West Fraser Mills Ltd. TFL 52
Pilot Change Monitoring Inventory
Sample Plan
Second Year

Prepared for

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Project: WFQ-030

July 15, 2002

Table of Contents

List of Tables

List of Figures

1. INTRODUCTION

1.1 TERMS OF REFERENCE

JS Thrower & Associates Ltd (JST) completed this Change Monitoring Inventory (CMI) sample plan for Tree Farm License (TFL) 52 for West Fraser Mills Ltd (West Fraser). Earl Spielman, *RPF* is the project leader for West Fraser while Guillaume Thérien, *PhD* (JST) prepared the sample plan. This sample plan is an updated version of the plan that was approved for the first year of the CMI program.[1]

1.2 BACKGROUND

West Fraser is implementing a CMI program in a continued effort to improve management of the forest and other resources on TFL 52.[2] The CMI program follows the completion of several significant programs over the last three years including an updated forest cover inventory, Terrestrial Ecosystem Mapping (TEM), and a site index adjustment (SIA) project for the TFL. West Fraser views this CMI program as the next logical step in building on these investments to provide better information for future management of the TFL, and to ensure that up-to-date information is included in each Management Plan.

1.3 GOALS & OBJECTIVES

West Fraser's primary goal for the CMI program is to provide a high level-of-comfort that growth and yield (G&Y) estimates used in timber supply analyses adequately reflect actual G&Y of trees and stands on the TFL. The intent is to focus initially on post-harvest regenerated (PHR) stands. The CMI program is designed to detect practically significant differences[3] between actual and predicted changes in key attributes – the program is not designed to explain why potential difference may exist. In other words, the CMI program functions as an early warning system to detect differences that may impact forest management on the TFL.

The specific objectives of the CMI program are to:

1. *Define West Fraser's corporate objectives*
2. *Prioritize these corporate objectives.*
3. *Develop a flexible sample design that meets the corporate objectives and that can be modified to address potential future objectives.*

2. CORPORATE OBJECTIVES

2.1 OVERVIEW

The many potential uses and needs for information that could come from a CMI program must be evaluated considering costs, benefits, uncertainty in management processes, and potential future changes. This CMI sampling design for TFL 52 focuses on addressing the primary and secondary

[1] J.S. Thrower & Associates Ltd. 2001. West Fraser Mills Ltd. TFL 52 Pilot Change Monitoring Inventory Sample Plan. Unpubl. Report, Contract No. WFQ-101-025, July 13, 2001. 13 pp.

[2] The TFL 52 landbase is described in Appendix I.

[3] Practically significant differences (as opposed to statistically significant differences) are defined as ones large enough to impact management decisions. Timber supply sensitivity analyses can be used to determine practically significant differences.

corporate objectives listed below. The other potential corporate objectives discussed below were also considered in developing this design.

2.2 PRIMARY OBJECTIVE

West Fraser's primary business need for a CMI program on TFL 52 is to monitor and track the G&Y of PHR stands (change in net merchantable volume and mean annual increment [MAI]). The volume in most PHR stands is projected to be higher than natural[4] stands on the same sites. This increased projected yield exerts upward pressure on forecasted timber supply, thus it is important that the G&Y of these stands is closely monitored to ensure this increased growth is achieved on the landbase. The need to closely monitor these stands will likely decrease over time as we develop more experience with PHR stands.

2.3 SECONDARY OBJECTIVE

West Fraser's most important secondary business need for a CMI program on TFL 52 is to monitor the site index of PHR stands. This is closely related to the primary need to monitor overall G&Y, but this specifically targets a major component that impacts overall G&Y. The increased site indices projected for PHR stands is the primary reason why overall G&Y is forecasted to be higher than in natural stands on the same site, thus it is critically important that site index is specifically addressed in the CMI program.

2.4 OTHER OBJECTIVES

Other potential objectives from a CMI program on TFL 52 were identified by West Fraser as:

1) **Monitoring G&Y in Natural Stands**
   The current objective is primarily focused at PHR stands, however, West Fraser would like the design to allow potential future sampling and monitoring of natural stands on the TFL. The suggested grid design described in this sample plan can accommodate this objective (discussed in more detail later in this sample plan).

2) **Monitoring Forest Health**
   West Fraser is concerned that the potentially large impact from some forest health elements may warrant monitoring in the future (e.g., spruce weevil and pine stem rusts [comandra, stalactiform, and western gall]). West Fraser would like information on endemic disease, insect attack, and the impact on PHR yields. However, we suggest that this CMI program is not appropriate for monitoring these attributes. The CMI program includes a very extensive and small sample across the TFL. This is appropriate for most G&Y attributes, but likely will not adequately sample forest health attributes. Specific forest health issues should be dealt with in special projects outside the CMI program. For instance, monitoring the population level of the spruce weevil can be better achieved by intensively sampling spruce stands with special temporary sample plots. These special programs can be linked to the CMI program, but the CMI program alone will not address these issues.

