Tree Farm License 1

Vegetation Resources Inventory
Strategic Inventory Plan

PREPARED BY:
LM FOREST RESOURCE SOLUTIONS

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This Vegetation Resource Inventory Strategic Inventory Plan is the result of input and support from many individuals. Stakeholders who spent the time and effort to guide this plan and share their considerable experience in the TFL include:

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EXECUTIVE SUMMARY

This Vegetation Resource Inventory (VRI) Strategic Inventory Plan (VSIP) for Tree Farm License 1 (TFL 1) was prepared in consultation with stakeholders in the Kalum District. The purpose of the plan is to outline the VRI activities and products needed to address forest management issues and business needs identified by stakeholders. It is recommended that this document be used by the District Land Base Investment Program (LBIP) steering committee to assist in long term inventory planning and to help guide the development of VRI Project Implementation Plans (VPIPs).

The BC Timber Sales Program (BCTS) and two non-replaceable forest licenses (NRFL) are currently operating within the TFL boundaries as a result of changes to tenure legislation established through the Forest Revitalization Act (the 20% take back initiative). Coast Tsimshian LP, the tenure holders for the TFL, have proposed an allowable annual cut (AAC) of 500,000 m^3 in Management and Working Plan 10 and intend on operating in the area once the working plan is approved. An accurate inventory is necessary to provide reasonable estimates of timber supply and to prepare both landscape level and operational level plans. A timber supply analysis was scheduled for Nov. 2006 and is likely imminent. The existing inventory is outdated and the accuracy and utility of existing air photos, linework, volume and decay estimates, and site index estimates have all been called into question. VRI activities and products that have been proposed to resolve these issues and meet the inventory and business needs of the stakeholders are:

- Phase I air photo acquisition and scanning for the entire TFL.
- Air photo interpretation of the entire TFL.
- Establishment of 60 Phase II timber emphasis ground samples in stands greater than 110 years of age.
- Destructive sampling of 100 NVAF trees.
- Adjustment of the inventory database and production of new maps.

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1. INTRODUCTION

1.1 SCOPE AND OBJECTIVES

A Vegetation Resources Inventory (VRI) Strategic Inventory Plan (VSIP) can provide strategies for photo interpretation, timber or ecological emphasis ground sampling, monitoring, decay and taper estimates, and associated research projects. This VSIP outlines potential VRI activities and products that can be used to address inventory issues and business needs identified by stakeholders at meetings on November 8, 2006 and January 16th, 2007.

LM Forest Resource Solutions prepared this report in consultation with the Kalum District stakeholders. These stakeholders included:

- BCTS representatives from the Kalum and Bulkley/Stikine Districts
- The MoF's Forest Analysis and Inventory Branch
- Coast Tsimshian Resources L.P.
- Representatives from the Kalum DFAM Land Base Investment Program (LBIP) steering committee.
- Representatives from the TFL 1 TSA Steering Committee.

Based on the strategic direction provided in this plan, it is expected that the District Land Base Investment Program (LBIP) steering committee will develop a VRI Project Implementation Plans (VPIPs) specifying how inventory activities will be implemented in the next three to five years.

1.2 VEGETATION RESOURCES INVENTORY

The Chief Forester is responsible for determining allowable annual cut (AAC) for TSAs (and TFLs) in accordance with Section 8 of the Forest Act. Under the BC government's defined forest area management (DFAM) initiative, responsibility for preparing a data package, undertaking timber supply analysis, and providing key information that is considered by the chief forester in making an AAC determination was to be the collective responsibility of the BC Timber Sales (BCTS) manager and the holders of replaceable forest licenses (the DFAM group). The legislation supporting the DFAM initiative was never brought into force and as of Feb. 2007, the Chief Forester declared that the program would be discontinued. The Chief Forester is encouraging licensees to voluntarily complete scheduled TSR data packages and timber supply analysis using the Forest Investment Account's (FIA) Land Based Investment Funding. Fundamental to this task is ensuring that the quality of forest inventory supporting timber supply analysis and the AAC determination is sufficient to provide a useful level of accuracy. Forest licensees (and other forest resource users) also need land and resource information to undertake other forest management activities such as timber harvesting, forest protection, and wildlife, water, and range management.

Inventory information supporting timber supply analysis and forest management operations, must answer two questions:
1. Where is the resource located?

2. How much of a given vegetation resource (for example, timber or coarse woody debris) is there?

The process to answer these two questions is carried out in two phases. Phase I (photo acquisition and interpretation) involves the delineation of polygons and the estimation of resource attributes from aerial photography and ground calls. Phase II (ground sampling) is the establishment of plot clusters in selected polygons to measure timber, ecological, and/or range attributes. This commonly includes measurement of tree and stand attributes from sample clusters established randomly within the target population, and can include stem analysis of individual trees to assess taper and decay (net volume adjustment factor measurements - NVAF). A third, less common type of Phase II sampling is "within polygon variation" - intensive sampling of selected polygons to determine the error between the estimated attribute values and the "true" attribute values. The information from ground samples is used to adjust or correct the photo-interpreted estimates for all polygons in an inventory unit or management unit.

1.3 VRI OVERRIDING PRINCIPLES

A vegetation resources inventory is guided by a number of fundamental principles:

- The inventory must satisfy the business needs of stakeholders.
- Inventory activities must be conducted to Provincial Resource Inventory Committee standards.
- Inventory activities must be coordinated.
- There must be adequate statistical confidence in timber value estimates.

To help ensure these principles are followed, standards and methods for VRI products have been produced (available at http://www.for.gov.bc.ca/hts/vri/standards/index.html). Periodic reviews of the standards are coordinated by a Resources Inventory Committee.

