Change Monitoring Inventory
Pilot Project for the Merritt IFPAs

Strategic Implementation Plan

Prepared for

Larry Henry, RPF
Nicola-Similkameen Innovative Forestry Society
Merritt, BC

Project: MTI-317
Contract No: 723803-6425

March 21, 2002

J.S. Thrower & Associates Ltd. *Consulting Foresters*
Vancouver – Kamloops, BC

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1. INTRODUCTION

1.1 BACKGROUND

The Nicola-Similkameen Innovative Forestry Society (NSIFS) was established by five Forest Licence holders, two First Nations Band Councils, and the Small Business Forest Enterprise Program (SBFEP) in the Merritt Timber Supply Area (TSA), to implement the Merritt Innovative Forestry Practices Agreements (IFPAs) on the TSA land base.[1] The IFPAs were granted in July 1997, and the implementation of the environmental and growth and yield programs began in 1998. Since then, Vegetation Resources Inventory (VRI), Predictive Ecosystem Mapping (PEM), Site Index Adjustment (SIA), and managed stand yield tables have been developed or are in progress to provide more accurate growth and yield (G&Y) estimates to incorporate into the spatial timber supply analysis. On December 31, 2001, the NSIFS Board of Directors sent a proposal to the Kamloops Regional Manager requesting a 430,000 m^3 increase in the Allowable Annual Cut (AAC) for the Merritt TSA, based on an aspatial timber supply analysis.[2]

The NSIFS wants to establish a process that will ensure that any change in the current AAC will not negatively affect other resource values. A Change Monitoring Inventory (CMI) program, associated with a series of audits, will help demonstrate that the projections from the G&Y models used in the spatial timber supply analysis are accurate, and that set inventory targets are achieved. The program will act as an early warning system should the productivity of the forest deviate from the G&Y projections.

1.2 CMI GOALS & OBJECTIVES

The overall goal of a CMI program is to ensure that forest management decisions are based on realistic projections of the different forest resources. The specific objectives of the CMI program are to:

1. *Define the NSIFS's CMI business needs.*
2. *Develop a flexible sampling design that meets these business needs, and that can be modified to address potential future needs.*
3. *Install sample plots across targeted areas in the IFPAs.*
4. *Maintain the program by remeasuring plots according to a predetermined schedule.*
5. *Compare actual with predicted G&Y estimates for the sampled area at each measurement.*
6. *Analyze the information to detect significant practical[3] differences, should they occur.*

1.3 REPORT OBJECTIVES

This report is a strategic implementation plan for the NSIFS CMI program. It describes the land base, outlines the CMI business needs, and proposes a sampling design for the CMI program. A detailed sampling plan will follow once the NSIFS and Ministry of Sustainable Resource Management (MSRM) review and accept this implementation plan.

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[3] Practical differences are differences that affect management decisions, and are not necessarily related to statistical differences.

1.4 TERMS OF REFERENCE

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2. MERRITT IFPA LAND BASE

2.1 GEOGRAPHIC LOCATION

The area in the Merritt IFPAs covers the entire Merritt TSA land base. The TSA is located in the Kamloops Forest Region and extends from the US border in the south to the Kamloops TSA in the north, and from the Coastal Range on its western border to the Okanagan Valley to the east. It covers 1.13 million ha (Table 1), of which 0.84 million ha is the public, productive forest land base (PFLB).[4]

Table 1. Land base net down of the Merritt IFPAs.

Land base	Area (ha)
Total IFPAs	1,129,494
Crown Land	932,655
PFLB	835,342

2.2 FOREST COVER

The PFLB in the Merritt IFPAs is divided in two main management zones: the selection management zone ([SMZ], about 112,000 ha) and the remaining areas ([Non-SMZ], about 723,000 ha). The SMZ is defined using the following criteria:[5,6]

1. Douglas-fir (Fd) leading stands with basal area greater than 80% of the total, or Fd leading with ponderosa pine (Py), larch (L) or deciduous as the second species in the BG biogeoclimatic (BGC) zone, or PPxh, IDFxh, IDFdk1, IDFdk2, and MSxk subzones.
2. Py or L leading in the BG zone, or PPxh, IDFxh, IDFdk1, IDFdk2, and MSxk subzones.

Due to the partial cutting history in the SMZ, most stands in this management zone are uneven-aged. In the Non-SMZ areas, clearcut is the most common harvesting method. The SMZ is mostly Fd leading, while the Non-SMZ areas are mostly lodgepole pine (Pl) leading. In the Non-SMZ areas, Fd, interior spruce (Sx), and balsam (Bl) are also important leading species. The age distribution in the Non-SMZ areas is skewed towards the older age classes (Table 2).[7]

Table 2. Area ('000 ha) in the PFLB of the Merritt IFPAs by management zone, species, and age class.

Species	SMZ All	Non-SMZ Age Class 1	2	3	4	5	6	7	8	9	Non-SMZ Total	IFPA Total
Pl	0	50.5	7.6	28.8	67.2	40.7	74.9	77.7	55.9	4.4	407.7	407.7
Fd	95.8	3.1	5.0	6.5	11.7	19.5	26.2	21.8	50.2	6.3	150.3	246.1
Sx	0	9.3	1.8	0.8	1.5	2.3	5.8	7.6	30.8	15.4	75.3	75.3
Bl	0	2.9	3.0	3.3	4.9	7.5	6.7	4.6	16.7	3.3	52.9	52.9
Py	15.5	0.2	0.2	0	0.1	0	0	0.1	1.3	0.5	2.4	17.9
Others	0.2	0.4	1.0	1.2	2.2	2.6	1.2	0.7	0.8	0.1	10.2	10.4
Total (ha)	*111.5*	*66.4*	*18.6*	*40.6*	*87.6*	*72.6*	*114.8*	*112.5*	*155.7*	*30*	*698.8*	*810.3*
(%)	*14%*	*8%*	*2%*	*5%*	*11%*	*9%*	*14%*	*14%*	*19%*	*4%*	*86%*	*100%*

Note: 24,701 ha of non-productive/not satisfactorily restocked areas in the PFLB are not included.

[4] The PFLB was defined as all area with ownership code ≥ 60, and with a null non-productive forest descriptor.

[5] This definition corresponds to analysis units 1 and 2 used in TSR 2.

[6] Ministry of Forests. 2001. Timber Supply Review (TSR 2). Merritt Timber Supply Area analysis report. British Columbia Ministry of Forests. Victoria, BC. March 2001. 126 pp.

[7] The age distribution in the SMZ is not reported since most stands in that zone are uneven-aged.

2.3 ECOLOGICAL DESCRIPTION

The climate of the Merritt TSA is variable and includes arid, hot lowlands, cold alpine areas, and more humid-temperate coastal transition areas. The TSA contains eight BGC zones that reflect this climatic variation (Table 3). Most of the area in the Merritt IFPAs is in three BGC zones: Interior Douglas-fir (IDF), Montane Spruce (MS), and Engelmann Spruce-Subalpine Fir (ESSF). Only a minor portion is located in coastal BGC zones (CWH and MH).

Table 3. Area distribution in the Merritt IFPAs by BGC zone.

			Area	
BGC Zone	SMZ	Non-SMZ	(ha)	(%)
IDF	97,469	246,973	344,442	41
MS	4,495	295,143	299,638	36
ESSF		175,805	175,805	21
PP	9,328	573	9,901	1
AT		3,544	3,544	0
CWH		1,428	1,428	0
BG	298	36	334	0
MH		250	250	0
Total (ha)	*111,590*	*723,752*	*835,342*	
(%)	*13%*	*87%*		*100%*

3. CMI BUSINESS NEEDS

3.1 PRIMARY NEED

The primary need for this CMI program is to demonstrate that the AAC is compatible with the observed growth in net merchantable volume. In the NSIFS's AAC application,[2] net merchantable volume growth was predicted using different methods for the Non-SMZ post-harvest regenerated (PHR), the Non-SMZ natural stands, and the SMZ stands. In Non-SMZ PHR stands, yield tables were generated using *Batch TIPSY* (version 3.0a) and the site index estimates were developed by a group of JST site productivity experts.[8] In the Non-SMZ natural stands, yield tables were generated using *Batch VDYP* (version 6.6d) and the inventory inputs. For SMZ stands, modified yield tables were developed using *Batch VDYP* (version 6.6d) and the inventory inputs.[9]

Non-SMZ natural stands are not a monitoring priority at this point for the NSIFS, so the CMI program target population will be stratified into SMZ and Non-SMZ PHR stands to monitor change in each stratum more accurately.

Non-SMZ PHR stands are defined as all stands between 21 and 40 years of age. Stands less than 21 years old likely do not have merchantable volume (assuming inventory age is correct). Hence, measuring these stands is not cost-effective. The upper limit of 40 years was chosen because very few stands established before 1962 are considered managed stands.

3.2 SECONDARY NEEDS

3.2.1 Wildlife Habitat

An AAC increase should not come at the expense of the quantity and quality of wildlife habitat. Rather than measuring the rate of change in wildlife habitats, criteria and indicators (C&I) will be defined and agreed upon by all stakeholders. Every five years, independent inventories will be used to measure indicators, and check that criteria have been met. These independent inventories will serve as audits for wildlife habitat. These C&I are not part of the CMI program and will be carried out separately.

3.2.2 First Nations Needs

It is important that an AAC increase respect the needs of the First Nations. There are eight First Nations bands involved in the Merritt IFPAs. While these bands have similar specific needs (e.g., berry production sites, plant collection areas, and fish and wildlife harvesting areas), they will need information for their individual territories rather than for the entire land base of the IFPAs. Defining C&I specific to each band followed by independent inventories is the most appropriate method to address this business need. This objective is not implicitly part of the CMI program.

Completing an independent inventory of each First Nations territory will provide accurate, but costly information. Thus, merging territories prior to sampling could increase the accuracy/cost ratio. Discussions with the First Nations should take place to explain the costs and benefits of merging territories before sampling.

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[8] These experts were Tara McCormick, *BSc*, Ian Cameron, *MSc RPF*, and Jim Thrower *PhD RPF.* More detail on this process is given in the AAC application document.

[9] Yield curves for the SMZ stands were adjusted based on revised periodic annual increments (PAIs) developed from previous studies.

