Tree Farm Licence 53

Vegetation Resources Inventory

Strategic Inventory Plan

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&
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EXECUTIVE SUMMARY

The objective of the Vegetation Resources Inventory (VRI) Strategic Inventory Plan (VSIP) is to outline the VRI activities and products that address forest management and inventory issues within a management unit. Dunkley Lumber Ltd. (Dunkley) manages Tree Farm Licence (TFL) 53 and is initiating a VRI to get improved inventory information.

Following discussions with the MFR VRI Audit Coordinator (Gary Johansen, RPF) and the Regional Inventory Team Leader (Dick Nakatsu, RPF), Dunkley is proposing to complete a VRI inventory that meets the current standards. The VSIP outlines some enhancements to the inventory process designed to introduce some flexibility to the methodology to:

1. Reduce uncertainty in timber supply analysis regarding the cumulative impact on managed stand yields of the progressive silviculture program practiced on TFL 53.
2. Improve the efficiency in conducting the inventory to produce a complete inventory in a cost efficient manner.

TFL 53 is approximately 88,000 ha in size and is located between Prince George and Quesnel in the Strathnaver area. The TFL is bordered by the Prince George Timber Supply Area (TSA) as well as TFL 52 and a small portion of the Quesnel TSA. The TFL is located east of Highway 97N generally between Hixon to the north and Ahbau Creek to the south. The eastern boundary is near the features of Ahbau Lake, Lodi Lake and Stony Lake. Figure 1 shows the general location of the TFL.

The TFL has been severely impacted by the Mountain Pine Beetle (MPB) epidemic. The Annual Allowable Cut (AAC) went from 239,500 m^3/yr to 880,000m^3/yr and was recently reduced back to an endemic level of 219,000m3/yr. As a result of the epidemic, there has been a significant change to the inventory attributes and subsequently they are no longer reliable, particularly in mixed lodgepole pine (Pl) stands. Both the heightened level of harvest and the MPB impacts on the remaining stands have had large impacts on the current inventory.

Specific inventory issues on TFL 53 include:

1. The volume and species attributes need to be updated to VRI standards as a result of changes to the inventory stemming from the impacts of the MPB.
2. In response to concerns raised by the Chief Forester, managed stand yields need to be compared against those used in timber supply review (TSR).
3. Many Provincial scale inventory projects rely on TFL information as part of the consolidated inventory needed to address these issues. The existing inventory is not to VRI standards which makes it difficult to roll-up provincially and to merge with adjacent Management Units.

Dunkley recognizes that a VRI will provide them with improved information that can contribute to addressing their management and business needs. The following VRI activities and products are planned:

1. Obtain aerial photography covering the entire TFL.
2. Produce an updated TRIM base for the TFL landbase.
3. Produce Orthophotos for the TFL landbase.

4. Complete Phase I photo-interpretation for the entire TFL.
5. Complete an enhanced Phase I ground calibration to provide improved polygon estimates.
6. Assess the managed stand yields as part of the ground calibration program.
7. Implement a Phase II ground sampling program to quantify risks around the Phase I attributes.
8. Complete a statistical adjustment of the inventory attributes.
9. Complete a NVAF sampling program to quantify decay, waste and breakage.
10. Obtain up to date inventory attributes with improved spatial accuracy.

As described in the activities and products planned for a VRI on TFL 53, there are some enhancements from the VRI standard which have been discussed with the MFR. These enhancements offer a great opportunity for the MFR and the Province to pilot changes for future VRI's, since the TFL is relatively small in scale and in comparison to larger Management Units in the Province. These are consistent with the objectives of innovative projects approved by FIA to improve sustainable management and to:

1. Improve management practices
2. Improve decision making
3. Revise the standard.

An enhanced Phase I ground calibration program may provide a cost savings in the Phase II sampling program. In turn, this change offers great potential to improve inventory practices in the Province.

VRI Project Implementation Plans (VPIPs) for Phase I and Phase II programs will be completed as appropriate and following discussion and approval of this VSIP. The Phase I VPIP will provide details on the target area, ground and air calls required, available data sources, and prioritization of areas for interpretation. The Phase II VPIP will identify the geographic areas, scheduling, priorities, plot location coordination, estimated costs (by year if necessary), and roles and responsibilities. Net Volume Adjustment Factoring will be completed following Phase II.

The overall cost of the TFL 53 VRI is estimated at approximately $384,500. Funding will be provided through the Forest Investment Account (FIA) or its equivalent or through focused funding at the time of commencement for each phase.

ACKNOWLEDGEMENTS

This plan was developed by Timberline Natural Resource Group Ltd. (Timberline) on behalf of Dunkley Lumber Ltd. (Dunkley). Direct support and plan development was carried out by various parties including the following persons: Doug Perdue, RPF (Dunkley), Trevor Joyce, RPF (Dunkley), Gary Johansen, RPF (Ministry of Forests and Range), Dick Nakatsu, RPF (Ministry of Forests and Range), Hamish Robertson, RPF (Timberline), Hugh Carter MSc, RFT (Timberline), Mike Sandvoss (Timberline), and Sean Curry, RPF (Timberline).

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1. INTRODUCTION

1.1 BACKGROUND

This Vegetation Resources Inventory (VRI) Strategic Inventory Plan (VSIP) outlines the VRI activities and products needed to address forest management and inventory issues in Tree Farm Licence (TFL) 53. The VSIP provides direction for photo interpretation, ground sampling, and statistical analysis of the inventory. Following VSIP approval, the next steps include completion of the photo acquisition and preparation and implementation of VRI Project Implementation Plans (VPIPs).

Dunkley Lumber Ltd. (Dunkley) and Timberline Natural Resource Group Ltd. met to discuss the management issues (Table 4.) within the TFL. The participants that attended the meeting are as follows:

- Trevor Joyce (Dunkley)
- Doug Perdue (Dunkley)
- Mike Sandvoss (Timberline – PG)
- Sean Curry (Timberline – Kamloops)
- Hugh Carter (Timberline – Vancouver)
- Hamish Robertson (Timberline – Vancouver)

Discussions[1] with the MFR VRI Audit Coordinator (Gary Johansen, RPF) and the Regional Inventory Team Leader (Dick Nakatsu, RPF) identified the need for a cost-effective program focused at the targeted inventory information needs.

1.2 VRI OVERVIEW

The VRI is a vegetation inventory process 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*.[2]

The typical VRI consists of four components (Appendix II):

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

One or more of these components can address specific forest management or inventory issues. For more detailed information, visit http://ilmbwww.gov.bc.ca/risc/pubs/teveg/index.htm.[3]

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[1] A conference call was held with the MFR, Dunkley, and Timberline on June 6, 2009.

