Boundary Timber Supply Area

Vegetation Resources Inventory
Strategic Inventory Plan

Prepared by:
IRC Spatial Data Group Inc.

Authors are:
Warren Eng (Atticus Consulting Group Inc.) and
Tracy Earle (Four Points Forestry Solutions)

March, 2008

Acknowledgements

This plan was developed by Four Points Forestry Solutions for IRC Spatial Data Group Inc. on behalf of BC Timber Sales- Kootenay Business Area. Direct support and plan develop was carried out by various parties including: George Edney RPF (BCTS), Brian Drobe RPF (Weyerhaeuser), Randy Waterous (Pope and Talbot),Tara DeCourcy RPF (Ministry of Forests and Range), Chris Mulvihill RPF (Ministry of Forests and Range), Warren Eng (Atticus Consulting Group Inc.), Tracy Earle (Four Points Forestry Solutions), Gary Johansen RPD (Ministry of Forests and Range), Laurence Bowdige RPF (Ministry of Forests and Range), Walter Hayashi RPF (Ministry of Forests and Range), Frank Wilmer (Integrated Land Management Bureau).

Funding for the project was provided through the Forest Investment Account Land-Based Investment Program.

1 Executive Summary

Stakeholders of the Boundary Timber Supply Area (TSA) are generally satisfied with the current TSA forest inventory and find the inventory adequately meets most resource manager's needs despite the inventory being more than 18 years old. Based upon the 1998 forest inventory audit:

- the differences between the audit volumes and the inventory volumes were not statistically significant for the mature, operable component of the landbase;
- the only main concern was the site index assignment in the immature inventory component may not be accurate.

However, stakeholders have identified that the inventory does not provide:

- adequate information to monitor volumes in second-growth stands;
- adequate information to determine inaccuracies in site productivity estimates;
- confidence in volumes calculated by VDYP7 in existing stands with actual ground measurements.

To address these issues, the following Vegetation Resources Inventory (VRI) activities are planned in this Vegetation Strategic inventory Plan (VSIP):

1) Phase II ground sampling
2) NVAF tree data collection
3) Data analysis and inventory attribute adjustment
4) Change Monitoring Inventory (CMI) plot establishment

Three hundred and fifty nine thousand and three hundred and fourteen (359,314) ha or 62% of the TSA area is to be included in the VRI activities. This area represents the vegetated treed portion of the operable and inoperable TSA landbase. The total budget for completing the VRI Phase II program component is estimated at $473,400[1] and for the CMI program is estimated at $119,000. The combined total VRI and CMI program requires $592,400.

The VRI portion of this plan is scheduled to be completed between 2008-2010 fiscal years in an effort to provide an adjusted inventory for TSR3 that is scheduled in 2013.

The initial installation of the CMI plots is planned to be completed in the 2010 fiscal year. Data collected under this program will be used in future TSR analyses.

This VRI program, including the CMI portion, is anticipated to be funded from the provincial government as part of the VRI focused funding initiative and the licensee FIA allocation. The specific allocation of the budget is as follows:

[1] Due to the highly variable nature of this unit, the sampling error objectives and total number of samples that should be installed will be reevaluated following the installation of the first 80 samples. This reevaluation may result in fewer plots established in this unit.

First Approximation of Budget and Schedule

VRI Phase/Task	Inventory Activity	Unit	# Units	Unit Cost $ / Unit	Total Cost $	Comments
II	**Phase II VPIP including a CMI program**	TSA		19,500	19,500	Includes CMI component
	Sample package preparation	Plot	185	100	18,500	Includes preparation of 11 replacement plot packages, if needed
	Ground Sampling- VRI	Plot	174	1600	278,400	
	Helicopter	TSA			30,000	Anticipated costs
	3rd party Quality Assurance	Plot	18	1,500	27,000	10% of ground samples
	NVAF	Tree	100	600 + 15,000	75,000	$600/tree + helicopter
Phase II plot Subtotal					448,400	
CMI	**Sample Packages**	Plot	50	160	8,000	
	CMI plots	Plot	50	1,600	80,000	Plot establishment
	Helicopter	TSA			15,000	Anticipated costs
	3rd party Quality Assurance	Plot	5	2,000	10,000	10% of ground samples
	Analysis and report	TSA	1	8,000	6,000	
CMI plot Subtotal					**119,000**	
II	**Statistical analysis and adjustment**	TSA			$25,000	
Statistical Adjustment Subtotal					**$25,000**	
GRAND TOTAL OF BOUNDARY VRI and CMI					**$592,400**	

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2 Introduction

2.1 Background

The objective of this VSIP is to provide guidance to the future investment of VRI activities and products needed to address forest management and inventory issues identified within the Boundary TSA. These issues were identified during the stakeholder meeting held February 28th, 2008 and in subsequent discussions. This document represents the overall strategic plan for VRI ground sampling and Change Monitoring Inventory program within the Boundary TSA.

