Tree Farm Licence 8

Vegetation Resources Inventory

Strategic Inventory Plan

PREPARED BY:

TIMBERLINE NATURAL RESOURCE GROUP LTD.

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EXECUTIVE SUMMARY

The Vegetation Resources Inventory (VRI) strategic inventory plan (VSIP) documents the outcomes of the TFL 8 stakeholders meeting and outlines the important business considerations related to inventory on the land base. VRI activities are identified that will satisfy the needs of the stakeholders, based on priorities set out by the business considerations.

The business considerations for completing a new inventory as identified by the stakeholders in the March 9, 2007 stakeholders meeting require improved information on:

- Polygon volume estimates and their accuracy,
- Inventory adjustment for Timber Supply Review (TSR),
- Height, age and site index,
- Dead volume,
- Coarse Woody Debris (CWD) to provide decision support on landscape-level biodiversity and sustainable forest management planning,
- Levels of Mountain Pine Beetle (MPB) attack, changes to current attributes, and
- Problem forest types.

The Tree Farm Licence (TFL) 8 stakeholders assessed the need to complete a Phase I program within the TFL and determined that given the current state of the MPB attack and the accuracy of the existing inventory, they will postpone this activity for approximately five years or until the MPB attack has subsided.

The stakeholders determined that a Phase II Ground Sampling and Net Volume Adjustment Factor (NVAF) program will provide improved information to address the business considerations. A Phase II/NVAF program will be implemented to address the above business considerations.

A Change Monitor Inventory (CMI) program will be implemented on the TFL. CMI is an important tool to provide information on the mid-term timber supply. This program will gather information for providing validation of models used in timber supply analysis, and can quantify stand attributes in younger aged stands. Information from the CMI program could also be used for decision support with regards to timber supply (in the target population) for short term AAC decisions.

Approximately 100 timber emphasis VRI Phase II plots will be established, approximately 100 trees will be destructively sampled for NVAF, and approximately 50 CMI plots will be installed. The approximate cost for completing these activities, including statistical adjustment is $336,500. The goal is to complete the ground sampling program by the end of the 2007/2008 fiscal year; however this is contingent on Forest Investment Account (FIA) funding priorities.

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1. 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 Tree Farm Licence 8 (TFL). The VSIP provides details for photo interpretation, ground sampling, and statistical adjustment of the inventory. Following VSIP approval, the next steps include preparation of VRI project implementation plans (VPIP), and implementation of these VPIPs.

The TFL 8 stakeholders group is comprised of, Pope and Talbot and the Ministry of Forests and Range (MoFR) represented by Forest Analysis and Inventory Branch (FAIB), and the Southern Interior Forest Region (SIR).

This VSIP follows a conference call with stakeholders that took place on March 9, 2007. The following is a list of attendees for this meeting:

- Randy Waterous (Pope & Talbot)
- Gord Currie (FIA Administrator)
- Chris Mulvihill (MoFR – SIR)
- Laurence Bowdige (MoFR – FAIB)
- Gary Johansen (MoFR – FAIB)
- Will Smith (MoFR – FAIB)
- Hamish Robertson (Timberline NRG)
- Guillaume Therien (Timberline NRG)

1.2 VRI OVERVIEW

The VRI is a vegetation inventory process that has been approved by the former provincial 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*.[1]

The VRI consists of several components:[2]

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. For more detailed information, VRI manuals are available on the MoFR – Forest Analysis and Inventory Branch website.[3]

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[1] Forest Resources Commission. 1991. The Future of Our Forests – Executive Summary. Unpublished, Victoria. 41 pp.

[2] A glossary of technical terms is provided in Appendix I.

[3] http://www.for.gov.bc.ca/hts/vri/

1.3 VRI PLANNING

The VRI planning process requires that a VSIP and VPIP be developed for defined units (e.g. Timber Supply Area [TSA] or 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.

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

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

The steps for preparing a VSIP include:

1. Licencee stakeholders work with MoFR staff to develop issue statements related to the VRI.
2. All agencies and stakeholders meet to refine issues and discuss why these issues need to be funded. The purpose of this meeting is to:
    a. Introduce the VRI tools and process.
    b. Identify new issues and address existing ones.
    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.
    d. Suggest the VRI tools to address currently fundable issues as well as those issues that may be funded in the future.
3. Meeting minutes are prepared and circulated to all participants for review and feedback.
4. A final VSIP is prepared, and incorporates items agreed to in Step 2 and 3 and is signed off by committee members.
5. VPIP process begins.

[4] The TFL 8 Sustainable Resource Management Plan 3(SRMP) was completed in October, 2005.

