Cranbrook
Timber Supply Area

Vegetation Resources Inventory

Strategic Inventory Plan

Tembec

May 8, 2008

EXECUTIVE SUMMARY

This Vegetation Resources Inventory (VRI) Strategic Inventory Plan (VSIP) outlines VRI activities and products needed to address forest management and inventory issues in the Cranbrook Timber Supply Area (TSA). The TSA is located within the Southern Interior Forest Region – Rocky Mountain Forest District, in southeast BC.

The main forest management and inventory issues identified by the participants at the February 26, 2007 stakeholders meeting include:

- Net merchantable volume;
- Height, age and site index;
- Volume of dead trees;
- Coarse woody debris to provide decision support on a landscape level biodiversity and sustainable forest management planning;
- Levels of mountain pine beetle (MPB) attack, current attributes and volumes of MPB stands;
- NDT 4 inventory validation; and
- Taper equations.

To address these issues, this VRI program will include a potential Phase I photo-interpretation project on the NDT4 types and the area previously covered by TFL 13, Phase II ground sampling on the vegetated treed area of the TSA, Net Volume Adjustment Factor sampling, and a proposed Change Monitoring Inventory (CMI) program.

At this point in time, the total expected cost of proposed VRI activities in the Cranbrook TSA is estimated to be approximately $519,600.

ACKNOWLEDGEMENTS

This plan was developed by Tembec Enterprises Inc. Direct support and plan development was carried out by various parties including the following: Darin Hancock (Chrysalid Tech & Resource Management), Marcie Belcher, RFT, Forest Investment Account [FIA] Administrator, (Tembec), and Chris Mulvihill, RPF, (Inventory Forester, Ministry of Forests and Range - Southern Interior Forest Region). Input was provided by the Ministry of Forests and Range, Forest Analysis and Inventory Branch in Victoria which includes Will Smith, RPF, Volume and Decay Sampling Officer, and Gary Johansen, RPF, VRI Audit Coordinator.

Tembec has been involved in the development of a VSIP for the Kootenay Lake and Invermere TSAs where they received direct support in VSIP development from Timberline Natural Resource Group (primary contact Hamish Robertson). The Cranbrook VSIP is structured in the same format as the Kootenay Lake and Invermere VSIPs and Section 1 – VRI overview process mimics the previous two plans.

Funding for this project was provided through the FIA Land Base Investment Program.

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1.0 INTRODUCTION

1.1 BACKGROUND

This Vegetation Resources Inventory (VRI) Strategic Inventory Plan (VSIP) outlines VRI activities and products needed to address forest management and inventory issues in the Cranbrook Timber Supply Area (TSA), as identified by stakeholders at the February 26, 2007 meeting. The VSIP provides details for photo interpretation, ground sampling, and statistical adjustment of the inventory. Following VSIP approval, the next steps are the preparation of Project Implementation Plans (VPIPs) based on this VSIP, and the implementation of the VPIPs.

The Cranbrook TSA stakeholders include willing participants operating within the TSA. The TSA stakeholders are:

- Ministry of Forests and Range (MOFR)
- BC Timber Sales (BCTS)
- Ministry of Environment (MOE)
- BC Parks
- First Nations
- Tembec Enterprises Inc. (Tembec)
- Galloway Lumber Co. Ltd

This VSIP follows a meeting that occurred on February 26th, 2007 in Cranbrook, BC. The following is a list of attendees at this meeting;

- Dave Brown, Tembec
- Paul Frasca, Tembec
- Marcie Belcher, Tembec
- Steve Temple, Tembec
- Cam Donaldson, Galloway
- Al Pollard, BC Timber Sales
- Chris Mulvihill, MOFR, Nelson
- Gary Johansen, MOFR, Victoria
- Will Smith, MOFR, Victoria
- Mike Black, MOFR, District
- Darin Hancock, Consultant

1.2 VRI OVERVIEW

The VRI is a vegetation inventory process that has been approved by the former Resources Inventory Committee (RIC) to assess the quantity and quality of BC's timber and vegetation resources. The VRI estimates overall population totals and averages, as well as individual polygon attributes, for timber and non-timber resources. Its design is simple, reasonably efficient, statistically defensible, and addresses issues raised by the Forest Resources Commission in its 1991 report, *The Future of Our Forests.* The VRI is broader in scope and more reliable than past inventories because it uses statistically accurate procedures and detailed ground sampling to augment the photo interpreted estimates.

The VRI consists of several components (See Glossary, Appendix I):

1. Photo Interpreted Estimates (Phase I).
2. Ground Sampling (Phase II) –timber emphasis, ecology, coarse woody debris.
3. Net Volume Adjustment Factor (NVAF) sampling.
4. Change Monitoring Inventory (CMI).
5. Statistical Adjustment.

One or more of these components can address specific forest management or inventory issues. An overview of the VRI design was presented at the stakeholder meeting. For more information, VRI manuals are available on the MOFR- Forest Analysis and Inventory Branch website.

http://www.for.gov.bc.ca/hts/vri/

1.3 VRI PLANNING

The VRI planning process requires that a VSIP and a VPIP be developed for defined units (e.g. TSA, Tree Farm Licence [TFL]). A VSIP outlines VRI products to address forest management issues and provides strategic direction for implementing the inventory activities. A VPIP details the operational activities identified in the VSIP (e.g., ground sampling or photo interpretation projects) and identifies project areas, priorities, and roles and responsibilities. Guidelines for preparing the VSIPs and VPIPs are available on the MOFR- Forest Analysis and Inventory Branch website.

http://www.for.gov.bc.ca/hts/vri/standards/index.html

The VRI planning process is an important component of the overall VRI process and related activities (figure 1). The intent of the VRI planning process is to ensure that baseline products meet a range of applications and that they are efficiently implemented. These processes and activities include:

1. Forest management decision processes (land integration planning);
2. Identifying forest management issues;
3. VRI strategic planning (VSIP);
4. VRI operational planning (VPIPs); and
5. Implementation, including development and maintenance of procedures and standards:
   a) Management inventories;
   b) Database management;
   c) Data interpretation.

