Merritt Timber Supply Area
Ground Sample Data Analysis
Young Stand Analysis

prepared for:
Ministry of Forests, Lands and Natural Resource Operations
Forest Analysis and Inventory Branch

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Executive Summary

This report documents the young stand monitoring (YSM) analysis for the Merritt Timber Supply Area (TSA). Thirty-seven YSM plots were established in 2005, 2006 and 2007 on a 2-km grid that sampled stands in the vegetated treed (VT) portion of the timber harvesting land base that were at least 20 years old and established on or after 1960 (16,594 ha). In 2013 the target population definition was expanded to include all crown land within the Merritt TSA identifed in the VRI Rank 1 layer as 15–50 years old (91,985 ha, 8% of the total TSA area). Due to the expanded definition of the population the decision was made to switch to a 4-km grid that was a subset of the original 2-km grid. This resulted in 14 of the original plots being kept and re-measured and an additional 41 plots being established in the target population. National Forest Inventory (NFI) plots have also been established in the Merritt TSA on the NFI 20-km grid. Two of these plots fell in the target population and were also used for the analysis. The end result is a total of 57 plots available for the analysis.

Preliminary data screening identified 14 of the 57 plots (25%) as possible multi-cohort stands due to the presence of veteran and residual trees as well as ground ages that were 25 years or more greater than the inventory ages. These plots were flagged and subsequent analyses were done with all plots and with the multi-cohort plots removed.

Forest health incidence (occurence of a damage agent) was high with 69% of the stems and 76% of the basal area with recorded incidence of damage. Forest health severity data was collected on the ground plots, but analysis of this data was outside the scope of this project. Given the high incidence rate, forest health specialists along with growth and yield specialists should review and analyse the severity data to determine potential impacts.

One objective of the ground sample data analysis is to evaluate the accuracy of the existing inventory data using the ground sample data as the benchmark for assessment. For the young stand analysis, species composition, height and age values are taken directly from the VRI rank 1 layer. Site index comes from the Provincial Site Productivity Layer (PSPL). Other inventory values including total stems per hectare (sph), basal area, and gross and merchantable volume[1] are estimated using TIPSY with inventory values as inputs.

Comparison of ground to PSPL site index estimates showed a significant difference between the ground and PSPL values for PL, with the ground values being on average 0.8 m higher. Ratios of ground averages to inventory averages and associated confidence intervals were determined for age, height, sph, basal area, merchantable volume and gross volume (Table 1).

[1]See Appendix B for a description of volumes.

Table 1: Ratio statistics - young stand population.

Attribute	Unit	n	Inventory	Ground	Ratio	Std. Err.	E	p	
Height	(m)	48	8.2	10.9	1.345	0.078	0.157	0.000	***
Age	(yrs)	50	26.2	38.0	1.496	0.133	0.267	0.000	***
Basal Area	(m^2/ha)	57	9.3	15.5	1.760	0.222	0.445	0.001	***
Trees/ha	(n)	57	1,204.1	1,740.2	1.443	0.173	0.346	0.007	***
Live Merch Vol.	(m^3/ha)	57	21.0	41.8	1.849	0.320	0.642	0.005	***
Live Gross Vol.	(m^3/ha)	57	37.3	71.9	2.161	0.400	0.801	0.003	***

Ground age, height, sph, basal area, merchantable volume and gross volume were all significantly greater than corresponding inventory attributes. This remained true when the multi-cohort plots were removed from the analysis. Basal area, merchantable and gross volume differences are attributable to higher ground site indices and older ages than the inventory values used to initiate TIPSY. However, interpreting these differences is confounded by the presence of the following in the young stands:

1. Veteran trees
2. Residual trees
3. Natural ingress (not accounted for in TIPSY planted only projections)
4. Dead volume (resulting from mountain pine beetle and other damage agents)
5. Forest health incidence

Net change in the key attributes was also significant for the 14 re-measured plots. Details of the components of change (ingrowth, mortality, and survivor growth) are presented for the 14 re-measured plots.

TIPSY projections of merchantable volume were very close to ground measures of merchantable volume when ground inputs where used to initiate TIPSY and ground top height was used as the reference point to extract projected volumes from TIPSY.

The following recommendations are made to improve both the information for the Merritt TSA and the overall YSM process.

1. Investigate the sensitivity of the Merritt AAC determination to young stand projections. Dependent on the outcome, investment may be required to upgrade the young stand inventory to provide the requiste stand attributes to project the development of these stands. Furthermore, if the AAC determination is sensitive to young stand projections, it is possible that custom TASS runs (as opposed to TIPSY runs) will be required to deal with variable stand structures.

2. Complete an indepth analysis of the Merritt forest health severity data with input from regional forest health experts and FAIB growth and yield experts. The high incidence of forest health agents in the young stand population makes understanding the potential impacts of this incidence a high priority.

3. Develop a separate or new component for the FAIB compiler that will handle change estimation, including additional error checking for shrinking and excessive individual tree growth between measurements. The change estimation procedures must address current changes in per hectare factors applied to individual trees when they cross tagging thresholds. Individual trees could be coded in a manner similar to that used in this analysis to allow for the estimation of components of change (ingrowth, mortality and survivor growth).

4. When a higher sample size of plots are re-measured compare change estimates to change predicted by TIPSY (or TASS).

5. Review YSM forest health severity coding to ensure compatibility with estimating change in forest health severity over time.

6. Develop a separate or new component for the FAIB compiler that will process and summarize the forest health incidence and severity data. Ensure that this is compatible with the change estimation.

7. Ensure that photos are taken at all YSM plots at each measurement.

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1. Introduction

1.1 Merritt TSA VRI Background

There is a need for the continued maintenance of a forest growth and yield monitoring program in the Merritt Timber Supply Area (TSA) to estimate the growth of young stands (stands between 15 and 50 years old), to report on the status and growth of mature stands (stands greater than 50 years old), and to support a broader province-wide Ministry of Forests, Lands and Natural Resource Operations (MFLRNO) monitoring initiative. A major concern has been the need to quantify the impacts of significant allowable annual aut (AAC) increases in the TSA, resulting from the mountain pine beetle epidemic (Table 1.1) (MFLNRO, FAIB, 2013).

Table 1.1: Merritt AAC

Year	AAC
1996	1,454,250
1999	2,004,250
2001	1,508,050
2005	2,814,171
2010	2,400,000

Previously completed growth and yield projects in the Merritt TSA include:

1. Change Monitoring Inventory (CMI) ground sample program established in 2005. Note that the CMI program has been renamed the Young Stand Monitoring (YSM) program.
2. VRI Phase II ground sampling program established in 1999 and 2000.

The ground sampling plan for the present project is documented in MFLNRO, FAIB (2013). The ground sampling included re-measurement of a subset of the VRI Phase II plots, re-measurement of CMI (now YSM) plots, establishment of new YSM plots, and establishment and re-measurement of National Forest Inventory (NFI) plots (note that the NFI plots are also refered to as 20-km grid plots as they are established on a 20-km grid).

1.2 Project Objectives

The Merritt TSA ground sample analysis project has two main objectives:

1. Perform a VDYP7 based VRI analysis for the Merritt TSA, using current standards (MFLNRO, FAIB, 2011) for the mature population (51 years and older).
2. Perform a YSM analysis for stands 15–50 years old.

1.3 Report Objectives

This report addresses the second project objective. The first objective is addressed in a separate report (mature stand analysis). A third report (stand and stock tables) includes stand and stock tables that provide additional information on both the mature and young stands. All reports are available from Forest Analsys and Inventory Branch (FAIB).

1.4 Terms of Reference

This project was completed by Associated Strategic Consulting Experts Inc. (ASCE) for FAIB. The ASCE team included Eleanor McWilliams, MSc, RPF and Guilaume Thérien, PhD. The FAIB contacts were Graham Hawkins, RPF, Rene deJong, RPF and Peter Ott, MSc.

2. Young Stand Monitoring

2.1 Overview

The framework for implementing YSM is described by Omule (2013). The foundation of YSM comes from the work done by the Growth and Yield Monitoring Task Force (GYMTF) lead by Resource Inventory Branch in the late 1990s and early 2000s. The primary focus of the YSM program is to check the accuracy of growth and yield predictions (assumptions) used in timber supply review (TSR). The program provides feedback to modellers and timber supply analysts, as well as providing information to assess silviculture and stand management practices.

2.2 Goals and Objective

The primary goals of FAIB's YSM are to:

- Characterize the young stand population, including composition, structure, mortality, growth, yield, and health.
- Assess the accuracy of some vegetation resources inventory (VRI) polygon attributes (e.g., age, height and site index) for young stands.
- Assess the accuracy of site index estimates in the provincial site productivity layer (PSPL).
- Compare observed stand yields (e.g., basal area/ha and trees/ha) to predictions generated from TIPSY.
- Once re-measurements are available, compare observed growth to forecasts from growth and yield models for the young stand population.

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

> *"To check the accuracy of the GY 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, and species composition, and succession."*

The YSM program uses permanent sample plots in order to track the components of change (growth, mortality, ingress) over time.

3. Target Population

3.1 Merritt TSA

The Merritt TSA is located in south central BC and covers approximately 1.1 million ha (Figure 3.1). It is surrounded to the South by the United States and clockwise from the West by the Fraser, Lillooett, Kamloops, and Okanagan TSAs. Three biogeoclimatic zones, the Interior Dry Fir (IDF), Montane Spruce (MS) and Engelmann Spruce Subalpine Fir (ESSF) make up 98% of the TSA area. The Merritt TSA also includes a narrow band of Coast-Interior transition along its border with the Fraser TSA. The two main cities in the Merritt TSA are Merritt and Princeton.

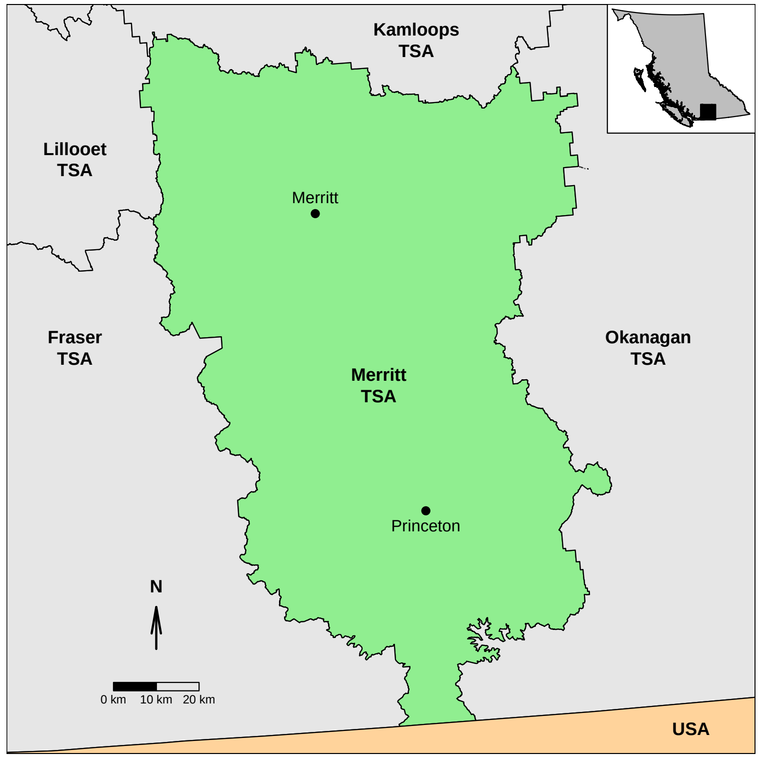

Figure 3.1: Location of the Merritt TSA in BC.

3.2 2013 Target Population

The target population for the entire project is all crown land within the Merritt TSA 15 years and older (Table 3.1) as defined by the VRI rank 1 layer. It is important to note that timber supply constraints are not considered when defining the target population. Of this target population, this report focuses on the young (15–50 years) stands. Of the total TSA area, 8% is in young stands 15–50 years old.

Table 3.1: Area netdown.

Land Class	Area (ha)	%
Total TSA	1,131,166	100%
Non-Crown Lands	211,456	19%
Non-Target Crown	206,218	18%
Target Population	*713,493*	*63%*
Young	*91,985*	*8%*
Mature	*621,508*	*55%*

Almost half (45%) of the young population is located within the MS biogeoclimatic zone (Table 3.2), with the remainder primarily in the IDF (29%) and ESSF (25%). Lodgepole pine (PL) is the dominate leading species at (69%) of the total target population, and is an even higher percentage (77%) of stands aged 15–30 years (Table 3.3). In contrast Pl is the leading species on 38% of the stands aged 31–50 years (Table 3.4). Other leading species include interior Douglas-fir (F) (12%), spruce (S) (12%) and balsam (B) (6%). Of the total young stand population area of 91,985 ha, 73,485 ha (80%) is in stands 15–30 years old, with the remainder (18,500 ha - 20%) in stands 31–50 years old.

Table 3.2: 2013 Young Stand Population Area by biogeoclimatic zone.

	15-30 yrs		31-50 yrs		Total	
Decade	(ha)	(%)	(ha)	(%)	(ha)	(%)
MS	35,472	48%	5,506	30%	40,978	45%
IDF	17,695	24%	9,189	50%	26,885	29%
ESSF	19,935	27%	3,439	19%	23,374	25%
CWH	333	0%	123	1%	456	0%
PP	49	0%	241	1%	290	0%
BG	1	0%	1	0%	2	0%
Total	*73,485*	*100%*	*18,500*	*100%*	*91,985*	*100%*

Table 3.3: 2013 Young Stand Population (15–30 years) by leading species and MFLNRO age class.

	MoF Age Class		Total	
Species	1	2	(ha)	%
PL	21,774	34,578	56,352	77%
S	2,269	6,626	8,895	12%
F	1,041	3,149	4,190	6%
B	996	2,293	3,290	4%
AT	61	306	367	1%
PY	143	173	316	0%
L	37	11	48	0%
PW	0	26	26	0%
Total (ha)	*26,322*	*47,163*	*73,485*	*100%*
(%)	*36%*	*64%*	*100%*	

3.3 2005 Target Population

The 2005 young stand target population was all vegetated treed (VT) polygons in the timber harvesting land base that were established on or after 1960 and at least 20 years old (J.S. Thrower & Associates Ltd., 2005). This population was a total of 16,594 ha. This prior definition was more restrictive than the new definition used in 2013. This combined with the accelerated rate of harvest resulting from the mountain pine beetle epidemic resulted in the target population area increasing to 91,985 ha in 2013.

Table 3.4: 2013 Young Stand Population (31-50 years) by leading species and MFLNRO age class.

	MoF Age Class		Total	
Species	2	3	(ha)	%
PL	5,859	1,220	7,078	38%
F	3,363	3,535	6,898	37%
S	1,530	334	1,864	10%
B	1,502	355	1,857	10%
AT	192	224	416	2%
PY	207	104	311	2%
H	54	1	55	0%
AC	1	9	11	0%
L	9	0	9	0%
E	0	1	1	
Total (ha)	*12,718*	*5,782*	*18,500*	*100%*
(%)	*69%*	*31%*	*100%*	*1%*

Thirty-seven plots were established on the original 2-km YSM grid in 2005, 2006 and 2007. With the much larger target population the decision was made to move to a 4-km grid that was a subset of the original 2-km grid (staying with the original 2-km grid would have resulted in over 200 sample points). Fifteen plots were retained and re-measured from the original 2-km grid. Of these 15, one plot (DMEM 18), is now in the mature (51 + years) population. The remaining 14 plots, for which there are change estimates, represent the 2005 target population.

4. Data Sources and Preparation

4.1 Species Labelling

The BC MoF uses different species naming standards with the different tools it manages. For example, the VRI compiler accepts FDC (coastal Douglas-fir) as a valid species while VDYP7 uses FD and the taper equation system will require the code F.

For most of the analyses completed for this project, the species codes used were standardized to the VDYP7 species code standard. There were two exceptions to this general rule. First, the leading species comparison was done using the 16 species codes used by the taper equation system. Second, because four species represent over 95% of the target population, the minor species were grouped under two labels: minor conifers and minor deciduous. Table A.1 in Appendix A shows the species codes used for this project.

4.2 Site Index - Provincial Site Productivity Layer

For the last 20 years, the MFLNRO has been working on developing relationships between site productivity and ecological classification and bio-physical features. The acquired knowledge has been collated into the Provincial Site Productivity Layer (PSPL), which provides site index estimates for 22 species across the entire province[1]. The PSPL is the inventory source for site index for which accuracy can be determined using the YSM ground data. The PSPL version used for this project was October 13 ver 3.1. This version includes an interim predictive ecosystem map for Merritt that had not yet passed standard accuracy assessment protocols, and therefore is subject to revision.

MFLNRO staff overlaid the Merritt ground sample data on the PSPL and provided us with the PSPL site index estimates available at each sampled point.

