Okanagan TSA
Vegetation Resources Inventory:
Further Analysis Report

Prepared for

Okanagan Innovative Forestry Society

Project: OKI – 004

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Okanagan IFPA
Okanagan Innovative Forestry Society

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1. INTRODUCTION

1.1 BACKGROUND

The Okanagan Innovative Forestry Society (OIFS) is completing a timber supply analysis for the Okanagan timber supply area (TSA). The OIFS completed a Vegetation Resources Inventory (VRI) project in the summer of 2002 to provide the Kamloops Regional Manager with a reasonable level of confidence that the existing overall forest-cover inventory volume is appropriate for use in timber supply review (TSR).

The target population for this project was the Crown vegetated-treed, which approximates the productive forest landbase. Sampling was focused in the operable vegetated-treed landbase in polygons >20 years. One hundred and ten (110) Phase II timber emphasis plots (TEPs) were installed. In addition, 93 trees were destructively sampled to derive net volume adjustment factors (NVAFs) to adjust the cruiser-called net volume to account for hidden decay, waste, and taper-equation bias. J.S. Thrower & Associates Ltd. (JST) recently completed the statistical adjustment of the current forest-cover inventory volume file using the Phase II volumes and NVAFs.[1]

Several inventory issues were identified during the VRI stakeholder workshop and noted in the Okanagan TSA VRI Strategic Implementation Plan (VSIP).[2] Further analyses of the VRI Phase II data were completed as part of this report in order to address many of these identified inventory issues.

1.2 DOCUMENT OBJECTIVES

The objective of this report is to describe the results of the extra analyses of the VRI Phase II data. It is intended to supplement the statistical adjustment work completed by JST and assure the Okanagan TSA VRI stakeholders that the issues identified during the VRI workshop have been addressed.

1.3 TERMS OF REFERENCE

This report was prepared by A.Y. Omule, *PhD RPF* of JST for Glen Dick, *RPF* of the OIFS. The data used in this report is from the field data collected during Phase II timber emphasis sampling and the resulting statistical adjustment.

[1] J.S. Thrower & Associates Ltd. 2002. Okanagan TSA Vegetation Resources Inventory Ground Sampling & Statistical Adjustment; Final Report. Contract report prepared for the Okanagan Innovative Forestry Society by J.S. Thrower & Associates Ltd. October 2002. 19 pp.

[2] J.S. Thrower & Associates Ltd. 2002. Okanagan TSA Vegetation Resources Inventory Strategic Inventory Plan (2002 Update). Contract report prepared for the Okanagan Innovative Forestry Society by J.S. Thrower & Associates Ltd. April 2002. 22 pp.

2. INVENTORY ISSUES

At the March 15, 2002 VRI workshop, several inventory issues were identified and discussed by the stakeholders. These issues were related to timber volume accuracy, forest health, mapping and updates, and monitoring growth and yield and non-timber attributes. The issues are listed below.

Timber Volume Accuracy

- Age of the inventory.
- Accuracy of forest-cover labels, and therefore polygon volumes.
- Species composition descriptions in stands managed through the selection system.
- Excluded (problem) forest types need to be field-checked.
- The accuracy of volume estimates in cedar/hemlock polygons.
- Accuracy of taper equations and loss factors.
- Highly variable decay in the TSA particularly between the wet and dry belts.
- Highly variable IDF polygons make it difficult to project volumes using existing models. Additional inventory attributes should be collected to project stand growth and guide selection of appropriate silviculture treatments. As well, smaller Phase I polygons with less variation are needed to help develop management guidelines.

Forest Health

- IDF stands infected with root rot need to be identified in the database.

Mapping and Update

- Mountain pine beetle (MPB) salvage and related logging history have created small patches that are not captured in inventory update.
- Pest infestations (e.g., MPB) increase stand variability making inventory update for depletion difficult, and poorer inventory projections.
- Polygon resolution is inadequate because individual polygon areas are large.

Monitoring Growth and Yield and Non-timber Attributes

- OIFS licensees agree on a need for certification, but there is no agreement on a common approach.
- The Okanagan IFPA Forestry Plan includes monitoring (e.g., to check the accuracy of growth and yield estimates). The OIFS is discussing this issue.

This report focuses on how the VRI Phase II can help address timber volume accuracy issues (Table 1). The forest health, mapping, and monitoring issues are not discussed any further. The forest health issue (root disease) was not analyzed in this report because disease was evident in four of the 110 Phase II plots.[3] The mapping and depletion update issues can be addressed through a new Phase I and ecological mapping. Monitoring of growth and yield and non-timber attributes, which is still being discussed by the OIFS, can be addressed by re-measuring VRI Phase II plots.

[3] Root disease occurred in the MSdm (2 plots, 10 trees), ICHmk (1 plot, 1 tree) and IDFdm (1 plot, 1 tree). The VRI auditor suspects that there is more root disease than identified by the VRI crews. A research study is needed to investigate this issue further in the IDF. This study could: 1) develop techniques to better identify root rot in the field, 2) develop correlations between root disease incidence observed on the ground and the Phase I polygon attributes, and 3) use these correlations to identify potential root-rot polygons in the VRI database.

Table 1. Inventory issues analyzed in this report.

Inventory Issue	Phase II Further Analysis	Report Section	Remarks
1. Age of the inventory	Yes	3.1	
2. Accuracy of forest cover	Yes	3.2, 4.2	
3. Species composition descriptions	Yes	3.2, 4.2	
4. Excluded (problem) forest types	No		This issue was examined in 1998.[4] There are too few Phase II plots (8) for further analysis (Appendix I).
5. Cedar/hemlock stands volumes	Yes	3.1, 4.1	ICH zone volumes checked.
6. Accuracy of taper equation/loss factors	Not necessary		Taper equation bias and decay and waste are accounted for in NVAF.
7. Decay variability in the TSA	Not necessary		The VRI net factoring localizes decay estimates.
8. IDF polygon variability	Yes	3.1, 4.1	

[4] J.S. Thrower & Associates Ltd. 1998. Inventory adjustment of smallwood pine and hemlock stands in the Okanagan TSA. Contract report to Ministry of Forests, Penticton Forest District. July 1998.

3. ANALYSIS METHODS

3.1 VOLUME ACCURACY & VARIABILITY

This analysis examines the accuracy of inventory age, species composition, and IDF polygon volume estimates. The intent is to identify volume bias and variability by biogeoclimatic (BGC) zone, and identify BGC zones that may require future analysis. The VRI Phase II sample was stratified by BGC, including the ESSF, ICH, IDF, MS, and PP zones. Data from the PP (1 plot) were merged with the IDF. Net inventory volume was compared to the Phase II volumes, by calculating their ratios and differences, and coefficients of variation (CV) of the ratios. The adequacy of the VRI Phase II plots for volume estimation was also investigated.