4. SAMPLING DESIGN

4.1 OVERVIEW

The sampling design must meet the monitoring needs of the NSIFS and the MSRM standards. The sampling design follows the MSRM CMI standards and procedures[10] with a few modifications. These modifications are discussed below and summarized in Appendix I.

4.2 OBJECTIVES

The objectives of the sampling design are to establish a sampling framework that:

- Meets the NSIFS's main business need that volume projections are being achieved on the ground.
- Is flexible enough to address future monitoring needs.

4.3 TARGET POPULATION

The target population is all SMZ stands and the Non-SMZ PHR stands between 21 and 40 years of age. The SMZ population (111,590 ha) will not change over time unless: 1) the species composition in the inventory is modified, or 2) the NSIFS undertakes alternative silviculture management of the SMZ. The Non-SMZ PHR target population (24,956 ha) will grow as more stands reach the minimum age of 21 years before the beginning of each measurement period. Stands that grow older than the upper age limit (40 years) will continue to be remeasured. Hence, stands can be added but not deleted from the PHR population.

4.4 REMEASUREMENT PERIOD

We recommend that the plots be remeasured every five years to coincide with the five year Forestry Plan (FP) cycle. The remeasurement period can be lengthened if the monitoring program becomes too costly or if FP cycles are lengthened. Based on a five year remeasurement period, the PHR population will grow by about 20,000 ha for the next two measurement periods, followed by another increase of about 15,000 ha in the fourth measurement period (Table 4).

Table 4. CMI plot remeasurement schedule.

Stratum	Age (yrs)	Measurement Period	Area (ha)	Plots		
				New	Remea-sured	Total
Non-SMZ PHR	21-40	2002-2006	24,956	31	0	31
	16-20	2007-2011	19,860	32	31	63
	11-15	2012-2016	20,630	37	63	100
	6-10	2017-2021	16,166	29	100	129
SMZ	All	2002-2006	115,590	52	0	52

4.5 SAMPLE SELECTION

We suggest that the CMI plot locations be based on a 2.5 km grid originating at the following coordinates: 617,500, 5,430,000 (Universal Transverse Mercator, North American Datum 83, zone 10). This will enable easy location of future plots as the Non-SMZ PHR population increases, since all possible plot locations are automatically known at the beginning of the CMI program.

[10] Ministry of Forests. 2001. Change Monitoring Inventory: ground sampling procedures for the provincial monitoring inventory program. Version 1.1. Ministry of Forests. Resources Inventory Branch. Victoria, BC. January 2001. 203 pp.

4.6 SAMPLE SIZE

4.6.1 Non-SMZ PHR Stratum

A 2.5 km grid corresponds to a sampling intensity of one plot/625 ha. However, the theoretical and achieved sampling intensities can be different due to the spatial distribution of the population. Based on the current inventory, the proposed grid size would provide a network of 129 plots in the Non-SMZ PHR stratum at the end of the fourth measurement period (Table 4).

The sample size must be large enough to allow post-stratification and still provide an adequate sample size for an important sub-set of the population. This can be achieved using the 2.5 km grid. For instance, Pl leading stands represent about 70% of the Non-SMZ PHR population. The proposed grid provides 42 plots in Pl-leading stands after the second measurement period, and 102 plots at the end of the fourth measurement period.

4.6.2 SMZ Stratum

To be cost-effective, we suggest sampling every other grid point in the SMZ stratum. This is equivalent to using a 5 km grid, or a sampling intensity of one plot/2,500 ha, creating a sample size of 52 plots. This sample size will likely be insufficient to detect statistical differences in the SMZ since there exists a wide variety of stand conditions in this management zone. However, considering the lack of G&Y information in the SMZ, the proposed sample size should provide basic information that could be used to prepare a more refined sampling design for that zone. If the SMZ monitoring sampling design is changed in the future, the 52 SMZ CMI plots can still be used for modeling purposes.

4.6.3 Measurement Schedule

The proposed sampling intensity suggests 83 CMI plots (31 in the Non-SMZ PHR stratum, 52 in the SMZ) should be established in the first measurement period. These plots need to be remeasured in the second period with 32 new plots being established in the Non-SMZ PHR stratum, for a total of 115 plots to be measured (63 in the Non-SMZ PHR stratum, 52 in the SMZ). The sampling for each measurement period should be done in the same year. If this is not possible, the plots should be measured within two years. For the first measurement period, that would mean 42 plots/year.

4.7 PLOT DESIGN

The plot design follows the MSRM standard CMI protocol for tree attributes (Figure 1).[5] The main plot is 400 m^2 (11.28 m radius) where all trees greater than 9.0 cm diameter at breast-height (DBH) are measured and tagged. Trees between 4 cm and 9 cm DBH are measured and tagged in the small-tree plot (100 m^2, 5.64 m radius), and trees taller than 30 cm and less than 4 cm DBH are measured and tagged in the regeneration plot (19.6 m^2, 2.50 m radius).

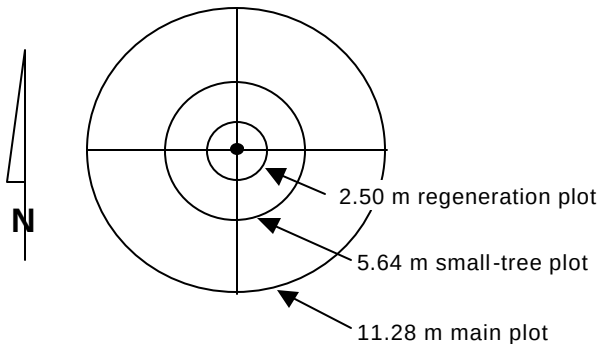

Figure 1. Monitoring sample plot.

4.8 PLOT MEASUREMENTS

4.8.1 Overview

All standard MSRM plot measurements will be recorded, except for range, coarse woody debris, soil, and ecological succession information. No custom measurements will be recorded in this project.

4.8.2 Plot Cards

Plot navigation and establishment will follow plot cards 1 to 3. No range (cards 4 and 5) or coarse woody debris data (cards 6 and 7) will be collected. Tree attributes (cards 8 to 11) will be collected as per the MSRM standards. Site classification and site features data (cards 12 and 13) will be collected. Soil information will not be taken at the pin location (card 12) or for the dominant stratum (card 13), vegetation lists of the tree, shrub, herb, and moss layers (cards 14 and 15) will not be recorded, and ecological succession data will not be taken (card 16).

4.8.3 Plot Establishment

The CMI plot will be established at the selected grid location. When a plot appears to cross the sample polygon boundary, a diagram will be drawn to explain clearly where the polygon boundary is located within the plot. This will allow 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-height rather than stump-height as recommended in the MSRM CMI standards and procedures. This simplifies the establishment and remeasurement work without making the plot unduly visible.

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 will be responsible for data entry quality control. The analysis contractor will then compile the data and complete the analysis after each field season.

4.10 ANALYSIS & INTERPRETATION

The first measurement will provide yield estimates to audit Non-SMZ PHR and SMZ yield tables used in the innovative timber supply analysis. A minimum of two measurements is needed to estimate change. Following the second measurement, differences between actual and predicted change can be estimated for the main attributes of interest. Graphical analysis of the data includes plotting actual versus predicted values and plotting residuals (actual-predicted) against stand age or any other variable of interest. The statistical analysis can include descriptive statistics and their respective confidence intervals. Observations will need to be weighted appropriately when statistics across measurement periods are computed, and if the achieved sampling intensity varied among measurement periods.

4.11 FUTURE MODIFICATIONS

Future modifications to the CMI program could include:

1. **Adding new information:**

New objectives can be added to the CMI program in the future. For example, branch size, tree taper, or wood quality measurements 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 coarse woody debris estimates.

2. **Decreasing sample intensity:**

Sampling intensity in PHR stands can be decreased in the future as more plots are located in Non-SMZ PHR stands. The number of plots will increase as more natural stands are harvested, regenerated, and brought to the minimum age of 21 years from disturbance. Future program costs may become excessive and the NSIFS may want to reduce costs. This can be done by randomly dropping some plots in stands where the comfort of predicting stand yield is higher, or by increasing the measurement period of some plots.

3. **Increasing measurement period:**

The five year remeasurement period is convenient because it corresponds to the FP schedule. However, this period could change if the FP cycle changes, if a sufficient level of comfort is developed in yield estimates, or if the NSIFS wants to decrease program costs. 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.

5. RECOMMENDATIONS

5.1 IMPLEMENTATION

We recommend that all CMI plots for the first measurement period be established in 2002. If this is not possible, then plot establishment should be completed over two field seasons. If the CMI plots are installed over more than one field season, we recommend that the plots 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.

Data should be entered and analyzed after each field season. A summary report should be prepared following the first field season if plot establishment takes more than one season. A detailed report should be prepared when all plots have been established for each measurement period.

5.2 NEXT STEPS

The next steps should include:

1. The NSIFS will confirm data needs, objectives, and agree on this plan.
2. The NSIFS will agree on an implementation schedule.
3. The CMI sample plan for the initial installation will be completed.

5.3 ROLES AND RESPONSIBILITIES

5.3.1 NSIFS

The NSIFS will:

- Coordinate the project
- Communicate with the MSRM
- Monitor the project budget and progress, and communicate to the 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 the sample packages

5.3.4 Field Contractor

The field contractor will:

- Complete the fieldwork
- Complete the quality control on fieldwork
- Enter the data
- Complete the 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 a report for the NSIFS

5.3.6 Data Analysis Contractor

The data analysis contractor will:

- Compile the data
- Check the 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.