The VPIP details the activities identified under the VSIP (Phase I Photo Interpretation or Phase II Ground Sampling) by providing project areas, priorities, scheduling, identifying the population and strata for sampling, and sample size. The steps for preparing the VRI Phase I & Phase II/NVAF VPIPs include:

1. Review and update VSIP recommendations as necessary.
2. Confirm funding.
3. Identify project activities, geographic areas, and costs.
4. Specify roles and responsibilities for project implementation.
5. Prepare the VPIP.

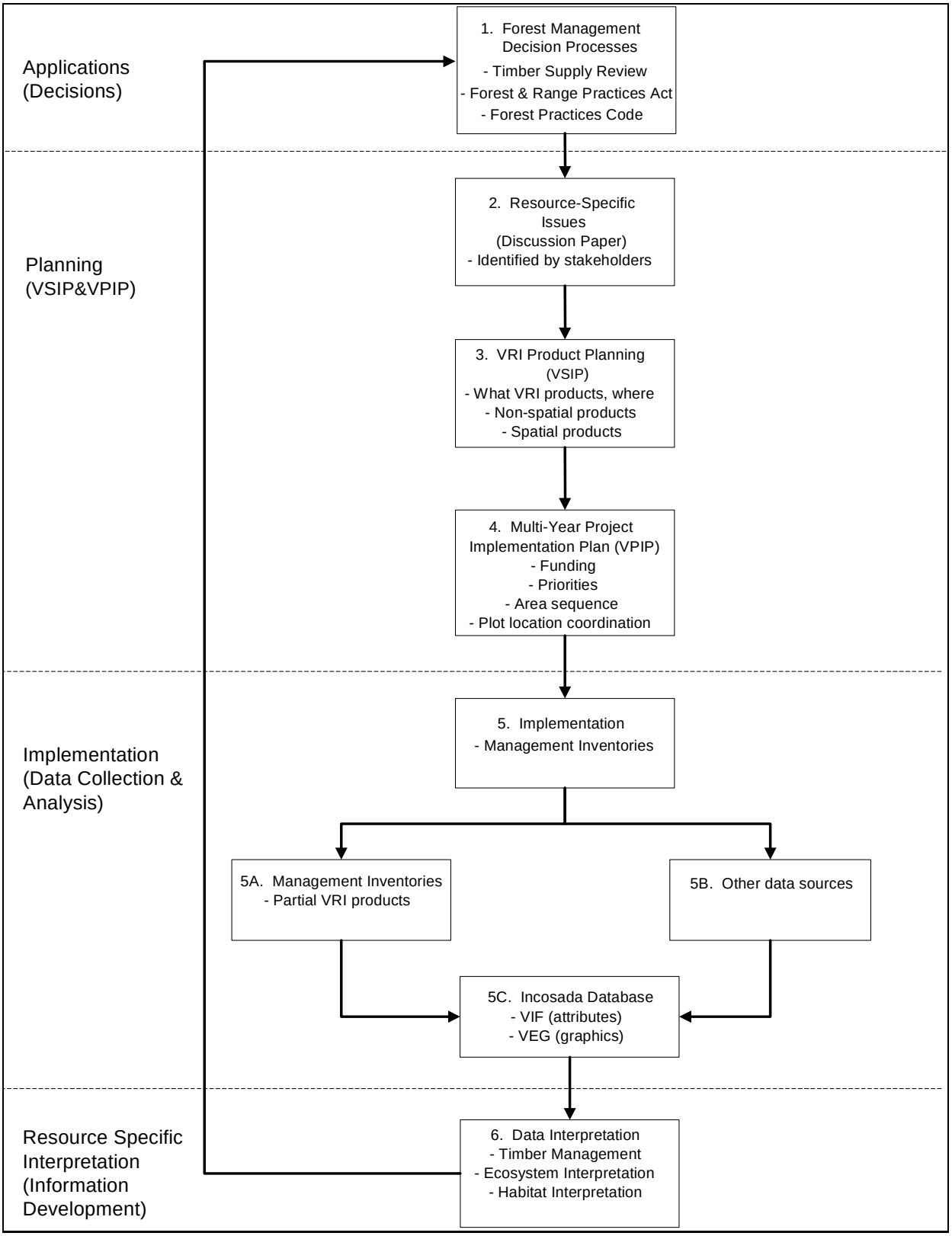

Figure 1. VRI planning process.

1.4 VRI METHODOLOGY

1.4.1 Phase I – Photo-Interpretation

Prior to commencing a Phase I VRI, a *VPIP for Photo Interpretation* must be completed and approved by the MoFR. This plan details photo acquisition requirements, the VRI Phase I process, standards for adherence, and a photo interpretation plan to implement 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 digital images. The delineation identifies the location of the forest resources and the attribute estimation component provides estimates of numerous attributes including land cover type, crown closure, tree species, height, age, stand structure, basal area, density, slope position, moisture and nutrient regime, snags, shrubs, herbs, and bryoids. The estimation of attributes from field reference points is based upon field procedures using a combination of air and ground calibration points.

