Change Monitoring Inventory
Pilot Project for the Adams Lake IFPA

Strategic Implementation Plan

Prepared for

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1. INTRODUCTION

1.1 BACKGROUND

International Forest Products Ltd. – Adams Lake Lumber Division (Interfor-Adams Lake) was awarded an Innovative Forestry Practices Agreement (IFPA) on November 17, 1997. The IFPA provides an opportunity for Interfor-Adams Lake to demonstrate the company's commitment to sustainable forest management. As part of this commitment, Interfor-Adams Lake recently completed a Vegetation Resources Inventory (VRI) audit,[1] Terrestrial Ecosystem Mapping (TEM),[2] and Site Index Adjustment (SIA)[3] projects. The next step is to develop a change monitoring inventory (CMI) program to test the growth and yield (G&Y) predictions used in timber supply analysis against actual field observations. The CMI program acts as an early warning system if sustainability criteria are not met.

A CMI program is an essential component of many third-party certification programs. Interfor-Adams Lake has obtained certification from the Sustainable Forestry Initiative (SFI) and ISO 14001, is pursuing certification through the Canadian Standards Association (CSA), and is considering certification under the Forest Stewardship Council (FSC).

1.2 PROJECT GOALS & OBJECTIVES

The goal of the Adams Lake CMI program is to develop a high level-of-comfort in the G&Y predictions for post-harvest regenerated (PHR) stands in the managing the IFPA area. This is done by periodically checking actual G&Y from sample plots in the IFPA area and comparing measured with predicted G&Y.

Interfor-Adams Lake's intent is to use the design described in this report as a blueprint for G&Y monitoring that can be extended beyond the IFPA area to the rest of the Kamloops TSA. Interfor-Adams Lake recognizes that the G&Y issues are not confined to the IFPA boundaries and that a coordinated approach among TSA licensees provides a most cost-effective program.

1.3 REPORT OBJECTIVES

The strategic implementation plan in this report describes the business needs and suggested sampling method to address these needs. A detailed sample plan, to be approved by the Ministry of Sustainable Resources Management (MSRM), will be developed under a separate report.

1.4 TERMS OF REFERENCE

This report was prepared by J.S. Thrower & Associates Ltd. (JST) for Al Thorne, *PEng RPF* of Interfor-Adams Lake. The JST project manager was Guillaume Thérien, *PhD*.

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[1] J.S. Thrower & Associates Ltd. 2001. Professional Memo, sent to Lloyd Wilson (MSRM-Kamloops Forest Region), 14 February, 2001.

[2] Shearwater Mapping Ltd. 1999. Terrestrial ecosystem mapping of Intefor Adams Lake planning area: summary report. Unpubl. Rep. Victoria. 14 pp.

[3] J.S. Thrower & Associates Ltd. 2001. Potential site index for the major commercial tree species in the Adams Lake IFPA area. Unpubl. Rep. Contract No. ALI-254-213. 12 pp.

2. ADAMS LAKE IFPA LANDBASE

2.1 GEOGRAPHIC LOCATION

The Adams Lake IFPA area is located northeast of Kamloops in the Kamloops Forest Region, encompassing both the Kamloops and Clearwater Forest Districts. The IFPA covers 179,700 ha of which 158,500 (88%) is forested land base. The long-term timber harvesting land base (THLB) covers 103,600 ha (58% of the total land base). For CMI purposes, the land base of interest is the forested land base.

Table 1. Land base net down in the Adams Lake IFPA.

Land base	Area (ha)
Total IFPA area	179,700
Forested	158,500
THLB	103,600

2.2 FOREST COVER

Interior Douglas-fir (Fdi) is the main leading species in the Adams Lake IFPA, covering almost 40% of all the forested land base (Table 2). Interior spruce (Sx), lodgepole pine (Pl), balsam (B) and western redcedar (Cw) are other important leading species. About one third of the area is in age class 8 and 9 (141 years and older), while the remaining areas are relatively well distributed among age class 1 to 7.