The net volumes are NVAF-adjusted cruiser-called net volumes using utilization limits of 12.5 cm+ for Pl and 17.5 cm+ for all other species. The volume ratios from neighboring management units and the Okanagan TSA Inventory Audit were also compiled (Appendix II). However, because of differences in volume definitions and target populations, it is difficult to make meaningful comparisons of the ratios from these studies with those of the Okanagan VRI.

3.2 ACCURACY OF POLYGON LABELS

This analysis examines the accuracy of forest cover and species composition descriptions. A polygon label in the current inventory typically consists of many variables, including; age, height, and species composition. The intent of this analysis is to quantify the error of these individual polygon attribute estimates. While a total estimate for the landbase may be known with precision (e.g., volume), individual polygons may be far from their individual estimated values. This comparison of individual polygon accuracy is important because:

1. Individual polygons (or small strata such as analysis units) are used in planning and forest management.
2. Individual stands are usually projected forward, so it is important to be able to specify the error in the starting values.

We cannot state how accurate each polygon attribute estimate is, but we can make a general statement about the accuracy of individual polygons, on average, for a small stratum (e.g., BGC zone).

The current inventory and Phase II data were analyzed to assess the accuracy of these attributes. Polygons with paired inventory heights and Phase II heights, or paired inventory ages and Phase II ages were used in the analysis. Unpaired values were discarded. The PP plot data were combined with the IDF. The mean inventory heights and ages were compared by BGC to the mean heights and ages of the top height trees from the Phase II data. Variability of the stands was depicted on scattergrams of the heights and ages, separately by BGC.

The accuracy of species composition (% basal area by species) was determined by considering only the leading species. An overall error matrix was constructed for all the BGC (Table 6); however there were too few plots to do the analysis separately by BGC. An error matrix depicts the number of polygons where leading species was correctly identified in the diagonal cells, and the number of polygons where leading species was misidentified in the off-diagonal cells.

4. RESULTS & DISCUSSION

4.1 VOLUME ACCURACY & VARIATION

4.1.1 Volume accuracy by BGC

The VRI Phase II data have shown that the net timber volumes are accurate overall and by BGC. A summary of the statistics including the ratio of means and their coefficients of variation (CVs) are given in Table 2.

Table 2. Okanagan TSA VRI net volume by BGC.

Statistics	ESSF	ICH (CH ldg)	ICH (All spp.)	IDF	MS	Overall (TSA)
Number of Plots	31	10	36	23	20	110
Mean Phase II volume (m^3/ha)	224.4	461.5	292.1	156.6	198.8	227.7
Mean Inventory volume (m^3/ha)	218.9	380.8	240.3	147.4	169.0	201.8
Differences in mean volume (m^3/ha)	5.5	80.7	41.8	9.2	29.8	25.9
Adjustment ratio (Ratio of means)	1.03	1.21	1.22	1.06	1.18	1.13
SE[a] of ratio of means (%)	23.1	46.1	23.2	31.7	31.5	12.9
CV of ratio of means (%)	63	64	69	73	67	68
Additional Plots:						
Target SE: ±20%	10	40	15	30	20	0
Target SE: ±15%	40	60	50	70	60	0

[a] Sampling Error (95% probability)

Notes:

1. The *number of plots* is the number of Phase II clusters per BGC, and are proportional to BGC area.
2. The *mean Phase II volume* is the cruiser-called net volume corrected with NVAF. The NVAF stem-analysis sampling is used to adjust the cruiser-called net volume to account for hidden decay, waste, and taper equation bias increasing the overall confidence in the inventory.
3. The *mean inventory volume* is the current volume in the inventory files (Phase I).
4. The *difference in mean volume* is the mean Phase II volume minus the mean inventory volume.
5. The *ratio of means* is the Phase II volume divided by the inventory volume. A ratio of 1 indicates that the two volumes are the same, and a ratio of less than 1 indicates that the inventory volume is over-stated. A ratio of more than 1 suggests that the inventory volume is under-stated.
6. The *SE of the ratio of means* is a measure of the precision of the estimated ratio; the lower the SE, the higher the confidence in the precision of the estimated ratio.
7. The *CV of the ratio* is the estimated relative variability of the polygon ratios between the Phase II volumes and the inventory volumes in the population. A high CV indicated a high variation in the ratios (or differences) in the population. The CV is useful for estimating the number of plots needed to achieve a target sampling error; the higher the CV, the more plots required.
8. *Additional plots* are extra plots needed to achieve a target sampling error of either ±20% (95% probability) or ±15% (95% probability). The additional number of plots under the ICH cedar-hemlock (CH) leading column refers to the number of extra plots needed if only the CH stands were sampled independently. Although the ICH CV (variability) is similar in the CH leading and all species, the number of plots needed in the CH is higher because the initial number of plots is much lower in the CH.

The volumes are consistently under-estimated by BGC zones and the overall TSA volume is under-estimated by 13% (ratio = 1.13) (Table 2). These biases are not statistically significant, but could be practically important. The ICH (notably in cedar-hemlock leading stands) and the MS appear to have the highest volume under-estimation.

The statistical adjustment corrects for the overall bias, however, individual polygon volumes could still be biased. Note that the overall impact of the statistical adjustment on the population is a 10% (ratio = 1.10) uplift in the overall TSA volume.[5] The 3% difference between the sample ratio and population ratio is probably due to:

- The use of the Fraser protocol for statistical adjustment procedure[6]
- Differences in inventory volume sample average and inventory volume population average, which ranged by BGC from 3-22%.

The cedar-hemlock stand volumes are under-estimated, probably because historical loss factors for these stand types were inappropriate. Unlike neighboring management units (e.g. Adams Lake IFPA), there does not appear to be a problem with the volumes in the ESSF (Appendix II).

4.1.2 Polygon variability

The average CV of the ratio was 68% and ranged from 63-73% (Table 2; Appendix III). As expected, the IDF polygons varied considerably (73%). This high variability could be reduced through finer polygon delineation in the Phase I.

4.1.3 Adequacy of sample size

The Phase II sample of 110 plots is adequate for overall net volume estimation. The sampling error of $\pm$ 12.8% (95% probability) obtained is within the target sampling error of $\pm$15% (95% probability). The resulting plot distribution by leading species is approximately proportional to the leading-species areas (Table 3). Most leading species had less than 30 plots each. It is, however, probably not necessary to have a minimum of 30 plots per species, since data from some species can be combined for statistical adjustment purposes and some of the species represent only a small portion of the target landbase. As expected, the sampling errors are higher by individual BGC zone. If required, these could be improved through additional sampling (Figure 1). The sample sizes in Figure 1 are based on CVs from Table 2. For example, additional ground plots could be installed in the ICH where stands are highly variable (CV 69%), and the volumes are significantly under-estimated. In this case, the ICH requires an additional 50 plots to achieve the target sampling error.

