Vegetation Resources Inventory

Guidelines for Preparing a Project Implementation Plan for Ground Sampling and Net Volume Adjustment Factor Sampling

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Executive Summary

The Ministry of Forests and Range (MOFR) Forest Analysis and Inventory Branch (FAIB) has developed a business planning process to ensure the successful implementation of Vegetation Resources Inventory (VRI) projects. The process involves the preparation of VRI Strategic Inventory Plans (VSIPs) and Project Implementation Plans (VPIPs). This document provides guidance to stakeholders responsible for preparing the VPIP for the ground sampling and net volume adjustment factor (NVAF) projects.

The VPIP is a working document that details the specific operational activities associated with implementation and documentation of the inventory project. It identifies project specifics such as project areas, sampling priorities, sample populations, sample sizes, sample lists, scheduling, steps in the process, and roles and responsibilities of parties involved.

Prior to initiating a VRI project, the VPIP must be completed to the standards outlined in this document. The document will be reviewed and signed-off by the proponent and the MOFR to ensure the appropriate technical standards are being followed and that final products will meet the business needs of the stakeholders.

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1.0 Introduction

The Ministry of Forests and Range (MOFR) Forest Analysis and Inventory Branch (FAIB) has developed a business planning process to ensure the successful implementation of Vegetation Resources Inventory (VRI) projects. The process involves the development of VRI Strategic Inventory Plans (VSIPs) and Project Implementation Plans (VPIPs). This document provides guidelines that can be used to prepare a VPIP for the ground sampling projects and net volume adjustment factor (NVAF) projects. The intent is that these guidelines will assist proponents in developing a VPIP and streamline the administration of the VRI planning process. Examples of completed VPIPs are available on the FAIB web site.

2.0 VRI Planning

The VRI planning process involves developing VSIPs and VPIPs that identify resource-specific management issues, desired inventory products and activities, and priorities. A VSIP broadly outlines the VRI activities and products needed to address the identified forest management issues.

The VPIP identifies the needs for VRI management inventories and provides the details for implementation of the VRI in terms of project areas, sampling priorities, sample populations, sample sizes, sample lists, scheduling, steps in the process, and roles and responsibilities of parties involved. Forest industry proponents are responsible for developing VSIPs and VPIPs. The MOFR, if requested, will provide assistance in the plan development. The MOFR is responsible for developing minimum standards for the planning of VRI projects, data capture and audit. In addition, the MOFR reviews plans to ensure the information is being collected to current standards and to ensure that the business needs have been addressed. The VSIP and VPIP must be signed-off by the MOFR and the proponent.

3.0 Project Implementation Plan Guidelines

The following sections document and outline the guidelines for preparing a VPIP for ground sampling and NVAF projects.

3.1 Introduction and Background Information

Briefly describe the VRI process and how this document relates to the overall planning process. Describe the information needs (i.e. Timber Supply Review, habitat mapping), and how the planned ground sampling fulfills the information requirements. Describe any relevant past VRI activities (i.e. previous ground sampling) and how this will be factored into this planned ground sampling project. Identify stakeholders, including the MOFR.

3.1.1 Document Objectives

Describe the objectives of the VPIP document. Unlike the VSIP, this document will include implementation specific details for planned activities that are required for analysis purposes. This information is also valuable for tracking project progress.

3.1.2 Landbase / State of the Inventory

Describe the landbase in terms of geographic area, forest types, and administrative zones. Describe the state of the current inventory. Include information regarding the year of the photo interpreted inventory, the currency of the update, the year of the inventory audit and results, availability of data, etc. Include a map of the unit and summary tables.

3.2 Ground Sampling Plan

3.2.1 Sampling Objectives

Define the objectives of the ground-sampling and NVAF projects. Define the overall target sampling error to be achieved for both the ground sampling and NVAF projects.

3.2.2 Target Population

The definition of the target population is very important. The target population for the proposed inventory should be defined in terms of stand type, geographic locations, stand attributes, ownership, operability, etc. The rationale for excluding areas from the population should be thoroughly explained, including how the exclusion will affect the adjustment.

A table showing total population and strata areas must be included.

3.2.3 Sample Size

Set a sample size for ground sampling and the NVAF sampling. Include a description of how the sample size was set, including the target sampling error (SE%), the estimated coefficient of variation (CV), and the source. The recommended CV to use in determining sample size is the CV from the inventory audit sampling for the unit (1992-1998), increased by an additional 10%. The increase is to account for the different sampling methodology used in VRI. The following table provides sample size estimates for planning purposes, based on a SE of 10% and various CVs.