With respect to business needs, in TFL 1, needs and priorities are identified by a Land Base Investment Program steering committee. This group met prior to the development of this VSIP to provide strategic direction. Within the context of funding available within each organization, and through the Forest Investment Accountant (FIA), the group identifies the type and quality of inventory information they will need to achieve their business goals. FIA inventory funding allocations, however, are determined by a different group – a provincial council of individuals known as the VRI Advisory Council that includes representatives from the Ministry of Forests (MoF) Forest Analysis and Inventory Branch (FIB), MoF Regional Offices, the MoF's BCTS program, the Integrated Land Management Bureau (ILMB), the Ministry of Environment (MoE), and the forest industry. The role of VIAC is to rank and prioritize forest inventory activities for all units in the province. The level of funding for any particular project will be a function of the total funding available, and the relationship between the various projects (relative priority, time frame for completion, etc).

1.4 VRI PLANNING

The VRI planning process requires that a Strategic Inventory Plan and Project Implementation Plans be developed for a defined forest management unit (e.g. TSA or TFL). A VSIP outlines the VRI products required to address forest management issues and provides strategic direction for implementing the inventory activities. The VPIP more specifically identifies the needs for VRI management inventories, and provides the details for implementation of the VRI in terms of geographic areas, scheduling, priorities, plot location, coordination, estimated inventory costs by year, and roles and responsibilities. Guidelines for preparing a VSIP and VPIPs are available at http://www.for.gov.bc.ca/hts/vri/standards/index.html.

1.5 FUNDING

Funding for VRI activities is a licensee responsibility that, in the Kalum District, is coordinated by the Kalum FIA Land Base Investment Program (LBIP) steering committee. The primary source of funding for inventory activities has been the Forest Investment Account's (FIA) land base investment program. While the FIA allocation for 2006/2007 is $59.84 million, VRI is only one component of the LBIP, and completion of Phase I and II VRI activities will take more than one year. The program is also in transition and it is expected that funding for future inventory work will likely come from a different source known as Focussed funding within the FIA program. The VRI Advisory Council is currently developing a set of criteria to rank TSA's and TFLs in terms of their forest inventory priorities. It is expected that only VRI projects attaining the *highest priority* ranking will be eligible. At present no figures are available regarding magnitude of funding and there is no guarantee of surplus funds for lower priority inventory units.

The FIA Forest Science Program (FSP) (previously known as the Forestry Innovation Investment) is another potential funding source for the activities outlined in this VSIP. Innovative aspects of the inventory, particularly the aspects of research into existing stand volumes and decay, may be eligible for funding under the FSP timber growth and value program.

In the absence of outside agency funding, stakeholders are encouraged to enter into partnerships to minimize the costs associated with the implementation of the activities outlined in this plan. It is government's intention that businesses invest in the necessary information, infrastructure, and human capital to run their business effectively.

2. BUSINESS CONSIDERATIONS

2.1 LANDBASE

TFL 1 lies within the Northern Interior Forest Region and is administered from the Kalum Forest District office in Terrace. The TFL comprises a total of 518,297 hectares centred on the community of Terrace. The TFL is bordered by the Kalum, Nass, Kispiox, North Coast and Bulkley TSAs, as well as Tree Farm License 41. Adjacent to the TFL are several parks, including the Nisga'a Memorial Lava Bed Provincial Park, the Lakelse Lake Provincial Park, the Exchamsiks River Provincial Park, and the Gitnadoix River Recreation Area (Figure 1). It is

expected that some of the area in TFL1 will be removed from the TFL and incorporated in the Kalum TSA in the near future. Hectares and dates for this transfer have not yet been determined.

Of the 518,297 hectares currently in the TFL, productive forest land totals 229,379 hectares or 44% of the total area (Table 1). Approximately 56% of the TFL (288,918 hectares) does not produce timber. This is comprised mainly of rock, swamp, alpine areas, and water bodies. Only 89,596 hectares, or approximately 17 percent, of the TFL is within the Timber Harvesting Landbase (THLB). Hemlock species dominate in stands on about 75 percent of the area of the THLB, balsam dominates on 17 percent, spruce on 1.9 percent, and lodgepole pine on 4.5 percent (Table 2).

