
TFL 5
Change Monitoring Inventory
Establishment Report

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Project: WWQ-036

March 10, 2004



Executive Summary

In 2003, Weldwood of Canada Ltd. (Weldwood) implemented a Change Monitoring Inventory (CMI) program on TFL 5. In 2003, a sample plan was written, thirty (30) CMI plots were established on the TFL, and compiled results summarized as part of this establishment report.

The 30 CMI plots represent an unbiased sample of the target population that will be used for growth and yield monitoring. Results presented in this report include summaries of the CMI plot data only. No comparison is made between the CMI data and the forest cover inventory associated with CMI plot locations. Such analyses can be completed in a future project.

The proportion of CMI plots by leading species (as measured on the ground) generally matches the inventory proportions in the target population for lodgepole pine (PI) and interior spruce (Sx), however, the Douglas-fir (Fdi) leading stands are fewer in occurrence (7% of the CMI plots), and deciduous leading stands are more frequent (23% of the CMI plots). The average net merchantable volume of all tree species is 57.6 m³/ha, with the conifer component representing 68% of the total. Average site index ranges from 20.5 m for balsam (BI), 22.1 m for (PI), 22.3m (Fdi), and 23.4 m for (Sx). Total coarse woody debris (CWD) volume is 130 m³/ha.

Major recommendations for subsequent steps in Weldwood's CMI program are to:

- Analyze the difference in growth & yield attributes between the CMI plots and the inventory-based attributes to support the next Management Plan.
- Evaluate the need for post-stratification and additional sampling to account for variability in the current target population.

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1. INTRODUCTION

1.1 BACKGROUND

In 2003, Weldwood of Canada Ltd. (Weldwood) implemented a Change Monitoring Inventory (CMI) program on TFL 5. The CMI program is designed to track growth & yield attributes for the sustainable forest management (SFM) plan, ensure that up-to-date growth & yield information is included in each Management Plan, and to provide information for other internal management functions, such as fiber allocation.

1.2 GOALS AND OBJECTIVES

The overall goal of the CMI program is to monitor and track the change in key growth & yield attributes including volume, mean annual increment (MAI), site index, top height, and species composition in regenerated stands. The deliverables for this project include

- Sample Plan Report
- CMI plot sample packages
- Establishment Report containing compiled results

1.3 TERMS OF REFERENCE

J.S. Thrower & Associates Ltd. (JST) completed this project for Allan Johnsrude, *RPF* of Weldwood. René de Jong, *RPF* was the project manager for JST, and Jim Thrower, *RPF, PhD* was the project advisor. The field program was coordinated by Mike Ciccotelli, *DoT* and the field work completed by field crews from both JST and Timberline Forest Inventory Consultants (TFIC).

2. SAMPLE DESIGN

2.1 OVERVIEW

JST prepared a sample plan that was submitted to the Ministry of Sustainable Resource Management (MSRM) for review and approval prior to field sampling.¹ The sample design adheres to MSRM standards and can accommodate new plot locations as the target population expands.

2.2 TARGET POPULATION

The target population for this CMI program is all conifer leading post-harvested-regenerated (PHR) stands in the TFL that are between 15 and 39 years of age (19% of the landbase). The minimum age of 15 years restricts sampling to stands that generally have merchantable volume. The maximum age was selected to ensure the majority of stands in the target population are of post-harvest origin. The CMI target population will expand over time as post-harvest regenerated (PHR) stands reach the minimum age of 15 years. Landbase summaries used to define the target population are provided in Appendix I.

¹ J.S. Thrower & Associates. 2003. Draft: TFL 5 Change Inventory Sample Plan. Contract report to Weldwood of Canada Ltd. 14 pp. October 7, 2003, and revised following MSRM feedback October 30, 2003.

2.3 SAMPLE PLOTS

A 1.0 km grid was positioned on the TFL in a geographic information system (GIS) using NAD83 coordinates. Fifty nine (59) points on the grid were in polygons that met the target population definition. In 2003, thirty (30) plots were randomly selected from these 59 grid points for initial establishment, resulting in a sampling frequency of 51%.