4.3 Phase I Inventory Data

The VRI Phase I data for recently harvested polygons comes from RESULTS (Reporting Silviculture Updates and Land status Tracking System). These polygons are projected using VDYP7 but attributes such as volume, trees per hectare and basal area are not generated until the stands are 7.5 m in height. This is due to the limitations of VDYP7 which was developed from a data set with minimal data for young stands. As a consequence, the Phase I inventory does not provide estimates for stands less than 7.5 m in height. For timber supply purposes, the young stands are modelled with TIPSY based on initial stand conditions from RESULTS.

4.4 Inventory Data Preparation

Three spatial layers were required to define and extract the VRI data for the target population.

1. The Merritt TSA boundary (obtained on July 22, 2014)
2. Land ownership (obtained on August 15, 2014)
3. The Merritt TSA VRI (obtained on August 19, 2014)

[1]The PSPL site index estimates are not always available for all species at all points.

The first two layers were downloaded from the BC Data Services website[2]. The VRI layer was obtained from the BC MFLNRO. All layers were projected in the BC Albers system, using the NAD83 datum.

The first two layers were overlaid in-house using GRASS 6.4svn (GRASS Development Team, 2010). This intermediate resultant was then provided to the BC MFLNRO who overlaid it with the VRI layer. The final resultant was used for the project.

The projected height and age of the second species was recorded as 0 in 99% of the cases where a second species was present. Since height and age of the second species was unavailable for all practical purposes, the common VRI Audit analysis of matching the leading ground species with either the leading or the second inventory species was not performed.

All VRI polygons were projected to January 1, 2013 to match with the year of ground sampling.

One objective of the ground sample data analysis is to evaluate the accuracy of the existing inventory data using the ground sample data as the benchmark for assessment. For the young stand analysis, species composition, height and age values are taken directly from the VRI rank 1 layer. Other inventory values including total stems per hectare, basal area, and merchantable volume are estimated using TIPSY with the following inputs:

- Inventory species composition
- PSPL site index
- A planting density of 1400 if VRI shows a harvest history and leading species is not BL or AT
- A natural density of 5000 if VRI shows no harvest history or leading species is BL or AT
- OAF1 = 0.85
- OAF2 = 0.95
- Inventory age

The values for stems per hectare, basal area, merchantable volume (12.5 cm +) and gross volume (TIPSY total volume dbh 0.0 +) are extracted at the inventory age of the leading species. The inventory variables used for the YSM analysis are listed in Table 4.1. A description of the volumes used in this projected is presented in Appendix B

4.5 Ground Sample Data

There are two sources (FAIB Programs) of ground sample data for young stands (Table 4.2).

1. Young stand plots established or re-measured in stands 15–50 years old.
2. Re-measured and newly established NFI plots in stands 15–50 years old.

[2] http://www.data.gov.bc.ca/dbc/geographic

Table 4.1: Inventory (Phase I) data variable list.

Attribute	Source	Variable
Leading Species	VRI	SPECIES_CD_1
Height-Ldg Spp	VRI	PROJ_HEIGHT_1
Age-Ldg Spp	VRI	PROJ_AGE_1
PSPL SI-Ldg Spp	PSPL SI Layer	SI_SPC#
TIPSY Basal Area	TIPSY	BASAL AREA 0.0+
TIPSY Stems/ha	TIPSY	TREE COUNT 0.0+
TIPSY Merch Volume	TIPSY	VOL. MERCH 12.5+
TIPSY Gross Volume	TIPSY	VOL. TOTAL 0.0+

Table 4.2: FAIB Merritt TSA ground sampling programs.

Program	Project Code	Project Description
Audit	DME1	VRI Phase II ground samples established in 1999 and 2000
NFI	CMI2	Monitoring plots established 2001 and 2003 on randomly chosen subset of NFI 20-km grid points
NFI	KAM1	Monitoring plots established 2013 on remaining NFI 20-km grid points
YSM	DME2	Original YSM plots established 2005 on 2-km grid that were dropped in 2013
YSM	DMEM	YSM plots on 4-km grid (subset of original 2-km grid) established or remeasured in 2013

4.5.1 YSM Plots

There are 57 plots established on a 4-km grid in the Merritt TSA. Two of these plots are actually located in stands 51 years old or greater leaving 55 for the young stand analysis[3].

4.5.2 NFI Plots

There are 15 NFI plots established on the 20-km NFI grid in the Merritt TSA. Of these 15, two are in stands 15–50 years old. These two plots were measured in 2013 and used for the young stand analysis.

4.5.3 Combined Data Set

The above two sources of data were combined (weighting is described below) and the variables used in the analysis are listed in Table 4.3. The sources listed for the variables refer to the output files from the MFLNRO ground data compilation. A summary of the numbers of ground plots (in the young and mature stands) is provided in Table 4.4. A complete listing of all 226 ground

[3]YSM Plot 18 was less than 50 years old when established, but greater than 50 when re-measured. The intended location for YSM plot 68 was in a young stand but due to poor Phase I linework the plot location is actually in a mature stand.

plots (mature and young) established in the Merritt TSA with relevant information is included in Appendix A of the mature stand report. The geographic distribution of the 55 YSM plots and the two NFI plots used for the young stand analysis is shown in Figure 4.1.

Table 4.3: YSM ground data variable list.

Attribute	Source	Variable	Utilization
Leading Species	SMY_NCS	SPECIES	4.0
Height	TREES_H	HEIGHT	7.5
Age	TREES_H	AGET_TOT	7.5
Site Index	TREES_H	SI_TREE	7.5
Basal Area	SMY_NC	BA_HA	4.0
Stems/ha	SMY_NC	STEMS_HA	4.0
Live Merch Volume	SMY_NC	NVL_NWB	12.5
Dead Merch Volume	SMY_NC	NVL_NWBD	12.5
Live Gross Volume	SMY_NC	GVL_WSV	4.0

Table 4.4: Summary of Merritt ground sample plots by program.

Program	Outside Target 2013	NVAF Sample	Not Measured 2013	Measured 2013 Mature	Measured 2013 Young	Total
Audit	26	29	20	50	0	160
NFI	6	0	0	13	2	27
YSM	3	0	20	2	55	80
Total	35	29	40	65	57	226

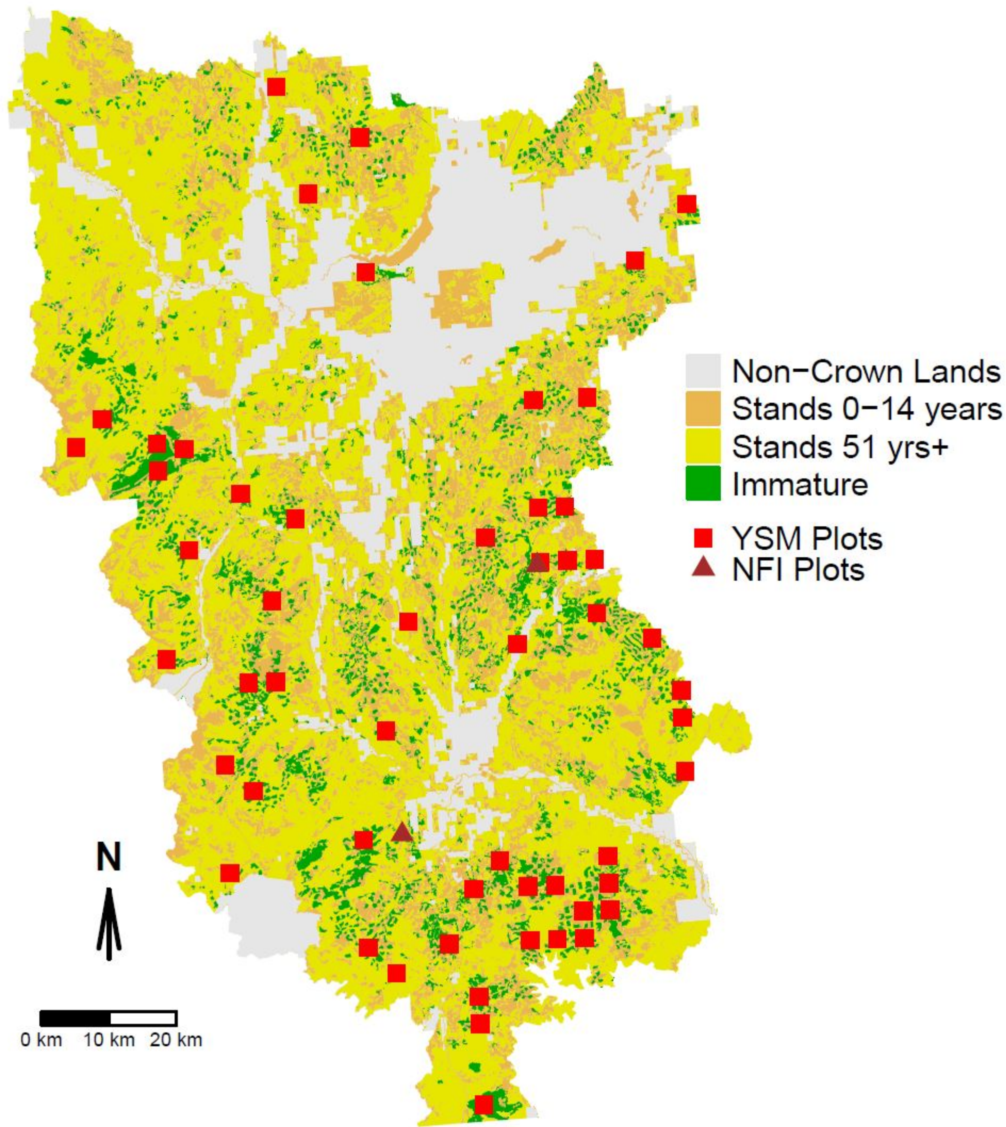

Figure 4.1: Geographic distribution of the YSM and NFI plots in the Merritt TSA young stand target population.

4.5.4 Weighting

Plots available for the young stand analysis come from two different sampling designs (YSM, NFI). Each individual design is a valid sample of the target population and we can weight the results from the two designs with what we refer to as "among-design" weights. The among-design weights are proportional to the number of plots in each sampling design (i.e., the number of plots in a sampling design divided by the total number of plots - 57) (Table 4.5).

For the YSM and NFI designs, each plot *within* these designs has the same weight. For the YSM program, based on a 4-km grid, each plot represents 1,600 ha. For the NFI program, based on a 20-km grid, each plot represents 40,000 ha (Appendix A).

Table 4.5: Among-design weights.

Program	No.Plots	Weight
NFI	2	0.0351
YSM	55	0.9649
Total	57	1.0000

4.6 Ground Data Preparation

The compiled ground sample data from the two sampling designs was provided by MFLNRO. Four YSM samples (32, 45, 47 and 79) were identified as edge plots (close enough to the edge for individual tree inclusion zones to overlap the adjacent stand). These plots were revisited by FAIB staff in September 2013 and the walkthrough method (Ducey and Valentine, 2004) was implemented. The data for these plots was then subsequently compiled accordingly. Sample maps and photos of the boundaries near the four edge plots are provided in Appendix D.

4.7 Ground Data Screening

4.7.1 Possible Multi-Cohort Stands

The plot data was screened for veteran or residual trees to identify potential multi-cohort stands. Three sources of information were used to do this:

1. The compiled ground plot age. If this was more than 25 years greater than the inventory age, the plot was flagged as a potential multi-cohort plot.

2. The variable ”residual” in the tree data. If a plot included a tree flagged as ”R” then it was flagged as a potential mult-cohort plot.

3. The variable ”treetype” in the tree data. If a plot included a tree flagged as ”V” then it was flagged as a potential multi-cohort plot.

This process resulted in 14 out of 57 plots (25%) being identified as potential multi-cohort plots (Table 4.6). A preliminary analysis by FAIB staff had identified 11 plots as possible multi-cohort plots. Our process captured these 11 plots plus an additional three. In all figures presented in the report these plots are identified with open blue triangles, while the remainder are identified with solid green circles. Note that the compiled ground ages are a function of the field crews call on trees acceptable for ages. Plot 74, for example, had no trees identified as residuals or veterans and the tree flagged as acceptable for age had an average age of 115. In contrast, plot 67 had a veteran tree identified, but this tree was not suitable for age. If there is no ground age recorded for a given plot, this means no acceptable age trees were identified by the field crew.

Table 4.6: Possible multi-cohort ground samples.

BEC ZONE	Project ID	Plot #	Inventory Age	Ground Age	Residual Identified	Veteran Identified
IDF	DMEM	74	21	115.0	No	No
IDF	KAM1	11	20	100.8	No	No
IDF	DMEM	55	19	94.5	No	No
IDF	DMEM	83	26	87.4	No	No
IDF	KAM1	19	15	84.0	No	No
IDF	DMEM	67	18	18.5	No	Yes
IDF	DMEM	81	32	NA	No	Yes
IDF	DMEM	70	17	NA	Yes	Yes
MS	DMEM	32	30	111.5	No	Yes
MS	DMEM	44	17	78.2	No	No
MS	DMEM	13	42	43.5	No	Yes
MS	DMEM	31	34	32.0	No	Yes
Other BEC	DMEM	58	25	33.0	No	Yes
Other BEC	DMEM	47	27	19.8	Yes	Yes

4.7.2 Zero Live Merchantable Volume

There are three different reasons why a ground plot could have zero merchantable volume (all references to merchantable volume in this report, for all species, is to a 12.5 cm dbh limit).

1. No trees at all in the plot resulting from the plot landing in a hole or void in the stand. These plots will only accrue merchantable volume over time if there is natural ingress.
2. All live trees in the plot are less than 12.5 cm dbh. Assuming the trees remain alive, these plots will have merchantable volume at future measurements.
3. All trees 12.5 cm dbh and greater are dead and no smaller trees on the plot. Any future merchantable volume is a function natural ingress over time.

There are a total of seven plots (12%) with zero merchantable volume (Table 4.7). None of the 57 plots landed in a complete void or hole in the stand. Six plots have zero merchantable volume but have 400– 2,827 stems per hectare between 4.0 and 12.4 cm dbh. All of the trees in plot 64 are dead. The dead trees in this plot range in dbh from 15.4–65.8 cm. Stand and stock tables of live merchantable volume by species and BEC zones are provided in the Merritt Ground Sample Data Analysis Stand and Stock Table report available from FAIB.

4.7.3 Standing Dead Merchantable Volume

Fourteen of the 57 plots (25%) had standing dead merchantable volume (Table 4.8) ranging from 2 - 100% of the total merchantable volume. Stand and stock tables of dead merchantable volume by species and BEC zones are provided in the Merritt Ground Sample Data Analysis Stand and Stock Table report available from FAIB.

Table 4.7: Ground plots with zero merchantable volume.

BEC Zone	Project ID	Plot #	Ground Age	Live Trees/ha 4.0-12.4 cm dbh	Dead Merch Volume
MS	DMEM	46	15	1,326	3
MS	DMEM	54	17	751	2
MS	DMEM	59	19	2,827	3
MS	DMEM	80	15	1,251	74
Other BEC	DMEM	60	NA	400	3
Other BEC	DMEM	62	16	2,802	3
MS	DMEM	64	NA	0	83

Table 4.8: Ground plots with standing dead merchantable volume.

BEC	Project	Plot	Ground	Merchantable Volume			Pct
Zone	ID	#	Age	Live	Dead	Total	Dead
IDF	DMEM	74	115	69	74	143	52%
IDF	DMEM	21	68	315	81	397	20%
IDF	KAM1	11	101	67	13	80	16%
IDF	DMEM	67	19	20	3	23	14%
IDF	DMEM	37	46	101	9	110	8%
MS	DMEM	46	15	0	3	3	100%
MS	DMEM	59	19	0	3	3	100%
MS	DMEM	64	NA	0	83	83	100%
MS	DMEM	12	38	129	23	152	15%
MS	DMEM	22	29	8	1	9	8%
MS	DMEM	13	44	42	2	44	5%
MS	DMEM	53	38	92	2	94	2%
Other BEC	DMEM	41	31	6	4	10	38%
Other BEC	DMEM	17	48	143	18	161	11%

5. Methods

5.1 Height, Age and Site Index Data Matching

Inventory (Phase I) estimates of heights and ages were only available for the inventory leading species. 53 of the 57 plots did not have an inventory height or age. Heights were estimated for the ground sample leading species if suitable measurements of height were available. In 51 of the 57 plots there were valid height measurements for the leading species. The end result was that height comparisons could be made for 48 plots. Ages were estimated for the ground sample if suitable age measurements were available. 53 of the 57 plots had age estimates. The end result was that comparisons could be made for 50 plots. The ratios calculated for height and age are simply the values for the ground leading species compared to the inventory leading species, with no attempt to match species.

Ground site indices were determined for all species within each plot that had valid height and age measurements. Inventory site indices were obtained from the PSPL. Matching by species was done wherever a ground and PSPL estimate was available.