3) **Developing G&Y Models**
   Data from the CMI plots could theoretically be used to develop G&Y models. However, the CMI sample size is likely too small to be of much use for G&Y modelling. Also, using the CMI data to develop G&Y models may compromise the independence of the monitoring data from the information

[4] For the purpose of this document, natural stands are all stands older than 40 years.

that it is to check. Thus, we suggest that each future modelling need be evaluated separately as to whether or not it is appropriate to use the CMI data for model development.

4) **Third Party Market Certification**
Third party certification may be a future objective on the TFL, thus West Fraser would like the CMI program to be flexible to increase the likelihood that it could provide information for certification. We do not know the exact requirements of potential future certification schemes, however, this CMI contains the basic elements that should allow reporting on the landbase to meet basic certification requirements. Some changes may be required to the CMI program described in this sample plan, such as sampling the entire TFL, or adding other non-tree attributes to those measured in each plot.

3. SAMPLE DESIGN

3.1 OVERVIEW

The sample design provides a set of representative sample points from a 2-km grid across PHR stands on TFL 52. The grid size was chosen to generate 50–100 points in PHR stands between 15 and 40 years of age in the first measurement period. This design will provide data to compare G&Y for all PHR stands in aggregate[5] and for spruce leading stands (the most predominant). The sample size is not large enough to separately check G&Y estimates for stands with other leading species.

3.2 OBJECTIVES

The primary objective of the CMI program on TFL 52 is to:

Monitor the change in net merchantable volume in PHR stands.

The secondary objectives of the CMI program are to:

1. *Monitor the change in site index in PHR stands.*
2. *Use a flexible design that can be modified for future potential information needs.*

In developing this program, we consider G&Y monitoring as *the process of comparing the actual G&Y of a forest or stand to the predicted or expected G&Y for that forest or stand.* This program is designed to check existing G&Y predictions for PHR stands – not to develop new G&Y predictions or estimate stand response to silviculture treatments; however, these data may be used to develop other tools.

3.3 TARGET POPULATION

The target population at the beginning of the TFL 52 CMI program is all PHR stands between 15 and 40 years of age (since disturbance). This age range is used to limit sampling to stands that have merchantable volume (thus the minimum of 15 years) and that are of post-harvest origin (thus the upper limit of 40 years). This definition may change in the future if West Fraser decides to include natural stands in the CMI program.

[5] The question being asked is: over the entire TFL, are PHR stands on average growing as expected?

3.4 SAMPLE LOCATION

We suggest locating CMI plots in PHR stands on a 2-km grid over the TFL. Plots can either be randomly or systematically located without compromising the statistical validity of the design. Plots located systematically on a grid will cover practically as many conditions as random plots and are more convenient since plot locations are automatically known once the grid size is defined.

3.5 SAMPLE SIZE

The 2-km grid[6] gives 78 plots in PHR stands as of 2001 and 141 PHR plots after 20 years (Table 1). A 4-km grid can then be used in natural stands if West Fraser decides this is a priority in the future. The 4-km grid would give a possibility of 117 plots in natural stands. The sample list for the first measurement period is given in Appendix III.

Table 1. Number of plots to be installed by measurement period.

Stand Type	Grid Size 2-km	4-km
PHR – 1st Period	78	21
PHR – 2nd Period	23	7
PHR – 3rd Period	15	4
PHR – 4th Period	25	10
Natural Stands	484	117

The sample size is determined by the grid spacing and the area targeted for sampling in the TFL. The two main criteria influencing the choice of grid size is the sample size that will be achieved in the target area today, and how this sample size will increase over time as the target area expands (i.e., as natural stands are harvested, regenerated, and included in the target population of PHR stands).

3.6 PLOT DESIGN

The plot design is the Ministry of Sustainable Resource Management (MSRM) standard CMI plot for tree attributes (Figure 1). The Main plot is 400 m^2 (11.28 m radius) where all trees greater than 9 cm diameter at breast-height (DBH) are measured and tagged. Trees between 4 and 9 cm are measured and tagged in the Small-Tree plot (100 m^2, 5.64 m radius), and all trees taller than 30 cm but less than 4 cm DBH are measured and tagged in the Regeneration plot (19.6 m^2, 2.50 m radius).