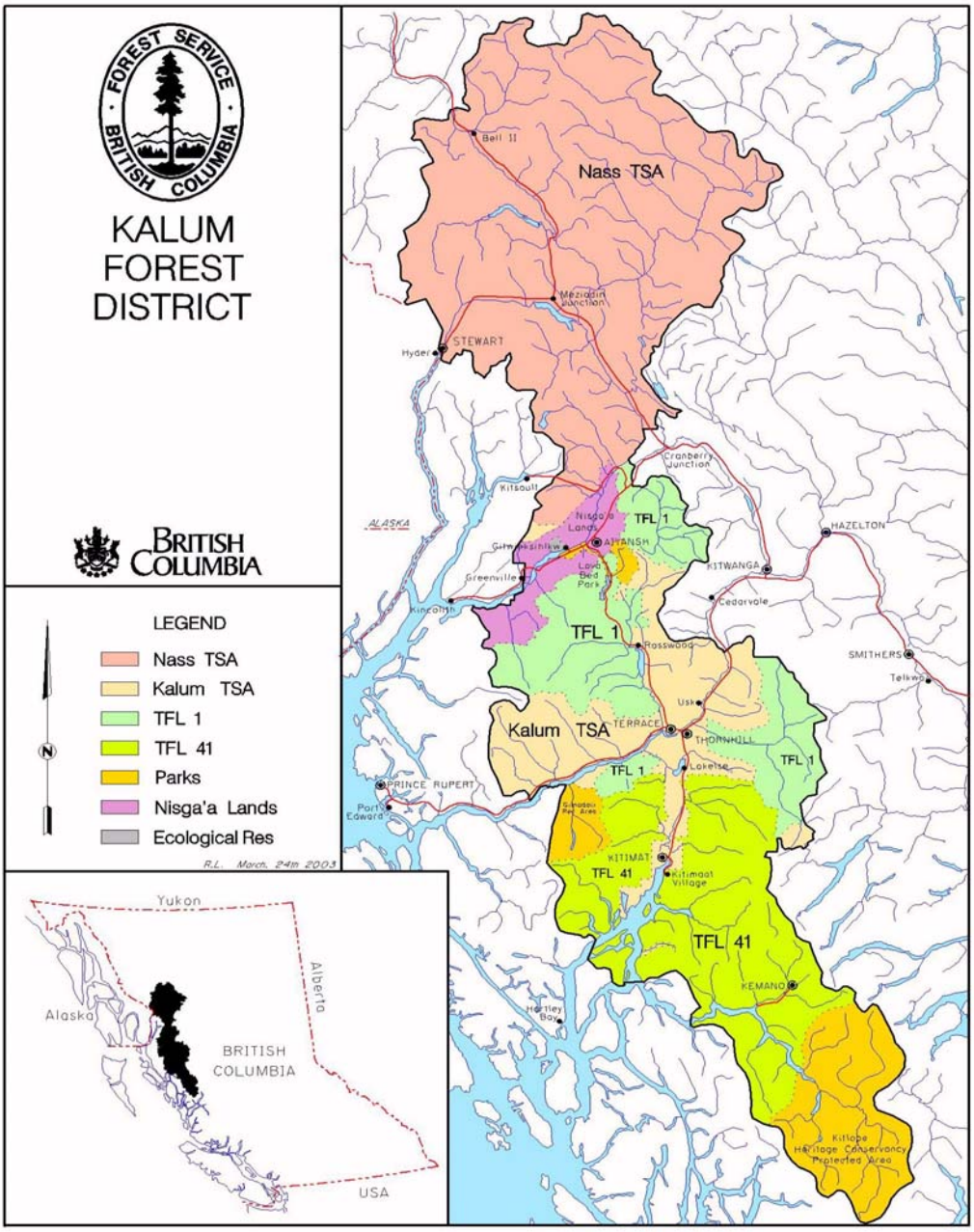

Figure 1. Tree Farm Licence 1

Table 1. Tree Farm Licence 1 landbase[1]

Landbase Classification	Area (ha)	Total area (%)	Productive forest (%)
Total TFL1 area	518,297		
Non-forest	274,042	52.9	
Non-productive forest	14,876	2.9	
Total Productive Forest	229,379	44.3	
less the following reductions:			
Inoperable	119,001	23.0	51.9
Non-commercial	87	0.0	0.0
Low site	2,950	0.6	1.3
Deciduous	1,459	0.3	0.6
Non-merchantable	1,500	0.3	0.7
ESAs	5,519	1.1	2.4
Alpine Tundra	112	0.0	0.0
Riparian zones	2,553	0.5	1.1
Specific geographically defined area	915	0.2	0.4
Goat winter range	1,102	0.2	0.5
Unclassified roads, trails and landings	2,059	0.4	0.9
NSR	2,940	0.6	1.3
Wildlife tree patch	2,526	0.5	1.1
Total Current Reduction	**142,723**	27.5	62.2
Initial THLB	**86,656**	**16.7**	**37.8**
NSR	2,940		
Current THLB	**89,596**	**17.3**	**39.1**
Future roads, trails, landings	3,435		
Future THLB	**86,161**	**16.6**	**37.6**

Table 2. TFL1 Timber Harvesting Land Base by Dominant Species

Dominant Species	Area (ha)	%
Hemlock	66,566	75.0
Abies	15,615	17.5
Spruce	1,695	1.9
Pine	4,015	4.5
Cedar	446	0.5
Deciduous	892	1.0
Total	**89230**	**100**

[1] This landbase information is summarized from the TFL 1 Timber Supply Analysis, 2003. It is different than the vegetated treed operable landbase defined in Feb. 2007 by LIM staff in the Kalum District.

2.2 INVENTORY HISTORY

The first inventory of area currently considered to be part of the TFL took place in 1948 in the Khutzeymateen. The next major inventory work was in 1973 and then 1991 (FC1 and FIP) and covered the entire landbase. Volumes in the 1991 inventory were derived using old yield curves rather than VDYP. Line work has not been updated since this time and is based on pre-1990 photos; however, database files were update for depletions such as timber harvesting, fire, and silviculture treatments in each subsequent year. The majority of the updates occurred in 1991, 1994, 1997 and 2003 with a relatively small number of polygons updated in 1998, 2000 and 2002. The 2003 update included 1082 polygons encompassing 8,695 ha. Apart from the edge of 6 or 7 mapsheets, TRIMII base maps are available for the entire TFL.

In 1999 and 2000 Sterling Wood and Associates Ltd. established 146 VRI clusters within the productive landbase. After subsequent deletions of the landbase resulting from the Nisgaa agreement, only 118 clusters remained in the TFL. Four types of stand were targeted (CWH 10 to 30 years of age, CWH 30 to 110 years, ICH 10 to 30 years, and ICH 30 to 110) and the target attributes included age, height, and derived values for site index and volume. The study applied to about 13% of the productive landbase.