Table 2. Species and age distribution in the forested land base[1] of the Adams Lake IFPA area.

	Age Class									Total	
Species	1	2	3	4	5	6	7	8	9	(ha)	(%)
Fdi	2,978	1,449	1,012	7,300	9,493	13,256	8,461	14,188	327	58,463	37.7
Sx	5,160	1,961	187	1,557	1,323	1,723	1,614	16,210	4,332	34,066	21.9
B	667	3,337	1,490	909	1,117	1,452	1,510	7,710	571	18,763	12.1
Pl	3,475	399	86	5,284	3,278	3,096	1,049	282		16,952	10.9
Cw	626	1,526	321	602	548	841	1,139	4,905	1,235	11,743	7.6
Decid.	1,035	963	399	2,123	2,010	1,618	560	365	31	9,103	5.9
Hw	182	528	145	130	332	269	223	2,414	1,035	5,258	3.4
Pw	25	41	34	98	78	86	297			659	0.4
Py					9	132	105			246	0.2
Lw	7									7	0.0
Total (ha)	14,154	10,203	3,674	18,004	18,188	22,473	14,958	46,074	7,532	155,260	
(%)	*9.1*	*6.6*	*2.4*	*11.6*	*11.7*	*14.5*	*9.6*	*29.7*	*4.9*		

[1] 3,259 ha are not satisfactorily restocked (NSR) or non-commercial brush (NCBR) in the forested land base.

2.3 ECOLOGICAL DESCRIPTION

The Adams Lake IFPA area is ecologically very diverse. Five biogeoclimatic (BGC) zones and 11 BGC subzones are present in the area. The most important subzones are the ICHmw, ESSFwc, and IDFmw, representing more than 75% of the forested land base (Figure 1).

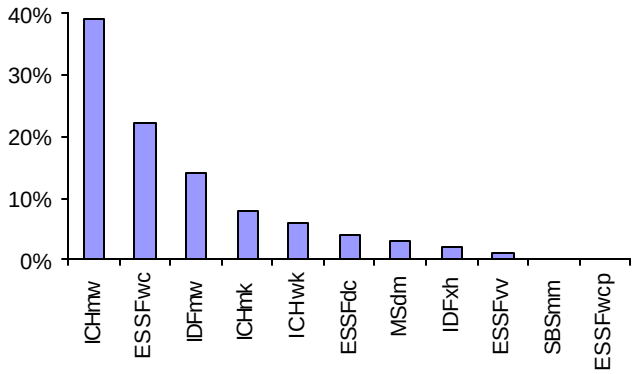

Figure 1. Subzone distribution in the forested land base of the Adams Lake IFPA area.

3. BUSINESS NEEDS

3.1 OVERVIEW

The goals and objectives of the CMI program are driven by Interfor-Adams Lake's business needs. The program must address current business needs and be flexible enough to address potential future business needs. Sections 3.2 to 3.4 describe and prioritize Interfor-Adams Lake business needs as established by Al Thorne, IFPA forester.

3.2 PRIMARY NEEDS

3.2.1 Site Index

Site index is the most important attribute requiring monitoring. Potential site index (PSI), based on ecological site series and species, was assigned to post-harvest regenerated (PHR) stands in the IFPA area for use in timber supply analysis.[3] The PSI represents the expected productivity in PHR stands as estimated from a limited sample. It is therefore imperative that the expected productivity be verified in the field; most specifically for Fdi- and Pl-leading stands as well as stands located in the ICHmw3 BGC subzone which are the most productive sites in the IFPA area.

3.2.2 Net Merchantable Volume

Net merchantable volume in PHR stands is the second most important attribute in the Adams Lake CMI program. The yield of PHR stands is expected to be higher than in natural stands on the same site, and this is a major assumption in the timber supply analysis process. To ensure a sustainable harvest flow, it is essential to ensure that the predicted yield of these PHR stands is achieved on the ground. For this project, it is not deemed necessary at this time to monitor young stands that have not reached merchantable size. Consequently, only stands greater than 20 years of total age are needed in the monitoring sample. This minimum age should also ensure that site trees will have 10 or more years height growth above breast height for site index monitoring.[4] Since there was little harvesting before 1960, we will limit the monitored population to stands established after 1960.