1.4.2 Phase II – Ground Sampling

Prior to commencing a Phase II VRI, a VPIP for Ground Sampling and NVAF Destructive Sampling Plan must be completed and approved by the MoFR. This plan details the Phase II sample selection process and standards for adherence.

Specifically the Phase II VPIP plan will:

- Detail the Phase II project and sampling objectives,
- Identify target and sample populations, sample selection, and sample size details,
- Quantify additional sample data that needs to be collected to address information gaps,
- Include discussion of the field program,
- Discuss the proposed data compilation, analysis, and statistical adjustment, and
- Include the proposed implementation schedule.
- Identify deliverables for the MoFR.
- Outline the estimated costs for the implementation.

The samples (samples are “plot clusters” and consist of a main plot and up to four associated auxiliary plots) 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 target population are provided for key inventory attributes.

1.4.3 Net Volume Adjustment Factor

As per MoFR VRI standards, all new VRI’s must complete an NVAF sampling program in addition to the Phase II. This sampling involves detailed stem analysis of sample trees that have

been selected from the Phase II auxiliary plots. The NVAF is used to correct the VRI estimates of net close tree utilization[5] for all species.

1.4.4 Statistical Adjustment

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

1.4.5 Change Monitoring Inventory

A Change Monitoring Inventory (CMI) program takes measurements at timed intervals with the intent of monitoring change over time of key forest inventory attributes. These change estimates can then be compared to predictions derived from growth and yield models. One of the objectives 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. Specific studies can 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.

[5] Whole stem volume minus top and stump (i.e. gross merchantable volume)

2. BUSINESS CONSIDERATIONS

2.1 LAND BASE DESCRIPTION

TFL 8 consists of 77,727 ha of crown land and water located within the Boundary Forest District in the south central interior of British Columbia. The TFL is surrounded by the Okanagan Highlands and the Midway Range and is located near the communities of Grand Forks, Greenwood, Midway, Rock Creek, Westbridge and Beaverdell. The licence consists of two separate units, the south block (Block 1) north of Greenwood and the north block (Block 2) north of Beaverdell. The productive forest comprises 93% of the TFL.

Most of the productive forest occurs near 1,200 meters elevation. The climate is dry to sub-humid. The TFLs productive forest comprises of four biogeoclimatic zones including: 49% Montane Spruce (MS), 29% Interior Douglas-fir (IDF), 14% Englemann Spruce-Subalpine fir (ESSF), and 8% Interior Cedar Hemlock (ICH). Douglas-fir, larch, lodgepole and ponderosa pine occur at lower and mid-elevations and lodgepole pine, spruce and balsam occur at higher elevations. Mule and white-tailed deer, moose, elk, black bear, many smaller mammals, birds, and reptiles are prevalent either within the TFL or the surrounding areas.

Figure 2. Overview of TFL 8.

Table 1. TSR 3 Timber Harvesting Land Base (THLB) net-down process.

Land Class	Area (ha)	% of TFL
Total TFL	77,727	
Non Crown Ownership	247	0.3%
Crown Ownership	77,480	99.7%
Non-Forested	2,845	3.7%
Non-Productive	2,242	2.9%
Productive Forest	72,393	93.1%
Non-THLB	7,789	10.0%
THLB	*64,605*	*83.1%*

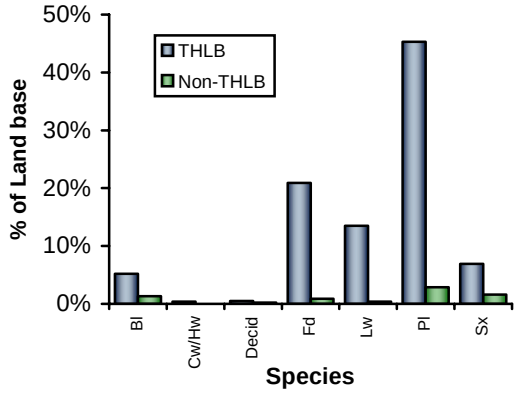

Figure 3. Species distribution in TFL 8.

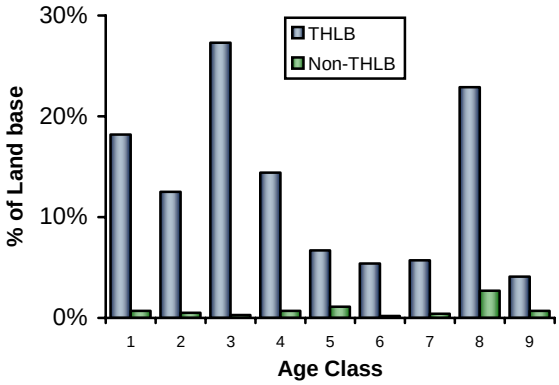

Figure 4. Age class distribution in TFL 8.