Item	Description	MSRM Standard	Merritt IFPAs
Card 1	Header card	Completed	Completed
Card 2	Compass card	Completed	Completed
Card 3	Cluster layout	Completed	Completed
Card 4	Range sampling – shrub transect 1	Completed	Not completed
Card 5	Range sampling – shrub transect 2	Completed	Not completed
Card 6	Coarse woody debris – transect 1	Completed	Not completed
Card 7	Coarse woody debris – transect 2	Completed	Not completed
Card 8	Tree details	Trees tagged at stump-height	Trees tagged at breast-height
Card 9	Tree loss indicators	Completed	Completed
Card 10	Small tree, stump, and site tree data	Completed	Completed
Card 11	Auxiliary plot card	Left blank	Left blank
Card 12	Ecological description 1	Soil features collected Soil description collected	Soil features not collected Soil description not collected
Card 13	Ecological description 2	Soil features collected Soil description collected	Soil features not collected Soil description not collected
Card 14	Tree and shrub layers	Completed	Not completed
Card 15	Herb and moss layers	Completed	Not completed
Card 16	Succession interpretations	Completed	Not completed

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Fd	95.8	3.1	5.0	6.5	11.7	19.5	26.2	21.8	50.2	6.3	150.3	246.1
Sx	0	9.3	1.8	0.8	1.5	2.3	5.8	7.6	30.8	15.4	75.3	75.3
Bl	0	2.9	3.0	3.3	4.9	7.5	6.7	4.6	16.7	3.3	52.9	52.9
Py	15.5	0.2	0.2	0	0.1	0	0	0.1	1.3	0.5	2.4	17.9
Others	0.2	0.4	1.0	1.2	2.2	2.6	1.2	0.7	0.8	0.1	10.2	10.4
Total (ha)	*111.5*	*66.4*	*18.6*	*40.6*	*87.6*	*72.6*	*114.8*	*112.5*	*155.7*	*30*	*698.8*	*810.3*
(%)	*14%*	*8%*	*2%*	*5%*	*11%*	*9%*	*14%*	*14%*	*19%*	*4%*	*86%*	*100%*

Note: 24,701 ha of non-productive/not satisfactorily restocked areas in the PFLB are not included.

[4] The PFLB was defined as all area with ownership code ≥ 60, and with a null non-productive forest descriptor.

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The climate of the Merritt TSA is variable and includes arid, hot lowlands, cold alpine areas, and more humid-temperate coastal transition areas. The TSA contains eight BGC zones that reflect this climatic variation (Table 3). Most of the area in the Merritt IFPAs is in three BGC zones: Interior Douglas-fir (IDF), Montane Spruce (MS), and Engelmann Spruce-Subalpine Fir (ESSF). Only a minor portion is located in coastal BGC zones (CWH and MH).

Table 3. Area distribution in the Merritt IFPAs by BGC zone.

			Area	
BGC Zone	SMZ	Non-SMZ	(ha)	(%)
IDF	97,469	246,973	344,442	41
MS	4,495	295,143	299,638	36
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PP	9,328	573	9,901	1
AT		3,544	3,544	0
CWH		1,428	1,428	0
BG	298	36	334	0
MH		250	250	0
Total (ha)	*111,590*	*723,752*	*835,342*	
(%)	*13%*	*87%*		*100%*

3. CMI BUSINESS NEEDS

3.1 PRIMARY NEED

The primary need for this CMI program is to demonstrate that the AAC is compatible with the observed growth in net merchantable volume. In the NSIFS's AAC application,[2] net merchantable volume growth was predicted using different methods for the Non-SMZ post-harvest regenerated (PHR), the Non-SMZ natural stands, and the SMZ stands. In Non-SMZ PHR stands, yield tables were generated using *Batch TIPSY* (version 3.0a) and the site index estimates were developed by a group of JST site productivity experts.[8] In the Non-SMZ natural stands, yield tables were generated using *Batch VDYP* (version 6.6d) and the inventory inputs. For SMZ stands, modified yield tables were developed using *Batch VDYP* (version 6.6d) and the inventory inputs.[9]

Non-SMZ natural stands are not a monitoring priority at this point for the NSIFS, so the CMI program target population will be stratified into SMZ and Non-SMZ PHR stands to monitor change in each stratum more accurately.

Non-SMZ PHR stands are defined as all stands between 21 and 40 years of age. Stands less than 21 years old likely do not have merchantable volume (assuming inventory age is correct). Hence, measuring these stands is not cost-effective. The upper limit of 40 years was chosen because very few stands established before 1962 are considered managed stands.

3.2 SECONDARY NEEDS

3.2.1 Wildlife Habitat

An AAC increase should not come at the expense of the quantity and quality of wildlife habitat. Rather than measuring the rate of change in wildlife habitats, criteria and indicators (C&I) will be defined and agreed upon by all stakeholders. Every five years, independent inventories will be used to measure indicators, and check that criteria have been met. These independent inventories will serve as audits for wildlife habitat. These C&I are not part of the CMI program and will be carried out separately.

3.2.2 First Nations Needs

It is important that an AAC increase respect the needs of the First Nations. There are eight First Nations bands involved in the Merritt IFPAs. While these bands have similar specific needs (e.g., berry production sites, plant collection areas, and fish and wildlife harvesting areas), they will need information for their individual territories rather than for the entire land base of the IFPAs. Defining C&I specific to each band followed by independent inventories is the most appropriate method to address this business need. This objective is not implicitly part of the CMI program.

Completing an independent inventory of each First Nations territory will provide accurate, but costly information. Thus, merging territories prior to sampling could increase the accuracy/cost ratio. Discussions with the First Nations should take place to explain the costs and benefits of merging territories before sampling.

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4. SAMPLING DESIGN

4.1 OVERVIEW

The sampling design must meet the monitoring needs of the NSIFS and the MSRM standards. The sampling design follows the MSRM CMI standards and procedures[10] with a few modifications. These modifications are discussed below and summarized in Appendix I.

4.2 OBJECTIVES

The objectives of the sampling design are to establish a sampling framework that:

- Meets the NSIFS's main business need that volume projections are being achieved on the ground.
- Is flexible enough to address future monitoring needs.

4.3 TARGET POPULATION

The target population is all SMZ stands and the Non-SMZ PHR stands between 21 and 40 years of age. The SMZ population (111,590 ha) will not change over time unless: 1) the species composition in the inventory is modified, or 2) the NSIFS undertakes alternative silviculture management of the SMZ. The Non-SMZ PHR target population (24,956 ha) will grow as more stands reach the minimum age of 21 years before the beginning of each measurement period. Stands that grow older than the upper age limit (40 years) will continue to be remeasured. Hence, stands can be added but not deleted from the PHR population.

4.4 REMEASUREMENT PERIOD

We recommend that the plots be remeasured every five years to coincide with the five year Forestry Plan (FP) cycle. The remeasurement period can be lengthened if the monitoring program becomes too costly or if FP cycles are lengthened. Based on a five year remeasurement period, the PHR population will grow by about 20,000 ha for the next two measurement periods, followed by another increase of about 15,000 ha in the fourth measurement period (Table 4).

Table 4. CMI plot remeasurement schedule.

Stratum	Age (yrs)	Measurement Period	Area (ha)	Plots		
				New	Remea-sured	Total
Non-SMZ PHR	21-40	2002-2006	24,956	31	0	31
	16-20	2007-2011	19,860	32	31	63
	11-15	2012-2016	20,630	37	63	100
	6-10	2017-2021	16,166	29	100	129
SMZ	All	2002-2006	115,590	52	0	52

4.5 SAMPLE SELECTION

We suggest that the CMI plot locations be based on a 2.5 km grid originating at the following coordinates: 617,500, 5,430,000 (Universal Transverse Mercator, North American Datum 83, zone 10). This will enable easy location of future plots as the Non-SMZ PHR population increases, since all possible plot locations are automatically known at the beginning of the CMI program.

[10] Ministry of Forests. 2001. Change Monitoring Inventory: ground sampling procedures for the provincial monitoring inventory program. Version 1.1. Ministry of Forests. Resources Inventory Branch. Victoria, BC. January 2001. 203 pp.

4.6 SAMPLE SIZE

4.6.1 Non-SMZ PHR Stratum

A 2.5 km grid corresponds to a sampling intensity of one plot/625 ha. However, the theoretical and achieved sampling intensities can be different due to the spatial distribution of the population. Based on the current inventory, the proposed grid size would provide a network of 129 plots in the Non-SMZ PHR stratum at the end of the fourth measurement period (Table 4).

The sample size must be large enough to allow post-stratification and still provide an adequate sample size for an important sub-set of the population. This can be achieved using the 2.5 km grid. For instance, Pl leading stands represent about 70% of the Non-SMZ PHR population. The proposed grid provides 42 plots in Pl-leading stands after the second measurement period, and 102 plots at the end of the fourth measurement period.

4.6.2 SMZ Stratum

To be cost-effective, we suggest sampling every other grid point in the SMZ stratum. This is equivalent to using a 5 km grid, or a sampling intensity of one plot/2,500 ha, creating a sample size of 52 plots. This sample size will likely be insufficient to detect statistical differences in the SMZ since there exists a wide variety of stand conditions in this management zone. However, considering the lack of G&Y information in the SMZ, the proposed sample size should provide basic information that could be used to prepare a more refined sampling design for that zone. If the SMZ monitoring sampling design is changed in the future, the 52 SMZ CMI plots can still be used for modeling purposes.

4.6.3 Measurement Schedule

The proposed sampling intensity suggests 83 CMI plots (31 in the Non-SMZ PHR stratum, 52 in the SMZ) should be established in the first measurement period. These plots need to be remeasured in the second period with 32 new plots being established in the Non-SMZ PHR stratum, for a total of 115 plots to be measured (63 in the Non-SMZ PHR stratum, 52 in the SMZ). The sampling for each measurement period should be done in the same year. If this is not possible, the plots should be measured within two years. For the first measurement period, that would mean 42 plots/year.

4.7 PLOT DESIGN

The plot design follows the MSRM standard CMI protocol for tree attributes (Figure 1).[5] The main plot is 400 m^2 (11.28 m radius) where all trees greater than 9.0 cm diameter at breast-height (DBH) are measured and tagged. Trees between 4 cm and 9 cm DBH are measured and tagged in the small-tree plot (100 m^2, 5.64 m radius), and trees taller than 30 cm and less than 4 cm DBH are measured and tagged in the regeneration plot (19.6 m^2, 2.50 m radius).

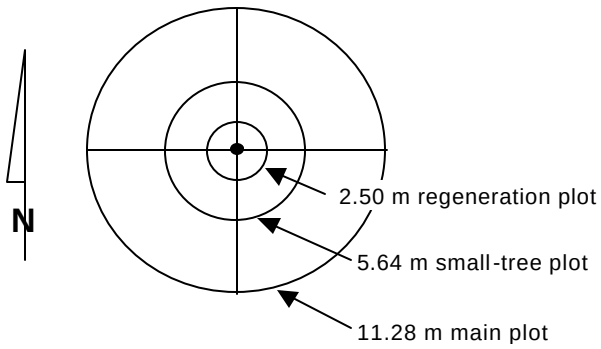

Figure 1. Monitoring sample plot.