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

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

2. METHODOLOGY

2.1 OVERVIEW

The following section outlines the traditional VRI process, enhancements to VRI methodology, and brief rationales. Dunkley is pursuing a more cost-effective, information needs based approach to the TFL 53 program. Section 4 provides more detail on the differences between the standard VRI and the proposed methods.

2.2 PHASE I – PHOTO INTERPRETATION

2.2.1 VRI Standard

Prior to commencing a VRI Phase I project, a VPIP for photo interpretation is prepared for review and signed-off by the MFR and the licensee. This plan covers photo acquisition requirements, the VRI Phase I process, adherence to standards, and details the photo interpretation work that will be implemented.

Phase I is the photo interpretation phase of a VRI and entails polygon delineation and attribute estimation by certified photo interpreters through the use of traditional aerial photographs or softcopy images. The delineation identifies the location of the forest resources and the interpretation component provides estimates of attributes including land cover type, crown closure, tree species, height, age, stand structure, basal area, and density.

Estimation of attributes from field reference points is based upon field procedures using a combination of air and ground calibration points. Any available historical data will be provided by Dunkley and the MFR and will be used to determine information gaps to focus field calibration to areas of need.

The Phase I VRI standards include:

1. VRI Vegetation Resources Inventory – Preparing a Project Implementation Plan for Photo Interpretation. Version 2.3. April 2009.[4]
2. Photo Interpretation Procedures. Version 3.2. April 2009.[5]

2.2.2 Enhancements

The Phase I program will follow MFR standards and include the following:

1. An average polygon size that reflects the level of detail observed in the existing inventory as well as an increased number of calibration points to improve attribute estimation;
2. Additional calibration data will be collected to address the Chief Foresters request to improve estimates in managed stands; and,
3. Where possible, using Dunkley's Terrestrial Ecosystem Map (TEM) ground calibration data to describe slope position, moisture and nutrient regimes, snags, CWD, shrubs,

[4] http://ilmbwww.gov.bc.ca/risc/pubs/teveg/vri_photointerp2k9/VRI Photo Interp PIP.pdf

[5] http://ilmbwww.gov.bc.ca/risc/pubs/teveg/vri_pip_2k9/vri_pip_2-5.pdf

herbs, and bryoids. For clarification, the VRI polygon delineation will be conducted following the VRI standard. The TEM information will supplement the VRI process when it falls within, and is applicable to, the VRI polygon characteristics.

Further details about these variances are outlined in Section 4.3 and will be more completely described in the Phase I VPIP.

2.2.3 Rationale

Dunkley requires more reliable information in mixed lodgepole pine (Pl) stands that have been impacted by MPB. The photo-interpreted attributes should have improved estimates at the polygon level. To ensure an accurate and usable inventory, both Dunkley and the MFR agree that most inventory resources should be focused on the Phase I. This includes maintaining an average polygon size that is consistent with the existing inventory and an enhanced ground calibration program to improve attribute description.

The Provincial Chief Forester requested an evaluation of the managed stand yields in the last AAC determination.[6] Following discussions with MFR and Dunkley it was determined that this was best achieved by increasing the size of the Phase I ground calibration program.

The focus of this inventory program is to improve the description of tree attributes. A TEM was completed on the TFL in 2002 and provides the opportunity to use the TEM ground calibration data to support describing appropriate inventory attributes.

2.3 PHASE II – GROUND SAMPLING

2.3.1 VRI Standard

Prior to commencing Phase II work, a VPIP will be completed and approved by the MFR. These plans detail the Phase II sample selection process and adherence to standards.

Specifically the Phase II VPIP will:

- Detail the Phase II project and sampling objectives;
- Identify current and past timber supply issues that should be addressed through the Phase II program;
- Identify target and sample populations, sample selection, stratification, and sample size details;
- Broadly quantify the amount of dead wood from MPB currently on the TFL;
- Include discussion of the field program;
- Include a list of sample polygons and point locations;
- Discuss the proposed data compilation, analysis, and statistical adjustment;
- Identify the roles and responsibilities; and,
- Include the proposed implementation schedule.

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[6] Ministry of Forests and Range. October 2005. *Tree Farm Licence 53 Dunkley Lumber Ltd. – Rationale for Annual Allowable Cut (AAC) Determination.* Unpublished. Pg. 42.

The samples selected for the Phase II ground sampling are based on the delineated polygons and attributes estimated during Phase I within a targeted portion of the TFL. Samples are selected in an unbiased manner from the target population. The goal of the Phase II program is to achieve a sampling error of +/-10% (95% confidence). The Phase II sampling will utilize a two-pass approach whereby approximately 50 timber emphasis plots (TEPs) will be installed in the first pass. On the second pass, a minimum number of samples will be installed to achieve the target sampling error.

The Phase II VRI standards include:

1. Vegetation Resources Inventory Guidelines for Preparing a Project Implementation Plan for Ground Sampling and Net Volume Adjustment Factor Sampling. Version 3.0. May 2007. [7]
2. Vegetation Resources Inventory Ground Sampling Procedures. Version 4.8. May 2008.[8]

2.4 NET VOLUME ADJUSTMENT FACTOR

2.4.1 VRI Standard

All new VRI programs require NVAF sampling, which involves detailed stem analysis of sample trees that have been randomly selected from the Phase II plots. The NVAF is used to correct estimates of net close tree utilization volume for all species. The NVAF adjusted VRI ground sample volumes are used to adjust the Variable Density Yield Prediction (VDYP) yield table model volumes. The Phase II VPIP also includes details on the NVAF program including sample size and sample selection.

The NVAF standards include:

1. Vegetation Resources Inventory Guidelines for Preparing a Project Implementation Plan for Ground Sampling and Net Volume Adjustment Factor Sampling. Version 3.0. May 2007.[9]
2. Net Volume Adjustment Factor Sampling Standards and Procedures. Version 4.3. May, 2008.[10]

2.4.2 Enhancements

Dunkley is proposing that the NVAF program be completed in two stages. These stages are:

1. Collate all NVAF data from adjacent Management Units and complete a NVAF gap analysis to determine a Management Unit specific NVAF sampling plan.

