TFL18

Analysis of Intermediate Utilization (IU) Balsam

Addendum to TFL 18 VRI Statistical Analysis

Prepared For:
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Executive Summary

The objective of this study was to assess the accuracy of the Intermediate Utilization (IU) Balsam portion of the Phase I inventory of TFL 18. In 2003, J.S. Thrower and Associates completed a study and found the previous inventory significantly underestimated the volume and site index of IU Balsam polygons. In the current study, the same ground samples were used and compared to the current inventory (projected backward to 2003). The underestimation of volume and SI in Phase I compared to the ground sampling persists. The average volume from the ground sample was 149 ± 35 m^3/ha compared to a Phase I estimate of 100 ± 31 m^3/ha. However, the results should be viewed with caution and put in context. The ground sample data were not considered statistically acceptable for timber supply calculations and the sampling error is high. A recent analysis of the TFL18 inventory also showed large differences in volume between Phase I and Phase II for all mature (age 51+) polygons. Mature balsam stands were, on average, underestimated (volume net of decay waste and breakage was 131 m^3/ha in Phase I vs. 157 m^3/ha in Phase II based on 16 ground sampled polygons). In contrast, the Douglas-fir/Pine/Other and Spruce substrata volumes were overestimated in Phase I. The sampling errors associated with the ratio of mean Phase I/Phase II were all high. Of the three substrata, Balsam had the ratio closest to 1 and had the lowest sampling error.

The report is an addendum to the TFL 18 Vegetation Resources Inventory Statistical Analysis (Forest Analysis 2012).

Acknowledgements

This project was coordinated by Graham Hawkins.

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1. Objective

In the previous inventory for TFL18, there was evidence volumes in intermediate utilization (IU) balsam polygons were consistently and significantly underestimated. The objective of this study is to assess whether this issue persists in the current (largely 2007) Phase I inventory for TFL18.

This report is an addendum to the Vegetation Resources Inventory Statistical Analysis (Forest Analysis 2012).

2. Background

One of the advantages of a new inventory identified in the VSIP (2005) for TFL18 with respect to residual balsam stands was the following

> New inventory will help to verify the findings of the JS Thrower report in such a way as to be statistically acceptable within timber supply calculations. The data collected from the JS Thrower study is not considered statistically acceptable for timber supply calculations but may be used as a consideration for the base case of timber supply analyses. The information from this report should be considered during the Phase I attribute estimation. It is anticipated that the site index and volumes of Balsam residual stands will increase due to the fact that the photo interpreter(s) will estimate the stand age/height based on this data. Furthermore, the layer information will be verified during the inventory to ensure that regeneration is properly identified within the Net Productive Forested Area.

New aerial photography was flown in 2007 over much of TFL18 and was used in the current Phase I.

3. Methods

The starting point for this study was the project report by JS Thrower (2003) and the current inventory.

Residual or intermediate utilization (IU) balsam stands were defined as balsam or spruce leading with a history of partial cutting between 1940 and 1979.

3.1 Ground Data

Phase II sampling was undertaken in TFL18 in 2011 but only 3 polygons met the age and leading species criteria for IU balsam (ignoring the partial cutting history requirement). Therefore, the original JS Thrower data were used.

JS Thrower sampled 22 IU balsam polygons in 2002/2003. Each polygon was sampled with

1. 10 prism full-measure plots
2. 30 prism count plots
3. 20 fixed-area site index plot (100 m^2)

In addition, each sample unit had 20 fixed-area brush plots (100 m^2), 10 fixed-area small tree plots (50 m^2) and 10 fixed-area regeneration plots (20 m^2)

Trees were classified as Live, Dead potential (veterans) and dead trees based on the tree class.

- Live - Tree Class 1, 2, 5, and 8
- Dead potential (veteran) - Tree Class 3, 7, and 9
- Dead – Tree Class 4 and 6

Only the live trees are considered here.