2.2 First Nations

At the time of the last AAC determination the Westbank First Nation was the only First Nation in proximity to TFL 8 to have lodged a "statement of intent" with the British Columbia Treaty Commission covering most of Block 2 of the TFL. The Osoyoos First Nation has in the past sought a relationship with P&T. This relationship has been more financial rather than traditional. Other First Nations have been invited to provide input on Forest Development Plans, however only the Spallumcheen First Nation took part in this process.

2.3 Current Forest Cover Inventory

The current TFL 8 inventory is a forest cover format inventory and was completed in 1993-1994 by Timberline Forest Inventory Consultants. The inventory audit results suggested that the inventory for both mature and immature volumes was statistically acceptable; however there was a portion of the examined polygons that were labeled as non-productive when they should have been called productive.

A MPB attack occurred in the late 1980's and early 1990's. At that time 90% of the cut was in MPB affected areas. Currently 50% of the cut is from this MPB affected area. The current inventory was completed after the last MPB outbreak.

The TFL 8 forest cover inventory has been updated for disturbance to Dec 31, 2005 and projected to 2006. In MP 10, a statistical adjustment of inventory attributes was applied to dense lodgepole pine stands, following the results of a study undertaken for P&T.[6] New Terrestrial Ecosystem Mapping (TEM) data has been completed as well as an approved site index adjustment (SIA) project for TFL 8.[7] Both the new TEM inventory and the results of the SIA project were used in the derivation of growth and yield relationships for TSR 3. Inventories of

[6] J.S. Thrower & Associates Ltd., 1999. Statistical Adjustment of Dense Lodgepole Pine Polygons in the Boundary Forest District – Version 2. Unpublished. 22p.

[7] J.S. Thrower & associates Ltd., 2006. Potential Site Index Estimates for Major Commercial Tree Species on TFL 8. Unpublished. 12p.

landscape units, known scenic areas, mule deer wintering areas, riparian classifications, and unstable terrain have recently been updated and are incorporated into the GIS.[8]

2.4 FOREST MANAGEMENT CONSIDERATIONS

Historically Pope & Talbot have selectively logged within TFL 8, particularly in the IDF biogeoclimatic zone which occupies approximately 30% of the land base. Over time these harvesting practices have left complex stands throughout the land base. Complex stand structures and spatial distributions provide uncertainties related to TSR as most timber supply prediction models do not deal with multi-layered, complex stands.

Taper and decay are aspects of uncertainty in small Pl and Fd (particularly in the transition between wet and dry belt fir areas of the IDF). Proper implementation of a NVAF plan may address both of these issues.

The MPB epidemic is spreading south towards TFL 8. The extent of the impact that this new epidemic will have on the land base is currently unknown, however based on what has happened in other land bases throughout the province there is the possibility that a decrease in mid-term timber supply could occur. P&T has the opportunity to implement aspects of VRI which would provide the advantage of monitoring the impact of MPB over the shot-term.

The following forest management issues have been identified and discussed by the stakeholders:

[8] Information taken from the TFL 8 information package for TSR 3 December 2006.

ISSUE	PHASE I IMPACT	PHASE II IMPACT	COMMENTS
1. Volume of Existing Stands	High	High	Pope and Talbot believe that the volumes they are recovering are less than those stated in the inventory. However, it is unknown to what degree these discrepencies are a result of inventory inaccuracies versus the difference between operational utilization standards and inventory utilization standards. Phase II ground and NVAF sampling will adjust the current inventory and possibly address discrepencies in volume estimates provided in the inventory. Within Polygon Variation (WPV) sampling would provide a range of possible polygon volume estimates which may address the percieved differences in recovery. An installed WPV (or modified version) could also be used as a benchmark of inventory accuracy for any future inventory updates without completing a resample.[9] A CMI program may be useful for volume projections for TSR as it could be used to monitor the performance of any models/yield curves being used.