3.3 SECONDARY NEEDS

3.3.1 Wood Quality

Interfor-Adams Lake recognizes the need to monitor the wood quality of PHR stands with attributes such as knot size, ring density, log size, and log grade. The current MSRM CMI sampling protocol does not contain wood quality measurements.

3.3.2 Green-up

Stand adjacency is the main harvesting constraint in the spatial timber supply analysis. A stand cannot be harvested if an adjacent stand is less than 3 m in height (green-up), and thus the time to reach green-up is a significant constraint in timber supply analysis. Currently, this information is derived from height-age curves but is known to be highly variable. Monitoring age to green-up will help define adjacency constraints in spatial timber supply analysis.

[4] The Ministry of Forests (MOF) recommends that tree measured for site index be at least 10 years, breast-height age.

3.3.3 Coarse Woody Debris

Coarse woody debris provides habitat for plants, animals, and insects, is an important source of soil nutrients, and contributes to forest biodiversity. It is therefore desirable to monitor the amount of coarse woody debris in the forests of the Adams Lake IFPA area.

3.3.4 Berry Sites for First Nations

The abundance of berry shrubs (mainly black huckleberry) is a major concern for First Nations for whom berry picking in the IFPA area is a traditional activity. Harvesting can have a major impact (either beneficial or detrimental) on berry sites. Monitoring will track the variation in richness and abundance of berry sites.

3.3.5 Environmental Values

Environmental values such as biodiversity and wildlife habitat will not be included at this stage in this monitoring program. They will be added to the program at a later stage.

4. SAMPLING DESIGN

4.1 OVERVIEW

The sampling design proposed in this section follows the MSRM CMI standards and procedures[5] with some additions to address Interfor-Adams Lake's business needs. These specific needs are described in the sections below and summarized in Appendix I.

4.2 OBJECTIVES

The objectives of the sampling design are to:

1. *Meet Interfor-Adams Lake's primary and secondary monitoring business needs, and*
2. *Provide a flexible system to address possible future needs.*

4.3 TARGET POPULATION

The target population is all the polygons in the forested land base of the Adams Lake IFPA area (excluding NSR and NCBR polygons) between 20 and 40 years of age (10,215). The target population will change over time as natural stands are harvested and regenerated. This population must be reassessed at the beginning of each measurement period to ensure that all new PHR stands are included in the sample. The minimum for future measurements should also be 20 years, but the upper age limit will be defined by the stand establishment year of 1961.

4.4 REMEASUREMENT PERIOD

We suggest that the remeasurement period coincides with the IFPA Forestry Plan (FP) cycle. This is currently set to five years, but could be modified in the future. The remeasurement period could also be lengthened if the CMI program becomes too expensive. A five-year measurement period means that the target population will increase by about 4,300 and 7,800 ha for the second and third measurement periods, respectively (Table 3).

Table 3. Target population area increase for the first three measurement periods.

Measurement Period	Area (ha)
2002-2006	10,215
2007-2011	4,277
2012-2016	7,832

4.5 SAMPLE LOCATION

We suggest that the CMI plot locations be based on a grid originating at the following position: easting=293000, northing=5635000 (Universal Transverse Mercator, North American Datum 83, Zone 11). This will enable easy location of future plots as the PHR population increases since all possible plot locations are automatically known once the grid size is known.

CMI plots will be installed at the selected location regardless or stand condition. The objective is not to study the treatment impacts but to determine if predicted stand growth is achieved in the working forest. Stands where a CMI plots are located should be available for future silvicultural treatments and no special protection consideration should be given to these areas.