The steps for preparation of a VSIP include:

1. The licensee stakeholders work with MOFR staff to develop TSA issue statements related to VRI.
2. All agencies and stakeholders meet to refine issues and discuss why these issues need to be considered fundable. The purpose of the meeting is to:
   a) Introduce the VRI tools and process;
   b) Table new issues and issues recorded to date;
   c) Discuss issues that can be funded or not (under current funding mechanisms); this discussion provides general direction for developing the VSIP. This discussion also affects the extent of photo interpretation and the number and type of VRI plots; and
   d) Suggest the VRI tools to address currently fundable issues as well as those issues that may be funded in the future.
3. VRI stakeholder meeting minutes are prepared and circulated to all participants for review and feedback.
4. A preliminary VSIP is prepared for review by all stakeholders.
5. A final VSIP is prepared and submitted for approval by, or on behalf of licensee stakeholders.
6. The VPIP process starts.

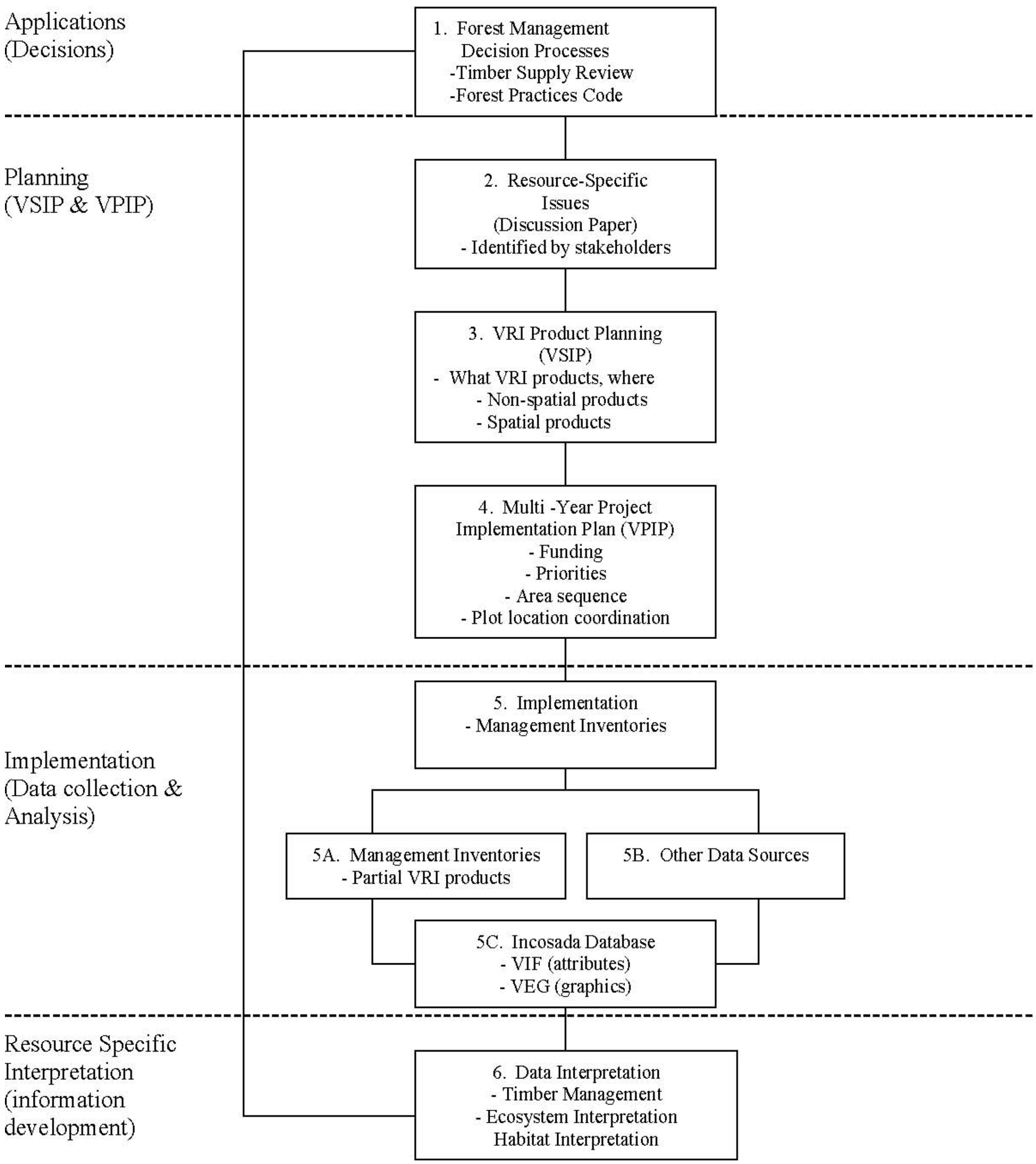
The steps for preparation of a VPIP include:

1. Review and update VSIP recommendations.
2. Secure funding.
3. Identify project activities, scheduling, geographic areas and estimated costs.
4. Specify roles and responsibilities for project implementation.
5. Prepare VPIP.

NOTE: Separate VPIPs are required for the Photo Interpretation and Ground Sampling programs. The

Ground Sampling VPIP covers both the Net Volume Adjustment Factor sampling and the analysis and statistical adjustment projects.

Figure 1. VRI Planning Process



1.4 VRI METHODOLOGY

1.4.1 Phase I – Photo Interpretation

Prior to commencing the Phase I of a VRI project, a VPIP for Photo interpretation must be completed and subsequently approved by the MOFR. This plan will detail photo acquisition requirements, the VRI Phase I process, standards for adherence, and a photo interpretation plan to carry out the Phase I of the VRI.

Phase I is the photo interpretation phase of a VRI and entails polygon delineation and attribute estimation by certified photo interpreters using aerial photographs or softcopy images. The delineation identifies the location of the forest resources and the attribute estimation component provides estimates of numerous attributes including cover type, crown closure, tree species, height, age, stand structure, basal area, density, slope position, moisture and nutrient regime, snags, shrubs, herbs and bryoids. Estimation of attributes is based upon field procedures using a combination of air and ground calibration points.

1.4.2 Phase II – Ground Sampling

Prior to commencing Phase II, a VPIP for Ground Sampling must be completed and subsequently approved by the MOFR. This plan details the Phase II sample selection process and standards for adherence.

