Young Stand Monitoring in the Kootenay Boundary Region: Plot Establishment Report

A Technical Report

Ministry of Forests, Lands, and Natural Resource Operations

Forest Analysis and Inventory Branch

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EXECUTIVE SUMMARY

This report presents results of Young Stands Monitoring (YSM) in the Kootenay Boundary Region. The YSM population covers approximately 8% of the region and consists of polygons where the age of the leading species is 15-50 years. As part of the YSM program, 105 monitoring field plots were established in the region. As part of an earlier YSM pilot study, 48 change monitoring plots were established and remeasured in the Kootenay Lake TSA.

The Vegetation Resources Inventory (VRI) attributes, including species composition and site index, are used to assign polygons to an analysis unit and project yields. Errors in these attributes will affect the accuracy of yield projections. The VRI attributes were compared to the ground samples.

The ground basal area is considerably higher than the inventory estimates for all TSAs (Table 1). The lower inventory BA may be due in part to BA not being projected for polygons with short trees. VDYP7 does not project BA of volume until the projected height is approximately 7m. The ground volumes are approximately double the VRI volumes with most of the difference due to attribute bias.

Table 1. The results of comparing the ground plots to the inventory are summarized. A p-value < 0.05 is generally considered an indication of statistically significant differences (or bias). Statistically significant biases are shaded. Basal area, density and volumes are at the 7.5 cm utilization level. Age, height and site index do not have a utilization level. There were 105 samples but not all samples had estimates of age, height, site index and volume.

TSA	Attribute	N	Estimate	Ground mean	Inventory mean	Bias		
						Magnitude	p-value	% of ground mean
Arrow	Basal area (m^2/ha)	22	VRI	15.5	4.7	10.8 ± 2.3	0	70%
Boundary		12	VRI	10.3	3.5	6.8 ± 2.5	0.02	66%
Cranbrook		19	VRI	15.4	2.5	12.9 ± 2.1	0	84%
Golden		20	VRI	20.4	7.3	13.1 ± 3	0	64%
Invermere		13	VRI	13.3	5.4	7.9 ± 2.6	0.012	59%
Kootenay		10	VRI	26.8	15	11.9 ± 4.5	0.027	44%
Revelstoke		9	VRI	24.5	5.4	19.1 ± 6.2	0.015	78%
All	Basal area (m^2/ha)	105	VRI	17.4	5.8	12 ± 1	0	67%
	Density (tree/ha)	105	VRI	949	2310	-1361 ± 241	0	-143%
	Leading species age (years)	95	VRI	40.8	31.2	9.6 ± 2.5	0	23%
	Leading spp dom height (m)	95	VRI	11.6	8	3.6 ± 0.5	0	32%
	Site index (m)	64	PSPL	20.5	18.8	1.74 ± 0.56	0.003	13%
	Whole stem volume (m^3/ha)	91	TIPSY	99	47	51 ± 10	0	52%
	Volume model bias (m^3/ha)	91	TIPSY			14 ± 8	0.107	14%
	Volume attribute bias (m^3/ha)	91	TIPSY			37 ± 9	0	38%

A pilot YSM program was established in the Kootenay Lake TSA in 2012 and the plots remeasured in 2017. The net annual change is summarized (Table 2).

Table 2. The average at time 0 and time 1 and the annual difference (± standard error) are given by attribute (Dbh ≥ 4.0 cm). The annual changes are statistically different from zero.

Attribute	N	Time 0	Time 1	annual change ± s.e.	p-value
Site index Height (m)	48	10.5	11.9	0.3 ± 0.05	0
Age (years)	47	33.8	36.7	0.67 ± 0.11	0
SI (m)	19	21.7	24.2	0.58 ± 0.11	0
BA (m^2/ha)	48	16.4	20.5	0.95 ± 0.08	0
TPH (trees/ha)	48	1486	1622	32.1 ± 14.1	0.027
WSV (m^3/ha)	48	92.7	121.8	6.65 ± 0.65	0
Netvol (m^3/ha)	48	53.9	73.3	4.36 ± 0.76	0

The change in whole stem volume is approximately 6.6 m^3/ha/yr, ranging from approximately 4.5 m^3/ha/yr for SE leading samples (n = 10) to 9.6 m^3/ha/yr for B leading samples (n = 5).

Acknowledgements

This project was coordinated by Graham Hawkins. Thank you to Graham Hawkins, Rene De Jong, Chris Mulvihill, Wenli Xu, Rhian Davies, Kathleen Hebb, Kristine Sacenieks and Scott MacKinnon for input. Thank you to Rene De Jong and Marc Rousseau for providing the data.

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1 Introduction

The Forest Analysis and Inventory Branch (FAIB) of the British Columbia Ministry of Forests, Lands and Natural Resource Operations has developed a framework for a Young Stand Monitoring (YSM) program to monitor the performance of young forest stands, especially those in high risk forest management units. The primary focus of YSM is to check the accuracy of the growth and yield assumptions and predictions of key timber attributes in young stands for timber supply review (TSR). This monitoring program helps to identify opportunities to improve the accuracy of timber supply forecasting for a management unit.

2 Objective

The objective of the YSM program (Omule 2013) is:

> To check the accuracy of the growth and yield predictions (assumptions) of key timber attributes of young stands used in TSR in a management unit, based on an independent random sample of monitoring plots. The TSR assumptions include stand gross and net volume (gross volume less cruiser-called decay and waste), site index, total age, species composition and succession.

This report summarizes YSM for the Kootenay Boundary Region. The monitoring plots for this region are established on a grid. The sample is not random but is unbiased.

The primary goals of FAIB's YSM are to:

1 Characterize the young stand population, including composition, structure, mortality, growth, yield and health.
2 Assess the accuracy of some Phase I Vegetation Resources Inventory (VRI) photo-interpreted polygon attributes (e.g., age, height, density and site index) for young stands.
3 Assess the accuracy of site index estimates in the Provincial Site Productivity Layer (PSPL).
4 Compare observed stand yields (e.g., basal area/ha and trees/ha) to predictions generated from growth models used in timber supply analysis.
5 Compare observed change to forecasts from growth and yield models for the young stand population once remeasurements are available.

Remeasurements are available for 48 plots stablished in the Kootenay Lake TSA as part of a YSM pilot study.

3 Sample Design

Field plots are a key component of BC's provincial forest inventory of which YSM sampling is a sub-component. The field plot program includes:

- Monitoring plots on a 20 x 20 km grid. This includes all land types across BC, including young stands.
- For the YSM population, the monitoring plot grid is intensified and sampling occurs at the intersection of young stands on a 5 x 10 km grid.

The ground sample in the Kootenay Boundary Region includes both sampling components. This report is focused on the intensive young stand sample.

3.1 Population

The monitoring unit, the geographic area of interest, is the Kootenay Boundary Region (Figure 1 and Figure 2).

Figure 1. The location of the Kootenay Boundary Region is given.

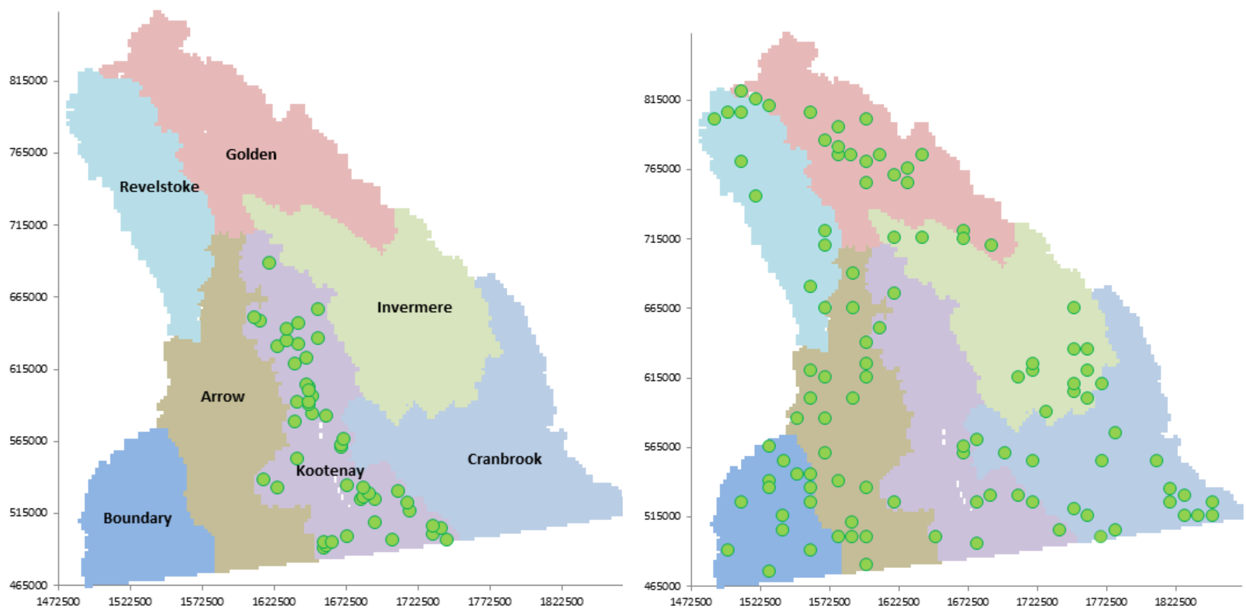

Figure 2. The left figure gives the locations of the growth analysis samples established in the Kootenay Lake TSA as part of a pilot monitoring program. The right figure gives the YSM establishment plots located throughout the Kootenay Boundary Region (FAIB 2014b).

Approximately 8% of the area within the region is part of the YSM population (Table 3). The VRI is used to define the YSM population as well as stratify the results presented here. For the YSM establishment samples, the oldest REFERENCE_YEAR (year of aerial photograph) and ATTRIBUTION_date (year of silvicultural survey information) was 1977.

Table 3. A summary of the YSM land base by TSA (from FAIB).

TSA	YSM area (age 15 – 50) (ha)
Arrow	144,069
Boundary	73,997
Cranbrook	103,622
Golden	93,885
Invermere	97,709
Kootenay Lake	77,206
Revelstoke	50,342
Total	640,829

3.2 Target Population

The YSM target population is composed of 15- to 50-year-old young stands as defined in the VRI vegcomppoly rank 1 layer, projected to the year of ground sample, within the Kootenay Boundary Region. The population was not restricted to vegetated treed polygons. It includes all stands in the age range (including silvicultural openings with crown closure < 10%). Two monitoring samples from the YSM pilot were older than the target population definition at the second measurement but were included (Table 4).

Table 4. The YSM plots that become older than the strict YSM definition are given. They are included in the change analysis.

Samples	Proj_Age_adj	Description
0131-0084-YO1	48	Used for change analysis
0131-0084-YR1	52	Used for change analysis
0131-0085-YO1	47	Used for change analysis
0131-0085-YR1	51	Used for change analysis

3.3 Sample Selection

The YSM ground sample data come from three data sources – CMI ground plots and two YSM programs (Table 5). The current YSM program was established in 2017 covering the Kootenay Boundary Region. There was also a YSM pilot program established in 2012 in the Kootenay Lake TSA only (FAIB 2014b). The pilot program was remeasured in 2017 to estimate change components. Three samples from the YSM pilot were incorporated into the current YSM program (0132_9576, 013Y_1005, 013Y_0311). Samples were identified as part of the YSM pilot project (ysm_pilot = "Y") or part of the current YSM project (ysm_main = "Y") by FAIB staff. In general, the YSM pilot samples were used to estimate growth with the exceptions noted in Table 26.

Table 5. The data sources are defined. All are circular, 0.04 ha fixed area plots.

Source	Data Source	Description	Use
CMI	Change monitoring inventory	Established on the 20 x 20 km NFI grid.	Establishment
YSM	Young Stand Monitoring	Established on a 5 x 10 km grid superimposed on the 20 x 20 km grid, and within the YSM population. Established in 2017 in the Kootenay Boundary Region	Establishment
YSM pilot	Young Stand Monitoring Pilot	Established on a 2 x 2 km grid in the YSM population. To achieve the desired sample size of 50 YSM plots, every third plot meeting the population definition was used. Established in 2012 in the Kootenay Lake TSA and remeasured in 2017	Growth (change)

3.4 Plot Design & Establishment

The ground samples are circular fixed-area (0.04 ha) permanent sample plots. Plot establishment and measurement followed provincial YSM standards and procedures[1]. The plot consists of three nested plots: a 400 m^2 (11.28 m radius) plot for measuring all trees with diameter at breast height (DBH) ≥ 9.0 cm; a 100 m^2 (5.64 m radius) for trees with DBH ≥ 4.0 cm and Dbh < 9.0 cm; and a 19.6 m^2 (2.50 m radius) plot for all trees at least 0.1 m tall and DBH < 4.0 cm. The sample plots are centered at the grid intersection points.

The walkthrough method (as specified in the YSM standards and procedures) was assessed for all YSM ground samples in proximity to a potential out-of-population polygon boundary.

The sampling intensity for the establishment analysis, the proportion of the area sampled, was approximately 0.0008% based on each 0.04 ha plot representing 5,000 ha (based on the 5 x 10 km grid).

4 Data Compilation

The attributes in Table 6 were taken or compiled from the FAIB files.

Table 6. The field names for the attributes are given.

Attribute	Utilization	Ground file	VDYP7 file
Age of leading species	NA	AGET_TXO	PRJ_TOTAL_AGE
Site index height of leading species	NA	HT_TXO	PRJ_DOM_HT
Dominant height of leading species	NA	See section 4.1	PRJ_DOM_HT
Site index of leading species	NA	See section 4.4	PRJ_SITE_INDEX
Basal area	7.5 cm	BA_HA	PRJ_BA
Trees per hectare	7.5 cm	STEMS_HA	PRJ_TPH
Whole stem volume	7.5 cm	VHT_WSV	PRJ_WSV
Merchantable volume Dwb – pine	12.5 cm	VHT_NWB	PRJ_VOL_DWB
– All other species	17.5 cm	VHT_NWB	PRJ_VOL_DWB

Some additional screening of site index (SI) trees was undertaken (section 4.4) to calculate a ground SI in addition to SI_M_TXO.

4.1 Ground plot attributes

The compiled summaries were used for most attributes (volume, BA, etc.). The height of the leading species was calculated as the arithmetic mean height of the live dominant/codominant trees (crn_cl =”D” or “C”) of the ground leading species, excluding trees identified as residual. The attributes are defined in the data dictionary[2] and summarized in Table 10.

4.2 Ground plot data screening

There were seven establishment walkthrough plots (001Y-0110-YO1, 005Y-0572-YO1, 007Y-1287-YO1, 007Y-1632-YO1, 013Y-0313-YO1, 0272-6971-MO1, 027Y-1505-YO1) and two change walkthrough plots

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[1] BC Ministry of Forests, Lands and Resource Management Operations. June 2015. Change Monitoring Inventory BC. Change Monitoring procedures for provincial reporting. Ver. 2.2. https://www.for.gov.bc.ca/hts/vri/standards/RISC/2015/cmi_ground_sampling_procedures_2015.pdf.

[2] Data Dictionary for Vegetation Resrouces Inventory and National Forest Inventory Timber Data. Ministry of Sustatinable Resource Management. By Gitte Churlish. Dec. 2003. 8p.

(0131-0055-YO1 and 0131-0085-YO1) and their remeasurements. They were included in the analysis and compiled as walkthrough plots.

Seventeen samples had non primary layers in the VRI (Table 27). These layers were not projected.

Trees with ST_FL = “F” are fallen and not included in the compilation of dead or live trees.

Residual trees are identified in the field. The following is taken from the CMI procedures (MSRM 2005, p.42)

> Classify all trees assessed on the larger tree plot as to whether it is a residual from a former stand. In making this assessment, refer to the general area around the plot. Trees are classed as residual if they are present in even aged stands, are living remnants of a former stand, and occur as the occasional (< 25 per ha) large stem of an older age class than the stand as a whole. Typically these trees have larger diameters, a higher incidence or indication of decay, thicker bark, larger branching and “ragged” or flat tops. These trees must be clearly residual. Uneven-aged stands do not generally have residual trees.

Residual and veteran trees are routinely included in ground compiler summaries and were included in the establishment analysis to compare leading species, basal area and trees/ha. Residual and veteran trees were not considered suitable age, height or SI trees and were not included in summaries of those attributes. For the comparison of ground vs. TIPSY volume, the residual and veteran trees were removed. The samples with live veteran or residual trees are given in the appendix in Table 28.

Multi-cohort conditions may be more difficult to inventory. Multi-cohort stands tend to be more heterogeneous and more difficult to project. TIPSY was not developed to simulate multi-cohort stands. As a result, it was expected that the differences between ground attributes and VRI and TIPSY estimates may differ for single-cohort stands relative to multi-cohort stands. The samples were examined for evidence of multi-cohort conditions and the results summarized for single-cohort and multi-cohort conditions. The screening included examining plots that met the conditions in Table 7. For the residual or veteran trees, the requirement that the residual or veteran trees had to make up between 20 and 80% of the volume was added. These limits are somewhat arbitrary but the intent was that if a sample only had a few residual or veteran trees, it was better characterized as a single cohort with scattered residuals. If the sample was almost entirely residual or veteran trees, it was a single cohort with minor ingress.

Table 7. The logic used to identify multi-cohort samples is summarized.

Abbreviation	Criteria	Description
Layer	Residual or veteran layer	A residual or veteran layer is identified in the inventory.
R or V	Residual or veteran trees	The ground sample includes residual or veteran trees that make up between 20 and 80% of the total whole stem volume.
Ht	VRI height	The difference between the projected VRI height of the leading species and second species is greater than 5m and the second species makes up more than 25% of the species composition
Age	VRI and ground age	The difference between the projected VRI age of the VRI leading species and ground age of the ground leading species is greater than 50 years.
Grd age	Ground age	Ground age of the ground leading species is greater than 100 years.

The 25 establishment samples identified as multi-cohort are given in Table 29

The samples with ground basal area greater than 30 m^2/ha are summarized in Table 8. All were included in the analysis.

Table 8. The plots where the ground basal area is greater than 35 m^2/ha. All attributes are at the 7.5 cm utilization level.

clstr_id	Basal area (m^2/ha)	Tree/ha	Whole stem volume (m^3/ha)	Dead volume (m^3/ha)	Measurement	Multi-cohort?
013Y-0311-YR1	65.4	801	655	33	1	Yes
007Y-1509-YO1	50.5	1726	347	4	0	Yes
013Y-0311-YR1	65.4	801	655	33	1	Yes
0131-0096-YR1	52.1	350	622	28	1	Yes

4.3 Ground sampling year and projection year

The ground sampling occurred throughout the growing season. The measurement year for measurements prior to June 30 was assumed to be the calendar year and the measurement year for measurements after June 30 was assumed to correspond to the subsequent calendar year. The VR I data were projected to the ground measurement year for the purpose of Objective 2: assessing the accuracy of some Phase 1 VRI photo interpreted polygon attributes for young stands.

4.4 Ground SI and years to breast height

Age and height were measured on sample trees on the ground plots. The trees used in SI assessment had a breast height or total age and height. In addition, the age, height and SI suitability flags had to be “Y”. There is a tendency for older trees to have a lower SI (Figure 3). The SIBEC standard (BC Ministry of Forests and Range, Research Branch 2009) is to exclude trees with breast height age < 10 or > 120 from SI calculations. To compare the ground SI to the PSPL SI, the SIBEC standard of excluding trees with breast height age < 10 or > 120 was used for the ground trees. To compare the ground SI to the VRI Phase I SI, all suitable SI trees were used. Because of the screening of SI trees, the trees used in the SI calculations are not necessarily the same as those used in the age and height calculations.

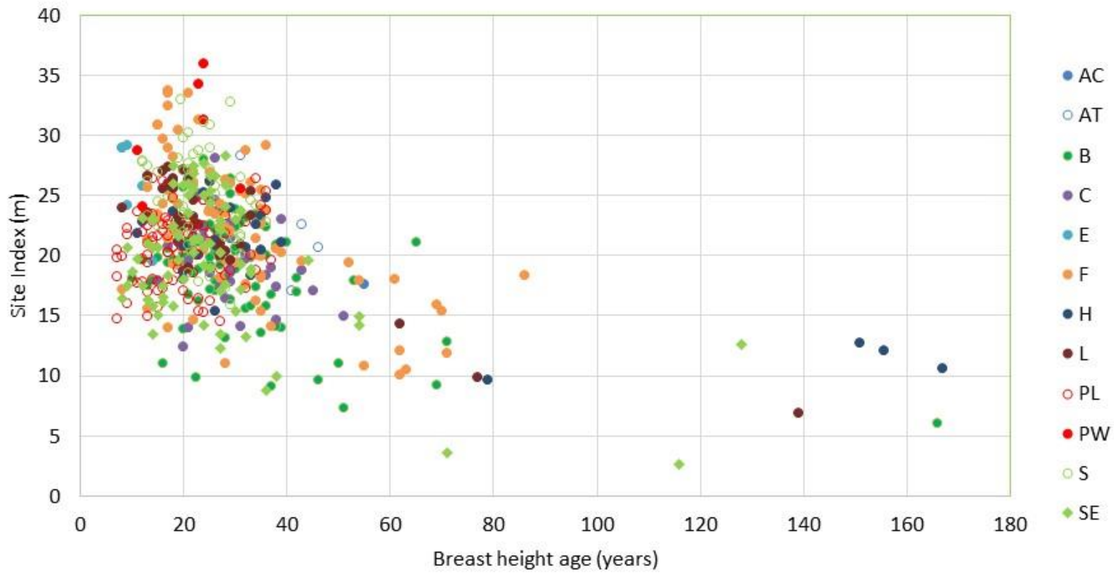


Figure 3. The site index estimates for the ground sampled trees are plotted against breast height age.

4.5 VRI (Phase I Photo Interpreted Inventory) data

The average reference year for the VRI information is 2001 for the establishment samples (Table 30) and 2006 for the change samples. Inventory information for recently disturbed polygons generally comes from the Reporting Silviculture Updates and Land status Tracking System (RESULTS). The RESULTS layer contains silvicultural information and summaries of field assessments by opening. The openings do not necessarily align with the VRI polygons and the VRI information is generally taken from the opening with the largest overlap with the target polygon. The RESULTS information for the opening is generally imported directly into the VRI database. As the area is re-inventoried, a photo-interpreter may make minor adjustments to the VRI label, usually not until the RESULTS Information is at least 10 years old. These polygons are processed by VDYP7 to project them to the year of ground sampling. For stands less than 7 m tall, VDYP7 will project the age and height until the height is 7 m and then generate the remaining attributes. Until the projected height is 7 m, the other attributes are not altered and the utilization limit is unchanged from the original data collection. This is illustrated by clstr_id = 0011-0196-MO1 which, in the original inventory file, had a PROJ_HEIGHT_1 = 5.7 m and 11,786 trees/ha and basal area = 0.0 m^2/ha, implying the quadratic mean DBH is 0 cm (below any of the common utilization limits). For some young stands, the VRI utilization limit is not known.

The VRI data were projected to the year of ground sampling. Approximately half of the establishment samples were too short to project basal area and trees/ha. Approximately one third of the change samples were too short at the time of establishment. For these measurements, basal area and trees/ha were copied from the input file. Volumes were set to zero. Ages and heights were projected.

The height of the second species is not projected by VDYP7. The height and age of the second species was projected by preparing a VDYP7 input file with the second species attributes (species, age and height) as the primary species attributes and projecting the height and age.

No polygons had dead layers. The polygons with non-primary layers are summarized in Table 27.

4.6 Stratification

The samples were stratified by TSA, Biogeoclimatic Ecozone Classification (BEC), leading species age, and whether or not the sample showed signs of being multi-cohort (Table 9). The stratification was based on the VRI polygon data with the exception of some of the criteria used to detect multi-cohort samples.

Note the small sample sizes for some strata.

Table 9. The strata used to summarize the establishment plot results are defined. All strata include the multi-cohort samples (Table 7) except for "All – single" which omits them.

TSA	BEC	VRI Spp1	Age	Multi-cohort	N	Include multi-cohort?
Arrow	All	All	All	All	22	Yes
Boundary					12	Yes
Cranbrook					19	Yes
Golden					20	Yes
Invermere					13	Yes
Kootenay Lake					10	Yes
Revelstoke					9	Yes
All	ESSF	All	All	All	38	Yes
	ICH				49	Yes
	IDF				4	Yes
	MS				14	Yes
All	All	AT	All		2	Yes
		BL			18	Yes
		CW			4	Yes
		FD & FDI			20	Yes
		HW			8	Yes
		LW			1	Yes
		PL & PLI			23	Yes
		PW			1	Yes
		SE			13	Yes
		S & SX			15	Yes
All	All	All	ages 15-30	All	54	Yes
			ages 31-50		51	Yes
All	All	All	All	All – multi	80	Yes
				All - single	25	No
All	All	All	All	All	105	Yes

4.7 Provincial Site Productivity Layer

The provincial site productivity layer (PSPL[3]), version 6.1, provides an alternative source of SI estimates, which is particularly useful for the YSM population where trees are young and SI estimates from age and height may be less reliable. The PSPL is a roll up of Terrestrial Ecosystem Mapping (TEM) and Predictive Ecosystem Mapping (PEM) data and the best estimate of what is there. The PSPL is the prime source of SI information used in Timber Supply Review (TSR) for existing managed stands. This layer provides SI

[3] http://www.for.gov.bc.ca/hts/siteprod/download/FLNR_Provincial_Site_Productivity_Layer.pdf

estimates for up to 22 species. The intersection of the provincial site productivity layer and the ground plots was provided by the FAIB.

As noted in the PSPL documentation[4], the PSPL site indices are more appropriately used for strategic, as opposed to operational, purposes. If used for site-specific applications, as is the case here, the SI estimates should be verified through a ground-based survey. The results presented here are an assessment of the PSPL for young stands.

Approved PEM/TEM data for PSPL version 6.1 is available for Boundary, Arrow, Invermere, Revelstoke and Cranbrook TSAs and not available for Golden and Kootenay Lake TSAs. The Kootenay Lake TSA PEM is limited by gaps in some of the non-forested site series.

The PSPL does not include SI for AC so the SI estimate for AT was used for AC.

5 Establishment stand structure and health

The ground data are summarized in Table 10. The ground data are compiled from 0.04 ha fixed area plots. The ranges and standard errors associated with small plots are considerably higher than what is expected for larger polygons.

Table 10. The Kootenay Boundary Region YSM establishment ground plots are summarized. SE is the standard error of the mean and SE% is standard error expressed as a percent of the mean.

	Util	N	Statistic				
Attribute	(cm)		Mean	Minimum	Maximum	SE	SE%
Basal area (m^2/ha)	4	105	19.5	0	65.4	1.3	7%
Trees per hectare (stems/ha)	4	105	1801	0	8781	129	7%
Gross volume live (m^3/ha)	4	105	107	0	655	10	9%
Basal area (m^2/ha)	7.5	105	17.4	0	65.4	1.3	8%
Trees per hectare (stems/ha)	7.5	105	949	0	2727	60	6%
Gross volume live (m^3/ha)	7.5	105	101	0	655	10	10%
Gross volume dead (m^3/ha)	7.5	105	8	0	158	2	25%
Volume net of decay, waste & breakage (m^3/ha)	7.5	105	56	0	424	7	12%
Dead trees per hectare (stems/ha)	7.5	105	42	0	650	7	17%
Leading species age (years)	NA	95	41	13	173	3	7%
Site index height of leading species (m)	NA	93	12.5	3.7	26.9	0.5	4%
Dominant height of leading species (m)	NA	102	12.3	3.8	40.2	0.6	5%

There is variation between TSA in attributes including basal area and age (Figure 4).