2.4 SAMPLE PLOT DESIGN

The plot design was based on MSRM CMI standards (Figure 1).² The main plot was 400 m² (11.28 m radius) where all trees greater than 4 cm diameter at breast-height (DBH) were measured and tagged. Trees between 4 cm and 9 cm were measured and tagged in the small-tree plot (5.64 m radius), and all trees taller than 30 cm but less than 4 cm DBH were measured and tallied by species in the regeneration plot (2.50 m radius).

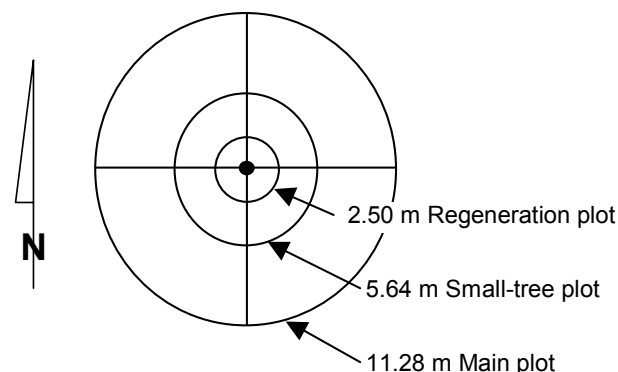


Figure 1. CMI sample plot.

2.5 FIELD MEASUREMENTS

Plot location and measurements generally followed MSRM CMI standard procedures³ however, the following modifications were made:

- No information was collected on range data.
- Visual estimation of the biogeoclimatic site series and site features at the pin location comprised the level of detail recorded on the Ecology Header (Ep) card.
- For timber attributes, potential site trees from all species were sampled from each quadrant in the 11.28 m radius plot and included a separate sampling of potential site trees by stepping down the DBH list (if the largest tree was deemed unsuitable by CMI standards).
- Blue tree tags were affixed at breast rather than at stump height as recommended in the CMI protocol.
- Coarse woody debris (CWD) sampling methods followed the 2002 CMI standards⁴ where CWD measurements were taken from two 24 m transects.
- Grid points located on a new permanent road (mainline, cleared mainline right-of-way, in-block road) were excluded from the sample list and noted.
- If a portion of the plot was outside the target population, all trees outside the target population were measured and tagged as per CMI standards and identified as being outside the target population. Separate site tree data were collected from both portions of the quadrant. A drawing of the plot was used to estimate the target population boundary line and was based on the 1:5,000 sample package maps.

² Ministry of Sustainable Resource Management National Forest Inventory–BC Change Monitoring Procedures for Provincial and National Reporting March 31, 2003. Ver. 1.3.
http://srmwww.gov.bc.ca/risc/pubs/teveg/cmi2k3/cmi_ground_2k3.pdf

³ <http://srmwww.gov.bc.ca/risc/pubs/teveg/index.htm>

⁴ Ministry of Sustainable Resource Management CMI – Ground Sampling Procedures for the provincial CMI program. March 29, 2002 Ver. 1.2.

2.6 FIELD SAMPLING

Field sampling was completed separately by crews from JST and TFIC. Fifteen plots were established by JST's field crew between October 1 and October 16, 2003, and fifteen plots were established by TFIC's field crew between October 20 and November 20, 2003. Plot locations were recorded using the Global Positioning System (GPS) unit Trimble Geoplotter II, and recordings subsequently adjusted using differential correction.

3. DATA MANAGEMENT

3.1 AUDITS

We completed internal audits on both JST and TFIC plots to ensure consistency in field sampling methods. Two separate external audits were completed by Inland Timber Management Ltd. from each of JST's and TFIC's plots. The audit for the JST plots was completed November 5, 2003 and the audit for the TFIC plots completed November 25, 2003. The results of these external audits were that all sample plots passed.⁵ Any plot card discrepancies noted by the auditor during the office check were addressed by the field crews prior to data entry.

