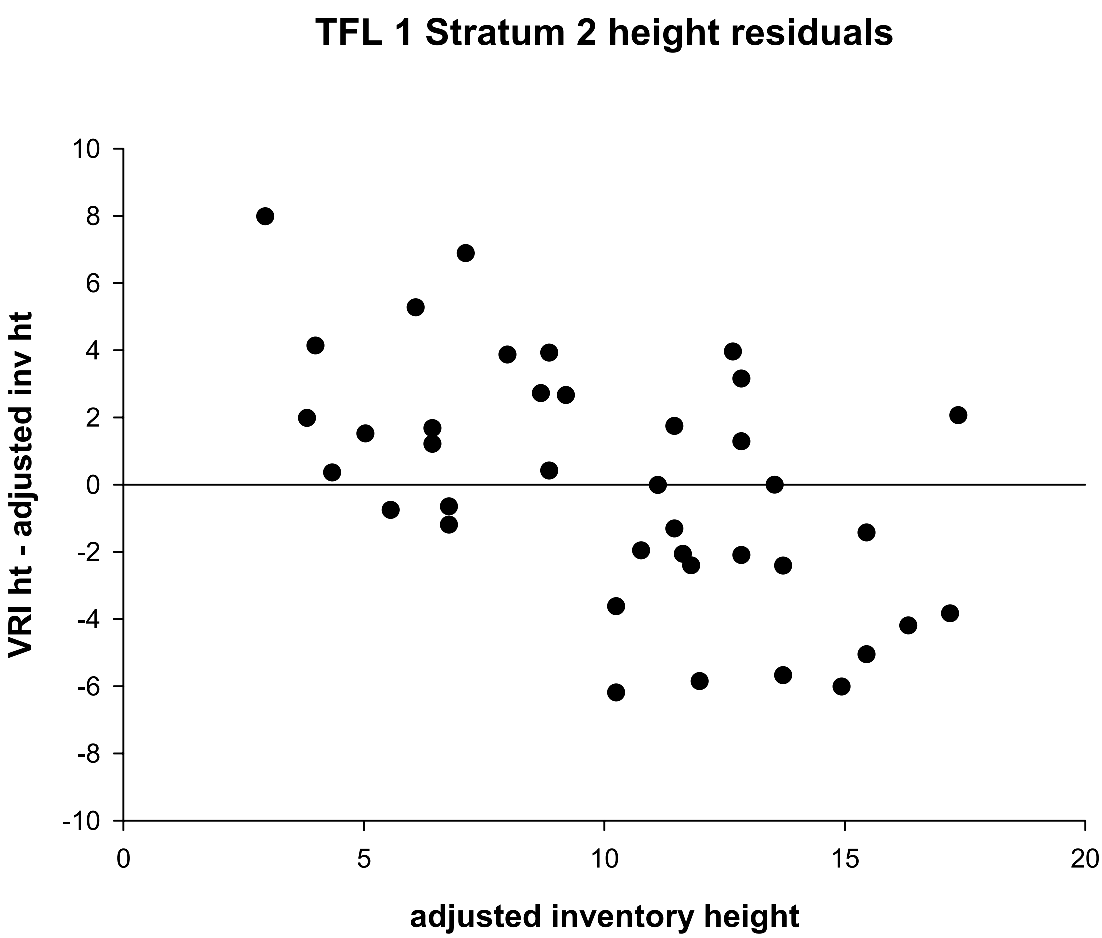
VRI Attribute Adjustment
Matched Plots

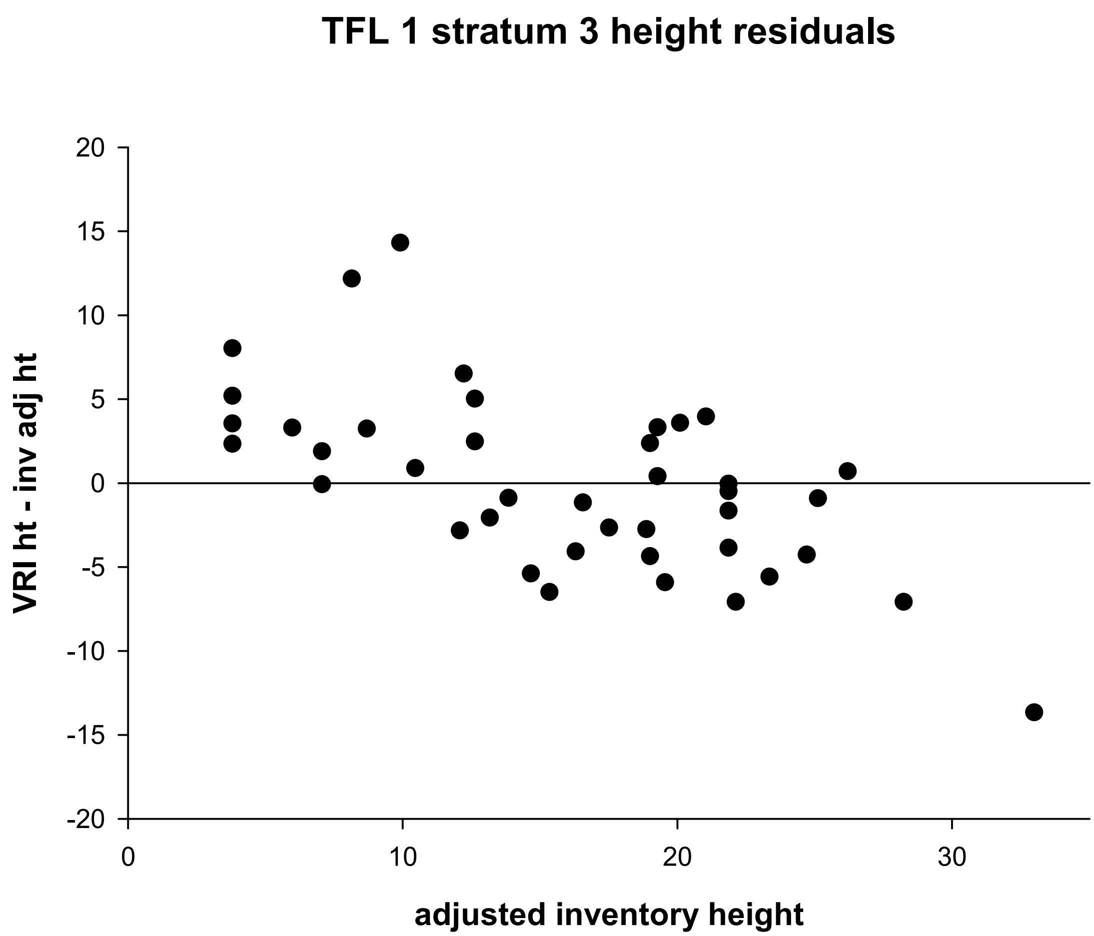
sample	map	poly	VRI leading spp	INV spp 1	Case	BEC	TLS age	INV age	TLS height	INV ht
1	093L021	45	Hw	H	3	MHmm2	82.87573	44	9.25	8.9
2	093L021	141	Hw	H	3	CWHws2	61.85596	44	21.375	14
3	093L031	226	Hw	H	3	CWHws2	76.66212	59	21.16	20.8
4	093L031	237	Hw	H	3	MHmm2	95.93303	84	12.21666	12
5	093L031	289	Hw	H	3	CWHws2	90.31423	59	17.65	9.3
6	093L031	648	Hw	HW	1	CWHws1	18.79833	12	4.8	3.2
8	093L041	507	Hw	H	3	CWHws1	174.6915	97	14.85	12.9
10	093L051	559	Sx	HW	5	CWHws2	12.00656	11	4.7	2.5
11	103I034	29	Dr	AC	5	CWHvm	29	32	24.3	18.4
12	103I034	43	Ac	AC	1	CWHvm	43.5	51	39.25	33.2
13	103I035	169	Ac	DR	5	CWHws1	37	38	30.6	20.2
14	103I035	223	Ac	AC	1	CWHws1	39.04587	40	40.6	31.6
17	103I035	294	Dr	AC	5	CWHws1	16.5	94	11.65	46
18	103I035	389	Ac	AC	1	CWHws1	51	87	27.6	33.4
19	103I036	176	Hw	H	3	CWHws1	19.99792	18	4.05	5.9
20	103I036	247	Hw	H	3	CWHws1	33.24654	35	14.64	14
22	103I036	440	Hw	H	3	CWHws1	42.08420	37	23.675	14.8
23	103I037	159	Ba	HW	5	CWHws1	22.37317	22	11.3	7.9
24	103I040	181	Hw	HW	1	CWHws1	19.66658	20	6.125	6.9
25	103I046	23	Dr	DR	1	CWHws1	47.33333	30	28.55	17.8
26	103I046	40	Ac	DR	5	CWHws1	36.5	49	26.65	21.9
27	103I046	67	Hw	HW	1	CWHws1	26.47506	21	10.75	7.4
28	103I047	107	Ba	HW	5	CWHws1	37.31931	36	13.63333	14.4
29	103I049	94	Hw	H	3	CWHws1	80.25731	97	18	16.1
30	103I049	136	Hw	H	3	CWHws1	70.54807	97	21.81666	16.1
31	103I049	136	Hw	H	3	CWHws1	61.78036	97	21.375	16.1
32	103I049	219	Hw	HW	1	CWHws1	29.99871	26	13.35	9.9