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7 http://ilmbwww.gov.bc.ca/risc/pubs/teveg/vri_gs_2k7/guidelines_for_gs_net_factoring.pdf

8 http://ilmbwww.gov.bc.ca/risc/pubs/teveg/vri_gs_2k8/vri_gs_4.8.pdf

9 http://ilmbwww.gov.bc.ca/risc/pubs/teveg/vri_gs_2k7/guidelines_for_gs_net_factoring.pdf

10 http://www.ilmb.gov.bc.ca/risc/pubs/teveg/nvaf_2k8/NVAF%20Sampling%20Standards.pdf

2. In consultation with FAIB, use the results of the gap analysis to determine the species, strata, and number of trees required to complete the NVAF program, complete the program design, and implement the program.

Further detail regarding this NVAF methodology is outlined in Section 4.5. The finalized implementation of these enhancements will be outlined in the Phase II VPIP.

2.4.3 Rationale

The Prince George Forest District and TFL 52 (Block A and B) have robust NVAF programs. The TFL 53 species compositions and stand types are similar to these land bases. By using appropriate NVAF tree data from these adjacent areas, it will allow Dunkley to significantly reduce NVAF program costs.

2.5 STATISTICAL ANALYSIS

2.5.1 VRI Standard

The final step in the VRI process is the statistical adjustment of the Phase I. In this process Phase II plot estimates are used to adjust the Phase I photo interpretation attribute estimates. 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 inventory at the Management Unit level.

The statistical analysis standards include VRI Interim Procedures and Standards for Statistical Adjustment of Baseline VRI Timber Attributes. January 2008.[11]

2.6 FUNDING

Currently funding for VRI activities is provided by the Forest Investment Account (FIA) Land Base Investment Program. Future funding is expected to come from FIA or its equivalent or focused funding at the time.

[11] http://www.for.gov.bc.ca/hts/vri/standards/data_analysis/interim_procedures_standards_for_statistical_adjustment.pdf

3. BUSINESS CONSIDERATIONS

3.1 LAND BASE DESCRIPTION

TFL 53 is held by Dunkley and covers approximately 88,000 ha. The TFL is located east of Highway 97N generally between Hixon to the north and Ahbau Creek to the south. The eastern boundary is near the features of Ahbau Lake, Lodi Lake and Stony Lake (Figure 1).

Table 1. THLB net-down process.

Land Class	Area (ha)	% of TSA
Total TFL	87,693	100%
Non-productive	8,056	9%
Productive Forest	79,637	91%
Productive Reductions[12]	11,194	13%
THLB	*68,644*	*78%*

The TFL is largely comprised of the Sub-Boreal Spruce (SBS) biogeoclimatic (BGC) zone with smaller components of Engelmann Spruce Subalpine Fir (ESSF) zone. The main commercial species include approximately 60% white spruce (Sw), 23% lodgepole pine (Pl), 15% Balsam (B), and the remainder in coniferous mixed wood stands and a small component of interior Douglas-fir.

In the current Management Plan (MP 4), 91% (or approximately 80,000 ha) of the TFL is considered productive forest. Approximately 13% (or approximately 11,000 ha) of the productive forest is excluded to account for low productivity sites, recreation areas, environmentally sensitive areas, non-merchantable forest types, riparian reserve and riparian management zones, terrain instability, and wildlife. Currently, about 78% (or approximately 69,000 ha) of the entire TFL is considered available for harvesting as per Table 1. The species and age class distribution as percent of the entire land base are presented in Table 2.

Table 2. Species and age distribution as the % of the entire land base.

	Age Class									
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	***Total***
S	9.0	14.4	1.0	3.4	6.9	1.0	0.7	19.1	0.3	***55.9***
Pl	10.4	2.6	0.1	2.0	4.1	0.9	0.2	2.3	0.0	***22.6***
B	0.5	1.4	1.3	1.6	2.7	1.7	1.8	3.7	0.1	***14.8***
At	1.5	0.5	0.1	0.7	1.5	0.1	0.0	0.0	0.0	***4.4***
Fd	0.1	0.1	0.0	0.2	0.6	0.2	0.1	0.2	0.0	***1.5***
Ep	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	***0.4***
Ac	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	***0.2***
Sb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	***0.1***
Total	***21.5***	***19.1***	***2.6***	***8.0***	***15.8***	***4.0***	***2.8***	***25.4***	***0.4***	***100.0***

[12] Productive reductions include low productivity sites, recreation areas, environmentally sensitive areas, non-merchantable, forest types, riparian reserve and riparian management zones, terrain instability, and wildlife.