5.2 Forest Health

Forest health results presented here are simple summaries of incidence (occurrence) by damage agent and tree species in terms of stems per hectare and basal area per hectare. Detailed information was also collected on damage severity. Reporting on severity was outside the scope, budget and time available for this report.

5.3 Post-Stratification of Ground Data

For the purposes of analysis and data summaries, the ground plot data was post-stratified three different ways:

- By BEC Zone (IDF, MS, and Other)
- By leading species (Fdi, Pl, Other)
- By age class (15–30 years, 31–50 years)

In addition, the stand and stock tables, and forest health information is summarized by species. Four major conifers are recognized (Pl, Fd, S, and Bl). All other minor conifers are summarized as "Con" for other minor conifers. In the young stand plots there were no minor conifers present, but the category "Con" is maintained for consistency with the mature stand analysis and the stand and stock table report as there were other minor conifers in the mature stand, as well as the young stand population. All deciduous species are summarized under the category "Dec".

5.4 Comparison of Ground to Inventory Values

One objective of the ground sample data analysis is to evaluate the accuracy of the existing Phase I inventory data using the ground sample data as the benchmark for assessment. For the young stand analysis, inventory site index, height and age values are taken directly from the VRI rank 1 layer. Other inventory values including total stems per hectare, basal area, and merchantable volume are estimated using TIPSY with the following inputs:

- Inventory species composition
- PSPL site index
- A planting density of 1400 if VRI shows a harvest history and leading species is not BL or AT
- A natural density of 5000 if VRI shows no harvest history or leading species is BL or AT
- OAF1 = 0.85
- OAF2 = 0.95

The values for stems per hectare, basal area, merchantable volume (12.5 cm dbh +) and gross volume (TIPSY total volume dbh 0.0 cm +) are extracted at the inventory age.

Ratios of ground averages to inventory averages (and associated confidence intervals) were determined for the following:

- Ground height (leading species) / Inventory height (leading species)
- Ground age (leading species) / Inventory age (leading species)
- Ground site index (matching species) / PSPL site index (matching species)
- Ground basal area (4.0 cm +)/ inventory basal area (from TIPSY 0.0 cm +)
- Ground trees per ha (4.0 cm +)/ inventory trees per ha (from TIPSY 0.0 cm +)
- Ground live merch vol per ha / inventory live merch vol per ha (from TIPSY 12.5 cm +)
- Ground gross vol per ha (4.0 cm +) / inventory gross vol per ha (from TIPSY total vol 0.0 cm +)

For each of the ratios listed above, three figures are provided. The first shows ground versus inventory with the 1:1 line (dashed line), the ratio line (solid line) and its associated 95% confidence interval (yellow area). The second is the residual (ground value - ratio adjusted inventory value) versus the ratio adjusted inventory value. The third is the ratio adjusted value versus the ground value, with the 1:1 line (dashed line). On each figure, the multi-cohort plots are represented by empty blue triangles; the remaining plots are represented by solid green circles.

5.5 Comparison of Ground to TIPSY Predictions

A second TIPSY run was completed for each sampled polygon with the following inputs:

- Ground species composition
- Ground site index
- A planting density of 1400 if VRI shows a harvest history and leading species is not BL or AT
- A natural density of 5000 if VRI shows no harvest history or leading species is BL or AT
- OAF1 = 0.85
- OAF2 = 0.95

Note that the differences in these TIPSY runs from the first set used to estimate inventory values are ground (plot) species composition and site index are used instead of inventory values. In order to extract the appropriate merchantable and gross volumes, an accompanying TIPSY run was completed with the same inputs as above, but just for the leading species. This allowed matching of the leading species ground top height to TIPSY top height to define an age at which to extract volumes.

TIPSY is used in TSR to project young stands. There are two potential sources of error (bias) in the projected volumes:

- Attribute bias - errors resulting from the wrong inputs being supplied to TIPSY (e.g., species composition, site index, trees/ha, assumptions regarding forest health).
- Model bias - errors resulting from the model itself, this is determined by inputing the ground sample data into the model.

For the purposes of determining the bias, the following variables are defined:

VOL A - Ground sample volume, this is assumed to be the true volume.

VOL B - TIPSY volume based on Phase I inventory attributes at the projected inventory age.

VOL C - TIPSY volume based on ground sample data where TIPSY and ground top heights match.

Total Bias = VOL A - VOL B

Attribute Bias = VOL C - VOL B

Model Bias = VOL A - VOL C

Two types of volume (merchantable and gross) are used for the analysis. Note that in this analysis the attribute bias is only a function of differences in site index and species composition. Other key possible sources of model projection error include incorrect input assumptions about forest health and residual trees.

5.6 Change Estimation

Fourteen plots were re-measured plots. These plots represent the original target population of stands between 20 and 45 years old in 2005 that were in the vegetated treed portion of the 2005 timber harvesting landbase.

Estimates provided by the VRI compiler at the 4.0+ utilization level were used when estimating plot-level change in all attributes in the immature population. The net change between the plot establishment and the 2013 measurement was estimated for seven variables:

1. Height;
2. Age;
3. Site index;
4. Basal area;
5. Trees/ha;
6. Merchantable volume, and
7. Gross volume

This was done by simply subtracting the first measurement values from the second measurement values.

For change components (ingrowth, mortality, and survivor growth), we compiled estimates ourselves using the tree-level data at the first and second measurements. Individual trees were assigned to one of seven categories:

- LL - trees alive at both measurements, the survivor trees
- LD - trees alive at time 1 and dead at time 2
- LX - trees alive at time 1 and missing at time 2, assumed to be dead
- XL - trees not present at time 1 and live at time 2, ingrowth trees
- XD - trees not present at time 1 and dead at time 2, ingrowth trees that died
- DD - trees dead standing at time 1 and time 2
- DX - trees dead standing at time 1 and missing at time 2

Trees between 4.0 and 9.0 cm dbh at time 1, that were tagged in the small tree plot, and then crossed the the main plot tagging limit of 9 cm before time 2 were assigned the tree factor based on the small tree plot. This was done to ensure that the selection probability of a tree remained constant over time and change component estimates are not confounded by a change in plot size.

6. Results

6.1 Stand Structure

The overall stand and stock tables for the young population are presented in Table 6.1 and Table 6.2. Additional detailed stand and stock tables are presented in the accompanying stand and stock table report available from FAIB.

Table 6.1: Stand table (trees/ha).

Species	DBH Class													
Group	5	10	15	20	25	30	35	40	45	50	55	60	65	67.5+	Total
B	126	63	23	6	3	0	0	0	0	0	0	0	0	0	221
Con	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec	60	34	7	4	4	1	1	0	0	0	0	0	0	0	111
F	95	47	29	21	7	4	1	3	0	0	0	0	0	0	207
PL	430	355	173	48	7	1	0	0	0	0	0	0	0	0	1,014
S	121	38	15	9	1	2	0	0	0	0	0	0	0	0	187
Total	832	537	248	89	22	7	2	3	0	0	0	0	0	0	1,740

Table 6.2: Stock table - merchantable volume 4.0 cm + (m^3/ha).

Species	DBH Class													
Group	5	10	15	20	25	30	35	40	45	50	55	60	65	67.5+	Total
B	0	0.3	1.0	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	2.3
Con	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0
Dec	0	0.1	0.5	0.7	1.0	0.4	0.5	0.0	0.0	0.0	0	0	0	0.0	3.2
F	0	0.1	1.3	3.2	2.1	1.3	0.6	2.5	0.9	0.6	0	0	0	1.1	13.8
PL	0	1.8	10.6	6.9	2.0	0.4	0.0	0.0	0.0	0.0	0	0	0	0.0	21.9
S	0	0.1	0.6	0.9	0.4	0.6	0.2	0.0	0.0	0.0	0	0	0	0.0	2.9
Total	0	2.5	14.0	12.3	6.0	2.7	1.3	2.5	0.9	0.6	0	0	0	1.1	44.0

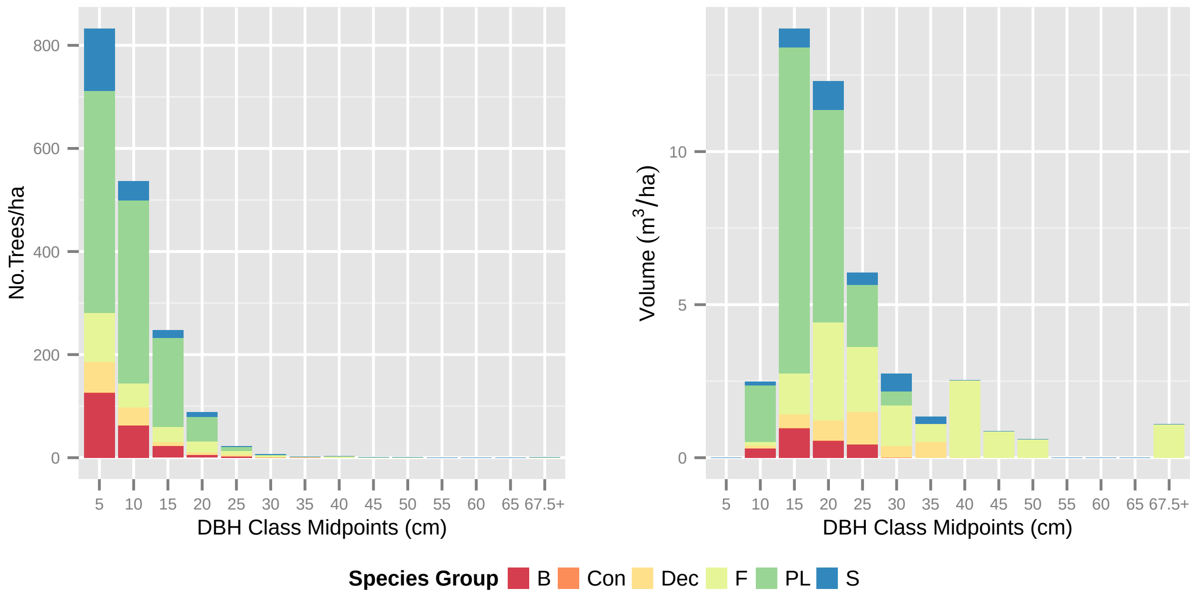

Figure 6.1: Stand and stock tables.

6.2 Health

There was a high incidence of forest health agents noted in the young population. Approximately 69% of the trees had some type of damage noted (Table 6.3, Figure 6.2). In terms of basal area, approximately 76% of the basal area had some type of damage noted (Table 6.4).

Table 6.3: Ground sample estimates of trees/ha with damage incidence.

Species Group	Abiotic	Animal	Disease	Insect	Treatment	Unknown	None	Total	None Pct
PL	29	45	543	126	1	68	201	1,014	19.9%
S	15	0	4	39	1	23	106	187	56.7%
F	15	2	10	66	1	32	81	207	39.0%
B	20	0	6	0	1	68	126	221	56.9%
Con	0	0	0	0	0	0	0	0	
Dec	17	3	6	16	2	48	20	111	17.8%
Total	96	50	568	247	6	239	534	1,740	30.7%

Table 6.4: Ground sample estimates of basal area (m^2/ha) with damage incidence.

Species Group	Abiotic	Animal	Disease	Insect	Treatment	Unknown	None	Total	None Pct
PL	0.3	0.5	5.0	1.1	0.0	0.7	0.9	8.6	10.8%
S	0.2	0.0	0.1	0.3	0.0	0.2	0.6	1.3	42.8%
F	0.6	0.2	0.2	0.4	0.0	0.5	1.3	3.1	40.6%
B	0.2	0.0	0.0	0.0	0.0	0.4	0.7	1.4	51.2%
Con	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Dec	0.1	0.0	0.0	0.1	0.0	0.5	0.1	1.0	13.4%
Total	1.4	0.8	5.3	2.0	0.1	2.3	3.6	15.5	23.5%

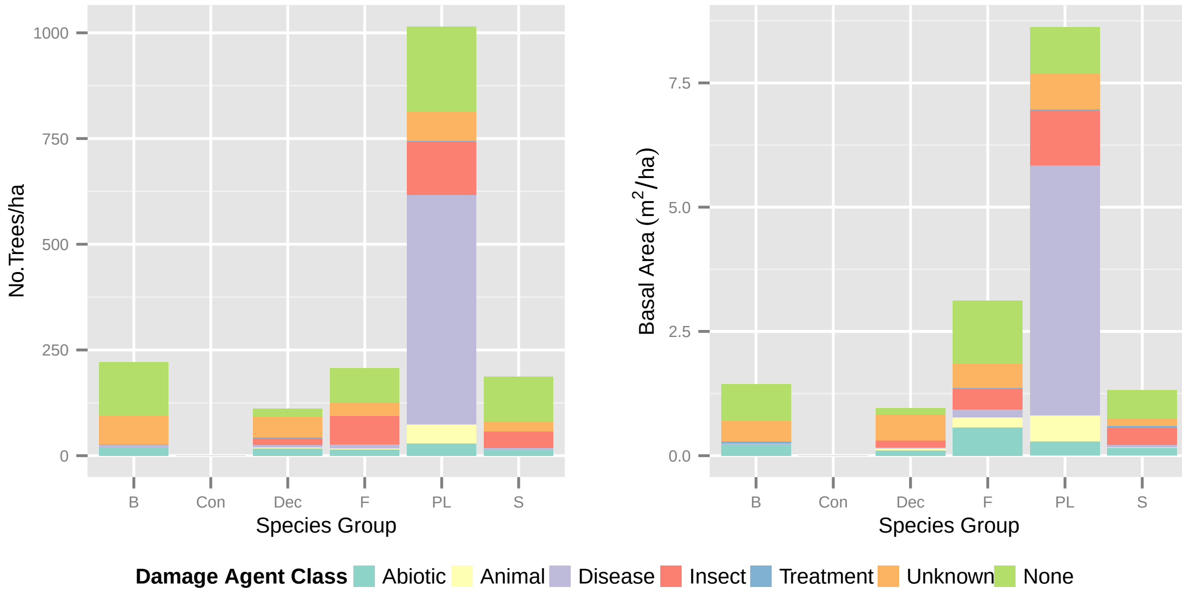

Figure 6.2: Damage agents by trees/ha and basal area.

6.3 Ground vs. Inventory Data

All inventory, ground and ratio values reported are the weighted averages from the two sample designs (YSM, NFI). The weighted ratio of means does not equal the ratio of the weighted ground and inventory averages; unless in a stratum that only has data from one of the sample designs.

6.3.1 Age

The overall ratio of ground to inventory age was 1.5 with the ground ages 11.8 years greater than the inventory ages (Table 6.5). The ratio reduces to 1.2, with a difference of 4.4 years when the multi-cohort plots are removed (Table 6.6). The largest differences between ground and inventory ages occur in the IDF and Fdi leading stands. There are six plots (Figure 6.3) with ages greater than 75 years. Note that open blue triangles in the figure are the plots flagged as multi-cohort. All sampling errors (E) and p values are at the 95% confidence leve.

Table 6.5: Inventory age (yrs) ratio statistics by strata.

Strata	n	Inventory	Ground	Ratio	Std. Err.	E	p	
IDF	12	25.7	59.8	2.454	0.741	1.652	0.039	***
MS	23	26.1	31.6	1.210	0.098	0.203	0.021	***
Other BEC	15	26.9	30.0	1.117	0.065	0.139	0.046	***
Fdi	7	34.8	52.0	1.673	0.327	0.840	0.047	***
Pl	37	24.3	34.2	1.448	0.165	0.334	0.005	***
Other Spp	6	28.2	44.2	1.571	0.341	0.877	0.078	
15-30 yrs	38	22.7	36.6	1.648	0.201	0.407	0.001	***
31-50 yrs	12	37.1	42.6	1.148	0.064	0.141	0.020	***
All	50	26.2	38.0	1.496	0.133	0.267	0.000	***

Table 6.6: Inventory age (yrs) ratio statistics by strata with multi-cohort plots removed.