3.2 DATA ENTRY AND COMPILATION

Field data were entered using the MSRM software program VIDE version 2.0. All data were compiled in-house by JST using the VRI / CMI compiler developed by MSRM (version June 27, 2002).

3.3 DATA COMPILATION STANDARDS

At this time, a consistent utilization standard of 12.5 cm was applied to all plot compilations. However, subsequent comparison of CMI data against projected inventory data will eventually have to consider different utilization standards depending on species (12.5 cm for PI leading, and 17.5 cm for all other species). Net merchantable volume was based on reductions from whole stem volume⁶ which included 10 cm top diameter, 30 cm stump height, and applicable decay and waste loss factors.⁷ Site index calculations were based on the Ministry of Forests' (MOF) most recent version of Site Tools.⁸

⁵ Inland Timber Management Ltd. TFL 5 Audit by L.A. Gulliford, A.T.E. Two separate reports dated November 5, 2003, and November 25, 2003.

⁶ Whole stem volumes computed in MSRM's VRI / CMI compiler use Kozak's 1994 BGC zone-based volume taper equations.

⁷ MSRM loss factors for TFL 5 are based on those developed for Public Sustained Yield Unit (PSYU) 305.

⁸ The VRI / CMI compiler currently uses the Site Tools library 'SINDEX33.DLL'.

4. RESULTS

4.1 PLOT DETAIL

Compiled plot level summaries include net merchantable volume, stand density, CWD, and site index (Table 1). Volume and stand density summaries are computed separately for all species combined, and just the conifer component. Site index data are based on conifer species with the greatest basal area. Descriptive statistics are also summarized for all 30 plots sampled. Reference information for the 30 plots is also provided in Appendix II.

Of the 30 plots, 10 are PI leading, nine are Sx leading, two are BI leading, two are Fdi leading, and seven are deciduous leading. While PI and Sx plot proportions generally match leading species inventory proportions of the target population (Appendix I), Fd leading stands are fewer (7% vs. 28%), and deciduous leading stands are greater (23% vs. 7%) in representation than in the inventory. It should be noted that stands identified as deciduous leading from the inventory were excluded from the target population in the sample plan.

One plot (#22) stands out from the rest in terms of volume. This plot was identified by field crews as a multi-storied and multi-aged stand with BI residuals. This stand type was identified in the sample plan and included in the target population because of its relatively low representation in the inventory.

One plot (#19) has zero volume reported, which is due to all trees being below the 12.5 cm merchantable limit. Three plots (#3, 5, and 28) were identified by field crews as having evidence of spacing. The range of different species, harvest histories, and treatment history should all be considered when conducting future analyses of the data, and used as potential justification to increase sample sizes to enable post stratification.

Four plots (#4, 7, 19, and 31) were also noted by field crews to overlap with areas outside the target population, as identified in the forest cover inventory maps. Subsequent analyses should also consider whether portions of the plots that are outside the target population may have to be excluded from the analyses.

Table 1. Compiled plot level summaries.