VRI inventory attribute adjustments were made by Sterling Wood in 2004 by developing a ratio of ground sampling volume to the volume predicted by running the adjusted inventory database through VDYP. The volumes produced using adjusted heights and ages in VDYP were less than volumes observed in the Sterling Wood assessment by 39 to 89% for stands 10 to 30 years old, and more than observed volumes by 21 to 33% for stands 31 to 110 years of age. Some bias was noted in these results. The inventory database was then adjusted by using the ratios of VDYP volume to ground volume and then multiplying it by the attribute adjusted volume in the database. Site index was also re-calculated for each polygon from the adjusted height and age using VDYP. It should be noted that using VDYP to predict volumes and site index in young stands, especially those under about 30 years of age, is inappropriate because the model was never calibrated for these young stands. These adjustments were applied to **13** percent of the productive landbase.

The only other inventory work of direct relevance to VRI in TFL 1 was a decay study in which 1169 trees (not all within TFL 1) were assessed. Actual net volume measured in the sample trees was compared to estimates of net tree volume based on taper equations and net factoring currently in use in VRI[2] Preliminary results indicated that the 1976 loss factors used in the past overestimated loss. The results of this study were never used and should be reviewed for their applicability in the TFL.

[2] The old inventory for TFL 1 used FIZ 1976 Loss Factors to predict volume reductions due to decay. These are still used today in appraisal analysis. They assign losses by class of trees (risk groups) that represent average levels of decay determined from historic destructive sampling. A new VRI uses net factoring (a cruiser's estimates of decay and waste) to assign decay loss by log based on the direct evidence of decay such as conks and scars. It also uses new taper equations that are different than those used in the old inventory.

2.3 INVENTORY AUDIT

An inventory audit was performed in the TFL 1 in 1996. The inventory audit tested three components of the current inventory:

- the accuracy of timber volumes in mature forested areas (forest stands older than 60 years),
- the accuracy of the site growth potential (site index) of immature stands (younger than 60 years of age but older than free growing age),
- the accuracy of the photo-interpreted classification of non-forest types in the inventory (areas such as lakes, gravel pits, and alpine meadows).

Results of the audit indicated that:

- It should be noted however that the r-value associated with this inference was 0.347 indicating a moderate lack of fit, despite the relative closeness in mean m^3/ha.in immature stands, site index was under estimated in the inventory database by $\geq$ 5m for 8 of 20 stands (40%), over estimated by $\geq$ 5m for 1 stand and within 5m for 11 of 20 stands (55%). Sterling Wood (2004) also found age and height in immature stands to be under estimated.
- 67 percent of stands assessed for non-forest classification were correct (the provincial minimum standard is 85%).

2.4 INVENTORY ISSUES

Key inventory issues that have been identified as important by TFL 1 stakeholders include:

1. **Inadequate aerial photos and old polygon line work**. Complete coverage was acquired during the 1990 inventory work. Photography flown in 2001 and 2003 (1:30,000 BW) for a variety of applications, including possible timber inventory, is considered to be inadequate for interpretation based on VRI standards. The existing inventory does not include all the VRI attributes and was not derived using modern technologies like softcopy photo interpretation. Practitioners in the area feel that the **spatial** accuracy of polygon line work in the existing inventory is inadequate and that the existing aerial photos are inappropriate for development of any new timber inventory.

2. **Uncertainty in volume estimates.** Stakeholders continue to be concerned about volume estimates for the TFL. Inaccuracies in height and volume estimates in young stands noted in both the Sterling Wood report and in the inventory audit, and the fact that mature volumes are have not been produced using VDYP, make volume estimates uncertain. The Sterling Wood report for example, indicated, in a study that affected only 13% of the productive landbase, that total inventory volume would increase from 2.5 million cubic metres (in the original inventory) to 4.9 million cubic metres (164 m^3/ha). More accurate height and volume estimates are needed to provide more accurate timber supply estimates and for operational applications like identification of potential harvest blocks, OGMAs, PEM mapping, and habitat analysis.

3. **Potentially inaccurate taper and decay estimates.** Evidence from adjacent inventory units indicates that decay and taper functions are inaccurate in similar biogeoclimatic conditions with similar stand types. The 1169 tree decay study conducted in part of the TFL also pointed to inaccuracies in decay estimates and stakeholders continue to express concern about differences in merchantable volume and volume predicted in the inventory database. More accurate decay estimates could have significant impact on short and mid-term timber supply given that stands older than 110 years occupy 75% of the vegetated treed portion of the operable landbase.

   Stakeholders in the Kalum District are also concerned with wood quality (merchantability). VRI log grades are collected in ground samples and this information can be used to determine log grade profile within the inventory database. During NVAF destructive sampling it may be beneficial to have a scaler assess log grade independently to evaluate the accuracy of VRI grade estimates. NVAF destructive data could also include a measurement of uneconomic sound wood to evaluate sensitivity around VRI net volume estimates.

4. **Inaccurate non-forest classification.** Thirty stands were assessed for accuracy as part of the 1996 audit. It was found that only 67 percent of the stands were classified correctly. This fails to meet the provincial standard of 85 percent. Non-forest classification is used in habitat supply analyses, determining how to meet biodiversity objectives like seral stage and patch size requirements, and in identification of berry patches and other First Nations interests on the land.

5. **Improving 2000 VRI Phase 2 sampling precision.** The coefficient of variation, in the young stand assessment undertaken by Sterling Wood in 2000 was 77percent for age and 46 percent for height. Sampling errors were 15.3 percent and 9.15 percent for age and height respectively. Both height and age could be re-visited to reduce sampling error to below 10 percent. Also, as noted above, VDYP is not normally used to simulate volume in stands as young as 30 years of age. Consideration should be given to revising volume predictions for these young stands using the MoF Table Interpolation Yield Program for Stand Yield (TIPSY). If a new Phase I inventory were completed, the Phase II adjustments completed in 2004 by Sterling Wood would have to be redone for the new database generated anyway, and this should be accomplished using a combination of TIPSY and VDYP to predict yield (rather than just VDYP as was done in the Sterling Wood report).