Four Points Forestry Solutions, with technical support from Atticus Consulting Group Inc. (Atticus) of IRC Spatial Data Group Inc. (IRC), prepared this plan on behalf of BC Timber Sales-Kootenay Business Unit, in consultation with other stakeholders including:

- BC Timber Sales
- Weyerhaeuser Canada Ltd.
- Pope and Talbot
- Ministry of Forests and Range (MoFR)
- Integrated Land Management Bureau (ILMB)

2.2 Vegetation Resources Inventory Overview

The VRI is a vegetation inventory process that is designed to assess the quality and quantity of British Columbia's timber and vegetation resources by estimating the overall inventory totals and averages for a particular management unit, as well as individual polygon attributes.

The VRI consists of the following 3 components:

1) Phase I photo interpretation

   - Delineation of vegetated and non-vegetated polygons;
   - Field calibration;
   - Polygon attribute estimation;
   - Digital capture of attributes and polygon boundaries to produce new forest cover maps.

2) Phase II ground Sampling

   - Information is collected in ground samples for purposes of determining how much of a given attribute is in the landbase.
   - There are two parts to this phase:
     a. Establishment of cluster samples (five-point cluster samples) that are randomly established across the landbase. These plots be timber emphasis plots and/or full plots which also measures vegetation attributes.
     b. Destructive sampling that measures and corrects for errors in the estimation of net close utilization tree volume (which is later used to calculate the net volume of a stand).

3) Analysis and Adjustment

- Data analysis is the process of compiling and comparing the Phase II ground samples to the Phase I photo estimates in order to determine the relationship between these two datasets;
- Applying the determined relationship to the photo interpreted estimates results in an attribute adjustment to remove any bias that may have been introduced by the photo interpreter.

Which VRI activities are undertaken largely depends upon the management issues present on the landbase.

For more detailed information, visit http://ilmbwww.gov.bc.ca/risc/pubs/teveg/index.htm

2.3 VRI Overriding Principles

The implementation of VRI throughout the province is based on the following guidelines:

- that inventory projects are implemented to satisfy identified business needs as defined in the VSIP and VPIP documents. The VSIP identifies the general strategic forest management and inventory issues for a specific land area, and lists the activities and products required to address those issues; the VPIP identifies the operational priorities and provides detailed information regarding the implementation of the proposed VRI activities.

- To develop VRI products in a coordinated and structured way.

- To implement inventory projects following approved standards developed by the Resource Information Standards Committee and located at:

  http://ilmbwww.gov.bc.ca/risc/pubs/teveg/index.htm.

- To ensure that there is statistical confidence in timber value estimates.

2.4 The VRI Planning Process

The VRI planning process requires that a Strategic Inventory Plan and a Project Implementation Plan be developed for a forest management unit prior to any inventory activities being carried out. The Strategic Inventory Plan (VSIP) is a strategic plan that identifies various VRI products or activities required to address forest management issues identified local stakeholders and provides strategic direction for their implementation. The Project Implementation Plan (VPIP) provides a more detailed plan regarding the various VRI activities including costs, priority areas, schedules, coordination, individual plot locations, standards and roles and responsibilities. Both documents seek to ensure that the identified VRI products address important management issues in priority areas. This VSIP outlines the framework for preparing the VRI products and should be consulted in the VPIP development. The VSIP was developed under the MoFR VRI planning process following the provincial guidelines that are available at:

http://www.for.gov.bc.ca/hts/vri/standards/plan/preparing_vri_strategic_inventory_plan.doc

Other documents referenced in this VSIP include:

- Boundary TSA Inventory Audit- November 1999
- Boundary TSA Timber Supply Review II- Timber Supply Analysis Report- November, 2000
- Boundary Timber Supply Area Rationale for AAC Determination- January, 2002
- Dense Pine Sub-unit Inventory Plan (1998)
- Statistical Adjustment of Dense lodgepole Pine Polygons in the Boundary Forest District, V. 2 (1999)
- Tree Farm License 8 VSIP (2007)

2.5 **Funding**

The VRI program outlined within this VSIP is subject to funding from the provincial Forest Investment Account (FIA). Currently, funding for VRI activities are FIA eligible. It is expected that the VRI Phase II, NVAF sampling and statistical adjustment of this program will be funded by the provincial government as part of the VRI focused funding initiative. The CMI program is not eligible for VRI focused funding and funded is expected through licensee FIA allocations.

The budget identified for the projects in this Plan has been developed utilizing historic costs from similar projects, and totals approximately $577,400.

3 Business Considerations

3.1 **Land and Resource Base**

The Boundary Timber Supply Area (TSA) encompasses 579,000 hectares in the south central portion of the province. Approximately 62 percent of the TSA land base is considered productive forest land[2]. Currently about 80% of the productive forest landbase or 50% of the total TSA is considered available for timber harvesting. The TSA is bordered to the west by the Okanagan Highland Range of the Monashee Mountains, the Christina Range to the east and the Canada-US border to the south (Figure 1). The Ministry of Forests and Range- Arrow-Boundary Forest District office administers this TSA.

The topography of the TSA consists of mountain ranges in the east and rolling terrain with flat valley bottoms in the west, as well as the Kettle and Granby River drainages. It is this varied topography and climatic conditions that contribute to the diverse forests within the Boundary TSA.