[4] http://www.for.gov.bc.ca/hts/siteprod/provlayer.html

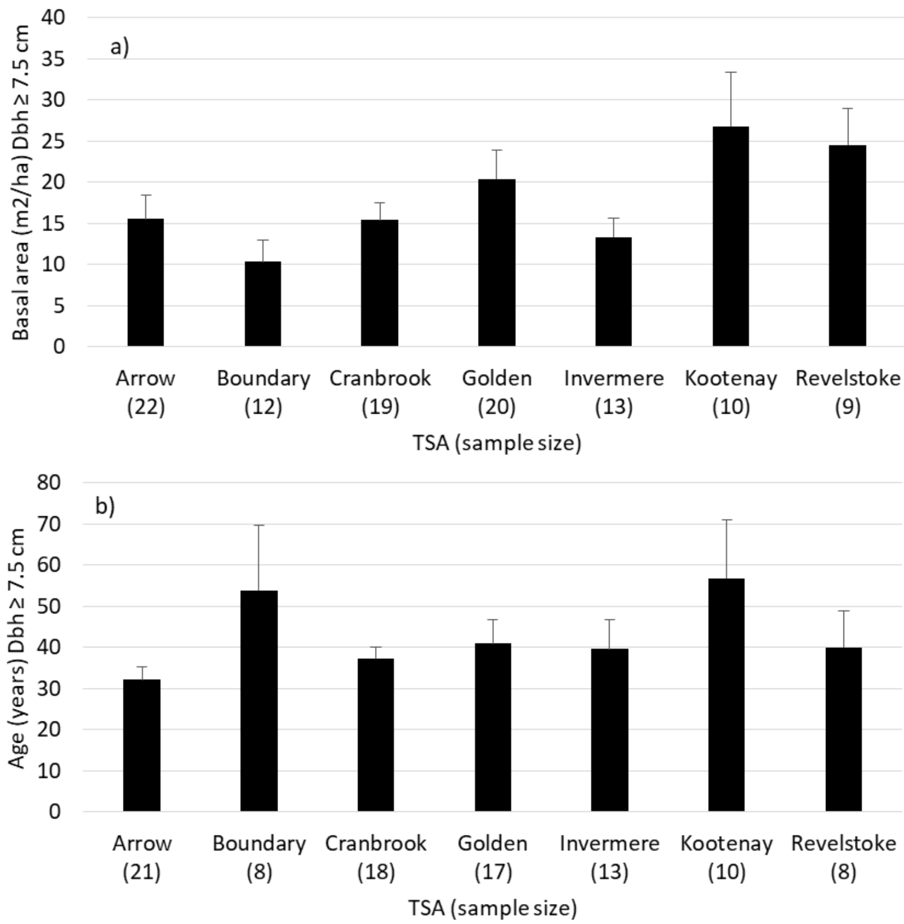


Figure 4. The average ground sample basal area (a) and age (b) are given by TSA for the establishment plots. The standard error bars are given.

The YSM subpopulation is dominated by pine and spruce with considerable variation from TSA to TSA and by BEC (Figure 5 and Figure 6).

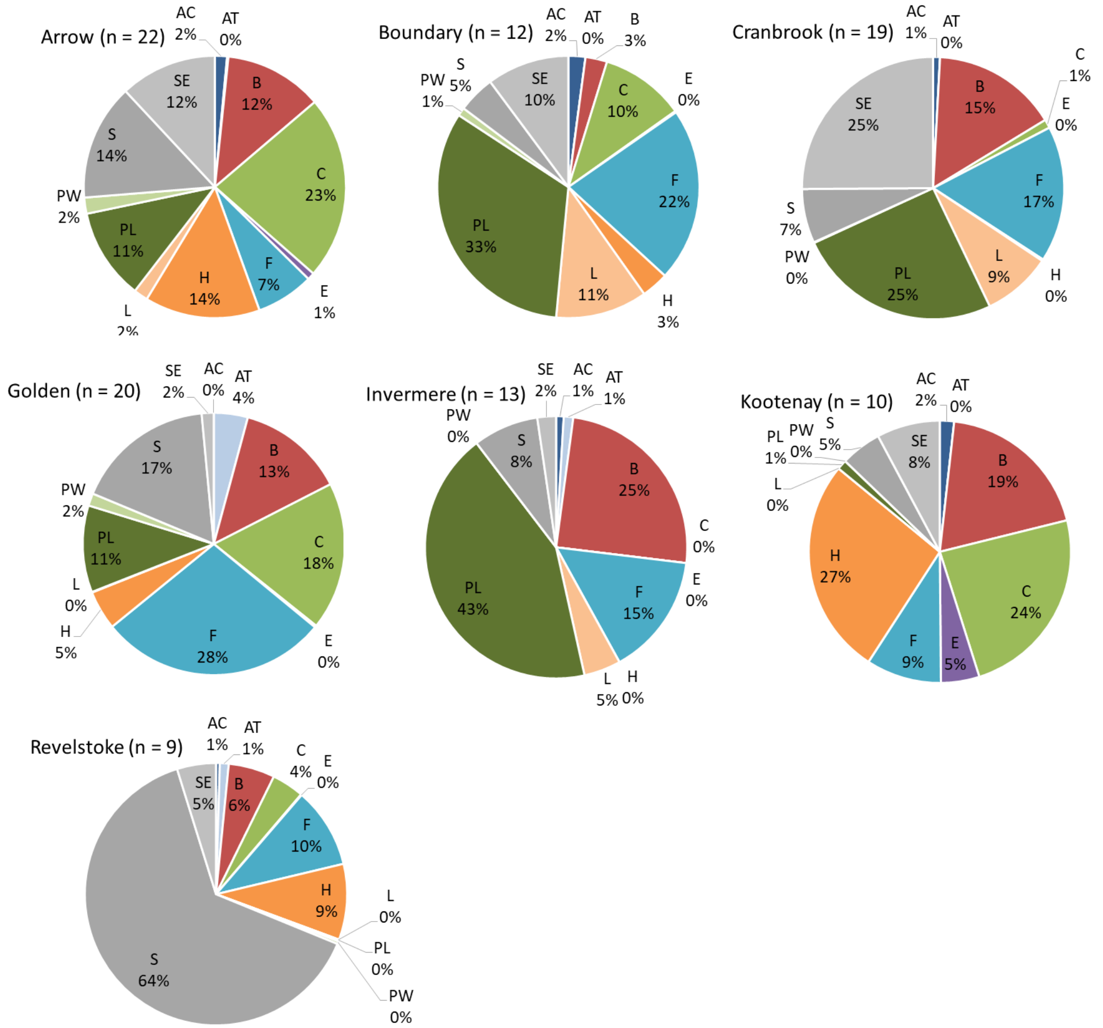


Figure 5. The percentage of live basal area is given by species and TSA based on the ground measurements for the establishment plots.

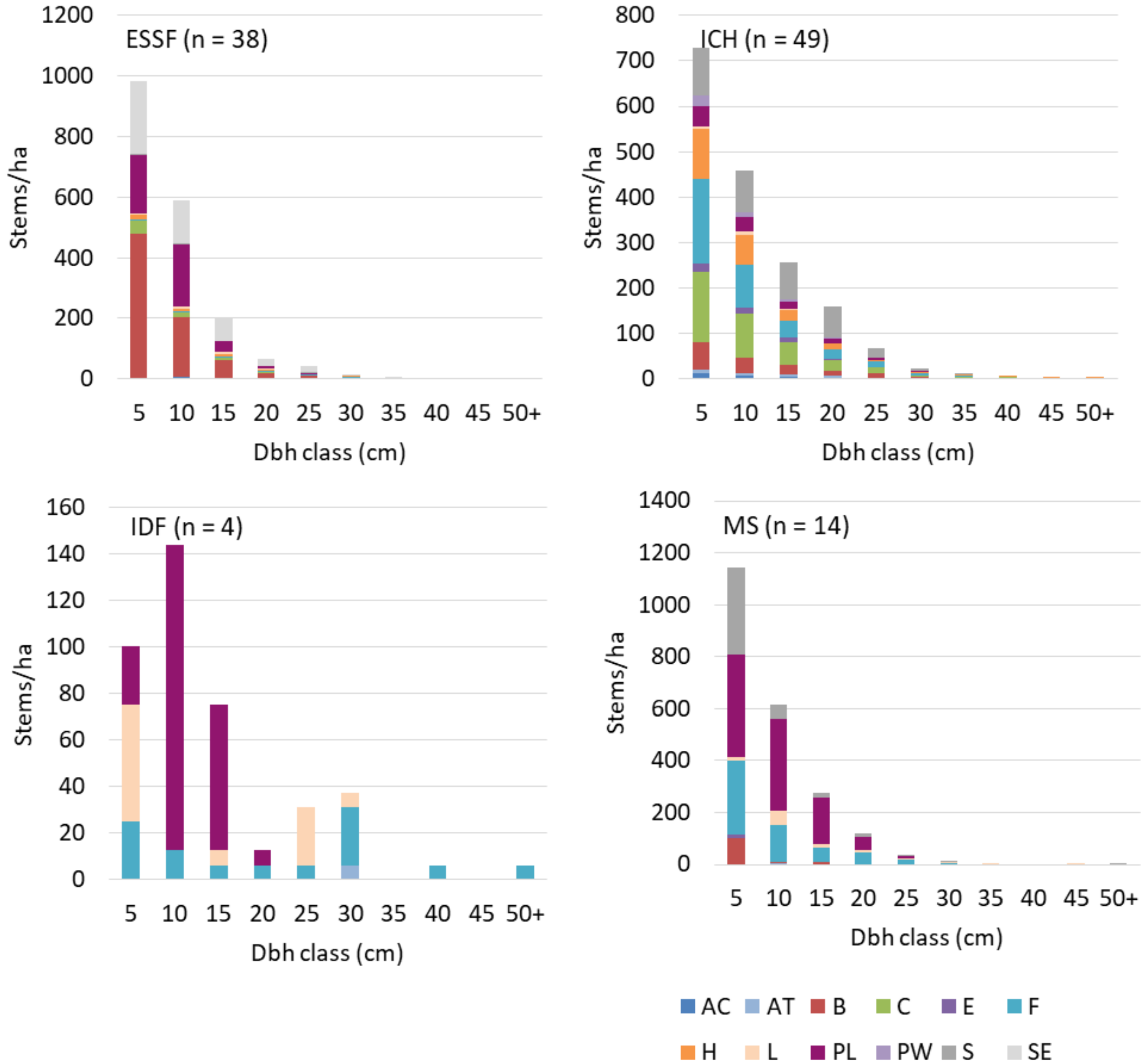


Figure 6. Stand tables based on the ground measurements are given for the establishment plots by BEC.

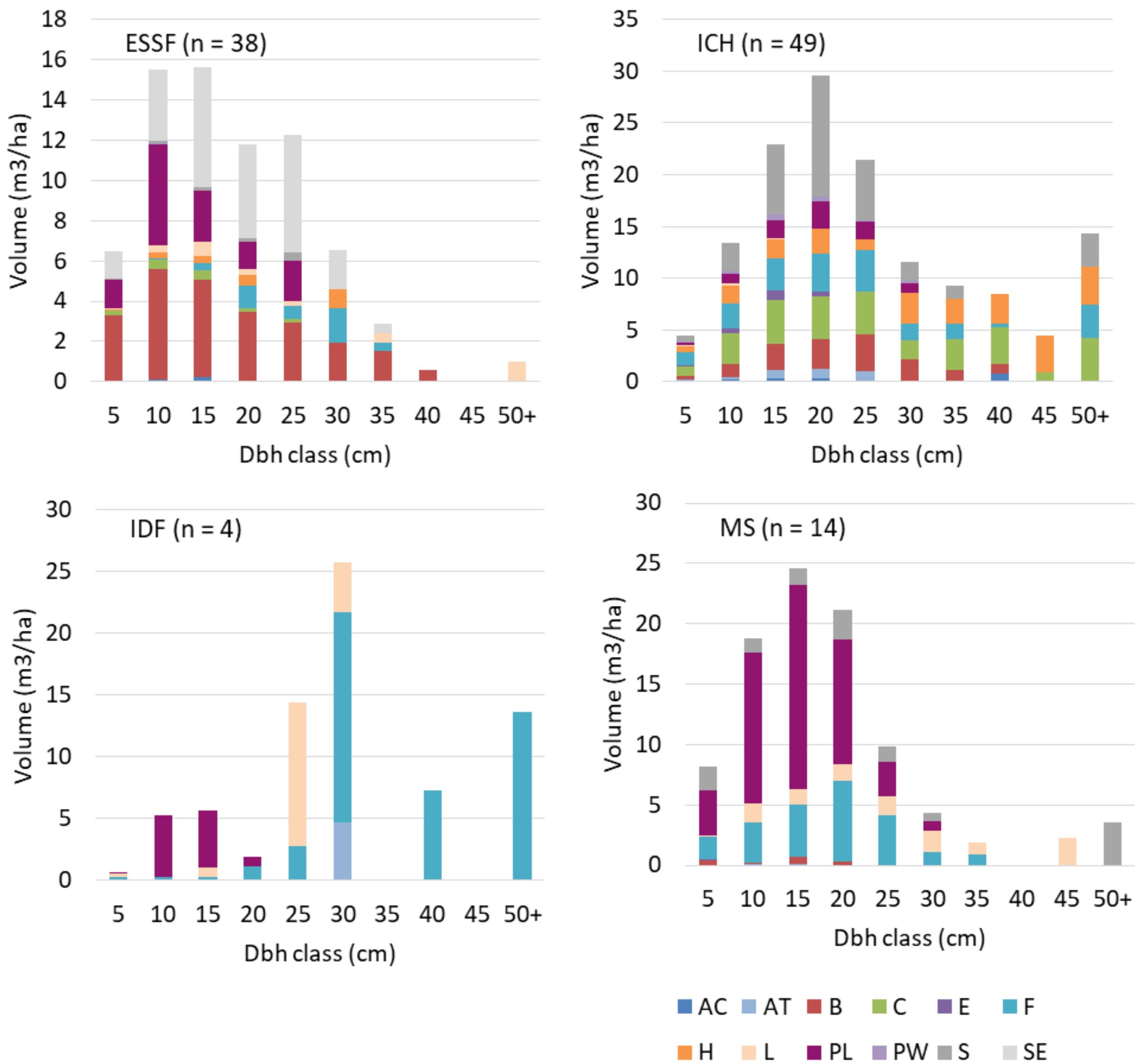


Figure 7. Stock tables based on the ground measurements are given for the establishment plots by BEC.

The size class distribution of the dead stems is given in Figure 8.

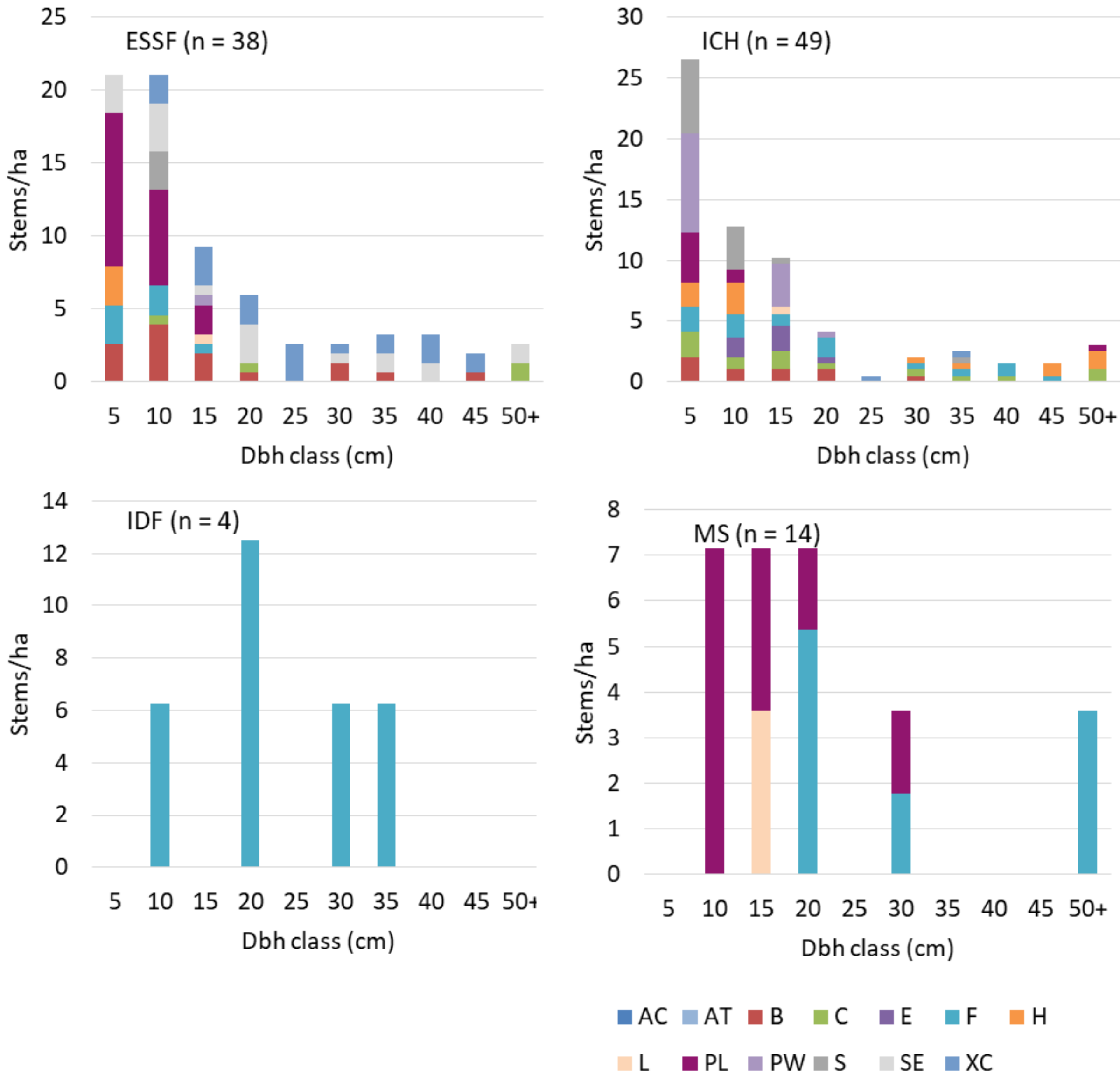


Figure 8. The dead trees are given by species, diameter and BEC.

Visible damage is recorded in the ground plots. There is a relatively high incidence of unknown damage agent in the Kootenay Boundary Region. Damage agent is coded as 'unknown' when the sampler cannot confirm the primary damage agent with any reasonable degree of certainty because the damage may be old or the damage agent not clear in terms of symptomology (characteristics of attack) and could be due to multiple causes. Samplers also record primary damage agent as "unknown" when there is indication of scars, forks or crooks which may affect wood quality. The level of severity, however, may vary and there may or may not be a significant impact on volume or change. The damage severity is not recorded when the damage agent is unknown. The trees where the primary damage agent = "Unknown" were split into those with form-related primary loss indicators (loss1_in = BTP, CRO, DTP, FRK, SCA) and those with non-form related primary loss indicators.

The visible damage is summarized by BEC (Figure 9). Approximately half of the stems have no damage. Of the stems with damage, approximately half of the damage is form-related (51%) followed by abiotic damage (21%) and disease (13%). No distinction was made between major and minor forks and crooks. Many minor forks and crooks have negligible effects on stem form. Future measurement will separate stem form issues into major vs. minor to better quantify impact.

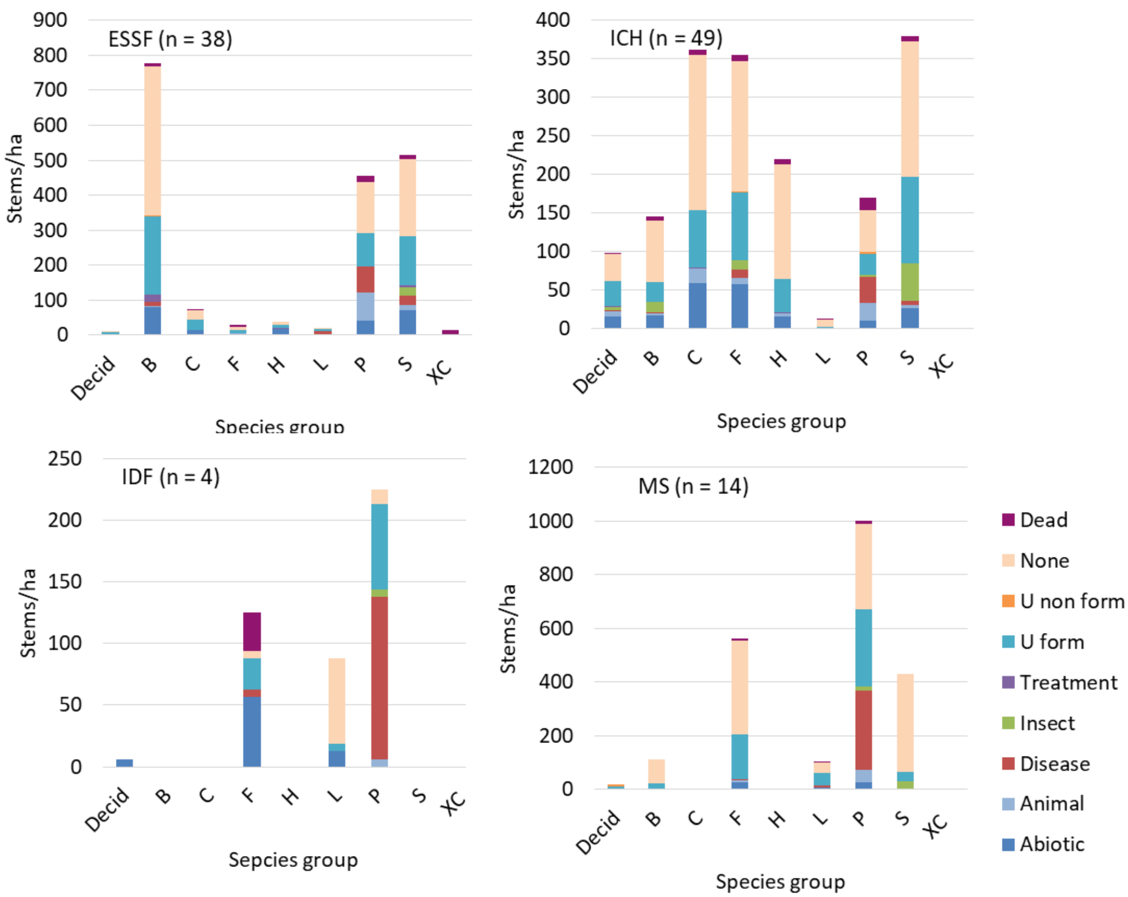


Figure 9. The stems/ha affected by each primary damage agent is given by species for live and dead trees, DBH ≥ 4.0 cm. Establishment plots only.

6 Ground vs. Inventory

6.1 Stand Age and Height

The leading species age, height and SI comparisons do not have a utilization level. The leading species ages are compared in Table 11 and the heights in Table 12. Note the large differences in age for the samples identified as multi-cohort. This is due in part to identifying multi-cohort stands on the basis of large differences between the ground and VRI ages. There are some differences between the VRI and ground definitions of age and height. The ground total age is based on the breast height age and calculations of years to breast height. The photo age is an estimate of total age. The ground age is based on the trees sampled to estimate top height for a given species. The photo interpretation of leading and second species height is the average height, weighted by basal area, of the dominant, codominant and high intermediate trees for the leading and second species of each tree layer identified (FAIB 2014a).

Table 11. The leading species ground plot and VRI Polygon ages are compared. The mean bias is followed by the standard error. Statistically significant differences are shaded.

Strata			Leading Spp Age (yrs)			
Type	Strata	N	Ground	VRI	Bias	p-value
TSA	Arrow	21	32.1	26.6	5.5 ± 3	0.087
	Boundary	8	53.9	26.3	27.6 ± 15.6	0.119
	Cranbrook	18	37.4	33.1	4.3 ± 3.2	0.199
	Golden	17	40.9	33.4	7.6 ± 4.8	0.133
	Invermere	13	39.6	32.7	6.9 ± 6	0.274
	Kootenay	10	56.8	35.9	20.9 ± 12.2	0.123
	Revelstoke	8	40	31.5	8.5 ± 7.5	0.294
BEC	ESSF	33	44.5	32	12.5 ± 5.1	0.019
	ICH	45	39.4	31.3	8.1 ± 3.2	0.016
	IDF	4	48.7	27.3	21.5 ± 15.1	0.25
	MS	13	33.9	30.5	3.5 ± 3.7	0.366
Species	AT	2	57.7	24.5	33.2 ± 7.5	0.142
	BL	16	59.2	32.7	26.5 ± 11.1	0.031
	CW	3	38.4	30.7	7.7 ± 2.8	0.113
	FD	18	41.6	28.8	12.8 ± 4.5	0.012
	HW	8	42.1	38.4	3.7 ± 3.1	0.267
	LW	1	28.4	33	-4.6 ± 0.00	
	PL	21	30.1	28.9	1.2 ± 2.1	0.589
	PW	1	18.2	16	2.2 ± 0.00	
	SE	12	40.8	34.8	6.1 ± 6.6	0.375
	SX	13	34.2	31.2	3.1 ± 3	0.324
Age	15-30	46	31.5	22.5	9 ± 3.2	0.007
	31-50	49	49.6	39.4	10.1 ± 3.8	0.01
Multi-cohort	N	71	34.4	30.5	3.8 ± 1.5	0.012
	Y	24	59.9	33.3	26.6 ± 7.8	0.002
All	All	95	40.8	31.2	9.6 ± 2.5	0

The relationship between ground and inventory age was strong with a few exceptions (Figure 10).

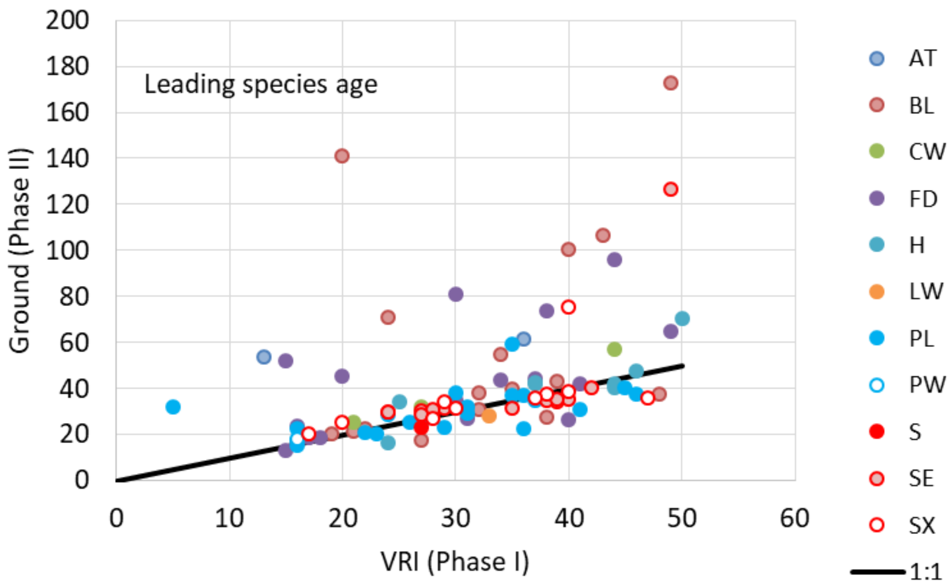
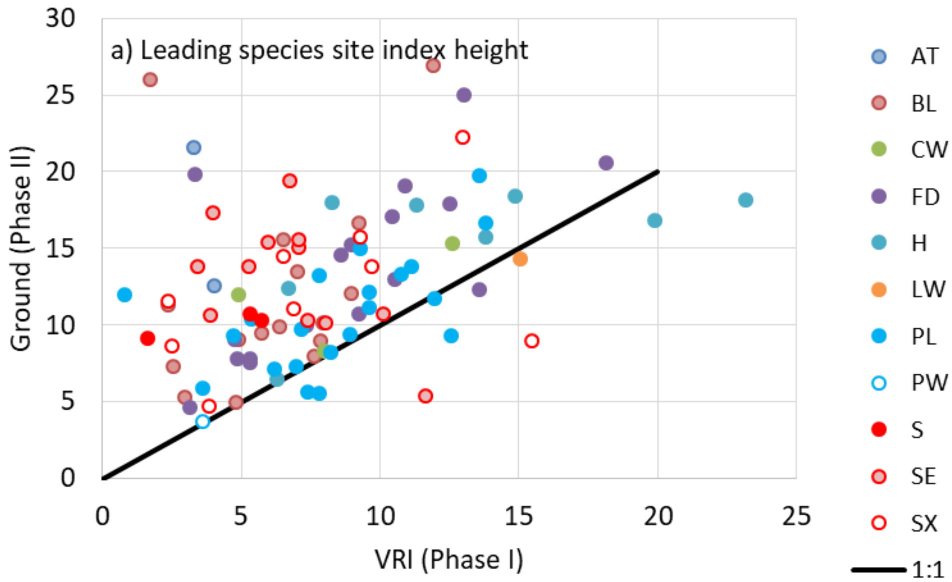


Figure 10. The VRI inventory (Phase I) and ground (Phase II) leading species ages are compared.

The relationship between ground and inventory height was variable (Figure 11) with some evidence of underestimation in the inventory (Table 12). The ground SI height is more similar to the top height used in TIPSY while the dominant/codominant height is more similar to the leading species height in the VRI.

The VRI age is used in TSR but the VRI height is not used directly. VRI age and height are used in the estimation of VRI SI. Another estimate of SI is available from the PSPL. The VRI is updated to the year of ground sampling using the VRI age and SI (either from the VRI or the PSPL). If the SI is biased, it will have an impact on the projected height. The VRI height indirectly affects TSR projections as height and age are used to estimate SI.