In addition to the key issues discussed above, a number of other forest management issues have been identified by stakeholders in the area as follows:

- Operability: This is something that is defined by users of inventory data based on inventory attributes rather than a directly measured attribute of the forest. This issue does not necessarily require further sampling but would be more accurate if the database were more accurate.

- Impact of WTPs, RMZs, OGMAs, VQOs etc on timber supply: Better inventory data obtained through VRI could result in more accurate impact estimates but this is essentially a GIS analysis and does not necessarily require more data to be collected.
- Better yield curves: Yield curves are used in VDYP to project future volumes and have a fundamental impact on timber supply. However, the curves have traditionally been developed through a growth and yield program using permanent sample plot data. Development of more accurate curves could be done in the future through change monitoring but this is a long term endeavour and is beyond the scope of a basic inventory program.
- PEM mapping. A PEM accuracy assessment undertaken for the Kalum District in 2006 indicated that existing mapping did not meet provincial standards. The likelihood of having an accuarate PEM product with poor inventory information is low. It might be appropriate to redo the PEM map with a new inventory database and compare revised results with the PEM audit field measurements to see if a better result can be achieved.

2.5 VRI ACTIVITIES AND PRODUCTS

There are a number of VRI products and activities that could be used to address the issues identified in section 2.3. Some options have been summarized below. Actual recommendations are summarized in Section 3.0 – the inventory plan.

2.5.1 Phase One Photo Acquisition and Interpretation

A Phase I inventory involves subjective delineation of polygons and photo estimation of attributes for all polygons in an inventory unit from medium scale aerial photographs (1:15,000 or 20,000) over the entire TFL landbase. This includes interpretation of conventional attributes such as: species, age, and height, as well as additional attributes such as basal area and soil moisture and nutrient classification. The VRI Phase I product is a spatial database consisting of unadjusted photo-interpreted estimates. In most modern VRI work, statistical adjustment is completed for a Phase I database. Statistical adjustment is the process of adjusting the values of the photo-interpretation variables using ground sampling observations obtained in a Phase II VRI. In each sampled polygon, ground observations are compared to photo-estimated values to develop adjustment factors, usually by groups (e.g. leading species). These factors are then applied to all polygons in the photo interpretation database group to produce the final adjusted database.

In TFL 1, one option to address poor quality and outdated photography, and perceptions that polygon linework is spatially inaccurate, is to acquire new photography and use it to develop new maps and an updated attribute database.

VRI Phase I photo acquisition and interpretation is estimated to cost $1.40 to $1.80/ha. Benefits from conducting this work could include:

- Complete 1:15,000 or 1:20,000 colour photo coverage of the TFL. The photos would be useful in a Phase I inventory and in many other forest management applications.
- Possible improvements in the accuracy of polygon attribute values. More accurate attribute values lead to more accurate future timber supply analyses and operational

analyses such as timber harvest planning, WTP, RMZ, VQO, and OGMA delineation, and post-harvest survey work.
- Improved quality/accuracy of information available for inoperable stands, which may lead to a reconsideration of their accessibility and merchantability.
- New attributes such as height and age on secondary species as well as basal area and density for all species. This information will be used in VDYP7 and should improve estimates of existing and projected stand volumes.

2.5.2 Acquisition of Phase I Data with a LiDAR/Hyperspectral System

The University of Victoria in partnership with Terra Remote Sensing Inc. of Sidney, B.C. has developed an integrated imaging platform. This platform is centered on three imaging technologies: digital photography, LiDAR, and hyperspectral imaging. The simultaneous collection, and integration, of data from all three sensors is made possible through the use of GPS (local base stations and on-board collection) and real-time navigation hardware and firmware. Positional accuracy better than 1 pixel is attainable. The instruments are permanently mounted in a twin engine Navajo aircraft. The relatively high speed of the aircraft allows for acquisition of up to 200 square km^2 per day, depending on pixel resolution. This platform was successfully flown last year in British Columbia, Alberta, and California.

To date the emphasis of the University of Victoria team has been on the extraction of forest attributes including inventory information, ecological data, and forest health information. In 2006, they initiated a pilot project with Canfor and the MoF in TFL 18 near Clearwater. In this project they acquired data for 60,000 ha of the TFL and are now processing and analysing the data to derive species composition, stand height, gap structure, and vertical canopy structure. It is possible with this system to map and measure individual trees.

One of the strengths of the approach being developed is it's repeatability and consistency over large areas (in contrast to variable interpretation in a conventionally produced inventory). Costs are initially higher ($4.00 to $5.00/ha) than is common with traditional aerial photography, data acquisition and interpretation, however, because of the detail and range of data collected it may often be possible to spread the costs amongst many users. For example one of the initial products of the LiDAR is a bare earth model. This is a digital elevation model where the height influence of vegetation has been removed and a more realistic representation of the ground surface is developed. This approach can typically generate an elevation model in with resolutions of 2-5 metres, depending on the vegetation density. Thus, projects such as PEM, TEM, terrain mapping and TRIM could partner to extract specific products from the data following VRI acquisition, potentially sharing the cost of data acquisition.