Specifically, the Phase II VPIP will:

- Detail the Phase II project and sampling objectives;
- Target and identify sample populations, sample selection and sample size details;
- Discuss how existing Phase II sample data will be applied to the new inventory;
- Identify gaps in the sample coverage;
- Quantify any additional sample data that will need to be collected to address these gaps;
- Include discussion of the field program;
- Discuss the proposed data compilation, analysis, and statistical adjustment;
- Include the proposed implementation schedule;
- Identify the timing and submission of annual deliverables including the Phase II and NVAF data, adjusted Phase I data and final analysis report; and
- Estimate costs to complete the Phase II.

The ground sampling objectives are to install an adequate number of samples to provide statistically sound information on volume and other attributes, which can be used to adjust the inventory. The samples, (samples are plot clusters and consist of a main plot and up to four associated auxiliaries) selected for the Phase II ground sampling are based on the delineated polygons and attributes estimated during Phase I. Samples are selected randomly using a two-step process. First, polygons are selected proportional to area. Second, a random point is selected within the polygon. Comparison between the sample and the population are provided for key inventory attributes.

1.4.3 Net Volume Adjustment Factor

As per the MOFR VRI standards, all new VRI Phase II must complete an NVAF sampling program. The NVAF sampling is the destructive tree sampling process that accounts for taper bias and hidden decay in the trees and is used to adjust the cruiser's net factor calls. This sampling involves detailed stem analysis of sample trees that have been randomly selected from the Phase II plots The NVAF is used to correct the VRI estimates of net close tree utilization for all species.

1.4.4 Statistical Adjustment

The final phase in the VRI is the statistical adjustment of the Phase I applying the results of the Phase II sampling data for the entire sampled area. The NVAF information is utilized to adjust the Phase II sample estimates for hidden decay and taper bias and the Phase II plot estimates are used to adjust the Phase I photo interpretation attribute estimates. The final product is a statistically valid new inventory, supported by re-adjustment of photo estimated attributes based on ground samples.

1.4.5 Change Monitoring Inventory

A CMI program monitors change over time in key forest inventory attributes. These change estimates can then be compared to predictions from growth and yield models. One objective of the CMI program is to act as an early warning system if assumptions used in growth and yield models are inaccurate. The CMI will only indicate that there is a problem with the model(s); it will not give information about the source of the problem. Special studies must be undertaken to investigate the source of the problem identified by the CMI program.

1.5 FUNDING

Funding for VRI activities is provided by the Forest Investment Account (FIA) Land Base Investment Program (LBIP).

2.0 BUSINESS CONSIDERATIONS

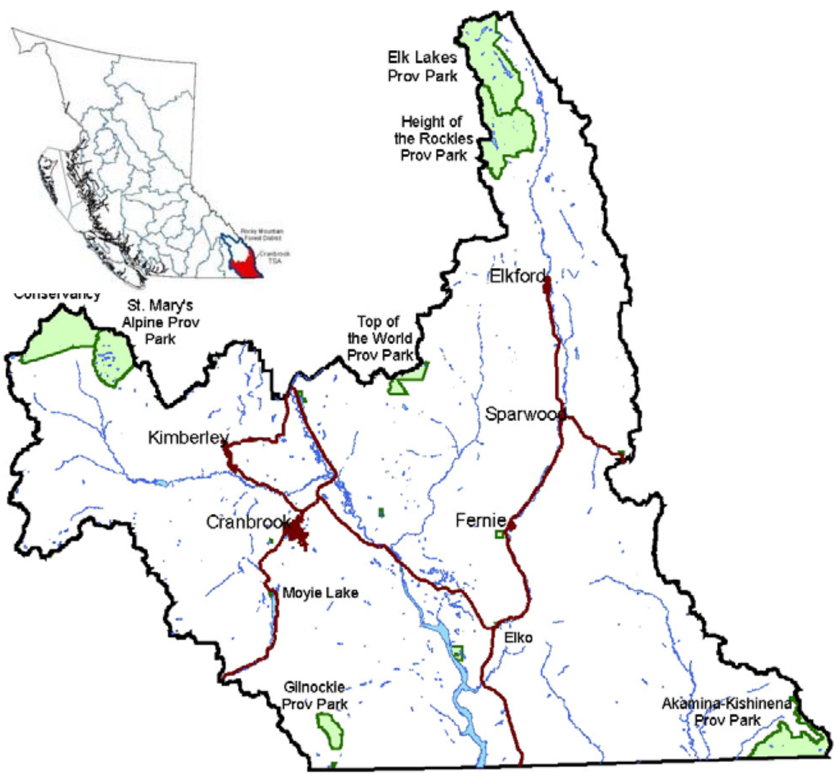
2.1 LAND BASE

The Cranbrook TSA is within the Rocky Mountain Forest District, Southern Interior Forest Region and is situated in the southeast corner of British Columbia (Figure 2). it is administered from the District office in Cranbrook. The District contains approximately 2.63 million hectares, of which 1.48 million hectares falls within the Cranbrook TSA.

Within the Cranbrook TSA, there are the Akamina-Kishinena, Elk Lakes, and Gilnockie Provincial Parks as well as numerous smaller parks and recreation areas and portions of the Purcell Wilderness Conservancy, Height of the Rockies Provincial Park, and Top of the World Provincial Park. Parks and reserves represent 22,389 hectares in the TSA.

Approximately 51% of the total area of the Cranbrook TSA is considered Crown Forested Land Base (CFLB)[1]. The remaining 49% is considered non- productive (i.e. rock, ice, alpine, etc), or is not managed by the MOFR (i.e. private, First Nations, woodlots, etc). Within the CFLB, only about 55% is considered available for timber harvesting (28% of the total TSA). Table 1 provides a landbase summary of the TSA.

Figure 2. Overview Map of the Cranbrook TSA



[1] The crown forested land base (CFLB) is the area of productive forest under crown ownership. This is the total area of land base that contributes to landscape level objectives for biodiversity and resource management. The crown forested land base excludes non-crown land, woodlots, non-forest and non-productive areas.