9 Iles, K. 1998. Establishing Polygon Accuracy – By sampling for "Within Polygon Variability (WPV)" in the Vegetation Inventory of British Columbia. p.8

ISSUE	PHASE I IMPACT	PHASE II IMPACT	COMMENTS
2. Complex Stands	Med	High	Past harvesting practices have created many different residual stands within the TFL that exhibit complex structure (i.e., multilayered, uneven aged). These stands pose a problem when trying to predict the future timber supply as growth and yield models are suited to even-aged stands. Better information is needed on these stands that can properly address their complexity in TSR. WPV sampling would provide a range of possible expected values for attributes in polygons of high variabilty. This may be valuable for sensitivity analyses in TSR as structurally complex stands are areas of uncertainty in timber supply. Other measurements could also be included (e.g., taking more ages) in WPV to allow for comparisons of the attribute estimate to the true value of the attribute in the polygon.
3. Decay	Low	High	The stakeholders believe there are issues with the estimates of decay, particularly in Pl, and Sx and Bl at higher elevations. A well implemented NVAF program will adjust volume estimates based on decay measures from destructively sampled trees. This will provide improved estimates of volume based on decay in the adjustment phase of the VRI. The NVAF should identify decay issues with netfactoring and loss factors, potentially leading to further studies.

ISSUE	PHASE I IMPACT	PHASE II IMPACT	COMMENTS
4. Taper	Low	High	The stakeholders believe there are taper issues in small Pl and in Fd in the transition between the wet and dry belt. Taper issues in small pine as well as high variablility in Fd taper in the transition zones of the wet and dry belt fir have been identified on other land bases throughout B.C., A well implemented NVAF program with a sufficient sample size for Pl and Fd may identify taper issues and could potentially lead to further studies. The NVAF should identify taper issues, potentially leading to further studies.

ISSUE	PHASE I IMPACT	PHASE II IMPACT	COMMENTS
5. Dry Belt Fir	High	High	The stakeholders require improved estimates of stand attributes in dry belt fir. Specifically they would like to address issues around Fd taper, and structural and spatial complexity in this transition area. The IDF BEC zone comprises almost 30% of TFL 8. Areas of dry Douglas-fir in the southern interior have typically been selectively logged for almost 50 years and as a result have left complex residual stand structures and spatial distributions.[10] During Phase I, areas of complex spatial distribution could be separately identified. Additional measurements could be included during the estimation stage of the Phase I to identify the managed layer. The dry-belt fir area of the TFL could be considered as a separate stratum during development of the Phase II VPIP. Extra measures (e.g. more ages) could be implemented to potentially address the structural complexity in the polygons. WPV sampling could be implemented in this area to provide accuracy around the adjusted inventory estimates (i.e., expected range of values found in these polygons) which could help with future TSR and provide a level of confidence in the recovered volumes .
6. Mountain Pine Beetle	Low	High	Previous MPB outbreaks occurred on TFL 8 in the 1980s and 1990s. projections for the current epidemic predict an imminent atack in the TFL, which could significantly impact timber supply on the land base. The impact of this new attack is currently unknown, however Pope & Talbot has the opportunity to track the impact of the MPB attack on the land base through remeasurment of VRI plots. CMI may prove to be useful for assessing the understory as a source of mid-term timber supply in areas affected by MPB.

[10] Kenner, W. and Vyse, A. *The Opax Mountain Silvicultural Systems Project: Evaluating Alternative Approaches to Managing Dry Douglas-fir Forests.* http://www.mountainforests.net/opax/articles/16.pdf

ISSUE	PHASE I IMPACT	PHASE II IMPACT	COMMENTS
7. Problem Forest Types	Low – Med	Low – Med	Dense, small pine stands have been identified as a problem forest type. These areas have historically been left out of the THLB. Some of these stands are merchantable but undesirable in many market conditions. A dense pine study completed by JST 1999[11] indicated that some of these stands could be included in the THLB. This analysis was carried through to TSR 3 and was included in that analysis. Upon overlaying these stands with recent harvest history it was determined that 14% of the dense pine stands have been developed over a six year time horizon. Due to this level of development it was suggested in the TSR 3 information package that these stands not be excluded from the land base.
8. Silvicultural Practices	Low	High	P&T would like to monitor the effects of certain silvicultural programs within the TFL. Practices such as mounding prior to planting, spacing, and the use of Class A seed have been implemented on the TFL and anecdotally these programs have increased productivity on managed stands. A CMI program could provide P&T with information on the performance of managed stands which should provide improved information for TSR.
9. Site Productivity	Low	High	In the previous AAC Determination[12] the Chief Forester suggested that site productivity might be underestimated. The completed TEM and SIA programs should resolve this issue. A Phase II program will adjust heights and ages within the existing inventory which are used to calculate polygon site index.
10. Ungulate Winter Range	Med	Med	Habitat attributes can be obtained through a Phase I program, Predictive Ecosystem Mapping (PEM), and collection of stand attributes in a Phase II program.

[11] J.S. Thrower & Associates Ltd., 1999. Statistical Adjustment of Dense Lodgepole Pine Polygons in the Boundary Forest District – Version 2. Unpublished. 22p.