Strata	n	Inventory	Ground	Ratio	Std. Err.	E	p	
IDF	6	30.8	39.3	1.276	0.088	0.227	0.013	***
MS	20	24.8	28.4	1.149	0.063	0.131	0.014	***
Other BEC	13	27.0	30.6	1.132	0.066	0.144	0.034	***
Fdi	5	35.6	46.4	1.303	0.075	0.207	0.008	***
Pl	30	24.5	27.5	1.123	0.047	0.097	0.007	***
Other Spp	4	29.5	36.3	1.229	0.136	0.431	0.095	
15-30 yrs	29	22.8	26.4	1.158	0.050	0.102	0.002	***
31-50 yrs	10	36.9	43.5	1.180	0.073	0.165	0.018	***
All	39	26.4	30.8	1.166	0.040	0.082	0.000	***

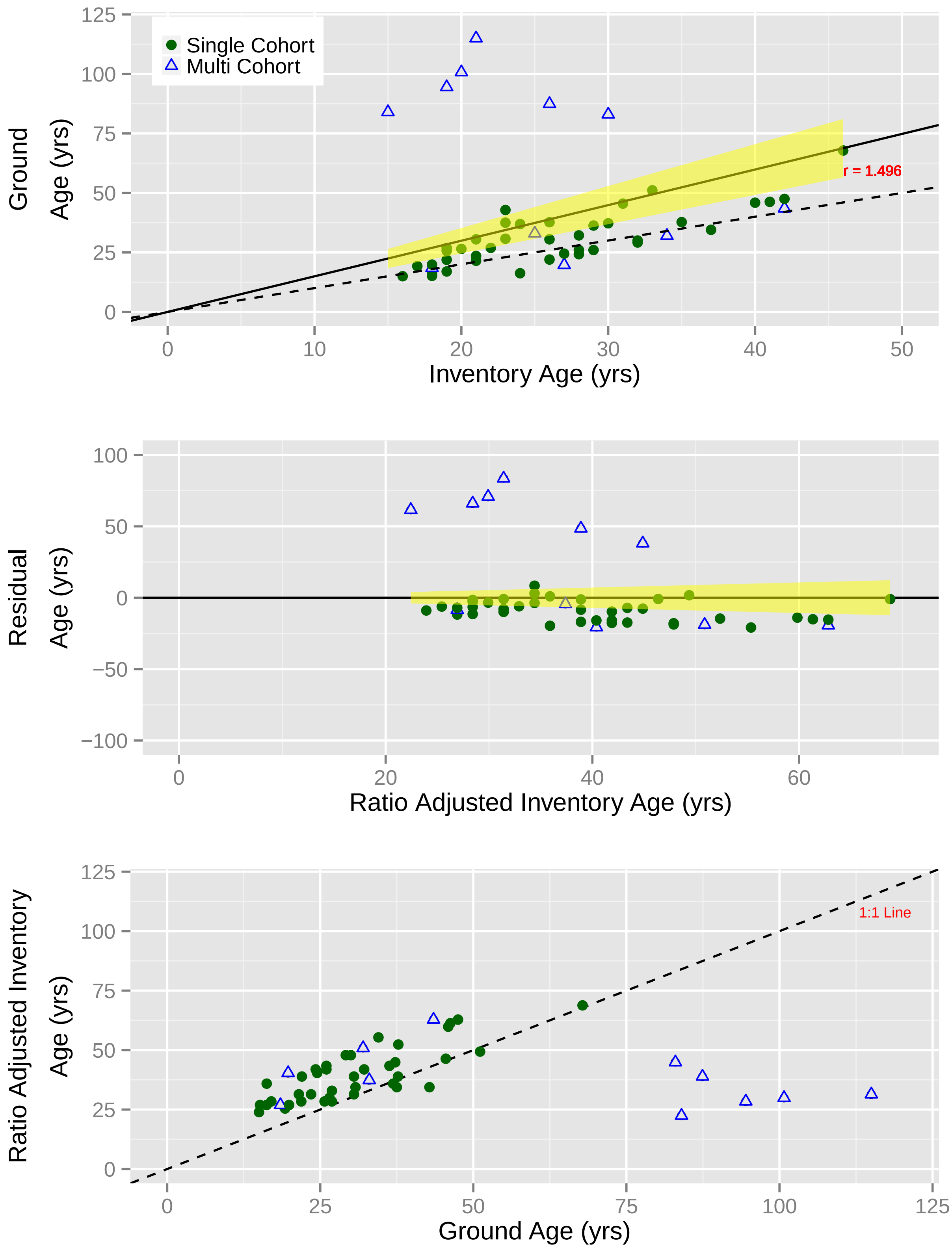

Figure 6.3: Ground versus inventory age in the young stand population.

6.3.2 Height

Overall, and for all strata, the ground heights are greater than the inventory heights. Ground to inventory ratios are significantly greater than one for the IDF and MS BEC zones, for Pl and Fdi leading, and for 15–30 years. The ratio is not significantly different from one for stands 31–50 years, nor the other BEC zones. The ratio of 1.5 for other species is not significant largely due to the small sample size. (Table 6.7, Figure 6.4). Removing the multi-cohort plots (Table 6.8) reduces the ratios and the differences between ground and inventory values, and makes the ratio for Fdi leading stands not significantly different from one.

Table 6.7: Inventory height (m) ratio statistics by strata.

Strata	n	Inventory	Ground	Ratio	Std. Err.	E	p	
IDF	11	8.5	14.5	1.775	0.313	0.708	0.018	***
MS	22	8.3	10.5	1.259	0.086	0.180	0.003	***
Other BEC	15	7.9	8.8	1.111	0.064	0.137	0.052	
Fdi	6	11.6	15.2	1.379	0.178	0.493	0.050	***
Pl	36	7.9	10.2	1.322	0.075	0.152	0.000	***
Other Spp	6	7.1	10.6	1.499	0.442	1.137	0.155	
15-30 yrs	37	6.7	9.8	1.480	0.105	0.213	0.000	***
31-50 yrs	11	13.1	14.2	1.085	0.082	0.184	0.164	
All	48	8.2	10.9	1.345	0.078	0.157	0.000	***

Table 6.8: Inventory height (m) ratio statistics by strata with multi-cohort plots removed.

Strata	n	Inventory	Ground	Ratio	Std. Err.	E	p	
IDF	6	10.8	13.9	1.293	0.105	0.270	0.019	***
MS	20	8.1	10.5	1.290	0.096	0.200	0.003	***
Other BEC	13	8.3	9.2	1.100	0.063	0.138	0.070	
Fdi	5	12.3	15.2	1.230	0.131	0.365	0.077	
Pl	30	7.9	9.9	1.255	0.068	0.139	0.000	***
Other Spp	4	9.0	9.5	1.054	0.064	0.205	0.231	
15-30 yrs	29	7.0	9.2	1.326	0.063	0.128	0.000	***
31-50 yrs	10	13.3	14.4	1.082	0.090	0.203	0.194	
All	39	8.6	10.6	1.229	0.054	0.110	0.000	***

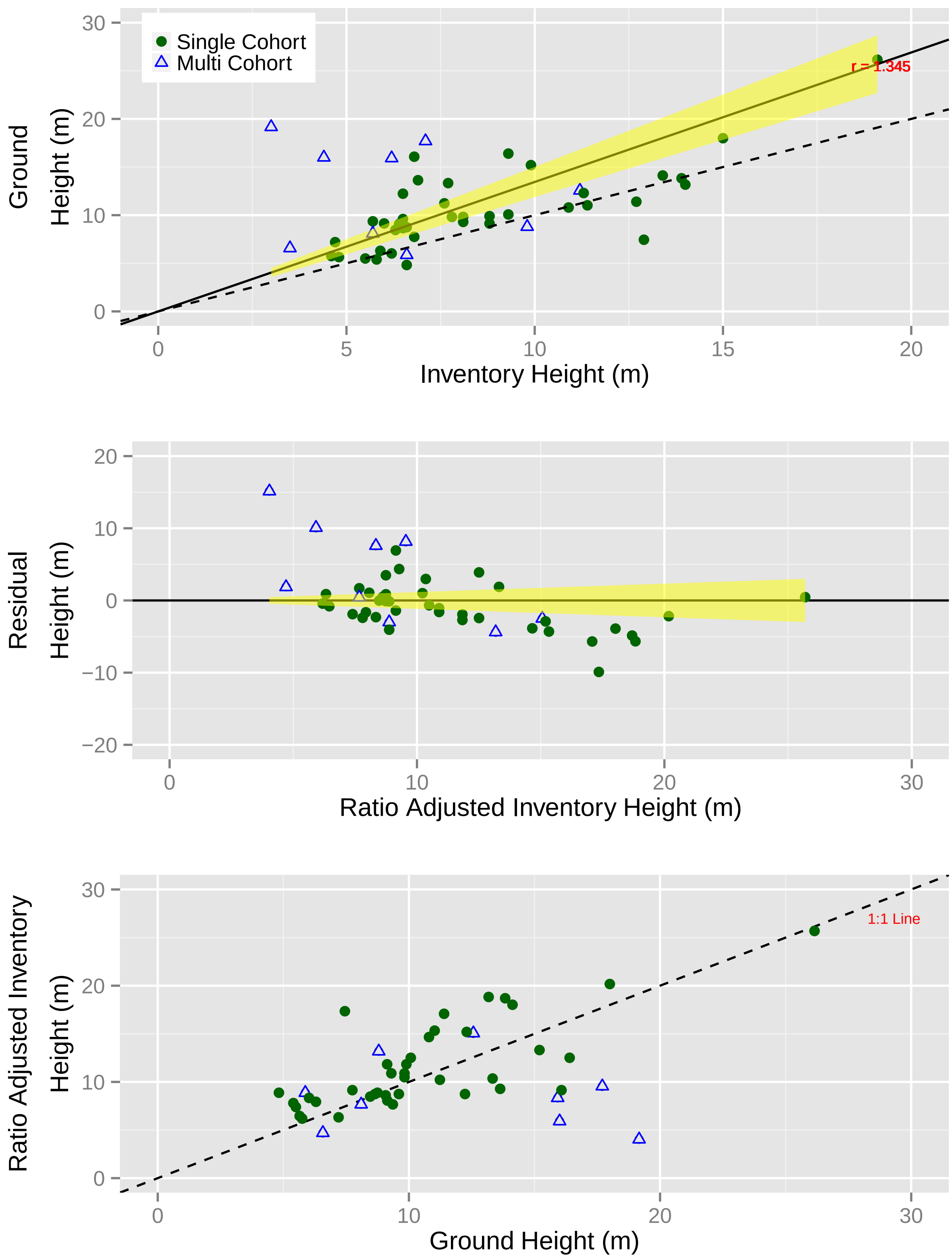

Figure 6.4: Ground versus inventory height in the young stand population.

6.3.3 PSPL Site Index

The ground plots show significantly higher Pl site indices than the provincial site productivity layer (Table 6.9), with the ground plots on average 0.8 m higher than the PSPL. The sample sizes for the other species limit the ability to detect differences.

Table 6.9: Provincial site productivity layer site index (m) ratio statistics by species.

Strata	n	PSPL	Ground	Ratio	Std. Err.	E	p	
B	7	16.3	14.9	0.914	0.112	0.274	0.764	
F	10	19.6	19.4	0.989	0.060	0.139	0.571	
PL	43	18.3	19.1	1.048	0.020	0.040	0.011	***
S	8	17.0	19.0	1.121	0.066	0.156	0.054	

6.3.4 Basal Area

The ground plots have significantly more basal area than inventory projections (TIPSY projections with inventory inputs) (Table 6.10), and this remains true when the multi-cohort plots are removed (Table 6.11).

Table 6.10: Basal area (m^2/ha) ratio statistics by strata.

Strata	n	Inventory	Ground	Ratio	Std. Err.	E	p	
IDF	16	9.2	15.3	2.016	0.727	1.558	0.092	
MS	25	9.9	15.1	1.532	0.287	0.593	0.038	***
Other BEC	16	8.5	16.2	1.903	0.350	0.747	0.011	***
Fdi	9	15.7	17.4	1.459	0.493	1.165	0.191	
Pl	41	8.4	15.6	1.951	0.284	0.575	0.001	***
Other Spp	7	6.4	12.4	1.926	0.868	2.124	0.164	
15-30 yrs	43	5.3	13.0	2.515	0.407	0.823	0.000	***
31-50 yrs	14	21.5	23.1	1.073	0.138	0.298	0.303	
All	57	9.3	15.5	1.760	0.222	0.445	0.001	***

Table 6.11: Basal area (m^2/ha) ratio statistics by strata with multi-cohort plots removed.

Strata	n	Inventory	Ground	Ratio	Std. Err.	E	p	
IDF	8	14.2	16.4	1.149	0.183	0.433	0.221	
MS	21	8.8	15.2	1.722	0.354	0.739	0.028	***
Other BEC	14	9.3	16.7	1.801	0.349	0.754	0.020	***
Fdi	7	15.4	17.2	1.113	0.176	0.430	0.271	
Pl	31	9.0	16.5	1.841	0.276	0.564	0.002	***
Other Spp	5	8.6	10.3	1.200	0.591	1.642	0.376	
15-30 yrs	32	5.8	13.0	2.249	0.336	0.686	0.000	***
31-50 yrs	11	22.2	24.3	1.097	0.157	0.349	0.276	
All	43	10.0	15.9	1.594	0.185	0.374	0.001	***

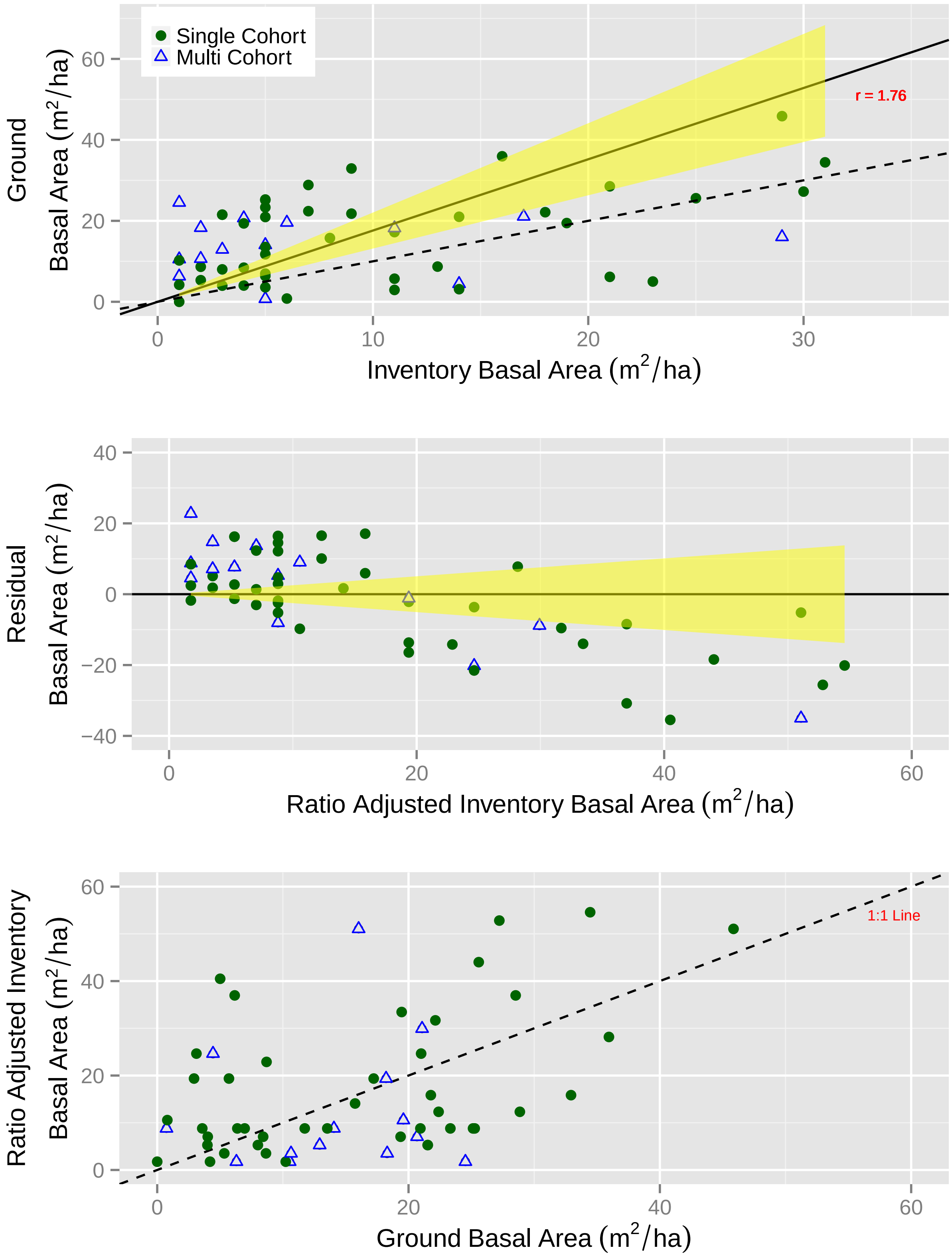

Figure 6.5: Ground versus inventory basal area in the young stand population.

6.3.5 Trees per Hectare

The ground plots have significantly more trees per hectare than the inventory projections (TIPSY projections with inventory inputs) (Table 6.12, Table 6.13). However, there are two plots where the inventory (TIPSY) projection is too high for stands assumed to be natural regenerated at 5000 stems per hectare (Figure 6.6). Recall the TIPSY density assumptions were 1400 planted or 5000 naturals. It appears these assumptions are too simplistic to describe many of the young stands. Some of the stands assumed to be planted at 1400 have in excess of 2000 trees indicating natural regeneration over and above planted trees.

Table 6.12: Trees/ha ratio statistics by strata.