Plot #	Species composition (by Basal Area)	Merch Volume (m ³ /ha)		Stand Density (# stems/ha)		CWD (m ³ /ha)	Site Tree Data of Leading Conifer species			
		All species	Conifer	All species	Conifer		Spc	Total Age (yrs)	Total Height (m)	Site Index (m)
1	PI 100	8.7	8.7	325	325	170.9	PI	16	8.5	24.3
2	PI 100	0.4	0.4	25	25	98.0	PI	17	6.3	19.9
3	Sx 70 Ep 23 Fdi 07	76.0	52.2	500	450	201.6	Sx	42	14.0	21.1
4	PI 36 Sx 29 Fdi 16 BI 15 Ac 04	130.1	124.9	525	500	68.9	PI	38	20.1	23.8
5	PI 100	4.9	4.9	150	150	345.6	PI	17	8.1	22.3
6	At 41 Sx 34 Ep 22 Fdi 03	150.3	56.5	776	200	53.5	Sx	38	17.8	26.7
7	BI 73 Sx 27	8.7	8.7	125	125	82.3	BL	38		
8	Ac 100	96.6	0.0	325	0	28.6	Sx			
9	Sx 48 At 33 PI 07 Fdi 06 Ep 06	13.2	7.8	375	225	131.5	Sx	29	10.9	23.6
10	PI 100	6.8	6.8	150	150	51.7	PI	22	10.6	22.9
11	Sx 42 Fdi 33 Ep 09 At 07 BI 05 PI 04	46.6	36.0	725	625	99.1	Sx	32	13.9	23.2
12	Sx 75 Fdi 25	131.9	131.9	801	801	66.2	Sx	44	16.0	20.9
13	Fdi 54 PI 46	1.4	1.4	50	50	309.1	Fdi	22	8.8	22.8
14	Ep 64 Fdi 23 Sx 13	32.0	5.7	100	75	92.1	Fdi	25	5.4	20.1
15	Fdi 42 Ep 26 At 24 Sx 05 BI 03	38.3	16.1	450	275	41.3	Fdi	35		
16	Ac 39 Sx 28 Ep 20 PI 09 BI 04	80.6	34.9	425	150	57.6	Sx	40	19.0	26.8
17	Ep 39 Fdi 39 Sx 18 At 04	76.3	60.6	550	175	42.5	Fdi	34	13.2	22.0
19	PI 39 Sx 35 BI 26	0.0	0.0	0	0	23.7	BI	29	6.0	16.5
20	Sx 77 Fdi 13 BI 10	37.4	37.4	550	550	205.1	Sx	36	12.4	23.6
21	Sx 60 PI 26 BI 14	46.1	46.1	500	500	239.1	Sx	37		
22	BI 51 Ep 27 Sx 18 Fdi 04	267.9	213.1	675	425	73.4	BI	46	27.4	25.2
23	PI 97 Sx 03	50.7	50.7	550	550	0.0	PI	27	13.0	22.5
24	PI 100	8.2	8.2	225	225	199.1	PI	20	9.4	22.3
25	Ep 45 Sx 34 Fdi 16 Ac 05	99.2	52.6	751	325	207.2	Sx	39	17.1	25.1
26	Sx 73 Ep 25 Fdi 02	70.5	53.0	500	375	221.4	Sx	40	16.6	23.4
27	PI 45 Sx 29 Ep 26	38.5	32.7	375	250	114.2	PI	29	14.3	22.9
28	Sx 35 Ac 21 Fdi 15 BI 14 PI 08 Ep 07	18.8	15.0	225	150	71.4	Sx	24	8.7	24.4
29	Sx 46 Ac 46 BI 08	58.3	17.2	525	425	224.7	Sx	27	9.6	24.1
30	PI 72 Ep 16 Sx 12	51.9	46.9	400	325	120.6	PI	29	13.2	21.7
31	Ep 35 Sx 32 BI 19 At 14	78.1	41.9	350	150	270.4	Sx	41	17.1	24.4
<i>Average</i>		57.6	39.1	400.3	285.2	130.4		31.5	13.0	22.9
<i>Minimum</i>		0	0	0	0	0		16.2	5.4	16.5
<i>Maximum</i>		267.9	213.1	800.5	800.5	345.6		45.8	27.4	26.8
<i>Standard Error</i>		10.5	8.5	41.9	36.6	16.7		1.6	1.0	0.4
<i>Sample size</i>		30	30	30	30	30		29	26	26
<i>Lower 95% Confidence Interval</i>		36.1	21.8	314.7	210.3	96.3		28.2	10.9	22.1
<i>Upper 95% Confidence Interval</i>		79.1	56.4	485.9	360.0	164.4		34.9	15.0	23.8

4.2 CMI SITE TREE SUMMARY

Site tree data were collected from all species regardless of their composition in the plot, as identified in the sample plan (Table 3). This provided additional information than was required under CMI standards, but provides greater confidence in site index estimates to be used in subsequent TFL Management Plans. Variability in site index within each species is low, as shown in the narrow range of the 95% confidence intervals.