[5] J.S. Thrower & Associates Ltd. 2002. Okanagan TSA Vegetation Resources Inventory Ground Sampling & Statistical Adjustment; Final Report. Contract report prepared for the Okanagan Innovative Forestry Society by J.S. Thrower & Associates Ltd. October 2002. 19 pp.

[6] In the Fraser protocol, height and age are adjusted by leading species first, the adjusted heights and ages are used to estimate volume, and then the estimated volume is adjusted using the Phase II volume by BGC.

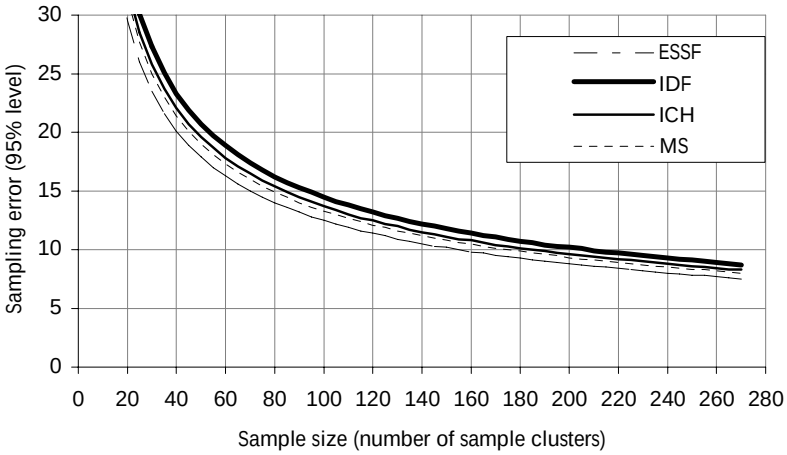


Figure 1. Sample size options for BGC zone ground sampling.

Table 3. Phase II plot distribution by leading species.

Ldg Spp.	Sample Plots No.	Sample Plots %	Pop. Area %
Pl	39	35	33
Fd	25	22	26
S	15	14	14
Bl	15	14	11
Cw	5	5	5
Hw	6	5	4
Lw	1	1	3
Other	4	4	1
Total	*110*	*100*	*100*

4.2 ACCURACY OF POLYGON LABELS

4.2.1 Height & age

The VRI Phase II data indicate that polygon heights are over-estimated in all BGC zones, except the MS where heights are under-estimated (Table 4; Appendix IV). The biases are highest in the ESSF and MS (Table 4).

Table 4. Okanagan TSA polygon heights by BGC.

Statistic	ESSF	ICH	IDF	MS
Number of Plots	30	29	20	18
Mean Phase II height (m)	19.5	23.7	20.3	21.1
Mean Inventory height (m)	22.1	24.7	21.5	18.5
Diff. in mean height (m)	-2.6	-1.0	-1.2	2.6
Ratio of means	0.88	0.96	0.94	1.14

The VRI Phase II data show that polygon ages are over-estimated in all BGC zones, with differences ranging from 3 to 42 years (Table 5). The biases are greatest in the ESSF and ICH, especially in older age classes (Table 5; Appendix IV).

Table 5. Okanagan TSA polygon ages by BGC.

Statistic	ESSF	ICH	IDF	MS
Number of Plots	31	32	20	19
Mean Phase II age (yr)	133.3	108.8	108.7	100.4
Mean Inventory age (yr)	156.7	150.6	128.0	103.4
Diff. in mean age (yr)	-23.4	-41.8	-19.1	-3.0
Ratio of means	0.85	0.72	0.85	0.97

The statistical adjustment of the inventory heights and ages using the Phase II data corrects for these biases on average by leading species. Note that the statistical adjustment ratios were calculated by leading species, not BGC. However, some individual polygon heights and ages could still be biased. The only way to ensure correct individual polygon values are accurate or consistent is estimation in VRI Phase I.

4.2.2 Species composition

The VRI Phase II data show that leading-species identification is generally accurate, ranging from 40% for Bl to 80% for Cw (Table 6). For example, for Pl, 26 of 39 inventory polygons were correctly labeled as Pl when compared to the VRI Phase II data. These species composition results should be confirmed through within polygon variation sampling (WPV) where the entire polygon is sampled as opposed to a single point in a polygon where the Phase II plot is located.

WPV sampling is used to indicate to users of the inventory what they should expect to find when they "check" an inventory in the field. WPV sampling is also used to estimate the actual error of the adjusted polygon database and to check the accuracy of individual polygons after the Phase I estimates have been statistically adjusted. Generally, 30 polygons are selected from the target population and intensively cruised using a combination of 20-50 full measure and count plots per sample polygon.

Table 6. Okanagan TSA leading-species error matrix (number of polygons).

	Leading Species in Inventory (No. of Poly's sampled & % Accurately Identified)									
Phase II Leading Species		Pl	Fd	S	Bl	Cw	Hw	Lw	Other	Total
	Pl	26 (67%)	2	3	1					32
	Fd	5	18 (72%)						1	24
	S	2		8 (53%)	6					16
	Bl	3		2	6 (40%)					11
	Cw	1	3			4 (80%)	2	1	2	13
	Hw		2		1	1	3 (50%)			7
	Lw							0		0
	Other	2		2	1		1		1 (25%)	7
	Total	*39*	*25*	*15*	*15*	*5*	*6*	*1*	*4*	*110*

Species composition labels are currently not statistically adjusted because the Terrestrial Information Branch of the Ministry of Sustainable Resource Management (MSRM) has no approved methods to do so. Thus, the only approach to further improve the accuracy of species composition is through revised Phase I.

5. CONCLUSIONS

The Okanagan TSA inventory issues were considered in four broad categories: timber volume accuracy, forest health, mapping and update, and monitoring. Further analyses of the VRI Phase II data were conducted to address or confirm some of the timber volume accuracy issues. The forest health, mapping, and monitoring issues were not discussed in this report; these issues are better addressed using other VRI tools.

Further analyses of the timber volume accuracy issues indicated that:

1. Timber volumes were generally accurate by BGC, except in the ICH and MS where the volumes were noticeably under-estimated. There may be a need for additional ground sampling to confirm this volume under-estimation, especially in the MS where the sampling error of the ratio is relatively high (±32%). Additional sampling could also be considered in the IDF where the sampling error of the ratio is also relatively high (±32%).
2. Polygon heights and ages were over-estimated in the Phase I inventory. There is a need to improve the accuracy of height and age estimates through the VRI Phase I.
3. Leading species identification was reasonably accurate (up to 80% correct identification); however, the results should to be confirmed through WPV sampling.