Strata	n	Inventory	Ground	Ratio	Std. Err.	E	p	
IDF	16	1,253	1,107	0.883	0.212	0.454	0.705	
MS	25	1,081	1,879	1.738	0.248	0.512	0.003	***
Other BEC	16	1,348	2,156	1.600	0.320	0.681	0.040	***
Fdi	9	1,060	1,607	1.516	0.367	0.867	0.101	
Pl	41	1,115	1,862	1.670	0.165	0.334	0.000	***
Other Spp	7	1,911	1,197	0.626	0.277	0.677	0.887	
15-30 yrs	43	1,224	1,686	1.375	0.204	0.411	0.036	***
31-50 yrs	14	1,144	1,907	1.667	0.245	0.529	0.009	***
All	57	1,204	1,740	1.443	0.173	0.346	0.007	***

Table 6.13: Trees/ha ratio statistics by strata with multi-cohort plots removed.

Strata	n	Inventory	Ground	Ratio	Std. Err.	E	p	
IDF	8	1,057.2	1,419.5	1.343	0.187	0.441	0.055	
MS	21	1,084.2	1,920.4	1.771	0.287	0.598	0.007	***
Other BEC	14	1,183.8	2,142.5	1.810	0.315	0.680	0.012	***
Fdi	7	1,058.1	1,483.0	1.402	0.405	0.992	0.180	
Pl	31	1,124.6	2,114.4	1.880	0.198	0.405	0.000	***
Other Spp	5	1,105.6	1,150.8	1.041	0.540	1.500	0.472	
15-30 yrs	32	1,092.2	1,883.3	1.724	0.210	0.428	0.001	***
31-50 yrs	11	1,167.9	1,946.7	1.667	0.291	0.648	0.022	***
All	43	1,111.6	1,899.5	1.709	0.171	0.345	0.000	***

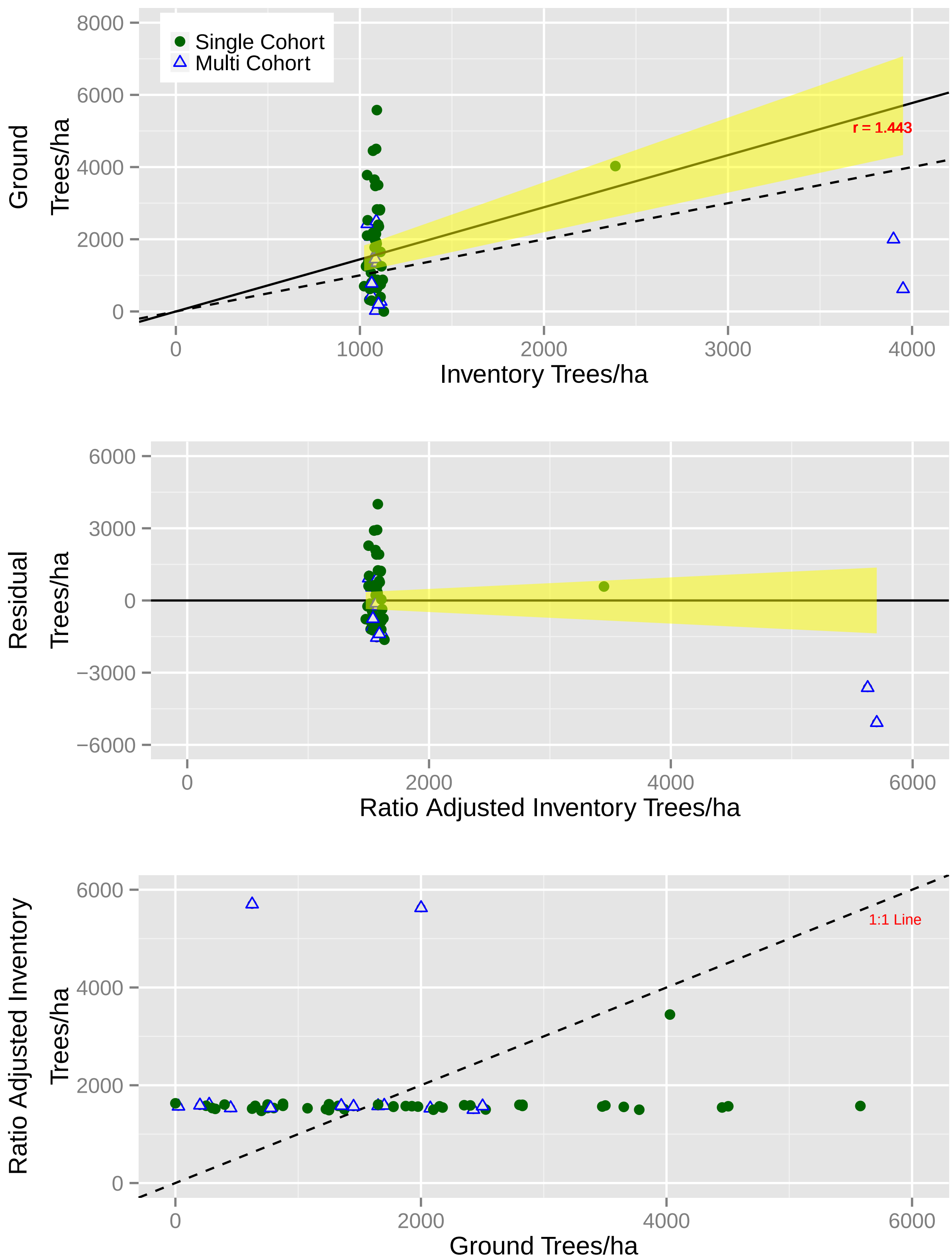

Figure 6.6: Ground versus inventory trees/ha in the young stand population.

6.3.6 Live Merchantable Volume

Live merchantable ground volumes are significantly greater than those projected by TIPSY (with inventory inputs) both with and without the multi-cohort plots removed (Table 6.14, Table 6.15, Figure 6.7). This will be partially due to the ground ages being older than the inventory ages, and therefore more trees above the merchantable limit of 12.5 cm dbh.

Table 6.14: Live merchantable volume (m^3/ha) ratio statistics by strata.

Strata	n	Inventory	Ground	Ratio	Std. Err.	E	p	
IDF	16	22.1	64.4	2.326	0.511	1.096	0.011	***
MS	25	23.9	37.1	1.552	0.479	0.989	0.131	
Other BEC	16	15.2	26.4	1.733	0.429	0.914	0.054	
Fdi	9	54.7	71.9	1.047	0.360	0.852	0.450	
Pl	41	15.4	36.0	2.249	0.504	1.019	0.009	***
Other Spp	7	10.6	37.1	3.512	2.684	6.566	0.193	
15-30 yrs	43	4.3	27.3	5.620	1.426	2.879	0.001	***
31-50 yrs	14	72.3	86.2	1.193	0.247	0.533	0.225	
All	57	21.0	41.8	1.849	0.320	0.642	0.005	***

Table 6.15: Live merchantable volume (m^3/ha) ratio statistics by strata with multi-cohort plots removed.

Strata	n	Inventory	Ground	Ratio	Std. Err.	E	p	
IDF	8	41.8	69.6	1.667	0.397	0.940	0.069	
MS	21	18.9	35.6	1.888	0.661	1.378	0.097	
Other BEC	14	17.4	28.5	1.643	0.410	0.885	0.070	
Fdi	7	51.3	76.8	1.498	0.414	1.013	0.137	
Pl	31	17.4	34.3	1.967	0.503	1.027	0.032	***
Other Spp	5	14.8	20.8	1.404	0.708	1.965	0.299	
15-30 yrs	32	4.8	21.5	4.463	1.411	2.877	0.010	***
31-50 yrs	11	74.5	92.4	1.241	0.255	0.569	0.184	
All	43	22.6	39.6	1.751	0.297	0.600	0.008	***

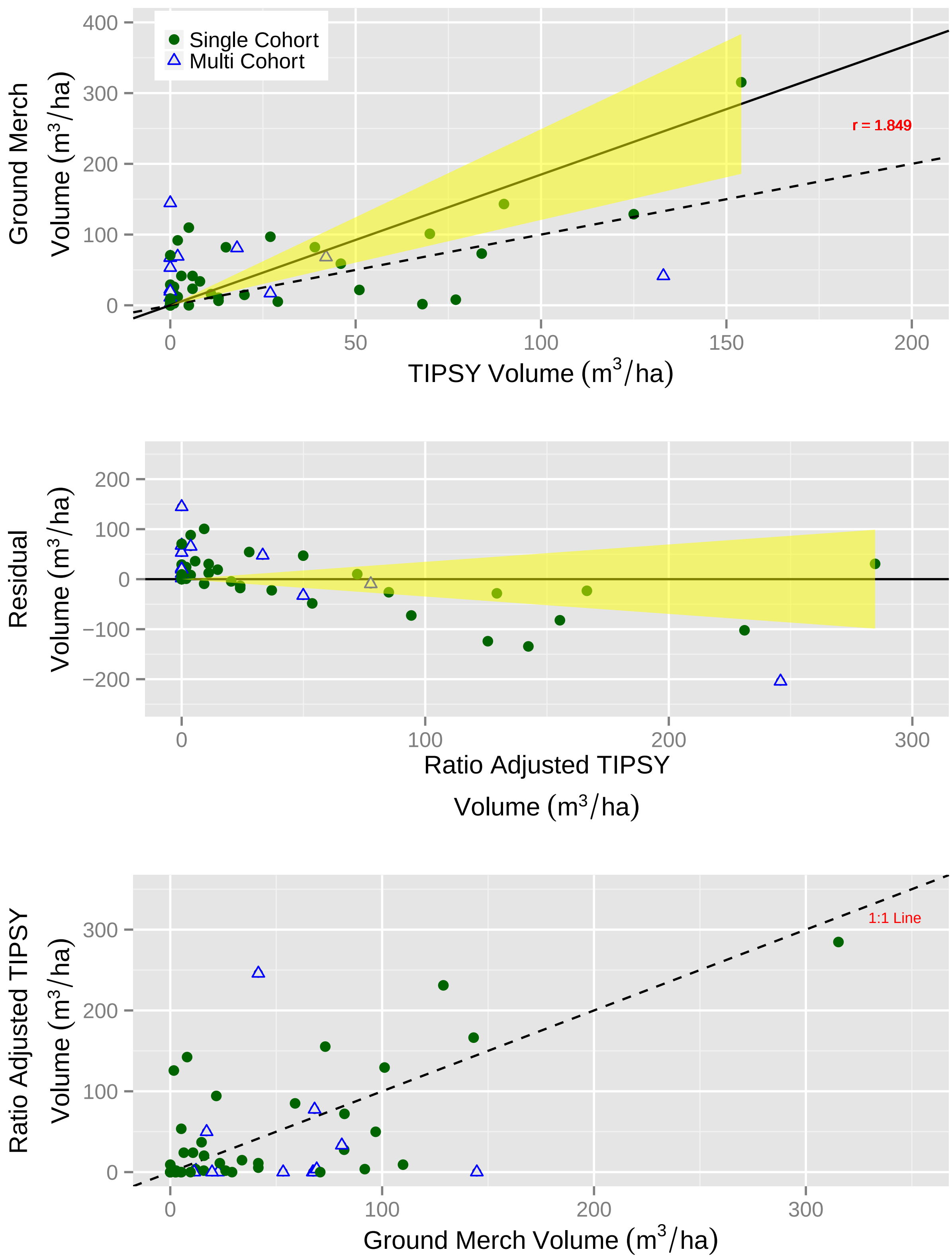

Figure 6.7: Ground versus TIPSY merchantable volume (inventory inputs) in the young stand population. Each point represents a ground plot. Blue triangles are possible multi-cohort, green dots are the remainder.

6.3.7 Live Gross Volume

Ground gross volumes are 1.8 (multi-cohort removed) to 2.1 (all plots) greater than TIPSY projected gross volumes (inventory inputs) (Table 6.16, Table 6.17, Figure 6.8)

Table 6.16: TIPSY gross volume (m^3/ha) ratio statistics by strata.

Strata	n	Inventory	Ground	Ratio	Std. Err.	E	p	
IDF	16	38.7	89.4	3.122	66.774	143.216	0.488	
MS	25	39.9	68.4	1.714	0.404	0.833	0.045	***
Other BEC	16	31.8	59.9	1.882	0.371	0.792	0.016	***
Fdi	9	78.0	100.6	2.139	49.192	116.322	0.491	
Pl	41	30.8	68.6	2.399	0.463	0.936	0.002	***
Other Spp	7	23.0	54.5	2.369	1.444	3.532	0.190	
15-30 yrs	43	16.1	55.1	3.594	0.874	1.766	0.002	***
31-50 yrs	14	102.3	123.5	1.207	0.194	0.420	0.153	
All	57	37.3	71.9	2.161	0.400	0.801	0.003	***

Table 6.17: TIPSY gross volume (m^3/ha) ratio statistics by strata with multi-cohort plots removed.

Strata	n	Inventory	Ground	Ratio	Std. Err.	E	p	
IDF	8	65.1	97.3	1.494	0.296	0.700	0.069	
MS	21	33.7	67.9	2.014	0.505	1.054	0.029	***
Other BEC	14	35.2	63.4	1.800	0.369	0.798	0.025	***
Fdi	7	74.6	103.6	1.389	0.301	0.736	0.122	
Pl	31	33.7	70.7	2.098	0.373	0.762	0.003	***
Other Spp	5	31.2	35.1	1.126	0.573	1.591	0.418	
15-30 yrs	32	17.6	51.3	2.909	0.516	1.052	0.000	***
31-50 yrs	11	105.3	131.9	1.253	0.200	0.445	0.117	
All	43	40.0	71.9	1.795	0.232	0.467	0.001	***

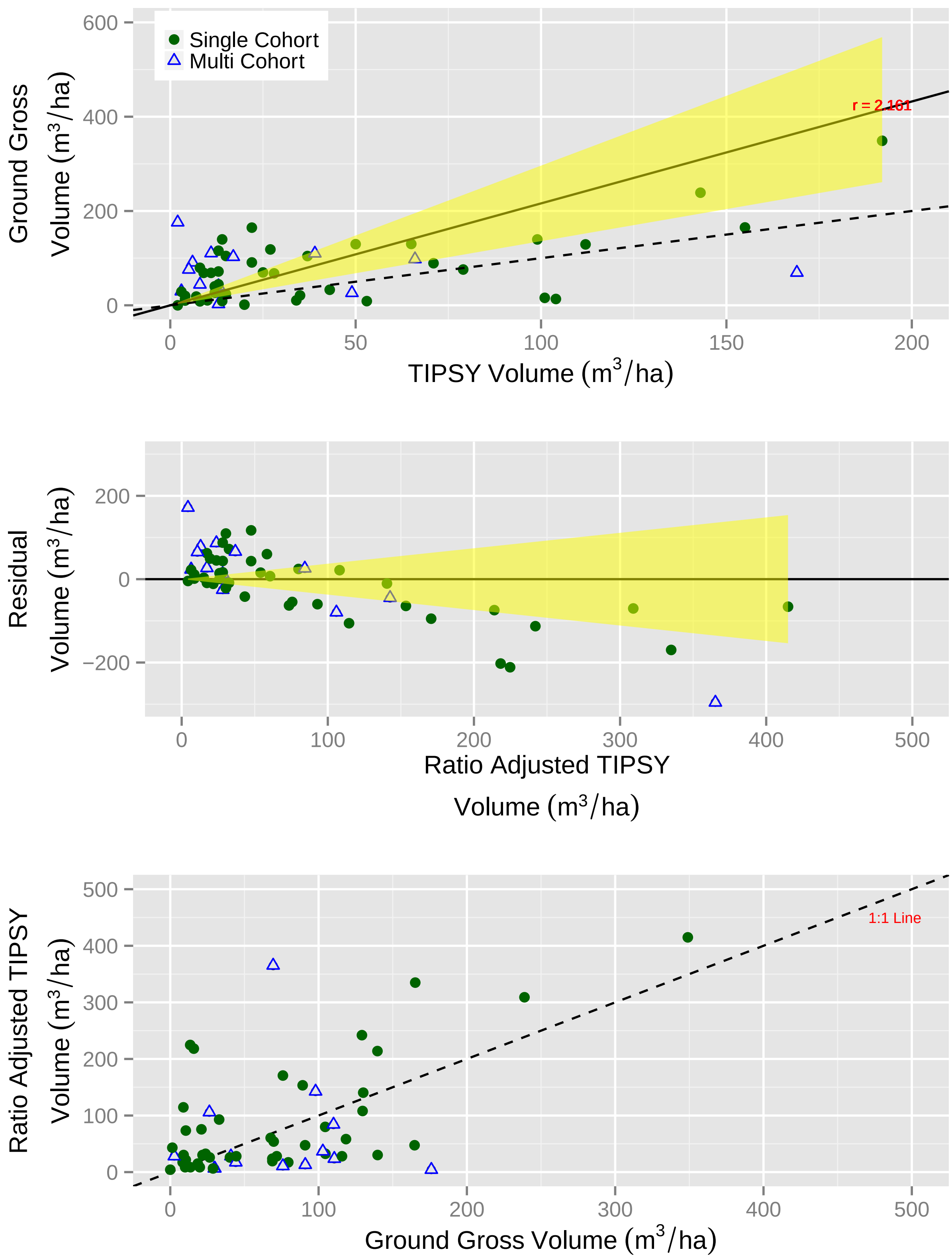

Figure 6.8: Ground versus TIPSY gross volume (inventory inputs) in the young stand population.