The sample plan identified the potential, that site trees could be sampled from outside the target population. This occurs when the CMI plot area overlaps with an adjacent polygon, which occurred in four plots. Site trees outside the target population were identified by the field crews to enable separate compilation of the subset inside the target population. While a total of 16 measured site trees were excluded, the majority were identified as unsuitable for site index by field crews, resulting in similar computed averages.

Table 2. Site index (m) statistics by species across all CMI plots.

Species	Site Index (m) descriptive statistics				95% Confidence Interval		
	Avg	Min	Max	Standard Error	n	Lower Limit	Upper Limit
<i>All Suitable Trees</i>							
BI	20.5	12.3	25.2	0.7	23	19.0	21.9
Fdi	22.3	17.0	28.4	0.5	26	21.2	23.4
PI	22.1	15.9	25.8	0.4	31	21.3	22.8
Sx	23.4	17.4	29.3	0.3	59	22.8	24.0
<i>Subset inside target Population</i>							
BI	20.4	12.3	25.2	0.7	22	18.9	21.9
Fdi	22.3	17.0	28.4	0.5	26	21.2	23.4
PI	22.1	15.9	25.8	0.4	30	21.3	22.9
Sx	23.4	17.4	29.3	0.3	54	22.8	24.1

5. RECOMMENDATIONS

The next steps JST recommends for Weldwood's CMI program are to:

- Analyze the difference in growth & yield attributes between the CMI plots and the inventory-based attributes to support the next Management Plan.
- Evaluate the need for post-stratification and additional sampling, to account for the variability in the current target population due to differences in species composition, harvest history, and stand tending treatments.
- Consider exclusion of plot areas that are outside the target population in subsequent analyses.

APPENDIX I – LANDBASE SUMMARIES

TFL 5 Landbase

Weldwood’s TFL 5 covers approximately 35,000 ha, of which 33,000 ha (95%) are productive (Table 3).

Douglas-fir (Fdi), interior spruce (Sx), and lodgepole pine (PI) account for 85% of all leading species in the productive forest of the TFL (Table 4, Figure 2).

Approximately 41% of the area is covered by stands up to 40 years of age, while 28% of the area is 121 years and older.

Table 3. TFL 5 Area distribution.

	Area	
	(ha)	(%)
Entire Landbase	34,640	100
Non-Forest, non-productive	1,680	5
Productive Forest	32,960	95

Table 4. Total area distribution of the TFL by leading species and age class within the PFLB.⁹

Species	Age Class										Total	
	0	1	2	3	4	5	6	7	8	9	(ha)	(%)
Fdi		1,602	2,085	319	1,111	1,378	1,011	1,368	2,667	141	11,683	35%
Sx		2,145	1,929	374	811	537	343	579	2,266		8,984	27%
PI		3,119	351	25	588	1,081	737	1,183	548		7,632	23%
BI		6	81	71	32	24	97	163	58		533	2%
Decid	188	631	219	371	421	456	359	229			2,876	9%
NSR	1,250										1,250	4%
Total	1,438	7,504	4,665	1,160	2,964	3,476	2,549	3,522	5,539	141	32,957	100%
%	4%	23%	14%	4%	9%	11%	8%	11%	17%	0%	100%	