3.2 Phase I photo-interpreted inventory data

The MFLNRO provided the Phase I data projected to 2011. This projection included the application of the BCMPB depletion algorithm to account for the impact of mountain pine beetle. The volume of dead pine volume in the spruce or balsam strata is small. Any Phase I dead volume (which is a result of applying the BCMPB model) was added back to the live volume. Most of the prism plots are in polygons with a photo acquisition year of 2007 (Table 1). The data were back projected to the year of ground sampling (2002 for samples 1, 2, 3 and 6; 2003 for the other samples) using VDYP7. The leading species site index (SI) was estimated using SiteTools 3.3 and the projected height and age of the leading species. The SI for the secondary species was also estimated.

In the previous inventory, the 40 plots associated with each sample unit fell within the target polygon. With the newer VRI, the polygon boundaries changed and all the plots in a sample unit were no longer in the same polygon. The Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) provided the polygon information for each plot and the sample unit summary based on the mean of the Phase I information associated with each of the 40 plots.

Table 1. Each sample consists of 40 ground plots. The proportion of plots in each sample is given by year of photography.

	Year of Photography					
Sample	1992	1993	2004	2005	2007	2008
1		25%			75%	
2					100%	
3	28%				60%	13%
4					100%	
5					80%	20%
6					100%	
7					53%	48%
8				3%	98%	
9					28%	73%
10					100%	
11					100%	
12					100%	
13					100%	
14		8%			73%	20%
15					100%	
16	3%				95%	3%
17					55%	45%
18		20%			80%	
19					98%	3%
20					100%	
21	3%				98%	
22			5%		95%	

3.3 Known Data Issues

The data collection was not considered statistically acceptable for timber supply purposes. That issue remains. The ground sample summaries are taken from the JSThrower file SGV008_InfoSummary_2003SEP05.xls. Data compilation procedures may have changed since 2003. This was not addressed.

3.4 Height and Age matching

The data matching followed the FAIB (2011) procedures and standards document. 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". Of the 22 samples, 19 had the same leading species (BL). For three samples, the Ground leading species was BL and the Phase I leading species was SX and the Phase I secondary species was BL. In all cases, the BL heights and ages were used.

3.5 Site index

BL and SX site index were not available for all polygons. For 12 polygons, BL site index was available both from the ground sampling and Phase I and SX site index was available for both from an additional 7 samples. Therefore, site index was compared on 19 samples.

4. Results and Discussion

4.1 Height

The ground summaries did not include height. In the JS Thrower report, the average ground height was 20.4 m ± 13.7[1] m vs. and inventory height of 15.7m. In the current study, the Phase I average height was 17.8 ± 2.1m. For height, the current Phase I estimates are closer to the ground than the previous Phase I estimated.

4.2 Site index

The ground site index (SI) was generally higher than the Phase I SI (Figure 1) and the relationship between Phase I and the ground was poor. There were 12 samples with estimates of site index on the ground and in Phase I. The ground average BL site index was 15.5 ± 3.6 m compared to a Phase I average of 13.1 ± 2.0 m. The previous Phase I average BL site index was 13.7 m.