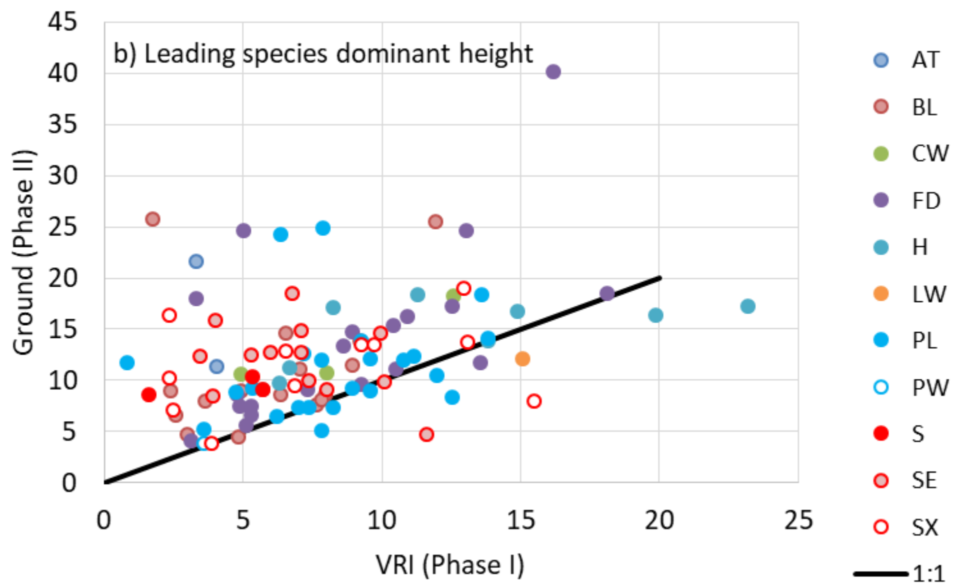


Figure 11. The VRI inventory (Phase I) and ground (Phase II) leading species SI height (a) and the ground leading species dominant height (b) are compared.

Fewer trees are SI height trees than are dominant/codominant trees and fewer samples had SI trees than had dominant/codominant trees so the sample sizes are smaller for SI height than dominant/codominant height. The average height of the dominant/codominant trees in the ground sample is less than the average height of the SI trees and closer to the VRI dominant height (Table 12). The differences between the ground sample height and the VRI are greater for the younger samples and for the multi-cohort samples. The differences are smaller for pine than for spruce, balsam or Douglas-fir.

Table 12. The leading species ground plot and VRI Polygon heights are compared. The mean bias is followed by the standard error. Statistically significant differences are shaded.

Strata			SI Height (m)					Dominant Ht (m)			
Type	Strata	N	Ground	VRI	Bias	p-value	N	Ground	VRI	Bias	p-value
TSA	Arrow	21	11.2	6.4	4.8 ± 10.2	0	21	10.2	6.4	3.7 ± 0.7	0
	Boundary	8	12.6	5.5	7.1 ± 12.2	0.041	8	12.2	5.5	6.7 ± 2.8	0.046
	Cranbrook	18	12.5	7.4	5.1 ± 11.4	0.001	18	11.4	7.4	4 ± 1.3	0.006
	Golden	16	13	9.9	3.1 ± 12.1	0.029	17	12.1	9.7	2.4 ± 1.2	0.065
	Invermere	13	11.1	8.9	2.2 ± 10.5	0.026	13	10.5	8.9	1.6 ± 0.9	0.096
	Kootenay	10	15.1	10.8	4.3 ± 14.3	0.061	10	14.3	10.8	3.5 ± 1.8	0.09
	Revelstoke	7	14.1	7.1	7 ± 12.6	0.003	8	12.6	7.9	4.7 ± 1.4	0.011
BEC	ESSF	33	10.4	7	3.5 ± 9.6	0.001	33	9.6	7	2.7 ± 1	0.008
	ICH	43	13.8	8.7	5.2 ± 12.7	0	45	12.7	8.7	4 ± 0.6	0
	IDF	4	16.1	7.2	8.9 ± 15.7	0.109	4	15.7	7.2	8.5 ± 4	0.123
	MS	13	12.4	8.8	3.6 ± 11.4	0.006	13	11.4	8.8	2.6 ± 1.1	0.037
Species	AT	2	17.1	3.7	13.4 ± 16.5	0.223	2	16.5	3.7	12.8 ± 5.5	0.259
	BL	16	12.2	6.2	6 ± 11.1	0.001	16	11.1	6.2	5 ± 1.5	0.006
	CW	3	11.9	8.5	3.4 ± 13.2	0.226	3	13.2	8.5	4.7 ± 1	0.04
	FD	17	13.7	8.8	4.8 ± 12.2	0	18	12.2	8.6	3.6 ± 1	0.002
	HW	8	15.5	13	2.4 ± 15.1	0.206	8	15.1	13	2.1 ± 1.8	0.287
	LW	1	14.3	15.1	-0.7 ± 0.00		1	12.2	15.1	-2.9 ± 0.00	
	PL	21	10.8	8.4	2.3 ± 10.2	0.004	21	10.2	8.4	1.7 ± 0.7	0.03
	PW	1	3.7	3.6	0.1 ± 0.00		1	3.9	3.6	0.3 ± 0.00	
	SE	12	13.1	6.7	6.4 ± 11.8	0.002	12	11.8	6.7	5.1 ± 1.5	0.007
	SX	12	11.8	6.8	4.9 ± 10.7	0.002	13	10.7	7.3	3.4 ± 1.1	0.01
Age	15-30	45	10.6	5.5	5.1 ± 9.8	0	46	9.8	5.5	4.3 ± 0.7	0
	31-50	48	14.4	10.4	4 ± 13.3	0	49	13.3	10.4	2.9 ± 0.7	0
Multi-cohort	N	69	12.1	7.9	4.2 ± 11.1	0	71	11.1	8	3.1 ± 0.5	0
	Y	24	13.6	8.3	5.4 ± 13.1	0	24	13.1	8.3	4.9 ± 1.2	0.001
All	All	93	12.5	8	4.5 ± 11.6	0	95	11.6	8	3.6 ± 0.5	0

6.2 Site index

The ground and PSPL SI are compared in Figure 12 and Table 13 and the ground SI was generally higher. The PSPL SI is based on broad average SI by species by site series / site series complexes, and the source tree data in the PSPL comes from tree data up to 120 years old, making it difficult to ensure the trees are free from past leader damage or height suppression. As a consequence, the PSPL SI may underestimate the potential SI of the site. SI estimates for young trees are sensitive to small differences or changes in age and height. By species, the differences were greatest for the spruces.

Some of the ground samples also include SI information for the secondary species. The PSPL was compared to the lead, second or third species, if they have ground SI estimates. As with the leading species comparison, the ground SIs are generally higher than the PSPL SI (Table 13).

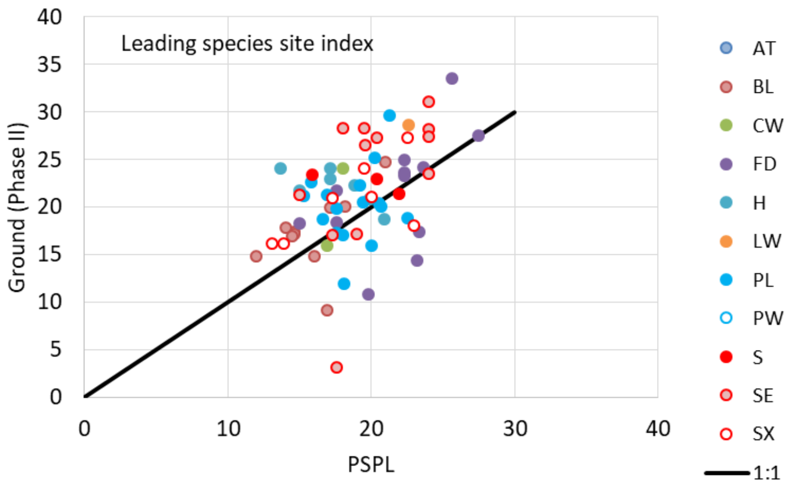


Figure 12. The ground SI and PSPL for the leading species are compared. The ground SI is based on trees with a breast height age ranging from 10 to 120 years.

Table 13. The ground plot and PSPL SI are compared for the ground leading species and by ground species regardless of rank (lead, second or third. Statistically significant differences are shaded. The ground SI is based on trees with a breast height age ranging from 10 to 120 years.

Strata Type	Strata	N	Leading Species Ground	SI (m) PSPL	Bias	p-value	N	All Species Ground	SI (m) PSPL	Bias	p-value
TSA	Arrow	12	22.2	20	2.19 ± 1.29	0.117	20	20.8	19.6	1.27 ± 0.91	0.181
	Boundary	4	19.1	16.6	2.48 ± 1.89	0.282	6	19.8	16.5	3.31 ± 1.31	0.053
	Cranbrook	15	19	17.4	1.55 ± 0.71	0.048	27	20	17.2	2.79 ± 0.73	0.001
	Golden	12	19.6	19.5	0.13 ± 1.64	0.937	18	20.8	19.7	1.13 ± 1.2	0.36
	Invermere	12	18.9	17.7	1.19 ± 1.35	0.396	15	19	17.9	1.05 ± 1.19	0.396
	Kootenay	4	26.5	19.8	6.68 ± 1.54	0.023	6	25.2	18.6	6.62 ± 1.13	0.002
	Revelstoke	5	23.5	21.7	1.83 ± 2.59	0.519	5	23.5	21.7	1.83 ± 2.59	0.519
BEC	ESSF	25	17.8	16.7	1.1 ± 0.99	0.279	41	18.1	16.5	1.58 ± 0.73	0.038
	ICH	26	23.4	20.9	2.54 ± 0.78	0.003	35	23.5	21	2.54 ± 0.66	0
	IDF	3	20.7	15.9	4.87 ± 1.05	0.043	3	20.7	15.9	4.87 ± 1.05	0.043
	MS	10	19.7	19.4	0.3 ± 1.5	0.847	18	20.9	18.9	2.06 ± 1.15	0.092
Species	BL	10	17.3	16.8	0.51 ± 1.1	0.654	19	18.1	17	1.13 ± 0.74	0.145
	CW	2	20	20.6	-0.53 ± 0.37	0.39	3	20.1	20.7	-0.61 ± 0.23	0.117
	FD	13	21	20.1	0.96 ± 1.6	0.558	19	21.6	20.2	1.37 ± 1.23	0.28
	HW	7	22.1	20	2.17 ± 0.68	0.018	10	23	19.6	3.44 ± 0.97	0.006
	PL	16	20.2	18.5	1.7 ± 0.89	0.074	25	20.3	17.9	2.39 ± 0.79	0.006
	PW						1	26.4	24	2.37 ± 0.00	
	SE	9	22.2	19.4	2.81 ± 2.51	0.295	11	22	19.2	2.84 ± 2.24	0.233
	SX	7	21.1	17.3	3.83 ± 0.7	0.002	9	20.1	16.6	3.53 ± 0.73	0.001
Age	15-30	25	21.5	19.6	1.94 ± 0.77	0.018	41	21.4	19.1	2.36 ± 0.61	0
	31-50	39	19.9	18.3	1.6 ± 0.78	0.048	56	20.1	18.1	1.94 ± 0.63	0.003
Multi-cohort	N	47	21.5	19	2.49 ± 0.52	0	73	21.4	18.6	2.82 ± 0.45	0
	Y	17	17.7	18.1	-0.36 ± 1.45	0.808	24	18.4	18.4	-0.01 ± 1.07	0.991
All	All	64	20.5	18.8	1.74 ± 0.56	0.003	97	20.6	18.5	2.12 ± 0.45	0

The ground SI was also compared to the Phase I VRI SI. The ground SI estimate included all suitable SI trees, regardless of breast height age.

Table 14. The ground plot is compared to the VRI SI. The ground SI includes all suitable SI trees, regardless of age. If the VRI leading species matches the ground leading species, the VRI leading species SI is used. If the VRI secondary species matches the ground leading species, the VRI secondary species SI is used. Statistically significant differences are shaded.

Strata Type	Strata	N	Leading Species SI (m) Ground	VRI	Bias	p-value
TSA	Arrow	10	20.7	17.8	2.92 ± 2.1	0.199
	Boundary	4	18.6	15.4	3.23 ± 1.67	0.148
	Cranbrook	11	18.5	15	3.46 ± 1.39	0.032
	Golden	6	18.4	17.9	0.52 ± 3.1	0.874
	Invermere	9	17.8	17.2	0.56 ± 1.65	0.742
	Kootenay	3	28.3	17.2	11.13 ± 3.94	0.106
	Revelstoke	3	21.3	19.5	1.78 ± 4.16	0.711
BEC	ESSF	20	17.3	15.3	2 ± 1.45	0.183
	ICH	15	22.6	18.9	3.68 ± 1.62	0.04
	IDF	2	20.5	18.5	1.98 ± 0.68	0.212
	MS	9	19.7	16.6	3.11 ± 1.85	0.131
Species	BL	0				
	CW	9	16.9	15.5	1.4 ± 1.7	0.435
	FD	1	16	17	-1 ± 0.00	
	HW	10	20.3	17.7	2.62 ± 2.67	0.352
	PL	3	21.4	16.4	4.98 ± 1.11	0.046
	PW	0				
	SE	12	19.3	15.7	3.54 ± 0.97	0.004
	SX	1	17.1	23	-5.87 ± 0.00	
Age	15-30	9	21.4	17.7	3.72 ± 2.64	0.197
	31-50	1	27.3	23	4.3 ± 0.00	
Multi-cohort	N	20	20.4	18.2	2.24 ± 1.03	0.043
	Y	26	19.1	15.9	3.17 ± 1.36	0.029
All	All	33	21.2	17	4.19 ± 0.92	0

6.3 Leading Species

The agreement between the VRI and ground leading species is generally low (Table 15). If the spruces are considered a single species group, the agreement rises from 42% to 49%. The ground species composition is based on sampling a small area (400 m^2) within the polygon while the Phase I species composition is an assessment of the entire polygon. Particularly for polygons with a mixture of species and no clear dominant species, the ground sample may not represent the polygon well.

Some samples had 10% or less difference between the leading and second species in terms of species composition on the ground or in the inventory. For instance, the VRI species composition for sample 002Y-01450YO1 is Bl40PLl40Sx20 while the ground species composition if Pl66Bl34. If the leading and second species in the inventory composition were switched when the difference ≤ 10%, 10 additional samples would have become case 1 matches. Another contributing factor to the poor agreement is changes in species composition over time and the mixed species nature of the samples. Five out of 48 of the growth samples changed leading species over the approximate 5 year remeasurement interval.

Table 15. The Ground and VRI leading species are compared (4.0 cm utilization level). Agreement cells are shaded gray.

Ground	VRI	Sp0											%
Sp0	AT	B	C	E	F	H	L	PL	PW	S	SE	Total	Agreement
None		1	1							1		3	0%
AT											1	1	0%
B		6						2		2	1	11	55%
C			1		4	4						9	11%
E	1											1	0%
F	1				11	3		4	1	2		22	50%
H		3			1	1				1		6	17%
L			1					3				4	0%
PL		5			4			14		2		25	56%
PW												0	0%
S										3	3	6	50%
SE		3	1				1			4	8	17	47%
	2	18	4	0	20	8	1	23	1	15	13	105	
	0%	33%	25%	0%	55%	13%	0%	61%	0%	20%	62%		42%

6.4 Basal area and trees/ha

VRI trees/ha (TPH) and basal area (BA) are compared to the YSM ground data in order to assess the accuracy of these VRI polygon attributes for young stands. Note that the VRI TPH and BA are not used in TSR. As noted in section 4.5, the original source of the VRI TPH and BA may be photo interpretation or silviculture surveys provided by RESULTS. When the inventory is projected using VDYP7, the TPH and BA are modified to represent only trees with DBH ≥ 7.5 cm in the projection year. However, BA and TPH are only updated by VDYP7 once the projected height is 7 m. The samples where the VRI BA and TPH have not been modified likely represent a lower utilization limit.

The ground and VRI BA and TPH are compared in Table 16.

Table 16. The ground plot and VRI Polygon BA and TPH are compared. Statistically significant differences are shaded.

Strata	VRI		BA (m^2/ha)				Trees/ha			
Type	Strata	N	Ground	VRI	Bias	p-value	Ground	VRI	Bias	p-value
TSA	Arrow	22	15.5	4.7	10.8 ± 2.3	0	940	2931	-1990 ± 517	0.001
	Boundary	12	10.3	3.5	6.8 ± 2.5	0.02	613	3964	-3351 ± 1031	0.008
	Cranbrook	19	15.4	2.5	12.9 ± 2.1	0	968	2290	-1322 ± 640	0.053
	Golden	20	20.4	7.3	13.1 ± 3	0	1071	1441	-370 ± 322	0.264
	Invermere	13	13.3	5.4	7.9 ± 2.6	0.012	1018	1687	-669 ± 595	0.283
	Kootenay	10	26.8	15	11.9 ± 4.5	0.027	871	2162	-1291 ± 689	0.094
	Revelstoke	9	24.5	5.4	19.1 ± 6.2	0.015	1101	1630	-530 ± 220	0.043
BEC	ESSF	38	13.2	2.9	10.3 ± 1.9	0	922	3186	-2265 ± 522	0
	ICH	49	21.6	8.6	12.9 ± 2	0	990	1789	-799 ± 230	0.001
	IDF	4	10.3	4	6.3 ± 2.4	0.079	313	1310	-998 ± 272	0.035
	MS	14	16.2	4.4	11.9 ± 2	0	1063	2043	-980 ± 641	0.15
Species	AT	2	10.7	2.5	8.2 ± 0.5	0.036	350	470	-120 ± 255	0.721
	BL	18	14.3	3	11.2 ± 2.5	0	841	4370	-3529 ± 957	0.002
	CW	4	20.3	6.2	14.1 ± 6.2	0.109	1057	2138	-1081 ± 1076	0.389
	FD	20	17.3	6.9	10.5 ± 2.6	0.001	936	1925	-989 ± 472	0.05
	HW	8	33.9	19.9	14 ± 5.3	0.033	1288	1753	-465 ± 408	0.292
	LW	1	13.1	16.3	-3.2 ± 0.00		600	1311	-710 ± 0.00	
	PL	23	13.2	3.9	9.3 ± 1.5	0	946	1618	-672 ± 341	0.061
	PW	1	0.6	0	0.6 ± 0.00		75	1627	-1552 ± 0.00	
	SE	13	22.1	3.6	18.5 ± 4.7	0.002	1064	1756	-692 ± 418	0.124
	SX	15	16.4	5	11.4 ± 3.5	0.006	956	2595	-1640 ± 450	0.003
Age	15-30	54	12.5	1.3	11.2 ± 1.5	0	812	2978	-2166 ± 366	0
	31-50	51	22.6	10.5	12.1 ± 1.8	0	1095	1604	-509 ± 264	0.059
Multi-cohort	N	80	16.8	5.2	11.6 ± 1.3	0	957	2276	-1320 ± 270	0
	Y	25	19.3	7.7	11.6 ± 2.6	0	927	2419	-1492 ± 533	0.01
All	All	105	17.4	5.8	12 ± 1	0	949	2310	-1361 ± 241	0

7 Ground vs. TIPSY Volumes

The current volumes associated with young stands are generally less important than future yields, estimated by growth curves, when the stands are more likely to be harvested. Growth curves are generated by analysis units (AUs) for TSR. The volumes evaluated here are the static volumes from the establishment plots. The growth model TIPSY was used to generate growth projections for the samples. TIPSY projects growth, given initial stand conditions.

No TIPSY curves are available for AC or EP so they were mapped to AT. SI estimates were constrained to 5 – 30m to meet TIPSY requirements. Residual trees were omitted from the analysis.

7.1 Analysis Unit yield curves

Each TSA within the Kootenay Boundary Region has its own analysis units. To combine samples across TSAs in this analysis, generic assumptions (Table 17) were used to generate analysis unit curves.

Table 17. The analysis unit criteria and TIPSY assumptions are given. For all AU curves, the regen delay = 2 years, OAF1 = 0.85, OAF2 = 0.95 and genetic gain = 0.

	Criteria		TIPSY	Input					
AU	Species composition	Site index	Spp1	Spp2	Pct1	Pct2	SI	Regen	Density
FD-pure	FD 65%+	SI ≥ 17.5	Fd		100		20	Plant	1500
FD-pure	FD 65%+	12.5 ≤ SI < 17.5	Fd		100		15	Plant	1500
FD-pure	FD 65%+	SI < 12.5	Fd		100		10	Plant	1500
FD-mixed	Fd leading, FD < 65%	SI ≥ 17.5	Fd	Sx	50	50	20	Natural	5000
FD-mixed	Fd leading, FD < 65%	12.5 ≤ SI < 17.5	Fd	Sx	50	50	15	Natural	5000
FD-mixed	Fd leading, FD < 65%	SI < 12.5	Fd	Sx	50	50	10	Natural	5000
PL-pure	PL 65%+	SI ≥ 17.5	PL		100		20	Plant	1500
PL-pure	PL 65%+	12.5 ≤ SI < 17.5	PL		100		15	Plant	1500
PL-pure	PL 65%+	SI < 12.5	PL		100		10	Plant	1500
PL-mixed	PL leading, PL < 65%	SI ≥ 17.5	PL	Sx	50	50	20	Natural	5000
PL-mixed	PL leading, PL < 65%	12.5 ≤ SI < 17.5	PL	Sx	50	50	15	Natural	5000
PL-mixed	PL leading, PL < 65%	SI < 12.5	PL	Sx	50	50	10	Natural	5000
S-pure	S 65%+	SI ≥ 17.5	Sx		100		20	Plant	1500
S-pure	S 65%+	12.5 ≤ SI < 17.5	Sx		100		15	Plant	1500
S-pure	S 65%+	SI < 12.5	Sx		100		10	Plant	1500
S-mixed	S leading, S < 65%	SI ≥ 17.5	Sx	Pl	50	50	20	Natural	5000
S-mixed	S leading, S < 65%	12.5 ≤ SI < 17.5	Sx	Pl	50	50	15	Natural	5000
S-mixed	S leading, S < 65%	SI < 12.5	Sx	Pl	50	50	10	Natural	5000
AT	AT leading	All	AT		100		15	Natural	5000
CW	CW leading	All	CW		100		15	Natural	5000
HW	HW leading	All	HW		100		15	Natural	5000
LW	LW leading	All	LW		100		15	Natural	5000
PW	PW leading	All	PW		100		15	Natural	5000

7.2 Predicted (Projected) Yield Estimates

For each sample, ground volumes were compared against two separate sets of TIPSY yield curves to quantify the overall volume bias as well as to partition the total bias into model bias and attribute bias. In addition, two types of volume were compared. Whole stem volume is the total stem volume of live trees with DBH ≥ 7.5 cm. Net volume is the stem volume minus stump, top and net downs for all live trees. The utilization level is for merchantable volume is 12.5 cm for pine and 17.5 cm for all other species.

<u>VOL1</u>: Ground based plot volume. VOL1 is identical to the ground compiled volume except for the removal of residual trees (if applicable).

<u>VOL2</u>: TIPSY estimated volumes using a combination of ground plot and AU assumption inputs. TIPSY simulations start with initial stand conditions. The main input attributes are species composition, SI, initial density and regeneration type (natural or planted). The species composition and SI were taken from the ground plot summaries. The initial density and the regen method for the ground plots were not known. Stands with a leading species of F, P or S and relatively pure species (ground species 1 percent ≥ 65%) were assumed to be planted with 1,500 stems/ha. All other stands were assumed to be natural origin with an initial density of 5,000 stems/ha. Regeneration delay was set to two years. Genetic gain was set to zero.

For each species, the average SI was computed as described in section 4.4. SI was not always available for the leading species, in part because of the age screening (4.4).

TIPSY does not model mixed stands but calculates the weighted average of pure species stand where the weights reflect the species composition. Pure species curves were generated for up to the top four species on the ground plots. For each species, the yield curve was generated assuming 100% species composition and the ground SI for that species. The ground SI was not always available for species other than the leading species. Where possible, the SI for additional species was generated using SiteTools and the SI for the leading species and the SiteTools SI conversion equations. If that was not possible, the PSPL SI was used. A mixed species, composite yield curve was generated by the weighted average pure species yield curves with weights equal to the species composition fraction. Height, BA, TPH and volume were taken as the species composition weighted average of the curves. The species-weighted average height is consistent with TIPSY output for multiple species runs which is the weighted top height by species.

The TIPSY total age is the age since disturbance and not necessarily breast height age plus years to breast height. It includes a regen delay, years to breast height and assumes an initial stock height. As a consequence, when the TIPSY total age is equal to the ground age, the TIPSY height will not necessarily equal the ground height. And the heights should match since the ground compiler and TIPSY use the same SI (SiteTools) curves. Rather than matching the ground and TIPSY at the same total age, the ground and TIPSY heights were matched and the corresponding TIPSY volume extracted. This is equivalent to matching the ground and TIPSY volumes at the same breast height age. For mixed species stands, the species-weighted average height from the TIPSY curves was matched to the species-weighted average height from the ground sample.

VOL3: TIPSY estimated volumes using the PSPL SI estimates and the VRI species composition. The VOL2 regeneration assumptions were used for VOL3. The TIPSY runs were similar to those for VOL2 except the species composition was taken from the VRI layer and SI from the PSPL. The TIPSY age was matched to PROJ_AGE_1 (corresponding to the age of ground sampling).

VOL4: The AU assumptions are described in section 7.1. Each sample was assigned to an AU, based on the VRI species composition and the PSPL SI. The volumes were generated using TIPSY. VOL4 is the volume from the TIPSY curve corresponding to PROJ_AGE_1 (adjusted to the year of ground sampling).

The bias was defined a follows.

Total Bias = VOL1 – VOL3 = Model Bias + Attribute Bias
Model Bias = VOL1 – VOL2
Attribute Bias = VOL2 – VOL3

VOL2 and VOL3 are based on regeneration assumptions so both the model bias and the attribute bias include biases resulting from the regeneration assumptions.

7.3 Bias analysis

The ground volumes (VOL1) tend to be higher than the TIPSY volumes based on the VRI species composition and the PSPL SI (VOL3) (Figure 13). This is an estimate of total bias.

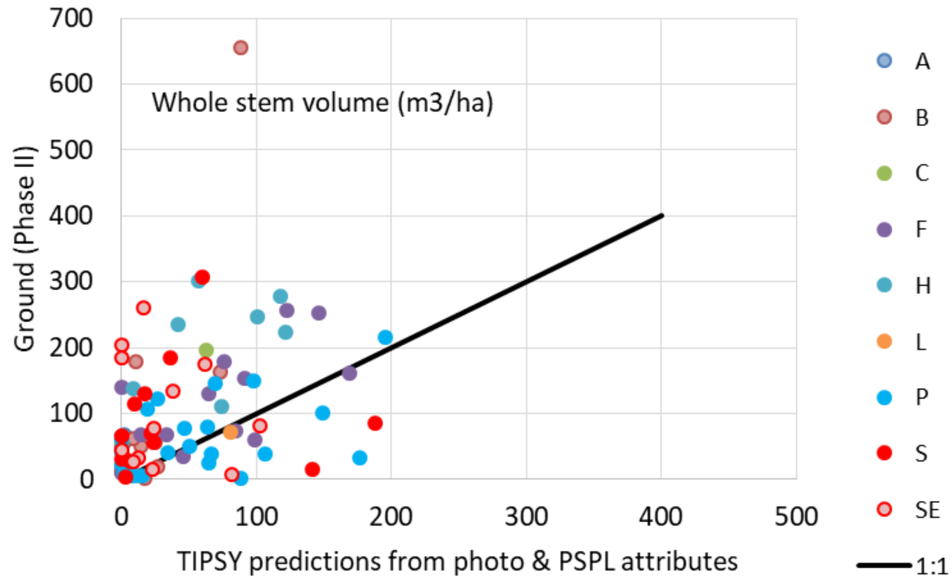


Figure 13. The ground volume (VOL1) is plotted against the TIPSY VOL3 predictions. Volumes are whole stem volume at the 7.5 cm utilization level.

The ground volumes (VOL1) were compared to the TIPSY volumes using the ground species composition and SI (VOL2) (Figure 14). The differences are an estimate of model bias.

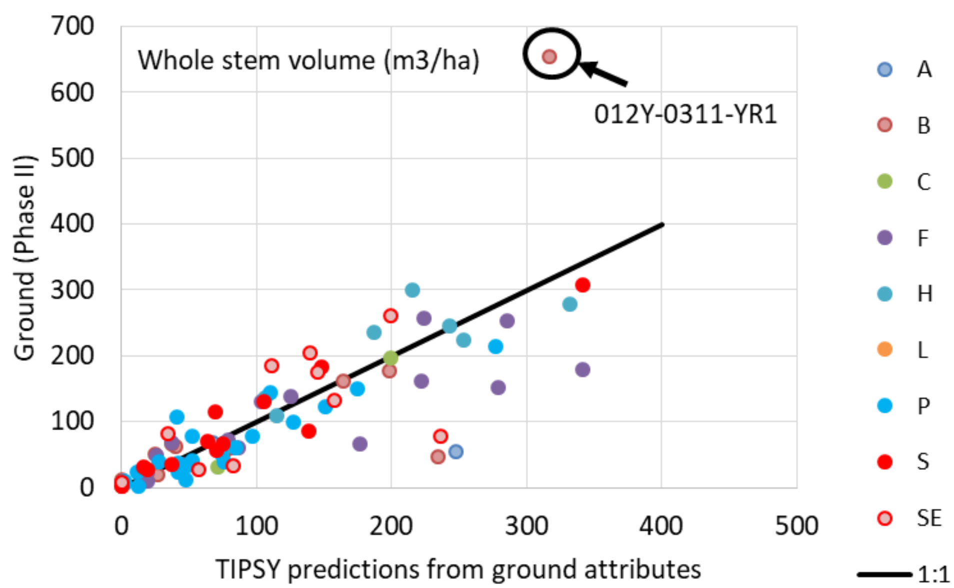


Figure 14. The ground volume (VOL1) is plotted against VOL2. Volumes are whole stem volume at the 7.5 cm utilization level.