[12] Tree Farm Licence 8 – Rationale for Allowable Annual Cut (AAC) Determination. December 1, 2002.

ISSUE	PHASE I IMPACT	PHASE II IMPACT	COMMENTS
11. Species at Risk Habitat	Med	Med	Species at Risk (SAR) is an emerging issue which requires better information. VRI may be able to provide information for broad strategic planning to address SAR habitat. A Phase I and Phase II may be able to provide information on habitat attributes for species at risk. These attributes could then be fed into habitat prediction models to determine the potential for SAR habitat.
12. Landscape Level Biodiversity	Low	High	Biodiversity estimates are an important component of Forest Stewardship and Sustainable Forest Management Plans. CWD, stand structure, and seral stage distribution have been recognized by the licencee as areas where more information is needed. The Phase II program can be used to provide improved estimates of biodiversity attributes. Stand structure data, as collected through the VRI Phase II process, should be reviewed to ensure that data is consistent with stakeholder needs. If not, new methods can be considered and incorporated into the Phase II VPIP process.
13. Mid to Long Term Timber Supply	Med	Med	Currently no issues around mid and long term timber supply have been identified for TFL 8. The impending MPB attack and its impact will determine issues related to timber supply. A Phase II ground sampling program with the capability of remeasurement could be useful to determine the changing impacts of losses to timber supply.
14. Fish and Wildlife	Med	Med	Habitat attributes can be obtained through a Phase I program, PEM, and through collection of stand attributes (i.e. large standing and fallen trees).
15. First Nations	Low	Low	No issues were identified surrounding First Nations.

2.5 SUMMARY OF INVENTORY ISSUES

The completion of VRI activities could provide better information on:

- Polygon volume estimates and their accuracy,
- Inventory adjustment for TSR,
- Height, age and site index,
- Dead volume,
- CWD to provide decision support on landscape-level biodiversity and sustainable forest management planning,
- Levels of MPB attack, changes to current attributes,
- Problem forest types, and
- Perceived decay and taper issues.

STRATEGIC INVENTORY PLAN

2.6 OVERVIEW

This section outlines the strategic inventory plan to develop the TFL 8 VRI program. The main product of the VRI program is a statistically unbiased vegetation inventory. For TFL 8 this requires Phase II Ground Sampling, NVAF, and Statistical Adjustment. In addition, a CMI program will be initiated to monitor second-growth stand performance (in stands <40 yrs) and potentially validate models and yield curves.

Pope & Talbot have decided to delay a Phase I program for approximately 5 years or until the current provincial MPB infestation has subsided. The current inventory suitably addresses the stakeholders' information needs; however, an adjustment should be completed based on the results of a Phase II program to address change that has occurred since the last inventory.

2.7 PHASE II - GROUND SAMPLING

2.7.1 Objective

The primary objective of the Phase II ground sampling program is to provide ground estimates to adjust the volume, age, and height of the existing inventory with a sampling error for volume of ±10% at a 95% confidence level. Secondary objectives of Phase II ground sampling are to address issues around decay, taper, stand complexity, and to facilitate collection of other stand attributes to support strategic and operational planning needs.

2.7.2 Target Population

The target population is the Vegetated Treed (VT) area within the TFL, age 30 years or older. If the BC Land Classification Scheme (BCLCS) information is unavailable, VT will be defined as polygons where a leading species exists and crown closure is greater than or equal to 10%.

2.7.3 Sample Size

The coefficient of variation (CV) for the ratio of means calculated from the inventory audit for mature volume was 40%.[13] MoFR recommends increasing the CV by 10% to 50%, requiring approximately 100 samples to achieve the target sampling error of ±10%.

2.7.4 Sampling Approach

Phase II certified samplers will install all VRI Timber Emphasis Plots (TEPs), plus CWD, and succession data to VRI ground sampling standards.[14] Sampling will follow a two-stage approach, which should be completed in a single field season. The first stage will be focused at installing a minimum number of TEPs (approximately 40) to support the information needs of the NVAF program, as well as providing enough information to allow for an interim analysis to assess the remaining plot requirements to achieve the target sampling error. The second stage will be to install enough TEPs to achieve a target sampling error of ±10% at a 95% confidence level. This approach will be refined and updated in the Phase II VPIP. If the information needs

[13] The CV of the ratio of means was calculated using the 1998 TFL 8 inventory audit results for the analysis of mature volumes.

[14] http://ilmbwww.gov.bc.ca/risc/pubs/teveg/vri_gs_2k4/vri_gs_2k4.pdf

are satisfied for the NVAF enhancement early in the field season, the NVAF tree selection and destructive sampling could run concurrently with the establishment of the remaining VRI plots.