34	103I049	250	Hw	HW	1	CWHws1	22.77769	16	6.116666	3.9
35	103I049	412	Ba	HW	5	CWHws1	25.41011	25	12.125	9.4
36	103I049	551	Ba	HW	5	CWHws2	24.38592	27	8.8	6.2
37	103I049	687	Ba	H	5	CWHws1	33.95952	24	14.02	8.9
38	103I050	102	Hw	H	3	CWHws1	72.54025	97	20.44	18.2
39	103I050	122	Ac	AC	1	CWHws1	23.66666	19	24.03333	11.3
40	103I050	169	Hw	H	3	CWHws1	73.17764	97	16.125	13.9
41	103I050	205	Hw	PL	5	CWHws1	129.2812	84	19.325	24.3
42	103I050	554	Hw	HW	1	CWHws1	27.09164	28	8.92	8.6
43	103I050	837	Hw	BA	5	CWHws1	24.79934	23	11.35	3.5
44	103I056	42	Hm	HM	1	CWHws2	157.5868	99	11.93333	6.4
45	103I057	20	Ba	BA	1	CWHws1	51.55184	27	19.425	10
46	103I057	90	Ba	BA	1	CWHws1	43.31294	36	22.6	14.2
47	103I057	120	Ba	HW	5	CWHws2	124.0227	94	26.9	19.3
48	103I059	53	Hw	H	3	CWHws1	73.00389	97	20.2	16.1
49	103I059	196	Hw	HW	1	CWHws1	30.41313	26	13.53333	7.8
50	103I059	229	Cw	HW	5	CWHws1	15.99133	13	8.1	3.7
51	103I066	111	Sx	HW	5	CWHws1	29.65057	29	9.4	6.8
52	103I066	186	Ba	BA	1	CWHws1	44.25393	31	20.325	6
54	103I066	440	Ba	BA	1	CWHws1	43.50918	39	25	15.5
55	103I067	350	Hw	BA	5	CWHws1	37.93889	41	15.05	16.3
56	103I067	352	Ba	HW	5	CWHws1	46.45221	45	24.2	18.5
57	103I067	519	Hw	BA	5	CWHws1	0	43	17.76666	17.2
58	103I075	190	Hm	BA	5	MHmm2	158.4784	99	9.266666	4.4
59	103I086	60	Hw	HW	1	CWHws1	33.63019	29	16.63333	7.3
60	103I076	106	Hw	HW	1	CWHws1	21.64289	34	9.275	10.8
61	103I076	110	Pl	PL	1	CWHws1	37.19930	35	12.96	10.2
63	103I076	290	Pl	PL	1	CWHws1	39.48919	32	15.1	9.3
64	103I076	430	Hw	HW	1	CWHws1	44.07025	38	15.4	12.2