The TSA contains portions of six biogeoclimatic zones including: Ponderosa Pine (PP), Interior Douglas-Fir (IDF), Interior Cedar Hemlock (ICH), Montane Spruce (MS), Englemann-Spruce Subalpine Fir (ESSF), and Alpine Tundra (AT).

[2] Boundary Timber Supply Area Analysis Report, November 2000

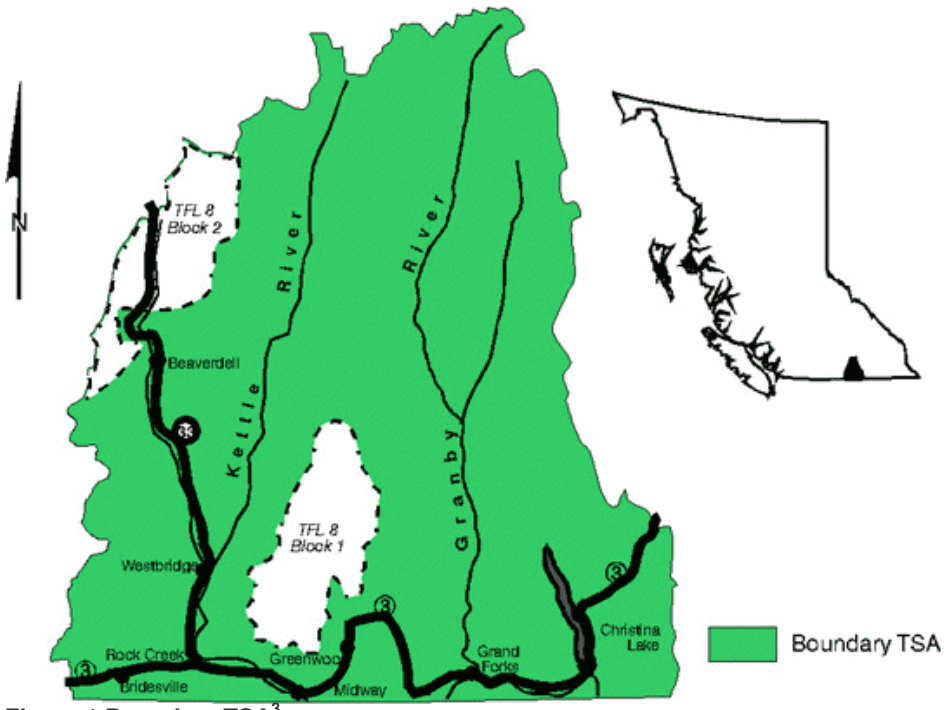

Figure 1 Boundary TSA[3]

The dominant tree species occurring on the timber harvesting land base are lodgepole pine (46%), but the forests also contain larch (20.5%), Douglas-fir (17.9%), spruce (7.7%), balsam (6%). Western red cedar, western hemlock, white pine, ponderosa pine, aspen and birch also occur, but in smaller amounts. Approximately 52% of the THLB is above the minimum harvest age[4] (Table 1).

Table 1 Species Representation by Area

Species	Area (ha)	% area
Lodgepole pine	132600	46.0
Larch	59100	20.5
Douglas-fir	51600	17.9
Spruce	22200	7.7
Balsam	17300	6.0
Cedar	2600	0.9
Hemlock	2350	0.8
Yellow Pine	600	0.2

[3] Ministry of Forests and Range website
[4] Boundary TSA Timber Supply Review II- Timber Supply Analysis Report- November, 2000

Table 2 provides a summary of key information about the landbase classification within the area.

Table 2 Boundary TSA Area Summary[5]

Landbase Classification	Final Area	% of Total Area	% of Productive Forest
Total TSA Area	578,609	100	
Not managed by the MoFR	63,968	11	
Non-forest and non-productive	84,313	14.6	
Non-commercial cover	575	0.1	
Not managed by the MoFR for timber supply	70,440	12.2	
Total productive forest managed by the MoFR	**359,314**	**62.1**	100
Reductions to Productive Forest			
Existing unclassified roads, trails and landings	4,868	0.8	1.4
Riparian management areas	5,681	1.0	1.6
Environmentally sensitive areas	26,438	4.6	7.4
Low timber productivity	2,860	0.5	0.8
Deciduous forest types	2,920	0.5	0.8
Inoperable	22,118	3.8	6.1
Problem forest types	6,182	1.1	1.7
Total reductions to Productive Forest	71,067	12.3	19.8
Current timber harvesting landbase	**288,247**	**49.8**	**80.2**
Future roads, trails and landings reductions	14,568	2.5	4.0
Long term timber harvesting landbase	**273,679**	47.3	76.2

3.2 First Nations

Within the Boundary TSA, there are no documented First Nations reserves or communities. The Okanagan Nation Alliance has identified the entire TSA as their traditional territory, and the Shuswap First Nation has identified a portion within the north part of TSA as part of their traditional territory. These First nations groups have been actively participating in TSA forest management planning at various levels.

3.3 Inventory History and Issues

The last inventory completed within the Boundary TSA was conducted between 1988 and 1989 with the last update for depletions in 2003. A second depletions update is scheduled for 2008.