6.4 Volume Total, Model and Attribute Bias

The volume bias statistics for gross and merchantable volume based on all plots are summarized in Table 6.18. The same statistics with the multi-cohort plots removed are presented in Table 6.19. The total and attribute bias percentages appear high in part because the denominator for the percentage is small. TIPSY predicts the ground merchantable volumes well when provided with ground inputs, and slightly underestimates the total volumes when provided with ground inputs.

Table 6.18: Volume bias statistics.

Bias	Formula	n	Inventory Input Volume (B)	Ground Input Volume (C)	Ground Volume (A)	Bias	Bias %
			Merchantable Volume				
Total Bias	A - B	57	21.0		41.8	20.8	99.1%
Model Bias	A - C	57		41.8	41.8	0.0	-0.1%
Attribute Bias	C - B	57	21.0	41.8		20.8	99.2%
			Gross Volume				
Total Bias	A - B	57	37.3		71.9	34.6	92.8%
Model Bias	A - C	57		62.5	71.9	9.4	15.0%
Attribute Bias	C- B	57	37.3	62.5		25.2	67.6%

Table 6.19: Volume bias statistics with multi-cohort plots removed.

Bias	Formula	n	Inventory Input Volume (B)	Ground Input Volume (C)	Ground Volume (A)	Bias	Bias %
			Merchantable Volume				
Total Bias	A - B	43	22.6		39.6	17.0	75.1%
Model Bias	A - C	43		39.9	39.6	-0.3	-0.7%
Attribute Bias	C - B	43	22.6	39.9		17.3	76.3%
			Gross Volume				
Total Bias	A - B	43	40.0		71.9	31.8	79.5%
Model Bias	A - C	43		61.0	71.9	10.9	17.9%
Attribute Bias	C- B	43	40.0	61.0		20.9	52.2%

6.5 Leading Species

The species compositions of the 15–30 year old stands (Table 6.20) and 31–50 year old stands (Table 6.21) both show high overall matching between ground and inventory considering within polygon variability.

Table 6.20: Leading species confusion matrix – 15-30 yrs population.

Inventory	Ground Spp								
Spp	AT	B	F	PL	PY	S	Empty	Total	Match %
AT	1	0	0	0	0	0	0	1	100%
B	0	1	0	0	0	0	0	1	100%
F	0	0	1	1	0	0	1	3	33%
PL	2	2	4	26	0	0	0	34	76%
PY	0	0	0	0	0	0	0	0	
S	0	0	0	1	0	3	0	4	75%
Empty	0	0	0	0	0	0	0	0	
Total	3	3	5	28	0	3	1	43	
Match %	33%	33%	20%	93%		100%	0%		74%

Table 6.21: Leading species confusion matrix – 31-50 yrs population.

Inventory	Ground Spp								
Spp	AT	B	F	PL	PY	S	Empty	Total	Match %
AT	0	0	0	0	0	0	0	0	
B	0	0	0	0	0	0	0	0	
F	1	0	5	0	0	0	0	6	83%
PL	0	0	1	6	0	0	0	7	86%
PY	0	0	0	0	0	0	0	0	
S	0	1	0	0	0	0	0	1	0%
Empty	0	0	0	0	0	0	0	0	
Total	1	1	6	6	0	0	0	14	
Match %	0%	0%	83%	100%					79%

6.6 Change

Fourteen re-measured plots were used to estimate change. These plots represent stands between 20 and 45 years old in 2005 that were in the vegetated treed portion of the 2005 timber harvesting landbase.

6.6.1 Net Change

Net change (simple difference between time 2 and time 1) is reported on an annual basis in Table 6.22. Annual net change is reported as these plots were established in 2005, 2006, and 2007 making the re-measurement period 8, 7, or 6 years respectively. There was a significant net increase in basal area, stems, live (merchantable) volume and gross volume. There was no significant change in site index estimates.

Table 6.22: Net average annual change.

Attribute	Unit	Establish.	Re-Meas.	Annual Difference	Std. Err.	p	
Height	(m)	11.1	13.0	0.3	0.0	0.000	***
Age	(yrs)	34.4	43.8	1.4	0.7	0.026	***
Site Index	(m)	18.3	18.6	0.0	0.0	0.172	
Basal Area	(m^2/ha)	17.9	22.9	0.8	0.3	0.007	***
Stems/ha	(n)	1,745.8	1,956.7	30.6	14.5	0.027	***
Merch Volume	(m^3/ha)	60.7	80.6	3.0	1.2	0.013	***
Gross Volume	(m^3/ha)	92.3	118.9	4.0	1.6	0.013	***

6.6.2 Components of Change

The re-measurement of permanent plots allows the estimation of components of change (ingrowth, survivor growth and mortality). These are presented for stems per hectare, merchantable volume and gross volume in Table 6.23, Table 6.24, and Table 6.25. All values are for a 4.0 cm dbh limit, including merchantable volume. The ingrowth in stems per hectare provides an estimate of the number of trees annually crossing the 4.0 cm dbh tagging limit. The individual plots showing a net decline are those where mortality exceeds ingrowth plus survivor growth. With only 14 plots, the high mortality rate in plot 21 has a significant influence on the overall averages.

Table 6.23: Component changes in stems per hectare.

Plot	Time 1	Measurement Period	Annual Ingrowth	Annual Mortality	Time 2
7	3,652	7	222	0	5,203
12	1,351	8	22	9	1,451
13	1,951	8	91	3	2,652
17	4,003	6	42	25	4,103
20	3,127	6	96	0	3,702
21	1,376	8	0	84	700
22	225	8	16	3	325
25	3,778	6	29	17	3,853
28	1,151	8	9	0	1,226
31	1,151	7	143	0	2,151
32	325	6	38	4	525
33	725	8	75	3	1,301
34	425	7	57	0	826
37	1,201	6	8	0	1,251
Means	1,851		60	12	2,187

Table 6.24: Component changes in merchantable volume per hectare.

Plot	Time 1	Measurement Period	Annual Ingrowth	Annual Mortality	Annual Survivor Growth	Time 2
7	5.0	7	1.4	0.0	5.1	50.8
12	90.9	8	0.1	2.0	7.2	133.2
13	57.2	8	0.0	3.0	1.1	42.0
17	99.7	6	0.0	0.1	8.6	150.8
20	46.7	6	0.0	0.0	6.6	86.3
21	384.3	8	0.0	13.6	5.1	315.9
22	2.0	8	0.1	0.0	0.7	8.6
25	16.9	6	0.0	0.0	1.2	24.5
28	39.3	8	0.5	0.0	7.1	100.1
31	33.4	7	0.1	0.0	5.2	70.6
32	11.5	6	0.1	0.0	1.1	18.3
33	18.2	8	1.1	0.0	4.5	62.9
34	2.8	7	0.2	0.0	1.2	12.2
37	73.4	6	0.5	0.0	4.4	102.4
Means	81.3		0.3	1.8	4.5	102.0

Table 6.25: Component changes in gross volume per hectare.

Plot	Time 1	Measurement Period	Annual Ingrowth	Annual Mortality	Annual Survivor Growth	Time 2
7	31.6	7	5.4	0.0	10.7	144.1
12	119.1	8	0.4	2.3	7.9	167.4
13	85.5	8	0.5	3.5	1.5	73.6
17	178.7	6	0.7	0.5	10.2	240.7
20	78.9	6	0.7	0.0	8.6	134.9
21	442.1	8	0.0	16.9	5.2	349.0
22	5.2	8	0.4	0.1	0.8	13.4
25	65.0	6	0.5	0.1	1.7	77.6
28	69.1	8	0.8	0.0	7.6	136.3
31	50.4	7	1.3	0.0	6.0	101.0
32	16.2	6	0.8	0.1	1.6	29.5
33	32.4	8	2.6	0.1	4.9	92.4
34	8.5	7	0.6	0.0	1.6	23.8
37	109.0	6	0.7	0.0	4.4	139.7
Means	114.0		1.1	2.2	5.5	144.0

7. Summary

Ground age, height, stems per hectare, basal area, merchantable volume and gross volume were all significantly greater than corresponding inventory attributes. Interpreting these differences is confounded by the presence of the following in the young stands:

1. Veteran trees
2. Residual trees
3. Natural ingress (not accounted for in TIPSY planted only projections)
4. Dead volume (resulting from mountain pine beetle and other damage agents)
5. Forest health incidence

Net change in the key attributes was also significant for the 14 re-measured plots. TIPSY projections of merchantable volume were very close to ground measures of merchantable volume when ground inputs where used to initiate TIPSY and ground top height was used as the reference point to extract projected volumes from TIPSY. However the attribute bias (projection error due to incorrect inputs) was high when inventory inputs were used. This is not surprising given the significant differences between ground and inventory site index for PL, and the significant differences in age (inventory less than ground). Extracting TIPSY projections of volume at the inventory age results in low predicted volumes as the stands are on average older than the inventory ages suggest.

7.1 Recommendations

The following recommendations are made to improve both the information for the Merritt TSA and the overall YSM process.

1. Investigate the sensitivity of the Merritt AAC determination to young stand projections. Dependent on the outcome, investment may be required to upgrade the young stand inventory to provide the requiste stand attributes to project the development of these stands. Furthermore, if the AAC determination is sensitive to young stand projections, it is possible that custom TASS runs (as opposed to TIPSY runs) will be required to deal with variable stand structures.
2. Complete an indepth analysis of the Merritt forest health severity data with input from regional forest health experts and FAIB growth and yield experts. The high incidence of forest health agents in the young stand population makes understanding the potential impacts of this incidence a high priority.
3. Develop a separate or new component for the FAIB compiler that will handle change estimation, including additional error checking for shrinking and excessive individual tree growth between measurements. The change estimation procedures must address current changes in per hectare factors applied to individual trees when they cross tagging thresholds. Individual trees could be coded in a manner similar to that used in this analysis to allow for the estimation of components of change (ingrowth, mortality and survivor growth).

4. When a higher sample size of plots are re-measured compare change estimates to change predicted by TIPSY (or TASS).
5. Review YSM forest health severity coding to ensure compatibility with estimating change in forest health severity over time.
6. Develop a separate or new component for the FAIB compiler that will process and summarize the forest health incidence and severity data. Ensure that this is compatible with the change estimation.
7. Ensure that photos are taken at all YSM plots at each measurement.

References

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A. Species Labelling Convention

Table A.1: Species labelling convention.

VRI	VDYP	TIPSY	Phase II	Sp0	Spp Group
ACT	AC	SW	AC	AC	Dec
AC	AC	SW	AC	AC	Dec
AT	AT	SW	AT	AT	Dec
AX	AX	N/A	N/A	N/A	Dec
B	B	BL	B	B	B
BA	BA	BL	BA	B	B
BG	BG	BL	N/A	N/A	B
BL	BL	BL	BL	B	B
CW	CW	CW	CW	C	Con
D	D	N/A	N/A	N/A	Dec
E	E	SW	N/A	N/A	Dec
EP	EP	SW	EP	E	Dec
FDC	FD	FD	FD	F	F
FDI	FD	FD	FD	F	F
FD	FD	FD	FD	F	F
H	H	HWI	N/A	N/A	Con
HM	HM	HWI	N/A	N/A	Con
HW	HW	HWI	HW	H	Con
L	L	LW	N/A	N/A	Con
LA	LA	LW	N/A	N/A	Con
LT	LT	LW	N/A	N/A	Con
LW	LW	LW	N/A	N/A	Con
PA	PA	PL	PA	PA	Con
PLI	PL	PL	PL	PL	PL
PL	PL	PL	PL	PL	PL
PW	PW	PW	PW	PW	Con
PY	PY	PY	PY	PY	Con
SX	SX	SW	SX	S	S
S	SX	SW	SX	S	S
SE	SX	SW	SX	S	S
SW	SX	SW	SX	S	S
SXL	SXL	N/A	N/A	N/A	S
XH	XH	SW	N/A	N/A	Dec
YC	YC	CW	YC	Y	Con
N/A	P	SW	P	PL	Con
N/A	XC	SW	XC	F	Con
N/A	JR	SW	JR	C	Con
N/A	J	SW	J	C	Con
N/A	DR	SW	DR	D	Dec

B. Volume Definitions

There are several, often confusing, differences between volume definitions used in timber cruising, inventory and growth and yield. The volumes analysed in this project are described below.

B.1 Gross Volume

In the VRI gross volume is defined as the whole stem inside bark volume including the top and the stump. This is generated for both standing live and standing dead trees. In contrast, TIPSY gross volume is the total cummulative production based on the inside bark volume of all living, dead and thinned trees including tops and stumps. The TIPSY equivalent to VRI live gross volume is total volume which is the inside bark volume of all living trees, including tops and stumps.

For this project the ground (plot) gross volume was the VRI compiled volume ”gvl_wsv” which is gross live whole stem volume multiplied by a gross volume adjustment factor (GVAF) to adjust for taper. The VRI compiler produces summaries for dbh limits of 4.0, 12.5, 17.5 and 22.5 cm. We used gvl_wsv at the 4.0 cm limit. The TIPSY value used to compare to this was total volume at a 0.0 limit. This therefore includes volume of trees 0.1 - 3.99 cm dbh that the ground volume does not, but we assumed the volume in these small trees was negible.

B.2 Merchantable Volume

In the VRI gross merchantable volume is whole stem volume less the top (10 cm top diameter inside bark) and the stump (30 cm stump height). Net merchanatable is gross merchantable volume less decay, waste and breakage. Both are reported out at dbh limits of 4.0, 12.5, 17.5 and 22.5 cm. Without the application of OAFs, TIPSY merchantable volume is equivalent to VRI gross merchantable. It is total standing volume less 30 cm stumps and 10 cm tops for trees above a specified dbh limit. TIPSY OAF 2 (or custom decay, waste and breakage factors) are applied to produce net merchantable volume.

For this project the ground (plot) merchantable volume was the VRI compiled volume ”nvl_nwb” which is net merchantable volume, or more specifically whole stem volume less cruiser called decay, volume of waste, top and stump multiplied by a net volume adjustment factor (NVAF) by strata. We used nvl_nwb at the 12.5 cm limit. The TIPSY value used to compare to this was merchantable volume at a 12.5 limit with OAF 2 = 5%.

B.3 Volume Change Estimates

Estimates of change in gross and merchantable volume for the ground plots were both done at 4.0 cm limit.

C. Inventory and Ground Data Sets

Table C.1: Ground plot locations and within-pass weights.

Proj_ID	Samp_No	UTM Zone	UTM Easting	UTM Northing	Feature_ID	BEC	Sampling Weight
DMEM	0007	10	710003	5500999	9175920	ESSF	1,600
DMEM	0012	10	638002	5529000	9406673	MS	1,600
DMEM	0013	10	638002	5532999	2584037	MS	1,600
DMEM	0017	10	645998	5468999	2520251	ESSF	1,600
DMEM	0020	10	649999	5496994	2551151	ESSF	1,600
DMEM	0021	10	650004	5525004	6395205	IDF	1,600
DMEM	0022	10	654001	5509005	9048432	MS	1,600
DMEM	0025	10	670003	5557000	2604558	PP	1,600
DMEM	0028	10	685995	5517007	9168920	MS	1,600
DMEM	0031	10	694009	5464996	9185432	MS	1,600
DMEM	0032	10	694008	5521002	9418083	MS	1,600
DMEM	0033	10	697993	5521000	9459384	MS	1,600
DMEM	0034	10	702004	5461005	9419614	MS	1,600
DMEM	0037	10	710000	5557000	2606073	IDF	1,600
DMEM	0041	10	682000	5432998	2486846	ESSF	1,600
DMEM	0042	10	681999	5444995	9422034	MS	1,600
DMEM	0043	10	682004	5449000	5845865	MS	1,600
DMEM	0044	10	669997	5452997	5862010	MS	1,600
DMEM	0045	10	666003	5457006	6368170	ESSF	1,600
DMEM	0046	10	678004	5457000	9123813	MS	1,600
DMEM	0047	10	690002	5456998	2512341	ESSF	1,600
DMEM	0048	10	694002	5457001	9177028	MS	1,600
DMEM	0049	10	698000	5456999	9422673	MS	1,600
DMEM	0051	10	698000	5460997	9165034	MS	1,600
DMEM	0052	10	682001	5465000	7706565	IDF	1,600
DMEM	0053	10	689999	5464997	6126172	MS	1,600
DMEM	0054	10	702002	5464999	9147529	MS	1,600
DMEM	0055	10	686002	5469007	5862087	IDF	1,600
DMEM	0056	10	702001	5469001	9169040	IDF	1,600
DMEM	0057	10	666003	5473001	2520929	ESSF	1,600
DMEM	0058	10	650001	5480997	6158588	ESSF	1,600
DMEM	0059	10	713999	5481005	6383891	MS	1,600
DMEM	0060	10	646001	5485000	2540907	ESSF	1,600
DMEM	0061	10	670000	5488996	6341519	IDF	1,600
DMEM	0062	10	714000	5488992	2544191	ESSF	1,600
DMEM	0063	10	713998	5492999	2544576	ESSF	1,600
DMEM	0064	10	654004	5497001	9411244	MS	1,600
DMEM	0065	10	638003	5501000	2550472	CWH	1,600
DMEM	0066	10	690002	5501002	9130294	IDF	1,600
DMEM	0067	10	673999	5504997	9141452	IDF	1,600

Continued on next page...