4.8 PLOT MEASUREMENTS

4.8.1 Overview

All standard MSRM plot measurements will be recorded, except for range, coarse woody debris, soil, and ecological succession information. No custom measurements will be recorded in this project.

4.8.2 Plot Cards

Plot navigation and establishment will follow plot cards 1 to 3. No range (cards 4 and 5) or coarse woody debris data (cards 6 and 7) will be collected. Tree attributes (cards 8 to 11) will be collected as per the MSRM standards. Site classification and site features data (cards 12 and 13) will be collected. Soil information will not be taken at the pin location (card 12) or for the dominant stratum (card 13), vegetation lists of the tree, shrub, herb, and moss layers (cards 14 and 15) will not be recorded, and ecological succession data will not be taken (card 16).

4.8.3 Plot Establishment

The CMI plot will be established at the selected grid location. When a plot appears to cross the sample polygon boundary, a diagram will be drawn to explain clearly where the polygon boundary is located within the plot. This will allow 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-height rather than stump-height as recommended in the MSRM CMI standards and procedures. This simplifies the establishment and remeasurement work without making the plot unduly visible.

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 will be responsible for data entry quality control. The analysis contractor will then compile the data and complete the analysis after each field season.

4.10 ANALYSIS & INTERPRETATION

The first measurement will provide yield estimates to audit Non-SMZ PHR and SMZ yield tables used in the innovative timber supply analysis. A minimum of two measurements is needed to estimate change. Following the second measurement, differences between actual and predicted change can be estimated for the main attributes of interest. Graphical analysis of the data includes plotting actual versus predicted values and plotting residuals (actual-predicted) against stand age or any other variable of interest. The statistical analysis can include descriptive statistics and their respective confidence intervals. Observations will need to be weighted appropriately when statistics across measurement periods are computed, and if the achieved sampling intensity varied among measurement periods.

4.11 FUTURE MODIFICATIONS

Future modifications to the CMI program could include:

1. **Adding new information:**

New objectives can be added to the CMI program in the future. For example, branch size, tree taper, or wood quality measurements 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 coarse woody debris estimates.

2. **Decreasing sample intensity:**

Sampling intensity in PHR stands can be decreased in the future as more plots are located in Non-SMZ PHR stands. The number of plots will increase as more natural stands are harvested, regenerated, and brought to the minimum age of 21 years from disturbance. Future program costs may become excessive and the NSIFS may want to reduce costs. This can be done by randomly dropping some plots in stands where the comfort of predicting stand yield is higher, or by increasing the measurement period of some plots.

3. **Increasing measurement period:**

The five year remeasurement period is convenient because it corresponds to the FP schedule. However, this period could change if the FP cycle changes, if a sufficient level of comfort is developed in yield estimates, or if the NSIFS wants to decrease program costs. 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.

5. RECOMMENDATIONS

5.1 IMPLEMENTATION

We recommend that all CMI plots for the first measurement period be established in 2002. If this is not possible, then plot establishment should be completed over two field seasons. If the CMI plots are installed over more than one field season, we recommend that the plots 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.

Data should be entered and analyzed after each field season. A summary report should be prepared following the first field season if plot establishment takes more than one season. A detailed report should be prepared when all plots have been established for each measurement period.

5.2 NEXT STEPS

The next steps should include:

1. The NSIFS will confirm data needs, objectives, and agree on this plan.
2. The NSIFS will agree on an implementation schedule.
3. The CMI sample plan for the initial installation will be completed.

5.3 ROLES AND RESPONSIBILITIES

5.3.1 NSIFS

The NSIFS will:

- Coordinate the project
- Communicate with the MSRM
- Monitor the project budget and progress, and communicate to the 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 the sample packages

5.3.4 Field Contractor

The field contractor will:

- Complete the fieldwork
- Complete the quality control on fieldwork
- Enter the data
- Complete the 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 a report for the NSIFS

5.3.6 Data Analysis Contractor

The data analysis contractor will:

- Compile the data
- Check the 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.

Item	Description	MSRM Standard	Merritt IFPAs
Card 1	Header card	Completed	Completed
Card 2	Compass card	Completed	Completed
Card 3	Cluster layout	Completed	Completed
Card 4	Range sampling – shrub transect 1	Completed	Not completed
Card 5	Range sampling – shrub transect 2	Completed	Not completed
Card 6	Coarse woody debris – transect 1	Completed	Not completed
Card 7	Coarse woody debris – transect 2	Completed	Not completed
Card 8	Tree details	Trees tagged at stump-height	Trees tagged at breast-height
Card 9	Tree loss indicators	Completed	Completed
Card 10	Small tree, stump, and site tree data	Completed	Completed
Card 11	Auxiliary plot card	Left blank	Left blank
Card 12	Ecological description 1	Soil features collected Soil description collected	Soil features not collected Soil description not collected
Card 13	Ecological description 2	Soil features collected Soil description collected	Soil features not collected Soil description not collected
Card 14	Tree and shrub layers	Completed	Not completed
Card 15	Herb and moss layers	Completed	Not completed
Card 16	Succession interpretations	Completed	Not completed

Change Monitoring Inventory
Pilot Project for the Merritt IFPAs

Strategic Implementation Plan

Prepared for

Larry Henry, RPF
Nicola-Similkameen Innovative Forestry Society
Merritt, BC

Project: MTI-317
Contract No: 723803-6425

March 21, 2002

J.S. Thrower & Associates Ltd. *Consulting Foresters*
Vancouver – Kamloops, BC

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1. INTRODUCTION

1.1 BACKGROUND

The Nicola-Similkameen Innovative Forestry Society (NSIFS) was established by five Forest Licence holders, two First Nations Band Councils, and the Small Business Forest Enterprise Program (SBFEP) in the Merritt Timber Supply Area (TSA), to implement the Merritt Innovative Forestry Practices Agreements (IFPAs) on the TSA land base.[1] The IFPAs were granted in July 1997, and the implementation of the environmental and growth and yield programs began in 1998. Since then, Vegetation Resources Inventory (VRI), Predictive Ecosystem Mapping (PEM), Site Index Adjustment (SIA), and managed stand yield tables have been developed or are in progress to provide more accurate growth and yield (G&Y) estimates to incorporate into the spatial timber supply analysis. On December 31, 2001, the NSIFS Board of Directors sent a proposal to the Kamloops Regional Manager requesting a 430,000 m^3 increase in the Allowable Annual Cut (AAC) for the Merritt TSA, based on an aspatial timber supply analysis.[2]

The NSIFS wants to establish a process that will ensure that any change in the current AAC will not negatively affect other resource values. A Change Monitoring Inventory (CMI) program, associated with a series of audits, will help demonstrate that the projections from the G&Y models used in the spatial timber supply analysis are accurate, and that set inventory targets are achieved. The program will act as an early warning system should the productivity of the forest deviate from the G&Y projections.

1.2 CMI GOALS & OBJECTIVES

The overall goal of a CMI program is to ensure that forest management decisions are based on realistic projections of the different forest resources. The specific objectives of the CMI program are to:

1. *Define the NSIFS's CMI business needs.*
2. *Develop a flexible sampling design that meets these business needs, and that can be modified to address potential future needs.*
3. *Install sample plots across targeted areas in the IFPAs.*
4. *Maintain the program by remeasuring plots according to a predetermined schedule.*
5. *Compare actual with predicted G&Y estimates for the sampled area at each measurement.*
6. *Analyze the information to detect significant practical[3] differences, should they occur.*

1.3 REPORT OBJECTIVES

This report is a strategic implementation plan for the NSIFS CMI program. It describes the land base, outlines the CMI business needs, and proposes a sampling design for the CMI program. A detailed sampling plan will follow once the NSIFS and Ministry of Sustainable Resource Management (MSRM) review and accept this implementation plan.

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[1] The licencees include Weyerhaeuser Company Limited, Riverside Forest Products Limited, Tolko Industries Ltd., Aspen Planers Ltd., and Ardew Wood Products Ltd., and the First Nations include the Nicola Tribal Association and the Upper Similkameen Indian Band.

[2] Nicola-Similkameen Innovative Forestry Society. 2001. Application for an AAC increase for the Merritt IFPAs: Amendment to Forestry Plan #1. December 13, 2001. 101 pp.

[3] Practical differences are differences that affect management decisions, and are not necessarily related to statistical differences.

1.4 TERMS OF REFERENCE

Guillaume Thérien, *PhD* of J.S. Thrower & Associates Ltd. (JST) developed this CMI strategic implementation plan for the Merritt IFPAs. Larry Henry, *RPF* is the NSIFS project leader. This strategic implementation plan was funded by Forest Renewal BC.

2. MERRITT IFPA LAND BASE

2.1 GEOGRAPHIC LOCATION

The area in the Merritt IFPAs covers the entire Merritt TSA land base. The TSA is located in the Kamloops Forest Region and extends from the US border in the south to the Kamloops TSA in the north, and from the Coastal Range on its western border to the Okanagan Valley to the east. It covers 1.13 million ha (Table 1), of which 0.84 million ha is the public, productive forest land base (PFLB).[4]

Table 1. Land base net down of the Merritt IFPAs.

Land base	Area (ha)
Total IFPAs	1,129,494
Crown Land	932,655
PFLB	835,342

2.2 FOREST COVER

The PFLB in the Merritt IFPAs is divided in two main management zones: the selection management zone ([SMZ], about 112,000 ha) and the remaining areas ([Non-SMZ], about 723,000 ha). The SMZ is defined using the following criteria:[5,6]

1. Douglas-fir (Fd) leading stands with basal area greater than 80% of the total, or Fd leading with ponderosa pine (Py), larch (L) or deciduous as the second species in the BG biogeoclimatic (BGC) zone, or PPxh, IDFxh, IDFdk1, IDFdk2, and MSxk subzones.
2. Py or L leading in the BG zone, or PPxh, IDFxh, IDFdk1, IDFdk2, and MSxk subzones.

Due to the partial cutting history in the SMZ, most stands in this management zone are uneven-aged. In the Non-SMZ areas, clearcut is the most common harvesting method. The SMZ is mostly Fd leading, while the Non-SMZ areas are mostly lodgepole pine (Pl) leading. In the Non-SMZ areas, Fd, interior spruce (Sx), and balsam (Bl) are also important leading species. The age distribution in the Non-SMZ areas is skewed towards the older age classes (Table 2).[7]

Table 2. Area ('000 ha) in the PFLB of the Merritt IFPAs by management zone, species, and age class.