The current forest inventory was completed to “traditional” inventory standards and “rolled over” into VRI format. Although the data is in VRI format, many of the VRI data attribute fields remain unpopulated, as this information was unavailable from the traditional inventory database and has not been gathered since the “roll over”.

[5] Boundary TSR2 Timber Supply Analysis Report, November, 2000

3.3.1 Inventory Audit

An inventory audit was completed in 1998 and assessed the overall accuracy of the then-current (1988-1989) inventory. Three components were tested:

1. the timber volumes of the mature forested area,
2. the site productivity of immature stands, and
3. the area classified as non-forest (lakes, gravel pits, alpine meadows, etc.).

The results of the inventory audit are as follows:

1. *Mature Volume Component*

The mature component of the inventory comprises of the operable and inoperable landbase for stands greater than 60 years of age. The findings were as follows:

Operable landbase

The difference between the audit volumes and the inventory volumes for the operable component of the landbase was found to be **not statistically significant**.

Inoperable landbase

The audit sample size within the inoperable landbase was too small to allow for any meaningful comparisons to be made, therefore volume estimates for this component of the inventory were not reported.

2. *Immature Volume Component*

For the immature component (stands <60 years of age), an examination of the site index was completed. The audit results concluded that the immature site index assignment **may not be accurate**.

3. *Non-forest Inventory Classification*

The non-forest classification portion of the audit was found to not meet the provincial minimum standard.

3.3.2 Dense Pine Study

In 1999, a study was completed on dense pine stands within the TSA. The objectives of the project were to:

- determine site productivity
- evaluate merchantability of dense pine
- determine piece size distribution by sawlog/small wood components
- develop a management strategy by establishing minimum harvest ages and thin/rehabilitation potential
- determine the feasibility of a stocking class conversion from 3 to 4
- determine growth rates

The target population included all polygons within the Boundary TSA that were considered dense Pl stands, which were defined by inventory type group, age, height, stocking and site classes (Table 3).

Table 3. Definition of dense Pl population in the Boundary Forest District[6]

Inventory Type Group	Age Class	Height Class	Stocking Class	Site Class
28-31	Any	Any	4	Any
28-31	3	1	0	P
28-31	3	2	0	P
28-31	4	2	0	P
28-31	Any	Any	3	Any

A total of 165 Phase II samples were established throughout the TSA, including TFL8, and a statistical analysis and adjustment of the landbase was completed based on the data collected. A summary of the results of this study is provided below, however more detail can be found in *Statistical Adjustment of Dense Pl Polygons in the Boundary Forest District, Version 2, 1999.*

The findings of the study were (for the target population):

- age in the inventory was relatively reliable
- height and SI in the inventory were under-estimated
- volumes in the inventory were underestimated
- 1/3 of the polygons met the minimum sawlog size (0.1m3 piece size for Pl, 0.2m3 for other species)
- After the statistical adjustments were applied to the age, height and site index attributes of the target population, the total area of dense Pl polygons dropped by approximately 50% in the TSA.
- The adjustment ratios for height, age, and SI were determined and used in the last TSR (2001-2002)[7].
- definition for dense Pl stands was applied to the adjusted inventory database (resulting in 50% less area within the TSA, 30% less area within the TFL).

Utilizing these Phase II plots as part of or in addition to the Phase II sampling efforts described under Section 3.5 of this VSIP should be examined further during the development of the VPIP for this TSA. A remeasurement of these samples may be a viable option that provides additional valuable information in the statistical adjustment phase of the landbase.

3.4 Forest Management Issues

The following forest management issues were identified in the most recent timber supply review document (TSR2 Rationale for AAC determination, January, 2002), the VSIP completed for TFL8 that lies within the Boundary TSA and/or brought forward by the stakeholder group in the February 28th,2008 stakeholder meeting and follow-up discussions. These issues are discussed in detail in this section in Table 4.

[6] Statistical Adjustment of Dense Lodgepole Pine Polygons in the Boundary Forest District- Version 2, 1999.
[7] The adjusted database was used only in TSR2. The inventory files that are stored in the Land and Resource Data Warehouse contain the unadjusted age, height and site index attributes.

Table 4 Summary forest management issues for the Boundary TSA related to the inventory