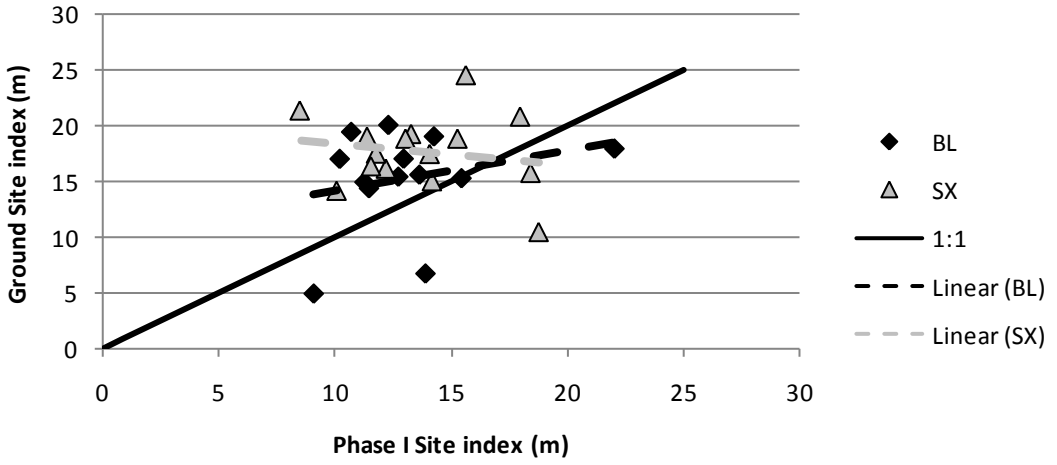

Figure 1. The Phase I inventory and Ground sample site index are compared by species. The solid line shows a perfect relationship between the Phase I and ground estimates. The dashed lines give the actual, linear relationship by species.

4.3 Volume

The ground volume was generally higher than the Phase I estimate for both whole stem volume and volume net of decay waste and breakage (Figure 2). The average whole stem volume for the ground sample was 156.2 ± 36.9 m^3/ha compared to an inventory volume of 123.0 ± 36.1 m^3/ha. The average volume net of decay waste and breakage for the ground sample was 148.6 ± 34.9 m^3/ha compared to an inventory volume of 100.5 ± 30.9 m^3/ha.

[1] The average is followed by the 95% confidence interval.

Note the net down from whole stem volume to net decay, waste and breakage volume was approximately 7.6 m^3/ha compared to 22.5 m^3/ha in the Phase I inventory.

The previous Phase I net merchantable volume (Dbh ≥ 17.5 cm) was 115 m^3/ha compared to a ground average of 155 m^3/ha.

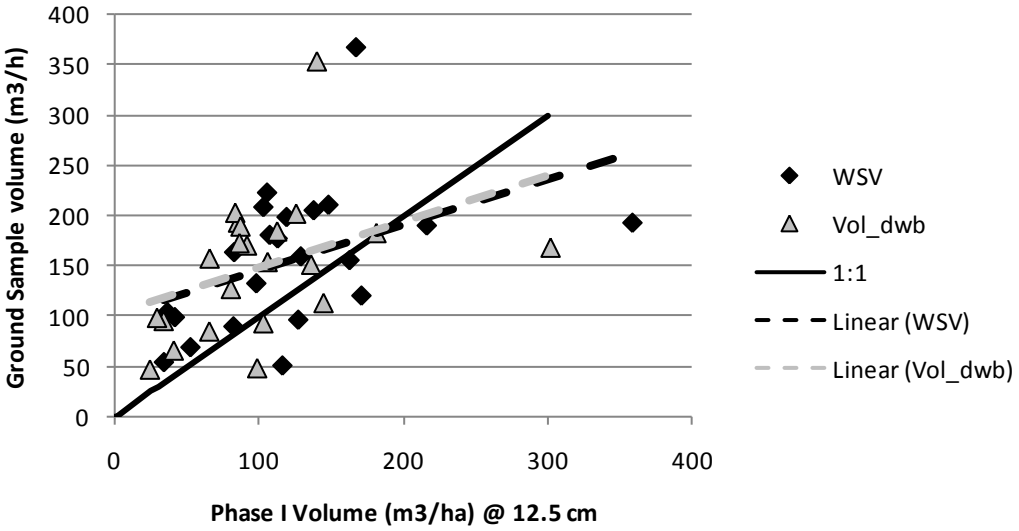

Figure 2. The Phase I inventory volume is compared to the ground sample polygons for live stems. Whole stem volume (WSV) is given as well as volume net of decay waste and breakage (Vol_dwb). The solid lien shows a perfect relationship between Phase I and the ground estimates. The dashed lines give the actual, linear relationship by volume type.

4.4 Age

The age data were not included in the ground summaries.

4.5 Basal area

The ground basal area was generally less than the Phase I estimate (Figure 3). The average basal area of the ground samples was 24.5 ± 4.0 m^2/ha compared to a Phase I inventory average of 16.9 ± 3.5 m^2/ha.