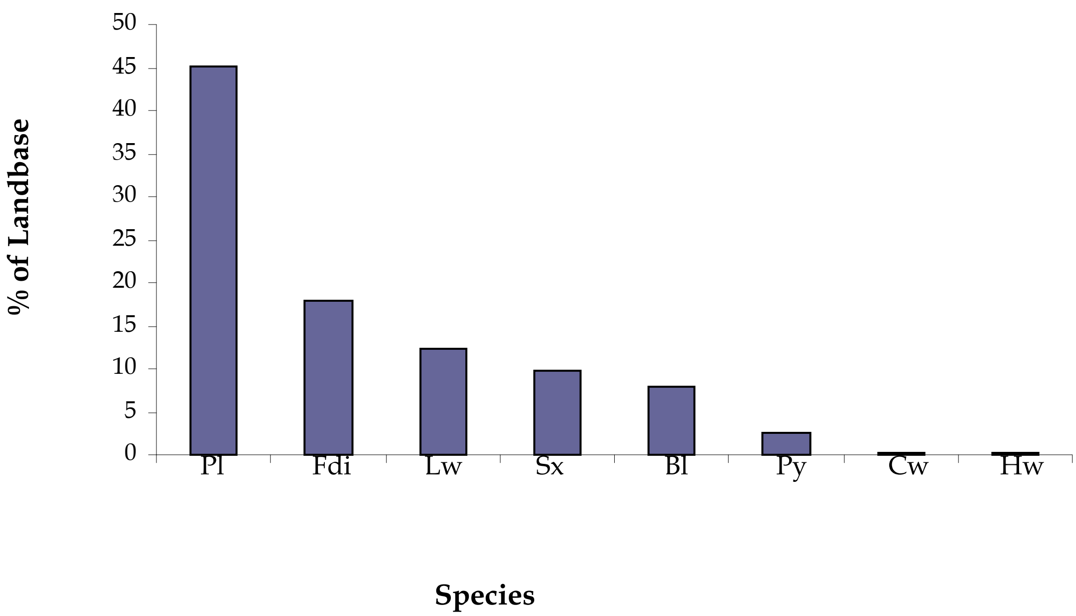
Table 1. TSR 3 Land Base Summary

Land Class	Area (ha)	% of TSA
Total TSA	1,484,302	
Non-Crown Ownership	239,951	16.2%
Crown Ownership	1,244,351	83.8%
Non-Forested	483,761	32.6%
Forested	760,590	51.2%
Non-THLB	344,394	23.2%
THLB	416,196	28.0%

The Cranbrook TSA is located in the interior dry-belt of the province and contains six biogeoclimatic (BGC) zones. These zones reflect distinct differences in terrain, climate and tree species. The BGC zones, in order of relative proportion of the THLB are: Montane Spruce (MS), Engelmann Spruce-Subalpine Fir (ESSF), Interior Douglas-fir (IDF), Interior Cedar-Hemlock (ICH) and Ponderosa Pine (PP). Lodgepole pine (Pl), Douglas-fir (Fdi), Western larch (Lw), Engelmann spruce (Se), and Subalpine fir or balsam (Bl) are the main species in the TSA (Figure 3). Minor species include ponderosa pine, western hemlock, western redcedar, whitebark pine, aspen, birch and western white pine.

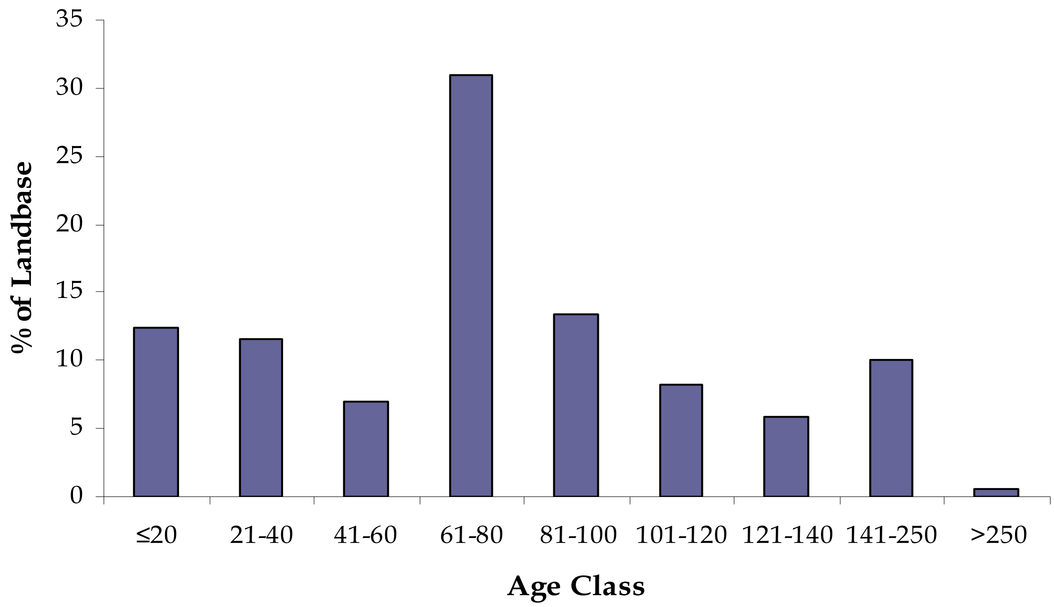
Approximately 30% of the THLB is currently older than the minimum harvest ages defined in the TSR 3 Analysis Report. The age class distribution in the TSA is not uniform. There is a higher proportion of Pl leading stands between the ages of 61 – 80 years compared to any other age class. Over 38% of the THLB is currently older than 80 years of age, (Figure 4).

Figure 3. Dominant Tree Species within the THLB, Cranbrook TSA.



***Source*: Cranbrook Timber Supply Area, Timber Supply Review #3, Analysis Report, Version 3.0, May 11, 2004, Forsite Consultants Ltd.**

Figure 4. Age Class Distribution in the Cranbrook TSA.



<u>Source</u>*: *Cranbrook Timber Supply Area, Timber Supply Review #3, Analysis Report, Version 3.0, May 11, 2004, Forsite Consultants Ltd.

2.2 FIRST NATIONS

The Cranbrook TSA is located within the "Ktunaxa Traditional Territory", which covers approximately 70,000 square kilometres in southeastern BC and historically included parts of Alberta, Montana, Washington and Idaho.

Ktunaxa kinship is comprised of members from seven communities located throughout the Ktunaxa Traditional Territory. Five communities are located in BC, and two are in the United States. The five BC communities are:

- Akisq'nuk First Nation (formally Columbia Lake Band) located near Windermere,
- St. Mary's Community located near Cranbrook,
- Tobacco Plains Community located near Grasmere,
- Lower Kootenay Community located near Creston, and
- Shuswap Community located near Invermere.