2.5.3 Phase Two Ground Sampling and Net Volume Adjustment Factors

Phase II ground sampling is the field measurement of timber, ecology, range, and/or coarse woody debris values at one or more locations within selected sample polygons. Sample polygons are selected using the probability proportional to size with replacement (PPSWR) method and plots are established in clusters within selected polygons. Information obtained from the ground samples is used to statistically adjust all polygons in the inventory database.

NVAF sampling involves detailed stem analysis of sample trees, calculation of actual net volume, and calculation of the ratio between actual net volume and estimated net volume (where estimated net volume is obtained from net factoring and taper equations). NVAF data is used to adjust the estimated net tree volume to account for hidden decay and taper equation bias. NVAF should be performed in conjunction with timber emphasis plots. The application of NVAF produces statistically valid VRI ground sample volumes, and it is a mandatory activity of a VRI ground sample inventory. It may also be beneficial to have a scaler assess log grade independently during NVAF sampling to evaluate the accuracy of VRI grade estimates and volume of uneconomic sound wood.

The issues of inaccurate inventory attributes could be addressed through the establishment of Phase II ground samples and net volume adjustment factoring. Benefits from conducting this work would include:

- More accurate decay estimates in all stands.
- Better estimates of derived site index.
- Increased statistical power of inventory attributes (for e.g. an overall sampling error for volume for mature stands of ~ 10%).
- Log grade information and a measure of the accuracy of VRI grade estimates (if a scaler were involved in the NVAF sampling).
- A basis for developing more accurate taper equations or adjustments to taper.

It should be further noted that Phase II ground sampling activities are not dependent on the outcomes of Phase I photo-acquisition and interpretation products. It may be advantageous in TFL 1 to implement ground sampling prior to any photo interpretation, due to the amount of information that can be derived from ground sampling and applied to resolving recognized business issues.

3. INVENTORY PLAN

3.1 OVERVIEW

This section outlines a preliminary strategic inventory plan that could be used to address forest management issues defined by the stakeholders in TFL 1. The toolbox of activities described below will be discussed with stakeholders, revised as necessary, and then used to develop Vegetation Resources Inventory Project Implementation Plans (VPIPs).

3.2 PHOTO ACQUISITION AND INTERPRETATION

3.2.1 Objectives

The Coast Tsimshian, holders of the tree farm license, are about to resurrect timber harvesting (500,000 m^3/year) and other land management activities on TFL1. The next timber supply

analysis was scheduled for November 2006 and is likely imminent. These two major initiatives drive much of the need for an accurate inventory. Specific applications include:

- timber supply analysis.
- land management planning including both strategic plans and operational plans.
- timber harvest planning.
- landscape level analyses including delineation of the timber harvesting landbase, OGMA delineation, biodiversity analyses, PEM mapping, and habitat analysis.
- other operational applications like silviculture and forest health treatment planning and analysis.

As described in section 2.4 there are a number of problems with the current inventory including:

- old (1990) or inappropriate photography (2001 and 2003) in which neither disturbances nor recent changes in forest cover are shown, or are shown with insufficient quality.
- spatial inaccuracies of forest cover polygon linework.
- an old database lacking the full slate of modern attributes necessary for some types of operational planning and analyses.
- inaccurate volume estimates based on old yield curves in all stands except those that are less than 110 years within the timber harvesting landbase.
- inaccurate taper and decay estimates.

The objective with photo acquisition and interpretation will be to produce an updated VRI with more accurate stand height and age information, including polygon delineation produced to VRI standards. It would include interpretation of conventional attributes such as species, age, and height in addition to new attributes such as basal area, soil moisture and nutrient classification. Acquisition of new photos also affords the opportunity to capture any new disturbance that may not have been reported through inventory updates. Any photo acquisition that does occur in TFL 1 should be coordinated with photo acquisition in neighbouring units such as the Kalum TSA and TFL41.

It is also recommended that consideration be given in the future to testing the practicality and utility of the LIDAR/Hyperspectral approach to the acquisition of inventory data. This may be done on a smaller test area or, if the technology has matured enough, for a larger operational unit.

3.2.2 Target Area

It is expected that air photo acquisition and scanning would be completed for the entire TFL. It is also recommended that photo interpretation be completed for the entire TFL excluding any parks or protected areas. This will ensure that any landscape level planning or analyses are completed with the most recent inventory information.

3.2.3 Target Attributes

All attributes listed on the VRI photo interpretation attribute form should be targeted. A list of these attributes can be found at: http://ilmbwww.gov.bc.ca/risc/pubs/teveg/vri-photointerp2k2/photo_interp2k2.pdf.

3.2.4 Standards

Air photo acquisition and scanning will be conducted in accordance with the Base Mapping and Geomatic Service (BMGS) standards. These can be found through the ILMB- BMGS website: http://ilmbwww.gov.bc.ca/bmgs/. Photo interpretation and ground call calibration will be conducted in accordance with the Resource Information Standards Committee (RISC) standards and those can be found through the ILMB- RISC website at: http://ilmbwww.gov.bc.ca/risc/pubs/teveg/index.htm .

3.3 VRI TIMBER EMPHASIS GROUND PLOTS AND NVAF SAMPLING

3.3.1 Inventory Objectives

It is recommended that additional timber emphasis, Phase II ground samples be established, and additional NVAF work be undertaken. The objectives in undertaking this work are:

- Improve the statistical validity of timber age, height, volume, and site index estimates in stands > 110 years.
- Obtain more accurate information on decay and taper in stands > 110 years.
- Obtain an overall volume sampling error of $^{+}$/-10 percent at the 95 percent level of probability, **all strata combined** (including strata previously sampled by Sterling Wood).
- Ensure that the inventory database reflects the findings of the Phase II work.
- Obtain inventory information in a timely manner so that it will be available to support timber supply analysis and operational needs planned for the immediate future.