The differences between the ground attributes and the TIPSY estimates (e.g., VOL1 vs .VOL3) include errors from a number of sources. The initial density for the TIPSY runs is based on generic AU assumptions and are average values for the AU and may not reflect the individual sample. VOL3 is based on the VRI species composition and PSPL SI while VOL1 is based on the ground measurements. The ground attributes represent a local 400 m^2 area while the VRI attributes represent a larger polygon and the PSPL SI represents a 1 ha tile. The results of TIPSY whole stem volume comparisons are given in Table 18.

Attribute bias dominates the total bias. Overall, the total bias is statistically significant and the attribute bias is statistically significant while the model bias is not statistically significant.

Table 18. Ground and TIPSY whole stem volumes are compared. The utilization level is 7.5 cm. Statistically significant biases are shaded.

	VRI	N	(m^3/ha)			Bias			p-value		
	Strata		VOL1	VOL2	VOL3	Total	Model	Attribute	Total	Model	Attribute
TSA	Arrow	19	84	63	37	45 ± 10	17 ± 18	26 ± 18	0	0.348	0.161
	Boundary	9	56	79	14	42 ± 13	-23 ± 30	65 ± 36	0.011	0.459	0.103
	Cranbrook	16	82	81	51	32 ± 14	1 ± 14	31 ± 13	0.038	0.956	0.035
	Golden	17	109	76	48	61 ± 24	33 ± 14	28 ± 17	0.02	0.034	0.12
	Invermere	13	63	47	63	0 ± 21	16 ± 14	-16 ± 22	0.986	0.272	0.474
	Kootenay	9	205	162	76	129 ± 66	42 ± 40	86 ± 44	0.086	0.315	0.084
	Revelstoke	8	129	135	37	92 ± 43	-6 ± 46	99 ± 31	0.07	0.898	0.016
BEC	ESSF	33	62	54	27	35 ± 9	8 ± 9	27 ± 10	0.001	0.416	0.012
	ICH	41	135	112	56	78 ± 19	21 ± 16	55 ± 15	0	0.193	0.001
	IDF	3	74	127	55	19 ± 56	-53 ± 56	72 ± 101	0.769	0.441	0.552
	MS	14	82	62	63	19 ± 19	20 ± 13	-1 ± 20	0.327	0.155	0.954
Species	AT	1	68	59	204	-136 ± NA	9 ± NA	-145 ± NA			
	BL	14	101	80	20	81 ± 39	21 ± 29	60 ± 22	0.059	0.474	0.018
	CW	3	94	66	22	72 ± 32	29 ± 22	44 ± 23	0.15	0.328	0.201
	FD	16	104	81	57	44 ± 13	18 ± 18	25 ± 20	0.005	0.321	0.248
	HW	8	192	147	67	125 ± 29	46 ± 26	80 ± 27	0.003	0.123	0.022
	LW	1	72	205	81	-9 ± NA	-133 ± NA	124 ± NA			
	PL	22	63	46	59	4 ± 12	16 ± 10	-12 ± 13	0.748	0.137	0.357
	SE	13	109	115	28	81 ± 27	-6 ± 28	86 ± 28	0.012	0.841	0.01
	SX	13	86	84	39	47 ± 27	2 ± 24	45 ± 25	0.109	0.922	0.102
Age	15-30	43	64	55	12	52 ± 10	8 ± 10	43 ± 11	0	0.407	0
	31-50	48	129	111	79	50 ± 17	18 ± 13	32 ± 14	0.005	0.171	0.03
Multi-cohort	N	67	97	78	45	51 ± 10	18 ± 9	32 ± 10	0	0.043	0.002
	Y	24	103	102	50	52 ± 26	1 ± 20	51 ± 20	0.056	0.959	0.018
All		91	99	84	47	51 ± 10	14 ± 8	37 ± 9	0	0.107	0

The volumes net of decay, waste and breakage are given in Table 19. The samples are young and should not have much decay but the trees are small with a high fraction of non-merchantable volumes and stand level volumes are very sensitive to utilization level. The results are similar to those for whole stem volume.

Table 19. Ground and TIPSY volumes net of decay waste and breakage are compared. The utilization level is 12.5 cm for pine and 17.5 cm for all other species.

	VRI Strata	N	VOL1 (m^3/ha)	VOL2	VOL3	Bias Total	Bias Model	Bias Attribute	p-value Total	p-value Model	p-value Attribute
TSA	Arrow	20	36	30	11	25 ± 8	5 ± 14	19 ± 13	0.006	0.699	0.157
	Boundary	9	33	45	3	30 ± 14	-13 ± 14	42 ± 26	0.073	0.392	0.142
	Cranbrook	16	42	42	22	20 ± 13	0 ± 12	20 ± 12	0.135	0.984	0.11
	Golden	17	58	28	15	43 ± 15	30 ± 10	13 ± 8	0.012	0.008	0.143
	Invermere	13	28	13	36	-8 ± 14	15 ± 11	-23 ± 14	0.567	0.197	0.134
	Kootenay	9	123	94	19	104 ± 44	29 ± 26	76 ± 33	0.044	0.31	0.053
	Revelstoke	8	79	86	13	65 ± 27	-8 ± 40	73 ± 30	0.046	0.855	0.046
BEC	ESSF	33	27	19	7	20 ± 7	8 ± 6	13 ± 5	0.007	0.191	0.027
	ICH	42	72	61	18	54 ± 13	11 ± 12	43 ± 12	0	0.372	0.001
	IDF	3	58	83	21	37 ± 51	-25 ± 30	62 ± 80	0.545	0.494	0.517
	MS	14	47	29	39	8 ± 16	18 ± 12	-10 ± 15	0.639	0.161	0.508
Species	AT	1	18	1	56	-38 ± NA	17 ± NA	-55 ± NA			
	BL	14	49	37	3	47 ± 28	13 ± 16	34 ± 16	0.117	0.445	0.048
	CW	3	39	19	3	36 ± 29	20 ± 15	17 ± 14	0.342	0.332	0.359
	FD	17	58	37	19	39 ± 14	21 ± 12	18 ± 15	0.011	0.104	0.226
	HW	8	107	72	18	89 ± 18	35 ± 22	54 ± 25	0.002	0.158	0.064
	LW	1	44	163	17	28 ± NA	-119 ± NA	147 ± NA			
	PL	22	31	22	35	-4 ± 10	9 ± 7	-13 ± 10	0.685	0.224	0.235
	SE	13	60	63	5	55 ± 17	-3 ± 25	57 ± 22	0.008	0.917	0.025
	SX	13	45	48	14	31 ± 19	-3 ± 20	34 ± 21	0.126	0.902	0.13
Age	15-30	44	31	27	3	29 ± 7	4 ± 8	25 ± 8	0	0.635	0.004
	31-50	48	71	56	31	40 ± 12	15 ± 10	25 ± 11	0.002	0.123	0.033
Multi-cohort	N	68	51	40	19	32 ± 7	12 ± 7	21 ± 8	0	0.121	0.012
	Y	24	54	49	13	41 ± 18	5 ± 12	36 ± 14	0.033	0.711	0.018
All		92	52	42	17	34 ± 7	10 ± 6	25 ± 7	0	0.123	0.001

7.4 Ground vs. AU volumes

The ground and inventory volumes are compared to AU volumes using generic AU assumptions and AU assignment based on VRI attributes.

Table 20. The ground and inventory volumes are compared to the AU volumes. Statistically significant differences are shaded.

	VRI	N	(m3/ha)			Bias	p-value
	Strata		VOL1	VOL3	VOL4	VOL1 – VOL4	
TSA	Arrow	20	36	9	11	26 ± 7	0.002
	Boundary	9	33	2	3	31 ± 15	0.077
	Cranbrook	17	42	18	22	24 ± 12	0.073
	Golden	17	58	15	15	43 ± 19	0.035
	Invermere	13	28	33	36	-5 ± 14	0.739
	Kootenay	9	123	30	19	93 ± 39	0.045
	Revelstoke	8	79	4	13	75 ± 23	0.014
BEC	ESSF	33	27	14	7	13 ± 8	0.127
	ICH	42	72	15	18	58 ± 12	0
	IDF	4	56	4	21	52 ± 32	0.201
	MS	14	47	30	39	17 ± 16	0.303
Species	AT	2	33	29	56	5 ± 44	0.93
	BL	14	49	5	3	45 ± 25	0.097
	CW	3	39	2	3	37 ± 30	0.344
	FD	17	58	8	19	50 ± 15	0.004
	HW	8	107	25	18	82 ± 18	0.003
	LW	1	44	19	17	25 ± NA	
	PL	22	31	27	35	4 ± 10	0.685
	SE	13	60	22	5	38 ± 22	0.106
	SX	13	45	11	14	34 ± 16	0.061
Age	15-30	45	31	1	3	31 ± 6	0
	31-50	48	71	31	31	40 ± 12	0.002
Multi-cohort	N	69	51	14	19	37 ± 7	0
	Y	24	54	22	13	32 ± 18	0.08
All		93	52	16	17	36 ± 7	0

8 Change

This section focuses on the remeasured plots from the YSM pilot study in the Kootenay Lake TSA and YSM objective 5 (see section 2) to compare observed change to forecasts from growth and yield models. The analysis follows the change estimation section of the Merrit TSA YSM analysis[5]. For trees present and tagged at plot establishment, the components of change used the tree factor at time of measurement. Some trees were tagged on the small tree plot at establishment (4.0 cm ≥ Dbh < 9.0 cm and had a tree factor = 100 stems /ha) and at remeasurement were tagged on the large tree plot (Dbh ≥ 9.0 cm and had

[5] Merritt Timber Supply Area Ground Sample Data Analysis Young Stand Analysis. Prepared by Associated Strategic Consulting Experts, March 31, 2015. 54p.

a tree factor = 25 stems/ha). For these trees, the components of change used the tree factor = 100 stems/ha. Ingress did not have a tree factor at the time of plot establishment and was assigned the tree factor at the time of remeasurement.

Seven samples had a non-primary layer (generally and older, taller layer) that was not projected (Table 21). The non-primary layer is not considered here.

Table 21. The seven samples with a non-primary layer are summarized.

Clstr_id	Layer	Layer Code	CC %	BA (m^2/ha)	TPH	Spp 1	spp 2	spp 3	spp 4	pct 1	pct 2	pct 3	pct 4	Age 1	ht 1	Age 2	ht 2
0131-0096-YO1	1		10	12	70	CW	HW			80	20	.	.	220	32	220	32
0131-0096-YO1	2	P	40	10	1099	FDI	HW	CW		60	20	20	.	30	11.1	30	11.1
0131-0084-YO1	1		10	15	70	HW	CW	BL	SE	80	10	5	5	240	32	240	32
0131-0084-YO1	2	P	20	0	3806	BL	SE	HW		80	10	10	.	42	2.1	42	2.1
0131-0078-YO1	1		10	10	90	SE	BL	HW		80	10	10	.	120	28	120	28
0131-0078-YO1	2	P	65	25	1450	FDI	HW	CW	SE	40	30	20	10	40	16	40	16
0131-0075-MO1	1	R	2	6	182	SE	HW	BL	CW	50	30	10	10	80	24	80	24
0131-0075-MO1	2	P	35	7	3384	SE	BL	CW		60	20	20	.	29	7	29	7
0131-0051-YO1	1	R	1	0.3	19	BL	SE			90	10	.	.	60	14	60	15.1
0131-0051-YO1	2	P	35	0	3408	SE	BL			90	10	.	.	25	3.3	25	3.6
0131-0095-YO1	1	R	3	0	20	BL				100	.	.	.	90	7	.	.
0131-0095-YO1	2	P	15	0	500	BL	SE			90	10	.	.	30	3.1	30	3.1
0131-0074-YO1	1	R	5	3	39	FDI	LW			70	30	.	.	120	30	120	31
0131-0074-YO1	2	P	35	5	749	PLI	EP	FDI	LW	45	25	20	10	17	9.2	15	13.1
0131-0061-YO1	1	R	1	3	100	LW	FDI			90	10	.	.	120	31	130	32
0131-0061-YO1	2	P	65	10	2725	FDI	PLI	BG		70	20	10	.	20	7	20	6.3

The components of change are defined in Table 22.

Table 22. The components of change are described.

Abbreviation	Component	Description
S	Survivor	Tree that is live at both measurements with Dbh ≥ 4.0 cm at both measurements. Estimated from both the small and large tree plots.
M	Mortality	Tree that is live at first measurement and Dbh ≥ 4.0 cm and dead at second measurement Tree that is live at first measurement and Dbh ≥ 4.0 cm and missing at second measurement (assumed dead and fallen or cut) Estimated from both the small and large tree plots.
I	Ingress	Tree that is not tallied at first measurement and is live with Dbh ≥ 4.0 cm at second measurement Estimated from the small tree plot only.
D	Dead	Dead at first measurement and dead at second measurement Missing at first measurement and dead at second measurement (ingress that died) Dead at first measurement and missing at second measurement (assumed dead and fallen) Estimated from both the small and large tree plots.

Let $\hat{Y}_0$ be the estimate of the attribute of interest at time 0 and $\hat{Y}_1$ be the estimate of the attribute of interest at time 1. The net change can be estimated as

$$\hat{\Delta}_Y = \hat{Y}_1 - \hat{Y}_0$$

Change may also be estimated using the components in Table 22. Mortality is a negative estimate.

$$\tilde{\Delta}_Y = \hat{S} + \widehat{M} + \hat{I}$$

For a single fixed area plot $\hat{\Delta}_Y = \tilde{\Delta}_Y$. For variable radius plots or nested plots where trees have different selection probabilities (as is the case here), the two estimates of change are not equivalent. That is, $\hat{\Delta}_Y \neq \tilde{\Delta}_Y$. The two estimates are unbiased so the difference between the two estimates has an expected value of zero (Gregoire 1993).

The net annual change of the main attributes are given in Table 23. The plot-level changes in trees/ha are given in Figure 15.

Table 23. The average at time 0 and time 1 and the annual change (± standard error) are given by attribute (Dbh ≥ 4.0 cm). The annual changes are statistically significant for all attributes.

Attribute	N	Time 0	Time 1	annual change ± s.e.	p-value
Site index Height (m)	48	10.5	11.9	0.3 ± 0.05	0
Age (years)	47	33.8	36.7	0.67 ± 0.11	0
Site index (m)	19	21.7	24.2	0.58 ± 0.11	0
BA (m^2/ha)	48	16.4	20.5	0.95 ± 0.08	0
TPH (trees/ha)	48	1486	1622	32.1 ± 14.1	0.027
WSV (m^3/ha)	48	92.7	121.8	6.65 ± 0.65	0
Netvol (m^3/ha)	48	53.9	73.3	4.36 ± 0.76	0

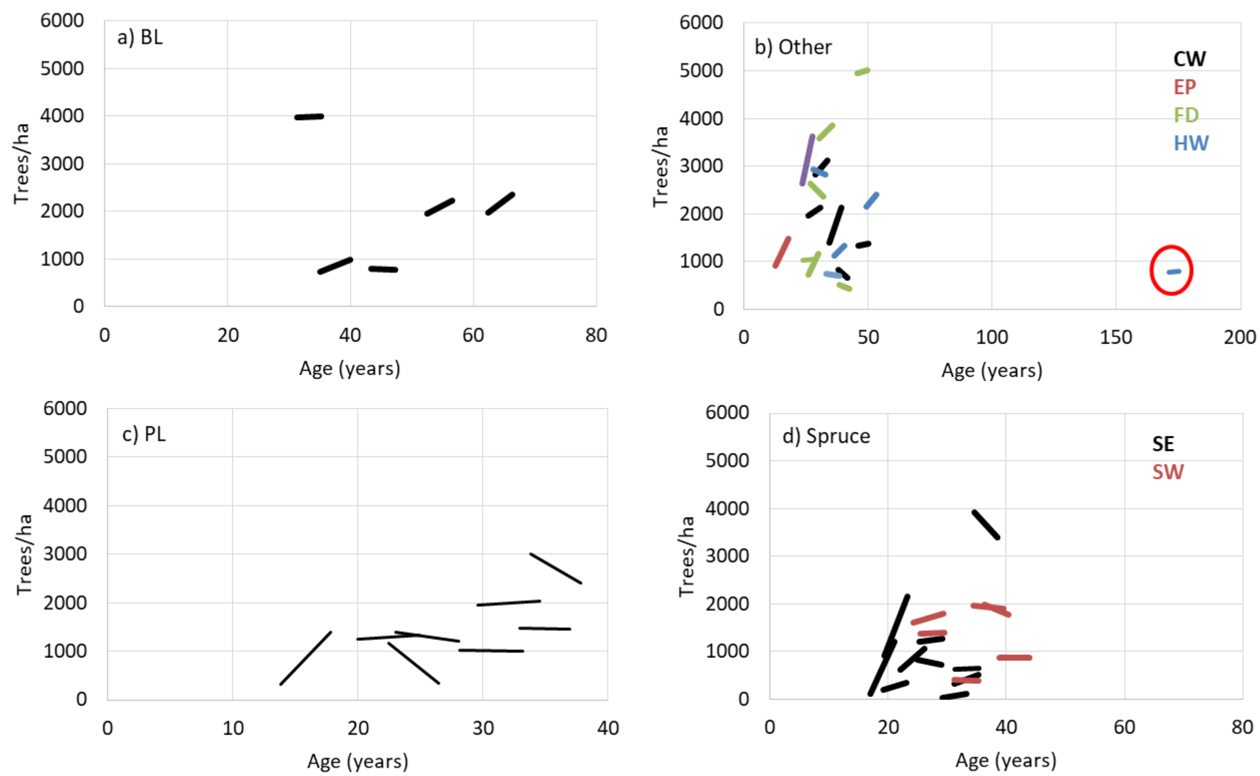


Figure 15. The change in trees/ha is given by ground leading species. Sample 311 is circled (b). One Cw leading sample (sample 96) did not have any age trees and is not plotted.

One issue associated with sampling is that the same trees are not necessarily sampled for age at remeasurement. Sample 88 was 52.5 years old at plot establishment and 41 years old at remeasurement (4 years later). Similarly the height trees may not be the same. As a consequence, the SI estimate may change from measurement to measurement. A reference breast height age = 50 years is used for SI estimation. The SI estimates should become more accurate the closer a site tree is to that reference age. Another issue is that some trees shrink between measurements, leading to a negative survivor "growth". For example, sample 51, tree 471 has Dbh = 15.9 cm and plot establishment and Dbh = 11.8 cm at first remeasurement.

The change in whole stem volume is relatively constant across strata (Figure 16 and Table 24) except for the BL strata (n = 2). There are some declines in volume over time due to mortality. As noted previously, different trees are sampled for age at each measurement and the age at the second measurement may be younger than the age at establishment, leading to an apparent decline in volume with age.

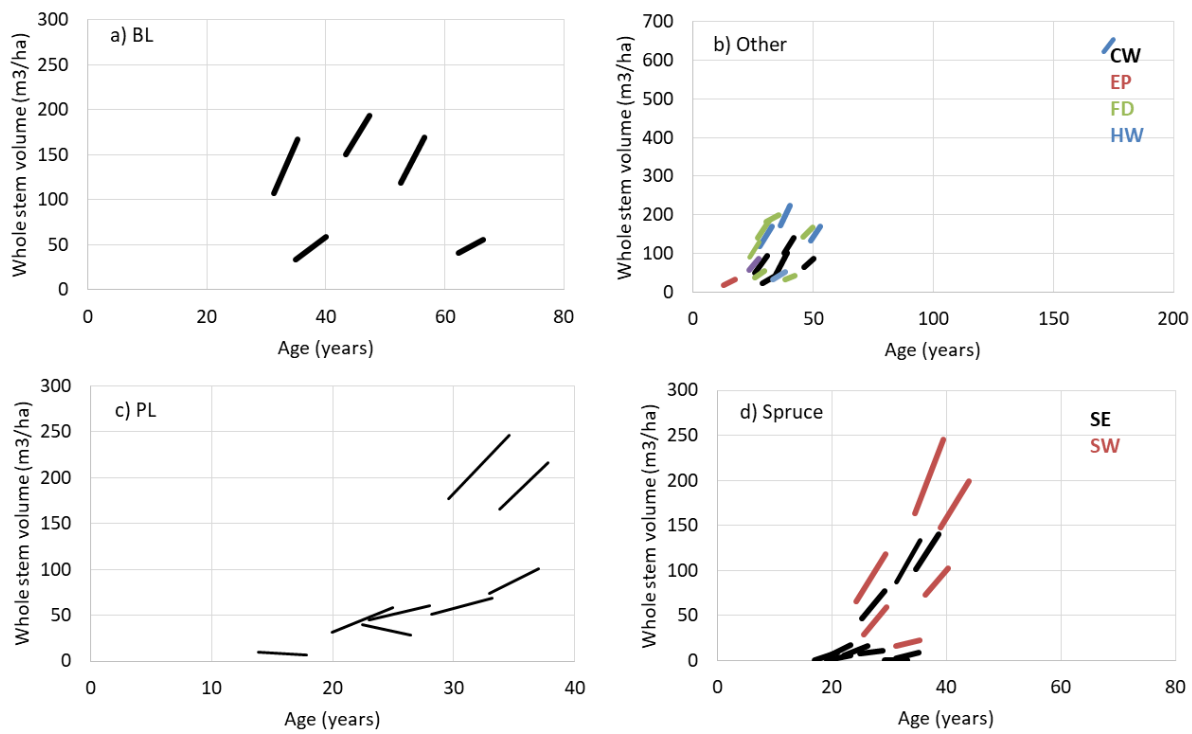


Figure 16. The change in whole stem volume (Dbh ≥ 4.0 cm) is given by ground leading species.

For BA and volume, most of the change is due to survivor growth with minor changes due to ingress and mortality (Table 24). For density, the biggest change was due to mortality followed by ingress.

Table 24. The average ground attributes at time 0 and time 1 and the change components are given (Dbh ≥ 4.0 cm).

Attribute	Strata	N	Growing seasons (years)	Average time 0	time1	Change dead	survivor	ingress	mortality
BA (m^2/ha)	BL	5	4.2	19.5	25.3	0.1	1.4	0.1	
	CW	6	5.4	19.3	24.7	0.7	1.1	0.1	0.0
	EP	1	5.0	4.5	7.7	0.0	0.6	0.4	0.0
	FD	6	4.3	19.9	23.3	2.3	0.9	0.1	-0.1
	HW	5	4.4	28.5	33.0	0.8	1.0	0.1	-0.1
	LW	1	4.0	15.1	21.4	0.0	1.2	0.5	0.0
	PL	8	4.5	15.1	17.8	0.4	0.9	0.1	-0.2
	SE	10	4.0	6.4	9.4	0.4	0.7	0.2	0.0
	SW	6	4.5	18.0	23.2	5.9	1.2	0.0	-0.1
	All	48	4.4	16.4	20.5	1.3	1.0	0.1	-0.1
Density (trees/ha)	BL	5	4.2	1886	2066	1	0	52	
	CW	6	5.4	1447	1643	1	0	55	-9
	EP	1	5.0	901	1476	5	0	180	-20
	FD	6	4.3	2235	2306	5	0	51	-16
	HW	5	4.4	1546	1611	4	0	32	-10
	LW	1	4.0	2627	3627	25	0	275	-6
	PL	8	4.5	1451	1395	1	0	42	-25
	SE	10	4.0	876	1141	0	0	85	-1
	SW	6	4.5	1363	1355	2	0	18	-10
	All	48	4.4	1486	1622	0	0	58	-10
Whole Stem Volume (m^3/ha)	BL	5	4.2	90.0	128.8	0.4	9.4	0.2	
	CW	6	5.4	146.5	180.6	2.4	7.1	0.3	-0.1
	EP	1	5.0	17.8	32.3	0.2	3.3	1.3	-0.1
	FD	6	4.3	103.6	130.2	16.9	6.7	0.2	-0.4
	HW	5	4.4	216.2	254.0	3.9	8.1	0.1	-0.2
	LW	1	4.0	56.4	87.1	0.1	6.9	1.3	-0.2
	PL	8	4.5	74.2	98.2	1.3	6.5	0.2	-0.6
	SE	10	4.0	25.6	41.6	1.0	4.1	0.4	0.0
	SW	6	4.5	82.3	124.4	14.2	9.3	0.1	-0.3
	All	48	4.4	92.7	121.8	5.0	6.9	0.3	-0.2
Net Merchantable Volume (m^3/ha)	BL	5	4.2	41.9	68.7	0.2	11.6	0.0	
	CW	6	5.4	108.4	117.5	1.0	3.5	0.0	0.0
	EP	1	5.0	5.5	11.1	0.1	3.1	0.0	0.0
	FD	6	4.3	55.3	74.6	7.7	8.1	0.0	-0.1
	HW	5	4.4	162.7	178.0	2.1	5.1	0.0	0.0
	LW	1	4.0	2.4	12.9	0.0	7.2	0.0	0.0
	PL	8	4.5	33.3	60.4	0.7	8.8	0.0	-0.3
	SE	10	4.0	8.2	17.6	0.0	4.2	0.0	0.0
	SW	6	4.5	37.5	75.1	6.6	11.6	0.0	-0.1
	All	48	4.4	53.9	73.3	2.3	7.2	0.0	-0.1

A difficulty associated in projecting growth occurs with species mixtures. At establishment, the species composition associated with sample 64 is BL54SE46. At remeasurement, the species composition is

SE50BL50, a change in leading species. Five samples (64, 80, 88, 91 and 97) changed leading species over the remeasurement interval.

The change monitoring plots can be used to investigate differential rates of ingress, growth and mortality by species. For sample 64, the spruces is growing more rapidly than the balsam and, due to ingress, the quadratic mean Dbh of balsam decreased over the measurement interval (Figure 17). FAIB should develop procedures to guide the analysis of the species dynamics on the change monitoring plots.

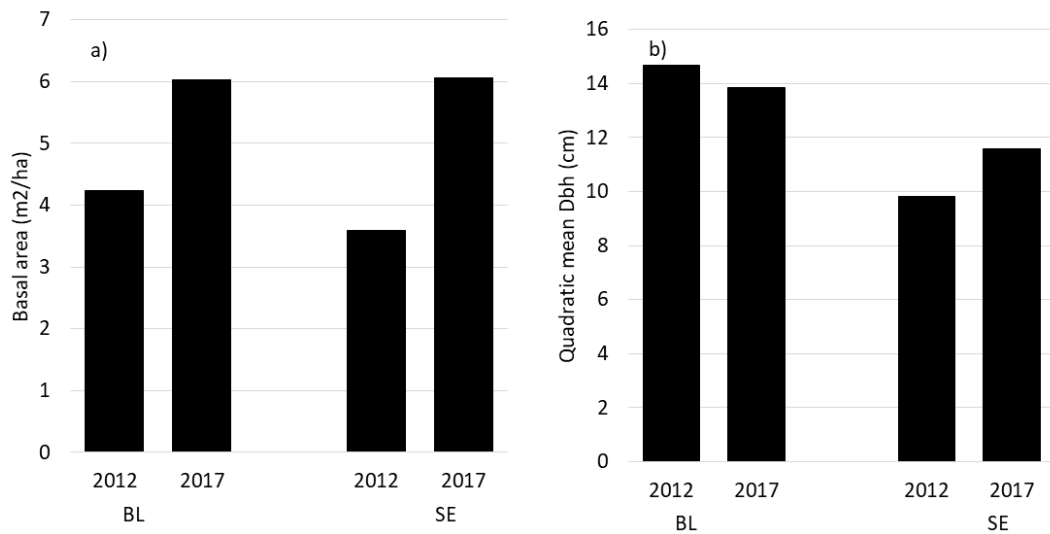


Figure 17. The live basal area (a) and quadratic mean Dbh (b) are given for sample 64, by species. The spruce is growing more rapidly than the balsam and, due to ingress, the quadratic mean Dbh of the balsam is decreasing.

9 Discussion and Recommendations

The ground and inventory estimates are summarized for the establishment samples (Table 25).

Table 25. The results of comparing the ground plots to the inventory and to the YSM assumptions are summarized. A p-value < 0.05 is generally considered an indication of statistically significant differences (or bias).