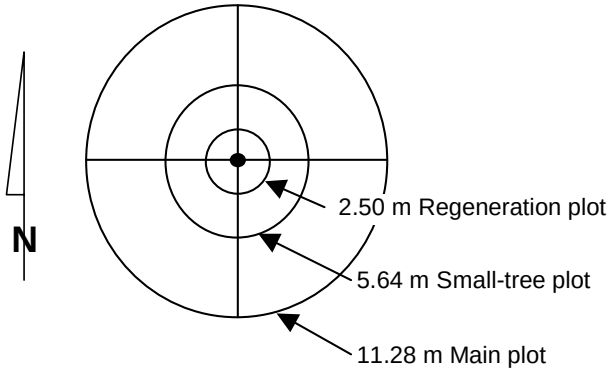

Figure 1. Monitoring sample plot.

3.7 REMEASUREMENT PERIOD

We recommend a five-year remeasurement period to coincide with the 5-year MP cycle. Remeasurement of these CMI plots every five years will provide new information to check the PHR yield curves for each timber supply analysis. The remeasurement period can be lengthened after more comfort is developed in yield estimates for PHR stands.

[6] Different grid sizes were discussed with Earl Spielman before the 2-km grid was chosen.

3.8 PLOT MEASUREMENTS

3.8.1 Overview

Most of the MSRM CMI standard field procedures are used. However, information is not collected on range data in the first measurement period. Among timber attributes, only stump data is not recorded. Unlike last year, coarse woody debris and stem-map information will be recorded this year. Only a visual estimate of the biogeoclimatic site series as well as site features at pin location are recorded on the Ecology Header (EH) card; however, future modifications to the program may include more detailed ecological measurements. Modifications to the MSRM standard field procedures are summarized in Appendix II.

3.8.2 Tree Tags

Brown tree tags are affixed at breast rather than at stump height as recommended in the CMI protocol. This simplifies the work without making the plot unduly visible.

3.8.3 Top Height Tree

The age of the largest diameter tree in the first quadrant is measured. This tree is the top height tree in the MSRM CMI standards and is identified as the "T" tree.[7] The MSRM standard is to select this tree from the 5.64 m radius plot, however, selecting from the first quadrant is simpler given our plot design that uses four quadrants.

3.8.4 Site Trees

Leading and second species are not determined prior to selecting site trees. The age of the largest diameter, dominant or co-dominant, tree of each species in each quadrant is measured. This automatically ensures that age for the leading and second species are collected. If the largest diameter tree of a given species (coded as "S" tree) is not suitable for height and age, the next largest diameter tree suitable for height and age will be selected (and coded as "O" tree). If a site tree is between 4 and 9 cm DBH, outside the Small-tree plot but inside the Main plot, this site tree will be tagged and the height will be recorded in the site tree section on Card 10.

3.9 DATA MANAGEMENT

Data will be entered at the end of the field season using the most recent version of VIDE, the data entry software for VRI and CMI data. JST will compile the data using the MSRM CMI data compiler.

3.10 ANALYSIS & INTERPRETATION

Only yield estimates are provided after the first measurement. These estimates can be used to audit the yield of PHR stands. Change can only be estimated with two or more measurements. After the second measurement is completed, differences between measured and predicted G&Y for the main attributes of interest can be estimated. After the field season, an analysis of the first two years of data will be completed. Graphical analysis will include plotting actual versus predicted values and plotting differences (actual-predicted) versus stand age or any other chosen variables to examine trends. The statistical analysis will include the average differences and associated confidence intervals.

[7] With the difference that the CMI top height tree is generally measured in the 5.64-m radius plot, not the first quadrant of the 11.28-m radius plot as we propose.

The graphical and statistical analysis methods are intended as tools to examine the data for possible overall trends of over- or under-prediction – these analyses are not meant as definitive tests. If the analyses suggest over- or under-prediction, then possible sources of the differences should be identified. For example, when considering volume estimates, potential factors to consider as sources of mean error are the differences between the inventory inputs to the model and the actual stand attributes. Potential inventory attributes to examine include stocking, site index, treatment, species composition, stand structure, and pest or disease incidence.

When the CMI program includes enough plots, it will be possible to post-stratify the data to examine issues on subsets of the PHR stands. A minimum sample size in a stratum would be approximately 30 plots. For example, if all 78 CMI plots established in the first measurement period are remeasured in the second measurement period, it would give 44 CMI plots in spruce leading polygons, a sample large enough to check G&Y predictions for spruce leading stands.