Issue and *Sub-issue*	Comments	VRI Component
1- Mature component- Volume *- volume overestimation*	No significant issues were identified. Ages, heights and volumes were all found to be reliable in the inventory audit. However, the changes in volumes due to VDYP7 remains unknown. A Phase II would provide actual ground volumes that could be used to determine the accuracy of the new release of VDYP7. NVAF sampling would also help provide more accurate volume estimates, as this sampling corrects errors in gross and net volumes.	Phase II, NVAF
2- Complex Stands- Volume *- volume estimates being over/under estimated*	On some occasions[8], volumes were found to be overestimated, notably in NDT3 (wetter ecosystems) stands and in non-Pl leading types. For the most part, the volume estimates in the current inventory were deemed reasonable when compared to stand volumes obtained operationally. However, the potential changes in volumes due to utilizing VDYP7 in place of VDYP6 in these stands remains unknown. A Phase II would provide actual volumes across the landbase that could be used to compare to VDYP7 volumes. NVAF sampling would also provide more accurate volume estimates, as this sampling corrects errors in gross and net volumes.	Phase II, NVAF
3- Forest Health *- Mountain Pine Beetle incidence*	A heavy MPB infestation occurred during the 1980's and early part of the 1990's impacting stands composed of lodgepole pine. As a result of this epidemic, harvesting was focused on lodgepole pine leading stands only, leaving those stands with a minor pine component largely untouched. The pine within many of these untouched stands have since died, resulting in stands with few, if any, pine in the overstorey. These stands are still described by the inventory as having a minor component of pine, resulting in an overstatement of lodgepole pine volumes. A Phase I would reinterpret the species composition of these stands, correcting this issue. Currently, MPB is at endemic levels throughout the TSA, and the second expected wave of infestation has not yet been encountered. Provincial spread modeling indicates that the next anticipated infestation could be within the next couple of years (2009-2010). Undertaking a Phase I for this TSA should be revisited after this second anticipated infestation has passed to address this issue. Installing Phase II plots prior to the expected infestation could provide valuable information in terms of mortality, pest incidence and stand dynamics, given that approximately 47% of the THLB is in either pure lodgepole pine or Douglas-Fir/lodgepole pine mixed stands.	Phase I, Phase II

[8] These instances were confined to an OGMA project that was focusing on the mature-old component of the inventory and in non-pine leading stands. Most often this overestimation was noted in complex stands in NDT3.

4- Dense Pine Stands *Variability of age, height and volumes in the current inventory is large[9] for dense pine stands, making it difficult for operational and long term planning and analysis.*	Utilizing the results of the Dense Pine Study at this time may not be the best approach. The dataset is currently 9 years old and it's utility may be limited. A Phase II could provide information regarding these types by identifying an adjustment ratio for particular attributes. CMI plots would also provide valuable information that could be used to monitor stand dynamics, provided plots fall within these stand types.	Phase II, CMI
5- Non-productive stands *-broad typing in non-productive stands*	Polygon sizes for within the non-productive component of the TSA were too broad and did not capture smaller patches of productive forest land. An FRBC project was undertaken in the 1990's (date unknown) that re-delineated and re-classified the non-productive polygons for the entire TSA. This exercise resulted in smaller polygons sizes, some of which were re-classified from non-productive to productive. These new productive polygons were later utilized in TSA-wide seral stage analyses, as their areas were now contributing to this type of forest analysis. A Phase I would provide more accurate delineation and attributes in these stand types. However, due to the expected MPB infestation as described in issue 3, undertaking a Phase I at this time would not be prudent.	Phase I
5- Site Productivity *- Potential underestimation of site productivity*	The inventory audit found that site productivity was being underestimated. As a result, in the last TSR process, the Chief Forester recommended to his staff to "review the assumptions to decrease the uncertainty about site productivity estimates.[10]" To date, there have not been any site productivity projects completed in the TSA, and the magnitude of any required adjustments remains unknown. Phase II plots would provide information necessary to identify adjustment ratios to be applied to age and height, or provide information that would help support another site productivity initiative, such as a SIA or SIBEC project. Change Monitoring Inventory (CMI) plots could also be used to refine site productivity in specific stands.	Phase II[11], CMI

[9] This variability is noted through local experience and is not available as a measured statistic, unless it is found that the stand types are similar to those utilized in determining the stand population for the Dense Pine Study (1999).
[10] Boundary TSA Rationale for Allowable Annual Cut Determination, January, 2002
[11] Data from the Phase II plots would provide information to support an adjustment of age and height (if required), thereby providing a more reliable site productivity estimate through the attribute site index. A Phase II, however, should not be initiated solely for this purpose, as site productivity can be better adjusted through other means (such as a Site Index Adjustment or Site Index BEC (SIBEC) project).

6- Species Habitat and Biodiversity Non-timber Attributes *- The current inventory lacks all of the non-timber attributes*	Although the existing inventory lacks several non-timber attributes, the existing inventory meets the stakeholders current planning needs. Several habitat modeling projects (grizzly bear and MDWR habitat planning/management, to name a few) have been completed within different areas of the TSA. The existing inventory was deemed appropriate for these habitat modeling projects, as these types of projects usually include the need for species-specific attribute information that is not included in the VRI. However, some stakeholders have indicated that, as described under issue 5, a Phase I would help support habitat planning initiatives. A Phase I would provide additional non-timber attributes that would benefit habitat planning, however, due to the expected MPB infestation as described in issue 3, undertaking a Phase I at this time would not be prudent.	Phase I
7- Monitoring *- approximately 47.7% of the THLB is projected to gain between 17 and 46% in volume[12] upon harvesting and is assigned to their appropriate managed stand yield curve.*	According to the TSA analysis report[13], 106,107ha of the THLB (36.8% of the total THLB), when harvested and assigned to a managed stand yield curve, stands to gain significant volumes. Furthermore, 31,497ha (10.9% of the THLB) has already been harvested and is 'growing' on managed stand yield curves (see table 3 for more details). With such a large proportion of the THLB falling with these analysis units showing a significant expected increase in volumes, it becomes important to monitor these expected gains in second-growth stands over time to ensure that these increases are indeed realistic and being realized. There is currently no existing program in place in the TSA designed to collect or monitor the necessary information of second-growth stand yields over time.	CMI