66	103I076	513	Pl	PL	1	CWHws1	38.67273	31	18.73333	9
67	103I076	606	Ba	HW	5	CWHws1	49.50505	35	24.22	7.3
68	103I076	629	Ba	BA	1	CWHws1	30.95134	28	12.78	5.1
70	103I076	754	Hw	HW	1	CWHws1	27.36210	29	10.4	8.9
72	103I085	79	Hw	HM	3	MHmm2	27.76691	40	8.95	5.2
73	103I085	101	Hw	HW	1	CWHws2	24.79736	40	6.98	5.2
75	103I086	295	Hw	HW	1	CWHws1	19.29711	27	9.566666	6.7
76	103I086	308	Pl	PL	1	CWHws1	20.09550	24	9.266666	5.1
77	103I086	472	Ba	HW	5	CWHws2	18.12896	19	11.4	5
78	103I086	618	Hw	HW	1	CWHws1	40.50766	25	16	7.4
79	103I086	629	Hw	HW	1	CWHws1	27.89365	31	11.1	9.7
80	103I086	636	Pl	PL	1	CWHws1	34.16475	34	11.33333	7.7
81	103I086	752	Ss	HW	5	CWHws1	26.07991	22	14.13333	7.4
86	103I094	62	Hw	HW	1	CWHws1	19.40553	18	6.62	5.9
87	103I096	429	Hw	BA	5	CWHws1	36.72741	25	14	4.1
88	103I096	526	Hw	HW	1	CWHws1	24.99305	27	11.86	5.3
89	103I096	536	Ba	SS	5	CWHws1	22.78719	12	5.8	2.2
90	103I096	620	Sx	PL	5	CWHws1	30.12934	24	10.15	6.6
91	103I096	629	Ac	AC	1	CWHws1	39	29	25.5	10.6
101	103P005	320	Hw	H	3	ICHmc2	163.6279	76	34.675	23.7
102	103P006	148	Ba	HW	5	ICHmc2	20.74788	14	4.6	3.4
103	103P006	273	Ba	BA	1	CWHws1	24.19484	22	10.93333	1.7
104	103P006	440	Ba	HW	5	CWHws2	24.56259	16	5.575	3.9
110	103P016	188	Hw	HW	1	ICHmc2	35.74897	29	14.95	8.9
111	103P016	316	Hw	HW	1	ICHmc2	104.0621	104	18.66	22.3
112	103P016	341	Hw	HW	1	ICHmc2	30.57011	23	10.46666	6.6
113	103P016	360	Hw	HW	1	ICHmc2	22.60572	24	9.725	7
115	103P016	513	Hw	HW	1	ICHmc2	32.52050	26	11.83333	7.8
119	103P028	388	Hm	H	3	MHmm2	97.75068	69	8.84	11.3
127	103P037	94	Hw	H	3	CWHws2	26.34580	37	11.825	2.8
128	103P037	98	Hw	H	3	CWHws2	29.42084	37	9	2.8
129	103P046	31	Pl	H	5	ICHmc2	33.96137	28	12.74	5.6
130	103P046	56	Pl	PL	1	ICHmc2	27.94097	31	10.925	9
131	103P046	70	Hw	HW	1	ICHmc2	12.93136	12	4.85	2.9
132	103P046	200	Hw	H	3	ICHmc1	86.52892	101	21.6	21.3
133	103P046	200	Hw	H	3	ICHmc1	64.71653	101	27.6	21.3
135	103P046	241	Hw	HW	1	ICHmc1	113.1586	110	22.38	21.1
136	103P046	258	Hw	H	3	ICHmc1	133.6772	91	9.733333	15.1
137	103P046	292	Hw	HW	1	ICHmc2	18.24973	23	6.65	4.3
140	103P046	474	Pl	S	5	ICHmc2	24.61719	25	13.475	3
144	103P047	105	Hw	H	3	CWHws2	29.02548	37	6.14	2.8
145	103P047	108	Hw	H	3	CWHws2	29.63157	37	7.35	2.8
146	103P056	50	Bl	H	5	ICHmc1	77.05455	99	25	23.4
147	103I034	4	Ac	AC	1	CWHvm	36.75	46	37.35	33.7
148	093L031	624	Hw	HW	1	CWHws1	16.15414	12	6.55	2.9
150	103I096	323	Pl	PL	1	CWHws1	19.17499	16	7.633333	3.7
151	103I040	385	Hw	HW	1	CWHws1	24.83958	19	11.1	6.4
152	103I037	156	Ba	HW	5	CWHws1	24.99961	22	8.04	7.9
153	103I050	239	Pl	HW	5	CWHws1	29.69235	23	13.2	6.6
154	103I086	98	Ba	HW	5	CWHws1	34.16477	24	11.85	4.6
160	103I050	758	Hw	H	3	CWHws1	39.77865	29	8.125	2.3
165	103I067	58	Hw	HW	1	CWHws1	42.28687	34	19.68	14.2