Species	SMZ All	Non-SMZ Age Class 1	2	3	4	5	6	7	8	9	Non-SMZ Total	IFPA Total
Pl	0	50.5	7.6	28.8	67.2	40.7	74.9	77.7	55.9	4.4	407.7	407.7
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- Meets the NSIFS's main business need that volume projections are being achieved on the ground.
- Is flexible enough to address future monitoring needs.

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The target population is all SMZ stands and the Non-SMZ PHR stands between 21 and 40 years of age. The SMZ population (111,590 ha) will not change over time unless: 1) the species composition in the inventory is modified, or 2) the NSIFS undertakes alternative silviculture management of the SMZ. The Non-SMZ PHR target population (24,956 ha) will grow as more stands reach the minimum age of 21 years before the beginning of each measurement period. Stands that grow older than the upper age limit (40 years) will continue to be remeasured. Hence, stands can be added but not deleted from the PHR population.

4.4 REMEASUREMENT PERIOD

We recommend that the plots be remeasured every five years to coincide with the five year Forestry Plan (FP) cycle. The remeasurement period can be lengthened if the monitoring program becomes too costly or if FP cycles are lengthened. Based on a five year remeasurement period, the PHR population will grow by about 20,000 ha for the next two measurement periods, followed by another increase of about 15,000 ha in the fourth measurement period (Table 4).

Table 4. CMI plot remeasurement schedule.

Stratum	Age (yrs)	Measurement Period	Area (ha)	Plots		
				New	Remea-sured	Total
Non-SMZ PHR	21-40	2002-2006	24,956	31	0	31
	16-20	2007-2011	19,860	32	31	63
	11-15	2012-2016	20,630	37	63	100
	6-10	2017-2021	16,166	29	100	129
SMZ	All	2002-2006	115,590	52	0	52

4.5 SAMPLE SELECTION

We suggest that the CMI plot locations be based on a 2.5 km grid originating at the following coordinates: 617,500, 5,430,000 (Universal Transverse Mercator, North American Datum 83, zone 10). This will enable easy location of future plots as the Non-SMZ PHR population increases, since all possible plot locations are automatically known at the beginning of the CMI program.

[10] Ministry of Forests. 2001. Change Monitoring Inventory: ground sampling procedures for the provincial monitoring inventory program. Version 1.1. Ministry of Forests. Resources Inventory Branch. Victoria, BC. January 2001. 203 pp.

4.6 SAMPLE SIZE

4.6.1 Non-SMZ PHR Stratum

A 2.5 km grid corresponds to a sampling intensity of one plot/625 ha. However, the theoretical and achieved sampling intensities can be different due to the spatial distribution of the population. Based on the current inventory, the proposed grid size would provide a network of 129 plots in the Non-SMZ PHR stratum at the end of the fourth measurement period (Table 4).

The sample size must be large enough to allow post-stratification and still provide an adequate sample size for an important sub-set of the population. This can be achieved using the 2.5 km grid. For instance, Pl leading stands represent about 70% of the Non-SMZ PHR population. The proposed grid provides 42 plots in Pl-leading stands after the second measurement period, and 102 plots at the end of the fourth measurement period.

4.6.2 SMZ Stratum

To be cost-effective, we suggest sampling every other grid point in the SMZ stratum. This is equivalent to using a 5 km grid, or a sampling intensity of one plot/2,500 ha, creating a sample size of 52 plots. This sample size will likely be insufficient to detect statistical differences in the SMZ since there exists a wide variety of stand conditions in this management zone. However, considering the lack of G&Y information in the SMZ, the proposed sample size should provide basic information that could be used to prepare a more refined sampling design for that zone. If the SMZ monitoring sampling design is changed in the future, the 52 SMZ CMI plots can still be used for modeling purposes.

4.6.3 Measurement Schedule

The proposed sampling intensity suggests 83 CMI plots (31 in the Non-SMZ PHR stratum, 52 in the SMZ) should be established in the first measurement period. These plots need to be remeasured in the second period with 32 new plots being established in the Non-SMZ PHR stratum, for a total of 115 plots to be measured (63 in the Non-SMZ PHR stratum, 52 in the SMZ). The sampling for each measurement period should be done in the same year. If this is not possible, the plots should be measured within two years. For the first measurement period, that would mean 42 plots/year.

4.7 PLOT DESIGN

The plot design follows the MSRM standard CMI protocol for tree attributes (Figure 1).[5] The main plot is 400 m^2 (11.28 m radius) where all trees greater than 9.0 cm diameter at breast-height (DBH) are measured and tagged. Trees between 4 cm and 9 cm DBH are measured and tagged in the small-tree plot (100 m^2, 5.64 m radius), and trees taller than 30 cm and less than 4 cm DBH are measured and tagged in the regeneration plot (19.6 m^2, 2.50 m radius).

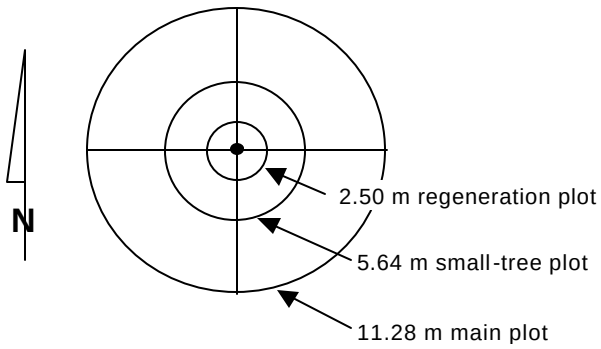

Figure 1. Monitoring sample plot.

4.8 PLOT MEASUREMENTS

4.8.1 Overview

All standard MSRM plot measurements will be recorded, except for range, coarse woody debris, soil, and ecological succession information. No custom measurements will be recorded in this project.

4.8.2 Plot Cards

Plot navigation and establishment will follow plot cards 1 to 3. No range (cards 4 and 5) or coarse woody debris data (cards 6 and 7) will be collected. Tree attributes (cards 8 to 11) will be collected as per the MSRM standards. Site classification and site features data (cards 12 and 13) will be collected. Soil information will not be taken at the pin location (card 12) or for the dominant stratum (card 13), vegetation lists of the tree, shrub, herb, and moss layers (cards 14 and 15) will not be recorded, and ecological succession data will not be taken (card 16).

4.8.3 Plot Establishment

The CMI plot will be established at the selected grid location. When a plot appears to cross the sample polygon boundary, a diagram will be drawn to explain clearly where the polygon boundary is located within the plot. This will allow 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-height rather than stump-height as recommended in the MSRM CMI standards and procedures. This simplifies the establishment and remeasurement work without making the plot unduly visible.

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 will be responsible for data entry quality control. The analysis contractor will then compile the data and complete the analysis after each field season.

4.10 ANALYSIS & INTERPRETATION

The first measurement will provide yield estimates to audit Non-SMZ PHR and SMZ yield tables used in the innovative timber supply analysis. A minimum of two measurements is needed to estimate change. Following the second measurement, differences between actual and predicted change can be estimated for the main attributes of interest. Graphical analysis of the data includes plotting actual versus predicted values and plotting residuals (actual-predicted) against stand age or any other variable of interest. The statistical analysis can include descriptive statistics and their respective confidence intervals. Observations will need to be weighted appropriately when statistics across measurement periods are computed, and if the achieved sampling intensity varied among measurement periods.

4.11 FUTURE MODIFICATIONS

Future modifications to the CMI program could include:

1. **Adding new information:**

New objectives can be added to the CMI program in the future. For example, branch size, tree taper, or wood quality measurements 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 coarse woody debris estimates.

2. **Decreasing sample intensity:**

Sampling intensity in PHR stands can be decreased in the future as more plots are located in Non-SMZ PHR stands. The number of plots will increase as more natural stands are harvested, regenerated, and brought to the minimum age of 21 years from disturbance. Future program costs may become excessive and the NSIFS may want to reduce costs. This can be done by randomly dropping some plots in stands where the comfort of predicting stand yield is higher, or by increasing the measurement period of some plots.

3. **Increasing measurement period:**

The five year remeasurement period is convenient because it corresponds to the FP schedule. However, this period could change if the FP cycle changes, if a sufficient level of comfort is developed in yield estimates, or if the NSIFS wants to decrease program costs. 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.

5. RECOMMENDATIONS

5.1 IMPLEMENTATION

We recommend that all CMI plots for the first measurement period be established in 2002. If this is not possible, then plot establishment should be completed over two field seasons. If the CMI plots are installed over more than one field season, we recommend that the plots 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.

Data should be entered and analyzed after each field season. A summary report should be prepared following the first field season if plot establishment takes more than one season. A detailed report should be prepared when all plots have been established for each measurement period.

5.2 NEXT STEPS

The next steps should include:

1. The NSIFS will confirm data needs, objectives, and agree on this plan.
2. The NSIFS will agree on an implementation schedule.
3. The CMI sample plan for the initial installation will be completed.

5.3 ROLES AND RESPONSIBILITIES

5.3.1 NSIFS

The NSIFS will:

- Coordinate the project
- Communicate with the MSRM
- Monitor the project budget and progress, and communicate to the 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 the sample packages

5.3.4 Field Contractor

The field contractor will:

- Complete the fieldwork
- Complete the quality control on fieldwork
- Enter the data
- Complete the 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 a report for the NSIFS

5.3.6 Data Analysis Contractor

The data analysis contractor will:

- Compile the data
- Check the 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.