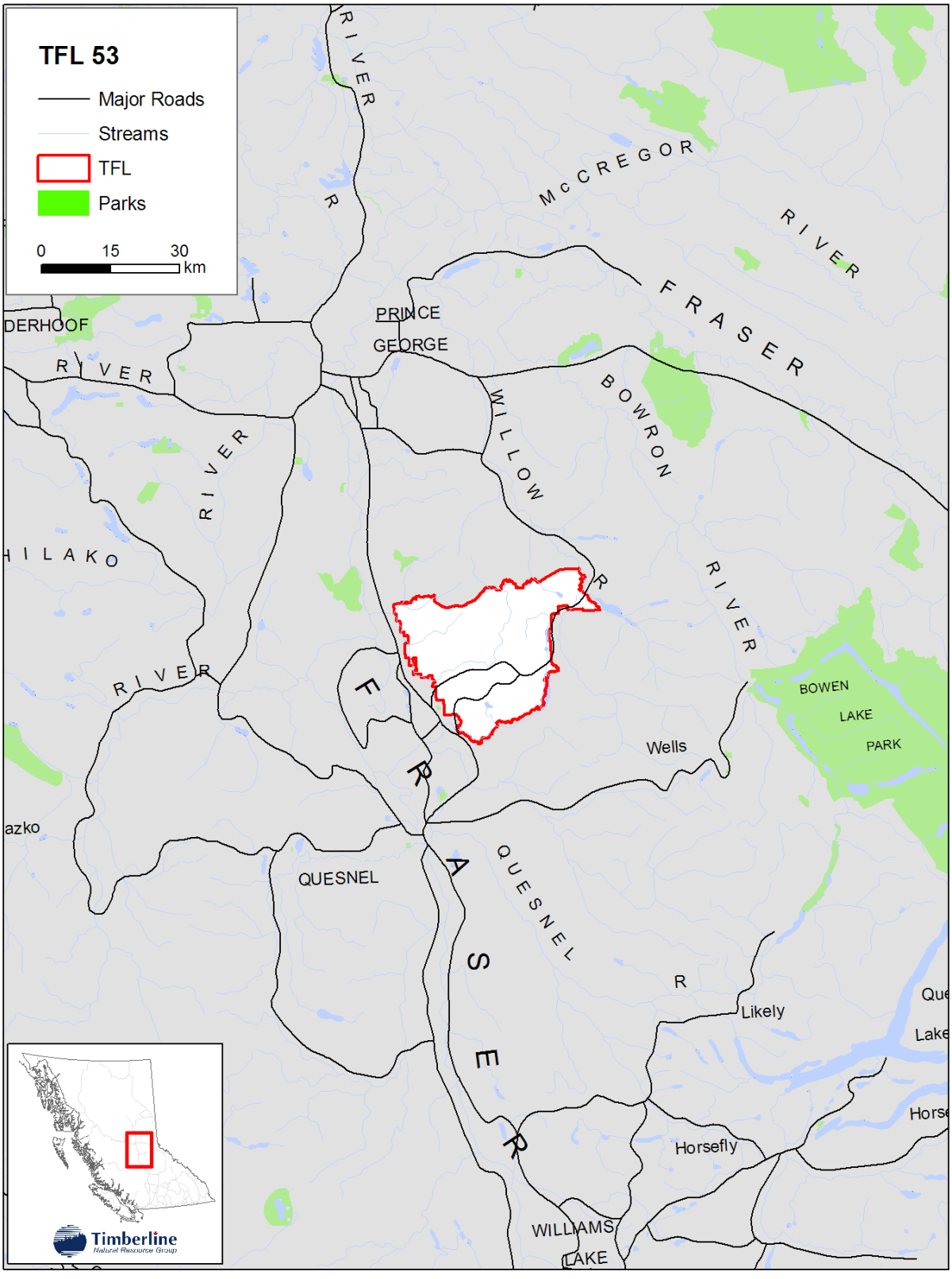

Figure 1. Overview map of TFL 53.

3.2 CURRENT FOREST INVENTORY STATUS

A complete forest cover inventory specific to the TFL was completed in 1991. Several inventory activities were initiated throughout the 1990's. Dunkley's harvesting and road construction data has been used to continually update the forest cover information.

An inventory audit was completed in 1998 using the inventory data available at the time. Three components of the inventory were assessed to determine whether there were significant differences between the interpreted values and ground data to account for both classification- and model- based bias. The audit showed no significant differences for the mature volumes in the inventory.[13]

Since the inventory audit, the MPB epidemic has rapidly altered the forest cover impacting the reliability of the inventory, particularly in mixed Pl stands. The continued maintenance of the inventory with these alterations would require a large expenditure of time and money.

In his 2005 AAC determination, the Chief Forester recognized that there was uncertainty associated with managed stand yield estimates used in timber supply analysis. Dunkley has an outstanding silviculture program designed to enhance fiber production on the TFL. The use of class A seed where available, reduced regeneration delays, increased densities in mixed species plantations, and aggressive fertilization all contribute to well performing managed stands. The cumulative impact of these programs creates uncertainty in forecasting the growth and yield of these stands in timber supply analysis. The inventory information in the current inventory is not sufficient to address the Chief Foresters concerns.

Dunkley and the MFR believe that a VRI should be given high priority for completion as opposed to rolling over and maintaining the existing inventory. The VRI provides the best way to provide an accurate inventory for Dunkley and the Province for future TSR analyses. Dunkley has applied for an extension to the TSR until 2015. Subsequently, Dunkley will work towards completing a VRI by 2013, in advance of the 2015 AAC determination and 2015 deadline for TSR.

3.3 FOREST MANAGEMENT CONSIDERATIONS

The TFL forest cover has been in a state of rapid evolution due to the recent MPB outbreak, and subsequent salvage operations. These changes are not entirely incorporated in to the current inventory. Pine mortality and stand structure changes need to be inventoried.

The existing forest cover inventory attributes are becoming less reliable as naturally evolving changes to the forest stands brings uncertainty into the inventory as it ages. Given the productive forest land comprising the TFL, these changes have had more of an impact on TFL 53 inventory attributes then they would have in a less productive environment.

The issues for forest inventory have changed since the 1991 TFL 53 inventory was developed. The concepts of biodiversity, carbon balance, growing silviculture opportunities programs, and climate change are examples of issues that did not exist when the inventory was completed. A new inventory would assist in making improved forest management decisions.

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[13] Ministry of Forests, 1998. *TFL 53 Inventory Audit*. Unpublished. pg.5.

When Dunkley conducted the last inventory in the early 1990s, it did so entirely at the Companies own cost. In subsequent years there have been numerous requests from the MFR for both the inventory data and the air photo component of the inventory. Many of the requests have been to address issues that are Provincial in scope. Aside from the obvious competitive disadvantage of funding the inventory out of pocket as compared to many other licensees, it has been hard to rationalize sharing privately funded information at times. A new inventory completed in a cooperative manner with the current funding structure would alleviate this situation.

The Chief Forester determined the TFL's managed stand yields as an area of uncertainty. Currently the VRI process has no way of determining whether there are significant difference between the actual yields and those produced by TIPSY. The most reasonable way to assess any differences would be through a ground calibration program in the age classes of interest. The most efficient method to address the Chief Foresters request is through the VRI program.

Dunkley is certified under the Sustainable Forest Initiative (SFI). Certification is extremely valuable from a stewardship and marketing perspective. Maintaining SFI certification requires a robust and accurate source of baseline information.

A well implemented and accurate inventory will help address the information issues that have been identified for TFL 53. All management issues identified by Dunkley and the impact of Phase I and Phase II (or a ground sampling program) have been assessed (Table 4):

Table 3. Forest Management Issues.

	ISSUE	PHASE I	GROUND SAMPLING	COMMENT
1.	***Mountain Pine Beetle***	High	High	TFL 53 has been impacted by the MPB outbreak. Since 2003, virtually all Pl greater than 60 years has been attacked and killed. Dunkley's harvesting from 2000-2008 focused on salvaging dead Pl in the TFL. Virtually all Pl leading stands greater than 60 years have been salvaged or left to address non-timber resource values. In non-Pl leading stands most Pl components are now dead and constitute approximately one million m^3. This Pl mortality has made the inventory labels unreliable. A new VRI Phase I inventory will provide polygon descriptions that are representative of the current forest conditions. The ground sampling component will broadly quantify the amount of dead wood currently on the TFL.