CV%	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Sample size (SE=10%)	16	25	36	49	65	82	101	122	145	170	198	227	258	291	327	364	403

Include a table showing the total area of the intended population, the strata areas, the number of samples per strata, and the number of hectares each sample is to represent. A footnote should also be included indicating that these numbers are subject to change following the completion of the ground sampling, and that the final analysis documentation will contain the actual areas and numbers of samples completed by strata. *See Appendix B for further information regarding the determination of sample size.*

3.2.4 Strata

3.2.4.1 Ground Sampling

The ground sampling target population is divided into strata. The basis for selection of strata will vary from unit to unit. The typical number of strata is 3-4 and has usually been based on species groupings. Other attributes such as age, location, BEC zone can also be used. The objective of the ground sampling should be taken into consideration when determining potential strata. The minimum number of samples in a stratum is 15. A request for a variance from the minimum sample size must be approved by the FAIB statistician.

3.2.4.2 NVAF

The strata for the NVAF must also be defined. The NVAF strata do not have to be the same as the ground sampling strata. The NVAF strata are typically based on species and/or age. Current MOFR guidelines for minimum NVAF sample size is 100 trees. The minimum strata size are 40 to 50 mature trees, 25 to 35 immature trees, and 25 dead trees but should be a function of variability (sample error, sample distribution) and importance of the strata. It is recommended this be discussed with the Forest Analysis and Inventory Branch Volume and Decay Sampling Officer.

3.2.5 Sample Selection

3.2.5.1 Ground Sampling

Describe the sample selection process. The MOFR document, Vegetation Resource Inventory Sample Selection Procedures for Ground Sampling, outlines the process in detail. The VPIP must include the reporting requirements outlined in the above document, including intended sample locations. It is important that the spatial and attribute files used for sample selection are well documented. This includes file versions, date they were received, source for the data, etc. A copy of the file must be maintained by the proponent and another copy must be forwarded to the MOFR with the VPIP. Details such as whether extra samples were selected and whether the samples selected allow for multi-year sampling must be included.

The criteria for excluding areas from or including areas in the target population must be documented. For example, if operability is one criterion for sample section, the procedure for handling polygons that have both operable and inoperable portions must be documented.

3.2.5.2 NVAF

The NVAF samples are a subset of the initial VRI sample selection. The 15-25 samples where NVAF will occur will be selected at this time as well. Enhanced sampling of the auxiliary plots will occur on these samples. The specific NVAF trees cannot be selected until the ground sampling on the selected NVAF samples has been completed and the data compiled. The plan must take this into consideration and indicate how and when the NVAF trees will be selected.

3.2.6 Sampling Approach

Describe the scheduling of the ground and NVAF sampling, such as:

- The total time-frame sampling will require to be completed
- Whether ground sampling will occur in the same year as NVAF sampling
- Whether ground sampling will occur over a number of years but NVAF sampling will take place after the first year, etc.

3.2.7 Sample Type

Describe the chosen sample type for the inventory. The sample type refers to how much information is collected on each sample. Details on the different types of samples can be found in the VRI Ground Sampling Procedures. Data collection is not restricted to these sample types, however it should be realized that extra data cannot be compiled with the standard VRI compiler. Any modifications to the sample type must be discussed with the MOFR.

3.3 Project Implementation

3.3.1 Scheduling

Outline in detail the activities and anticipated timing needed to implement the ground sampling and NVAF projects.

3.3.2 Sample Packages

Sample packages should be prepared for each sample and contain the necessary information for the field crews to successfully navigate to, and complete the sample. Details in the sample package include: intended UTM coordinates, maps, photos or orthophotos, number of auxiliary plots, sample type, auxiliary plots to be NVAF enhanced, access considerations, fixed radius or variable radius, etc. Example access maps can be found on the MOFR VRI website (http://www.for.gov.bc.ca/hts/vri/standards/index.html)

3.3.3 Standards

Identify the standards that will be used for all phases of the project. The most current version of standards in effect at the time of VPIP preparation should be referenced.

3.3.4 Roles and Responsibilities

Identify the main participants and their responsibilities, including who is responsible for deliverables.

Project Coordinator

Identify the main contact for the project and what they are responsible for. Indicate who is responsible for providing the following:

- field supplies such as aluminum stakes, tags, etc.;
- technical support for GPS, GIS work;
- sample package preparation.