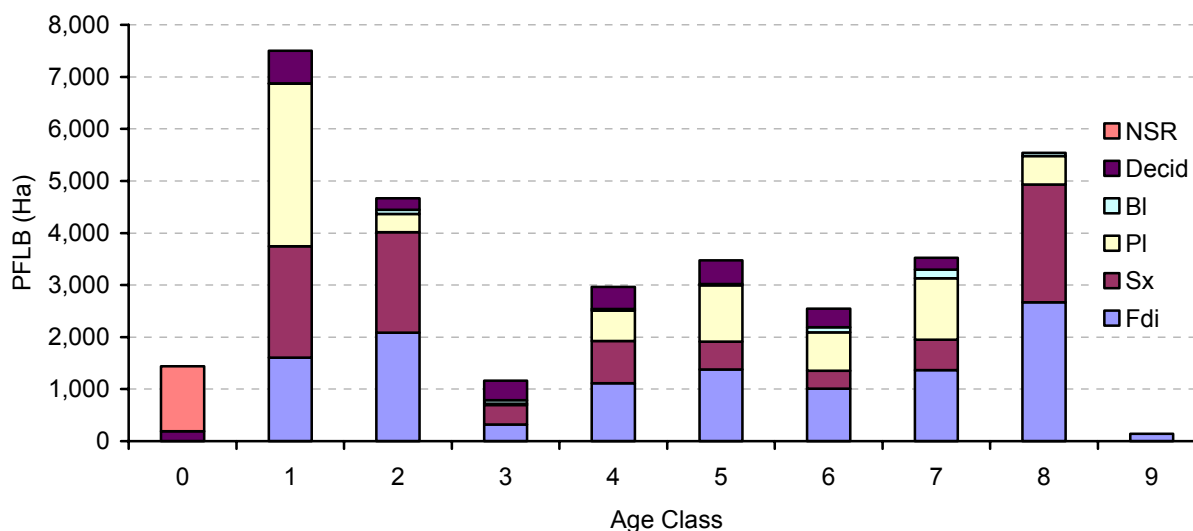


Figure 2. Total area distribution of the TFL by leading species and age class within the PFLB.

⁹ Age class attributes are projected in the inventory file to the year 2002.

Area distribution by age and leading species

Table 5. Area distribution by species and age class for the target population.

Age class	Leading Species						Total	%
	NSR	Fdi	PI	Sx	Decid	BI		
0 – 4	1,250	70	503	160			1,982	14%
5 – 9		147	886	247			1,279	9%
10 – 14		614	1,100	856	83		2,652	19%
15 - 19		680	491	662	106	6	1,939	14%
20 – 24		493	257	590	43	1	1,382	10%
25 – 29		565	210	582	62	2	1,418	10%
30 – 34		861	24	580	127	48	1,591	11%
35 - 39		230	0	357	380	31	968	7%
40 – 44		197		300	121	29	619	4%
45 – 49		88		47	48	0	183	1%
50 – 54		12	7	35	47	41	101	1%
Total	1,250	3,956	3,477	4,416	1,017	158	14,273	100%
%	9%	28%	24%	31%	7%	1%	100%	

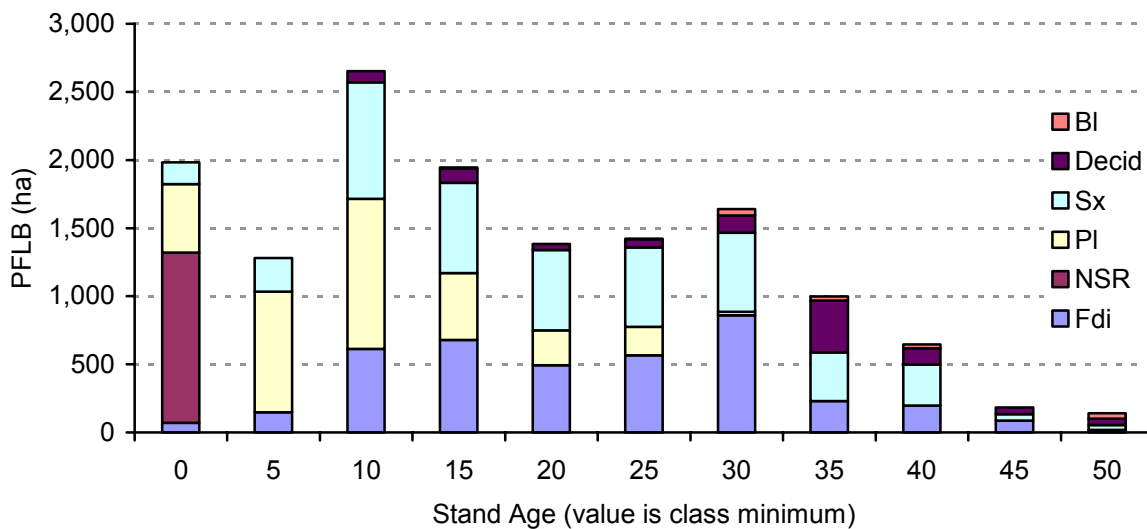


Figure 3. Area distribution by species and age class for the target population.