[5] Ministry of Forests. 2001. Change Monitoring Inventory: Ground Sampling Procedures for the Provincial Change Monitoring Inventory Program. Version 1.1. Victoria, BC. March 30, 2001. 203 pp. (http://www.for.gov.bc.ca/RIC/PUBS/TEVEG/cmi/assets/cm1.pdf)

4.6 SAMPLE SIZE

Selection of a sample size is one of the most important decisions in designing a G&Y monitoring program. The sample size determines the budget needed to establish and maintain the program over time, and the ability of the data to make meaningful comparisons of G&Y attributes.

We recommend that the CMI plots in the IFPA area be installed on a square grid. The grid size then determines the sample size now and in the future as the population of PHR stands increases over time. The IFPA area now contains about 10,000 ha of PHR stands, which would give sample sizes of about 25 plots using the 2.0 km grid, 45 plots using the 1.5 km grid, and 102 plots using the 1.0 km grid. The sample size for these grids increases at about 2.5 plot/year for the 2.0 km grid, 5 plots/year for the 1.5 km grid, and at about 10 plots/year for the 1.0 km grid.

The sample of 25 plots with the 2.0 km grid is probably adequate to make high-level comparisons of stand volume, but is not enough plots to monitor site index.[6] Given that Interfor's primary goal is to monitor site index, the 1.5 km grid with a sample size of 45 plots may be more appropriate. Alternatives are to use a different grid size to give an intermediate sample size, or to supplement the sample from the 2.0 km grid with temporary plots until the sample size increases to an adequate size in about 10 years.

Assuming establishment costs of $2,500/plot and a re-measurement cost of $1,200/plot, after 15 years, the CMI costs could vary between $90,000 and $368,000, depending on the grid size selected (Table 4). Options to reduce sampling intensity from the basic grid sizes are discussed in Section 4.11.

Table 4. Approximate CMI sample size and cost associated with different grid size for the Adams Lake IFPA area.

Grid Size	Measurement Period	Area (ha)	Plots		Budget		
			Est.	Remeas.	Est.	Remeas.	Total
2.0 km	2002-2006	10,215	25	0	$62,500	$0	$62,500
	2007-2011	4,277	10	25	$25,000	$30,000	$55,000
	2012-2016	7,832	19	35	$47,500	$42,000	$89,500
1.5 km	2002-2006	10,215	45	0	$112,500	$0	$112,500
	2007-2011	4,277	19	45	$47,500	$54,000	$101,500
	2012-2016	7,832	34	64	$85,000	$77,000	$162,000
1.0 km	2002-2006	10,215	102	0	$255,000	$0	$255,000
	2007-2011	4,277	42	102	$105,000	$122,000	$227,000
	2012-2016	7,832	78	144	$195,000	$173,000	$368,000

Note: These costs only include field costs. Costs related to project management, sample plan preparation, data entry, analysis, and reporting are not included.

4.7 PLOT DESIGN

The plot design follows the MSRM CMI plot design standard. This plot is composed of three super-imposed plots divided into eight sectors (Figure 2). In the Main plot (11.28 m radius) all trees larger than 9 cm diameter at breast height (DBH) are tagged and measured. In the Small-tree plot (5.64 m radius),

[6] Stand conditions will not be suitable to estimate site index in all CMI plots, thus the 2.0 km grid that gives 25 sample points will give fewer observations of site index. For example, a relatively high suitability rate of 90% would give 22 observation of site index from these 25 plots. In addition, the site index for all species will be not observed on all plots, thus species specific comparisons of site index would contain much fewer than 22 plots.

trees between 4 and 9 cm DBH are tagged and measured. In the Regeneration plot (2.5 m radius), trees taller than 30 cm but less than 4 cm DBH are tallied by species.