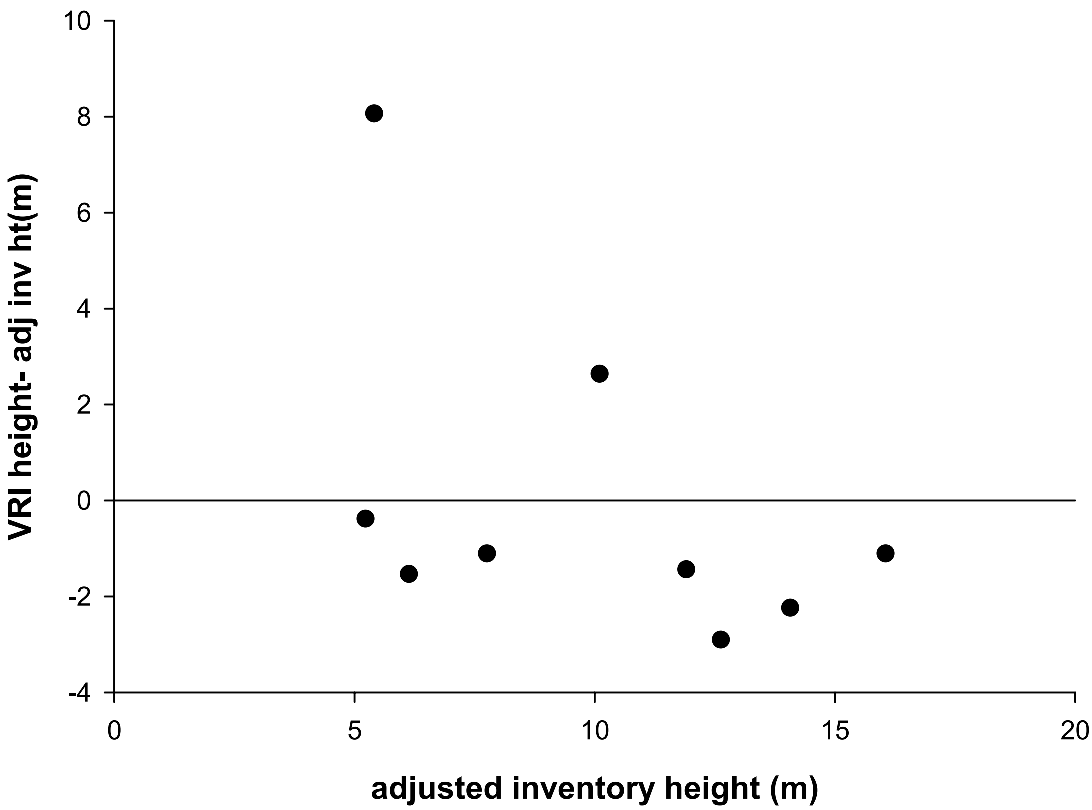
APPENDIX 6-1-2

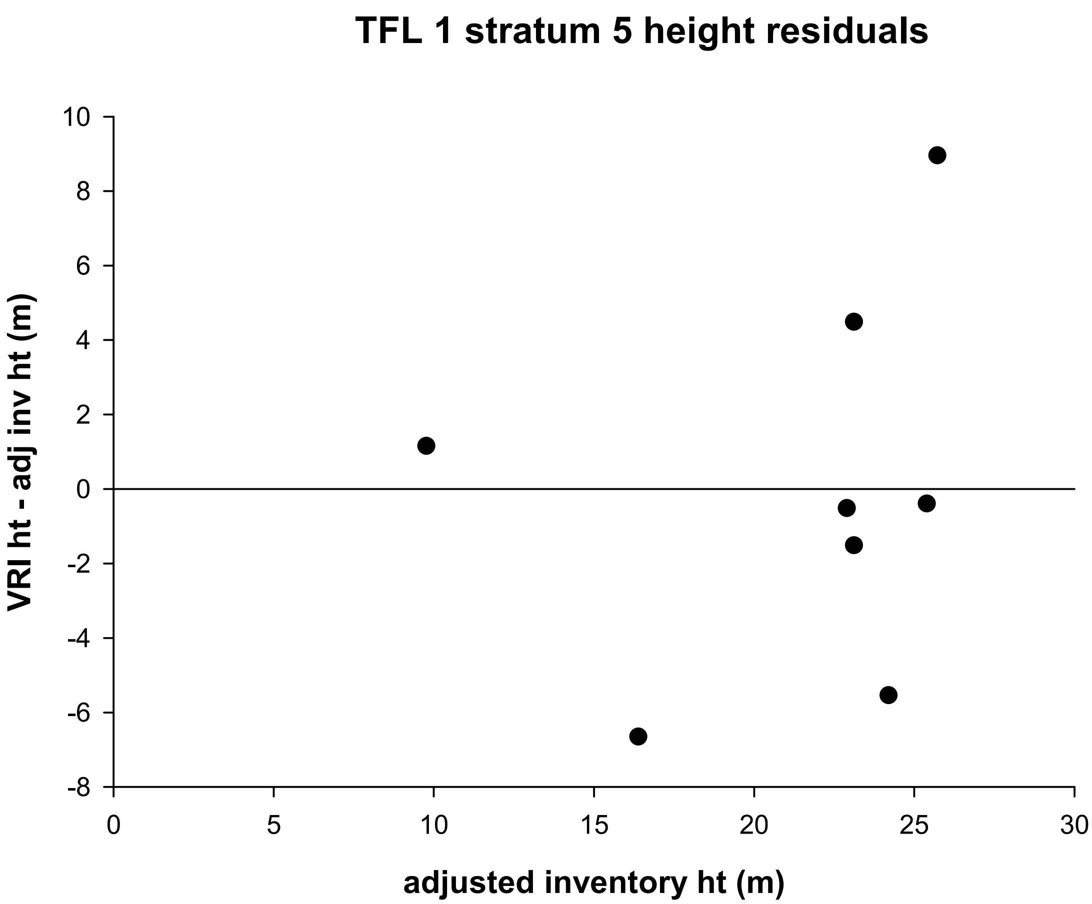
Residual Plots – Age, Height and Volume