2.7.5 Sample Selection

Sample locations will be selected using the standard MoFR methods. First, polygons will be selected using the probability proportional to size with replacement (PPSWR) method. Second, a random point will be selected within the selected polygon using the provincial 100-m grid. If no 100-m grid point falls within the selected polygon, the grid will be halved until at least one point falls within the polygon.

2.8 NET VOLUME ADJUSTMENT FACTOR

2.8.1 Objective

The objective of the NVAF component is to estimate NVAF ratios with a sampling error of ±7.5% for all live trees at a 95% confidence level. A NVAF program will provide improved information on decay and taper in small Pine and Douglas-fir.

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.

2.8.2 Sample Size

The MoFR recommends a minimum sample size of 100 NVAF trees of which 90 are live and 10 dead.[15] The final sample size and distribution by species will be determined during development of the Phase II VPIP. The relative species distribution (in terms of total net merchantable volume) will be estimated and the actual sample size for each species group will be determined based on the species distribution.

The stakeholders specifically noted that Pl and Fd tree taper is an area of uncertainty and believe that current taper equations do not adequately model these trees in TFL 8. A NVAF program with an increased Pl and Fd sample size (dead and alive) may identify taper and decay issues and provide information for use in future studies. Increasing the sample sizes for these species should be considered when completing the Phase II VPIP.

2.8.3 Sample Selection

The number of VRI Phase II plots that will be enhanced for NVAF sampling will be determined following discussion with MoFR and will be updated in the VRI Phase II VPIP.

Following completion of the first stage of the Phase II ground sampling program, a tree matrix will be built with all trees from the auxiliary plots of the NVAF-enhanced samples. The sample in each matrix cell will be selected systematically with a random start after sorting the tree list by species and diameter at breast height (DBH).

[15] Based on an email provided by Will Smith (Feb. 8, 2007) suggesting that the sample size requirements for live and dead trees will change to 10 dead and 90 live for the 2007/2008 fiscal year.

2.9 CHANGE MONITORING INVENTORY

2.9.1 Objective

CMI is an important tool for tracking growth performance and improving the modeling assumptions for second-growth stands. CMI will be used to monitor the performance of second growth stands, validate models predicting timber supply, develop or modify current yield curves, and quantify attributes in stands < 40 years.

2.9.2 Target Population

The stakeholders intend to implement a CMI program to obtain improved information on the performance of their managed stands. Typically the target population for these programs would include only areas that have been harvested in the last 40 years. This population may be too narrow to address the information needs of the licencee and expansion of the target area should be considered before implementing the CMI ground sampling program.

2.9.3 Sample Size

An effective sample size for CMI would be a minimum of 50 plots as it must be both cost-effective and large enough to allow for post-stratification. It is expected that the sample size will increase as the number of stands coming into the target population increases.

2.9.4 Sample Selection

Sample selection will follow the CMI standards at the time of selection. For continuity and consistency, it is recommended that the Phase II VPIP and CMI VPIP be completed concurrently; however funding limitations may require that the two plans be completed independently.

2.10 WITHIN POLYGON VARIABILITY

WPV sampling provides information for expressing the true individual polygon error, assessed as the difference between the adjusted polygon value and the “true” value for that polygon. The “true” value for the polygon is an estimate derived from a small sample of polygons that are intensively sampled on the ground.

Measuring for variability in structurally and spatially complex stands should be considered during the development of the TFL 8 Phase II VPIP. In stands of high variability the use of WPV sampling (or a modified version of it) may provide information that could be used for sensitivity analysis in future TSR. Implementation of this activity will require collaboration with the MoFR to develop an appropriate methodology to gather the information required by the licencee.

2.11 ESTIMATED COSTS

The costs provided include the approximate costs for a Phase I VRI. The total project cost for a Phase II Ground Sampling program including NVAF is approximately $336,500. The total project cost for a CMI program is approximately $125,500. If the licencee decides to complete a Phase I program and new photos are not needed the total approximate cost will be $129,625.

Table 2. Estimated costs for VRI activities in the TFL 8.