		UTM					Sampling
Proj_ID	Samp_No	Zone	Easting	Northing	Feature_ID	BEC	Weight
DMEM	0069	10	702000	5505002	2554105	MS	1,600
DMEM	0070	10	694004	5513004	6294358	IDF	1,600
DMEM	0071	10	698003	5513002	9138278	IDF	1,600
DMEM	0072	10	701998	5513002	2565337	MS	1,600
DMEM	0073	10	642001	5516998	2560939	ESSF	1,600
DMEM	0074	10	658006	5521008	2573940	IDF	1,600
DMEM	0075	10	626000	5533003	2583053	ESSF	1,600
DMEM	0076	10	642002	5532000	2584455	IDF	1,600
DMEM	0077	10	630002	5537001	2584055	ESSF	1,600
DMEM	0078	10	694002	5536996	7721370	MS	1,600
DMEM	0079	10	701999	5536998	2587866	MS	1,600
DMEM	0080	10	718004	5565001	7661190	MS	1,600
DMEM	0081	10	661998	5569001	9184507	IDF	1,600
DMEM	0082	10	670005	5576996	7725123	MS	1,600
DMEM	0083	10	658001	5584998	2619462	IDF	1,600
KAM1	0011	10	671719	5473547	5853294	IDF	40,000
KAM1	0019	10	693459	5512534	6294449	IDF	40,000

Table C.2: Phase I inventory data.

Feature_ID	Leading Spp	Leading Height (m)	Leading Age (yrs)	Leading SI (m)	Leading SI (m)	Lorey Height (m)	Basal Area (m^2/ha)	Stems/ Ha (n)	Volume Live (m^3/ha)	Volume Dead (m^3/ha)	Volume Phase II Input (m^3/ha)
9175920	PL	8.1	28	16.0	15.6	7.8	9	1,071	1.6	0.0	179.3
9406673	PL	15.0	35	19.0	21.8	11.4	30	1,046	26.4	0.4	226.9
2584037	FD	17.7	42	20.0	22.3	13.1	29	1,040	63.0	0.3	0.0
2520251	PL	13.9	42	16.0	19.6	11.4	29	2,388	20.6	0.2	229.3
2551151	SX	11.4	33	19.0	19.9	7.8	16	1,084	1.2	0.0	136.3
6395205	FD	19.1	46	14.0	22.1	9.8	31	1,023	27.2	0.0	311.7
9048432	PL	12.9	32	16.0	20.7	9.1	23	1,051	5.4	0.0	47.0
2604558	FD	12.7	40	17.0		10.7	18	1,039	26.9	3.5	70.7
9168920	PL	9.9	29	16.0	18.0	8.3	14	1,060	2.9	0.0	151.0
9185432	PL	11.2	34	16.0	17.9	9.5	17	1,059	7.7	0.7	118.6
9418083	PL	9.8	30	21.0	17.6	11.5	14	1,063	18.1	0.9	180.7
9459384	PL	11.3	32	19.0	18.1	10.7	19	1,048	12.5	0.0	115.2
9419614	SX	7.8	30	15.0	17.3		5	1,113	0.0	0.0	49.6
2606073	FD	14.0	41	19.8	18.2	12.2	21	1,033	47.0	0.0	122.2
2486846	PL	8.8	26	16.0	17.5	7.2	11	1,063	1.0	0.0	44.0
9422034	PL	6.9	23	16.0	18.7		5	1,099	0.0	0.0	124.3
5845865	PL	13.4	37	20.0	18.9	12.8	25	1,042	33.4	0.0	214.6
5862010	PL	NA					2	1,098	0.0	0.0	62.2
6368170	PL	5.7	21	18.0	16.6		3	1,103	0.0	0.0	63.5
9123813	PL	5.8	18	18.0	18.4		3	1,094	0.0	0.0	9.8
2512341	PL	6.6	27	16.0	14.4	7.6	5	1,089	1.5	0.0	23.7
9177028	PL	8.1	29	16.0		8.2	9	1,079	2.8	0.0	122.6
9422673	PL	6.8	23	18.0		7.2	5	1,094	1.0	0.0	33.7
9165034	PL	7.7	26	16.0	16.6	7.3	7	1,080	1.0	0.0	152.2
7706565	PL	NA				8.8	8	1,070	6.5	0.0	68.5
6126172	PL	6.8	23	16.0	18.4		5	1,100	0.0	0.0	167.4
9147529	PL	6.2	19	15.0	18.2		4	1,089	0.0	0.0	6.4
5862087	PL	6.5	19	18.0	19.7		5	1,086	0.0	0.0	0.0

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Feature_ID	Leading					Lorey	Basal	Stems/	Volume		
	Spp	Height (m)	Age (yrs)	SI (m)	SI (m)	Height (m)	Area (m^2/ha)	Ha (n)	Live (m^3/ha)	Dead (m^3/ha)	Phase II Input (m^3/ha)
9169040	FD	9.3	31	16.0	16.3	7.8	11	1,054	5.3	0.1	106.1
2520929	PL	6.6	24	16.0	16.5		5	1,094	0.0	0.0	22.7
6158588	BL	3.5	25	15.0	18.0		1	3,899	0.0	0.0	33.6
6383891	PL	4.7	17	16.0	16.4		1	1,109	0.0	0.0	17.9
2540907	SX	8.3	24	15.0	22.9		6	1,112	0.0	0.0	0.0
6341519	FD	6.5	20	17.0	18.9		5	1,089	0.0	0.0	80.4
2544191	PL	4.8	18	16.0	16.0		2	1,108	0.0	0.0	8.6
2544576	PL	6.5	24	15.0	16.2		5	1,093	0.0	0.0	131.3
9411244	FD	NA					1	1,130	0.0	0.0	0.0
2550472	SX	10.9	27	24.0		9.5	14	1,095	16.7	0.3	87.4
9130294	PL	6.4	19	16.0	18.8		4	1,087	0.0	0.0	27.4
9141452	PL	5.7	18	13.0	18.7		3	1,095	0.0	0.0	111.1
2554105	PL	8.8	26	16.0	17.5	7.2	11	1,063	1.1	0.1	85.0
6294358	PL	5.2	17	15.0	18.0		2	1,101	0.0	0.0	0.0
9138278	PL	9.3	28	16.0	17.5	7.7	13	1,063	2.7	0.1	121.5
2565337	PL	6.0	19	16.0	17.5		3	1,092	0.0	0.0	34.7
2560939	PL	7.6	22	17.0	20.1		7	1,087	0.0	0.0	90.9
2573940	PL	7.1	21	16.0	19.8		6	1,084	0.0	0.0	88.4
2583053	PL	5.5	18	15.0	20.1		3	1,112	0.0	0.0	18.1
2584455	FD	NA				6.8	21	1,039	2.6	0.0	1.5
2584055	SX	5.9	28	15.0	15.6		2	1,124	0.0	0.0	0.0
7721370	PL	6.5	21	16.0	17.9		5	1,091	0.0	0.0	153.3
2587866	PL	6.3	19	21.0	18.3	7.4	4	1,088	0.7	0.2	30.6
7661190	PL	4.6	16	18.0	19.2		1	1,117	0.0	0.0	9.5
9184507	PL	9.4	32	16.0	16.5	8.8	11	1,064	10.4	0.5	0.0
7725123	PL	6.6	21	16.0	17.1		5	1,083	0.0	0.0	72.5
2619462	AT	3.0	26	12.0	13.5		1	3,951	0.0	0.0	120.1
5853294	FD	6.2	20	17.0	18.1		4	1,092	0.0	0.0	90.5

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Feature_ID	Leading					Lorey	Basal	Stems/	Volume		
	Spp	Height (m)	Age (yrs)	SI (m)	SI (m)	Height (m)	Area (m^2/ha)	Ha (n)	Live (m^3/ha)	Dead (m^3/ha)	Phase II Input (m^3/ha)
6294449	PL	4.4	15	18.0	18.0		1	1,113	0.0	0.0	39.7

Table C.3: Phase I TIPSY attributes.

Feature_ID	VRI Input		Phase II Input	
	Merch (m^3/ha)	Gross (m^3/ha)	Merch (m^3/ha)	Gross (m^3/ha)
9175920	8	27	23	46
9406673	125	155	184	218
2584037	133	169	0	0
2520251	90	143	72	124
2551151	39	65	29	56
6395205	154	192	291	337
9048432	77	104	2	20
2604558	51	79	25	51
9168920	27	50	128	157
9185432	42	66	55	80
9418083	27	49	9	26
9459384	46	71	62	88
9419614	1	14	17	40
2606073	70	99	41	70
2486846	13	34	25	49
9422034	3	15	72	98
5845865	84	112	100	129
5862010	0	6	78	108
6368170	0	8	20	42
9123813	0	8	0	6
2512341	1	13	0	3
9177028	11	28	16	36
9422673	2	15	11	27
9165034	5	22	82	110
7706565	6	25	54	83
6126172	2	14	145	176
9147529	0	10	0	8
5862087	0	13	0	0
9169040	15	37	78	112
2520929	1	14	0	2
6158588	0	3	9	31
6383891	0	3	1	18
2540907	5	20	0	0
6341519	1	12	10	29
2544191	0	4	0	8
2544576	1	13	13	34
9411244	0	2	0	0
2550472	29	53	23	49
9130294	0	12	14	36
9141452	0	8	2	16
2554105	13	35	17	39

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Feature_ID	VRI Input		Phase II Input	
	Merch (m^3/ha)	Gross (m^3/ha)	Merch (m^3/ha)	Gross (m^3/ha)
6294358	0	5	0	0
9138278	20	43	24	47
2565337	0	9	16	38
2560939	6	22	45	70
2573940	2	17	115	150
2583053	0	7	0	4
2584455	68	101	1	8
2584055	0	4	0	5
7721370	0	13	56	82
2587866	0	11	8	29
7661190	0	4	0	9
9184507	18	39	0	0
7725123	0	13	10	31
2619462	0	2	203	267
5853294	0	11	125	156
6294449	0	3	72	106

Table C.4: Ground data.

Proj_ID	Samp_No	Spp	Height (m)	Age (yrs)	SI (m)	Lorey Height (m)	Basal Area (m^2/ha)	Stems/ ha (n)	Volume Live (m^3/ha)	Volume Dead (m^3/ha)	Volume Gross (m^3/ha)
DMEM	0007	PL	9.8	26	19.4	8.0	32.9	4,453	33.8	0.0	118.5
DMEM	0012	PL	18.0	38	23.3	14.1	27.2	1,376	128.9	29.9	165.2
DMEM	0013	FD		44		6.8	16.0	2,427	41.6	7.4	69.4
DMEM	0017	PL	13.8	48	15.7	11.3	45.9	4,028	143.2	25.7	238.8
DMEM	0020	BL	11.0	51	14.4	7.9	35.9	3,477	82.2	0.0	130.1
DMEM	0021	FD	26.1	68	24.1	21.8	34.5	700	315.4	136.6	349.0
DMEM	0022	PL	7.4	29	14.5	6.5	5.0	325	7.9	1.1	13.4
DMEM	0025	FD	11.4	46	15.4	7.7	22.1	3,778	21.7	0.0	75.9
DMEM	0028	PL	15.2	36	21.0	13.2	21.0	1,076	96.9	0.0	129.7
DMEM	0031	PL	12.6	32	19.8	9.1	21.1	2,076	68.1	0.0	98.0
DMEM	0032	PL	8.8	83	18.3	8.9	4.4	450	17.2	0.0	26.4
DMEM	0033	PL	12.3	30	20.5	10.9	19.5	1,226	58.9	0.0	89.3
DMEM	0034	SX	9.8	37	17.9	7.6	6.4	751	11.7	0.0	21.7
DMEM	0037	FD	13.2	46	16.8	11.6	28.5	1,251	101.1	12.0	139.7
DMEM	0041	PL	9.9	30	17.2	7.3	2.9	300	6.4	6.2	10.5
DMEM	0042	PL	13.6	31	21.9	9.4	25.1	3,502	41.6	0.0	104.6
DMEM	0043	PL	14.1	34	20.5	11.6	25.6	2,527	73.1	0.0	129.2
DMEM	0044	AT	13.9	78	10.9	10.9	18.3	1,701	53.3	0.0	91.0
DMEM	0045	PL	9.4	24	20.1	8.2	21.5	2,352	29.1	0.0	79.6
DMEM	0046	PL	5.4	15	20.0	4.4	4.0	1,326	0.0	5.4	8.4
DMEM	0047	PL	5.9	20	16.9	6.0	14.1	2,502	12.1	0.0	40.9
DMEM	0048	PL	9.3	26	17.3	6.6	21.8	3,652	15.9	0.0	67.7
DMEM	0049	BL	7.8	43	14.5	6.9	7.0	876	12.0	0.0	23.8
DMEM	0051	PL	13.3	38	18.5	12.2	28.9	1,776	109.9	0.0	164.7
DMEM	0052	AT	12.4	37	16.5	10.1	15.7	2,176	23.4	0.0	69.7
DMEM	0053	PL	16.1	38	21.5	12.3	25.3	2,402	91.8	2.8	139.8
DMEM	0054	PL	6.0	17	19.8	5.4	4.0	751	0.0	0.0	10.4
DMEM	0055	FD		94		9.7	0.7	25	2.1	0.0	2.7

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Proj_ID	Samp_No	Spp	Height (m)	Age (yrs)	SI (m)	Lorey Height (m)	Basal Area (m^2/ha)	Stems/ ha (n)	Volume Live (m^3/ha)	Volume Dead (m^3/ha)	Volume Gross (m^3/ha)
DMEM	0056	FD	16.4	46	20.5	14.4	17.2	625	82.1	0.0	104.5
DMEM	0057	PL	4.8	16	17.6	4.9	3.6	650	2.7	0.0	9.0
DMEM	0058	BL	6.6	33	15.8	5.7	10.5	2,001	11.3	0.0	29.7
DMEM	0059	PL	7.2	19	19.8	5.6	10.2	2,827	0.0	4.5	28.8
DMEM	0060	PL				3.0	0.8	400	0.0	0.0	1.4
DMEM	0061	FD	8.7	26	20.8	7.2	11.7	1,926	15.8	0.0	40.2
DMEM	0062	PL	5.7	16	19.4	4.5	8.7	2,802	0.0	0.0	19.9
DMEM	0063	BL	9.6	37	17.5	7.8	20.9	2,827	26.1	0.0	71.8
DMEM	0064	NA				0.0	0.0	0	0.0	173.1	0.0
DMEM	0065	SX	10.8	24	25.4	5.8	3.1	250	5.2	0.0	8.8
DMEM	0066	PL	9.1	26	18.4	7.3	8.4	1,776	2.4	0.0	26.6
DMEM	0067	PL	8.1	18	21.7	7.6	12.9	1,351	19.7	7.6	44.2
DMEM	0069	PL	9.1	22	20.6	7.3	5.7	751	10.7	0.0	21.0
DMEM	0070	FD				14.0	10.6	200	67.6	0.0	75.9
DMEM	0071	PL	10.1	24	20.6	8.6	8.7	801	14.8	0.0	33.0
DMEM	0072	PL	9.1	27	18.0	7.3	21.5	5,579	5.3	0.0	68.8
DMEM	0073	PL	11.2	27	20.4	8.9	22.4	2,151	41.5	0.0	90.9
DMEM	0074	FD	17.7	115	11.8	10.9	19.6	1,451	69.1	99.2	102.9
DMEM	0075	PL	5.5	20	17.2	4.7	8.0	1,651	2.4	0.0	18.5
DMEM	0076	AT	6.2	49	8.1	5.5	6.2	2,101	1.7	0.0	15.9
DMEM	0077	SX	6.3	32	15.6	5.5	5.3	876	4.8	0.0	13.6
DMEM	0078	PL	12.2	30	20.2	10.6	23.3	1,876	70.8	0.0	115.8
DMEM	0079	PL	8.5	22	19.9	7.3	19.4	4,503	2.7	0.0	68.8
DMEM	0080	PL	5.8	15	20.5	4.9	4.2	1,251	0.0	0.0	10.0
DMEM	0081	FD				9.3	18.2	776	81.0	0.0	110.1
DMEM	0082	PL	8.8	22	20.6	7.1	13.5	1,976	9.6	0.0	44.5
DMEM	0083	AT	19.2	87	14.8	16.4	24.5	625	144.7	0.0	176.0
KAM1	0011	PL	15.9	101	12.3	11.6	20.7	1,651	67.3	17.2	110.6

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Proj_ID	Samp_No	Spp	Height (m)	Age (yrs)	SI (m)	Lorey Height (m)	Basal Area (m^2/ha)	Stems/ ha (n)	Volume Live (m^3/ha)	Volume Dead (m^3/ha)	Volume Gross (m^3/ha)
KAM1	0019	FD	16.0	84	12.6	10.6	6.3	275	22.6	0.0	30.1

D. YSM Edge Plot Maps and Photos

The photos included in this appendix were taken during the implementation of the walk through method. They were taken to document the boundaries between the young stand population and the adjacent mature population. A boundary intersected plot 32, and while no boundaries intersected plots 45, 47, and 79, the boundaries were close enough to intersect the inclusion zones of trees in these plots.