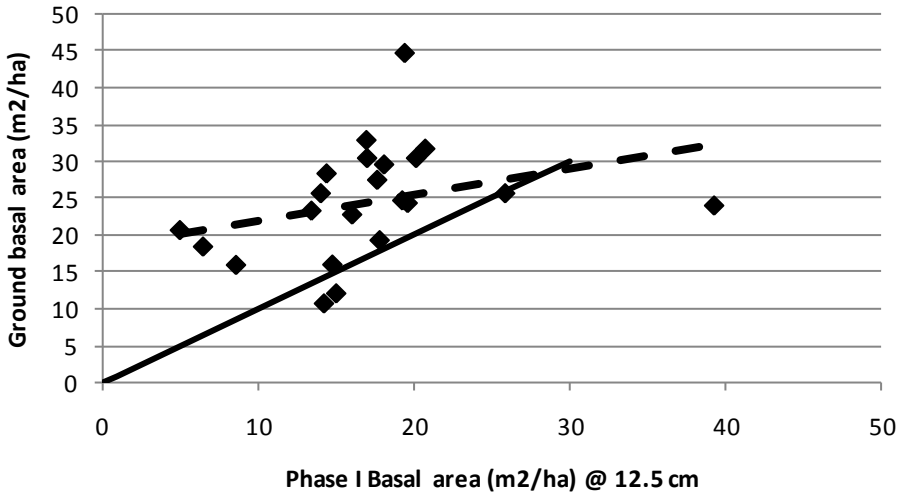

Figure 3. The Phase I inventory basal area is plotted against the ground sample basal area. The solid line shows a perfect relationship between Phase I and the ground estimates. The dashed line gives the actual, linear relationship.

4.6 Trees per hectare

The ground tree per hectare was generally greater than the Phase I estimate (Figure 4). The average trees per hectare (TPH) of the ground samples was 632 ± 75 stems/ha compared to a Phase I inventory average of 487 ± 150 stems/ha. There was one very high Phase I estimate of TPH corresponding to a polygon with a Phase I age of 27. The relationship between the Phase I estimates and the ground estimates is very poor (Figure 4).

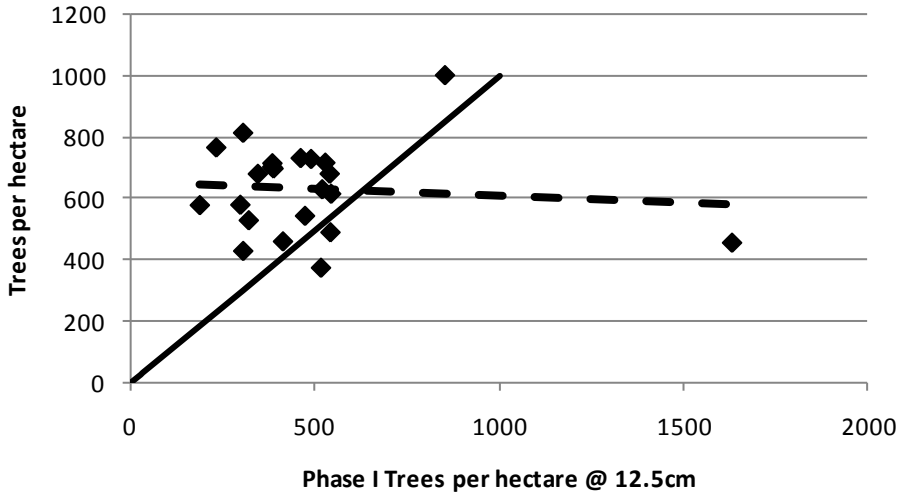

Figure 4. The inventory trees per hectare are compared to the ground sample polygons for live stems. One Phase I sample has a very high trees/ha and corresponds to a Phase I age of 27. The solid line shows a perfect relationship between Phase I and the ground estimates. The dashed line gives the actual, linear relationship.

4.7 Quadratic mean Dbh (QMD)

The ground quadratic mean diameter (QMD) was generally close to the Phase I estimate (Figure 5). The average QMD of the ground samples was 22.1 ± 15 cm compared to a Phase I inventory average of 22.7 ± 2.5 cm.