3.11 FUTURE MODIFICATIONS

Future modifications to the CMI program could include:

1) **Decreasing sample intensity**
   The intensity of sampling PHR stands can be decreased in the future as more plots are located in PHR stands. The number of plots in the CMI program will increase as more natural stands are harvested, regenerated, and brought to the minimum age of 15 years from disturbance. At some point in the future, the cost of the program may become too high and West Fraser may want to reduce costs. This can be done by randomly dropping some plots in older PHR stands where the comfort on predicting stand yield is higher, or by increasing the measurement period of some plots.

2) **Increasing measurement period**
   The 5-year measurement period is convenient because it corresponds to the MP schedule. However, this period could change if the MP cycle changes, if a higher level of comfort is developed in PHR yield estimates, or if West Fraser wants to decrease the cost of the program. The advantage of an increased measurement period is lower costs, however, the disadvantage is that less information can be obtained from the data, and linking previous measurements will be more complicated.

3) **Expanding the CMI program to natural stands**
   West Fraser has indicated a potential need to monitor the G&Y of the entire TFL, including natural stands. The CMI program described in this sample plan can be modified to meet this need by establishing plots on a 4-km grid in these natural stands. This would require 117 plots in natural stands in addition to the 78 plots to be located in PHR stands (Table 1). However, as harvesting occurs on the TFL, the sample size in natural stands decreases and the sample size in PHR stands increases. Assuming a constant level of funding, we can expect that for each new natural stand sampled, a PHR sample point will be randomly dropped (Section 3.4).

4) **Adding other information**
   New tree measurements can be added to the CMI program at any time in the future. For example, measurements of branch size, tree taper, or wood quality could be included in the next measurement cycle. This would provide the same representative sample, but change estimates could not be

computed until two or more measurements of the same attribute were taken. Future additions could also include more detailed ecological descriptions or estimates of coarse woody debris.

4. SCHEDULE AND BUDGET

We have suggested that the CMI plots be established over a 3-year period. Last year, first year of the CMI program, 24 plots were established. This year we suggest establishing 30 plots. We suggest using the plot schedule for 2002 included in the original sample plan (Appendix III). An interim report will be produced at the end of the second year and a detailed report will be produced after the initial set of plots is established in the 2003/2004 fiscal year.

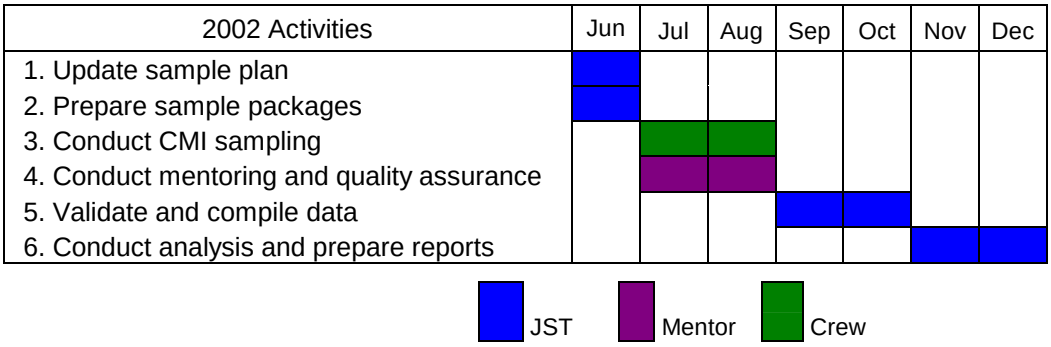

Figure 2. CMI implementation schedule in 2002.

Total budget for this project is **$78,000.**

5. ROLES AND RESPONSIBILITIES

5.1 WEST FRASER

West Fraser will:

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

5.2 QUALITY ASSURANCE/MENTORING CONTRACTOR

An independent third party contractor will:

- Mentor field crews at the beginning of the fieldwork.
- Conduct quality control of the fieldwork.

5.3 J.S. THROWER & ASSOCIATES LTD.

JST will:

- Prepare the sample plan.
- Select the plot locations.
- Transfer plot locations from GIS to air photos.
- Prepare sample packages.
- Conduct fieldwork.
- Conduct quality assurance of fieldwork.
- Enter data.
- Conduct quality assurance on data entry.
- Compile data.
- Check data after initial compilation.
- Analyze and report on the data.

APPENDIX I – TFL 52 LANDBASE

West Fraser's TFL 52 is located northeast of Quesnel and west of the Bowron Lake Provincial Park. The TFL covers approximately 260,000 ha, of which 234,000 ha (90%) are productive (Table 2). The TFL contains rolling plateaus in the west and the Cariboo Mountains in the east. The TFL contains the headwaters of the Cottonwood, Bowron, and Willow Rivers, which all flow into the Fraser River.

Table 2. Area distribution.