Table 5. Summary of area and Percent Increase in Volume/ha for Pine-Pure or Pine Leading/mixed stands

Stand Type	Unmanaged Analysis Unit	Volume at 100 years (m3/ha)	Area in Unmanaged-AU	Managed Analysis Unit	Volume at 100 years (m3/ha)	Area in Managed-AU	% Increase in volume from unmanaged to managed AU
Pl (pure)	112	290	19,530	111	374	3,561	29
Pl (pure)	122	230	23,351	121	270	14,701	17
Pl mixed	212	259	224,140	211	377	2,398	45
Pl mixed	222	208	29,979	221	273	10,625	31
Fd, Py	312	236	9,107	311	344	212	46
Total			**106,107**			**31,497**	
% of THLB			**36.8%**			**10.9%**	

[12] At 100 years. Boundary TSA TSR Analysis Report, November, 2000, Appendices A4, A5, A6.
[13] Boundary TSA TSR Analysis Report, November, 2000, Appendices A4, A5, A6.

3.5 **VRI Activities and Products**

The current inventory within the Boundary TSA meets the majority of the existing stakeholder needs with regards to resource management; however there are some shortcomings in meeting future needs. The recommended VRI activities and products needed for addressing the forest management issues identified are listed in this section. These recommendations are based on the issues identified in Table 4 under Section 3.4, including the discussions at the stakeholder meeting and follow-up discussions held with the stakeholders.

There were a couple management issues identified that would benefit from a Phase I, however current provincial spread modeling of the mountain pine beetle infestation indicates that a second epidemic is forecasted for the TSA for 2009-2010. With this potential threat, it is best to revisit undertaking a Phase I after the threat has passed or is no longer expected to impact the stands within this TSA to address those management issues.

Recommended VRI activities and products:

1- Undertake Phase II ground sampling (timber emphasis plots) in the vegetated treed areas of the operable and inoperable landbase, excluding Parks and Protected Areas, to provide:

   a. Information that can be utilized to compare VDYP7 estimated volumes to actual stand volumes;
   b. A basis for evaluating site indices within the current inventory;
   c. Statistically adjust the existing inventory.

2- Conduct Net Volume Adjustment Factor (NVAF) sampling to statistically adjust the volume attribute for hidden decay and taper equation bias.

3- Complete an inventory analysis and statistical adjustment to the existing inventory.

4- Initiate a Change Monitoring Inventory program that will provide:

   a. Data necessary for determining long-term managed stand growth trends;
   b. Data necessary for determining trends in stand dynamics related to certain insect or disease outbreaks.

4 Inventory Plan

4.1 Overview

This section outlines a strategic inventory plan to develop the identified VRI products discussed in Section 3.5. The VRI products include conducting a timber emphasis Phase II sampling program in the operable and inoperable, vegetated treed landbase of the Boundary TSA. The final activity planned is an inventory analysis and statistical adjustment to Phase I attribute estimates.

4.2 Ground Sampling (Phase II)

4.2.1 Ground Sampling Objectives

The main objective of the ground sampling is to install an adequate number of Phase II sample plots required to statistically adjust specific attributes within the Phase I photo interpretation. The total number of VRI samples will aim to achieve a minimum sampling error of +- 10% (95% probability) for net merchantable timber volume and allow for calculation of sampling errors for other VRI attributes, therefore enough samples need to be installed to achieve this target. The VRI ground plots will also provide ground sample volumes against which VDYP7 volume comparisons can be assessed.

In order to obtain a completed VRI at a reasonable cost, Timber Emphasis Plots (TEP) will be installed at each identified location and may include data collection on some or all of the following attributes: coarse woody debris, range and ecology. These details will be finalized in the VPIP.

Additional samples will be considered during the VPIP development stage and will be based on:

- the need to collect more information in certain populations;
- the need to reduce the sampling error.

The NVAF destructive sampling is designed to statistically adjust VRI ground sample volumes to correct for errors in the estimation of net close utilization volume caused by hidden decay and taper equation bias. The net volume estimate assigned to forested polygons in a forest inventory is the gross volume of the stand less stumps, tops, decay, waste and breakage. The decay and waste portion will be estimated using VRI call grading/net factoring and NVAF sampling, as well as completing the call grading to interior call grading standards. This extra data collection[14] (to interior call grading standards) will help address the log quality issues identified in this TSA.

[14] Collecting data to interior log grade standards is not part of the current VRI standards, therefore a request for a variation to the standards will be required. If this variation is not granted, this portion of the data collection will be done at a cost to the licensees, or, alternatively, can be dropped from the sampling protocol.

4.2.2 Quality Assurance- Phase II

The quality assurance component of this Phase of VRI also usually includes the use of a third-party independent certified VRI sampler who checks the following:

- plot location and establishment;
- data collection.