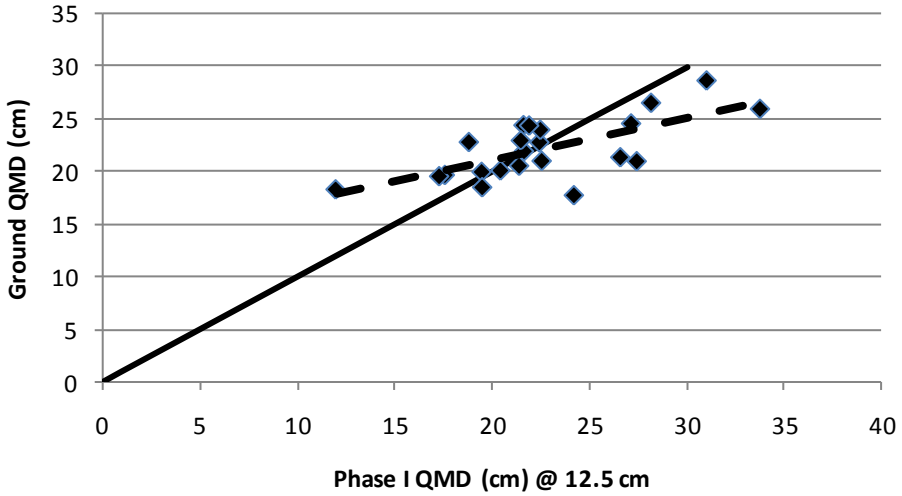

Figure 5. The quadratic mean Dbh from the Phase I Inventory is compared to the ground sample. The solid line shows a perfect relationship between Phase I and the ground estimates. The dashed line gives the actual, linear relationship.

4.8 Species comparison

There was generally good correspondence between the leading species from the Phase I inventory and the leading species from the ground sample (Table 2). Balsam is the leading species in all the ground plots based on the live basal area at the 12.5cm utilization level. Three of the Phase I samples had SX leading and BL secondary and the rest were all BL leading.

Table 2. The Phase I and Phase II leading species are cross tabulated by maturity. The leading species was the same in 86% of the samples.

Phase I inventory	Ground sample leading species		
leading species	BL	SX	Total
BL	19	0	19
SX	3	0	3
Total	22	0	22

The fraction balsam was generally higher in ground samples (Figure 6) with a poor relationship with the Phase I balsam fraction (Figure 7).

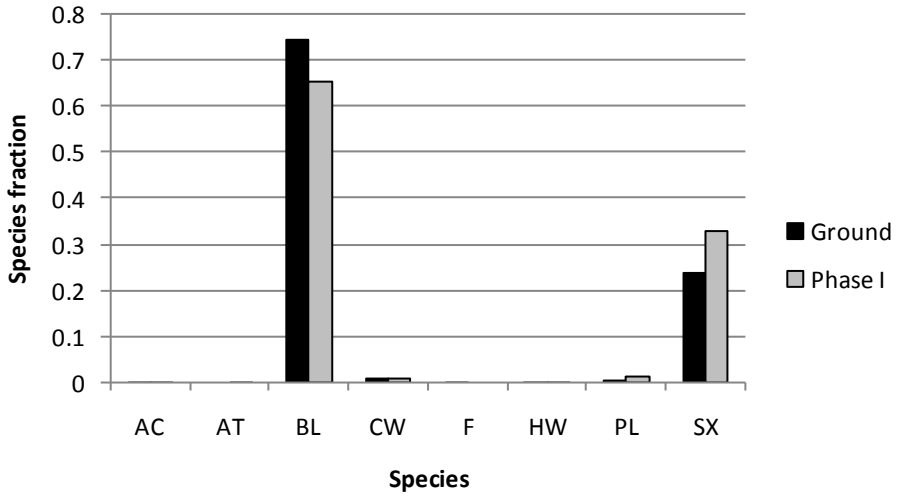

Figure 6. The average species composition of the 22 sample polygons is contrasted.