TSA	Attribute	N	Estimate	Ground mean	Inventory mean	Bias		
						Magnitude	p-value	% of ground mean
Arrow	Basal area (m^2/ha)	22	VRI	15.5	4.7	10.8 ± 2.3	0	70%
Boundary		12	VRI	10.3	3.5	6.8 ± 2.5	0.02	66%
Cranbrook		19	VRI	15.4	2.5	12.9 ± 2.1	0	84%
Golden		20	VRI	20.4	7.3	13.1 ± 3	0	64%
Invermere		13	VRI	13.3	5.4	7.9 ± 2.6	0.012	59%
Kootenay		10	VRI	26.8	15	11.9 ± 4.5	0.027	44%
Revelstoke		9	VRI	24.5	5.4	19.1 ± 6.2	0.015	78%
All	Basal area (m^2/ha)	105	VRI	17.4	5.8	12 ± 1	0	67%
	Density (tree/ha)	105	VRI	949	2310	-1361 ± 241	0	-143%
	Leading species age (years)	95	VRI	40.8	31.2	9.6 ± 2.5	0	23%
	Leading spp dom height (m)	95	VRI	11.6	8	3.6 ± 0.5	0	32%
	Site index (m)	64	PSPL	20.5	18.8	1.74 ± 0.56	0.003	13%
	Whole stem volume (m^3/ha)	91	TIPSY	99	47	51 ± 10	0	52%
	Volume model bias (m^3/ha)	91	TIPSY			14 ± 8	0.107	14%
	Volume attribute bias (m^3/ha)	91	TIPSY			37 ± 9	0	38%

The differences between the ground samples and the VRI estimates are generally statistically significant. The samples are young, often in variable conditions in terms of species composition and size classes. Small changes in height and age can have a large impact on SI estimates. The trees are generally small and many of the trees may be smaller than the utilization level and not included in the compilation. For polygons of shorter stands, the VRI may not provide updated estimates of basal area and volume until the polygon reaches a minimum height. Most of the volume bias is due to attribute bias.

Much of the VRI information for young stands comes from a generalized RESULTS layer. VRI polygons are populated with attributes from the silvilcultural opening with the largest overlap with the polygon. The FAIB should investigate using the actual RESULTS database and the opening associated with the ground sample.

There is considerable variation in species composition and average basal area from TSA to TSA, limiting the usefulness of comparisons across TSAs. The sample sizes are small within a TSA (ranging from 9 to 22 samples) which led to the pooling of samples across TSAs. The FAIB should investigate stratification schemes that have reasonably small within strata variation across TSAs.

The screening of SI trees based on age for the ground compilation removes older trees that may have been suppressed or have had leader damage when they were younger. However, the issue of how to evaluate SI for older trees and older polygons should be discussed further within FAIB.

Approximately 25% of the samples were identified as multi-cohort, using ad hoc rules. The FAIB should develop a standard protocol for the identification of multi-cohort conditions. The FAIB should also develop inventory assessment protocols for assessing the VRI In multi-cohort conditions and protocols for using TIPSY in multi-cohort conditions. The VRI and VDYP7 now accommodate multiple layers. Veteran and residual trees are identified in the ground plots. The assessment protocols need to be updated for these conditions.

The change monitoring plots were summarized in terms of net change and the components of change – ingress, growth and mortality. The plots can also be used to investigate differential rates of growth and ingress by species. The potential of the plots to provide additional information on species dynamics should be investigated.

10 List of References

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MSRM. 2005. National Forest Inventory – British Columbia. Change Monitoring Procedures for Provincial and National Reporting. Ministry of Sustainable Resource Management. March 31, 2005. Version 1.4.

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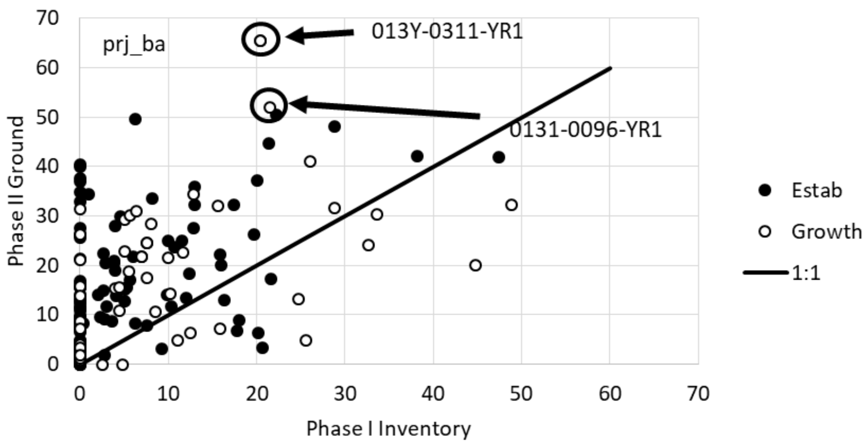
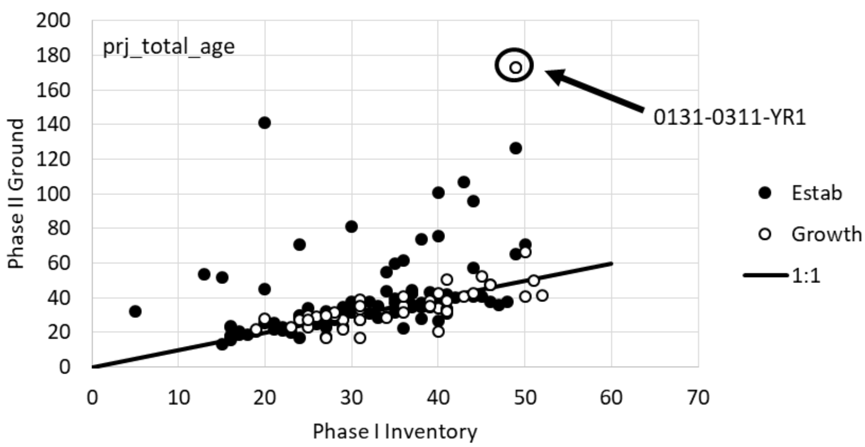
11 Appendix A – Data screens





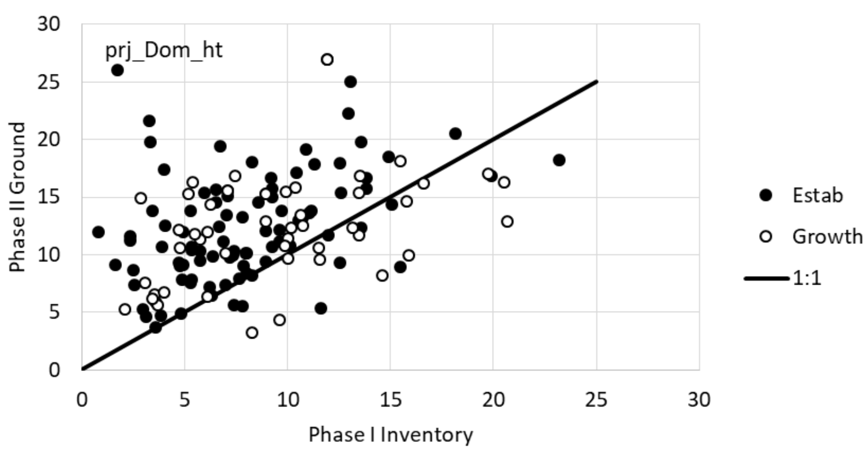


Figure 18. The Phase II ground measurements are plotted against the Phase I VRI estimates. The ground data for the change plots is the second measurement.

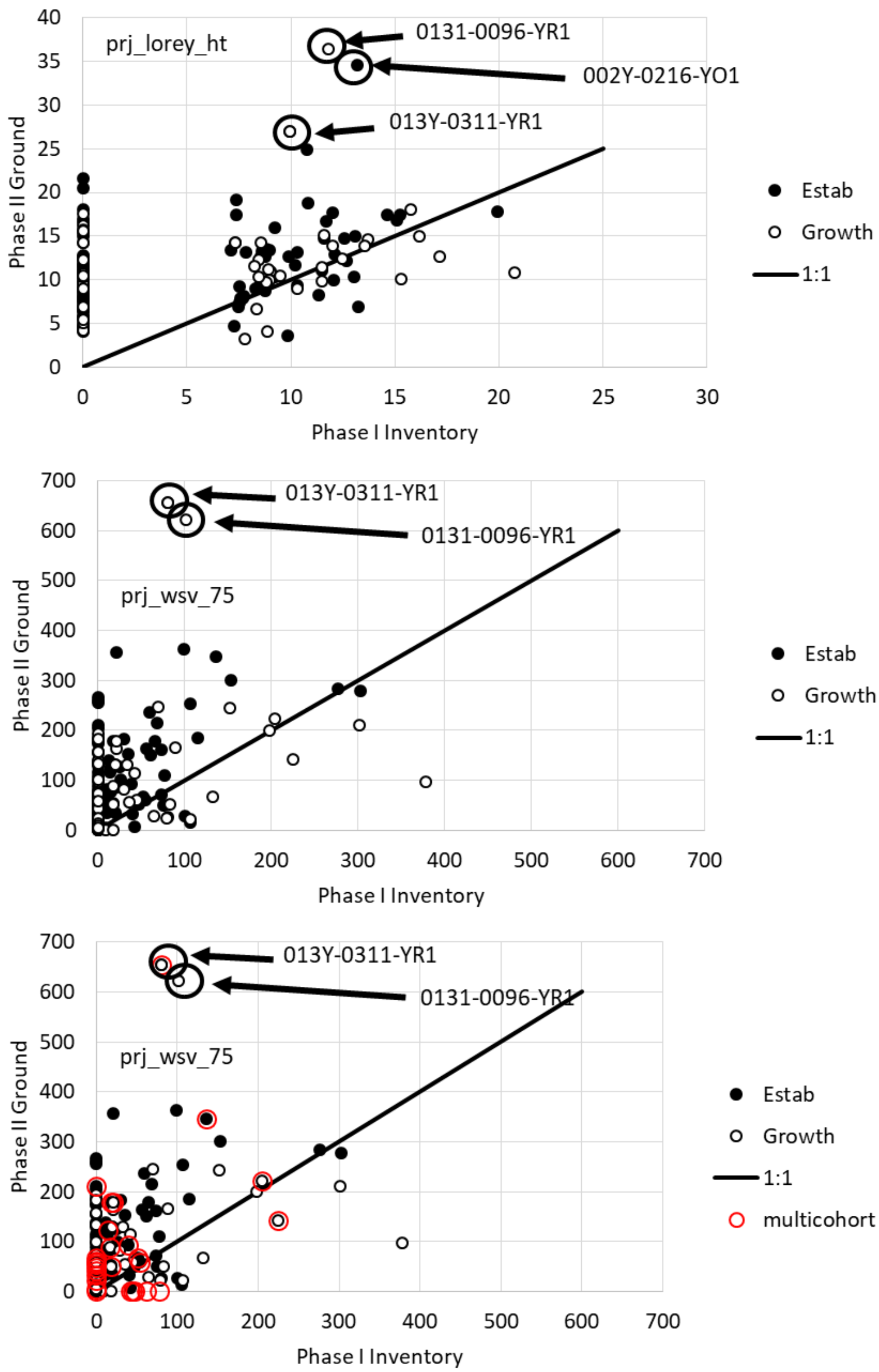


Figure 18 (cont.)

12 Appendix B – samples used for both monitoring and establishment and plots with non-primary layers, Veteran or residual trees and multi-cohort conditions

Table 26. The three YSM pilot plots used for establishment are given along with one NFI monitoring plot used for the establishment analysis.

Sample_id	clastr_id	TSA	meas_no	Use for Estab	Use for growth
013Y_0311_YSM	0131-0069-YO1	Kootenay	0	N	Y
013Y_0311_YSM	0131-0098-YO1	Kootenay	1	Y	Y
013Y_1005_YSM	013Y-0311-YR1	Kootenay	0	N	Y
013Y_1005_YSM	013Y-1005-YR1	Kootenay	1	Y	Y
0132_9576_CMI	0131-0075-MO1	Kootenay	0	N	Y
0132_9576_CMI	0132-9576-MR1	Kootenay	1	Y	Y
CMI3_0521_NFI	CMI3-0521-FO1	Cranbrook	0	N	N
CMI3_0521_NFI	CMI3-0521-FR1	Cranbrook	1	Y	N

Table 27. For samples with non primary layers, the non primary layers are summarized (Dbh ≥ 7.5 cm).

clstr_id	Layer	VDYP7 layer Cd	Species 1	Pct 1	CC %	Basal area (m^2/ha)	Tree/ha
007Y-1604-YO1	1	R	FDI	90	3	0.4	9
002Y-0216-YO1	1		FD	78	10	.	400
002Y-0216-YO1	3		PW	50	1	.	767
0011-0211-MO1	1		HW	60	10	15.0	70
001Y-0830-YO1	1	R	LW	80	4	1.2	58
002Y-0059-YO1	1		CW	40	6	.	2440
002Y-0361-YO1	1	R	S	56	4	.	629
0131-0096-YO1	1		CW	80	10	12.0	70
0131-0084-YO1	1		HW	80	10	15.0	70
0131-0078-YO1	1		SE	80	10	10.0	90
0131-0075-MO1	1	R	SE	50	2	6.1	182
0131-0051-YO1	1	R	BL	90	1	0.3	19
0131-0095-YO1	1	R	BL	100	3	0.0	20
005Y-0510-YO1	2		LW	80	15	.	89
005Y-0510-YO1	3		SX	60	7	.	222
0131-0074-YO1	1	R	FDI	70	5	3.0	39
002Y-0009-YO1	1		FD	60	9	.	400
0051-3356-MO1	1	R	BL	70	4	1.3	76
0131-0061-YO1	1	R	LW	90	1	3.1	100

Table 28. The samples with live veteran or residual trees are summarized. VRI = Phase I primary layer, grd = ground (Phase II). % residual is % of ground volume in residual trees. If there is an additional non-primary layer in Phase I it is given.

		Spp1		BA		Age		WSV		%	Non	primary			
clstr_id	msmt	VRI	grd	VRI	grd	VRI	grd	VRI	grd	residual	Layer	Code	CC	BA.	.TPH
0011-0211-MO1	0	HW	Cw	6.2	49.7	46.0	47.4	21	356	37%	1		10	15	70
001Y-0429-YO1	0	PLI	Bl	13.0	32.3	35.0	37.1	56	164	12%					
001Y-0676-YO1	0	CW	Lw	0.0	8.3	21.0	25.6	0	33	8%					

		Spp1		BA		Age		WSV		%	Non	primary			
clstr_id	msmt	VRI	grd	VRI	grd	VRI	grd	VRI	grd	residual	Layer	Code	CC	BA.	.TPH
001Y-0678-YO1	0	PLI	Pl	0.0	7.9	16.0	17.5	0	24	4%					
001Y-0860-YO1	0	BL	Hw	20.0	37.2	35.0	39.6	0	211	23%					
											1	R	4	1.2	58
002Y-0059-YO1	0	CW	Se	2.6	22.4	27.0	32.1	14	123	57%	1		6	.	2440
002Y-0216-YO1	0	FD	Fd	21.6	17.3	34.0	.	115	185	84%	1		10	.	400
											3		1	.	767
002Y-0294-YO1	0	PLI	Lw	2.3	9.6	21.0	.	7	70	83%					
											1	R	4	.	629
002Y-0430-YO1	0	BL	Hw	0.0	1.3	21.0	.	0	5	87%					
005Y-0335-YO1	0	BL	Bl	0.0	9.8	38.0	27.7	0	42	53%					
005Y-0477-YO1	0	PL	Lw	3.9	20.5	31.0	29.3	13	116	32%					
											2		15	.	89
											3		7	.	222
007Y-1459-YO1	0	SE	Bl	6.0	21.9	48.0	.	25	126	88%					
007Y-1509-YO1	0	CW	Cw	22.2	50.5	44.0	57.3	136	347	44%					
007Y-1604-YO1	0	FDI	Fd	12.4	18.4	34.0	44.0	39	93	22%	1	R	3	0.4	9
007Y-1619-YO1	0	HW	Hw	0.0	6.9	24.0	16.7	0	30	93%					
007Y-1632-YO1	0	FDI	Cw	0.0	34.9	20.0	.	0	267	90%					
009Y-0687-YO1	0	PLI	Pl	0.0	11.6	16.0	22.8	0	60	31%					
009Y-1290-YO1	0	PLI	Bl	5.0	15.1	35.0	59.5	0	88	78%					
013Y-0125-YO1	0	SX	Bl	21.4	44.6	40.0	75.7	99	363	15%					
013Y-0543-YO1	0	HW	Cw	47.4	42.0	44.0	42.0	277	284	13%					
027Y-1080-YO1	0	SX	Hw	0.0	27.5	20.0	.	0	155	98%	1	R	1	0.3	19
0131-0061-YO1	0	FDI	Fd	10.0	25.7	26.0	26.7	0	134	36%	1	R	1	3.1	100
0131-0061-YR1	1	FDI	Fd	6.4	30.9	31.0	30.6	21	179	29%					
0131-0067-YO1	0	SX	Bl	0.0	21.4	27.0	31.2	0	93	5%					
0131-0067-YR1	1	SX	Bl	0.0	31.3	31.0	35.1	0	156	4%					
0131-0068-YO1	0	PLI	Pl	3.0	0.9	27.0	13.8	9	9	100%					
0131-0073-YO1	0	HW	Hw	12.9	24.4	41.0	49.1	67	128	27%					
0131-0073-YR1	1	HW	Hw	15.6	32.0	45.0	52.2	89	165	15%	1	R	5	3	39
0131-0074-YO1	0	PLI	Ep	8.0	3.4	22.0	12.6	45	15	73%					
0131-0074-YR1	1	PLI	Ep	11.1	4.8	27.0	16.7	80	23	67%					
0131-0078-YO1	0	FDI	Hw	30.6	24.5	46.0	36.4	175	171	63%	1		10	10	90
0131-0078-YR1	1	FDI	Hw	33.7	30.4	50.0	40.6	204	223	56%					
0131-0084-YO1	0	BL	Cw	0.0	17.3	48.0	37.8	0	100	10%	1		10	15	70
0131-0084-YR1	1	BL	Cw	0.0	21.4	52.0	41.6	0	139	10%					
0131-0085-YO1	0	CW	FD	28.3	21.4	47.0	45.7	182	119	43%					
0131-0085-YR1	1	CW	Fd	32.7	24.2	51.0	49.9	225	142	41%					
0131-0087-YO1	0	PLI	Fd	11.0	4.9	22.0	25.7	46	33	100%					
0131-0087-YR1	1	PLI	Fd	15.8	7.2	26.0	29.1	82	51	91%					
0131-0094-YO1	0	PLI	Fd	0.0	23.5	36.0	30.4	0	168	87%					
0131-0094-YR1	1	PLI	Fd	0.0	26.4	41.0	33.6	0	182	82%					
0131-0096-YO1	0	FDI	Cw	17.2	50.2	36.0	.	74	596	94%	1		10	12	70
0131-0096-YR1	1	FDI	Cw	21.5	52.1	40.0	.	101	622	94%					

Table 29. The samples identified as multi-cohort are summarized. "Grd" = ground. The criteria are described in Table 7.

Use	TSA	Clstr_id	VRI Spp 1	VRI Spp 2	VRI Pct 1	VRI Pct 2	Grd Spp 1	VRI BA	Grd BA	VRI Age 1	VRI Age 2	Grd Age 1	VRI Ht 1	VRI Ht 2	VRI Ht 1	Ht	Age	R or V	Grd age	layer
Estab	Arrow	0011-0211-MO1	HW	CW	40	30	Cw	6	50	46	44	47	8.3	7.7	18.0			Y		Y
Estab	Arrow	001Y-0017-YO1	FDI	CW	50	30	Fd	12	13	30	.	81	12.5	.	17.9		Y		Y	
Estab	Arrow	001Y-0289-YO1	BL	PLI	50	30	Pl	0	7	21	25	22	2.6	7.8	7.4	Y				
Estab	Arrow	001Y-0676-YO1	CW	HW	40	30	Lw	0	8	21	24	26	4.9	10.6	12.0	Y				
Estab	Arrow	001Y-0830-YO1	FD	CW	50	20	Hw	11	24	37	37	44	10.9	12.6	19.1					Y
Estab	Arrow	001Y-0860-YO1	BL	HW	30.1	30	Hw	20	37	35	40	40	6.5	9.7	15.6			Y		
Estab	Boundary	0021-6421-MO1	BL	SX	40.1	39.9	Se	0	5	20	15	141	1.7	1.8	26.0		Y		Y	
Estab	Boundary	002Y-0009-YO1	FD	PL	90	10	Fd	16	20	44	.	96	13.0	.	25.0		Y		Y	Y
Estab	Boundary	002Y-0059-YO1	CW	BL	50	30	Se	3	22	27	.	32	8.0	.	8.4			Y		Y
Estab	Boundary	002Y-0216-YO1	FD	HW	60	13	Fd	22	17	34	.	.	16.2	.	.					Y
Estab	Boundary	002Y-0361-YO1	S	BL	92	8	Se	0	9	28	.	30	5.7	.	10.3					Y
Estab	Cranbrook	0051-3356-MO1	BL	PLI	74	18	Pl	0	4	19	21	20	3.0	7.5	5.3					Y
Estab	Cranbrook	005Y-0335-YO1	BL	SE	60	40	Bl	0	10	38	.	28	7.6	.	8.0			Y		
Estab	Cranbrook	005Y-0477-YO1	PL	LW	70	30	Lw	4	21	31	.	29	9.6	.	12.1			Y		
Estab	Cranbrook	005Y-0510-YO1	LW	SX	80	20	Se	16	13	33	.	28	15.1	.	14.3					Y
Estab	Golden	007Y-1509-YO1	CW	HW	40	20	Cw	22	51	44	44	57	12.6	14.4	15.4			Y	Y	
Estab	Golden	007Y-1512-YO1	SE	BL	70	30	Se	9	3	49	49	127	11.6	9.1	5.4		Y		Y	
Estab	Golden	007Y-1604-YO1	FDI	SE	90	10	Fd	12	18	34	34	44	10.5	2.0	13.0			Y		Y
Estab	Invermere	009Y-0687-YO1	PLI	LW	70	30	Pl	0	12	16	11	23	5.4	4.6	10.4			Y		
Estab	Invermere	009Y-0764-YO1	BL	SE	58	42	Bl	5	30	43	.	107	9.2	.	16.6		Y		Y	
Estab	Invermere	009Y-1290-YO1	PLI	BL	70	15	Bl	5	15	35	50	59	7.2	9.4	9.7			Y	Y	
Estab	Kootenay	013Y-0071-YO1	AT	EP	60	30	Ep	5	13	36	36	62	4.0	9.6	12.6	Y			Y	
Estab	Kootenay	013Y-0311-YR1	BL	SE	50	30	Hw	20	65	49	49	173	11.9	12.4	26.9		Y		Y	
Estab	Kootenay	013Y-0313-YO1	PLI	BL	43	37	Pl	0	2	22	22	21	7.4	1.2	5.6	Y				
Estab	Revelstoke	0272-6971-MO1	BL	SE	70	15	Bl	4	14	40	40	101	8.9	9.0	12.0		Y		Y	
Growth	Kootenay	0131-0051-YO1	SE	BL	90	10	Se	0	0	32	32	31	4.9	6.8	5.0					Y
Growth	Kootenay	0131-0051-YR1	SE	BL	90	10	Se	0	2	36	36	32	6.1	8.2	6.4					Y
Growth	Kootenay	0131-0061-YO1	FDI	PLI	70	20	Fd	10	26	26	26	27	7.2	9.8	10.5			Y		Y
Growth	Kootenay	0131-0061-YR1	FDI	PLI	70	20	Fd	6	31	31	31	31	8.9	11.9	12.9			Y		
Growth	Kootenay	0131-0064-YR1	SX	BL	70	30	Se	9	11	31	41	39	10.4	5.1	15.8	Y				
Growth	Kootenay	0131-0067-YO1	SX	PLI	50	30	Bl	0	21	27	27	31	3.6	13.1	10.2	Y				
Growth	Kootenay	0131-0067-YR1	SX	PLI	50	30	Bl	0	31	31	31	35	4.7	15.1	12.2	Y				
Growth	Kootenay	0131-0069-YO1	BL	SE	50	30	Hw	16	63	45	45	171	10.7	11.0	26.3		Y		Y	
Growth	Kootenay	0131-0073-YO1	HW	CW	50	20	Hw	13	24	41	41	49	12.1	12.2	13.2			Y		
Growth	Kootenay	0131-0074-YO1	PLI	EP	45	25	Ep	8	3	22	20	13	12.7	9.9	7.9			Y		Y
Growth	Kootenay	0131-0074-YR1	PLI	EP	45	25	Ep	11	5	27	25	17	15.9	12.0	9.9			Y		
Growth	Kootenay	0131-0075-MO1	SE	BL	60	20	Se	7	16	35	35	31	5.8	9.1	13.2					Y
Growth	Kootenay	0131-0078-YO1	FDI	HW	40	30	Hw	31	24	46	46	36	18.3	18.4	15.5		Y			Y
Growth	Kootenay	0131-0078-YR1	FDI	HW	40	30	Hw	34	30	50	50	41	19.8	19.9	17.0		Y			Y
Growth	Kootenay	0131-0084-YO1	BL	SE	80	10	Cw	0	17	48	48	38	2.5	2.6	13.1					Y
Growth	Kootenay	0131-0084-YR1	BL	SE	80	10	Cw	0	21	52	52	42	2.9	3.0	14.9					Y
Growth	Kootenay	0131-0085-YO1	CW	FDI	40.1	39.9	FD	28	21	47	45	46	14.4	14.2	13.8		Y			
Growth	Kootenay	0131-0085-YR1	CW	FDI	40.1	39.9	Fd	33	24	51	49	50	15.8	15.3	14.7		Y			

			VRI	VRI	VRI	VRI	Grd	VRI	Grd	VRI	VRI	Grd	VRI	VRI	VRI					
			Spp	Spp	Pct	Pct	Spp			Age	Age	Age						R	Grd	
Use	TSA	Clstr_id	1	2	1	2	1	BA	BA	1	2	1	Ht 1	Ht 2	Ht 1	Ht	Age	or V	age	layer
Growth	Kootenay	0131-0092-YO1	FDI	EP	40.1	39.9	Cw	0	11	20	20	26	7.3	14.1	9.1	Y				
Growth	Kootenay	0131-0092-YR1	FDI	EP	40.1	39.9	Cw	6	19	25	25	30	10.0	16.6	11.4	Y				
Growth	Kootenay	0131-0095-YO1	BL	SE	90	10	Fd	0	7	36	36	38	4.3	4.4	13.8					Y
Growth	Kootenay	0131-0095-YR1	BL	SE	90	10	Fd	0	9	40	40	42	5.2	5.4	15.3					Y
Growth	Kootenay	0131-0096-YO1	FDI	HW	60	20	Cw	17	50	36	36	.	13.6	13.7	.					Y
Growth	Kootenay	0131-0096-YR1	FDI	HW	60	20	Cw	21	52	40	40	.	15.1	15.4	.					Y
Growth	Kootenay	013Y-0311-YR1	BL	SE	50	30	Hw	20	65	49	49	173	11.9	12.4	26.9		Y		Y	

13 Appendix C – Plot Data Summaries

Table 30. The Plot data summaries are given. "Ref year" = REFERENCE_YEAR, "Att year" = ATTRIBUTION_YEAR.