6. RECOMMENDATIONS

We recommend that the OIFS consider implementing the following VRI activities:

1. *New Phase I estimation*. Individual polygon heights and ages were over-estimated in the inventory. After statistical adjustment, the Phase I age, height, and volume were unbiased, on average, for the adjustment strata. However, individual polygon heights, ages, and volumes could still be biased. As recommended in the VSIP[2], the accuracy of the individual polygon values should be improved through a Phase I where new attribute estimates and smaller, more homogeneous polygons are created.
2. *WPV sampling.* The accuracy of adjusted individual polygon ages, heights, and volumes is uncertain. Moreover, the accuracy of species composition, which was not adjusted, is also uncertain. The data from WPV (within polygon variation) sampling would provide a level of confidence on the accuracy of the adjusted individual polygon labels and species composition.[7] The OIFS should weigh the cost of the WPV sampling (at least $60,000) against these benefits. The WPV sampling should be implemented after a new Phase I and statistical re-adjustment is completed.
3. *Additional ground sampling in the IDF and MS*. The sampling error and over-estimation in the MS, and sampling error in the IDF, were relatively high. Additional sampling (20 Phase II plots in the MS and 30 plots in the IDF) could reduce the sampling errors to ±20%, thereby increasing the level of confidence in the adjusted forest cover inventory in these zones.

[7] Procedures for WPV sampling are available from the MSRM.

APPENDIX I – EXCLUDED (PROBLEM) FOREST TYPES

The polygons labeled as problem forest types (PFTs) in the inventory and sampled in the 2002 VRI Phase II are provided in Table 7. These PFTs are based on the PFT definition used in Okanagan TSA TSR II.

Table 7. Okanagan TSA sampled problem forest types polygons.

Mapsheet - Polygon number	Leading species	Phase I height (m)	Phase I age (yrs)	Phase II height (m)	Phase II age (yrs)
082E011 - 494	S	16.9	290	15.6	110.8
082E011 - 542	S	17.6	210	19.3	135.0
082E095 - 38	Pl	19.5	99	20.5	93.7
082M036 - 14	CH	37.0	286	Missing	337.0
082L014 - 210	Pl	11.1	66	23.2	73.2
082E092 - 202	Pl	16.1	84	19.8	73.8
082L004 - 156	Pl	16.8	124	23.9	112.6
082L004 - 296	Pl	11.8	84	16.8	67.9

APPENDIX II – OKANAGAN TSA INVENTORY AUDIT AND ADJACENT INVENTORIES

PROJECTS

Inventory results from the Okanagan TSA and neighboring management units were collated to assist in identifying inventory-related issues and develop a cost-effective VRI Phase II sampling design. These inventory results are summarized for the following management units and projects:

- Okanagan TSA Audit – 50 audit samples were established in the mature (60+) component in 1996.
- Adams Lake VRI – 65 VRI samples were established in the mature (60+) THLB in 1999 - 2000.
- TFL 15 VRI – 65 VRI samples were established in the THLB in 2000 - 2001.
- Merritt VRI – 125 plots were established in the VT landbase in 1999 - 2000.
- TFL 49 VRI – 67 VRI samples were established in mature (80+) component in 1998 - 1999.

The Okanagan TSA VRI (110 VRI timber emphasis plots installed in 2002) results are also included here for easy reference.

RESULTS

A summary of the ratio of means (ground volume/estimated volume) and their CVs from these projects are provided in Tables 8 and 9, respectively. The overall volume CVs vary considerably and range from 50-95%, with an average of 70% (Table 9). The variability in IDF polygons appears high (about 80%). Detailed results for each project are given in Tables 10-13; detailed results for the Okanagan VRI are given in Table 2.

Table 8. Volume ratios (ground volume/estimated volume) by unit and BGC.

Management unit	ICH	ESSF	IDF	MS	Other	Overall
Okanagan TSA VRI	1.22 (36)*	1.03 (31)	1.06 (23)	1.18 (20)		1.13 (110)
Okanagan Inventory Audit	1.16 (10)	0.93 (12)	0.94 (10)	1.25 (9)		1.02 (41)
Adams Lake IFPA VRI		0.63 (15)			0.89 (50)	0.83 (65)
Merritt TSA VRI		0.97 (16)	0.97 (55)	1.13 (41)		
TFL 15 VRI (Pl)						0.92 (40)
TFL 15 VRI (Other species)						0.98 (25)
TFL 49 VRI (mature)						1.05 (67)

*Values in brackets are number of plots.

Table 9. Net volume coefficients of variation (%) of the ratios by management unit and BGC.

Management unit	ICH	ESSF	IDF	MS	Other	Overall
Okanagan TSA VRI	69	63	73	67		68
Okanagan Inventory Audit*	49	28	39	36		44
Adams Lake IFPA VRI		40			48	48
Merritt TSA VRI		74	81	66		
TFL 15 VRI (Pl)						70
TFL 15 VRI (Other species)						95
TFL 49 VRI (mature)						43

* The inventory audit CVs should be multiplied by 1.5-2 to account for cluster differences with the VRI.

Table 10. Okanagan TSA Inventory audit results (mature stands).

Statistics	ICH	ESSF	IDF	MS
Number of Samples	10	12	10	9
Mean VRI audit volume (m^3/ha)	160	191	117	122
Ratio of means (audit/inventory)	1.162	0.929	0.944	1.249
95% SE ratio	30.8%	16.3%	24.6%	24.1%

Table 11. Merritt TSA VRI results.

	ESSF	IDF	MS
Number of Samples	16	55	41
Mean VRI audit volume (m^3/ha)	206	126	228
Ratio of means (audit/inventory)	0.97	0.97	1.13
95% sampling error of ratio	18.5%	10.9%	10.3%
CV ratio	74%	81%	66%

* Only results of plots that could be assigned to a BGC are reported.

Table 12. Adams Lake IFPA preliminary VRI results (mature stands; cruiser-called/NVAF volume).