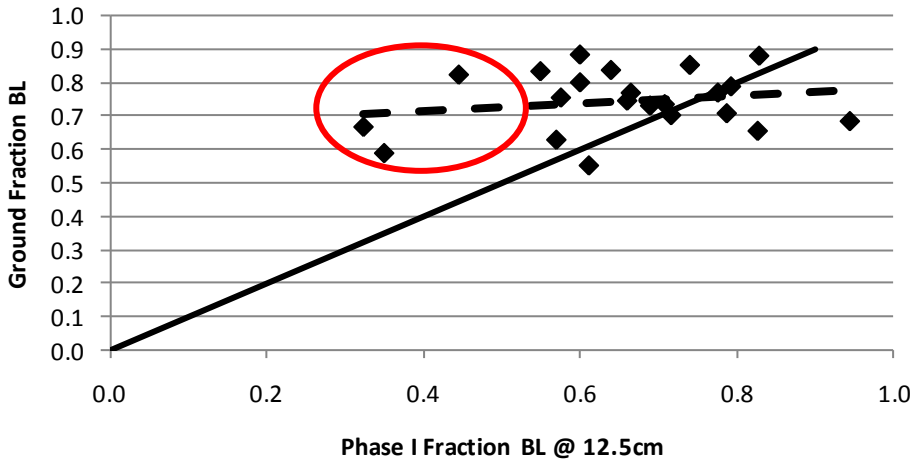

Figure 7. The Balsam fraction in the Phase I inventory is plotted against the ground sample. The three circled samples were SX leading in Phase I. The solid line shows a perfect relationship between the Phase I and ground estimates. The dashed line gives the actual, linear relationship.

4.9 Comparison with VRI analysis

Phase II field sampling was completed in 2011 for TFL18and a statistical analysis of the VRI conducted (Forest Analysis 2012). IU Balsam was not analyzed separately but Balsam leading polygons within the mature stratum (age 51+) were summarized. In general, the results from the VRI analysis for balsam leading polygons are similar to this study – Phase I underestimates basal area, tree per hectare and volume (Table 3). As a consequence, the ratio of the Phase I mean to the ground mean for basal area, trees per hectare and volume is greater than one (Table 4). The results for site index are not consistent – in this study, site index was underestimated in Phase I and in the VRI analysis it was overestimated.

In the VRI analysis, the balsam stratum means from Phase I and Phase II were generally closer than the other leading species strata (that is, the ratio was closer to 1). As well, the sampling error was generally smaller. Comparing this study to the balsam stratum of the VRI analysis, the IU balsam estimates in Phase I are generally worse (larger ratio, larger sampling error) than the balsam stratum as a whole.

Table 3. The ground estimates and Phase I inventory are contrasted. For the VRI analysis, basal area and trees/ha are at the 7.5cm utilization level. All other summaries are for trees with Dbh ≥ 125 cm. The ground height (shaded cell) is taken directly from JS Thrower (2003).

Attribute	Statistic	Current Study	From VRI analysis (mature stratum, age 51+)			
			Balsam	Df/Pine/Oth	Spruce	Subtotal
Height (m)	n	22	16	14	21	51
	Ground mean	20.4	17.9	24.0	25.1	22.4
	Phase I inventory mean	17.7	18.0	26.5	26.7	23.7
Basal area (m^2/ha)	n	22	16	14	21	51
	Ground mean	24.5	28.3	22.7	22.4	24.5
	Phase I inventory mean	16.9	24.9	36.3	30.1	30.1
Trees/ha	n	22	16	14	21	51
	Ground mean	632	1179	1102	738	987
	Phase I inventory mean	482	970	465	508	651
Volume (m^3/ha) at 12.5 cm+ Dbh net dwb	n	22	16	14	21	51
	Ground mean	148.6	157.3	125.2	153.3	146.9
	Phase I inventory mean	100.2	130.7	196.7	235.7	189.7
SI (m)	n	19	16	8	21	45
	Ground mean	16.2	10.5	16.0	11.9	12.1
	Phase I inventory mean	12.8	12.4	16.0	13.2	13.4

Table 4. The ratios of means (Phase II Ground/Phase I Inventory) are given by strata for TFL 18. The ratio is followed in brackets by the sampling error expressed as a percent of the mean. The height ratio (shaded cell) is based on the ground mean from JS Thrower (2003).