	ISSUE	PHASE I	GROUND SAMPLING	COMMENT
2.	***Species Composition and Mature Volumes***	High	Medium	The MPB impact within non-pine leading stands has been significant. The inventory species compositions and mature volumes are not representative of the on-the-ground conditions. A new VRI will provide more reliable species labels and better estimates of live and dead volume.
3.	***Managed Stand Yields***	Medium	High	In the last determination the Chief Forester identified the managed stand yields in TFL 53 as an area of uncertainty, predominately in stands established in 1974-1998 (no genetic gain) and since 1998 (stands with genetic gain). The main issue is the assessment of managed stand growth used in TSR (i.e., TIPSY). A well designed ground calibration program will provide reliable attribute estimates to compare against those managed stand attributes used in timber supply analysis.
4.	***Attribute Accuracy***	High	Medium	Dunkley requires a higher resolution[14] and accurate inventory for effective decision support, given the high standard of forest management practiced on the TFL. A higher intensity ground calibration component in the defined areas of interest will improve the level of accuracy to support strategic and operational planning.
5.	***Problem Forest Types***	High	Medium	Approximately 4,700 ha of problem forest types have been identified in the TFL, of which 1,700 ha are Balsam (Bl) intermediate utilization stand types. This area represents only a small portion of the TFL and represents no significant source of uncertainty.
6.	***Certification Requirements***	High	Medium	Dunkley is certified by SFI. This certification is rigorous and requires a robust

[14] High resolution refers to a focused Phase I in terms of decreased average polygon size and increased field and air calibration than is typically derived through a Phase I process.

	ISSUE	PHASE I	GROUND SAMPLING	COMMENT
				and accurate source of baseline information. Certification is extremely valuable from a stewardship and marketing perspective. A new VRI will assist Dunkley in maintaining their certification by providing a reliable and standardized information source.
7.	***Decay and Taper***	Low	High	In consultation with FAIB, use the results of the gap analysis to determine the species, strata, and number of trees required to complete the NVAF program, complete the program design, and implement the program.
8.	***Forest Health***	Low	High	Generally, the forest conditions within TFL 53 are healthy with minor occurrences of leader weevil and spruce beetle. Regenerating stands have a relatively low occurrence of insects and disease. The current VRI ground sampling standards have procedures for collecting data related to occurrence of forest health. This data could be used to broadly quantify the occurrence of forest health issues on the TFL 53.
9.	***Commercial Forest Reserve***	High	High	Dunkley has applied to the MFR to have the TFL considered as a commercial forest reserve. A VRI will provide the required inventory information to develop the commercial forest reserve programs to implement the intent of the commercial forest reserve.
10.	***Inventory Vintage***	High	High	The inventory was last completed in 1991 (approximately 18 years old) to Forest Inventory Planning (FIP) standards. Generally, an inventory in the BC interior is expected to provide reliable estimates for 15-20 years before the information becomes unreliable for planning purposes. The existing inventory is not as spatially accurate as a new VRI Phase I. The older mono-restituted data will be replaced by more spatially accurate means. VRI is the current Provincial standard for inventory in BC.

	ISSUE	PHASE I	GROUND SAMPLING	COMMENT
11.	***Carbon and Bioenergy***	High	Medium	Dunkley's main markets and products revolve around sawable timber. Currently bioenergy production in the form of chips and hog material form a part of the business conducted on the TFL. Dunkley recognizes the importance of good information for these products, and a VRI would help determine the amount of available material for bioenergy.
12.	***Fish and Wildlife***	Medium	Low	Dunkley has a Biodiversity Plan for TFL 53 that outlines the strategies used to manage for fish and wildlife and other components of the ecosystem. Updated inventory information will enable an update to the biodiversity Plan to reflect post MPB conditions.
13.	***First Nations***	Medium	Low	No First Nations inventory issues were identified on the TFL.
14.	***BC Forest Inventory Program***	High	High	VIAC (Vegetation Inventory Advisory Council) is accountable for: 1. Strategic oversight of the VRI program 2. Developing and assessing options 3. Making recommendations for consideration by the Chief Forester. A VRI on TFL 53 offers a great opportunity to test some innovative enhancements to the VRI standard and to address specific considerations of the Chief Forester.
15.	***Silviculture Opportunities***	High	High	The inventory will provide a mechanism to update the status of the TFL lands to reflect the Silviculture program results.
16.	***Forest Round Table***	High	High	Inventory information was recognized as a high priority in the Forestry Roundtable recommendations.

3.4 VRI ACTIVITIES AND PRODUCTS

The following VRI activities and products are needed to address the forest management issues identified for TFL 53. These recommendations address the issues identified in Section 3.4 and Table 3:

1. Obtain aerial photography that covers the TFL. Upon completion of flying, the photos should be scanned, Aerial Triangulated (AT), and put into DIAP models.
2. Complete new photo interpretation (Phase I) to provide more accurate, reliable and up-to-date spatial attribute data. A ground calibration program will be implemented to increase the accuracy of polygon estimates.
3. Complete a managed stand yield assessment as part of the Phase I calibration program. This program should focus on stands established between 1974-1998 (no genetic gain) and post-1998 (with genetic gain) to assess whether the modeled assumptions are being achieved on the ground. The data, collected during the ground calibration phase, should focus on species composition, volume, site productivity, density, and age.
4. Complete Phase II ground sampling to adjust the Phase I attributes. A modified NVAF program will be implemented based purely on information need rather than on a minimum tree policy. As this approach to NVAF sampling is not traditionally done, this program will be designed together with input from MFR staff.
5. A TRIM update project is being completed concurrently with the VRI. As such, ortho photos will be one of the products associated with this project.

4. STRATEGIC INVENTORY PLAN IMPLEMENTATION

4.1 OVERVIEW

This section outlines the strategic inventory plan to develop the VRI program. The main product of this VRI program is a higher resolution and reliable vegetation inventory, and includes photo acquisition, Phase I photo interpretation, a ground sampling phase, and statistical analysis.

4.2 PHASE I – PHOTO ACQUISITION

The first step in the inventory will be to acquire new aerial photography. The TFL comprises only 11 mapsheets with very small portions of private and/or protected areas. This photography is expected to be 1:15,000 colour, scanned to 12-14 micron. The imagery will be scanned, the aerial triangulation (AT) completed, and DIAP models produced. A TRIM update will be done concurrently with the VRI.

4.3 PHASE I – PHOTO INTERPRETATION

4.3.1 Objective

The objective of a VRI Phase I is to use Softcopy technology to improve the TFL's polygon information. The VRI product is a spatial database consisting of photo-interpreted estimates. A ground and air calibration component is a critical part of this process used to assist the photo interpreters in making accurate estimates. This process is outlined in Section 4.4.