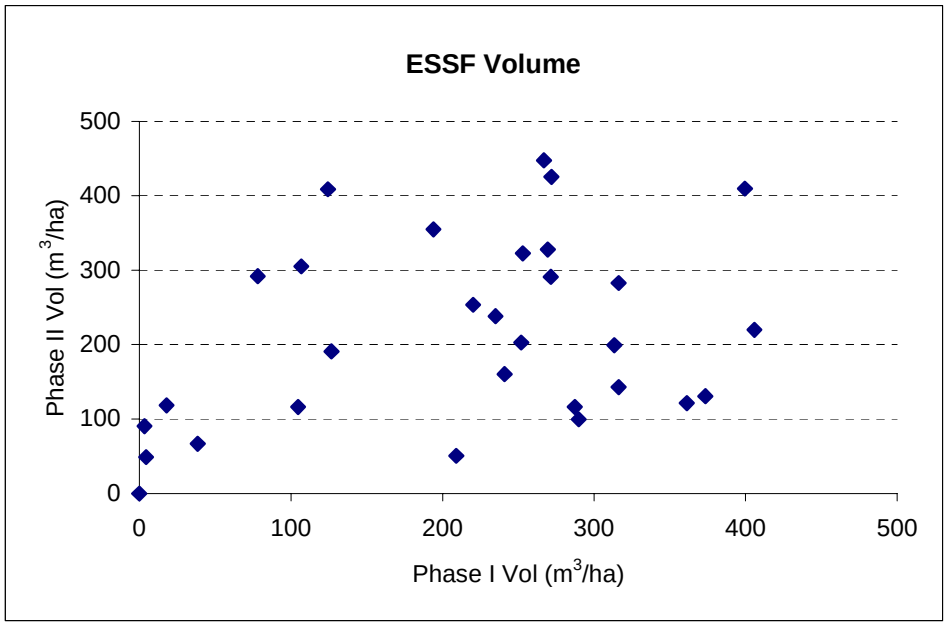
	ESSF BGC Zone	Other BGC Zones	Overall
Number of Samples	15	50	65
Mean VRI audit volume (m^3/ha)	170.1	255.7	235.9
Mean inventory volume (m^3/ha)	272.2	286.2	283.0
Mean difference (m^3/ha)	102.1	30.5	47.0
Ratio of means (audit/inventory)	0.625	0.893	0.834
95% Confidence Interval of ratio	[0.42, 0.83]	[0.76, 1.03]	[0.72, 0.95]
95% Sampling error of ratio	20.8%	13.7%	11.8%

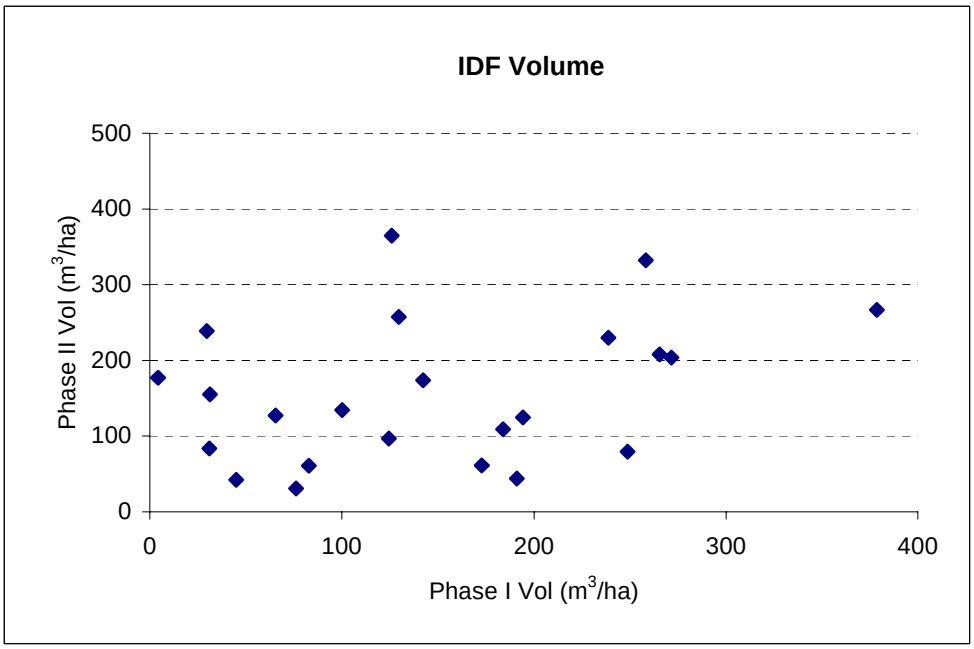
Table 13. TFL 15 Preliminary VRI results.

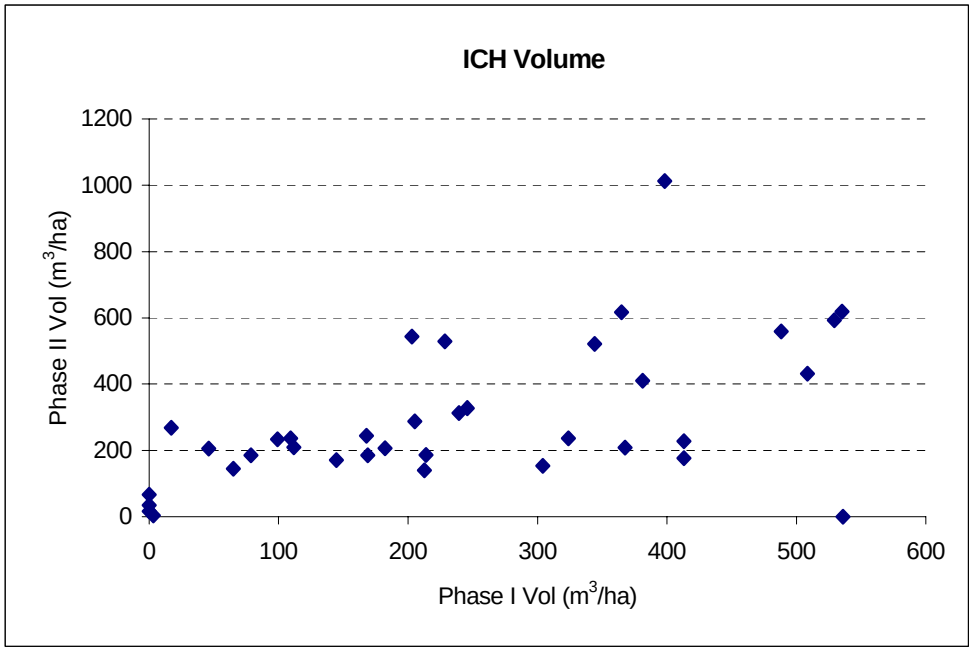
Spp	Sample Ground Avg.	Ratio*
Pl	96.9	0.923
Others	100.3	0.978