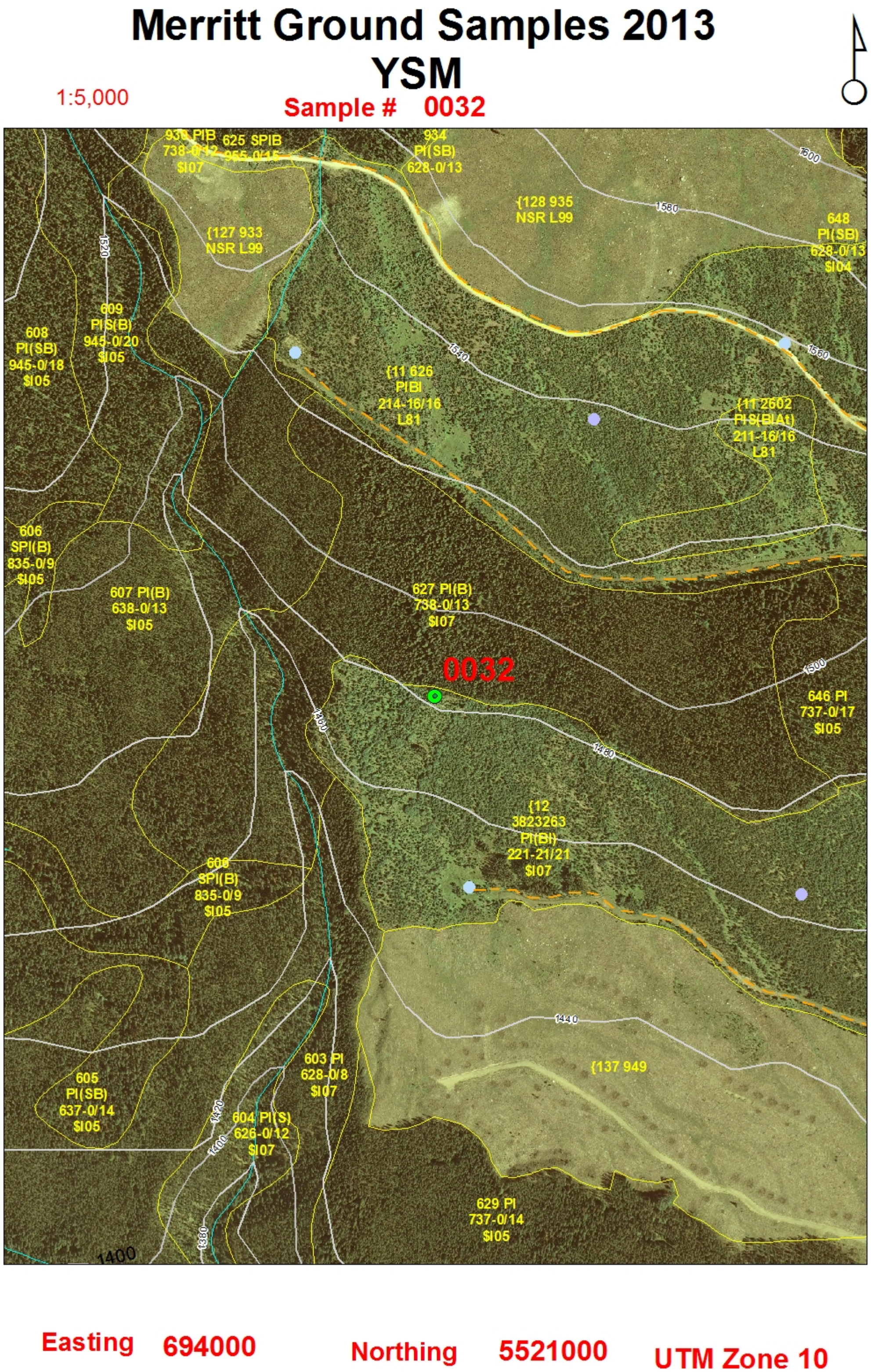

Figure D.1: YSM Plot 32.

Figure D.2: YSM Plot 32.

Figure D.3: YSM Plot 32.

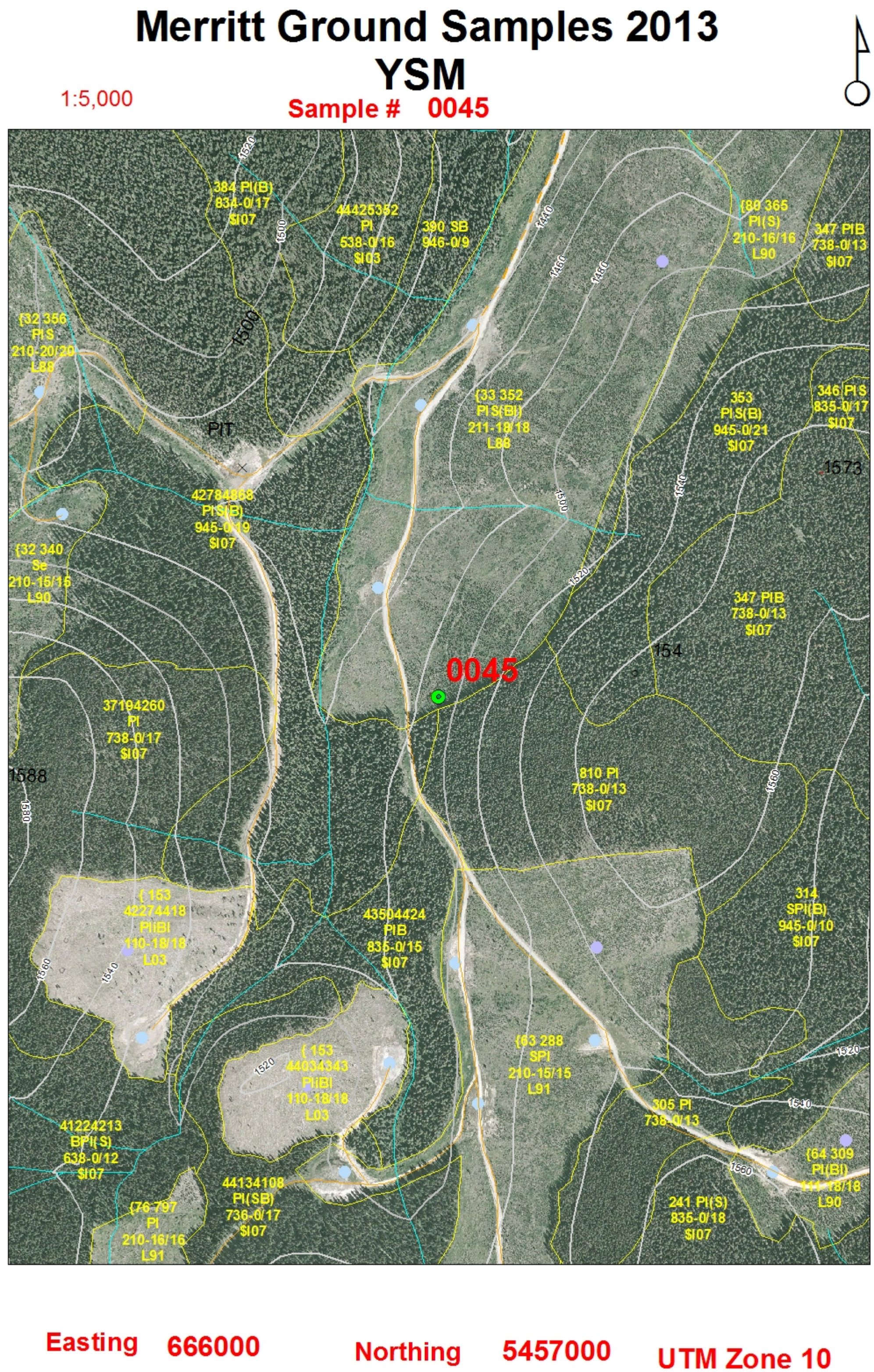

Figure D.4: YSM Plot 45.

Figure D.5: YSM Plot 45.

Figure D.6: YSM Plot 45.

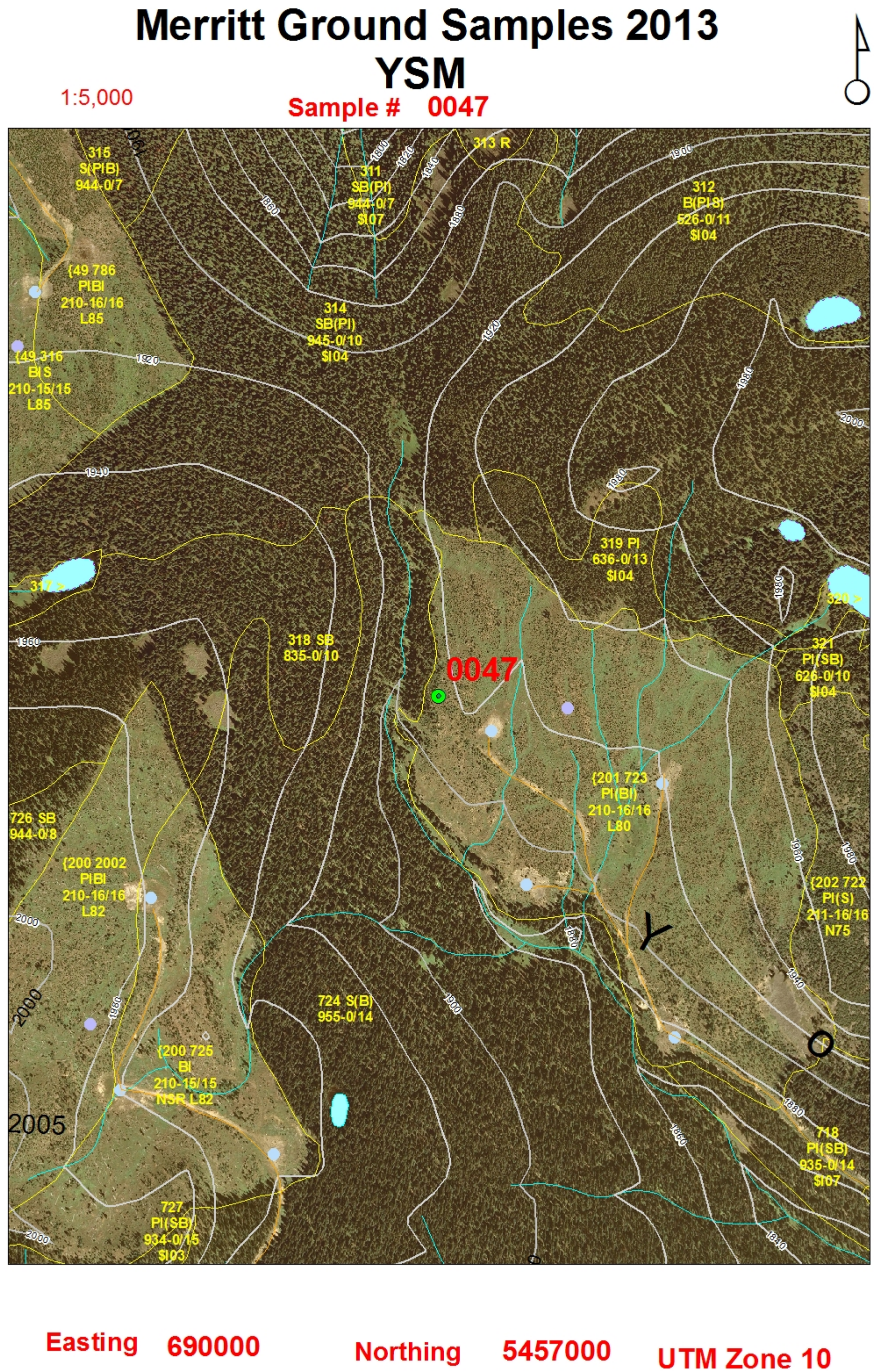

Figure D.7: YSM Plot 47.

Figure D.8: YSM Plot 47.

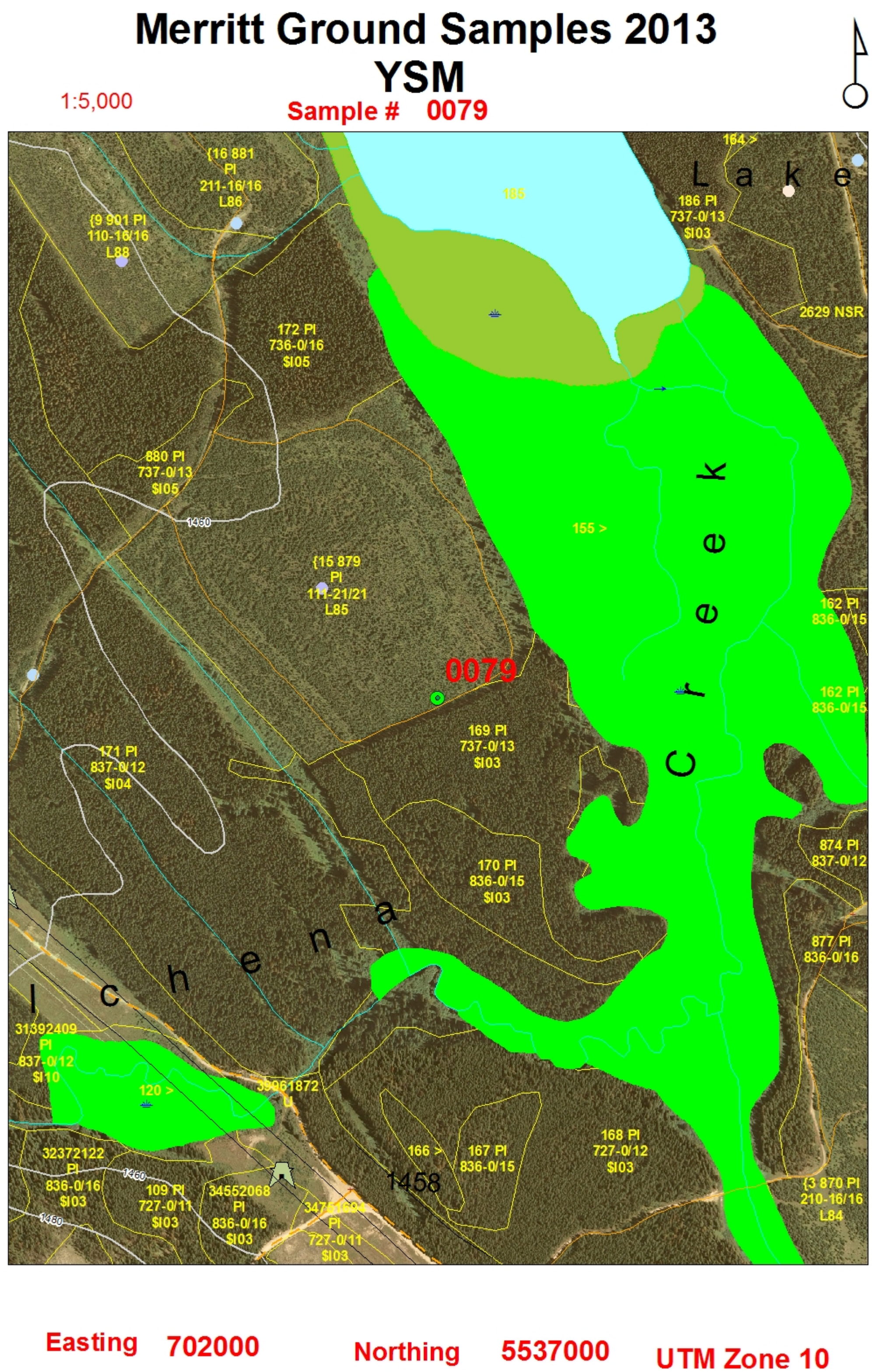

Figure D.9: YSM Plot 79.

Figure D.10: YSM Plot 79.

Figure D.11: YSM Plot 79.