Stand history of Target Population

Table 6. Area distribution by harvest history and age class for the target population.

Age class	Stand history						Total	%
	Managed	Backlog Rehab	Decid	Overstory Residuals	Natural	Fdi Partial cut		
0 – 4	1,982						1,982	14%
5 – 9	1,243	36					1,279	9%
10 – 14	2,324	246	83				2,652	19%
15 - 19	1,698	142	106				1,946	14%
20 – 24	1,201	122	43	17			1,383	10%
25 – 29	1,356		62	2			1,420	10%
30 – 34	1,435		127		78		1,639	11%
35 - 39	509		380	18	36	55	998	7%
40 – 44	406		121	56	56	8	648	5%
45 – 49	85		48	4	45	2	183	1%
50 – 54	43		47	30	23		142	1%
Total	12,282	546	1,017	126	237	65	14,273	100%
%	86%	4%	7%	1%	2%	0%	100%	

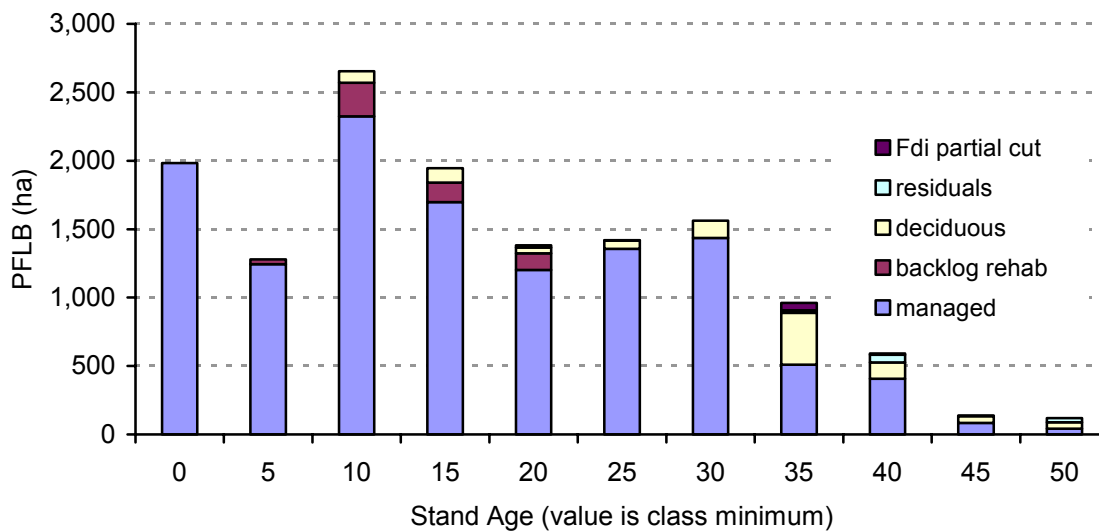


Figure 4. Area distribution by harvest history and age class for the target population.