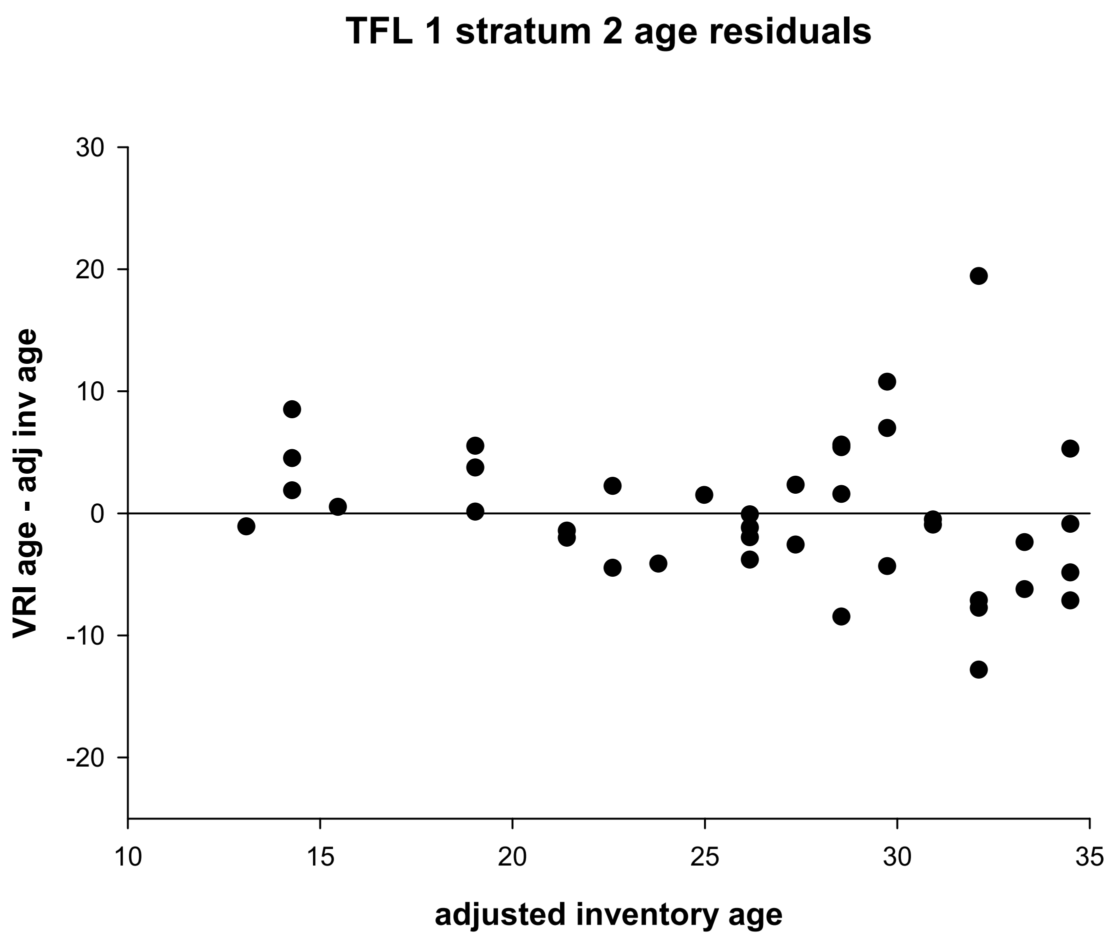

TFL 1 Stratum 2 height residuals
VRI ht - adjusted inv ht
adjusted inventory height
10
8
6
4
2
0
-2
-4
-6
-8
-10
0
5
10
15
20