It is expected that an outcome of the work would be a readjustment of the inventory database. As noted above, it is recommended that the 2000 VRI project data also be used to adjust any new phase one inventory.

3.3.2 Target Population

The target population for this work will be stands > 110 years within the vegetated treed portion of the operable landbase in TFL 1[3]. Adjustment of inventory attributes in younger stands (30 - 110 years old) will be accomplished by utilizing the VRI clusters established by Sterling Wood in 2000. Ground sampling will not be done in stands less than 30 years of age because, in most cases, information from these stands comes from relatively intensive silviculture survey work.

[3] The vegetated treed portion of the operable landbase was defined as follows:
- Ralph Leonard, the Kalum LIM officer provided an operability coverage in Feb. 2007.
- Using GIS analysis, all stands that fell within this overlay that were not NCBr and had a tree species crown closure of at least 10% were considered to be part of the vegetated treed portion of the operable landbase.

3.3.3 Sample Size

Ground Sampling

The coefficient of variation (CV) in the 1996 inventory audit for mature stands was 37%. In neighbouring inventory units it has more typically been 46%. If a conservative approach were taken, using a CV of 45%, it is estimated that approximately 80 sample clusters would be required to achieve an overall sampling error for volume for all strata combined of 10% (at a 95% level of probability). This sample size is a based on the formula: Sample Size = t^2 x CV^2/SE^2. However, because 49 samples were already established in stands aged 31 to 110 in 2000, only an additional 31 would be required if the Sterling Wood sample had been area weighted. The Sterling Wood sample was not proportionate to the area occupied by 30 to 110 year old stands in the vegetated treed portion of the operable landbase, however, and so an additional 60 samples will be required, determined as follows:

Area in the vegetated treed portion of the operable landbase (VTO): 129,584 ha
Area in stands greater than 110 years of age in the VTO: 97,752 ha (see table 3)
Number of samples required: 97,752/129,584 * 80 = 60

Table 3. Dominant Species by Age Class in the Vegetated Treed Portion of the Operable Landbase.

	Age (years)	Area (Ha)	Percent of VTO
HemBal	31 to 110	15,155	11
	111 to 250	11,443	9
	>250	83,462	64
Other Species	31 to 110	3,825	3
	111 to 250	2,016	2
	>250	832	1
Total	n/a	116,733	90*

* the remaining 10% of the VTO is occupied by stands < 30 years of age

To ensure that there is a reasonable distribution of clusters across timber types, it is normally recommended that sampling be further stratified on the basis of leading species group and/or age class, volume class, or site productivity class. However, as can be seen in table 3, species other than hemlock and balsam represent only 3% of the vegetated treed portion of the operable landbase that is greater than 110 years. It is recommended, therefore, that stratification for the purpose of establishing the 60 clusters from stands greater than 110 years of age, be distributed on an area weighted basis by site index class (for example: <15, 15 to 25, > 25) or volume class (for example: <250, 250 to 500, > 500 m^3/ha) but not by species group.

NVAF Sampling

In accordance with Forest Analysis and Inventory Branch policy, it is recommended that 100 NVAF trees be destructively sampled with a target sampling error of 7.5% for all strata combined at the 95% level of probability. Because stands less than 110 years will not be sampled during ground sampling, trees from this age class will need to be chosen from polygons other than those in which ground sampling occurs. Recommended sample distribution is as follows:

- Stands < 110 years: 12 trees from within 4 polygons, no dead trees.
- Stands > 110 years: 78 live trees stratified on an area weighted basis by species group (hemlock, balsam, and other, excluding deciduous) plus 10 dead trees with a maximum of 3 trees coming from any one polygon.

Because decay in young stands is not considered to be as big an issue as in older stands, and because stands 31 to 110 years of age occupy only 14% of the VTO, relatively little emphasis has been assigned to this category.

It is also recommended that a scaler assess log grade independently during NVAF destructive sampling to evaluate the accuracy of VRI grade estimates. NVAF sampling should also include a measurement of uneconomic sound wood to evaluate sensitivity around VRI net volume estimates.

3.3.4 Sample Selection

Ground sample polygons would be selected randomly using the probability proportional to size with replacement (PPSWR) method and plots would be established in clusters within selected polygons. NVAF enhanced samples should be established at a ratio of one per three sample trees. The VRI Vegetation Resources Inventory Sample Selection Procedures for Ground Sampling, ver. 3.3, 2002 should be used to guide sample selection.

3.3.5 Sampling Standards

VRI Timber Emphasis Plots (TEPs) will be established in accordance with the *VRI Ground Sampling Procedures Manual* , ver 4.5, March 2004 and the document *Vegetation Resources Inventory Data Collection Standards for VRI Ground Sampling*, ver 2.1, March 2006. NVAF work will be conducted in accordance with *Net Volume Adjustment Factor Sampling Standards and Procedures*, ver. 4.1, March 2006. These manuals are currently available at: http://www.for.gov.bc.ca/hts/vri/standards/index.html#sampleselection.

3.3.6 Database Adjustment

Once the data from the timber emphasis plots and NVAF trees has been collected, compiled, and sorted, it will need to be analysed to produce adjustment factors for stands > 110 years. It is recommended that attribute adjustment of young stands (30-110 years of age) also be considered based on the 118 VRI clusters established in 2000. This could be done whether a new Phase I inventory is completed or not. Inventory database attribute adjustments should be completed in accordance with the MOF standards in existence at the time of analysis.