Fieldwork

As the contractor(s) will probably not be known at the time of VPIP preparation, indicate whether the plan is for one contract for both ground sampling and NVAF, or two separate contracts.

Quality Assurance

Indicate who is expected to complete the quality assurance, timing during the contract, etc.

Data Compilation, Analysis and Adjustment

As the contractors will probably not be known at the time of VPIP preparation, indicate whether the plan is for one contract for all activities or if there will be separate contracts for each phase. The MOFR will run the data through the validation process to identify any errors before the samples are compiled. Indicate who will be completing each component listed below, and include timelines for each component:

- data compilation;
- statistical analysis; and
- inventory file adjustment.

3.3.5 Sample List

Include a complete sample list, and a comparison of the sample and population, as per the sample selection standards.

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

3.3.6 Deliverables

All deliverables for ground sampling projects must be provided to MOFR Regional VRI staff and must meet Ministry standards. Digital sample data, copies of QA reports, and any modifications to sample lists resulting from the dropping or addition of samples must be provided.

3.3.7 Costs

Provide cost estimates for all aspects of implementation of this plan, including project coordination, ground sampling, NVAF sampling, compilation and analysis and file adjustment.

3.3.8 Sign-off Sheet

Identify the proponent responsible for signing off of the plan. The VPIP will be signed off by both the Forest Analysis and Inventory Branch, Vegetation Resource Inventory manager and the proponent (see example next page).

XXX Timber Supply Area Vegetation Resources Inventory Phase II Ground Sampling Plan

It is the intention of the proponent to implement the XXX Timber Supply Area Vegetation Resources Inventory Phase II Ground Sampling Plan (VPIP) as described. As a key stakeholder in the inventory, Ministry of Forest and Range (MOFR) VRI staff has been consulted throughout the development of this plan.

Proponent Name date
Title,
Company
Location

I have reviewed the XXX Timber Supply Area Vegetation Resources Inventory Phase II Ground Sampling Plan. I will be advising Pricewaterhouse Coopers that the work proposed in this plan meets Vegetation Resources Inventory standards and MOFR business needs.

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

Appendix A: Glossary of Terms

Ground Sampling
Ground sampling is the field measurement of timber, ecology, range, and/or coarse woody debris values at one or more locations within each sample polygon. The sample polygons are selected proportional to their area from a sorted list. 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.

Inventory Unit
An inventory unit is the target population from which the samples are chosen. For management unit inventories, the unit is usually a TSA or TFL.

Land Cover Classification
The BC Land Cover Classification Scheme (BCLCCS) 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 BCLCCS is hierarchical and reflects the current state of the land cover (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.

Management Unit.
A management unit is an administrative area used for inventory reporting purposes. The most common inventory units are TFLs and TSAs. However, forest districts or provincial parks could also be considered as inventory units if they were identifies as areas of interest for reporting purposes.

Net Volume Adjustment Factor (NVAF) Sampling
NVAF sampling provides factors to adjust net tree volume from the ground sampling, where net tree volume is estimated from the VRI net factoring process and taper equations. The factors account for hidden decay and possible taper equation bias. Sampling involves detailed stem analysis of sample trees to calculate actual net volume. The actual net volume is compared to the estimated net volume. March 2004 13
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Photo Interpretation
Photo-interpretation involves the subjective delineation of polygons and the photo estimation of attributes for all polygons in an inventory unit. Medium scale aerial photographs are most often used in the photo-interpretation process.

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 may be applied to the corresponding population post-strata to improve the precision of the inventory's overall averages and totals. In the VRI, these strata (leading species) are usually pre-defined in the sample selection phase.

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
A set of sampling units selected randomly to represent a population.

Sample Size
The sample size for an inventory is the minimum number of ground samples to be established in an inventory unit to meet the target precision. The current sampling error requirements for a management unit is +/- 10% at the 95% level of probability.

Sampling Unit
The smallest indivisible unit in the population that is eligible for sample selection.

Statistical Adjustment
Statistical adjustment is the application of adjustment factors, computed from a random sample, to adjust timber attributes.

Sub-unit
A sub-unit is a small area or stratum of interest within an inventory unit such as a TSA or a TFL

Target Population
The population is the portion of a forest district, TFL, or TSA, for which statistical estimates are required. For instance, in a TSA where vegetated treed, vegetated non-treed, and non vegetated polygons are delineated, the target population may be only the vegetated treed (VT) polygons.

Target Sampling Error
Is the precision we expect a sample of a given sample size to produce. This precision depends on confidence we wish to place on a sample and the variability (CV) within the population.