4.3.2 Target Area

The target area for the Phase I VRI is the entire TFL 53 land base. Specific focus (i.e., increased ground/air calibration) will be concentrated in areas identified in the Phase I VPIP.[15] The existing inventory and available data sources will be used as a guide for determining the areas of concern, areas of uncertainty, areas where no data exists, and areas that require special attention for planning purposes.

4.3.3 Target Attributes

All attributes listed in the VRI Photo Interpretation Procedures[16] will be targeted. These attributes will be interpreted to current VRI photo interpretation standards utilizing as much information as possible from the historical data sources to decrease the cost of field work.

4.3.4 Photo Interpretation Approach

The photo interpretation objectives will be achieved with the use of VRI-certified photo interpreters using aerial photography in a Softcopy environment. The photo interpreters will use

[15] These are areas that lack data sources, are areas of uncertainty, and areas where enhanced information is required. These are identified in the Phase I VPIP and in the gap analysis completed by the Phase I contractor.

[16] Ministry of Forests and Range. April 2009. *Photo Interpretation Procedures Version 2.5*. Unpublished. Pg. 126.

a variety of existing and new information sources to enable them to produce more detailed and accurate estimates. These data sources will include:

1. Any historical data available from the MFR and Dunkley, including old document photos, ground samples, ground calls/observations and air calls;
2. New field calibration data (ground calls and air calls) collected by the interpreters to fill in data gaps especially in economically important and problem forest types;
3. RESULTS data for young stands, partially cut stands, and recently disturbed areas;
4. Historical silviculture records held by Dunkley and the MFR;
5. Suitable cruise data (non-logged stands only)
6. TEM attributes; and,
7. Any other valid data source.

A photo interpretation VPIP will be developed following the MFR guidelines in the Vegetation Resources Inventory Guidelines for Preparing a Project Implementation Plan for Photo Interpretation.[17] The VPIP preparation involves identifying attributes to be improved (attributes or delineation) and identifying where and how these attributes should be improved.

4.3.5 Managed Stand Yields

One of the Chief Forester's and Dunkley's main concerns is assessing the managed stand volume and productivity estimates used in timber supply analysis. Following discussions with MFR, it was agreed that the most cost-effective and reasonable approach was to implement this as part of the Phase I ground calibration program. The main objective of this portion of the Phase I is to

Assess volume and productivity in managed stands as compared to predicted outputs.

The likely target population for this part of the calibration program is the Vegetated Treed (VT) area within the TFL for stands 20 - 40 years. The sampling required will follow the MFR VRI standards where applicable for the information being collected. The information being collected will focus on volume, species, height, age, density and site index.

4.4 PHASE II – GROUND SAMPLING

4.4.1 Ground Sampling Objective

The primary objective of the Phase II ground sampling program is to use ground estimates to adjust the volume, age, height, basal area, and stems per hectare of the existing inventory with a ±10% sampling error at a 95% confidence level. A secondary objective of Phase II ground sampling can be to facilitate the collection of other stand attributes that cannot be estimated through the Phase I (e.g., small trees, forest health, CWD, etc.).

[17] Ministry of Forests and Range. April 2009. *Vegetation Resources Inventory – Preparing a Project Implementation Plan for Photo Interpretation*. Unpublished. pg 34.

4.4.2 Target Population

The target population for this objective will be the Vegetated Treed (VT) area within the TFL for natural stands 30 years and older. Inclusion of non-contributing areas in the target population will be discussed during development of the Phase II VPIP. Both the operable and inoperable areas will be sampled for the Phase II program. The intensity of sampling in the operable vs. inoperable areas will be discussed and finalized during the development of the Phase II VPIP.

4.4.3 Sample Size

Sample size is typically determined by the sampling error requirement for volumes. The coefficient of variation (CV) for the ratio of means calculated from the inventory audit for mature volume was approximately 30%.[18] The MFR typically recommends increasing the CV by 10% (CV of 40% for sample size determination), meaning that approximately 65 samples is required to achieve the target sampling error of ±10%.

Sampling will occur in a two-pass approach. In the first pass, approximately 50 plots will be established in the defined strata during the first pass. An interim analysis will be completed to determine the exact number of plots required to achieve the target sampling error.

A possible stratification scheme for quantifying the risk in the Phase I estimates is based on leading species distributed by age groupings. Table 4 shows the likely stratification and associated sample size for the ground sampling program; however this should be re-examined and potentially modified when the Phase II VPIP is created, to ensure the business needs at the time are being addressed.

Table 4. Probable stratification and sample size for Phase II sampling.

Stratum	Sub-stratum	% of Total TFL	Estimated number of samples
S	30 – 120 years	15 %	14
	121+ years	18 %	16
Subtotal		***32 %***	***30***
Other	30 – 120 years	18 %	15
	121+ years	8 %	5
Subtotal		***26 %***	***20***
Total		***58%***	***50***

4.4.4 Sample Selection

Sample locations will be selected according to MFR standards (Sample Selection Procedures for Ground Sampling version 3.3). First, polygons will be selected using the probability proportional to size with replacement (PPSWR) method.[19] Second, a random point will be selected within the selected polygon using the provincial 100m 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.

[18] The CV of the ratio of means was calculated using the 1998 TFL 53 inventory audit results for the analysis of mature volumes for the inventory.

[19] An intensified grid based sample selection (systematic sampling) may be used if the NFI-BC samples are to be included as part of the ground sampling audit process. Refer to section 4.6.

4.5 NET VOLUME ADJUSTMENT FACTOR

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.

4.5.1 Objective

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

4.5.2 Sample Size

Typically, the MFR recommends a minimum sample size of 100 NVAF trees of which 90 are live and 10 dead. However, to increase the cost-effectiveness of the program and make better use of existing data, Dunkley suggests that a gap analysis be completed to determine those NVAF tree observations from adjacent Management Units that can be used on the TFL. Dunkley will consult the FAIB regarding the appropriate number of additional NVAF trees required for the TFL. The results of this program will be updated in the VPIP.

4.6 NATIONAL FOREST INVENTORY – BRITISH COLUMBIA

The MFR has been tasked with reporting on measures of climate change, carbon sequestration, and biomass. The main tool being proposed by the MFR to obtain this information is the NFI-BC permanent installations.[20]

If requested, Dunkley will contribute to the NFI-BC endeavor by collecting appropriate data at selected grid points within the TFL if focused funding is provided by MFR. The sampling scheme will be described in the Phase II VPIP. Data management, storage, and future remeasurement of these samples will be the responsibility of the MFR.[21] It is the expectation that the NFI-BC sample points will be funded by appropriate government funding agencies.