Item	Description	MSRM Standard	Merritt IFPAs
Card 1	Header card	Completed	Completed
Card 2	Compass card	Completed	Completed
Card 3	Cluster layout	Completed	Completed
Card 4	Range sampling – shrub transect 1	Completed	Not completed
Card 5	Range sampling – shrub transect 2	Completed	Not completed
Card 6	Coarse woody debris – transect 1	Completed	Not completed
Card 7	Coarse woody debris – transect 2	Completed	Not completed
Card 8	Tree details	Trees tagged at stump-height	Trees tagged at breast-height
Card 9	Tree loss indicators	Completed	Completed
Card 10	Small tree, stump, and site tree data	Completed	Completed
Card 11	Auxiliary plot card	Left blank	Left blank
Card 12	Ecological description 1	Soil features collected Soil description collected	Soil features not collected Soil description not collected
Card 13	Ecological description 2	Soil features collected Soil description collected	Soil features not collected Soil description not collected
Card 14	Tree and shrub layers	Completed	Not completed
Card 15	Herb and moss layers	Completed	Not completed
Card 16	Succession interpretations	Completed	Not completed

Change Monitoring Inventory
Pilot Project for the Merritt IFPAs

Strategic Implementation Plan

Prepared for

Larry Henry, RPF
Nicola-Similkameen Innovative Forestry Society
Merritt, BC

Project: MTI-317
Contract No: 723803-6425

March 21, 2002

J.S. Thrower & Associates Ltd. *Consulting Foresters*
Vancouver – Kamloops, BC

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1. INTRODUCTION

1.1 BACKGROUND

The Nicola-Similkameen Innovative Forestry Society (NSIFS) was established by five Forest Licence holders, two First Nations Band Councils, and the Small Business Forest Enterprise Program (SBFEP) in the Merritt Timber Supply Area (TSA), to implement the Merritt Innovative Forestry Practices Agreements (IFPAs) on the TSA land base.[1] The IFPAs were granted in July 1997, and the implementation of the environmental and growth and yield programs began in 1998. Since then, Vegetation Resources Inventory (VRI), Predictive Ecosystem Mapping (PEM), Site Index Adjustment (SIA), and managed stand yield tables have been developed or are in progress to provide more accurate growth and yield (G&Y) estimates to incorporate into the spatial timber supply analysis. On December 31, 2001, the NSIFS Board of Directors sent a proposal to the Kamloops Regional Manager requesting a 430,000 m^3 increase in the Allowable Annual Cut (AAC) for the Merritt TSA, based on an aspatial timber supply analysis.[2]

The NSIFS wants to establish a process that will ensure that any change in the current AAC will not negatively affect other resource values. A Change Monitoring Inventory (CMI) program, associated with a series of audits, will help demonstrate that the projections from the G&Y models used in the spatial timber supply analysis are accurate, and that set inventory targets are achieved. The program will act as an early warning system should the productivity of the forest deviate from the G&Y projections.

1.2 CMI GOALS & OBJECTIVES

The overall goal of a CMI program is to ensure that forest management decisions are based on realistic projections of the different forest resources. The specific objectives of the CMI program are to:

1. *Define the NSIFS's CMI business needs.*
2. *Develop a flexible sampling design that meets these business needs, and that can be modified to address potential future needs.*
3. *Install sample plots across targeted areas in the IFPAs.*
4. *Maintain the program by remeasuring plots according to a predetermined schedule.*
5. *Compare actual with predicted G&Y estimates for the sampled area at each measurement.*
6. *Analyze the information to detect significant practical[3] differences, should they occur.*

1.3 REPORT OBJECTIVES

This report is a strategic implementation plan for the NSIFS CMI program. It describes the land base, outlines the CMI business needs, and proposes a sampling design for the CMI program. A detailed sampling plan will follow once the NSIFS and Ministry of Sustainable Resource Management (MSRM) review and accept this implementation plan.

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[1] The licencees include Weyerhaeuser Company Limited, Riverside Forest Products Limited, Tolko Industries Ltd., Aspen Planers Ltd., and Ardew Wood Products Ltd., and the First Nations include the Nicola Tribal Association and the Upper Similkameen Indian Band.

[2] Nicola-Similkameen Innovative Forestry Society. 2001. Application for an AAC increase for the Merritt IFPAs: Amendment to Forestry Plan #1. December 13, 2001. 101 pp.

[3] Practical differences are differences that affect management decisions, and are not necessarily related to statistical differences.

1.4 TERMS OF REFERENCE

Guillaume Thérien, *PhD* of J.S. Thrower & Associates Ltd. (JST) developed this CMI strategic implementation plan for the Merritt IFPAs. Larry Henry, *RPF* is the NSIFS project leader. This strategic implementation plan was funded by Forest Renewal BC.

2. MERRITT IFPA LAND BASE

2.1 GEOGRAPHIC LOCATION

The area in the Merritt IFPAs covers the entire Merritt TSA land base. The TSA is located in the Kamloops Forest Region and extends from the US border in the south to the Kamloops TSA in the north, and from the Coastal Range on its western border to the Okanagan Valley to the east. It covers 1.13 million ha (Table 1), of which 0.84 million ha is the public, productive forest land base (PFLB).[4]

Table 1. Land base net down of the Merritt IFPAs.

Land base	Area (ha)
Total IFPAs	1,129,494
Crown Land	932,655
PFLB	835,342

2.2 FOREST COVER

The PFLB in the Merritt IFPAs is divided in two main management zones: the selection management zone ([SMZ], about 112,000 ha) and the remaining areas ([Non-SMZ], about 723,000 ha). The SMZ is defined using the following criteria:[5,6]

1. Douglas-fir (Fd) leading stands with basal area greater than 80% of the total, or Fd leading with ponderosa pine (Py), larch (L) or deciduous as the second species in the BG biogeoclimatic (BGC) zone, or PPxh, IDFxh, IDFdk1, IDFdk2, and MSxk subzones.
2. Py or L leading in the BG zone, or PPxh, IDFxh, IDFdk1, IDFdk2, and MSxk subzones.

Due to the partial cutting history in the SMZ, most stands in this management zone are uneven-aged. In the Non-SMZ areas, clearcut is the most common harvesting method. The SMZ is mostly Fd leading, while the Non-SMZ areas are mostly lodgepole pine (Pl) leading. In the Non-SMZ areas, Fd, interior spruce (Sx), and balsam (Bl) are also important leading species. The age distribution in the Non-SMZ areas is skewed towards the older age classes (Table 2).[7]

Table 2. Area ('000 ha) in the PFLB of the Merritt IFPAs by management zone, species, and age class.

Species	SMZ All	Non-SMZ Age Class 1	2	3	4	5	6	7	8	9	Non-SMZ Total	IFPA Total
Pl	0	50.5	7.6	28.8	67.2	40.7	74.9	77.7	55.9	4.4	407.7	407.7
Fd	95.8	3.1	5.0	6.5	11.7	19.5	26.2	21.8	50.2	6.3	150.3	246.1
Sx	0	9.3	1.8	0.8	1.5	2.3	5.8	7.6	30.8	15.4	75.3	75.3
Bl	0	2.9	3.0	3.3	4.9	7.5	6.7	4.6	16.7	3.3	52.9	52.9
Py	15.5	0.2	0.2	0	0.1	0	0	0.1	1.3	0.5	2.4	17.9
Others	0.2	0.4	1.0	1.2	2.2	2.6	1.2	0.7	0.8	0.1	10.2	10.4
Total (ha)	*111.5*	*66.4*	*18.6*	*40.6*	*87.6*	*72.6*	*114.8*	*112.5*	*155.7*	*30*	*698.8*	*810.3*
(%)	*14%*	*8%*	*2%*	*5%*	*11%*	*9%*	*14%*	*14%*	*19%*	*4%*	*86%*	*100%*

Note: 24,701 ha of non-productive/not satisfactorily restocked areas in the PFLB are not included.

[4] The PFLB was defined as all area with ownership code ≥ 60, and with a null non-productive forest descriptor.

[5] This definition corresponds to analysis units 1 and 2 used in TSR 2.

[6] Ministry of Forests. 2001. Timber Supply Review (TSR 2). Merritt Timber Supply Area analysis report. British Columbia Ministry of Forests. Victoria, BC. March 2001. 126 pp.

[7] The age distribution in the SMZ is not reported since most stands in that zone are uneven-aged.

2.3 ECOLOGICAL DESCRIPTION

The climate of the Merritt TSA is variable and includes arid, hot lowlands, cold alpine areas, and more humid-temperate coastal transition areas. The TSA contains eight BGC zones that reflect this climatic variation (Table 3). Most of the area in the Merritt IFPAs is in three BGC zones: Interior Douglas-fir (IDF), Montane Spruce (MS), and Engelmann Spruce-Subalpine Fir (ESSF). Only a minor portion is located in coastal BGC zones (CWH and MH).

Table 3. Area distribution in the Merritt IFPAs by BGC zone.

			Area	
BGC Zone	SMZ	Non-SMZ	(ha)	(%)
IDF	97,469	246,973	344,442	41
MS	4,495	295,143	299,638	36
ESSF		175,805	175,805	21
PP	9,328	573	9,901	1
AT		3,544	3,544	0
CWH		1,428	1,428	0
BG	298	36	334	0
MH		250	250	0
Total (ha)	*111,590*	*723,752*	*835,342*	
(%)	*13%*	*87%*		*100%*

3. CMI BUSINESS NEEDS

3.1 PRIMARY NEED

The primary need for this CMI program is to demonstrate that the AAC is compatible with the observed growth in net merchantable volume. In the NSIFS's AAC application,[2] net merchantable volume growth was predicted using different methods for the Non-SMZ post-harvest regenerated (PHR), the Non-SMZ natural stands, and the SMZ stands. In Non-SMZ PHR stands, yield tables were generated using *Batch TIPSY* (version 3.0a) and the site index estimates were developed by a group of JST site productivity experts.[8] In the Non-SMZ natural stands, yield tables were generated using *Batch VDYP* (version 6.6d) and the inventory inputs. For SMZ stands, modified yield tables were developed using *Batch VDYP* (version 6.6d) and the inventory inputs.[9]

Non-SMZ natural stands are not a monitoring priority at this point for the NSIFS, so the CMI program target population will be stratified into SMZ and Non-SMZ PHR stands to monitor change in each stratum more accurately.

Non-SMZ PHR stands are defined as all stands between 21 and 40 years of age. Stands less than 21 years old likely do not have merchantable volume (assuming inventory age is correct). Hence, measuring these stands is not cost-effective. The upper limit of 40 years was chosen because very few stands established before 1962 are considered managed stands.

3.2 SECONDARY NEEDS

3.2.1 Wildlife Habitat

An AAC increase should not come at the expense of the quantity and quality of wildlife habitat. Rather than measuring the rate of change in wildlife habitats, criteria and indicators (C&I) will be defined and agreed upon by all stakeholders. Every five years, independent inventories will be used to measure indicators, and check that criteria have been met. These independent inventories will serve as audits for wildlife habitat. These C&I are not part of the CMI program and will be carried out separately.