The Ktunaxa Nation Council (KNC) represents the communities within the BC portion of the Traditional Territory, and KNC leadership is comprised of the Chiefs from each community. The KNC provides governance to the communities, including Lands & Resources, Economic Development, Traditional Knowledge and Language, Child and Family, and Corporate including Communications and Information Technology.

The Shuswap Community Leadership have recently joined the Shuswap Nation Tribal Council (SNTC), which is comprised of many First Nation located in the North Okanagan and Shuswap regions.

The Ktunaxa Kinbasket Treaty Council (KKTC), which is affiliated with the KNC, is negotiating a comprehensive Treaty with the Provincial and Federal Governments. The Treaty is comprised of many chapters affecting different areas such as governance, cultural resources, and forest resources within the Ktunaxa Traditional Territory.

2.3 CURRENT FOREST COVER INVENTORY

The current forest cover inventory for the Cranbrook TSA was completed in 1992 based on air-photo interpretation using 1988 photos. The Forest Inventory Planning (FIP) lines and attributes were rolled over to the VRI format in 2000. The inventory is missing the VRI attributes that were not a part of the FIP database. Legacy attributes from the FIP database, that are not part of the VRI, are still available in the rolled over databases. The database used for TSR 3 was updated for disturbances to January 2003. The forest cover has been formally updated for disturbances to August 2003.

The area previously covered by TFL 13 (37,000 hectares) was not part of the 1992 re-inventory. The forest cover inventory for this area was completed in 1981 using 1963 photography for the timber-typing. Ground sampling was for mature strata only and immature types were poorly sampled.

An inventory audit was conducted on the TSA in 1997. The audit compared the inventory volumes of mature natural stands to field results. The audit showed natural stand volume on the operable land base was 4.2% lower than the predicted inventory volumes. This difference is not deemed to be statistically significant. In general, the inventory audit results show that the volume estimates for the Cranbrook TSA are statistically acceptable.

Fire Maintained NDT4 areas are located in the hot, dry Rocky Mountain Trench area of the TSA and are composed generally of Douglas-fir /yellow pine leading stands. These areas make up the open forest and open range timber supply analysis units as well as the NDT 4 managed forest stands. A discrepancy between cruise information and inventory yields has been noted and the Chief Forester, in his November 2005 Rationale Report has recommended that further work occur on the NDT4 inventory validation.

In the fall of 2007, the Southern Interior Region conducted preliminary sampling in the NDT4 types to review the volume issue. Fifty-two samples were randomly located in the IDF-PP BEC zone in the Cranbrook TSA. Three plots were established at each location and data was collected to estimate gross volume. Data was compiled to 12.5cm utilization and results indicate that gross volume in the inventory is not overestimated in these types. Gross volume on the ground was approximately 10% higher than in the inventory. Results should be viewed with caution as sampling errors were high. Approximately sixty VRI ground samples would be required in the IDF-PP type to achieve a 15% sampling error.

2.4 FOREST MANAGEMENT CONSIDERATIONS

Table 2 lists the main VRI – related forest management and inventory issues identified for the Cranbrook TSA. A priority ranking has not been identified in this table.

Table 2. Cranbrook TSA: VRI Related Forest Management and Inventory Issues

Issue	Photo Interpretation (Phase I)	Ground Sampling (Phase II)	Remarks
1. ***Mountain Pine Beetle Impacted Stands***	Low	Moderate -High	Pine comprises 66% of the Cranbrook TSA harvest. Pine leading stands makeup over 45% of the TSA's THLB and is often a minor species in the remaining THLB. New interpreted photo estimates (Phase I) will not be useful in management of MPB but will be useful once the infestation is finished. Ground sampling (Phase II) provides good volume estimates in stands affected by MPB. CMI samples can also be used to monitor the long term effects of the MPB infestation.
2. ***Mountain Pine Beetle Shelf Life***	Not Applicable	Moderate -High	It is unlikely that dead pine stands will retain economic value for up to ten years. Licensee staff suggest that under current drought conditions, salvage operations may only be for two to five years following attack. The MOFR is piloting collection of shelf life attributes in other VRI and CMI projects in order to build a shelf life model. Data collection can be incorporated for the Cranbrook TSA.
3. ***Volume of Dead Wood***	Low	High	Changes in interior log grades may require the Provincial Chief Forester to consider dead wood volumes in TSA determinations. Phase II data would provide improved information on dead potential volumes. Alternatively, the inventory audit estimates can be used to estimate dead wood volumes.
4. ***Ungulate Winter Range***	Moderate	Low	The UWR maps in the TSA are PEM based. Phase I may provide more detailed information on non-forest attributes for input into the PEM. The effectiveness depends on how the PEM incorporates forest cover attributes into the prediction process.
5. ***Landscape Level Biodiversity***	Moderate	High	Phase I can provide more detailed information on non-forest attributes. Phase II will provide data on coarse woody debris, forest succession and (potentially) ecological attributes.

6. ***Cutblock Adjacency and Green-up***	Low	Low	Polygon delineation will identify species composition and height estimates in younger age classes. CMI can provide feedback on whether regenerating stands are meeting expected green-up projections. Data collected through other survey methods may better address this issue (i.e. silviculture type survey). New Phase I can improve delineation and species composition estimates on openings older than those populated by RESULTS. Phase II will provide attribute information for openings greater than 30 years.
7. ***Site Productivity Estimates in Managed Stands***	Low	High	The Provincial Chief Forester states "licensees may want to put more work into developing predictive ecosystem mapping of sufficient detail to allow for its use in a SIBEC assessment of managed stand site indices". CMI samples in stands less than 40 years will provide very good information on whether the stands are performing as expected. Phase I provides better height estimates to determine site index and the Phase II provides improved data for estimating site index of current stands. Target populations (managed stands) can become strata in either sampling process.
8. ***Predictive Ecosystem Mapping***	Moderate	Mod	PEM is required to incorporate a site index adjustment for managed stands into the base case of the next timber supply review. A PEM /TEM project is currently underway in the Cranbrook TSA. New Phase I can provide better attributes to use as input into the PEM. Phase II can collect site series information at sample locations as a random check (validation) on the PEM.
9. ***Volume Estimates for Unmanaged Stands***	Moderate	Very High	Overestimation of volume in older age classes and the underestimation of volume in younger age classes. New Phase I may provide better attributes for VDYP to use in deriving volumes. Phase II will provide very good data on actual volumes and can be used to adjust the existing inventory.
10. ***Errors in Inventory Attributes***	Moderate	High	Potential error in species composition, age and height attributes. Both the Phase I and II may improve individual polygon values and reduce errors in attributes, further analysis by age and species could also identify trends within the inventory.
11. ***Problem Forest Types***	Moderate	Mod - High	For TSR 3, a total of 38,845 hectares of problem forest types (PFTs) was estimated with a sequential netdown of 17,856 hectares of true PFTs being excluded from the THLB. A significant amount of work was completed in 1998-1999 on problem forest types and helped to identify a post wood opportunity. The current approach on defining PFTs is considered to be accurate.