The NFI-BC sample points are selected using the national 20 km grid. If the NFI-BC points are to be integrated into the audit samples as part of the overall sample size then the VRI samples would likely be chosen on an intensified grid within the TFL. By selecting all samples systematically the selection probabilities will be consistently calculated for both the VRI and NFI-BC which will simplify the analysis. The details of this integration will be outlined in the Phase II VPIP.

Currently there is one NFI-BC sample located in TFL 53 which will be remeasured in 2009. The need for remeasurement or establishment of samples on TFL 53 will be evaluated when the Phase II VPIP is developed.

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[20] Ministry of Forests and Range, March 2005. *National Forest Inventory BC Change Monitoring Procedures for Provincial and National Reporting*. Unpublished. Pg. 222.

[21] The number of NFI-BC grid points landing within the TFL is expected to be 2-5.

4.7 ESTIMATED COSTS

Table 5 shows estimated costs for the implementation of a VRI on TFL 53. The focus of this inventory is on a rigorous Phase I with an appropriate average polygon size and an enhanced ground calibration program. The Phase II program will be a traditional two-pass approach with the goal being to achieve the target sampling error. The goal of the NVAF program is to utilize existing data where possible and augment this data with localized data, as appropriate.

Table 5. Estimated costs for VRI activities in TFL 53.

VRI Activity	Units	Unit Cost ($/Unit)	Total Cost ($)	Estimated Projected Fiscal Year
PHOTO ACQUISITION				
Photo Acquisition	~90,000 ha	~$0.28/ha	$25,000	Year 1
Scan, AT, and digital models. (1:15,000)	~90,000 ha	~$0.33/ha	$30,000	Year 1
Sub-Total			$55,000	
PHASE I (INTERPRETATION)				
Phase I VPIP (including managed stand assessment plan)	1		$10,000	Year 1
Phase I – estimation incl. field calibration	~90,000 ha.	~$1.50/ha	$135,000	Year 2
Quality Assurance			$5,000	Ongoing
Sub-Total			*$150,000*	
PHASE II (GROUND SAMPLING)				
Phase II VPIP (includes NFI)	1	$10,000	$10,000	Year 2 or 3
Prep of sample packages			$8,000	Year 2 or 3
Modified VRI Plots	50	$1,500/sample	$75,000	Year 2 or 3
NFI Plots	~3	$3,000/sample	$9,000	Year 2 or 3
NVAF samples	60	$750/sample	$45,000	Year 2 or 3
Helicopter*	5	$1,000/sample	$5,000	Year 2 or 3
Quality Assurance (including helicopter*)	5	$1,500/sample	$7,500	Ongoing
Sub-Total			*$159,500*	
STATISTICAL ANALYSIS				
Analysis & Report	1	$20,000	$20,000	Year 3
Sub-Total			*$20,000*	
Estimated Photo Acquisition Cost			***$55,000***	Year 1
Estimated Phase I Cost			***$150,000***	Year 2
Estimated Phase II Cost			***$159,500***	Year 3
Statistical Analysis Cost			***$20,000***	Year 3
Estimated Total Cost			***$384,500***	

**All helicopter costs are estimates, and are based on previous projects.*

5. SIGN-OFF SHEET

I have read and concur that TFL 53 VRI Strategic Inventory Plan dated July, 2009 meets current VRI standards with the variations as described. 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.

_____ _____

Doug Perdue, RPF *Date*

(Dunkley Lumber)

_____ _____

Jon Vivian, RPF Manager, *Date*

Vegetation Resources Inventory Section,
Forest Analysis and Inventory Branch,
Ministry of Forests and Range

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.

APPENDIX II – VRI PLANNING PROCESS

The VRI planning process requires that a VSIP and VPIPs are 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.

The VRI planning process is an important component of the overall VRI process and related activities (see Figure 1). The intent of the VRI planning process 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);
2. Identifying forest management issues;
3. VRI strategic planning (prepare a VSIP);
4. VRI operational planning (prepare VPIPs); and,
5. Implementation, including development and maintenance of procedures and standards
    a) Management inventories;
    b) Data base management; and,
    c) Data interpretation.

The steps for preparing a VSIP include:

1. Licensee VRI committee work with MFR staff to develop issue statements related to VRI.
2. The including all agencies and the VRI committee, meet to refine issues and discuss why these issues need to be considered fundable. The purpose of this meeting is to:
    1. Introduce the VRI tools and process;
    2. Table new issues and revisit existing issues;
    3. Discuss issues to fund (under current funding mechanisms) and provide general direction for developing the VSIP; and,
    4. 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. A final VSIP is prepared incorporating items agreed to in Steps 2 and 3 and is signed off by the lead proponent and the Manager of the VRI Forest Analysis and Inventory Branch.
4. VPIP process begins.

The VPIP details the activities 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.
2. Secure funding.
3. Identify project activities, geographic areas, and costs.
4. Specify roles and responsibilities for project implementation.
5. Prepare VPIP.