3.2.2 First Nations Needs

It is important that an AAC increase respect the needs of the First Nations. There are eight First Nations bands involved in the Merritt IFPAs. While these bands have similar specific needs (e.g., berry production sites, plant collection areas, and fish and wildlife harvesting areas), they will need information for their individual territories rather than for the entire land base of the IFPAs. Defining C&I specific to each band followed by independent inventories is the most appropriate method to address this business need. This objective is not implicitly part of the CMI program.

Completing an independent inventory of each First Nations territory will provide accurate, but costly information. Thus, merging territories prior to sampling could increase the accuracy/cost ratio. Discussions with the First Nations should take place to explain the costs and benefits of merging territories before sampling.

---

[8] These experts were Tara McCormick, *BSc*, Ian Cameron, *MSc RPF*, and Jim Thrower *PhD RPF.* More detail on this process is given in the AAC application document.

[9] Yield curves for the SMZ stands were adjusted based on revised periodic annual increments (PAIs) developed from previous studies.

4. SAMPLING DESIGN

4.1 OVERVIEW

The sampling design must meet the monitoring needs of the NSIFS and the MSRM standards. The sampling design follows the MSRM CMI standards and procedures[10] with a few modifications. These modifications are discussed below and summarized in Appendix I.

4.2 OBJECTIVES

The objectives of the sampling design are to establish a sampling framework that:

- Meets the NSIFS's main business need that volume projections are being achieved on the ground.
- Is flexible enough to address future monitoring needs.

4.3 TARGET POPULATION

The target population is all SMZ stands and the Non-SMZ PHR stands between 21 and 40 years of age. The SMZ population (111,590 ha) will not change over time unless: 1) the species composition in the inventory is modified, or 2) the NSIFS undertakes alternative silviculture management of the SMZ. The Non-SMZ PHR target population (24,956 ha) will grow as more stands reach the minimum age of 21 years before the beginning of each measurement period. Stands that grow older than the upper age limit (40 years) will continue to be remeasured. Hence, stands can be added but not deleted from the PHR population.

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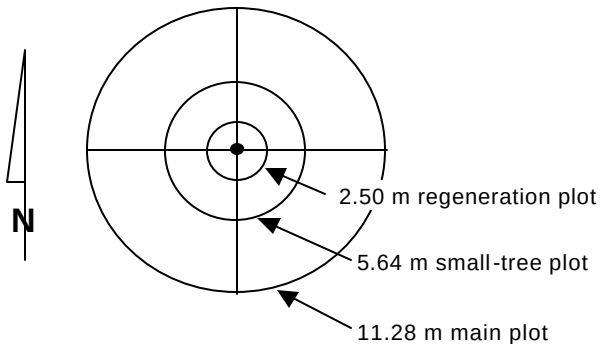

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New objectives can be added to the CMI program in the future. For example, branch size, tree taper, or wood quality measurements could be included in the next measurement cycle. This would provide the same representative sample, but change estimates 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 coarse woody debris estimates.

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We recommend that all CMI plots for the first measurement period be established in 2002. If this is not possible, then plot establishment should be completed over two field seasons. If the CMI plots are installed over more than one field season, we recommend that the plots 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.

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Change Monitoring Inventory
Pilot Project for the Merritt IFPAs

Strategic Implementation Plan

Prepared for

Larry Henry, RPF
Nicola-Similkameen Innovative Forestry Society
Merritt, BC

Project: MTI-317
Contract No: 723803-6425

March 21, 2002

J.S. Thrower & Associates Ltd. *Consulting Foresters*
Vancouver – Kamloops, BC

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1. INTRODUCTION

1.1 BACKGROUND

The Nicola-Similkameen Innovative Forestry Society (NSIFS) was established by five Forest Licence holders, two First Nations Band Councils, and the Small Business Forest Enterprise Program (SBFEP) in the Merritt Timber Supply Area (TSA), to implement the Merritt Innovative Forestry Practices Agreements (IFPAs) on the TSA land base.[1] The IFPAs were granted in July 1997, and the implementation of the environmental and growth and yield programs began in 1998. Since then, Vegetation Resources Inventory (VRI), Predictive Ecosystem Mapping (PEM), Site Index Adjustment (SIA), and managed stand yield tables have been developed or are in progress to provide more accurate growth and yield (G&Y) estimates to incorporate into the spatial timber supply analysis. On December 31, 2001, the NSIFS Board of Directors sent a proposal to the Kamloops Regional Manager requesting a 430,000 m^3 increase in the Allowable Annual Cut (AAC) for the Merritt TSA, based on an aspatial timber supply analysis.[2]

The NSIFS wants to establish a process that will ensure that any change in the current AAC will not negatively affect other resource values. A Change Monitoring Inventory (CMI) program, associated with a series of audits, will help demonstrate that the projections from the G&Y models used in the spatial timber supply analysis are accurate, and that set inventory targets are achieved. The program will act as an early warning system should the productivity of the forest deviate from the G&Y projections.

1.2 CMI GOALS & OBJECTIVES

The overall goal of a CMI program is to ensure that forest management decisions are based on realistic projections of the different forest resources. The specific objectives of the CMI program are to:

1. *Define the NSIFS's CMI business needs.*
2. *Develop a flexible sampling design that meets these business needs, and that can be modified to address potential future needs.*
3. *Install sample plots across targeted areas in the IFPAs.*
4. *Maintain the program by remeasuring plots according to a predetermined schedule.*
5. *Compare actual with predicted G&Y estimates for the sampled area at each measurement.*
6. *Analyze the information to detect significant practical[3] differences, should they occur.*

1.3 REPORT OBJECTIVES

This report is a strategic implementation plan for the NSIFS CMI program. It describes the land base, outlines the CMI business needs, and proposes a sampling design for the CMI program. A detailed sampling plan will follow once the NSIFS and Ministry of Sustainable Resource Management (MSRM) review and accept this implementation plan.

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[1] The licencees include Weyerhaeuser Company Limited, Riverside Forest Products Limited, Tolko Industries Ltd., Aspen Planers Ltd., and Ardew Wood Products Ltd., and the First Nations include the Nicola Tribal Association and the Upper Similkameen Indian Band.

[2] Nicola-Similkameen Innovative Forestry Society. 2001. Application for an AAC increase for the Merritt IFPAs: Amendment to Forestry Plan #1. December 13, 2001. 101 pp.

[3] Practical differences are differences that affect management decisions, and are not necessarily related to statistical differences.

1.4 TERMS OF REFERENCE

Guillaume Thérien, *PhD* of J.S. Thrower & Associates Ltd. (JST) developed this CMI strategic implementation plan for the Merritt IFPAs. Larry Henry, *RPF* is the NSIFS project leader. This strategic implementation plan was funded by Forest Renewal BC.

2. MERRITT IFPA LAND BASE

2.1 GEOGRAPHIC LOCATION

The area in the Merritt IFPAs covers the entire Merritt TSA land base. The TSA is located in the Kamloops Forest Region and extends from the US border in the south to the Kamloops TSA in the north, and from the Coastal Range on its western border to the Okanagan Valley to the east. It covers 1.13 million ha (Table 1), of which 0.84 million ha is the public, productive forest land base (PFLB).[4]

Table 1. Land base net down of the Merritt IFPAs.

Land base	Area (ha)
Total IFPAs	1,129,494
Crown Land	932,655
PFLB	835,342

2.2 FOREST COVER

The PFLB in the Merritt IFPAs is divided in two main management zones: the selection management zone ([SMZ], about 112,000 ha) and the remaining areas ([Non-SMZ], about 723,000 ha). The SMZ is defined using the following criteria:[5,6]

1. Douglas-fir (Fd) leading stands with basal area greater than 80% of the total, or Fd leading with ponderosa pine (Py), larch (L) or deciduous as the second species in the BG biogeoclimatic (BGC) zone, or PPxh, IDFxh, IDFdk1, IDFdk2, and MSxk subzones.
2. Py or L leading in the BG zone, or PPxh, IDFxh, IDFdk1, IDFdk2, and MSxk subzones.

Due to the partial cutting history in the SMZ, most stands in this management zone are uneven-aged. In the Non-SMZ areas, clearcut is the most common harvesting method. The SMZ is mostly Fd leading, while the Non-SMZ areas are mostly lodgepole pine (Pl) leading. In the Non-SMZ areas, Fd, interior spruce (Sx), and balsam (Bl) are also important leading species. The age distribution in the Non-SMZ areas is skewed towards the older age classes (Table 2).[7]

Table 2. Area ('000 ha) in the PFLB of the Merritt IFPAs by management zone, species, and age class.

Species	SMZ All	Non-SMZ Age Class 1	2	3	4	5	6	7	8	9	Non-SMZ Total	IFPA Total
Pl	0	50.5	7.6	28.8	67.2	40.7	74.9	77.7	55.9	4.4	407.7	407.7
Fd	95.8	3.1	5.0	6.5	11.7	19.5	26.2	21.8	50.2	6.3	150.3	246.1
Sx	0	9.3	1.8	0.8	1.5	2.3	5.8	7.6	30.8	15.4	75.3	75.3
Bl	0	2.9	3.0	3.3	4.9	7.5	6.7	4.6	16.7	3.3	52.9	52.9
Py	15.5	0.2	0.2	0	0.1	0	0	0.1	1.3	0.5	2.4	17.9
Others	0.2	0.4	1.0	1.2	2.2	2.6	1.2	0.7	0.8	0.1	10.2	10.4
Total (ha)	*111.5*	*66.4*	*18.6*	*40.6*	*87.6*	*72.6*	*114.8*	*112.5*	*155.7*	*30*	*698.8*	*810.3*
(%)	*14%*	*8%*	*2%*	*5%*	*11%*	*9%*	*14%*	*14%*	*19%*	*4%*	*86%*	*100%*

Note: 24,701 ha of non-productive/not satisfactorily restocked areas in the PFLB are not included.

[4] The PFLB was defined as all area with ownership code ≥ 60, and with a null non-productive forest descriptor.

[5] This definition corresponds to analysis units 1 and 2 used in TSR 2.

[6] Ministry of Forests. 2001. Timber Supply Review (TSR 2). Merritt Timber Supply Area analysis report. British Columbia Ministry of Forests. Victoria, BC. March 2001. 126 pp.

[7] The age distribution in the SMZ is not reported since most stands in that zone are uneven-aged.