Stratum	Leading species substratum	n	Ratio of weighted means (with 95% sampling error[2] shown as % of the ratio)				
			Height (m)	Basal area (m^2/ha)	Trees/ha	Volume net dwb (m^3/ha)	SI (m)
This study	IU Balsam	21	1.153	1.448 (16.0%)	1.312 (29.4%)	1.484 (26.1%)	1.262 (15.4%)
VRI Analysis Age 51+	Balsam	16	0.994 (9.5%)	1.140 (14.8%)	1.216 (32.7%)	1.204 (16.0%)	0.847 (18.4%)
	Df/pine/oth	14	0.904 (10.1%)	0.626 (28.3%)	2.370 (41.3%)	0.637 (41.4%)	0.999 (21.3%)
	Spruce	21	0.939 (9.2%)	0.742 (21.7%)	1.453 (26.1%)	0.650 (25.0%)	0.901 (16.3%)
	Subtotal	51	0.942 (5.6%)	0.814 (14.0%)	1.515 (22.0%)	0.777 (17.2%)	0.903 (10.5%)

5. Conclusions and recommendations

Based on the ground sampled polygons, there is evidence that the Phase I inventory underestimates the volume net of decay, waste and breakage for IU Balsam in TFL18. This is consistent with the recent VRI analysis which found the volume balsam leading, mature (age 51+) polygons was underestimated in Phase I. The underestimation in the IU balsam polygons was generally greater, with a larger sampling error, than the entire mature Balsam stratum. In the VRI analysis, volume estimates in the Douglas-fir/pine/other and spruce strata were worse (ratio further from one and with higher sampling error).

[2] One half the 95% confidence interval associated with the ratio.

The Phase I estimates for volume for IU Balsam are poor (the ratio of ground to Phase I mean is different from 1 and has a high sampling error), Phase I estimates of volume are generally poor for all mature (age 50+) polygons. The Phase I volume for balsam leading polygons is generally underestimated while the volume for other leading species is generally overestimated.

In general, the linear relationships between ground and Phase I estimates for the IU balsam stand attributes was poor.

6. Literature cited

CanFor. 2005. Canadian Forest Products Ltd. Vavenby Division, Tree Farm License #18 Vegetation Resource Inventory Strategic Inventory Plan (VSIP). Dated March 7, 2005, 19p.

FAIB 2011. Vegetation Resources Inventory – VRI sample data analysis procedures and standards. Version 1, June 2011. Ministry of Forests and Range, Forest Analysis and Inventory Branch. 23p. + app.

Forest Analysis Ltd. 2012. TFL 18 – Documentation of Vegetation Resources Inventory Statistical Analysis. 14pp + app.

JS Thrower and Associates. 2003. Growth & yield of residual balsam stands on TFL 18. Prepared for Slocan Forest Products. Ltd. Project SGV-008. Dated November 17, 2003. 21p + app.

Table 5. The Phase I and ground estimates are summarized by sample. The summaries are for trees with Dbh ≥ 12.5 cm. The Phase I attributes were projected to the year of ground sampling.