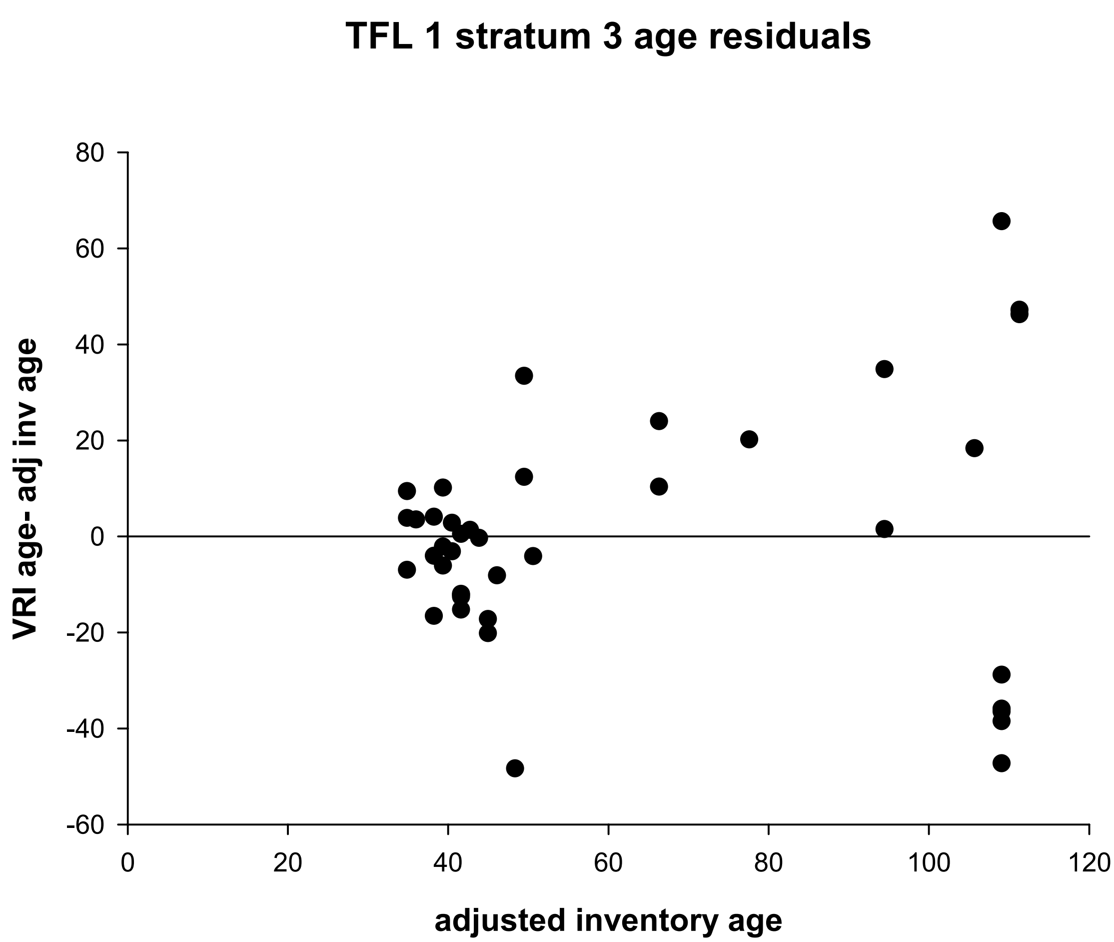

TFL 1 stratum 3 height residuals
VRI ht - inv adj ht
20
15
10
5
0
-5
-10
-15
-20
0
10
20
30
adjusted inventory height