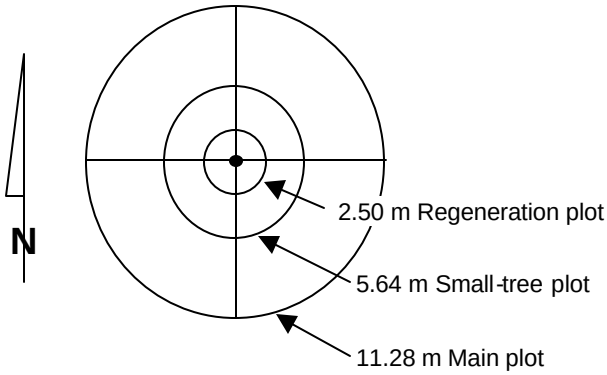

Figure 2. Monitoring sample plot.

4.8 PLOT MEASUREMENTS

4.8.1 Overview

All standard MSRM CMI measurements will be recorded except for the differences outlined in section 4.8.2 to 4.8.6. Additional non-standard measurements will also be recorded (Appendix I).

4.8.2 Plot Cards

Plot navigation and establishment will follow plot cards 1 to 3. Range data (cards 4 and 5) will not be collected. Coarse woody debris (cards 6 and 7) and tree attribute data (cards 8 to 11) will be recorded except stump information (card 10). Soil information will be recorded neither at the pin location (card 12) nor for the dominant stratum (card 13). No ecological succession data will be recorded (card 16). All other ecological data (cards 12 to 15) will be recorded.

4.8.3 Plot Establishment

The CMI plot will be established at the selected grid location. A diagram will show plot crossing the sample polygon boundary and where the polygon boundary is located within the plot. This allows the appropriate comparison of the sample plot to the area-weighted yield tables of the component polygons.

4.8.4 Tree Tags

Brown tree tags will be located at breast rather than stump height. This should simplify the establishment and remeasurement work compared to the MSRM suggestion of stem mapping.

4.8.5 Top Height Trees

The top height tree will be measured in the northeast quadrant of the 11.28 m, rather than from the 5.64 m radius plot. This should facilitate the measurement of site trees without affecting the sampling intensity of top height trees.

4.8.6 Site Trees

The largest diameter tree of all species in a plot quadrant will be measured for breast-height age. If the largest diameter tree of a species is not suitable for estimating site index,[7] the next largest diameter tree suitable for site index will also be cored for age. The largest diameter tree of the leading species (by basal area) will be recorded as the "L" tree, the largest diameter trees of all species representing more than 20% of basal area will be recorded as "S" trees. All other site trees will be recorded as "O" trees. The crew will also record whether the height and age can be used for site index calculations on all site trees.

[7] A tree is not suitable for site index if it has a significant broken top, a significant dead top, a fork or crook that significantly affected height growth, abnormally high amount of scarring or other damage that would have affected height, or if it is a residual tree.

4.8.7 Wood Quality Data

The diameter of branches on whorls closest to 1 and 2 m (from the ground) will be measured and live/dead status recorded. Branch diameter will be measured 2 cm from the bole, but can be estimated if measurement is not practical. The crown radius, height to base of live crown, and height to lowest live limb will also be recorded.

4.9 DATA MANAGEMENT

The field contractor will enter the data into the MSRM VRI data entry software at the end of each field season, and be responsible for data entry quality control. The analysis contractor will compile the data and complete the analysis after each field season.

4.10 ANALYSIS & INTERPRETATION

The first measurement provides estimates to audit PHR stand yield, and stand growth can be analyzed after the second measurement. Graphical analysis of the data can include plotting actual versus predicted values and plotting differences (actual-predicted) versus stand age or other variables of interest. The statistical analysis can include the average differences and associated confidence intervals.

The graphical and statistical analysis methods are tools to examine the data for bias in the growth trends. If the analyses suggest over- or under-prediction, then sources of the differences should be identified. For example, for volume estimates, potential sources of error are the differences between the inventory inputs to the model and the actual stand attributes. Inventory attributes to examine include age, stocking, site index, treatment, species composition, stand structure, and pest or disease incidence.

In the future, as the CMI program develops, it will become possible to post-stratify the data to examine issues on subsets of the PHR stands. A minimum stratum size is approximately 25-30 plots.