	Ground Live only								VRI Phase I										
Sample	%BL	BA (m^2/ha)	TPH	WSV (m^3/ha)	Vol_dwb (m^3/ha)	QMD (cm)	Bl SI (m)	Sx SI (m)	%BL	%SX	BA (m^2/ha)	TPH	Ht (m)	Age (years)	QMD (cm)	WSV (m^3/ha)	Vol_dwb (m^3/ha)	Bl SI (m)	Sx SI (m)
1	0.73	28.4	697	222.3	193.9	22.8	17.1	15.8	0.71	0.29	14.3	390	18.2	97.0	22.6	105.4	84.8	13.0	18.5
2	0.88	23.3	702	132.0	127.8	20.5	15.0	17.3	0.83	0.17	13.4	386	16.6	95.9	21.5	97.9	79.9	11.3	
3	0.73	31.7	680	204.7	185.0	24.4	19.1	16.2	0.69	0.30	20.7	542	16.0	73.8	21.8	137.7	112.0	14.3	
4	0.75	25.7	629	163.0	158.1	22.8	17.1	16.1	0.58	0.33	14.0	522	13.2	79.0	18.8	82.5	65.1	10.2	12.2
5	0.75	27.5	728	176.7	171.1	21.9	15.7	17.5	0.66	0.34	17.6	492	17.1	91.3	21.6	112.7	91.0	13.6	11.8
6	0.84	24.7	714	155.0	151.9	21.0		15.0	0.64	0.36	19.2	387	21.0	149.5	27.5	162.6	135.6	9.8	14.2
7	0.71	32.9	731	208.0	203.6	23.9	6.8	21.4	0.79	0.21	16.9	464	18.8	115.3	22.5	102.8	82.9	13.9	8.5
8	0.83	12.0	455	53.5	47.7	18.3	18.0	24.6	0.55	0.30	15.0	1633	9.3	27.3	11.6	33.8	23.7	22.0	15.7
9	0.68	30.5	1001	198.0	189.9	19.7			0.94	0.06	20.1	855	15.4	61.1	17.6	118.9	86.5	15.8	18.2
10	0.88	24.0	374	192.3	168.9	28.6		18.4	0.60	0.40	39.3	519	23.7	196.0	31.0	359.0	301.7	9.1	
11	0.55	15.9	528	68.3	66.7	19.6	20.1	22.4	0.61	0.33	8.5	323	10.9	61.0	17.3	52.2	40.2	12.3	
12	0.80	19.3	615	95.7	93.8	20.0		16.4	0.60	0.36	17.8	546	15.3	81.2	19.5	127.0	102.4	15.2	11.6
13	0.59	10.6	428	50.1	49.1	17.8	18.2	19.3	0.35	0.60	14.2	308	22.4	111.0	24.2	116.0	98.1		13.3
14	0.63	44.8	813	367.0	354.0	26.5			0.57	0.40	19.4	307	25.0	146.6	28.2	167.1	139.5	11.0	15.1
15	0.67	30.5	578	210.2	202.7	25.9		18.9	0.32	0.61	17.0	190	24.0	128.5	33.7	148.0	125.2	14.2	13.1
16	0.65	24.3	680	158.8	154.6	21.3		14.1	0.83	0.17	19.6	348	17.9	101.2	26.6	128.8	105.4	11.8	
17	0.70	25.7	543	189.6	183.4	24.5	15.4	18.9	0.72	0.28	25.8	475	23.3	114.3	27.1	216.2	180.9	15.4	15.3
18	0.77	15.9	460	89.1	85.6	21.0		10.4	0.78	0.22	14.7	416	15.4	82.3	22.6	82.0	64.9	11.3	18.8
19	0.77	18.4	579	98.3	96.0	20.1	14.5	12.8	0.66	0.34	6.4	300	17.6	102.7	20.4	41.4	33.2	11.5	
20	0.82	22.8	489	119.7	113.9	24.3	5.0	14.1	0.45	0.55	16.0	544	18.5	146.0	21.9	170.9	144.2	9.1	10.1
21	0.85	29.6	716	180.1	173.4	22.9	19.5	19.0	0.74	0.26	18.0	530	15.9	103.9	21.5	107.2	85.8	10.7	11.4
22	0.79	20.6	766	103.3	99.1	18.5		20.9	0.79	0.20	4.9	235	14.5	77.0	18.7	36.1	28.6	11.9	18.0
Mean	0.74	24.5	632	156.2	148.6	22.1	15.5	17.5	0.65	0.32	16.9	487	17.7	101.9	22.6	123.0	100.5	12.7	14.1
Standard deviation	0.05	4.0	75	36.9	34.9	1.5	3.3	1.9	0.08	0.07	3.5	150	2.2	18.8	2.5	36.1	30.9	1.6	2.0