3.4 IMPLEMENTATION

3.4.1 Timelines

This VSIP outlines seven potential categories of work to be completed:

1. air photo acquisition and scanning,
2. ground calls and air photo interpretation,

3. map preparation,
4. database preparation,
5. Phase II ground sampling,
6. Phase II NVAF sampling, and
7. Phase II data analysis and database adjustment.

Phase II field work would ideally follow the air photo acquisition and interpretation tasks so that Phase II samples can be selected from an updated database and newly delineated polygons. However, if the risk of inappropriate polygon selection were not considered to be too great, ground sampling and NVAF sampling could be completed concomitantly with air photo acquisition and interpretation. Phase II analysis and database adjustment would normally be completed after photo interpretation and the unadjusted Phase I database has been completed. Recommended timelines for all tasks, assuming the acquisition of air photos begins in 2007, and that interpretation and phase two occurs subsequent to this, is shown in the Gannt chart below.

Table 3. VRI timelines with photo acquisition.

	2007 Su	2007 Wi	2008 Su	2008 Wi	2009 Su	2009 Wi
Photo acquisition						
Photo interpretation						
Map and dbase prep						
NVAF & Gd Sampling						
Analysis and Adjustm						

The timelines indicated in the Table 3 could be achieved if all aspects of the project went smoothly and there were sufficient funding and certified crews available. Although the scenario suggested above means that updated linework (maps) will not be available for three years, it does provide a new inventory to current standards by 2009. As noted above, the ground sampling could be done concurrent with Phase I field work with little extra risk but it would mean that the database adjustment would need to be done twice (once for the old database and once for the new database created from the Phase I work) at an additional cost of about $25,000.00.

3.4.2 Project Implementation Plan

Once stakeholder input and approval of this VSIP has been obtained, VPIPs will be prepared in accordance with *Vegetation Resources Inventory Guidelines for Preparing a Project Implementation Plan for Ground Sampling and Net Volume Adjustment Factor Sampling*, Ver. 2.0, March 2006 and *Vegetation Resources Inventory Guidelines for Preparing a Project Implementation Plan for Photo Interpretation*, Ver. 2.0, April 2006.

It is expected that a photo-interpretation VPIP for TFL 1 will be completed before the end of March, 2007.

3.4.3 Roles and Responsibilities

The three major stakeholder groups in TFL 1 are the forest licensee, the Ministry of Forests Analysis and Inventory Branch, and the Integrated Land Management Bureau. Roles and responsibilities of each in the VRI process are summarized below.

Licensee:

- Identify funding sources and relative priorities.
- Approve VSIP and VPIP products.
- Manage the implementation of the project implementation plan.
- Submit plans to the FIA fund manager (Price Waterhouse Coopers) for funding approval.
- Submit plans to Forest Analysis and Inventory Branch for technical review.
- Submit all FIA funded products, including digital and analog data, maps, and QA reports to the MoF Northern Interior Region.

Forest Analysis and Inventory Branch

- Develop standards and make them available to Licensee and inventory contractors.
- Develop yield models used in the inventory and timber supply analysis process.
- Provide technical advice and support.
- Review and approve plan and analysis to ensure the products will meet MoF business needs.
- Undertake inventory audits and report them to stakeholders.
- Potentially act as the data guardians for any new data or inventory information collected.

Integrated Land Management Bureau

- Develop data archiving standards and make them available to inventory proponents.
- Maintain the Land and Resource Data Warehouse.
- Upload all inventory information to the LRDW.
- Ensure inventory users have appropriate access to the data warehouse.

4. COSTS

Estimated sample sizes and preliminary costs for TFL 1 VRI activities are listed in Table 4. Costs are approximations based on comparative analysis in other inventory units. Cost estimates may change once stakeholder feedback is received.

Table 4. Potential costs for VRI activities in TFL 1[1]

VRI Project Component	Unit Cost	Total Cost
Photo acquisition[2]	$0.21 - $0.27/ha	$115,500 - $148,500
Scanning, AT, and Diap Viewer Sets	$0.12 - $0.20/ha	$66,000 - $110,000
Orthophotos	$0.04 – $0.07/ha	$22,000 - $38,500
VRI Phase 1 QA audit (Third Party)	$0.05/ha	$27,500
Photo interpretation and data prep	$0.900 - $ 1.10/ha	$485,500 – $593,300
Total Phase 1 Costs[1]		**$716,500 - $917,800**
VRI Phase II sample plan		$21,645
NVAF (100 trees)	$600/tree	$60,000

NVAF heli cost (15 polygons)	$2,100/polygon	$31,500
NVAF 10% QA audit (10 trees, 4 polys)[3]	$600/tree +heli costs	$9,000
Compilation and analysis		$3,000
Sub total		**$125,145**
Ground Samples - timber and ecology data collection - 60 clusters (option 1)	$2000/cluster	$120,000
Ground Samples - timber data only - 60 clusters (option 2)	$1500/cluster	$90,000
Ground Samples - heli cost (20 clusters)	$2,100/cluster	$42,000
Ground Samples QA Audit (7 clusters)[3]		$14,350
Compilation, analysis and adjustment		$20,000
Sub total		**$166,350 - $196,350**
Re-adjustment of young stand attributes (30 - 110 yrs; 118 clusters)		$9,000
Total Phase II Costs		**$300,495 – $330,495**
All VRI Projects		**$1,016,995 - $1,248,295**

[1] Target area is the entire landbase- 518,297 ha but it is assumed that ~ 550,00 ha will need photography to capture the entire landbase.

[2] Costs at the low end of the range are for 1:20,000 scale photos and costs at the high end of the range are for 1:15,000 scale photos.

[3] Cost assumes helicopter access for half the plots.

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