				Phase II								Phase I						PSPL									
Ref year	Att year	TSA	clstr_id	BA 7.5	TPH 7.5	WSV 7.5	WSV D 7.5	Spp	HT	Age	SI	BA 7.5	TPH 7.5	WSV 7.5	Spp	HT	Age	At	Bl	Cw	Ep	Fd	Hw	Lw	Pl	Se	Sx
			Establishment																								
1997	2002	Arrow	0011-0196-MO1	12.7	1451	51	2	Bl	9.5	31	20.0	0.0	11786	0	BL	5.7	32		18.2	15		19.1	18	23.3	20.5	18.2	18.2
1997	2002	Arrow	0011-0211-MO1	49.7	1251	356	79	Cw	18.0	47	18.7	6.2	683	21	HW	8.3	46		18	16.3	17.4	22.7	20.9	22.4	21.3		21.8
1997	2002	Arrow	0011-5796-MO1	8.2	1001	34	0	Fd	10.7	26	25.0	6.2	635	20	FDI	9.2	27	25.3	20.2	18	19.4	22.3	19.9	24.2	21		24.9
2014	2015	Arrow	0011-9551-MO1	2.7	325	9	3	Fd	7.8	52		0.0	3480	0	FDI	5.3	15	22.9	18.3	18	19.6	22.3	19.9	24.2	21		22.9
2010	2011	Arrow	001Y-0017-YO1	13.4	675	67	0	Fd	17.9	81	14.4	12.0	1156	52	FDI	12.5	30	25.5	16.2	17.8	20.9	23.2	16.7	22.9	21.2		23.1
1997	2002	Arrow	001Y-0108-YO1	14.0	1051	56	0	Se	9.2	30	21.4	0.0	2368	0	S	1.6	24	22.6	18	16.1	19.5	21.8	20.3	24.1	22.3		21.9
1997	2002	Arrow	001Y-0110-YO1	3.1	150	21	1	Lw				0.0	4960	0	PL	6.3	24		17.3			15		18	15	17.5	17.5
2013	2015	Arrow	001Y-0174-YO1	0.0	0	0	0	Pl	4.6	13		0.0	3360	0	FDI	3.1	15	19.1	18	12	18.6	19.5	15	19.8	21.7		21.1
2004	2009	Arrow	001Y-0289-YO1	7.2	776	23	4	Pl	7.4	22		0.0	2880	0	BL	2.6	21		15.3			18.2			18.6	18.3	18.3
2008	2008	Arrow	001Y-0357-YO1	1.8	225	5	0	Pl	5.5	20	17.1	2.8	366	8	PLI	7.8	23		14.2						18	17	17
1992	1997	Arrow	001Y-0394-YO1	34.4	1101	175	78	Se	15.1	34	26.6	1.0	2315	0	SE	7.1	39		21	18		18	16.9	21	21	19.6	19.6
2011	2014	Arrow	001Y-0429-YO1	32.3	2627	164	5	Bl	13.3	37		13.0	2216	56	PLI	10.8	35		17.6	15		20.6		21	18.3	19.2	19.2
2005	2009	Arrow	001Y-0676-YO1	8.3	851	33	0	Lw	12.0	26	24.0	0.0	3560	0	CW	4.9	21	22.1	18.7	18	19.3	22.3	19.9	24.2	21		23.6
2014	2015	Arrow	001Y-0678-YO1	7.9	1001	24	26	Pl	7.2	18		0.0	4212	0	PLI	6.2	16		17.6	15		20.6		21	18.3	19.2	19.2
2011	2014	Arrow	001Y-0757-YO1	24.9	1376	137	14	Cw	12.4	34	20.9	10.0	2200	0	HW	6.7	25	21.8	20.3	18	18.5	22.3	19.9	24.2	21		23.3
1997	2002	Arrow	001Y-0830-YO1	23.7	1326	153	12	Hw	19.1	44	23.3	10.7	840	35	FD	10.9	37		21.2	18	18.9	22.3	19.9	24.2	21		25.5
2010	2011	Arrow	001Y-0833-YO1	6.6	926	24	0	Pl	7.5	19	23.6	0.0	4040	0	FDI	5.3	18	21.3	20.1	18	19.2	22.3	19.9	24.2	21		22.8
2011	2015	Arrow	001Y-0860-YO1	37.2	2026	211	15	Hw	15.6	40	24.8	20.0	5667	0	BL	6.5	35		21	21	17.7	24	21				24
1997	2002	Arrow	001Y-0881-YO1	12.3	1001	44	0	Se	10.7	30	23.6	0.0	3467	0	SE	3.9	24		21	18	19.2	25.4	18				24
2011	2015	Arrow	001Y-0958-YO1	14.0	725	67	2	Pl	11.6	25		2.0	1300	0	SX	2.4	20		18.8	15		18	15				22
2010	2014	Arrow	001Y-1078-YO1	0.6	75	2	0	Fd	3.7	18		0.0	1627	0	PW	3.6	16		21	18	17.2	24	18	24			21
2011	2011	Arrow	001Y-1188-YO1	26.2	751	162	1	Cw	17.1	26	27.5	19.6	1357	73	FDI	10.4	40		21	18	19.4	27.5	18				24
2011	2011	Boundary	0021-6421-MO1	4.6	75	47	15	Se	26.0	141		0.0	6840	0	BL	1.7	20		14.6						17.9	12.8	12.8
1992	1992	Boundary	002Y-0009-YO1	20.0	325	178	0	Fd	25.0	96	18.3	15.9	1061	65	FD	13.0	44			16.2	20.1	15		21.9	21.4		21.2
1994	1994	Boundary	002Y-0059-YO1	22.4	1651	123	0	Se	8.4	32		2.6	308	14	CW	8.0	27	21.6	18.9	17.7	18.5	23.8	19.1	25.9	23.7		17.7
2008	2009	Boundary	002Y-0065-YO1	26.1	2727	107	0	Pl	9.3	29		0.0	4045	0	PLI	4.7	24		14.6			17.8			17.7	15.5	15.5
2009	2010	Boundary	002Y-0145-YO1	0.9	150	2	6	Pl	4.9	17	17.4	0.0	5300	0	BL	4.8	27		14.6						17.7	15.5	15.5
1997	1997	Boundary	002Y-0216-YO1	17.3	125	185	4	Fd				21.6	1572	115	FD	16.2	34	23.4	21.6	18	20.5	26.7	20.4	26.4	24.1		23.4

				Phase II								Phase I						PSPL									
Ref year	Att year	TSA	clstr_id	BA 7.5	TPH 7.5	WSV 7.5	WSV D 7.5	Spp	HT	Age	SI	BA 7.5	TPH 7.5	WSV 7.5	Spp	HT	Age	At	Bl	Cw	Ep	Fd	Hw	Lw	Pl	Se	Sx
2005	2006	Boundary	002Y-0294-YO1	9.6	375	70	0	Lw				2.3	306	7	PLI	7.9	21		15.4			18		21	18.2		16.1
1997	1997	Boundary	002Y-0361-YO1	8.6	751	34	0	Se	10.3	30	23.4	0.0	6743	0	S	5.7	28		14.6			18.3			17.7	15.9	15.9
2009	2010	Boundary	002Y-0364-YO1	9.3	650	61	7	Pl	11.3	71	17.2	0.0	12200	0	BL	2.4	24		14.6						17.7	15.9	15.9
2012	2013	Boundary	002Y-0430-YO1	1.3	75	5	24	Hw				0.0	4133	0	BL	3.6	21	20.5	19.6	19.8	18.9	24.5	19.4	26.5	24.6		19.2
2009	2010	Boundary	002Y-0495-YO1	3.5	450	10	0	Pl	5.9	16		0.0	2412	0	PLI	3.6	16		15.6						21	18	18
2001	2002	Boundary	002Y-0557-YO1	0.0	0	0	6					0.0	2647	0	SX	1.4	16		15			18.1			21	18	18
2006	2006	Cranbroo	0051-3356-MO1	4.3	725	11	0	Pl	5.3	20	14.9	0.0	10158	0	BL	3.0	19		16			20	14.8	20.5	17.3	18.7	18.7
2008	2008	Cranbroo	005Y-0120-YO1	13.1	1851	48	0	Pl	7.8	19	21.8	0.0	6957	0	FDI	4.9	17		18			17.6		16.9	17.5		17.8
1988	1988	Cranbroo	005Y-0190-YO1	7.5	550	33	0	Se	10.3	36	17.1	0.0	3126	0	SE	7.4	40		15			18		18	19.2	17.3	17.3
1983	1983	Cranbroo	005Y-0191-YO1	17.0	1351	100	0	Pl	13.9	37	20.1	5.7	547	26	PL	11.2	36		18			19.4		22.8	20.7		18.4
1988	1988	Cranbroo	005Y-0192-YO1	10.9	625	60	0	Pl	12.0	32	18.8	0.0	2595	0	PL	0.8	5		21.3			21.5		21.7	22.5		27
1986	1986	Cranbroo	005Y-0194-YO1	24.9	801	150	3	Pl	16.7	38	21.2	11.5	822	61	PL	13.8	46		19.2			16.2		17.9	15.3		15
1993	2013	Cranbroo	005Y-0259-YO1	25.7	1901	115	0	Se	11.1	37	21.0	0.0	6235	0	SX	6.9	38		15			18		18	19.2	17.3	17.3
1986	1986	Cranbroo	005Y-0263-YO1	14.8	1101	63	4	Se	10.2	43	17.9	2.7	336	9	BL	8.0	39		14			15.5		15	16.6	15.6	15.6
1986	1986	Cranbroo	005Y-0273-YO1	20.5	1876	81	0	Se	10.2	40	17.2	2.9	372	10	SE	8.0	42		20.8			21	15	21.1	21	19	19
1987	1987	Cranbroo	005Y-0299-YO1	39.9	1151	256	3	Fd	19.8	65	18.4	0.0	0	0	FD	3.3	49		18			17.6		16.9	17.5		17.8
1986	1986	Cranbroo	005Y-0335-YO1	9.8	901	42	0	Bl	8.0	28	20.0	0.0	2783	0	BL	7.6	38		17.1						18	18	18
2012	2014	Cranbroo	005Y-0468-YO1	0.0	0	0	5					0.0	4009	0	BL	2.9	24		14			15.5		15	16.6	15.6	15.6
1979	1979	Cranbroo	005Y-0472-YO1	8.6	25	55	0	Fd	21.6	54		0.0	400	0	AT	3.3	13				20	20.6		22.6	22.5		22.3
1989	1989	Cranbroo	005Y-0477-YO1	20.5	1276	116	3	Lw	12.1	29	22.3	3.9	413	13	PL	9.6	31		15			18		18	19.2	17.3	17.3
2011	2011	Cranbroo	005Y-0510-YO1	13.1	600	72	0	Se	14.3	28	28.6	16.3	1311	73	LW	15.1	33	22.6	19.8	15	19.7	22	18	22.6	20.1		19.7
1988	1988	Cranbroo	005Y-0572-YO1	15.5	976	79	0	Se	13.5	38	21.4	0.0	0	0	BL	7.0	48			18		22.3	19.9	24.2	21		
1985	1985	Cranbroo	005Y-0592-YO1	8.4	175	39	0	Fd	13.3	35	20.5	0.3	37	1	PL	7.8	37	20.3	19	15	17	17.7	16.4	20.1	19.4		16.8
1988	1988	Cranbroo	005Y-0787-YO1	16.4	1651	65	0	Bl	9.9	55	14.8	0.0	2980	0	BL	6.4	34		12						16	12	12
2004	2006	Cranbroo	CMI3-0521-FR1	21.0	851	122	4	Pl	15.0	38	18.7	3.9	423	13	PL	9.3	30		14			15.5		15	16.6	15.6	15.6
2013	2014	Golden	0072-0096-MO1	1.9	300	5	0	Fd		17		0.0	2183	0	FDI	5.1	16		19.1	17.8	17.5	23.6	17.3				21.7
2009	2009	Golden	0072-4536-MO1	26.3	1401	130	1	Fd	14.5	34	24.1	0.0	4495	0	SX	6.5	29		19.5						19.9		19.5
2002	2003	Golden	007Y-1264-YO1	28.0	951	139	23	Fd	14.6	35	23.5	4.0	434	12	FDI	8.6	30		19						18.9		19.7
2008	2008	Golden	007Y-1287-YO1	6.9	776	27	0	Bl	9.0	39	16.1	17.8	1294	100	SX	15.5	40		14			17.1			16	13.1	13.1
1979	2014	Golden	007Y-1440-YO1	15.6	1001	86	8	Fd	13.8	36	18.1	5.2	611	21	SX	9.7	47		19.8	17.5			18.4		21.7		23
2013	2014	Golden	007Y-1443-YO1	48.1	2552	300	3	Fd	18.5	43	24.1	28.8	2163	154	HW	14.9	37	21.7	19	16.9	18.8	24.3	17.1		21.8		21.4
1993	2012	Golden	007Y-1459-YO1	21.9	801	126	0	Bl				6.0	667	25	SE	9.9	48		13.7			17.6			16.1	12.6	12.6

				Phase II								Phase I						PSPL									
Ref year	Att year	TSA	clstr_id	BA 7.5	TPH 7.5	WSV 7.5	WSV D 7.5	Spp	HT	Age	SI	BA 7.5	TPH 7.5	WSV 7.5	Spp	HT	Age	At	Bl	Cw	Ep	Fd	Hw	Lw	Pl	Se	Sx
2009	2011	Golden	007Y-1475-YO1	0.0	0	0	0					0.0	3067	0	CW	3.8	21	20.1	20.1	15.7	16.7	23.3	18.4		21.8		21.8
1997	1999	Golden	007Y-1496-YO1	11.5	700	77	0	At	19.4	35	28.3	0.0	150	0	SE	6.8	38		17.1	17.2		21.1	15.8		18.9		19.5
1997	1999	Golden	007Y-1509-YO1	50.5	1726	347	7	Cw	15.4	57	16.0	22.2	1617	136	CW	12.6	44		18.8	16.9			17.4		20.1		21.1
1997	1999	Golden	007Y-1512-YO1	3.1	325	8	0	Se	5.4	127	3.1	9.3	930	42	SE	11.6	49		17.1			18.8			18.2	17.6	17.6
2010	2010	Golden	007Y-1514-YO1	32.3	1301	253	20	Pl	20.6	42	24.2	17.4	938	107	FD	18.1	41	20.3	19.7	16.4	18.5	23.6	18		21.8		21.7
2000	2012	Golden	007Y-1515-YO1	11.7	826	51	2	Fd	11.7	25	29.6	10.4	1066	47	PLI	12.0	26	21.1	17.6	16.1	18.3	23.9	15		21.3		20.7
1990	2012	Golden	007Y-1532-YO1	35.9	1251	236	0	Fd	17.8	42	24.1	13.0	1146	59	HW	11.3	37	19.9		16.1	19.4	23.2	13.7		20.8		20.5
1997	1999	Golden	007Y-1548-YO1	37.0	1851	185	0	Sx	13.8	31	27.3	0.0	0	0	SE	3.4	27		17.8	16.5	17.5	23.6	15.7				20.4
2008	2009	Golden	007Y-1576-YO1	0.9	200	2	158	Se	4.8	27	16.2	0.0	1854	0	SX	3.9	28		14.1						16	13.9	13.9
2006	2006	Golden	007Y-1587-YO1	16.9	1826	67	0	Cw	10.0	45	15.3	0.0	1557	0	FDI	7.3	20	19.7	19.6	16			18.1		21.4		21.4
1997	2000	Golden	007Y-1604-YO1	18.4	1976	93	21	Fd	13.0	44	17.4	12.4	1071	39	FDI	10.5	34		19.1	17.2		23.3	17.8				20.9
2013	2013	Golden	007Y-1619-YO1	6.9	500	30	5	Hw	6.5	17	22.3	0.0	3577	0	HW	6.3	24	19.3	20.1	16.7	17.5	24.7	18.8		21.8		21.9
1997	2000	Golden	007Y-1632-YO1	34.9	1151	267	69	Cw				0.0	0	0	FDI	5.0	20		19.3	16.7	19.1	25.1	17.3				22
2013	2014	Invermer	009Y-0687-YO1	11.6	826	60	0	Pl	10.4	23	22.7	0.0	2120	0	PLI	5.4	16	20.9			20	15.7		15.4	15.8		18
1991	1991	Invermer	009Y-0737-YO1	11.8	1601	40	0	Pl	8.2	26	17.3	3.0	389	9	PL	8.2	27		14.5			17.6		17.7	17.6	14.1	14.1
1987	1987	Invermer	009Y-0764-YO1	29.9	1701	178	1	Bl	16.6	107	17.0	4.6	508	18	BL	9.2	43		14.5			17.6		17.7	17.6	14.1	14.1
1993	1993	Invermer	009Y-0789-YO1	19.0	1851	77	10	Fd	11.1	32	19.9	3.9	414	14	PL	9.6	31		14.5			17.6		17.7	17.6	14.1	
1994	1994	Invermer	009Y-0819-YO1	14.0	1276	60	9	Fd	12.3	74	10.8	9.9	728	54	FD	13.6	38		18.2			19.8		17.8	20.1		21.1
1991	1991	Invermer	009Y-0840-YO1	8.7	1026	38	0	Pl	9.4	23	20.4	3.6	458	12	PL	8.9	29		18.2			20		18.1	20.5		20.9
1985	1985	Invermer	009Y-0844-YO1	7.9	901	33	3	Pl	9.3	31	15.9	7.6	662	40	PL	12.6	41	19.5	17.6			19.8		18	20		20.4
1988	1988	Invermer	009Y-0869-YO1	0.8	75	2	19	Fd	7.4	23	21.3	0.0	1660	0	PL	7.0	36	18.9			19.5	16.8		16.5	16.9		20
1994	1994	Invermer	009Y-0917-YO1	15.6	1126	70	1	Pl	10.7	23	23.0	0.0	2080	0	S	5.3	27	19.5	17.6			19.8		18	20		20.4
1991	1991	Invermer	009Y-0918-YO1	27.6	876	215	0	Pl	19.8	41	25.1	12.9	990	68	PL	13.6	45		15.9			18.2		20.5	20.2		21.7
2007	2007	Invermer	009Y-1062-YO1	4.8	475	20	3	Pl	9.1	23		0.0	7117	0	BL	4.9	22	23	16.4	15.3		20.7		23.5	20.4		20.7
2011	2012	Invermer	009Y-1290-YO1	15.1	926	88	0	Bl	9.7	59	12.0	5.0	2000	0	PLI	7.2	35		14.7			17.9		18	18.1	14.3	14.3
2011	2013	Invermer	009Y-1292-YO1	6.3	575	27	0	Se	10.8	32	21.3	20.1	2802	81	SE	10.1	35		12						18	15	15
2006	2010	Kootenay	0132-9576-MR1	21.7	650	133	38	Se	15.6	35	28.3	7.0	3384	0	SE	7.1	39		18.2						19.9	18	18
2005	2011	Kootenay	013Y-0071-YO1	12.7	675	68	15	Ep	12.6	62		5.0	540	0	AT	4.0	36	24.2	18.9	17.4	19.4	25	18.9	25.6	23.9		23.9
2010	2011	Kootenay	013Y-0125-YO1	44.6	1651	363	5	Bl	22.2	76	21.1	21.4	1955	99	SX	13.0	40	19.9	17.6	17.4	18	21.4			20.3		20
2006	2010	Kootenay	013Y-0277-YO1	9.1	951	34	0	Bl	9.0	38		2.8	355	10	BL	7.9	32		15.5			18.1			17.7	14.9	14.9
2011	2011	Kootenay	013Y-0283-YO1	4.6	425	18	0	Cw	9.0	24		0.0	6400	0	FDI	4.8	16	21.5	20.3	18.5	18	23.6	17.8	25	22.6		22.6
2006	2010	Kootenay	013Y-0311-YR1	65.4	801	655	45	Hw	26.9	173		20.5	1155	80	BL	11.9	49	21.9	18.7	17.3	18.9	22.6	16.1		21.6		21.2

Ref year	Att year	TSA	clstr_id	Phase II BA 7.5	TPH 7.5	WSV 7.5	WSV D 7.5	Spp	HT	Age	SI	Phase I BA 7.5	TPH 7.5	WSV 7.5	Spp	HT	Age	PSPL At	Bl	Cw	Ep	Fd	Hw	Lw	Pl	Se	Sx
2006	2009	Kootenay	013Y-0313-YO1	1.8	225	6	0	Pl	5.6	21		0.0	4111	0	PLI	7.4	22		16.2			18.4			17.9	15.6	15.6
2006	2009	Kootenay	013Y-0543-YO1	42.0	1801	284	0	Cw	16.8	42	23.0	47.4	1891	277	HW	19.9	44		19.3	18.1	17	23.6	17.1		21.6		21.3
2005	2009	Kootenay	013Y-1005-YR1	24.6	1051	130	2	Fd	15.2	27	33.6	7.6	729	20	FDI	8.9	31	23.1	20.9	17.5	18.4	25.6	19		23.1		22.4
2006	2008	Kootenay	013Y-1121-YO1	42.1	475	278	52	Cw	18.2	71		38.2	1098	302	HW	23.2	50		18.9	18.3		23.7	17.6				20.8
2007	2008	Revelsto	0272-4511-MO1	9.5	1101	31	0	Sx	8.6	20	27.3	0.0	1660	0	SX	2.5	17		19.5	21	18.3	24	18				22.5
2011	2013	Revelsto	0272-6971-MO1	13.8	650	56	3	Bl	12.0	101	9.2	4.1	444	14	BL	8.9	40		16.9							18	18
2006	2007	Revelsto	027Y-1080-YO1	27.5	1526	155	2	Hw				0.0	2580	0	SX	2.4	20		18.4			19.7			20.6	18.8	18.8
2012	2012	Revelsto	027Y-1148-YO1	33.5	976	184	2	Sx	15.7	32		8.1	956	30	SX	9.3	30		19	19.2	18.2	23.6	17.6				22.1
1977	1977	Revelsto	027Y-1277-YO1	22.1	1101	110	13	Fd	15.7	41	21.7	15.9	1264	77	H	13.8	44		18	15	16.3	21	15		21		18
1990	2012	Revelsto	027Y-1416-YO1	40.3	1801	260	1	Sx	17.4	31	31.0	0.0	2253	0	SE	4.0	29	25.1	21	19	20.1	24	20.3		24		24
2006	2008	Revelsto	027Y-1505-YO1	3.3	150	14	0	Sx		36		20.6	2152	106	SX	13.1	37		21	20.1	18.1	24.9	18				24
1998	2015	Revelsto	027Y-1609-YO1	37.6	1326	204	0	Sx	15.4	31	28.2	0.0	1820	0	SE	6.0	28		21	19.5	17.9	25.5	18				24
1994	1994	Revelsto	027Y-1610-YO1	32.9	1276	175	0	Se	13.8	29	27.4	0.0	1543	0	SE	5.3	27		21	21	17.8	24	18				24
		Growth																									
2005	2010	Kootenay	0131-0051-YO1	0.3	25	1	0	Se	5.0	31	13.8	0.0	3408	0	SE	4.9	32		12.4						15.1	11	11
2005	2010	Kootenay	0131-0051-YR1	2.4	300	7	0	Se	6.4	32		0.0	3408	0	SE	6.1	36		12.4						15.1	11	11
2005	2010	Kootenay	0131-0052-YO1	23.3	2527	91	0	Se	10.0	35	20.2	4.1	552	15	SE	9.1	37		15.7						17.1	15.4	15.4
2005	2010	Kootenay	0131-0052-YR1	28.5	2302	130	1	Se	12.5	39		8.0	944	33	SE	10.7	41		15.7						17.1	15.4	15.4
2005	2010	Kootenay	0131-0053-YO1	16.0	1176	67	314	Sx	10.9	36	19.9	10.0	6275	0	SE	4.9	32		16.1						18	15.7	15.7
2005	2010	Kootenay	0131-0053-YR1	21.6	1376	100	316	Sx	12.0	41		10.0	6275	0	SE	6.1	36		16.1						18	15.7	15.7
2005	2010	Kootenay	0131-0054-YO1	10.5	700	44	0	Se	9.1	25	23.5	4.0	2533	0	SE	4.3	30		15.3						17	15	15
2005	2010	Kootenay	0131-0054-YR1	15.2	776	73	0	Se	11.8	29	27.5	4.0	2533	0	SE	5.5	34		15.3						17	15	15
2014	2014	Kootenay	0131-0055-YO1	6.6	450	31	3	HW	11.3	33	19.8	14.2	1625	0	BL	8.6	28	23.2	19.6	17.7	18.2	23.3	16.5	23.9	22.4		21.6
2014	2014	Kootenay	0131-0055-YR1	8.8	400	49	3	Hw	13.6	35	21.1	18.0	1925	75	BL	11.0	33	23.2	19.6	17.7	18.2	23.3	16.5	23.9	22.4		21.6
2005	2011	Kootenay	0131-0056-YO1	11.3	926	50	0	Pl	10.0	28	20.0	17.8	2839	77	SE	10.6	36	22.3		16.4	19.1	22.9		22.9	22		20.9
2005	2011	Kootenay	0131-0056-YR1	13.2	801	67	0	Pl	12.4	32		24.7	3299	132	SE	13.2	41	22.3		16.4	19.1	22.9		22.9	22		20.9
2005	2010	Kootenay	0131-0057-YO1	18.4	976	70	5	Pl	8.6	33	14.9	5.0	800	0	PLI	6.1	32		13			17.4			15.3	11.1	11.1
2005	2010	Kootenay	0131-0057-YR1	22.8	1051	97	4	Pl	10.1	37		5.0	800	0	PLI	7.0	36		13			17.4			15.3	11.1	11.1
2010	2011	Kootenay	0131-0058-YO1	28.0	1951	177	0	Pl	14.9	30	23.9	9.5	1084	43	PLI	11.3	26	21.2	19.3	16.7	19.2	23		23.6	22.1		21.4
2010	2011	Kootenay	0131-0058-YR1	34.3	2026	246	2	Pl	16.8	34		12.8	1257	69	PLI	13.5	31	21.2	19.3	16.7	19.2	23		23.6	22.1		21.4
2010	2011	Kootenay	0131-0059-YO1	26.7	876	147	0	Sx	14.3	39	22.2	22.9	1172	137	SX	17.6	39	20.4	18.3	17.2	18.4	21.8		23.2	20.9		20.6
2010	2011	Kootenay	0131-0059-YR1	31.6	876	199	0	Sx	16.3	43		28.9	1281	198	SX	20.5	44	20.4	18.3	17.2	18.4	21.8		23.2	20.9		20.6

Ref year	Att year	TSA	clstr_id	Phase II BA 7.5	TPH 7.5	WSV 7.5	WSV D 7.5	Spp	HT	Age	SI	Phase I BA 7.5	TPH 7.5	WSV 7.5	Spp	HT	Age	PSPL At	Bl	Cw	Ep	Fd	Hw	Lw	Pl	Se	Sx
2000	2013	Kootenay	0131-0060-YO1	6.4	650	26	0	Pl	9.3	20	22.5	0.0	3983	0	PLI	7.3	18	22.3	19.1	17	19	23		23.5	22		21.2
2000	2013	Kootenay	0131-0060-YR1	10.8	926	53	0	Pl	10.8	23		4.5	532	18	PLI	9.9	23	22.3	19.1	17	19	23		23.5	22		21.2
2005	2010	Kootenay	0131-0061-YO1	25.7	2126	134	0	Fd	10.5	27	23.8	10.0	2725	0	FDI	7.2	26	19.6	17.8	17.8	18.3	21.9	14.6	23.4	20.4		20.2
2005	2010	Kootenay	0131-0061-YR1	30.9	1951	179	1	Fd	12.9	31	26.1	6.4	638	21	FDI	8.9	31	19.6	17.8	17.8	18.3	21.9	14.6	23.4	20.4		20.2
2010	2011	Kootenay	0131-0062-YO1	32.6	1551	161	1	Sx	16.1	35	27.8	19.4	1773	94	SX	12.6	34	21.9	19.1	16.9	18.7	23.1	16.2	23.2	21.9		21.3
2010	2011	Kootenay	0131-0062-YR1	41.0	1601	244	1	Sx	18.2	38	29.4	26.0	2028	152	SX	15.5	39	21.9	19.1	16.9	18.7	23.1	16.2	23.2	21.9		21.3
2010	2011	Kootenay	0131-0064-YO1	6.9	325	31	9	Bl	9.2	35	18.0	2.0	1800	0	SX	7.4	26		16.1			18			18.1	15.4	15.4
2010	2011	Kootenay	0131-0064-YR1	10.7	475	55	9	Se	15.8	39	23.8	8.6	1012	35	SX	10.4	31		16.1			18			18.1	15.4	15.4
2006	2010	Kootenay	0131-0065-YO1	7.5	876	26	0	Se	8.4	26	23.0	0.0	1000	0	SE	3.4	24			17.8		21.9	14.9		20.2		19.8
2006	2010	Kootenay	0131-0065-YR1	13.9	1201	58	0	Se	10.6	30		0.0	1000	0	SE	4.8	28			17.8		21.9	14.9		20.2		19.8
2013	2013	Kootenay	0131-0066-YO1	0.0	0	0	0	Se		17		0.0	2754	0	SX	1.3	15		13.3						15.8	11.4	11.4
2013	2013	Kootenay	0131-0066-YR1	0.8	100	2	0	Se	5.3	22	20.7	0.0	2754	0	SX	2.1	19		13.3						15.8	11.4	11.4
2008	2009	Kootenay	0131-0067-YO1	21.4	2076	93	0	Bl	10.2	31	20.7	0.0	5873	0	SX	3.6	27		15.7			18.2			17.3	14.8	14.8
2008	2009	Kootenay	0131-0067-YR1	31.3	2602	156	0	Bl	12.2	35	19.2	0.0	5873	0	SX	4.7	31		15.7			18.2			17.3	14.8	14.8
2006	2010	Kootenay	0131-0068-YO1	0.9	25	9	26	Pl	3.5	14		3.0	366	9	PLI	8.2	27		16.5			18.4			18.2	15.9	15.9
2006	2010	Kootenay	0131-0068-YR1	0.0	0	0	17	Pl	4.4	17	17.8	4.8	523	18	PLI	9.6	31		16.5			18.4			18.2	15.9	15.9
2006	2010	Kootenay	0131-0069-YO1	62.5	776	623	88	Hw	26.3	171		16.3	1028	57	BL	10.7	45	21.9	18.7	17.3	18.9	22.6	16.1		21.6		21.2
2006	2009	Kootenay	0131-0070-YO1	0.0	0	0	0	Se	3.2	19		0.0	1588	0	SE	2.5	21		13.8						16.3	12.3	12.3
2006	2009	Kootenay	0131-0070-YR1	1.2	150	4	0	Se	5.7	23	21.0	0.0	1588	0	SE	3.7	25		13.8						16.3	12.3	12.3
2005	2009	Kootenay	0131-0071-YO1	11.5	1001	41	4	Pl	8.9	23	20.0	6.0	629	21	PLI	9.3	24	22.9	19.5	18.4	18.1	23.7	16.8	24.6	22.3		21.8
2005	2009	Kootenay	0131-0071-YR1	14.2	1001	59	8	Pl	9.6	28	23.1	10.2	932	45	PLI	11.6	29	22.9	19.5	18.4	18.1	23.7	16.8	24.6	22.3		21.8
2006	2010	Kootenay	0131-0072-YO1	9.6	876	38	4	Pl	9.7	22	21.3	6.1	694	26	HW	9.2	21		16.6			18.8			19	16	16
2006	2010	Kootenay	0131-0072-YR1	6.4	350	28	5	Pl	10.6	26		12.5	1277	65	HW	11.5	25		16.6			18.8			19	16	16
2006	2009	Kootenay	0131-0073-YO1	24.4	1351	128	0	Hw	13.2	49	17.5	12.9	1605	67	HW	12.1	41	22.6	19.4	18.2	18.7	23.2	16.8	24.3	22.1		21.8
2006	2009	Kootenay	0131-0073-YR1	32.0	1801	165	1	Hw	15.4	52		15.6	1781	89	HW	13.5	45	22.6	19.4	18.2	18.7	23.2	16.8	24.3	22.1		21.8
2006	2010	Kootenay	0131-0074-YO1	3.4	300	15	0	Ep	7.9	13	19.6	8.0	1017	45	PLI	12.7	22	21.4	19.7	18.1	18.4	23.5	17.3		22.2		22
2006	2010	Kootenay	0131-0074-YR1	4.8	375	23	1	Ep	9.9	17		11.1	1198	80	PLI	15.9	27	21.4	19.7	18.1	18.4	23.5	17.3		22.2		22
2006	2010	Kootenay	0131-0075-MO1	16.2	625	87	38	Se	13.2	31	25.4	7.0	3384	0	SE	5.8	35		18.2						19.9	18	18
2010	2011	Kootenay	0131-0076-YO1	4.2	400	16	0	Sx	10.0	31	21.2	18.4	1877	65	SX	11.2	32		17.3						19.1	16.6	16.6
2010	2011	Kootenay	0131-0076-YR1	4.8	275	22	1	Sx				25.6	2287	106	SX	13.5	36		17.3						19.1	16.6	16.6
2010	2011	Kootenay	0131-0076-YR1	4.8	275	22	1	Sx	11.7	35	22.7	25.6	2287	106	SX	13.5	36		17.3						19.1	16.6	16.6
2006	2009	Kootenay	0131-0077-YO1	13.6	725	61	7	Cw	11.6	46	18.8	4.4	545	15	SE	8.5	37		17.8						19.5	17.4	17.4