12. ***Forest Health Issues***	Low	Mod	Phase II sampling can provide data on the occurrence of Armallaria.
13. ***Criteria and Indicators for Sustainable Forest Management***	Moderate	Mod-High	The Phase II can provide timber, ecological, range and coarse woody debris data to provide spatial and non-spatial baseline data for use in Criteria and Indicator development, monitoring, and reporting as defined by the Canadian Council of Forest Ministers (CCFM). Monitoring involves measuring changes and trends in indicators, including percent and extent of area by forest type and age class, and mean annual increment by forest type and age class.
14. ***Partial Harvesting***	Low-Moderate	Mod-High	Information needed on the volume left in partially harvested stands and the performance of the new stands growing in the understory. Phase I can provide spatial information on the blocks and estimated attributes. Phase II will provide data on current standing volume. It is preferred that a separate stratum be created to capture this type and sufficiently sample. CMI samples can track performance, though other survey methods may provide better information.
15. ***Forest Cover for Parks is Needed for Planning Purposes***	High	Low	New Phase I may be needed if the existing information is not suitable. The applicability of Phase II depends on the level of information necessary. The ability to use FIA investment funds on this part of the landbase will have to be reviewed by MOFR and FIA staff.
16. ***Operational Adjustment Factor (OAF)***	Low	Low	Deductions for OAF 1 may be too high. OAF 1 sampling procedures may be incorporated into Phase II and CMI plots or may best be done by using other sampling methodologies.
17. ***Ownership Coverage***	Low	Low	An up to date ownership coverage is required. The VRI cannot help with this issue. The ownership data is needed so that VRI activities do not occur on private land.
18. ***Implementation of VDYP 7***	Low	High	VDYP7 is scheduled for release in the next year and will produce different volumes than VDYP6, the current yield model. Key factors in this model are basal area and height. Phase II will provide validation of the volume estimates produced by VDYP7.
19. ***Taper Equations***	Low	High	Potential problems with the taper equations for some species (especially pine, age class 4 and younger) in the TSA. NVAF sampling can identify trends and will be investigated during the Phase II VPIP development as part of the NVAF program.
20. ***Implications for Managing Species at Risk***	Moderate	Low	Phase I can provide finer delineation and specific attributes for non-forest areas.

21. ***NDT 4 Inventory Validation***	High - Mod	High	Natural Disturbance Type (NDT) 4 is mainly the IDF and the Ponderosa Pine fire-maintained ecosystems. Cruise volumes in these areas of the Cranbrook TSA are often only about half that shown in the actual inventory. The Chief Forester requests that further work occur on the NDT 4 inventory validation. New photo interpretation will provide for improved delineation of these types. Phase II ground sampling will supply very good data on volumes in this class.

2.5 SUMMARY OF INVENTORY ISSUES

It was determined at the stakeholders meeting that the completion of VRI activities could provide better information on the following:

- Net merchantable volume;
- Height, age and site index;
- Volume of dead trees;
- Coarse woody debris to provide decision support on landscape level biodiversity and SFM planning;
- Levels of MPB attack, current attributes and volumes;
- NDT 4 inventory validation; and
- Taper equations.

3.0 STRATEGIC INVENTORY PLAN

3.1 OVERVIEW

This section outlines a strategic inventory plan to develop the VRI program for the Cranbrook TSA. The main product of the VRI program is a statistically unbiased vegetation inventory. This will require a review of the need for Photo Interpretation (Phase I) on select areas (NDT4 and the previous TFL 13 area), Ground Sampling (Phase II), Statistical Adjustment and Net Volume Adjustment Factoring (NVAF). A Change Monitoring Inventory (CMI) program will also be implemented to monitor second growth stand performance.

3.2 PHOTO-INTERPRETATION (PHASE I)

The current Phase 1 inventory is relatively recent and the stakeholders did not feel that the issues with the inventory warranted a complete new Phase 1 for the TSA.

There was discussion about the possibility of completing a new Phase 1 on the NDT 4 areas in the TSA to improve the mapping and attributes on these areas. In addition, if a Phase 1 was to be initiated, the area covering previous TFL 13 should also be reviewed. The issue of completing a Phase 1 on only part of a TSA needs to be further explored before a project would be recommended. Issues that would need resolution include the following:

- definition of NDT4 area,
- objectives of the project,
- problems with combining new VRI mapping with rolled-over VRI in TSR, and
- cost and methodology.

It is recognized that the "normal / standard" procedure regarding photo-interpretation is that if it is to be completed, it must cover the entire TSA area. The TSA members feel that it is essential to review various options / alternatives in an effort to be efficient in addressing the needs of the TSA.

The Cranbrook TSA stakeholders expressed interest in the use of Light Detection and Ranging (LiDAR) technology for use in VRI Phase 1 work. LiDAR is an optical remote sensing technology that measures the properties of scattered light to gather information of a distant target such as the ground. High speed, high frequency laser pulses are emitted from aircraft, equipped with software that measures time delay from transmission of the signal to detection of the reflected signal back to the aircraft. It is recognized that the MOFR is reviewing and assessing the use of LiDAR and hyper spectral imagery for vegetation assessments. At the present time, LiDAR is not eligible for FIA funding.

3.3 GROUND SAMPLING (PHASE II)

3.3.1 Sampling Objectives

The objective of the ground sampling component of the VRI program is to install an adequate number of samples to estimate the average net merchantable volume in the target population with a sampling error of +/- 10% at a 95% confidence level.

3.3.2 Target Population

The target population will be the Vegetated Treed (VT) area within the TSA, 30 years of age or older. If the BC Land Classification Scheme information is not fully available, the vegetated treed area will be defined as polygons with a leading species and a minimum crown closure of 10%. This definition can be refined during the development of the Phase II VPIP.