2.3 ECOLOGICAL DESCRIPTION

The climate of the Merritt TSA is variable and includes arid, hot lowlands, cold alpine areas, and more humid-temperate coastal transition areas. The TSA contains eight BGC zones that reflect this climatic variation (Table 3). Most of the area in the Merritt IFPAs is in three BGC zones: Interior Douglas-fir (IDF), Montane Spruce (MS), and Engelmann Spruce-Subalpine Fir (ESSF). Only a minor portion is located in coastal BGC zones (CWH and MH).

Table 3. Area distribution in the Merritt IFPAs by BGC zone.

			Area	
BGC Zone	SMZ	Non-SMZ	(ha)	(%)
IDF	97,469	246,973	344,442	41
MS	4,495	295,143	299,638	36
ESSF		175,805	175,805	21
PP	9,328	573	9,901	1
AT		3,544	3,544	0
CWH		1,428	1,428	0
BG	298	36	334	0
MH		250	250	0
Total (ha)	*111,590*	*723,752*	*835,342*	
(%)	*13%*	*87%*		*100%*

3. CMI BUSINESS NEEDS

3.1 PRIMARY NEED

The primary need for this CMI program is to demonstrate that the AAC is compatible with the observed growth in net merchantable volume. In the NSIFS's AAC application,[2] net merchantable volume growth was predicted using different methods for the Non-SMZ post-harvest regenerated (PHR), the Non-SMZ natural stands, and the SMZ stands. In Non-SMZ PHR stands, yield tables were generated using *Batch TIPSY* (version 3.0a) and the site index estimates were developed by a group of JST site productivity experts.[8] In the Non-SMZ natural stands, yield tables were generated using *Batch VDYP* (version 6.6d) and the inventory inputs. For SMZ stands, modified yield tables were developed using *Batch VDYP* (version 6.6d) and the inventory inputs.[9]

Non-SMZ natural stands are not a monitoring priority at this point for the NSIFS, so the CMI program target population will be stratified into SMZ and Non-SMZ PHR stands to monitor change in each stratum more accurately.

Non-SMZ PHR stands are defined as all stands between 21 and 40 years of age. Stands less than 21 years old likely do not have merchantable volume (assuming inventory age is correct). Hence, measuring these stands is not cost-effective. The upper limit of 40 years was chosen because very few stands established before 1962 are considered managed stands.

3.2 SECONDARY NEEDS

3.2.1 Wildlife Habitat

An AAC increase should not come at the expense of the quantity and quality of wildlife habitat. Rather than measuring the rate of change in wildlife habitats, criteria and indicators (C&I) will be defined and agreed upon by all stakeholders. Every five years, independent inventories will be used to measure indicators, and check that criteria have been met. These independent inventories will serve as audits for wildlife habitat. These C&I are not part of the CMI program and will be carried out separately.

3.2.2 First Nations Needs

It is important that an AAC increase respect the needs of the First Nations. There are eight First Nations bands involved in the Merritt IFPAs. While these bands have similar specific needs (e.g., berry production sites, plant collection areas, and fish and wildlife harvesting areas), they will need information for their individual territories rather than for the entire land base of the IFPAs. Defining C&I specific to each band followed by independent inventories is the most appropriate method to address this business need. This objective is not implicitly part of the CMI program.

Completing an independent inventory of each First Nations territory will provide accurate, but costly information. Thus, merging territories prior to sampling could increase the accuracy/cost ratio. Discussions with the First Nations should take place to explain the costs and benefits of merging territories before sampling.

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[8] These experts were Tara McCormick, *BSc*, Ian Cameron, *MSc RPF*, and Jim Thrower *PhD RPF.* More detail on this process is given in the AAC application document.

[9] Yield curves for the SMZ stands were adjusted based on revised periodic annual increments (PAIs) developed from previous studies.

4. SAMPLING DESIGN

4.1 OVERVIEW

The sampling design must meet the monitoring needs of the NSIFS and the MSRM standards. The sampling design follows the MSRM CMI standards and procedures[10] with a few modifications. These modifications are discussed below and summarized in Appendix I.

4.2 OBJECTIVES

The objectives of the sampling design are to establish a sampling framework that:

- Meets the NSIFS's main business need that volume projections are being achieved on the ground.
- Is flexible enough to address future monitoring needs.

4.3 TARGET POPULATION

The target population is all SMZ stands and the Non-SMZ PHR stands between 21 and 40 years of age. The SMZ population (111,590 ha) will not change over time unless: 1) the species composition in the inventory is modified, or 2) the NSIFS undertakes alternative silviculture management of the SMZ. The Non-SMZ PHR target population (24,956 ha) will grow as more stands reach the minimum age of 21 years before the beginning of each measurement period. Stands that grow older than the upper age limit (40 years) will continue to be remeasured. Hence, stands can be added but not deleted from the PHR population.

4.4 REMEASUREMENT PERIOD

We recommend that the plots be remeasured every five years to coincide with the five year Forestry Plan (FP) cycle. The remeasurement period can be lengthened if the monitoring program becomes too costly or if FP cycles are lengthened. Based on a five year remeasurement period, the PHR population will grow by about 20,000 ha for the next two measurement periods, followed by another increase of about 15,000 ha in the fourth measurement period (Table 4).

Table 4. CMI plot remeasurement schedule.

Stratum	Age (yrs)	Measurement Period	Area (ha)	Plots		
				New	Remea-sured	Total
Non-SMZ PHR	21-40	2002-2006	24,956	31	0	31
	16-20	2007-2011	19,860	32	31	63
	11-15	2012-2016	20,630	37	63	100
	6-10	2017-2021	16,166	29	100	129
SMZ	All	2002-2006	115,590	52	0	52

4.5 SAMPLE SELECTION

We suggest that the CMI plot locations be based on a 2.5 km grid originating at the following coordinates: 617,500, 5,430,000 (Universal Transverse Mercator, North American Datum 83, zone 10). This will enable easy location of future plots as the Non-SMZ PHR population increases, since all possible plot locations are automatically known at the beginning of the CMI program.

[10] Ministry of Forests. 2001. Change Monitoring Inventory: ground sampling procedures for the provincial monitoring inventory program. Version 1.1. Ministry of Forests. Resources Inventory Branch. Victoria, BC. January 2001. 203 pp.

4.6 SAMPLE SIZE

4.6.1 Non-SMZ PHR Stratum

A 2.5 km grid corresponds to a sampling intensity of one plot/625 ha. However, the theoretical and achieved sampling intensities can be different due to the spatial distribution of the population. Based on the current inventory, the proposed grid size would provide a network of 129 plots in the Non-SMZ PHR stratum at the end of the fourth measurement period (Table 4).

The sample size must be large enough to allow post-stratification and still provide an adequate sample size for an important sub-set of the population. This can be achieved using the 2.5 km grid. For instance, Pl leading stands represent about 70% of the Non-SMZ PHR population. The proposed grid provides 42 plots in Pl-leading stands after the second measurement period, and 102 plots at the end of the fourth measurement period.

4.6.2 SMZ Stratum

To be cost-effective, we suggest sampling every other grid point in the SMZ stratum. This is equivalent to using a 5 km grid, or a sampling intensity of one plot/2,500 ha, creating a sample size of 52 plots. This sample size will likely be insufficient to detect statistical differences in the SMZ since there exists a wide variety of stand conditions in this management zone. However, considering the lack of G&Y information in the SMZ, the proposed sample size should provide basic information that could be used to prepare a more refined sampling design for that zone. If the SMZ monitoring sampling design is changed in the future, the 52 SMZ CMI plots can still be used for modeling purposes.

4.6.3 Measurement Schedule

The proposed sampling intensity suggests 83 CMI plots (31 in the Non-SMZ PHR stratum, 52 in the SMZ) should be established in the first measurement period. These plots need to be remeasured in the second period with 32 new plots being established in the Non-SMZ PHR stratum, for a total of 115 plots to be measured (63 in the Non-SMZ PHR stratum, 52 in the SMZ). The sampling for each measurement period should be done in the same year. If this is not possible, the plots should be measured within two years. For the first measurement period, that would mean 42 plots/year.

4.7 PLOT DESIGN

The plot design follows the MSRM standard CMI protocol for tree attributes (Figure 1).[5] The main plot is 400 m^2 (11.28 m radius) where all trees greater than 9.0 cm diameter at breast-height (DBH) are measured and tagged. Trees between 4 cm and 9 cm DBH are measured and tagged in the small-tree plot (100 m^2, 5.64 m radius), and trees taller than 30 cm and less than 4 cm DBH are measured and tagged in the regeneration plot (19.6 m^2, 2.50 m radius).

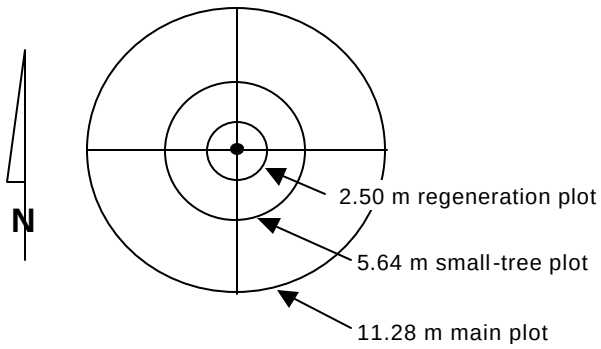

Figure 1. Monitoring sample plot.

4.8 PLOT MEASUREMENTS

4.8.1 Overview

All standard MSRM plot measurements will be recorded, except for range, coarse woody debris, soil, and ecological succession information. No custom measurements will be recorded in this project.

4.8.2 Plot Cards

Plot navigation and establishment will follow plot cards 1 to 3. No range (cards 4 and 5) or coarse woody debris data (cards 6 and 7) will be collected. Tree attributes (cards 8 to 11) will be collected as per the MSRM standards. Site classification and site features data (cards 12 and 13) will be collected. Soil information will not be taken at the pin location (card 12) or for the dominant stratum (card 13), vegetation lists of the tree, shrub, herb, and moss layers (cards 14 and 15) will not be recorded, and ecological succession data will not be taken (card 16).

4.8.3 Plot Establishment

The CMI plot will be established at the selected grid location. When a plot appears to cross the sample polygon boundary, a diagram will be drawn to explain clearly where the polygon boundary is located within the plot. This will allow the appropriate comparison of the sample plot to the area-weighted yield tables of the component polygons.

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New objectives can be added to the CMI program in the future. For example, branch size, tree taper, or wood quality measurements 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

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