Ref year	Att year	TSA	clstr_id	Phase II BA 7.5	Phase II TPH 7.5	Phase II WSV 7.5	Phase II WSV D 7.5	Phase II Spp	Phase II HT	Phase II Age	Phase II SI	Phase I BA 7.5	Phase I TPH 7.5	Phase I WSV 7.5	Phase I Spp	Phase I HT	Phase I Age	PSPL At	PSPL Bl	PSPL Cw	PSPL Ep	PSPL Fd	PSPL Hw	PSPL Lw	PSPL Pl	PSPL Se	PSPL Sx
2006	2009	Kootenay	0131-0077-YR1	17.5	776	82	7	Cw	12.3	51		7.6	824	29	SE	10.2	41		17.8						19.5	17.4	17.4
2006	2010	Kootenay	0131-0078-YO1	24.5	725	171	28	Hw	15.5	36	23.3	30.6	1507	175	FDI	18.3	46		17.5						18.8	18.2	18.2
2006	2010	Kootenay	0131-0078-YR1	30.4	926	223	27	Hw	17.0	41		33.7	1502	204	FDI	19.8	50		17.5						18.8	18.2	18.2
2006	2010	Kootenay	0131-0080-YO1	25.9	1701	155	22	Pl	14.4	34	21.1	43.7	7085	248	CW	14.9	36		20.6	17.5	18.9	24.9	19.3		24.1		24.1
2006	2010	Kootenay	0131-0080-YR1	32.2	1801	211	21	Cw	16.2	34		48.8	6872	301	CW	16.6	40		20.6	17.5	18.9	24.9	19.3		24.1		24.1
2006	2010	Kootenay	0131-0081-YO1	16.7	1226	107	1	Hw	13.8	28	26.3	0.0	5856	0	SE	3.5	23	27.3	17.2	17.4	20.9	27	19.7	26	24.7		24.8
2006	2010	Kootenay	0131-0081-YR1	21.1	1126	158	2	Hw	16.3	32		0.0	5856	0	SE	5.4	28	27.3	17.2	17.4	20.9	27	19.7	26	24.7		24.8
2006	2010	Kootenay	0131-0082-YO1	24.8	801	150	0	Bl	15.4	43	20.6	5.0	2857	0	BL	6.5	42		17.6			19			20	17.9	17.9
2006	2010	Kootenay	0131-0082-YR1	29.3	776	193	0	Bl	16.8	47	23.5	5.0	2857	0	BL	7.5	46		17.6			19			20	17.9	17.9
2006	2010	Kootenay	0131-0084-YO1	17.3	625	100	5	Cw	13.1	38	19.8	0.0	3806	0	BL	2.5	48		17			19.2			18.6	17.2	17.2
2006	2010	Kootenay	0131-0084-YR1	21.4	550	139	3	Cw	14.9	42		0.0	3806	0	BL	2.9	52		17			19.2			18.6	17.2	17.2
1980	2013	Kootenay	0131-0085-YO1	21.4	1651	119	5	FD	13.8	46	17.7	28.3	1739	182	CW	14.4	47	22.9	19.6	18	19	25.4	17.2	25	22.8		22.3
1980	2013	Kootenay	0131-0085-YR1	24.2	1701	142	9	Fd	14.7	50	20.0	32.7	1794	224	CW	15.8	51	22.9	19.6	18	19	25.4	17.2	25	22.8		22.3
2006	2009	Kootenay	0131-0086-YO1	11.2	926	46	0	Lw	12.5	23	26.4	0.0	3147	0	LW	4.9	20	23	19.4	18	18.9	24.6	16.9	24.5	22.5		21.9
2006	2009	Kootenay	0131-0086-YR1	15.8	1426	71	1	Lw	14.4	27	26.6	0.0	3147	0	LW	6.3	24	23	19.4	18	18.9	24.6	16.9	24.5	22.5		21.9
2012	2014	Kootenay	0131-0087-YO1	4.9	125	33	52	Fd	5.3	26	14.8	11.0	1119	46	PLI	12.2	22	23.3	19.6	17.8	18.7	24	16.9	24.4	22.7		22.1
2012	2014	Kootenay	0131-0087-YR1	7.2	350	51	49	Fd	8.2	29		15.8	1432	82	PLI	14.6	26	23.3	19.6	17.8	18.7	24	16.9	24.4	22.7		22.1
2005	2009	Kootenay	0131-0088-YO1	22.7	1251	113	0	Bl	13.2	53	20.0	2.6	302	9	BL	8.6	39		17.1			18.7			19	17.6	17.6
2005	2009	Kootenay	0131-0088-YR1	30.0	1426	163	0	Se	15.5	41	25.9	5.7	570	21	BL	9.9	43		17.1			18.7			19	17.6	17.6
2014	2015	Kootenay	0131-0089-YO1	1.8	325	6	0	Cw	5.1	29	14.8	0.0	5940	0	CW	2.3	15	23.2	19.7	17.9	18.6	23.6	16.8	24.4	22.6		22.1
2014	2015	Kootenay	0131-0089-YR1	7.1	1126	23	0	Cw	6.5	28		0.0	5940	0	CW	3.5	20	23.2	19.7	17.9	18.6	23.6	16.8	24.4	22.6		22.1
2005	2009	Kootenay	0131-0091-YO1	0.2	25	1	0	Se	5.5	29	15.8	1.0	1576	0	BL	7.0	36		14.6						16.6	14.6	14.6
2005	2009	Kootenay	0131-0091-YR1	0.0	0	0	0	Bl	3.2	20		2.5	297	9	BL	8.3	40		14.6						16.6	14.6	14.6
2005	2009	Kootenay	0131-0092-YO1	10.5	951	42	0	Cw	9.1	26	20.8	0.0	1200	0	FDI	7.3	20	22.6	18.4	17.1	19.6	24.3	17.9	24.8	23		23.2
2005	2009	Kootenay	0131-0092-YR1	18.7	1526	88	3	Cw	11.4	30		5.5	510	17	FDI	10.0	25	22.6	18.4	17.1	19.6	24.3	17.9	24.8	23		23.2
2005	2009	Kootenay	0131-0093-YO1	14.9	1101	62	32	Sx	10.6	24	26.9	3.9	573	11	SE	8.0	29	21.6	18.8	17.8	17.9	23.5	16.7		21.3		20.9
2005	2009	Kootenay	0131-0093-YR1	22.5	1301	114	36	Sx	13.5	28		11.7	1451	42	SE	10.7	34	21.6	18.8	17.8	17.9	23.5	16.7		21.3		20.9
2005	2009	Kootenay	0131-0094-YO1	23.5	1076	168	74	Fd	9.2	30	18.9	0.0	800	0	PLI	5.0	36		21.1			23.1	19.1		22.7		23.4
2005	2009	Kootenay	0131-0094-YR1	26.4	1251	182	74	Fd	11.4	34	19.7	0.0	800	0	PLI	5.8	41		21.1			23.1	19.1		22.7		23.4
2006	2009	Kootenay	0131-0095-YO1	7.4	400	31	294	Fd	13.8	38	20.7	0.0	500	0	BL	4.3	36		20.3	17.7	17.1	22.9	18		22.2		22.4
2006	2009	Kootenay	0131-0095-YR1	8.8	325	43	294	Fd	15.3	42		0.0	500	0	BL	5.2	40		20.3	17.7	17.1	22.9	18		22.2		22.4
2006	2009	Kootenay	0131-0096-YO1	50.2	350	596	73	Cw				17.2	1562	74	FDI	13.6	36	22.1	19.3	17.5	17.8	23.9	16.7	23.9	22.2		21.7

Ref year	Att year	TSA	clstr_id	Phase II BA 7.5	TPH 7.5	WSV 7.5	WSV D 7.5	Spp	HT	Age	SI	Phase I BA 7.5	TPH 7.5	WSV 7.5	Spp	HT	Age	PSPL At	Bl	Cw	Ep	Fd	Hw	Lw	Pl	Se	Sx
2006	2009	Kootenay	0131-0096-YR1	52.1	350	622	48	Cw				21.5	1728	101	FDI	15.1	40	22.1	19.3	17.5	17.8	23.9	16.7	23.9	22.2		21.7
2005	2009	Kootenay	0131-0097-YO1	9.9	801	41	0	Cw	10.7	34	18.9	38.7	1690	287	HW	18.2	36		21.4	17.7	18	25.2	19.3		23.9		23.5
2005	2009	Kootenay	0131-0097-YR1	20.1	1326	98	0	Hw	12.9	33	25.3	44.8	1749	378	HW	20.7	41		21.4	17.7	18	25.2	19.3		23.9		23.5
2005	2009	Kootenay	0131-0098-YO1	19.2	926	89	0	Fd	13.4	24	32.6	4.3	473	10	FDI	7.6	27	23.1	20.9	17.5	18.4	25.6	19		23.1		22.4
2006	2008	Kootenay	0131-0099-YO1	1.0	125	3	0	Se	6.0	22	21.2	0.0	1500	0	SE	2.1	21		16.7						18	17.8	17.8
2006	2008	Kootenay	0131-0099-YR1	3.9	550	14	0	Se	7.6	27	22.4	0.0	1500	0	SE	3.1	25		16.7						18	17.8	17.8
2006	2008	Kootenay	0131-0100-YO1	11.9	1176	37	0	Bl	8.9	62	10.9	2.8	390	10	SE	8.8	46		13.3						15.1	12.4	12.4
2006	2008	Kootenay	0131-0100-YR1	15.5	1351	51	0	Bl	9.7	66		4.4	564	17	SE	10.0	50		13.3						15.1	12.4	12.4
2006	2010	Kootenay	0131-0261-YO1	2.4	425	6	0	Se	4.8	25	16.2	0.0	1470	0	SE	2.4	23		15.5						17.7	15.8	15.8
2006	2010	Kootenay	0131-0261-YR1	3.2	425	9	0	Se	6.2	30	18.4	0.0	1470	0	SE	3.4	27		15.5						17.7	15.8	15.8
2006	2009	Kootenay	0131-0265-YO1	0.0	0	0	0	Se	4.1	19	18.7	0.0	8120	0	SE	2.9	25		16.8			19.4			18.8	16.6	16.6
2006	2009	Kootenay	0131-0265-YR1	1.7	250	5	0	Se	6.7	22	23.1	0.0	8120	0	SE	4.0	29		16.8			19.4			18.8	16.6	16.6
2006	2010	Kootenay	0132-9576-MR1	21.7	650	133	38	Se	15.6	35	28.3	7.0	3384	0	SE	7.1	39		18.2						19.9	18	18
2006	2010	Kootenay	013Y-0311-YR1	65.4	801	655	45	Hw	26.9	173		20.5	1155	80	BL	11.9	49	21.9	18.7	17.3	18.9	22.6	16.1		21.6		21.2
2005	2009	Kootenay	013Y-1005-YR1	24.6	1051	130	2	Fd	15.2	27	33.6	7.6	729	20	FDI	8.9	31	23.1	20.9	17.5	18.4	25.6	19		23.1		22.4

14 Appendix D – Volume predictions

Table 31. The volume predictions associated with the establishment samples are given.

		Ground					VOL2			VOL3				
Sample	Use	Leading species	Leading species age	SI	WSV (m^3/ha)	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)	VRI Spp	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)
007Y-1496-YO1	Estab	At	35	28.3	77	15.9	1529	15.1	139	SE	4.8	255	5.5	24
0011-0196-MO1	Estab	Bl	31	20.0	51	3.0	862	8.9	24	BL	2.0	344	7.1	15
001Y-0429-YO1	Estab	Bl	37		145	2.8	814	8.7	24	PLI	10.6	1355	10.9	70
005Y-0335-YO1	Estab	Bl	28	20.0	20	2.4	617	8.3	15	BL	4.7	869	9.3	27
005Y-0787-YO1	Estab	Bl	55	14.8	65	3.3	950	9.2	27	BL	0.0	0	3.9	0
007Y-1287-YO1	Estab	Bl	39	16.1	27	3.4	740	8.8	29	SX	0.9	176	6.3	7
007Y-1459-YO1	Estab	Bl			15	12.0	913	9.7	88	SE	4.2	782	9.1	24
009Y-0764-YO1	Estab	Bl	107	17.0	178	23.7	1807	15.7	169	BL	1.1	493	7.7	11
009Y-1290-YO1	Estab	Bl	59	12.0	24	5.7	1138	9.9	41	PLI	10.2	1240	10.2	65
013Y-0125-YO1	Estab	Bl	76	21.1	307	40.9	1572	21.1	314	SX	8.2	1320	10.9	60
013Y-0277-YO1	Estab	Bl	38							BL				
0272-6971-MO1	Estab	Bl	101	9.2	56	10.8	1533	12.0	80	BL	2.8	887	9.0	25
0011-0211-MO1	Estab	Cw	47	18.7	224	21.9	1669	17.0	226	HW	12.4	1329	12.2	122
001Y-0757-YO1	Estab	Cw	34	20.9	137	7.7	1300	11.6	67	HW	1.0	386	7.3	9
001Y-1188-YO1	Estab	Cw	26	27.5	162	3.5	729	8.1	40	FDI	21.3	1711	17.3	169
007Y-1509-YO1	Estab	Cw	57	16.0	197	15.3	1535	14.6	147	CW	6.3	1126	9.6	64
007Y-1587-YO1	Estab	Cw	45	15.3	67	2.1	152	7.0	10	FDI	4.0	459	6.8	15
007Y-1632-YO1	Estab	Cw								FDI				
013Y-0283-YO1	Estab	Cw	24		18	3.7	649	9.1	34	FDI	0.0	29	3.9	1
013Y-0543-YO1	Estab	Cw	42	23.0	246	18.2	1663	15.9	197	HW	11.1	1692	12.5	101
013Y-1121-YO1	Estab	Cw	71		278	36.1	1607	20.7	351	HW	12.0	1268	11.1	118
013Y-0071-YO1	Estab	Ep	62		68	6.5	1297	12.2	59	AT	22.3	1746	18.2	204
0011-5796-MO1	Estab	Fd	26	25.0	34	3.3	929	8.8	28	FDI	6.0	1254	9.6	46
0011-9551-MO1	Estab	Fd	52		9	0.6	345	6.3	7	FDI	0.0	7	3.6	0

		Ground					VOL2			VOL3				
Sample	Use	Leading species	Leading species age	SI	WSV (m^3/ha)	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)	VRI Spp	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)
001Y-0017-YO1	Estab	Fd	81	14.4	67	19.7	1670	16.5	151	FDI	4.0	789	9.1	33
001Y-1078-YO1	Estab	Fd	18							PW				
002Y-0009-YO1	Estab	Fd	96	18.3	178	38.4	1438	25.8	342	FD	9.8	1407	11.4	77
002Y-0216-YO1	Estab	Fd								FD				
005Y-0299-YO1	Estab	Fd	65	18.4	256	21.5	1734	16.5	163	FD	17.1	1515	13.3	123
005Y-0472-YO1	Estab	Fd	54		55	30.3	1629	21.7	248	AT				
005Y-0592-YO1	Estab	Fd	35	20.5	39	15.8	995	13.3	76	PL	21.2	1109	13.4	107
0072-0096-MO1	Estab	Fd	17							FDI				
0072-4536-MO1	Estab	Fd	34	24.1	130	10.9	1383	11.3	78	SX	2.7	409	6.8	18
007Y-1264-YO1	Estab	Fd	35	23.5	139	15.2	1691	14.4	118	FDI	0.0	22	1.4	0
007Y-1440-YO1	Estab	Fd	36	18.1	86	6.8	1238	10.8	57	SX	26.3	1796	16.3	188
007Y-1443-YO1	Estab	Fd	43	24.1	300	16.9	1704	15.0	130	HW	6.9	1262	11.0	57
007Y-1515-YO1	Estab	Fd	25	29.6	51	1.6	392	5.4	12	PLI	7.7	1230	9.2	51
007Y-1532-YO1	Estab	Fd	42	24.1	236	17.9	1699	14.8	135	HW	4.7	702	9.7	42
007Y-1604-YO1	Estab	Fd	44	17.4	73	12.0	933	11.5	55	FDI	16.7	918	13.4	85
009Y-0789-YO1	Estab	Fd	32	19.9	77	6.0	659	7.6	24	PL	11.4	931	9.3	47
009Y-0819-YO1	Estab	Fd	74	10.8	60	10.7	1538	12.7	86	FD	13.6	1576	12.7	99
009Y-0869-YO1	Estab	Fd	23	21.3	2	3.0	556	7.2	13	PL	15.9	1360	12.9	89
013Y-1005-YR1	Estab	Fd	27	33.6	130	19.2	1064	15.0	102	FDI	9.7	1007	11.8	65
027Y-1277-YO1	Estab	Fd	41	21.7	110	13.6	953	12.1	63	H	11.5	1324	12.2	75
001Y-0830-YO1	Estab	Hw	44	23.3	153	5.0	1152	9.7	41	FD	11.4	1503	13.1	92
001Y-0860-YO1	Estab	Hw	40	24.8	162	13.1	1411	13.1	123	BL	8.9	1528	11.5	74
002Y-0430-YO1	Estab	Hw								BL				
007Y-1619-YO1	Estab	Hw	17	22.3	6	0.4	113	5.2	3	HW	1.3	418	7.5	12
013Y-0311-YR1	Estab	Hw	173		655	31.7	1642	20.8	312	BL	11.9	1262	10.3	89
027Y-1080-YO1	Estab	Hw								SX				
001Y-0110-YO1	Estab	Lw								PL				
001Y-0676-YO1	Estab	Lw	26	24.0	31	6.4	1069	9.1	47	CW	0.3	90	4.8	2

		Ground					VOL2			VOL3				
Sample	Use	Leading species	Leading species age	SI	WSV (m^3/ha)	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)	VRI Spp	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)
002Y-0294-YO1	Estab	Lw			12	0.0	3	3.8	0	PLI	0.3	225	6.1	4
005Y-0477-YO1	Estab	Lw	29	22.3	79	13.1	1599	12.3	93	PL	9.6	1463	10.4	64
001Y-0174-YO1	Estab	Pl	13			0.0	5	4.5	0	FDI	0.2	85	4.5	1
001Y-0289-YO1	Estab	Pl	22		23	5.9	605	6.9	22	BL	1.2	206	4.2	5
001Y-0357-YO1	Estab	Pl	20	17.1	5	0.0	25	4.5	0	PLI	4.0	571	6.6	15
001Y-0678-YO1	Estab	Pl	18		23	0.5	183	5.7	3	PLI	0.0	18	4.1	0
001Y-0833-YO1	Estab	Pl	19	23.6	24	1.3	331	6.0	6	FDI	1.5	387	7.1	8
001Y-0958-YO1	Estab	Pl	25		67	16.2	998	10.4	61	SX	0.0	18	4.5	1
002Y-0065-YO1	Estab	Pl	29		107	10.6	936	8.9	39	PLI	5.2	675	7.1	20
002Y-0145-YO1	Estab	Pl	17	17.4	2	0.9	249	5.2	5	BL	4.7	410	6.3	18
002Y-0364-YO1	Estab	Pl	71	17.2	61	9.1	1411	9.9	59	BL	0.5	199	4.0	4
002Y-0495-YO1	Estab	Pl	16		10	0.3	122	5.0	2	PLI	0.4	117	4.0	2
0051-3356-MO1	Estab	Pl	20	14.9	11	0.1	104	4.8	2	BL	0.0	4	2.5	0
005Y-0120-YO1	Estab	Pl	19	21.8	48	3.6	648	7.2	15	FDI	0.1	50	4.7	1
005Y-0191-YO1	Estab	Pl	37	20.1	100	26.9	1100	13.7	126	PL	26.3	1265	14.9	150
005Y-0192-YO1	Estab	Pl	32	18.8	60	21.2	1107	12.0	85	PL	0.0	0	0.6	0
005Y-0194-YO1	Estab	Pl	38	21.2	150	24.3	1699	16.2	173	PL	13.9	1637	12.8	98
007Y-1514-YO1	Estab	Pl	42	24.2	253	31.5	1116	16.1	181	FD	24.3	1168	17.4	146
009Y-0687-YO1	Estab	Pl	23	22.7	41	6.6	786	8.4	26	PLI	0.0	2	3.7	0
009Y-0737-YO1	Estab	Pl	26	17.3	40	7.5	883	8.3	28	PL	9.2	803	8.2	34
009Y-0840-YO1	Estab	Pl	23	20.4	38	5.0	696	7.4	19	PL	16.2	1006	11.2	67
009Y-0844-YO1	Estab	Pl	31	15.9	33	11.0	1071	9.6	47	PL	31.4	1147	15.6	177
009Y-0917-YO1	Estab	Pl	23	23.0	70	8.6	771	8.0	32	S	5.1	637	8.7	22
009Y-0918-YO1	Estab	Pl	41	25.1	215	7.7	917	8.5	51	PL	28.8	1451	15.2	196
009Y-1062-YO1	Estab	Pl	23		20	1.6	501	6.0	13	BL	0.4	144	3.9	3
013Y-0313-YO1	Estab	Pl	21		6	0.1	51	4.8	1	PLI	2.0	325	4.9	8
CMI3-0521-FR1	Estab	Pl	38	18.7	122	20.3	1726	14.5	141	PL	3.5	878	7.8	27
001Y-0108-YO1	Estab	Se	30	21.4	56	0.2	50	3.3	2	S	2.7	638	7.8	24

		Ground					VOL2			VOL3				
Sample	Use	Leading species	Leading species age	SI	WSV (m^3/ha)	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)	VRI Spp	BA (m^2/ha)	TPH	Top height (m)	WSV (m^3/ha)
001Y-0394-YO1	Estab	Se	34	26.6	175	25.7	1145	14.7	131	SE	13.7	1082	11.5	62
001Y-0881-YO1	Estab	Se	30	23.6	44	31.0	699	18.8	268	SE	0.0	3	2.7	0
0021-6421-MO1	Estab	Se	141		47	32.4	1761	18.1	234	BL	0.0	20	2.4	0
002Y-0059-YO1	Estab	Se	32		55	0.3	119	4.3	3	CW	0.0	14	5.0	0
002Y-0361-YO1	Estab	Se	30	23.4	34	7.4	861	9.7	31	S	0.2	94	6.1	2
005Y-0190-YO1	Estab	Se	36	17.1	33	11.0	976	10.9	80	SE	1.3	548	7.9	13
005Y-0259-YO1	Estab	Se	37	21.0	115	5.3	1199	10.1	41	SX	1.0	435	7.5	10
005Y-0263-YO1	Estab	Se	43	17.9	63	6.9	771	9.4	31	BL	1.6	350	7.4	9
005Y-0273-YO1	Estab	Se	40	17.2	81	6.2	788	9.5	30	SE	17.6	1452	13.1	102
005Y-0510-YO1	Estab	Se	28	28.6	72	26.2	749	15.7	205	LW	10.9	1462	12.4	81
005Y-0572-YO1	Estab	Se	38	21.4						BL				
007Y-1512-YO1	Estab	Se	127	3.1	8	1.6	64	5.1	12	SE	11.3	1624	12.1	82
007Y-1576-YO1	Estab	Se	27	16.2	2	0.0	2	4.8	0	SX	0.9	100	5.4	3
009Y-1292-YO1	Estab	Se	32	21.3	27	8.3	1188	10.9	64	SE	1.4	169	5.6	9
0132-9576-MR1	Estab	Se	35	28.3	133	19.3	1072	12.7	90	SE	8.2	1013	10.2	38
027Y-1610-YO1	Estab	Se	29	27.4	175	31.0	699	18.8	268	SE	0.0	0	1.6	0
007Y-1548-YO1	Estab	Sx	31	27.3	185	20.8	1139	13.2	98	SE	0.0	0	2.0	0
0272-4511-MO1	Estab	Sx	20	27.3	31	1.8	583	8.1	16	SX	0.0	0	2.6	0
027Y-1148-YO1	Estab	Sx	32		184	27.7	1152	15.4	148	SX	7.7	773	10.1	36
027Y-1416-YO1	Estab	Sx	31	31.0	260	18.1	1165	12.6	84	SE	2.5	415	6.3	17
027Y-1505-YO1	Estab	Sx	36		14	33.3	751	19.7	284	SX	24.7	1191	15.1	142
027Y-1609-YO1	Estab	Sx	31	28.2	204	26.7	1150	15.1	140	SE	0.0	0	1.7	0

15 Appendix E - Case matched comparisons

The height and age data matching followed the FAIB (2011) VRI procedures with exceptions for the spruces. The ground plot data were matched with the corresponding VRI Phase I photo interpreted inventory data for the polygon. The ground plot heights and ages were based on the average values for the T, L, S, X and O trees by species. The objective was to match the ground leading species to the Inventory (Phase I) leading or secondary species and compare the ages and heights. If a match could not be made at the Sp0 (genus) level, conifer-to-conifer (or deciduous-to-deciduous) matches were allowed. However, conifer-deciduous matches were not acceptable. The spruces were classified as SB, SE, SS or SW (including SX and SXW). The five possible matching cases are given in Table 32.

Table 32. The height and age matching cases are described.

Case	Description
1	VRI polygon leading Sp0 matches the ground leading Sp0
2	VRI polygon second Sp0 matches the ground leading Sp0
3	VRI polygon leading species and the ground leading species are both coniferous or both deciduous.
4	VRI polygon second species and the ground leading species are both coniferous or both deciduous.
5	No match

Less than half of the samples had case 1 matches (Table 33).

Table 33. The number of measurements are given by TSA, species matching case and use (establishment vs. change).

		Last	Case					
Use	TSA	Msmt	1	2	3	4	5	Total
Estab	Arrow	Y	8	6	8			22
	Boundary	Y	4	2	5		1	12
	Cranbrook	Y	9	6	2	1	1	19
	Golden	Y	6	3	10		1	20
	Invermere	Y	8	3	2			13
	Kootenay	Y	4	3	3			10
	Revelstoke	Y	5	1	3			9
Change	Kootenay	N	24	10	14			48
		Y	26	8	14			48

The differences in the case-matched ages and heights are given (Table 34).