	Area	
Landbase	(ha)	(%)
Entire Landbase	259,805	
Non-Forested	20,655	8
Forested	239,150	92
Non-Productive	5,125	2
Productive	234,025	90

Interior spruce (Sx), lodgepole pine (Pl), and balsam (Bl) account for about 95% of all leading species in the productive forest of the TFL (Table 3). Almost half the area is covered by stands 121 years and older and 25% of the stands are less than 40 years of age.

Table 3. Area distribution by species and age class.

	Age Class									Total	
Spp	1	2	3	4	5	6	7	8	9	(ha)	*(%)*
Sx	25,957	7,105	1,334	6,189	7,390	5,044	4,266	51,538	1,977	110,800	*47%*
Pl	15,988	4,474	597	4,411	8,767	10,237	7,579	7,347	13	59,412	*25%*
Bl	649	777	3,576	4,228	8,664	5,971	6,186	23,882	176	54,109	*23%*
At	556	1,154	433	1,125	863	815	483	13	0	5,442	*2%*
Fd	157	567	13	28	78	240	166	1,131	5	2,387	*1%*
Ep	46	252	97	67	146	21	0	0	0	629	*0%*
Sb	0	2	29	34	12	305	72	109	0	563	*0%*
Ac	65	102	7	14	92	118	35	96	3	532	*0%*
Cw	11	0	0	0	0	0	0	63	14	87	*0%*
Hw	0	0	0	0	0	0	2	62	0	64	*0%*
Total (ha)	*43,429*	*14,433*	*6,084*	*16,097*	*26,011*	*22,751*	*18,790*	*84,241*	*2,189*	*234,025*	
(%)	*19%*	*6%*	*3%*	*7%*	*11%*	*10%*	*8%*	*36%*	*1%*		

APPENDIX II – PLOT MODIFICATIONS FROM MOF CMI STANDARDS

Attribute	MOF CMI Standard	TFL 52
Plot Establishment		
Tree tags	tags affixed at stump height	tags affixed at breast height
Plot Measurements		
Range data	Collected	Not collected
Ecology data	Collected	Not collected except for a visual estimation of site series
Tree Measurements		
Top Height	Chosen in 5.64-m plot	Chosen in northeast quadrant of 11.28-m plot
Leading/Second Species	Determined in the field	Not determined in the field
Non-Largest DBH trees	No age measured	Age measured if largest DBH tree not suitable for site index
Stumps	Collected	Not collected

APPENDIX III – TFL 52 CMI SAMPLE LIST – SECOND YEAR

Sample Year	Plot Number	UTM Easting	UTM Northing	Mapsheet-Polygon	Total Age
2002	546-5890	546,000	5,890,000	093G019 322	25
2002	548-5878	548,000	5,878,000	093G009 480	30
2002	548-5888	548,000	5,888,000	093G019 405	26
2002	548-5890	548,000	5,890,000	093G019 347	26
2002	550-5880	550,000	5,880,000	093G009 345	24
2002	552-5880	552,000	5,880,000	093G009 408	29
2002	558-5880	558,000	5,880,000	093G010 232	23
2002	558-5884	558,000	5,884,000	093G020 1083	28
2002	558-5890	558,000	5,890,000	093G020 1218	17
2002	562-5894	562,000	5,894,000	093G020 131	16
2002	564-5910	564,000	5,910,000	093G040 172	20
2002	570-5872	570,000	5,872,000	093A091 198	30
2002	572-5870	572,000	5,870,000	093A091 477	27
2002	576-5902	576,000	5,902,000	093H021 477	23
2002	576-5904	576,000	5,904,000	093H021 1249	18
2002	576-5906	576,000	5,906,000	093H021 188	15
2002	578-5870	578,000	5,870,000	093A091 469	19
2002	580-5864	580,000	5,864,000	093A091 1380	20
2002	586-5856	586,000	5,856,000	093A082 858	15
2002	590-5906	590,000	5,906,000	093H022 107	19
2002	592-5896	592,000	5,896,000	093H022 1359	37
2002	598-5896	598,000	5,896,000	093H023 1299	23
2002	602-5904	602,000	5,904,000	093H023 367	23
2002	606-5892	606,000	5,892,000	093H013 540	29
2002	606-5908	606,000	5,908,000	093H033 203	17
2002	608-5910	608,000	5,910,000	093H034 170	35
2002	610-5906	610,000	5,906,000	093H024 124	21
2002	612-5906	612,000	5,906,000	093H024 93	17
2002	614-5886	614,000	5,886,000	093H014 717	28
2002	616-5884	616,000	5,884,000	093H004 136	27