An estimated cost for undertaking a third party audit of the Phase II ground samples is included in the budget table. MOFR staff will be asked to complete the NVAF sampling QA, thus no estimated costs for this activity is included.

4.2.3 Target population

The target population will be the vegetated treed (VT) portion of the operable and inoperable landbase within the TSA. Private land will be excluded. Only that portion with >10% crown closure and over 30 years old will be sampled.

The population will be pre-stratified using the existing forest inventory and based on species or species groupings that reflect both the actual species composition of the landbase and stakeholder interests. Each individual stratum must be of sufficient size in the population to derive adequate sampling to reach a conclusion that will be statistically significant, as would be discussed in the analysis.

4.2.4 Sample Size

To meet the +-10% sampling error requirement for estimating the average net merchantable volume, the approximate number of samples is 174 plots[15]. 80 plots will be established initially, and based on these data, the coefficient of variation will be recalculated to refine the total number of plots required to meet the +-10% sampling error at a +-95% confidence level[16]. These 80 samples will be established proportionally across all strata.

Based upon the current species distribution used for TSR 2 as shown in section 3.1 and considerations expressed by stakeholder with respect to specific species group, the suggested landbase stratification for the Boundary TSA based upon recommendation by MoFR-Forest Analysis and Inventory Branch is as follows:

Stratum	**Approximate number of samples**
Lodgepole Pine	80
Larch	36
Douglas-Fir	31
Other	27
Total samples	***174***

[15] Based on the audit estimates of a Coefficient of Variation of 66% and a Standard Error of 16.6%.
[16] Due to the highly variable nature of this unit, reevaluating the sampling error objectives and total number of samples following the first 80 samples may result in fewer plots established in this unit.

The sample stratification for the initial 80 samples will be as follows:

Stratum	Approximate number of samples
Lodgepole Pine	37
Larch	16
Douglas-Fir	14
Other	13
Total samples	***80***

Stands less than 30 years would not be sampled.

4.2.5 Sampling Approach

All VRI ground plots to be established will be Timber Emphasis Plots (TEP), with NVAF tree enhancement of approximately 30 samples at the same time as plot establishment. Certified VRI Phase II samplers will conduct all ground sampling.

4.2.6 Sample Selection

For selecting the sample polygons within the current inventory, the MoFR approach 'probability of selection proportional to size with replacement (PPSWR)' will be followed. The applicable document that details this selection procedure is *Sample Selection Procedures for Ground sampling v3.3, December, 2002.*

80% of the plots will be in the operable landbase and 20% will be in the inoperable landbase.

4.3 Net Volume Adjustment Factor Sampling

4.3.1 NVAF Objective

The overall objective of NVAF sampling is to statistically adjust VRI ground sample volumes through destructive sampling in order to correct for any errors in gross and net volume. A secondary objective is to obtain local information on hidden decay, waste and stem taper. These data will later be used to adjust the initial adjustments of net volume in the Phase II.

NVAF sampling is required under the current VRI standards and includes 3 components:

1. the destructive sampling and detailed stem analysis of selected sample trees;
2. the calculation of net volume; and
3. the calculation of the ratio between the actual net volume (from NVAF samples) and estimated net volume (from the Phase II). The calculated ratio is then used to statistically adjust the estimated net merchantable volume of the VRI phase II samples.

4.3.2 Sample Size

A minimum of 100 trees (approximately 85 live and 15 dead) will be selected from the established NVAF enhanced VRI Phase II auxiliary plots. The VPIP will provide additional details on the stratification used for selecting the trees for destructive sampling.

4.3.3 Sample Selection

The following stratification is suggested for the NVAF sampling component:

Stratum	Number of Sample Trees
Lodgepole Pine	25
Larch	20
Douglas-Fir	20
Other	20
Dead	15
Total samples	***100***

4.4 Inventory Statistical Analysis and Adjustment of Existing Inventory

In order to create a statistically valid final inventory product that combines the information from the Phase II sampling with the existing inventory, an adjustment to the existing inventory for the entire VRI project area will be completed.

4.5 Change Monitoring Inventory

4.5.1 Change Monitoring Inventory Objective

The objective of the CMI program is to provide a solid inventory foundation to monitor managed stand yield estimates for purposes of providing input into future TSR analyses (to improve growth modeling assumptions) as well as to identify potential yield short-falls that may be corrected through adaptive management practices. A CMI program is particularly important in this TSA, as 47% of the THLB can potentially realize gains in volumes ranging from 17% to 46% when these stands move from an unmanaged to a managed yield curve. With this amount of potential increase on almost half of the timber harvesting landbase, the stakeholders have identified a need to monitor these stands to ensure that these gains are indeed realistic.

A CMI program in this TSA will be initiated to monitor growth in second-growth stands and to provide valuable information for yield curve validation. The target stands will be <40 years of age.

4.5.2 Target Population

The CMI program will be targeted at obtaining growth information in second-growth, managed stands that are >20 years and less than <40 years of age throughout the TSA. A second update for depletions is scheduled for 2008, therefore the amount of area within the target population is unknown at this time[17].