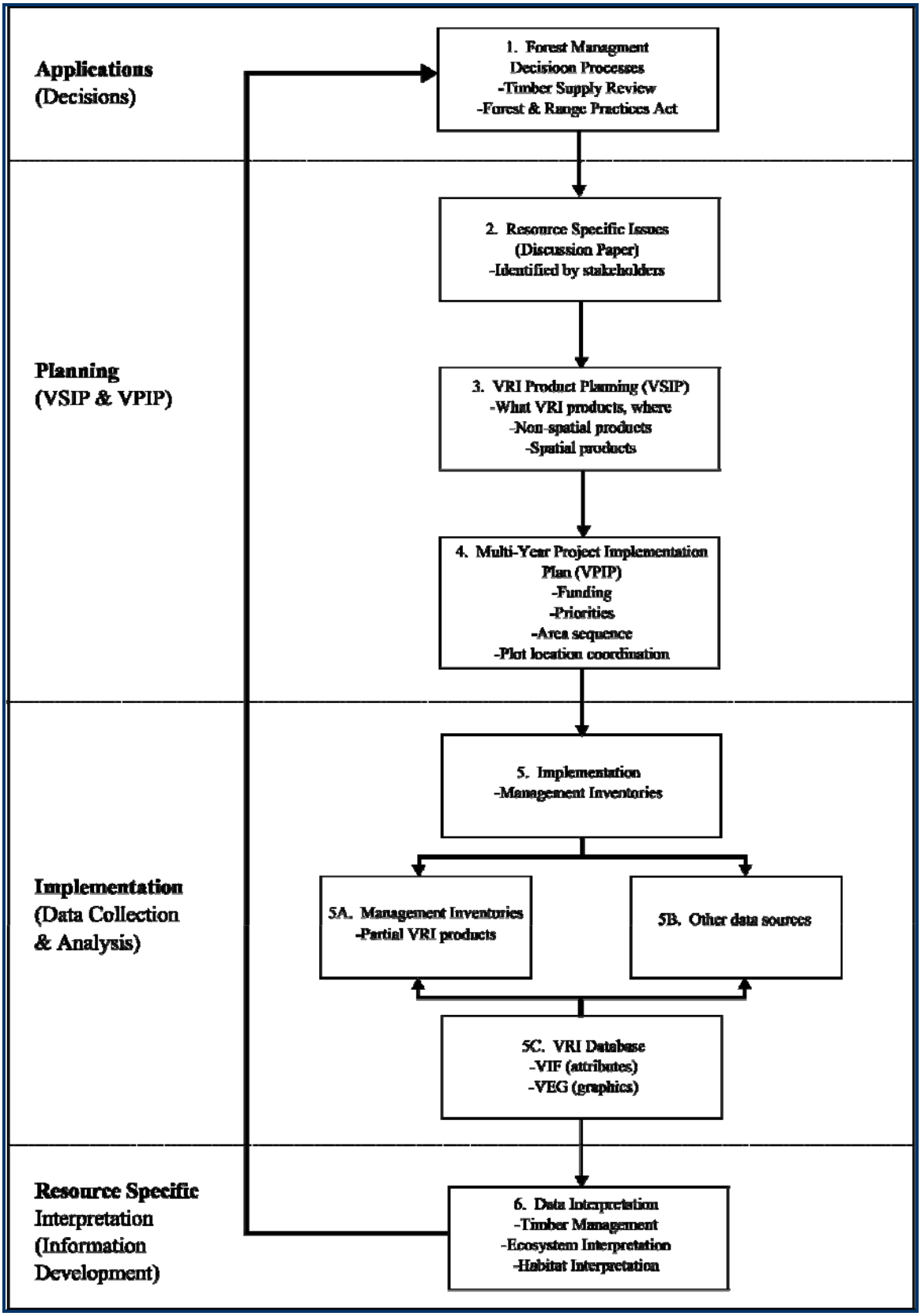

Figure 2. The VRI inventory process.

APPENDIX III – MAP OF TFL 53 WITH A MAPSHEET GRID

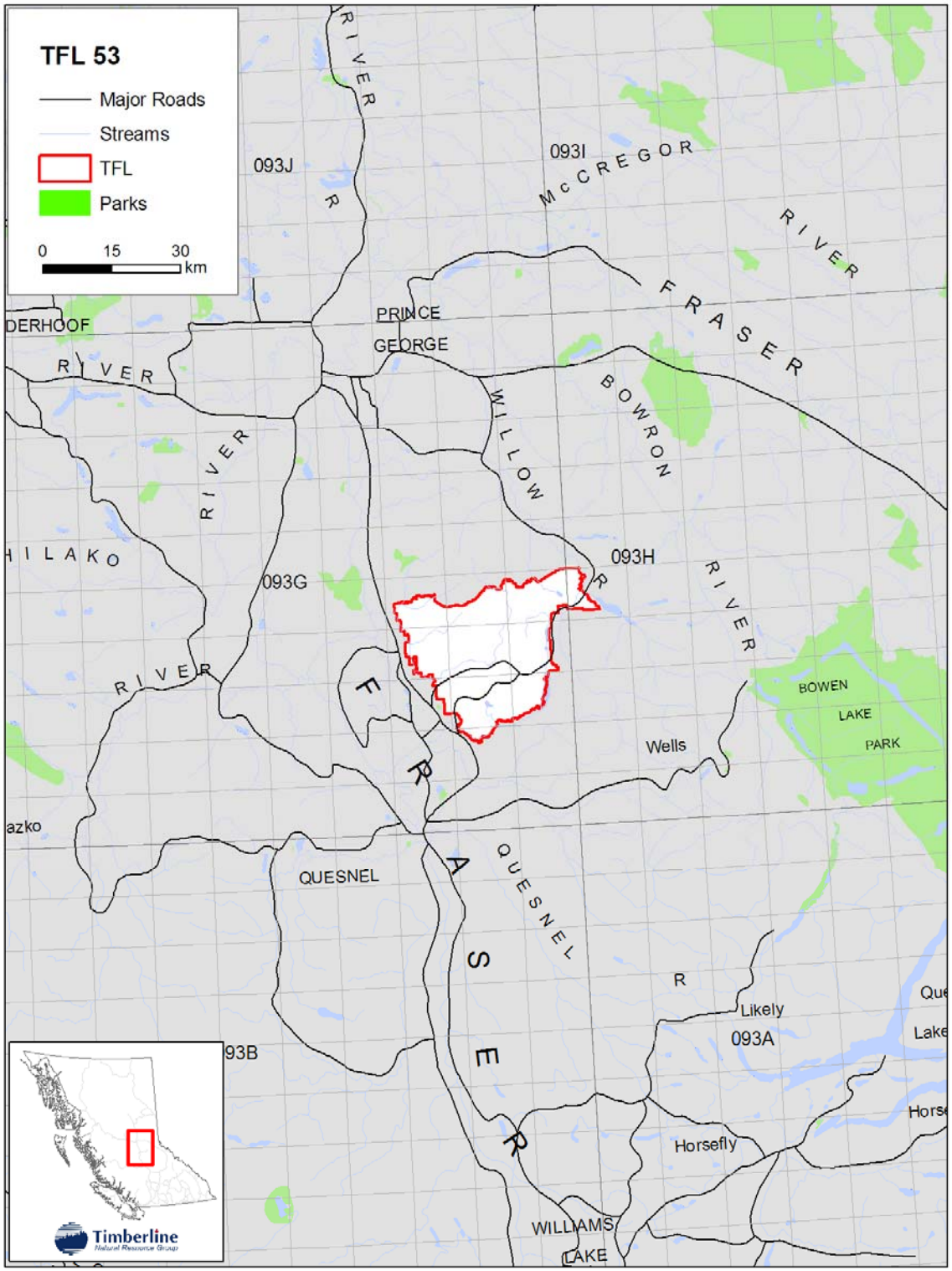

Figure 3. Overview map of TFL 53 with a map sheet grid.