Stakeholders agreed to focus the sampling on the VT area rather than the timber harvesting landbase (THLB). More than 80% of the VT area is in the THLB. This approach eliminates the problems associated with weighting data if disproportionate numbers of samples were used in the THLB and the non-THLB of the VT area.

3.3.3 Sample Size

Approximately 100-120 VRI ground samples are needed to meet the +/- 10% sampling error (95% probability) requirement for net timber volume in the VT area. Additional samples may be necessary depending on the breakdown of the final strata for sampling and/or if there is a need to have better confidence in the strata level results. These samples would be distributed among leading-species strata proportional to their area. Age or biogeoclimatic zone may also be used to define strata. The specific strata and exact distribution of the samples will be defined during Phase II VPIP development.

3.3.4 Sampling Approach

VRI Timber Emphasis Plots (TEP) will be used to gather data following the current VRI Ground Sampling Manual. The measurements would include timber attributes and coarse woody debris (CWD). These TEPs could also provide a sampling framework for a monitoring program where a subset of the TEPs would be re-measured over time.

3.3.5 Sample Selection

Sample polygons will be selected using the MOFR standard stratified probability proportional to size with replacement (PPSWR) sampling method, and a random point will be selected within the polygon using the provincial 100 m grid. If no 100m grid point falls within the selected polygon, the grid will be halved until at least one point falls within the polygon.

3.4 NET VOLUME ADJUSTMENT FACTOR SAMPLING

3.4.1 Overview

NVAF sampling involves detailed stem analysis of sample trees, calculation of actual net volume, and calculation of the ratio between actual net volume and estimated net volume. This ratio is used to statistically adjust the estimate of net merchantable volume of VRI ground samples. A subset of the TEP samples (30-40) will be enhanced for NVAF sample tree selection.

The stakeholders noted that tree taper is an area of uncertainty and believe that current taper equations do not sufficiently model trees in the Cranbrook TSA. A well designed NVAF program will identify taper issues and increased NVAF sampling may be required if localized taper equations are needed. This increased sampling would most likely be specific to individual strata. Discussion with MOFR Revenue Branch will be required before collecting data to localize the equations.

The NVAF program can start as soon as the NVAF enhanced samples are completed.

3.4.2 Sampling Objective

The objective of the NVAF component is to estimate NVAF ratios with a sampling error of ±7.5%[2] at a 95% confidence level.

The stakeholders realize there may be a benefit in co-ordinating the collection of this data with adjacent TSAs with similar issues ie. Invermere. This approach should be reviewed and addressed in the VPIP as there may be sample weighting issues involved.

3.4.3 Sample Size

The sample size of the NVAF component will be determined after the Phase II data is collected. The MOFR minimum sample size is 100 NVAF trees, 90 live and 10 dead.

More sample trees may be necessary if there is interest in specific strata such as taper in small diameter lodgepole pine. This will be reviewed and addressed in the VPIP.

[2] *In conversation with Will Smith, RPF, Volume and Decay Officer, MOFR, Inventory and Analysis Branch, Victoria, March 2007.*

3.4.4 Sample Selection

Sampling selection for NVAF will be as per the NVAF Sampling Selection and Procedures, ver. 4.2, June 19, 2007. Approximately 30 of the VRI Phase II plots will be enhanced for NVAF sampling, which will be completed during the Phase II ground sampling portion of the VRI. A tree matrix will be built with all trees from the auxiliary plots of the NVAF-enhanced samples. NVAF samples will be selected systematically, with a random start, from a list of trees (the matrix) sorted by species and diameter at breast height (DBH).

3.5 CHANGE MONITORING INVENTORY (CMI)

CMI can be used to track and calibrate the modeling assumptions used for second growth stands and is a key component of sustainable forest management planning. The Cranbrook TSA stakeholders intend to implement a CMI program in stands less than 40 years of age which comprises a significant portion of second growth stands in the TSA. The sample size must be both cost effective and large enough to allow some post stratification. It is expected that the sample size of the CMI program will increase over time as the population of second growth stands increases. In the first time period, the program should include establishment of approximately 60 plots.

A review of the Invermere TSA CMI program will be made prior to the development of a CMI plan for the Cranbrook TSA.

3.6 ESTIMATED COSTS

Estimated costs for the Cranbrook TSA VRI activities are listed in Table 3. Timeframes are dependant on FIA funding and have not been identified at this point in time.

As previously stated, the Cranbrook TSA stakeholders would be interested in initiating a pilot VRI project with LiDAR based products if the opportunity arose.

Table 3. Estimated Costs for VRI Activities in the Cranbrook TSA

VRI Activity	Units	Estimated Unit Cost ($/Unit)	Total Estimated Cost ($)
PHASE I – PHOTO INTERPRETATION			
****** to be reviewed to identify the issues involved with completing a Phase 1 on only part of a the TSA***			$3,000.00
Sub-total			*$3,000.00***
	***costs to be up-dated once the review is complete*		
PHASE II – GROUND SAMPLING			
Project Management			$ 10,000
Phase II VPIP	1	$10,000	$ 10,000
Sample Packages			$ 10,000
Ground Plots	100	$1,800	$180,000
Helicopter			$ 45,000
Quality Assurance	10	$1,800	$ 18,000
Sub-total			*$273,000*
STATISTICAL ADJUSTMENT			
Project Management	1	$2,000	$ 2,000
Data Compilation	1	$1,000	$ 1,000
Report	1	$20,000	$20,000
Sub-total			*$23,000*
NVAF SAMPLING			
VPIP Update/Tree Selection	1	$2,000	$ 2,000
Destructive Sampling	100	$600/tree	$60,000
NVAF analysis and reporting	1	$5,000	$ 5,000
Helicopter			$20,000
Sub-total			*$87,000*
CMI			
Project Management			$10,000
CMI VPIP	1	$7,000	$ 7,000
Plot Establishment	60	$1,600/plot	$96,000
Sample Packages	60	$100	$ 6,000
Quality Assurance	6	$1,600/plot	$ 9,600
Analysis and Installation Report	1	$5,000	$ 5,000
Sub-total			*$133,600*
Total	***costs to be up-dated once the review is complete*		*$519,600*

4.0 VRI STRATEGIC INVENTORY PLAN APPROVAL: SIGN-OFF SHEET

I have read and concur that the Cranbrook TSA VRI Strategic Inventory Plan dated February 14, 2008 meets current VRI Standards and 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.