VRI Activity	Units	Estimated Unit Cost ($/Unit)	Total Estimated Cost ($)	Estimated Projected Fiscal Year
PHASE I (PHOTO INTERPRETATION)				
Photo Acquisition	77,500	$0.20	$15,500	2013/2014
Phase I VPIP	1		$10,000	2013/2014
Polygon Delineation and Attribute Estimation [a]	77,500	$1.00 – $1.30/ha	$89,125	2013/2014
Quality Assurance			$15,000	2013/2014
Sub-Total			*$129,625*	
PHASE II (GROUND SAMPLING)				
Phase II VPIP	1	$10,000	$10,000	2007/2008
Sample Packages			$8,000	2007/2008
VRI Plots (TEP)	100	$1,600	$160,000	2007/2008
Helicopter			$35,000	2007/2008
Interim Analysis			$10,000	2007/2008
WPV			TBD	2007/2008
Quality Assurance	10	$1,500	$15,000	Ongoing
Sub-Total			*$238,000*	
STATISTICAL ADJUSTMENT				
Data Compilation	1	$1,000	$1,000	2007/2008
Adjustment & Report	1	$20,000	$20,000	2007/2008
Sub-Total			*$21,000*	
NVAF				
VPIP update / Tree Selection	1	$2,500	$2,500	2007/2008
Destructive Sampling	100	$500/tree	$50,000	2007/2008
Helicopter			$15,000	2007/2008
Quality Assurance		$5,000	$5,000	Ongoing
NVAF Analysis and Reporting	1	$5,000	$5,000	2007/2008
Sub-Total			*$77,500*	
CMI				
CMI VPIP [b]	1	$7,500	$7,500	2007/2008
Sample Packages	50		$8,000	2007/2008
Plot Establishment	50	$1,600	$80,000	2008/2009
Helicopter			$15,000	2008/2009
Quality Assurance	5	$1,500	$7,500	Ongoing
Analysis & Installation Report	1	$7,500	$7,500	2008/2009
Sub-Total			*$125,500*	
Phase II/NVAF Ground Sampling Total Estimated Cost			***$336,500***	
CMI Ground Sampling Total Estimated Cost			***$125,500***	
Phase I Total Estimated Cost			***$129,625***	
Total Estimated Cost			***$591,625***	

[a] Includes variable costs for air and ground calibration calls and helicopter.
[b] This cost assumes that the Phase II VPIP and the CMI VPIP are completed at the same time.

3. SIGN-OFF SHEET

I have read and concur that the TFL 8 VRI Strategic Inventory Plan dated March, 2007 meets current VRI standards. 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.

_____ _____

Jon Vivian, R.P.F. Manager, *Date*

Vegetation Resources Inventory Section,
Forest Analysis and Inventory Branch,

Ministry of Forests and Range

_____ _____

Pope & Talbot (lead proponent) *Date*

APPENDIX I – GLOSSARY OF TERMS

Ground Sampling

VRI ground sampling (Phase I) is the field measurement of timber, ecology, range, and/or coarse woody debris values at one or more locations within each sample polygon. To accommodate the wide variety of resources, various types and sizes of sampling units (e.g., fixed and variable plots, transects) are used to make the measurements.

Landcover Classification

The BC Landcover Classification Scheme (BCLCS) was designed specifically to meet the requirements of the VRI, 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 estimate net volume is obtained from net factoring and taper equations).

Photo-Interpretation (Phase I)

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

Post-Stratification

Post-stratification involves the division of an 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.

Pre-Stratification

Pre-stratification involves the division of 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 the 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 specified 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 Adjustment

Statistical adjustment (or analysis) is the process of adjusting the values of the photo-interpreted estimates variables using the ground sampling observations. For each sampled polygon, the ground observations are compared to the photo-estimated values to develop an adjustment factor. This factor is then applied to all polygons in the photo-interpreted estimates 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 land base) or stand type (e.g., problem forest types) within the management unit.

Target Population

The target population is the unit from which the samples are chosen. For management inventories, the inventory unit is a TSA, TFL or other geographic area or specific attribute set, depending upon the sampling objectives.

Target sampling error

Target sampling error expresses the desired accuracy of the attribute of interest (e.g., timber volume). It is usually expressed as a percentage value at a given probability level (e.g., ±10 at the 95% probability level). This means that 95% of the time we are confident that the volume estimates are within 10% of the actual volume. Target sampling error is used to calculate the minimum sample size for subsequent ground sampling; see ***Sample Size***.

Vegetation Resources Inventory (VRI)

The VRI is an improved vegetation inventory process for assessing the 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 of procedures, which include:

- BC Landcover Classification Scheme (BCLCS).
- *Photo-interpreted estimates (Phase I)*: the delineation of polygons from aerial photography and the estimation of resource attributes.
- *Ground sampling (Phase II)*: the establishment of plot clusters in selected polygons to measure timber, ecological, and/or range attributes. The data are used for the adjustment of the photo-interpreted estimates for all polygons in an inventory unit or management unit.
- *NVAF Sampling*: Stem analysis sampling of individual trees for net volume adjustment.
- *Change Monitoring Inventory (CMI)*: Assessing performance of existing models and acts as an early detection system for issues in managed stands.

The VRI can be deployed over the entire province (provincial VRI) measuring timber and non-timber resources, or over a large management unit (management VRI) measuring selected resources in specific portions of the land base. 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.