4.11 FUTURE MODIFICATIONS

Potential future modifications to the CMI program could include:

1. **Decreasing sample intensity**
   The sampling intensity was selected to build an adequate CMI program as quickly as possible; however, the program will become increasingly expensive as more plots are included in the sample over time. To reduce costs, the sampling intensity can be decreased or plots can be dropped from the program over time. This can be after a high level of reliability has been developed over time in the G&Y predictions used in the IFPA area.
2. **Increasing measurement period**
   Increasing the measurement period is an effective method to reduce sampling costs while maintaining all plots in the program. This option is preferred if we believe that all plots contribute useful information to the CMI program and that historical data are too valuable to be discontinued.
3. **Adding other information**
   Management priorities change over time and this CMI program should provide the flexibility to modify the system as needed to meet new business needs. For example, measurements of other tree and stand attributes can be added to the program at any future time.

5. RECOMMENDATIONS

5.1 IMPLEMENTATION

Interfor-Adams Lake should select a grid size to define the sample size deemed appropriate for the IFPA area. All CMI plots for the first measurement period should be established in 2002. If plots are established over more than one field season, we recommend they be randomly chosen from the plot list for the measurement period. This allows inference to the population after the first field season and maintains the statistical integrity of the sample, if the sample size is reduced.

5.2 NEXT STEPS

The next steps should include:

- Confirm data needs, objectives, and agree on this plan.
- Select the CMI grid size.
- Agree on an implementation schedule.
- Complete the CMI sample plan for the initial installation.

5.3 ROLES AND RESPONSIBILITIES

5.3.1 Interfor-Adams Lake

Interfor-Adams Lake will:

- Coordinate the project.
- Communicate with MSRM.
- Monitor project budget and progress, and communicate to MSRM.
- Ensure the sample packages are assembled and complete.
- Oversee ground-sampling activities.
- Ensure quality assurance is complete.
- Assist in coordinating technical expertise where required.

5.3.2 MSRM

The MSRM will:

- Approve the CMI sample plan.

5.3.3 JST

JST will:

- Write the CMI sample plan.
- Select the plot locations.
- Transfer the plot locations from GIS to air photos.
- Prepare sample packages.

5.3.4 Field Contractor

The field contractor will:

- Complete the fieldwork.
- Complete quality control of fieldwork.
- Enter data.
- Complete quality control on data entry.

5.3.5 Field Auditor

The field auditor will:

- Mentor field crews at the beginning of the fieldwork.
- Perform quality assurance of the fieldwork.
- Prepare report to Interfor-Adams Lake.

5.3.6 Data Analysis Contractor

The data analysis contractor will:

- Compile data.
- Check data after initial compilation.
- Analyze and report on the data.

APPENDIX I – PLOT MODIFICATIONS FROM MSRM CMI STANDARDS

Table 5. Comparison table between MSRM standard and proposed methods.

Card		MSRM Standard	Interfor-Adams Lake
1	Header card	Completed	Completed
2	Compass card	Completed	Completed
3	Cluster layout	Completed	Completed
4	Range sampling – shrub transect 1	Completed	Not completed
5	Range sampling – shrub transect 2	Completed	Not completed
6	Coarse woody debris – transect 1	Completed	Completed
7	Coarse woody debris – transect 1	Completed	Completed
8	Tree details	Trees tagged at stump height	Trees tagged at breast height
9	Tree loss indicators	Completed	Completed
10	Small tree, stump, and site tree data	Stump data collected	Stump data not collected
		Age collected only for largest diameter tree of a species	Age collected for the largest diameter tree and the largest diameter tree suitable for site index
11	Auxiliary plot card	Left blank	Left blank
12	Ecological description 1	Soil features collected	Soil features not collected
		Soil description collected	Soil description not collected
13	Ecological description 2	Soil features collected	Soil features not collected
		Soil description collected	Soil description not collected
14	Tree and shrub layers	Completed	Completed
15	Herb and moss layer	Completed	Completed
16	Successional interpretations	Completed	Not completed