DPCBrown

Tembec (lead proponent)
Divisional Forester
Western Canada - B.C.
Forest Resource Management.

Date July 9, 2008

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

Date

APPENDIX I — GLOSSARY OF TERMS

Change Monitoring Inventory (CMI)
Change Monitoring Inventory (CMI) is the process of estimating and monitoring the change over time in timber and non-timber attributes, based on repeated measurements of the same objects over a time series. The MOFR Forest Analysis and Inventory Branch is currently implementing the CMI over the province. The provincial procedures can also be deployed to address management-unit level monitoring objectives.

Ground Sampling (Phase II)
VRI ground sampling is the field measurement of timber, ecology, range, and/or coarse woody debris values at one or more locations within each sample polygon. Sample polygons are selected using the probability proportional to size with replacement (PPSWR) method. To accommodate a wide variety of resources, various types and sizes of sampling units (e.g., fixed and variable plots, transects) are used to make the measurements.

Inventory Unit
An inventory unit is the target population from which the samples are chosen. The inventory unit could be a specific geographic area (e.g. TSA or TFL) where a specific set of attributes is needed. The size of the inventory unit depends upon the sampling objectives.

Landcover Classification
The BC Land Cover Classification Scheme (BCLCS) was designed specifically to meet VRI requirements, in addition to providing general information useful for "global vegetation accounting" and "integrated resource management." The BCLCS is hierarchical and reflects the current state of the landcover (e.g., presence or absence of vegetation, type and density of vegetation) and such fixed characteristics as landscape position (i.e., wetland, upland, alpine). There are two main classes of polygons: Vegetated and Non-Vegetated.

Net Volume Adjustment Factor (NVAF) Sampling
NVAF sampling provides factors to adjust net tree volume estimated from net factoring and taper equations. The adjustment accounts for hidden decay and possible taper equation bias. NVAF sampling involves detailed stem analysis of sample trees, calculation of actual net volume, and calculation of the ratio between actual net volume and estimated net volume (where estimated net volume is obtained from net factoring and taper equations). The NVAF (and VRI net factoring) replaces the existing loss factors for inventory applications. It does not, however, replace the loss factors for revenue applications.

Photo-Interpretation (Phase I)
Photo-Interpretation involves subjective delineation of polygons and photo estimation of attributes for all polygons in an inventory unit. Medium scale aerial photographs (1:15,000) are most often used in photo-interpretation.

Post-Stratification
Post-stratification involves dividing inventory unit into mutually exclusive sub-populations (strata) *after* ground sampling has been completed. Samples that fall in each post-stratum are analyzed separately and the results are applied to the corresponding population post-strata to improve the precision of the inventory's overall averages and totals.

Pre-Stratification
Pre-stratification divides an inventory unit into mutually exclusive sub-populations (strata) *before* ground sampling to provide estimates for specific areas, or to increase the confidence in the overall estimates by considering special characteristics of each stratum.

Sample Size
The sample size for an inventory is the minimum number of ground samples to be established in an inventory unit to meet the target precision or cost. Calculation of a theoretical target sample size requires an estimate of the CV of the key attributes of interest under the proposed sampling procedures

and a statement of the precision desired in these attributes.

The formal process for determining sample size for an inventory unit is to anticipate the results (e.g., target sampling error for timber volume) and then determine the approximate sample size corresponding to this desired result. This process would, for example, involve the following steps:

1. Set the target accuracy for the overall inventory unit accuracy to *E* for timber volume (i.e., the sampling error, or half the confidence interval associated with a given probability, e.g., ±15% at the 95% probability level). The number of samples should be adequate to meet the target precision.
2. Estimate the population coefficient of variation (CV_{sample}) of the attribute of interest based on a small sample. This CV_{sample} is defined as a relative measure of the average difference between a polygon ground measurement (assumed the true value) and its corresponding estimate from the inventory.
3. The following formula would then be used to estimate sample size:

$$n = [\frac{t * CV_{sample}}{E}]^2$$

where *t* is the "*t*-value" associated with a given probability and degrees of freedom, and CV_{sample} is a sample-based estimate of the population CV.

The sample size calculations suggested here are general guidelines, not exact requirements. The sample size used in practice is usually a trade-off between the calculated sample size and the expected cost, timing, credibility, flexibility, and comparability of the inventory. The size of the population is usually large enough that it does not affect sample size. The calculated sample size may be increased arbitrarily to allow for post-stratification, increased credibility, more flexibility, and a better starting point for growth projections.

Statistical Analysis
Statistical analysis or adjustment is the process of adjusting the values of the photo-interpreted estimate variables using ground-sampling observations. Ground observations are compared to photo-estimated values to develop adjustment factors by species groups. These factors are then applied to the polygons in the photo interpretation database to produce the final adjusted database.

Sub-unit
The term sub-unit describes the inventory unit within a management unit. A sub-unit may be defined by a specific geographic area (e.g., operable landbase) or stand type (e.g., problem forest types) within the management unit.

Target Precision
Target precision expresses the amount of variation in key attributes (e.g., timber volume) desired in the final results. Target precision, usually expressed as the coefficient of variation (CV), is used to calculate the minimum sample size for subsequent ground sampling. The current target precision for timber volume is ±10% (90% or 95% probability); stakeholders define the probability (uncertainty) level.

Vegetation Resources Inventory (VRI)
VRI is an improved vegetation inventory process for assessing quantity and quality of BC's vegetation resources. The VRI process is designed to include a flexible set of sampling procedures for collecting vegetation resource information. The VRI is essentially a toolbox for procedures, which include:

- BC Landcover classification scheme (BCLCS).
- *Photo-Interpretation:* the delineation of polygons from aerial photography and the estimation of resource attributes.
- *Ground Sampling:* the establishment of plot clusters in selected polygons to measure timber, ecological, and /or range attributes.
- *NVAF Sampling:* stem analysis sampling of individual trees for net volume adjustment.
- *Statistical Adjustment:* the adjustment of the photo-interpreted estimates for all polygons in an inventory unit or management unit using the values measured during ground sampling.

The VRI can be deployed over the entire province measuring timber and non-timber resources, or over a large management unit (management VRI) measuring selected resources in specific portions of the landbase. The VRI Sampling process produces spatial and non-spatial databases that can be used in multiple resource management applications including timber, ecosystem, and wildlife habitat management.