Table 34. The case-matched ground plot and VRI Polygon ages and heights are compared. Statistically significant differences are shaded.

Strata			Leading	Species	Age (yrs)			Leading	Spp	Height	(m)
Type	Strata	N	Ground	VRI	Bias	p-value	N	Ground	VRI	Bias	p-value

Strata			Leading	Species	Age (yrs)			Leading	Spp	Height	(m)
Type	Strata	N	Ground	VRI	Bias	p-value	N	Ground	VRI	Bias	p-value
TSA	Arrow	21	32.1	26.8	5.3 ± 3	0.1	21	11.2	6.9	4.4 ± 0.8	0
	Boundary	8	53.9	24.8	29.1 ± 15.3	0.099	8	12.6	5.8	6.8 ± 2.9	0.049
	Cranbrook	13	36.4	33.2	3.3 ± 3.2	0.324	13	11.9	8.1	3.8 ± 1.4	0.021
	Golden	16	41.9	33.8	8.1 ± 5.1	0.13	15	13.1	10.5	2.6 ± 1.2	0.041
	Invermere	12	41	34.3	6.8 ± 6.3	0.307	12	11.2	9.7	1.4 ± 0.9	0.138
	Kootenay	9	54.7	36.1	18.6 ± 13.7	0.213	9	14.3	10.9	3.4 ± 2	0.122
	Revelstoke	7	39.9	29.7	10.2 ± 8.4	0.271	6	13.8	6	7.8 ± 1.4	0.003
BEC	ESSF	31	45	32.1	12.9 ± 5.4	0.023	31	10.4	7.3	3.1 ± 1.1	0.007
	ICH	40	39	30.5	8.5 ± 3.5	0.02	38	13.7	8.8	4.8 ± 0.7	0
	IDF	3	47.1	32	15.1 ± 19.3	0.517	3	14.2	8.5	5.8 ± 3.4	0.229
	MS	12	34.9	30.8	4.1 ± 4	0.324	12	12.5	9.7	2.8 ± 1.2	0.04
Species	AT	1	61.7	36	25.7 ± 0.00		1	12.6	9.6	3 ± 0.00	
	BL	14	61.8	30.9	30.9 ± 12.3	0.026	14	12.2	7.4	4.9 ± 1.9	0.024
	CW	3	38.4	30.7	7.7 ± 2.8	0.113	3	11.9	8.5	3.4 ± 2	0.226
	FD	18	41.6	28.7	12.9 ± 4.5	0.011	17	13.7	9	4.6 ± 1.1	0.001
	HW	7	42.3	38.1	4.2 ± 3.7	0.304	7	15.5	12.5	3 ± 1.9	0.172
	LW	1	28.4	33	-4.6 ± 0.00		1	14.3	15.1	-0.7 ± 0.00	
	PL	18	30.1	29.3	0.8 ± 2.1	0.713	18	10.5	8.3	2.2 ± 0.8	0.017
	PW	1	18.2	16	2.2 ± 0.00		1	3.7	5	-1.3 ± 0.00	
	SE	12	40.8	34.8	6.1 ± 6.6	0.375	12	13.1	7.6	5.6 ± 1.5	0.004
	SX	11	31.5	30.7	0.8 ± 1.4	0.606	10	10.9	6.4	4.5 ± 1.4	0.012
Age	15-30	43	31.3	22.3	9 ± 3.3	0.01	42	10.3	5.9	4.4 ± 0.8	0
	31-50	43	50.4	39.9	10.5 ± 4.2	0.016	42	14.4	10.9	3.5 ± 0.7	0
Multi-cohort	N	63	33.4	29.9	3.5 ± 1.5	0.021	61	11.8	8.1	3.7 ± 0.5	0
	Y	23	61.2	34.4	26.8 ± 8.2	0.003	23	13.7	9.1	4.6 ± 1.4	0.003
All	All	86	40.8	31.1	9.7 ± 2.7	0	84	12.3	8.4	3.9 ± 0.5	0

16 Appendix F - Close species composition

The samples with 10% or less difference between the leading and second species in terms of species composition on the ground or in the inventory are given (Table 35).

Table 35. The samples with 10% or less difference between the leading and second species in terms of species composition. “Approx Case” is the case matching if the leading and second species are switched.

		VFI								Ground									Approx
Clstr_id	TSA	Spp 1	Pct1	Spp 2	Pct2	Spp 3	Pct3	Spp 4	Pct 4	Spp 1	Pct1	Spp 2	Pct 2	Spp 3	Pct 3	Spp 4	Pct 4	Case	Case
0011-0196-MO1	Arrow	BL	50	SE	40	PLI	10		.	Bl	54	Se	44	Pw	2		.	1	1
0011-0211-MO1	Arrow	HW	40	CW	30	SE	20	BL	10	Cw	65	Hw	31	Se	3	Bg	1	2	1
001Y-0174-YO1	Arrow	FDI	40	PLI	40	BL	10	LW	10	Pl	100		.		.		.	2	1
001Y-0676-YO1	Arrow	CW	40	HW	30	SX	20	LW	10	Lw	30	Pl	25	Hw	23	Cw	14	3	3
001Y-0833-YO1	Arrow	FDI	40	EP	30	PLI	10	LW	10	Pl	80	Pw	9	Lw	8	Cw	3	3	3
001Y-0860-YO1	Arrow	BL	30	HW	30	SX	29.9	CW	10	Hw	33	Cw	25	Bl	23	Se	19	2	1
001Y-0958-YO1	Arrow	SX	50	BL	50		.		.	Pl	90	Se	10		.		.	3	3
001Y-1078-YO1	Arrow	PW	40	FDI	40	CW	10	HW	10	Fd	38	Pw	34	Cw	28		.	2	1
0021-6421-MO1	Boundary	BL	40	SX	40	PLI	20		.	Se	100		.		.		.	3	3
002Y-0145-YO1	Boundary	BL	40	PLI	40	SX	20		.	Pl	66	Bl	34		.		.	2	1
002Y-0364-YO1	Boundary	BL	40	PLI	30	SX	30		.	Pl	88	Bl	12		.		.	2	1
002Y-0495-YO1	Boundary	PLI	40	SX	40	BL	20		.	Pl	83	Bl	9	Se	8		.	1	1
005Y-0190-YO1	Cranbrook	SE	50	BL	50		.		.	Se	51	Bl	40	Ac	6	Fd	3	1	1
005Y-0194-YO1	Cranbrook	PL	40	FD	30	LW	20	BL	10	Pl	52	Fd	25	Lw	23		.	1	1
005Y-0273-YO1	Cranbrook	SE	50	BL	50		.		.	Se	79	Bl	18	Pl	3	Pw	.	1	1
005Y-0299-YO1	Cranbrook	FD	40	PL	30	BL	20	SE	10	Fd	52	Se	35	Bl	10	Pl	3	1	1
005Y-0572-YO1	Cranbrook	BL	40	SE	30	CW	30		.	Se	45	Bl	26	Cw	20	Hw	9	2	1
005Y-0592-YO1	Cranbrook	PL	50	FD	40	AT	10		.	Fd	100		.		.		.	2	1
007Y-1443-YO1	Golden	HW	25	SX	25	FDI	20	CW	20	Fd	49	Sx	29	Bl	17	Cw	2	3	2
007Y-1587-YO1	Golden	FDI	40	PLI	30	SX	20	HW	10	Cw	68	Fd	13	Hw	11	Pl	6	3	3
007Y-1619-YO1	Golden	HW	30	EP	30	FDI	20	CW	20	Hw	59	Cw	23	Ep	15	Fd	3	1	1
0131-0098-YO1	Kootenay	FDI	30	HW	30	CW	20	AT	20	Fd	96	Pw	3	Hw	1		.	1	1
013Y-0283-YO1	Kootenay	FDI	30	PW	20	PLI	20	BL	20	Cw	41	Fd	27	Ac	23	Hw	9	3	3
013Y-0313-YO1	Kootenay	PLI	43	BL	37	SE	14	PW	5	Pl	85	Bl	15		.		.	1	1
013Y-1005-YR1	Kootenay	FDI	30	HW	30	CW	20	AT	20	Fd	96	Hw	4		.		.	1	1
027Y-1080-YO1	Revelstoke	SX	40	FD	30	PL	20	CW	10	Hw	49	Se	30	Cw	13	Fd	5	3	3
027Y-1416-YO1	Revelstoke	SE	40	CW	30	HW	20	FDI	10	Sx	68	Hw	12	Cw	7	At	5	3	3
001Y-1188-YO1	Arrow	FDI	55	ACT	25	HW	15	SX	5	Cw	49	Se	46	Hw	3	Ep	2	3	3
002Y-0059-YO1	Boundary	CW	50	BL	30	SE	20		.	Se	33	Cw	32	Hw	14	Ac	13	3	1
002Y-0430-YO1	Boundary	BL	40	PLI	20	SX	20	CW	10	Hw	53	Pl	47		.		.	3	2
005Y-0477-YO1	Cranbrook	PL	70	LW	30		.		.	Lw	52	Pl	47	Ac	1		.	2	1
CMI3-0521-FR1	Cranbrook	PL	60	LW	30	SX	10		.	Pl	45	Se	35	Lw	19	Bl	1	1	1
009Y-0918-YO1	Invermere	PL	70	AT	10	SE	10	EP	10	Pl	43	Se	42	Fd	7	Lw	7	1	1
009Y-1292-YO1	Invermere	SE	60	BL	30	PLI	10		.	Se	39	Pl	32	Ac	29		.	1	1
013Y-0277-YO1	Kootenay	BL	60	SE	40		.		.	Bl	47	Se	39	Pl	14		.	1	1

17 Appendix G - Summaries by TSA

The YSM subpopulation is dominated by pine and spruce with considerable variation from TSA to TSA.

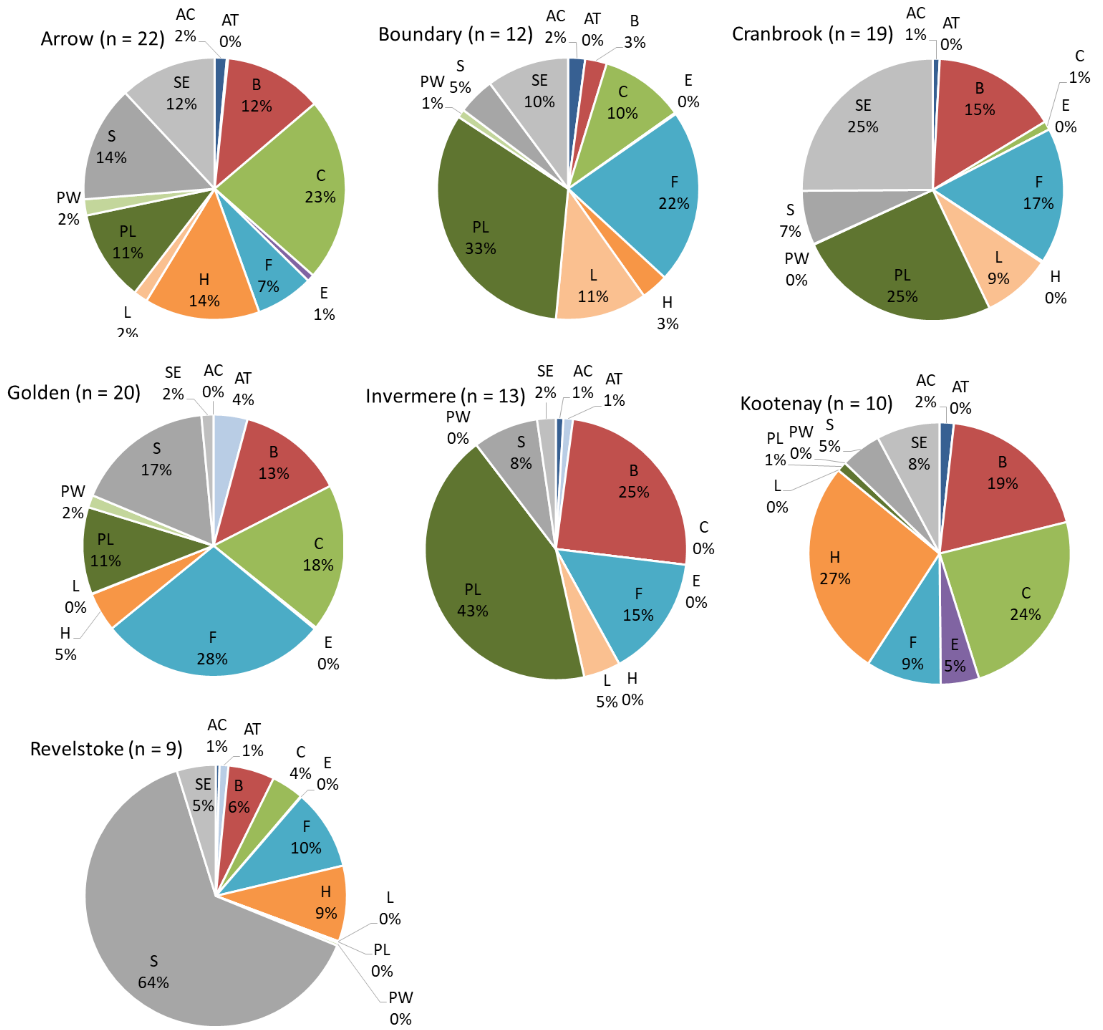


Figure 19. The percentage of live basal area is given by species and TSA based on the ground measurements for the establishment plots.

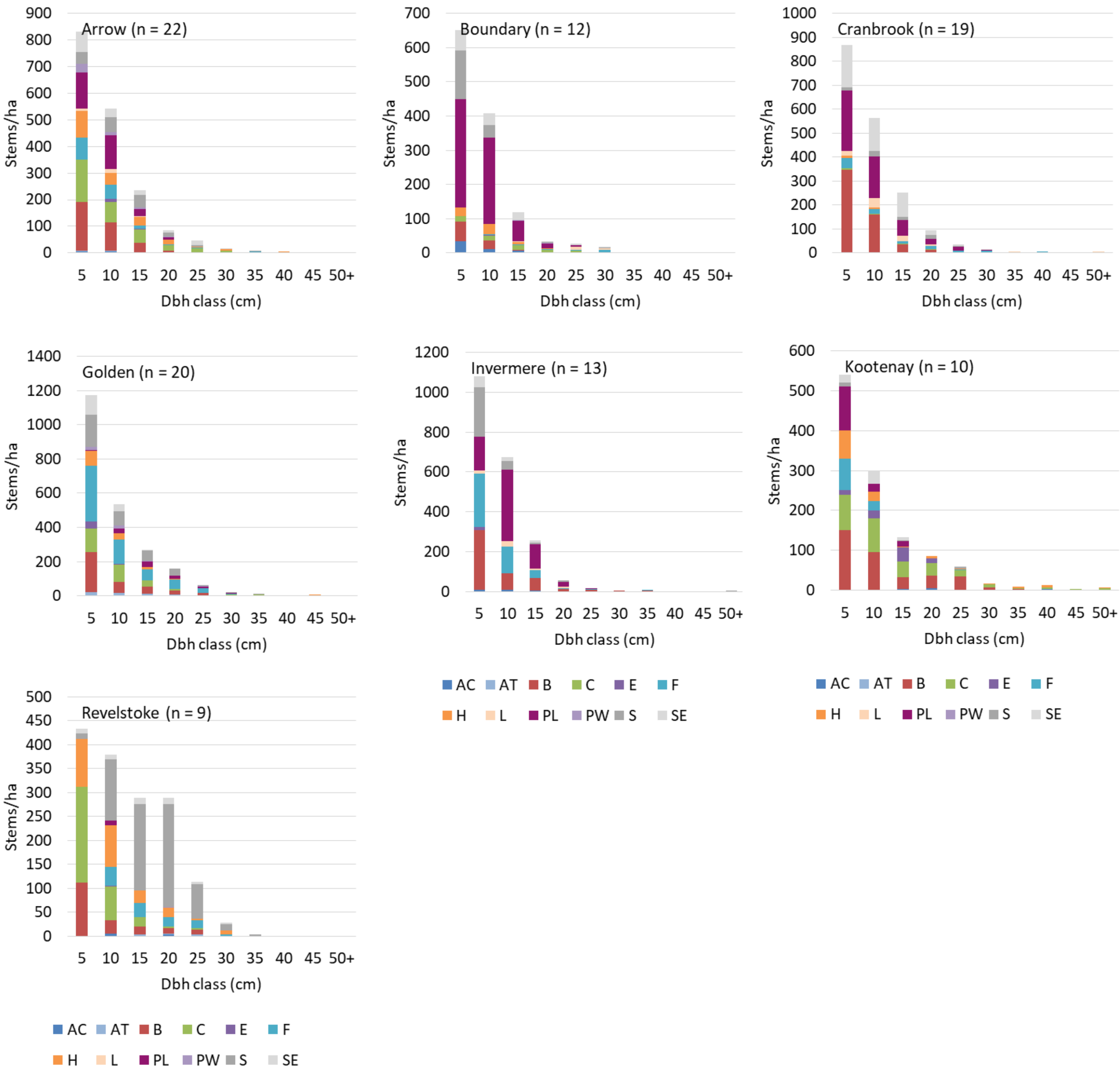


Figure 20. The stand table based on the ground measurements are given for the establishment plots by TSA.

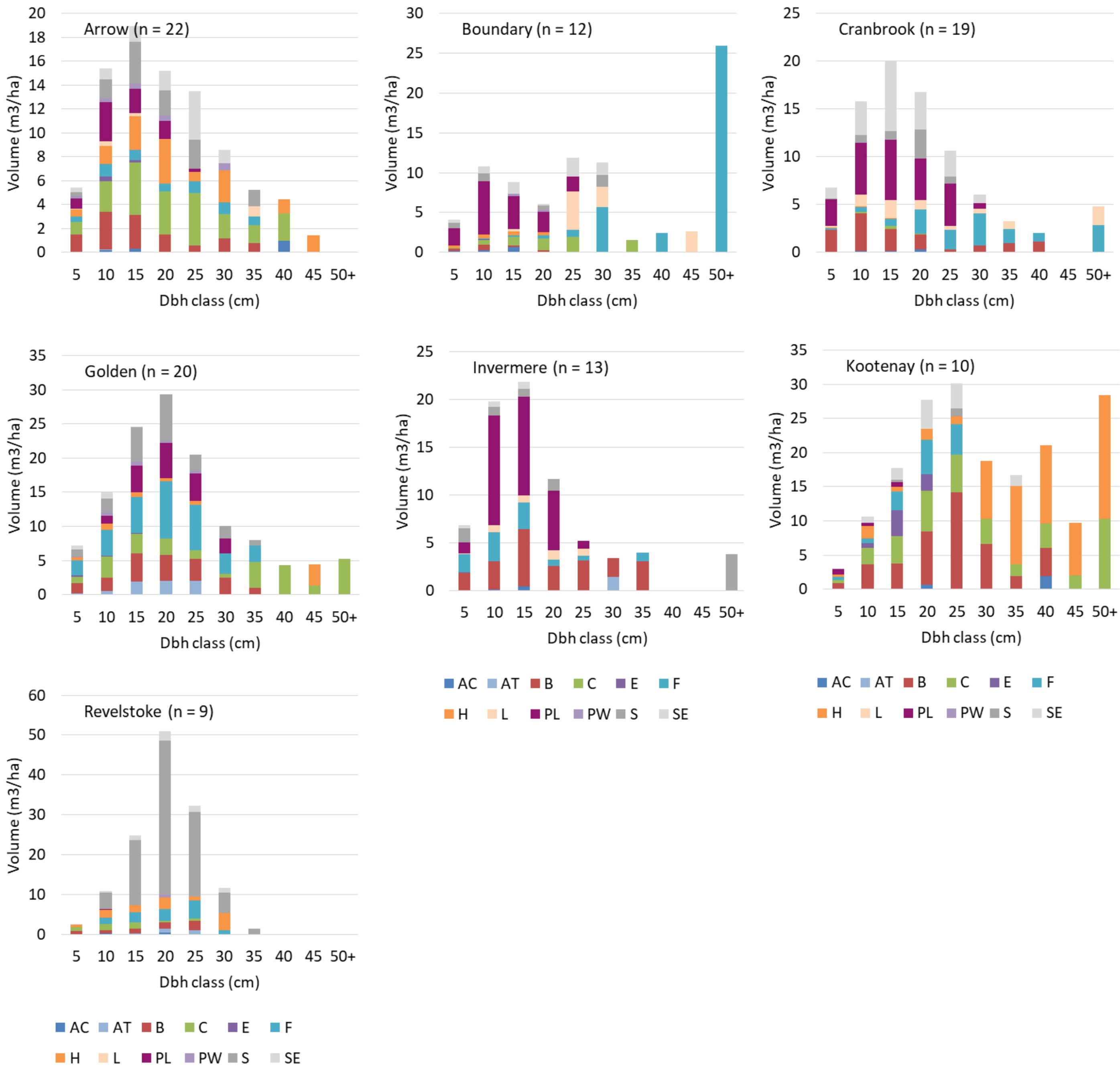


Figure 21. The stock table based on the ground measurements are given for the establishment plots by TSA.

The size class distribution of the dead stems is given.

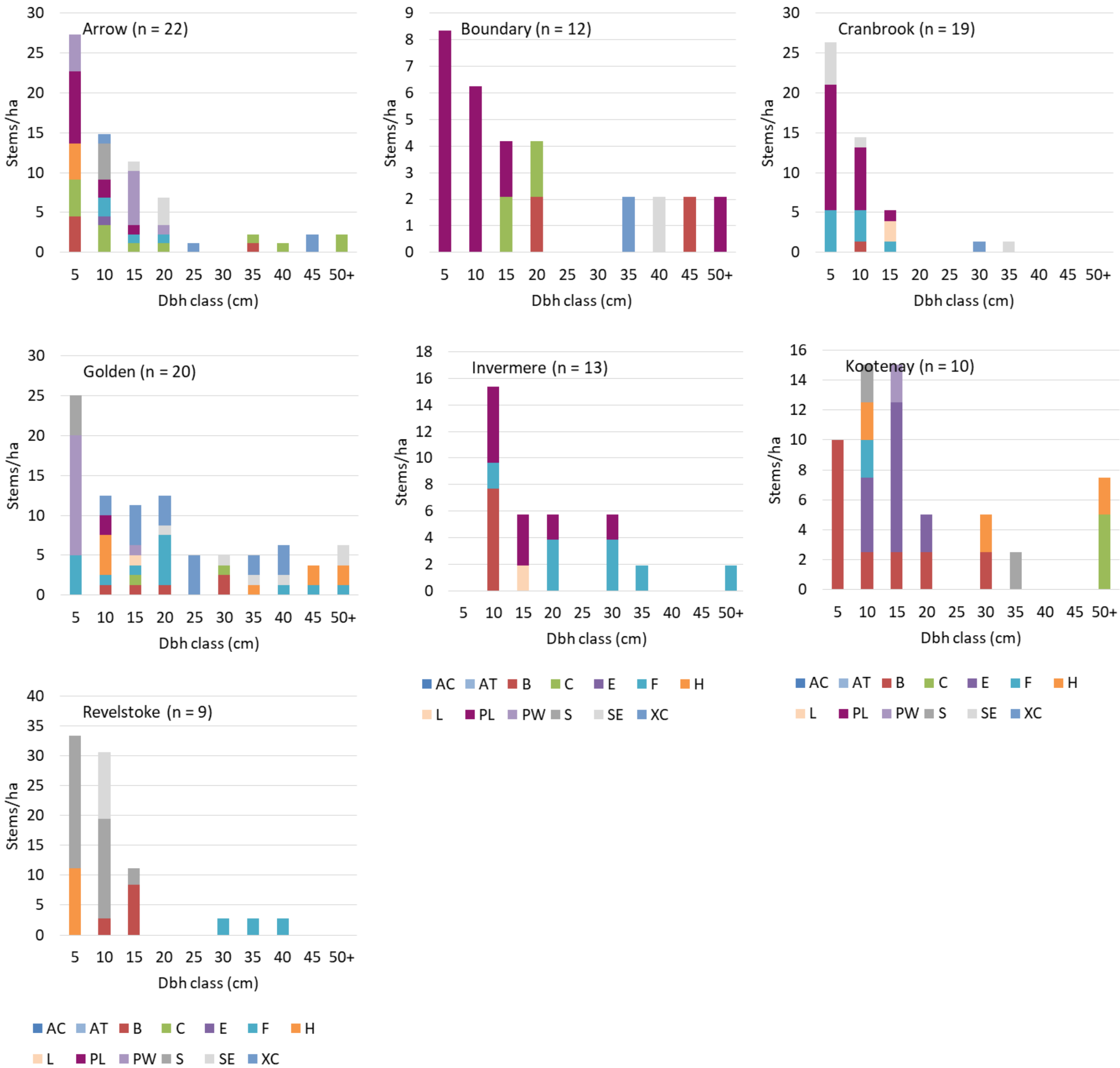


Figure 22. The dead trees are given by species, diameter and TSA.

The visible damage is summarized by TSA. Approximately half of the stems have no damage. Of the stems with damage, approximately half of the damage is form-related (51%) followed by abiotic damage (21%) and disease (13%).

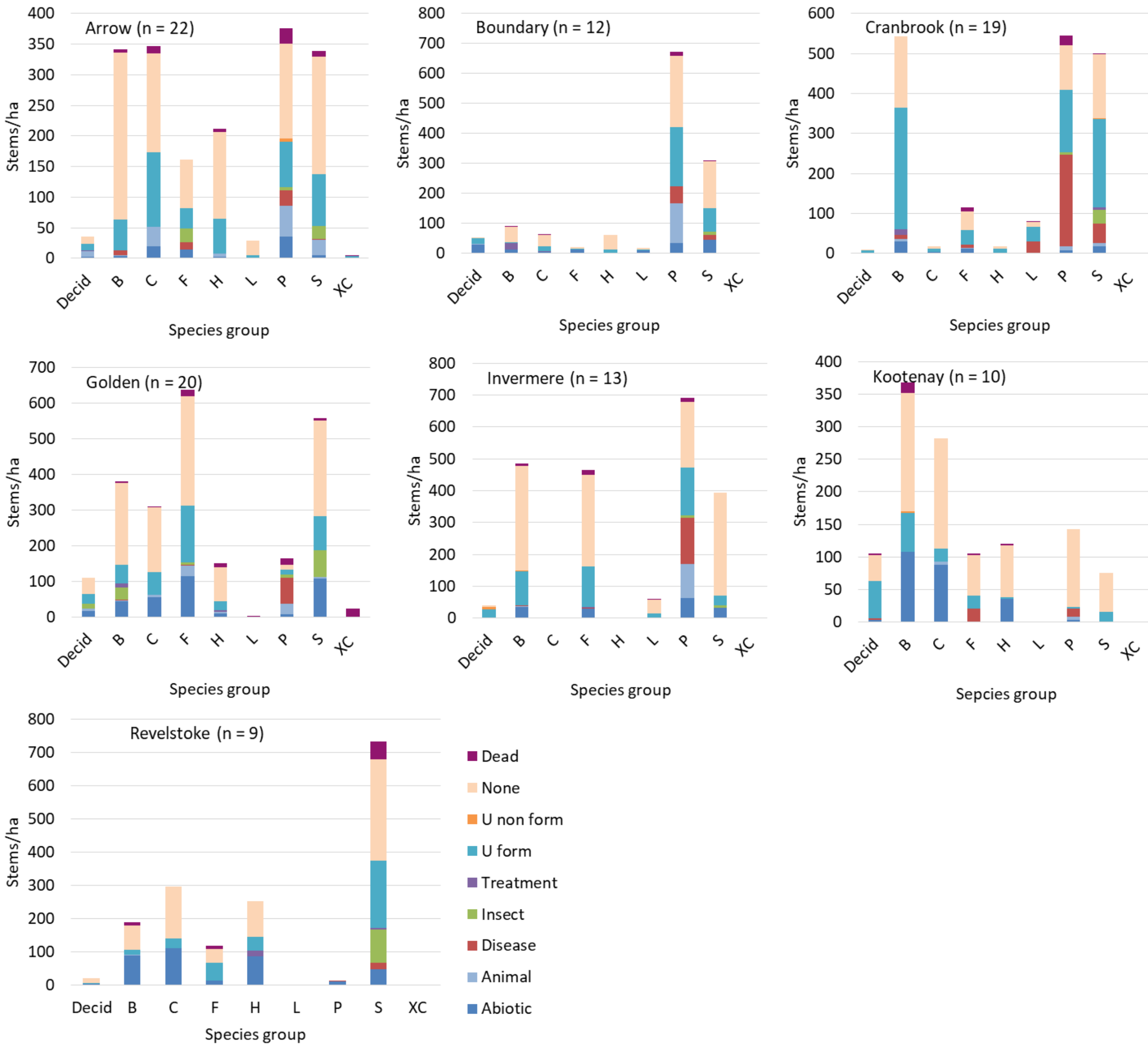


Figure 23. The stems/ha affected by each primary damage agent is given by species for live and dead trees, DBH ≥ 4.0 cm. Establishment plots only.