TFL 1 stratum 4 height residuals

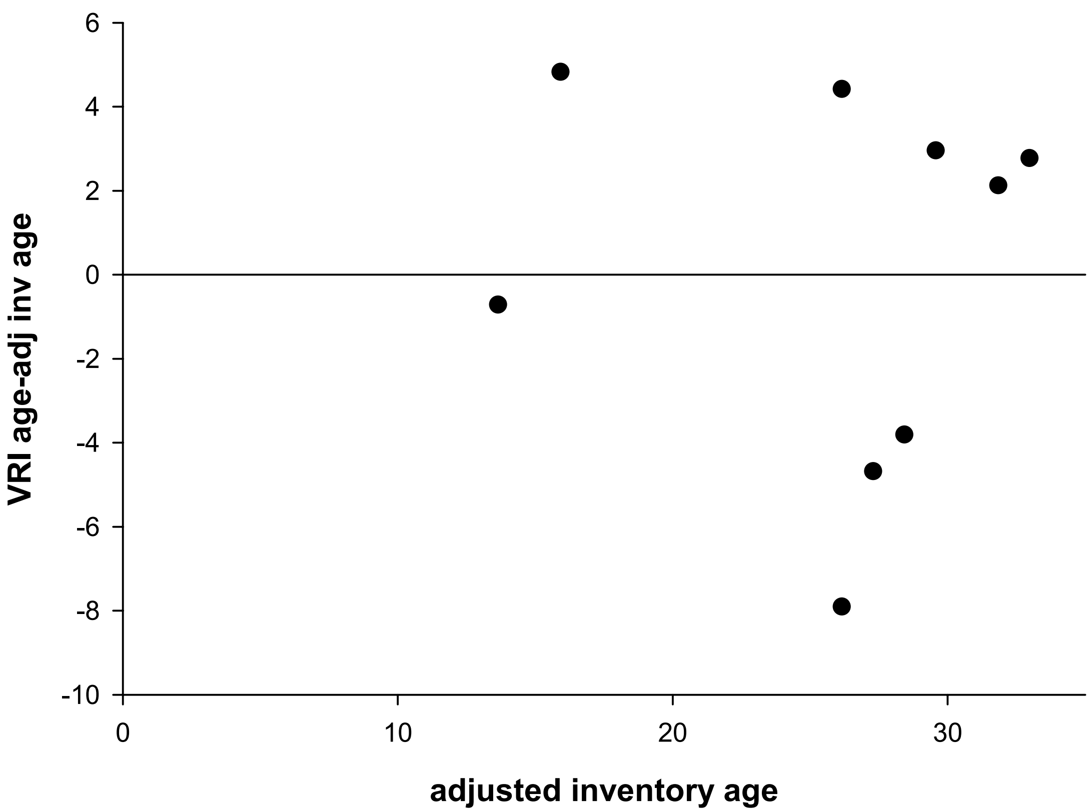


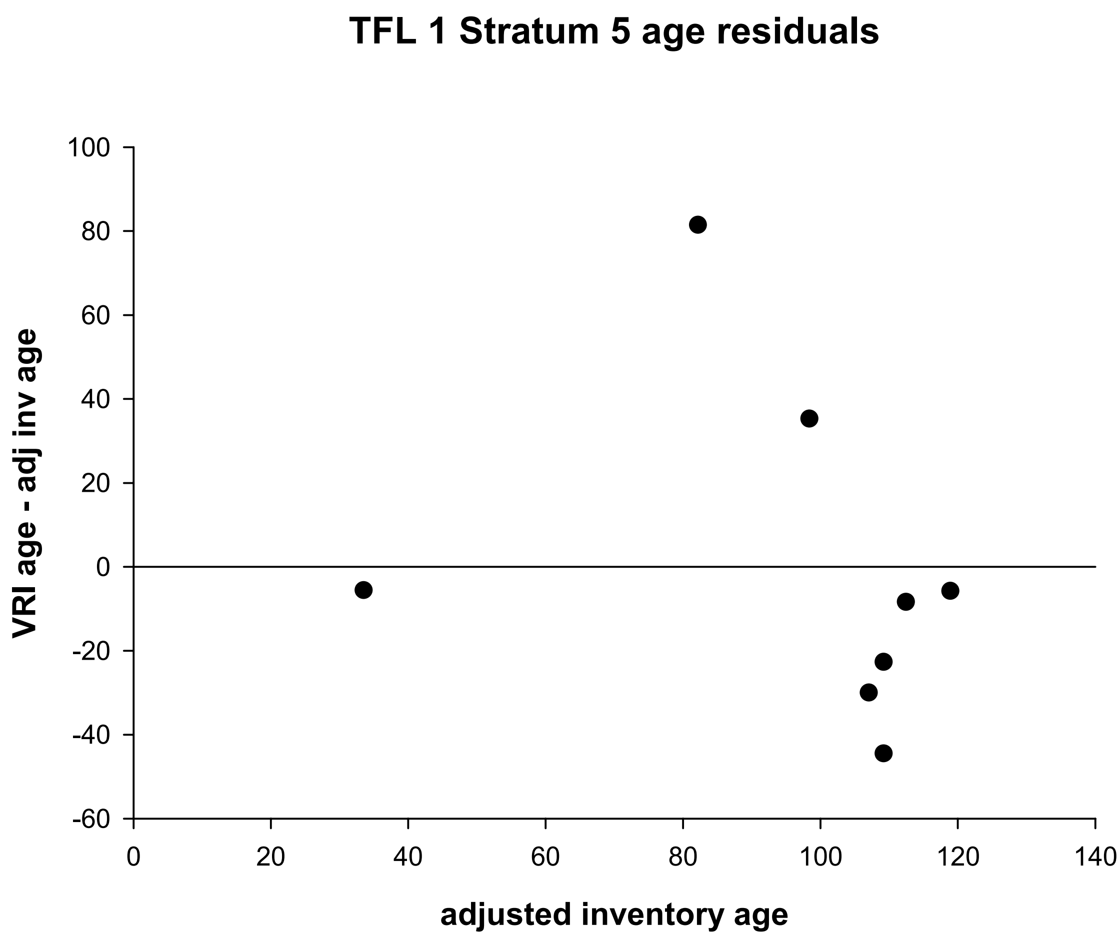

TFL 1 stratum 5 height residuals
10
8
6
4
2
0
-2
-4
-6
-8
VRI ht - adj inv ht (m)
0
5
10
15
20
25
30
adjusted inventory ht (m)


TFL 1 stratum 2 age residuals
VRI age - adj inv age
30
20
10
0
-10
-20
10
15
20
25
30
35
adjusted inventory age

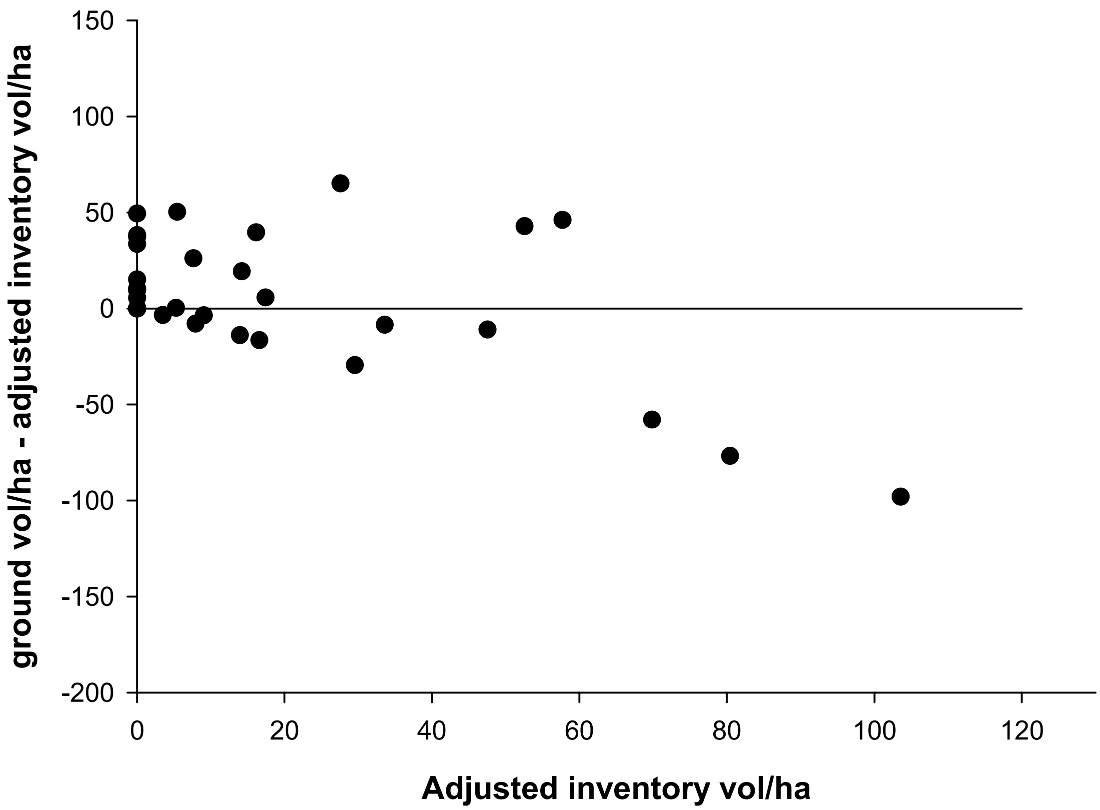

TFL 1 stratum 3 age residuals
80
60
40
20
0
-20
-40
-60
VRI age- adj inv age
0
20
40
60
80
100
120
adjusted inventory age