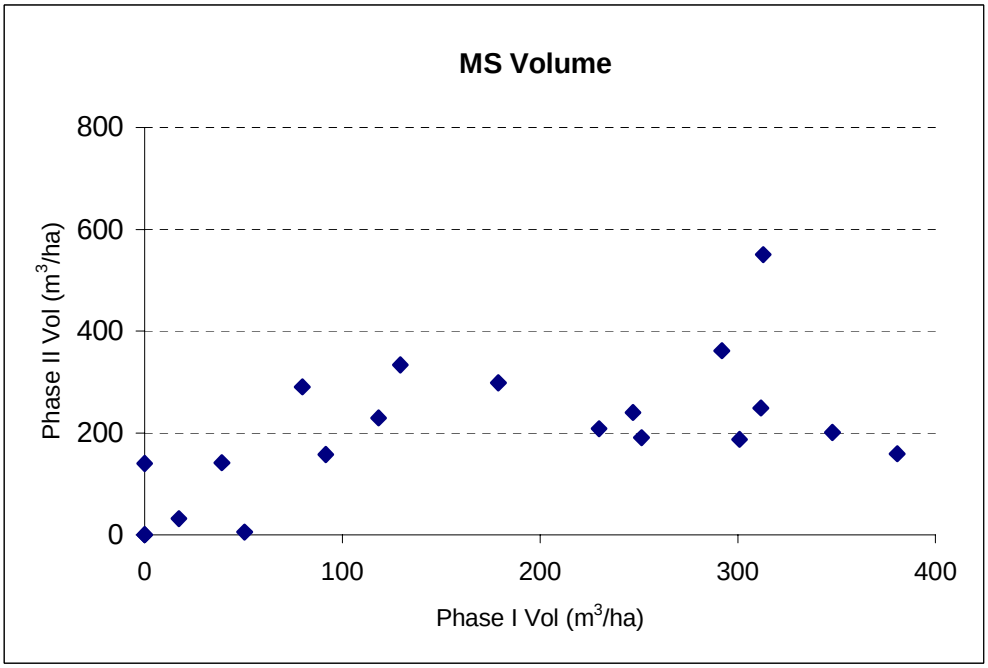
* Sampling errors: 22% and 38% for Pl and Other, respectively; average 31% for the entire THLB.