Vegetation Resources Inventory (VRI)

The VRI is the MOFR standard 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:

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

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

Appendix B: Sampling Error Requirements for the British Columbia Vegetation Resources Inventory

Introduction

The VRI system in British Columbia is based on double sampling principles. Double sampling involves collecting inventory data by two methods. The first method, which is relatively inexpensive, is used to collect large quantities of data. The second method, which is more expensive per unit, is used to collect more accurate data on a small, unbiased sample data set.

In the VRI system, the first method of data collection is photo interpretation from medium scale photography. Estimates of attributes of interest are obtained from delineated polygons identifying the features within the polygons.

The second data collection method is ground data measurement. This information has higher resolution, and can be considered to represent reality of the attributes in the population. The vastness of the areas involved in forest inventory, make it uneconomical to visit each polygon identified on the photos, and measure all individual objects in the population. Statistical principles show that valuable information can be obtained from a few sample objects at random locations, and that this information can be extrapolated to estimate population values of the attributes.

The use of random selection of objects and locations is critical to obtaining unbiased information from the double sampling process.

What is the Benefit of Double Sampling?

The accuracy of the information collected by the two methods (photo interpretation and ground sampling) is not the same. The photo interpretation is at lower resolution, therefore, it tends to be inaccurate (or can be biased). The ground data is random and is collected at a higher resolution therefore it is more accurate (and is considered to be unbiased).

We can use the ground sample data without any additional information to assess the risk and uncertainty of the inventory. However, this approach is not efficient. Extrapolation of this information to the population would be limited to making statements about population totals (or averages) of attributes of interest. The estimates of sampling error in this approach are usually higher, and extrapolation to individual polygons is not possible.

Double sampling takes advantage of the two data situations to produce more concise inventory information. In particular, the use of the ratio estimation methodology reduces the magnitude of sampling error thus reduces the number of random locations we may need to visit in order to generate reliable statistics of reality on the ground.

Sampling error is used to define the lower and upper bounds of totals (or means) of attributes of interest. For example if we have an inventory unit that after ground sampling has an estimated net volume of 1,000,000m³ and has a computed sampling error of 10% at the 95% level of probability, the lower limit of net volume would be 900,000m³ and the upper limit would be 1,100,000m³. The 1,000,000 m³ total is a statistical estimate. The actual (true) total volume we would get if we were to measure every tree in the unit is not known. The sampling error allows us to say, we are 95% sure that the actual total falls between 900,000m³ and 1,100,000m³.

Lower limit @10% SE Estimated Net Volume Upper Limit@10% SE

900,000m³ <----------1,000,000m³----------> 1,100,000m³

(Actual inventory unit net volume will fall within these limits 95% of the time)

Given the importance of sampling error in assessing the risk and uncertainty of volume estimates in an inventory, it is essential to specify concisely what sampling error values would be acceptable for any ground sampling project. Recommendations for sampling error targets are provided in Table 1 below.

Table 1. VRI, and NVAF sampling error targets and tolerances.

Project type	Unit level	Sampling error required	Level of probability	Remedial measures if SE limit is exceeded
VRI	TSA/TFL	10%	95%	Collect addition sample data
NVAF	TSA/TFL	10%	95%	Obtain more NVAF trees
NVAF	stratum	15%	95%	Pool tree strata or obtain more tree data

Note that minimum stratum sample size for VRI samples is 15, and that an acceptable sampling error for each stratum must be determined by the stakeholders, including the FAIB statistician.

How should the sampling errors be used?

In decision-making processes where population of strata volume totals or averages are used, the sampling errors computed for the totals (or averages) should be used to define the range of possible outcomes in scenario analysis.

For instance, in the example provided earlier, the actual (true) total volume on the ground might actually be as low as 900,000m³. If that was the case, what would be the best course of action, in order to meet economic and social obligations. The actual (or true) total volume could also be as high as 1,100,000m³. If that was the case, how would decisions be modified? The sampling errors should be used to discuss option both at the population and the strata levels. This is particularly important when a stratum is identified for partition cut decisions.

How do sampling error specifications affect inventory planning?

The lower the sample error required means the higher the number of samples that are required to meet the target. This is illustrated in Table 2 below.

Table 2. An illustration of the relationship between sampling error and sample size.

Assumptions:

1. Coefficient of variation (CV) = 60%
2. Probability level = 95% (t-value ≈2.0)
3. Sample size equation: $\left(n = \frac{t^2 CV^2}{E^2} \right)$