4.5.3 Sample Size

A minimum of 50 plots will be established for continuous monitoring. This number may be refined after the second depletions update is completed and the area that falls within the <40 years of age is identified. This landbase stratification needs to be conducted prior to sample selection and determination of the final sample size.

4.5.4 Sample Selection

The CMI sample selection should form part of the VRI Phase II VPIP and follow the most current CMI standards. A copy of the most current standards can be found at:.

http://ilmbwww.gov.bc.ca/risc/pubs/teveg/nficmp05/nfi_cmp_2k5.pdf

4.6 Implementation of the Phase II and CMI program

The implementation process is outlined below:

1. Complete a Phase II VPIP, including a CMI component, according to the most recent provincial standards and following the guidance of the approved VSIP (this document).
2. Compile a list of all polygons within the TSA and identify those that will form the target population for both the Phase II sampling and the CMI sampling.
3. Stratify the population by the criteria of interest (suggested strata were provided in Section 4.3.2 'Sample Size' for Phase II plots and Section 4.5.3 'Sample Size' for CMI plots) and allocate the samples to each stratum accordingly.
4. For VRI Phase II plots:
    a. Select sample polygon locations using the PPSWR process;
    b. Select a random plot location within the selected sample polygons;
    c. Identify the ground samples that will be NVAF-enhanced and also have ecological data collected;
    d. Prepare sample packages;
    e. Establish and collect data from ground sample plots;
    f. Complete quality assurance of the field data collection and procedures during the field sampling component;
    g. Recompile the CV to determine total number of samples required

[17] The current inventory is updated for depletions to 2003, therefore five years worth of harvesting is not yet contained within the inventory. An area estimate for the CMI population would not be meaningful.

    h. Complete Phase II sampling
    i. Complete quality assurance of the field data collection and procedures during the field sampling component;
    j. Submit complete Phase II plots to the MoFR;
    k. Compile the Phase II data.
5. Complete the interim analysis to determine if additional ground samples are required to achieve the stated precision.
6. For the NVAF sampling:
    a. Prepare the NVAF sampling matrix and identify the NVAF trees;
    b. Complete NVAF sampling;
    c. Complete quality assurance of the field data collection and procedures during the NVAF sampling portion;
    d. Compile all data.
7. Complete the statistical adjustment of the Phase II and report the results.
8. Submit results to the MoFR.
9. For the CMI program:
    a. Select sample grid locations using the provincial 100m grid. Grid spacing to be determined in the development of the VPIP;
    b. Prepare sample packages;
    c. Establish and collect data from ground sample plots;
    d. Complete quality assurance of the field data collection and procedures during the field sampling component;
    e. Submit complete CMI plots to the MoFR;

4.7 **Summary of costs**

A summary of costs for completing the VRI products for the Boundary TSA is provided in Table 6 for budgeting purposes. Costs are based on establishing 174 VRI Phase II plots. More detailed costs will be developed and presented in the VPIP.

Table 6. Total Estimated VRI project costs

Total Area VRI 359,314

First Approximation of Budget and Schedule Total Area CMI[18]

VRI Phase/Task	Inventory Activity	Unit	# Units	Unit Cost $ / Unit	Total Cost $	Comments
II	**Phase II VPIP including a CMI program**	TSA		19,500	19,500	Includes CMI component
	Sample package preparation	Plot	185	100	18,500	Includes preparation of 11 replacement plot packages, if needed
	Ground Sampling- VRI	Plot	174	1600	278,400	
	Helicopter	TSA			30,000	Anticipated costs
	3rd party Quality Assurance	Plot	18	1,500	27,000	10% of ground samples
	NVAF	Tree	100	600 + 15,000	75,000	$600/tree + helicopter
Phase II plot Subtotal					448,400	
CMI	**Sample Packages**	Plot	50	160	8,000	
	CMI plots	Plot	50	1,600	80,000	Plot establishment
	Helicopter	TSA			15,000	Anticipated costs
	3rd party Quality Assurance	Plot	5	2,000	10,000	10% of ground samples
	Analysis and report	TSA	1	8,000	6,000	
CMI plot Subtotal					**119,000**	
II	**Statistical analysis and adjustment**	TSA			$25,000	
Statistical Adjustment Subtotal					**$25,000**	
GRAND TOTAL OF BOUNDARY VRI and CMI					**$592,400**	

[18] Area should be recalculated upon second depletions update.

5 Vegetation Resources Inventory Strategic Inventory Plan Approval

I have read and concur that the Boundary TSA Vegetation Resources Inventory Strategic Inventory Plan, prepared by IRC Spatial Data Group and Four Points Forestry Solutions dated March 31, 2008, meets current Vegetation Resources Inventory Standards, business needs and considerations. It is understood that this is an agreement-in-principle and does not commit the signatories to completing the inventory activities outlined within the plan. Any major modifications to this plan will need to be reviewed and approved by the signatories.

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Shane Bowden , RPF
Timber Sales Manager,
BCTS- Kootenay Business Area

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Jon Vivian, RPF
Manager, VRI
Ministry of Forests and Range,
Forest Analysis and Inventory Branch

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Date