APPENDIX III – VOLUME SCATTERGRAMS

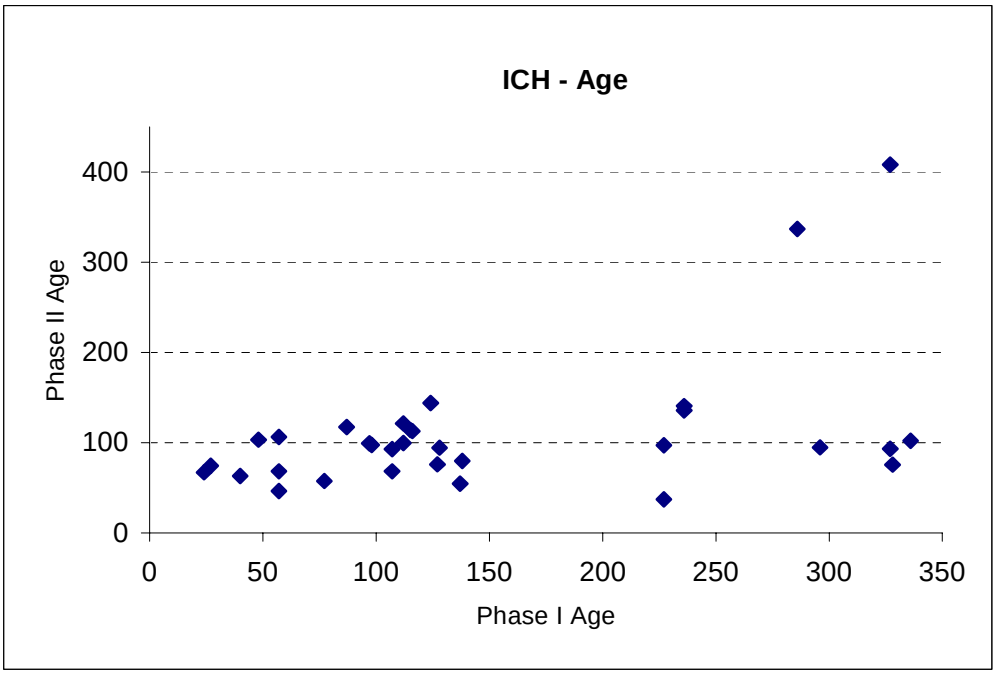


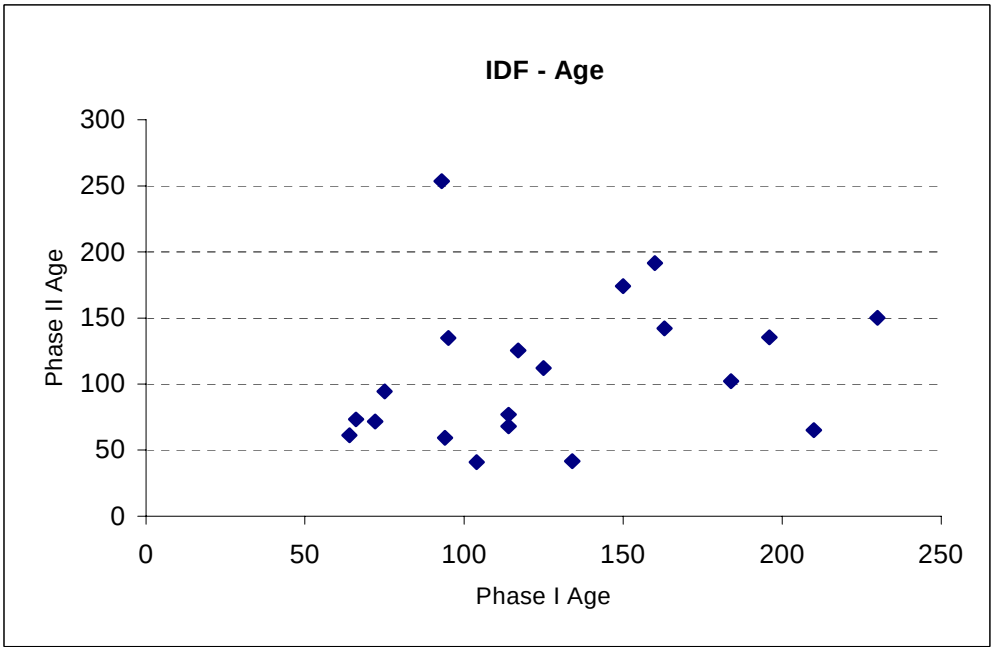


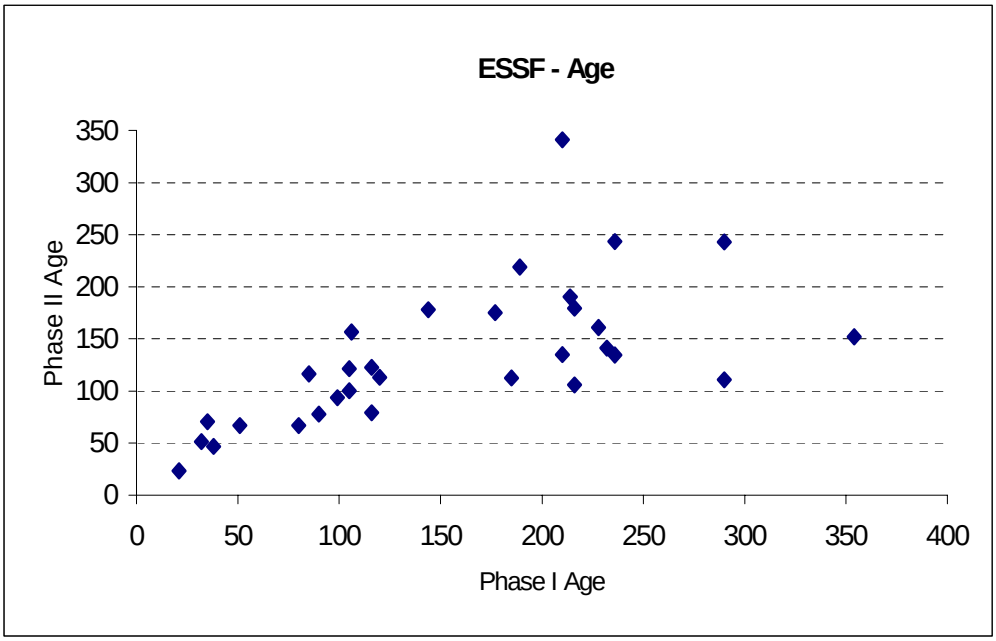

ICH Volume
1200
1000
800
600
400
200
0
Phase II Vol (m3/ha)
0
100
200
300
400
500
600
Phase I Vol (m3/ha)

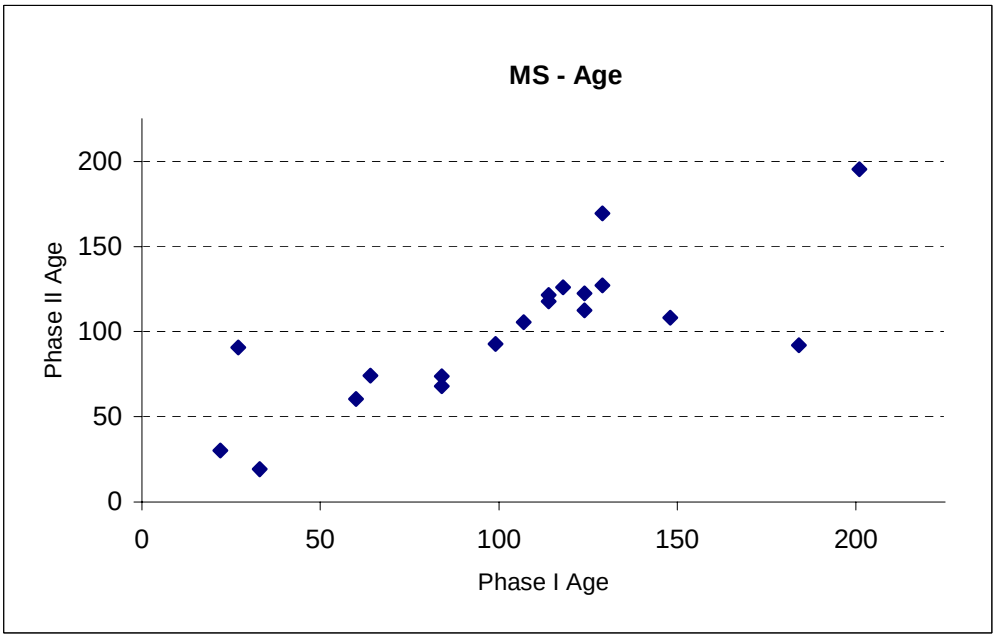

MS Volume
800
600
400
200
0
Phase II Vol (m3/ha)
0
100
200
300
400
Phase I Vol (m3/ha)

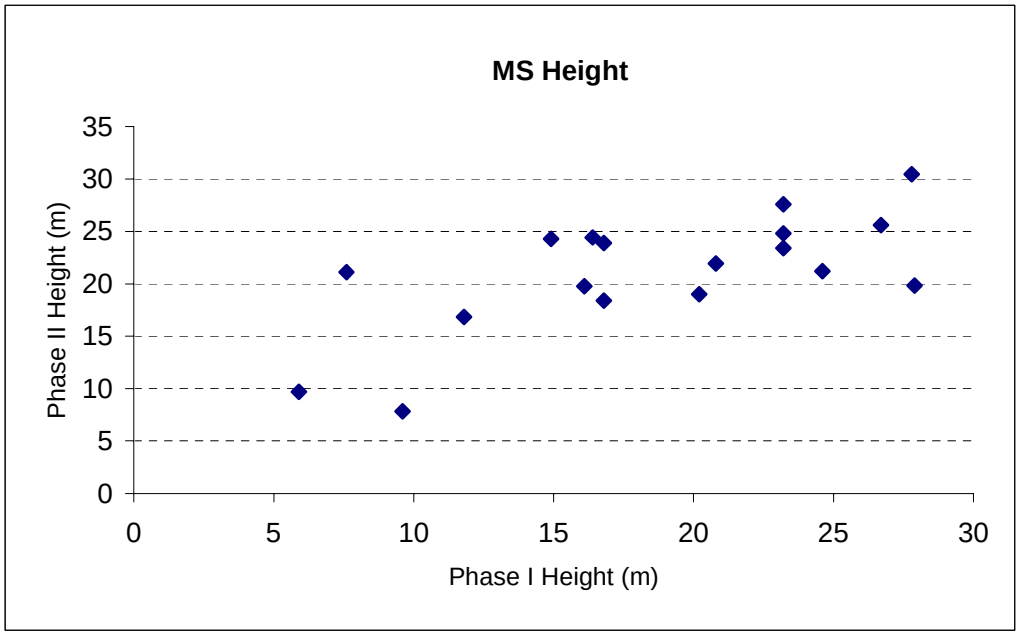
APPENDIX IV – AGE AND HEIGHT SCATTERGRAMS