APPENDIX II – PLOT REFERENCE INFORMATION

Table 7. CMI sample plot information

Plot	Mapsheet	Polygon	GPS corrected		Elev. (m)	Inventory Attributes			Harvest Year	Company	Field crew	Field comments		
			Northing (m)	Easting (m)		Leading species	Second species	Third species					Age (yrs)	Height (m)
1	093G017	320	5,891,966	519,997	736	Pl	At	Fdi	15	4.4	0	1986	JST	Open Pl stand, adjacent to old skid trail
2	093G018	77	5,893,009	529,996	775	Sx	Pl	Fdi	27	5.5	0	1984	JST	Very open stand
3	093G036	405	5,912,995	507,997	674	Sx	Fdi	Ep	31	14.7	18.1	1962	JST	Previously spaced stand
4	093G017	70	5,894,000	520,003	785	Fdi	Sx	Pl	15	4.5	0	1983	JST	Plot adjacent to stand outside target population
5	093G018	76	5,893,004	527,002	822	Pl	Sx	Ep	18	9	0	1983	JST	Previously spaced stand, high incidence of forks / crooks
6	093G036	496	5,912,002	507,994	662	Fdi	Sx	Ep	29	9.2	2.7	1973	JST	Open stand, with high deciduous component
7	093G037	495	5,910,001	515,997	781	Sx	At	Bl	31	19.8	17.7	1973	JST	Portion of plot outside target population, creek bisects plot
8	093G037	467	5,910,000	519,000	0	Sx	Fdi	Pl	26	4.7	0	1973	JST	On former inblock road, 100% deciduous
9	093G036	122	5,915,998	505,004	778	Sx	Fdi	At	27	5.1	0	1972	TFC	-
10	093G036	686	5,910,999	503,001	779	Fdi	Pl	At	20	6	0	1982	TFC	-
11	093G036	241	5,913,994	505,001	829	Fdi	Sx	At	31	12.5	41.5	1972	TFC	-
12	093G018	121	5,891,987	527,005	813	Fdi	Sx	Pl	26	8.1	0	1959	JST	-
13	093G036	203	5,914,999	507,001	688	Pl	Sx	Fdi	21	11.1	4.2	1985	TFC	-
14	093G047	95	5,916,997	515,005	788	Fdi	Sx	Pl	16	4.2	0	1982	TFC	-
15	093G036	699	5,910,994	507,005	753	Fdi	Sx	Ep	33	11.4	37.6	1962	TFC	-
16	093G037	648	5,908,001	517,992	851	Sx	Fdi	Pl	30	6.3	0	1971	JST	-
17	093G036	234	5,913,997	509,002	685	Sx	Fdi	Ep	36	13.4	56.9	1969	JST	Plot bisected by former inblock road / landing
19	093G027	634	5,895,000	521,004	796	Sx	Pl	Fdi	16	1.6	0	1984	TFC	Plot adjacent to stand outside target population
20	093G036	166	5,915,000	506,002	727	Sx	Fdi	At	27	5.1	0	1975	TFC	-
21	093G036	384	5,912,999	505,003	843	Fdi	Sx	Bl	26	8.6	2.2	1972	TFC	-
22	093G036	536	5,912,006	512,989	695	Sx	Fdi	Pl	22	3	0.1	1975	JST	Multi storied / multi aged stand, includes large Bl residuals
23	093G036	395	5,911,997	504,005	840	Fdi	Sx	At	31	16.6	60.3	1970	TFC	Plot adjacent to former inblock road
24	093G018	71	5,892,988	528,998	804	Pl	Sx	At	16	5.2	0	1984	JST	High frequency of forks / crooks noted
25	093G036	201	5,915,001	510,000	740	Sx	Fdi	Ep	36	13.4	56.9	1969	TFC	-
26	093G036	952	5,908,988	504,993	732	Fdi	Sx	Ep	36	10.6	19.2	1965	TFC	-
27	093G036	103	5,915,994	510,005	735	Fdi	Sx	Pl	20	4.9	0	1974	TFC	-
28	093G037	245	5,912,997	517,996	735	Sx	Ep	Fdi	17	1.8	0	1962	JST	Previously spaced stand
29	093G037	381	5,911,007	519,995	800	Pl	Fdi	Sx	25	9.3	0.9	1975	JST	-
30	093G036	320	5,914,003	507,001	707	Sx	Ep	Fdi	39	12.5	38.4	1963	TFC	-
31	093G036	415	5,912,999	506,000	783	Fdi	Sx	At	35	12.4	55.6	1967	TFC	Plot adjacent to stand outside target population