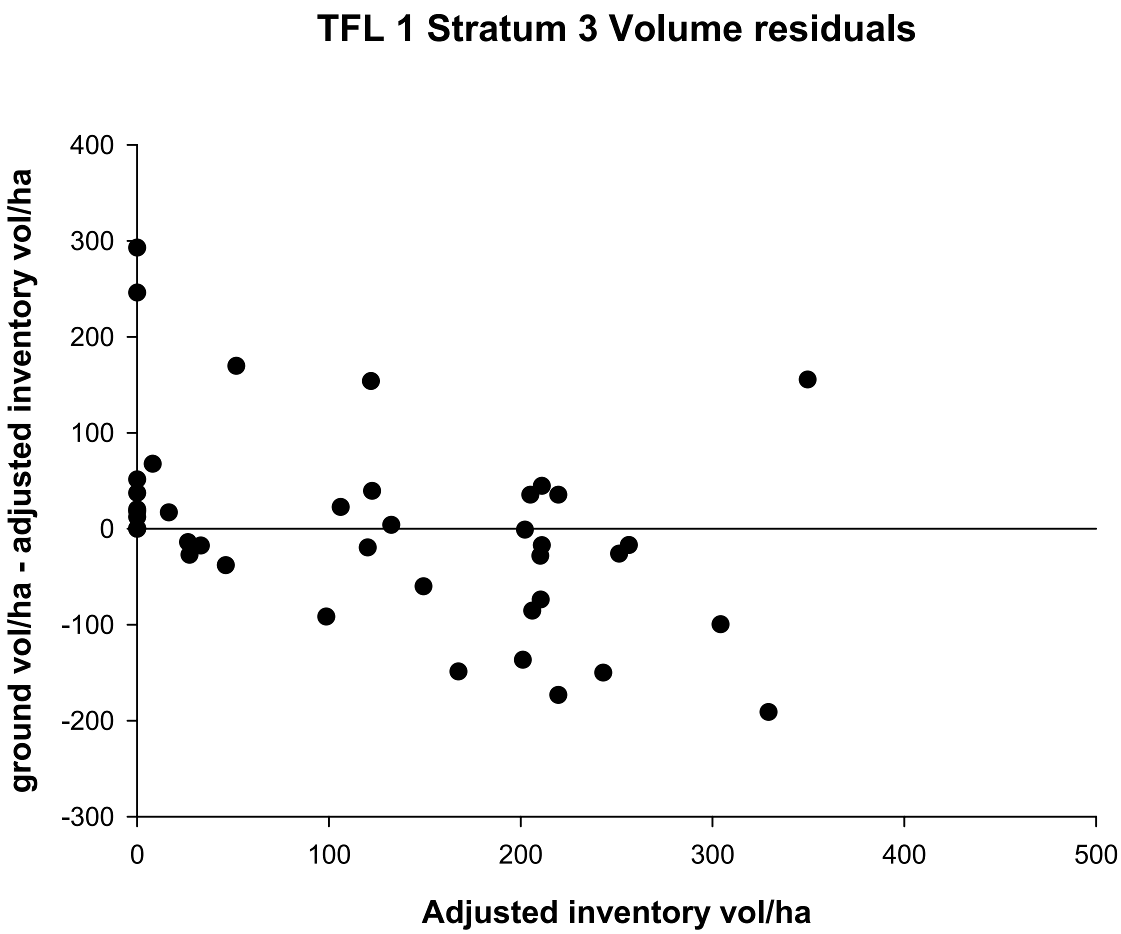
TFL 1 Stratum 4 age residuals



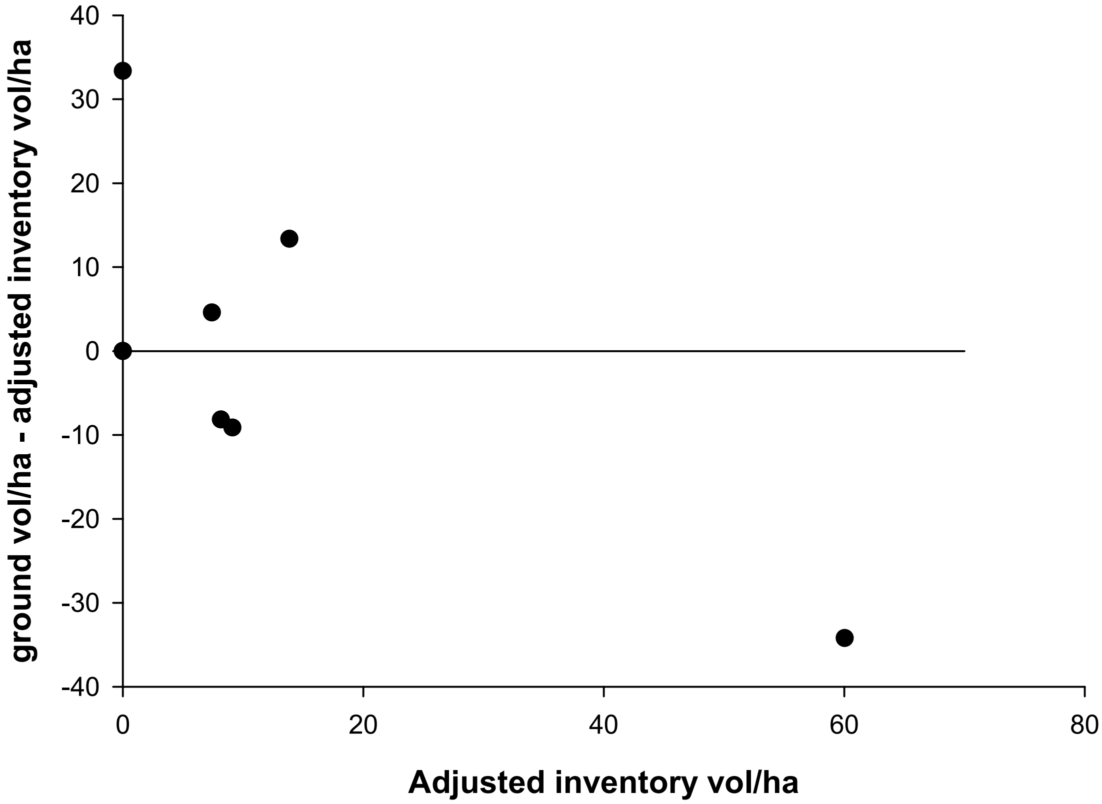

TFL 1 Stratum 5 age residuals
VRI age - adj inv age
100
80
60
40
20
0
-20
-40
-60
0
20
40
60
80
100
120
140
adjusted inventory age

TFL1 Stratum 2 Volume Residuals




TFL 1 Stratum 3 Volume residuals
ground vol/ha - adjusted inventory vol/ha
400
300
200
100
0
-100
-200
-300
0
100
200
300
400
500
Adjusted inventory vol/ha

TFL 1 Stratum 4 Volume residuals



TFL 1 Stratum 5 Volume residuals