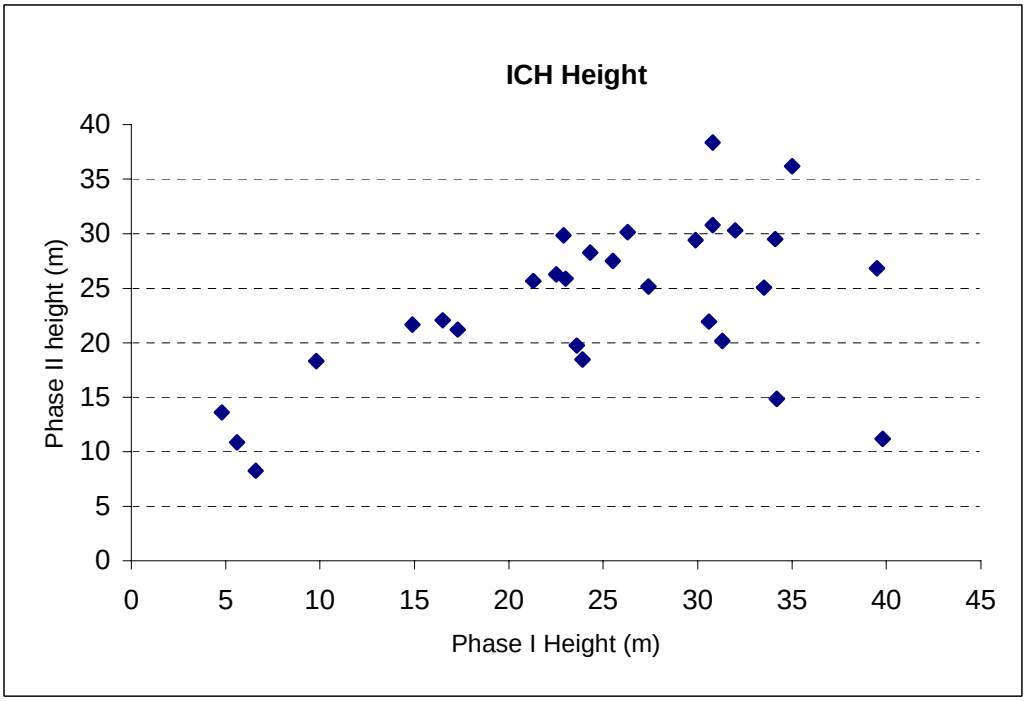


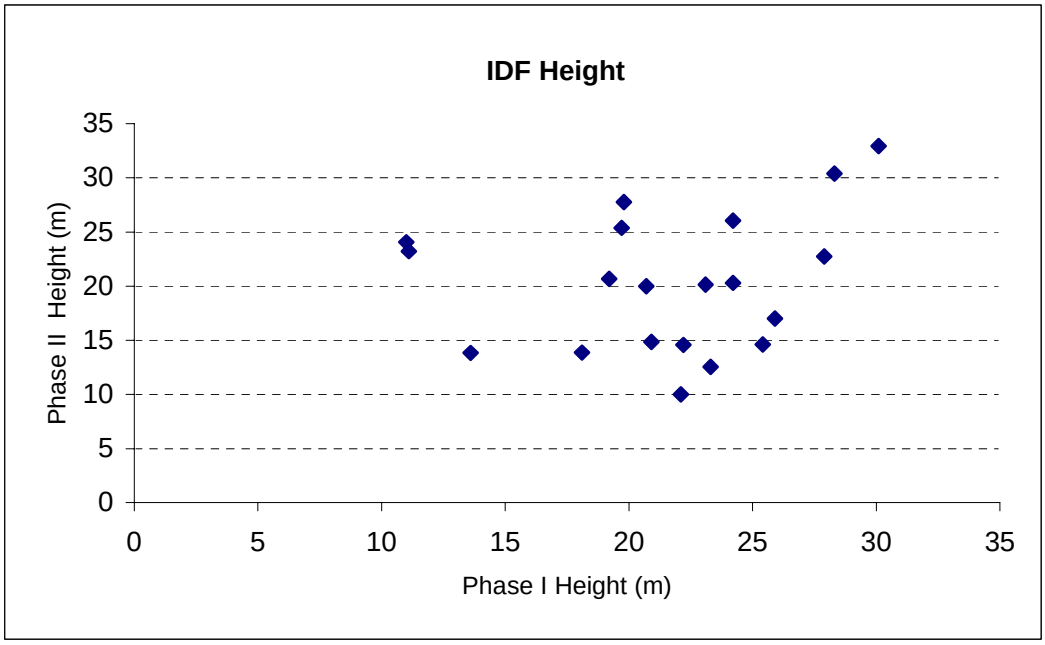


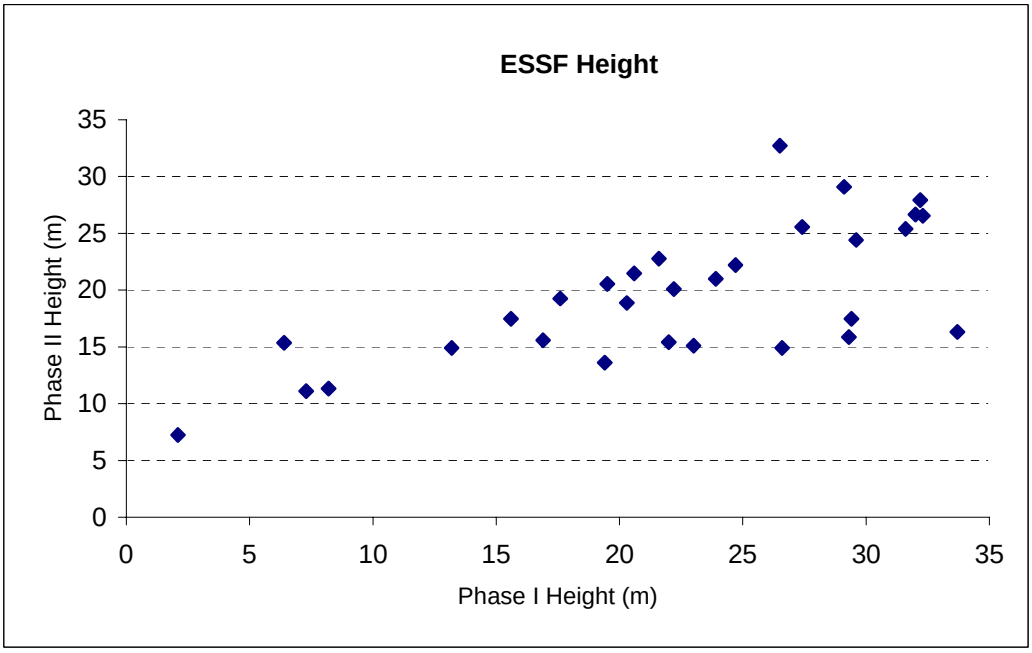

ESSF - Age
Phase II Age
Phase I Age
0
50
100
150
200
250
300
350
400


MS - Age
Phase II Age
Phase I Age
0
50
100
150
200


MS Height
Phase II Height (m)
0
5
10
15
20
25
30
35
Phase I Height (m)
0
5
10
15
20
25
30


ICH Height
Phase II height (m)
0
5
10
15
20
25
30
35
40
Phase I Height (m)
0
5
10
15
20
25
30
35
40
45


IDF Height
Phase II Height (m)
Phase I Height (m)
0
5
10
15
20
25
30
35


ESSF Height
Phase II Height (m)
Phase I Height (m)
0
5
10
15
20
25
30
35