QUESNEL TIMBER SUPPLY AREA
VEGETATION RESOURCES INVENTORY &
CHANGE MONITORING INVENTORY
GROUND SAMPLING:
SAMPLE PLAN

Prepared for:

Quesnel TSA Mitigation Committee

Prepared by:

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Vancouver, BC

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TABLE OF CONTENTS

Timberline Natural Resource Group

List of Figures

List of Tables

1.0 INTRODUCTION

1.1 Background

The mountain pine beetle (MPB) began attacking the Quesnel Timber Supply Area (TSA) forests in 2001. Since then, the outbreak reached an epidemic, significantly altering the forest ecosystems within the TSA. The outbreak is subsiding and the impacted lodgepole pine (Pl) stands that remain are in a state of decay. The focus of the forest sector has been to salvage the dead Pl stands before they become uneconomic to harvest. The salvage window is closing and the focus will soon shift to harvesting non-Pl.

The Ministry of Forests and Range (MFR), Forest Analysis and Inventory Branch (FAIB) is leading Timber Supply Review (TSR4), with an expected allowable annual cut (AAC) Determination due in 2010. TSR5 is no more than five years away, and the AAC is expected to be significantly reduced.

The licensees and MFR are investing to improve inventory information to support TSR5. These initiatives include, but are not limited to:

- Developing a Predictive Ecosystem Map to better describe forest ecosystems in the TSA;
- Completing a Site Index Adjustment project to ensure that more realistic forest productivity estimates are used to grow stands in the forest estate model; and
- Completing an Economic Operability Assessment to define the economically operable timber within the TSA.

Approximately 70 percent of the TSA is covered by stands leading in Pl, much of which is now dead and decaying. The inventory labels used to describe these stands are no longer reliable and this erodes the confidence in timber supply forecasting. To improve the forest inventory information, the FAIB created a pilot program to assess ways in which the Vegetation Resources Inventory (VRI) can better describe the forests affected by MPB. A series of initiatives have been completed as part of this pilot program. Notably:

- An image based re-inventory test was completed on 10 mapsheets whose polygons were predominantly leading in Pl. The polygons were difficult to describe mostly because the imagery was poor and the generally grey colour of dead Pl stands. This program was completed in 2007.
- A VRI Phase I program was completed on 83 mapsheets in the east portion of the TSA on mapsheets that were predominantly mature green (ie, non-Pl leading). This program was completed in December 2009.

The next step is to design a field program that supports the key inventory information needs for TSR5.

1.2 Terms of Reference

This sample plan was completed for the Quesnel TSA licensees and the MFR, FAIB by Eleanor McWilliams, MSc, RPF (technical support), Hugh Carter, MSc, RFT (technical support) and Hamish Robertson, RPF (project manager) of Timberline Natural Resource Group Ltd. Gary

Johansen, RPF, Gordon Nienaber, RPF, Sam Otukol, PhD RPF of FAIB and Matt Makar, RPF of FAIB worked directly with Timberline staff to develop the methods contained in the sample plan.

1.3 Goals and Objectives

The primary goal of the overall program is to provide a level of comfort (reduced risk for decision makers) on the actual volumes and health of stands on the Quesnel TSA. The objective of this program was to:

1. Determine the key inventory business needs for the TSA to support TSR5;
2. Develop flexible sample designs for each of the strata;
3. Describe the proposed field program for post-harvest and regenerated (PHR) stands;
4. Describe the proposed field program for stands that underwent VRI Phase 1 in 2009 (generally described as mature green stands);
5. Identify potential inventory options for the area not included in the 2009 VRI Phase 1 program (generally described as dead-Pl); and
6. Document the proposed implementation program.

2.0 BUSINESS NEEDS ASSESSMENT

2.1 Business Needs Consultation

The key stakeholders identified in this initiative are:

- The Quesnel TSA licensees; and
- MFR (FAIB and Southern Interior Forest Region).

The licensee representatives were Earl Spielman, RPF (West Fraser Mills Ltd.)[1] and Phil Winkle, RPF (DecisionTree Forestry on behalf of C&C Timber). A preliminary list of inventory business needs was developed in February 2009 for natural and post-harvest and regenerated (PHR) stands within the Quesnel TSA.

Timberline staff met with MFR representatives in June 2009 to review and update the inventory business needs for the TSA. MFR representatives included Albert Nussbaum RPF, Gary Johansen RPF, Gordon Nienaber RPF, Jon Vivian RPF, Atmo Prasad RPF, Matt Makar, RPF, Chris Mulvihill RPF, and John Wakelin RPF. At this point, it was determined that Timberline would work directly with Gordon Nienaber and Matt Makar in designing the Quesnel program.

2.2 Primary Business Needs

The business needs focused on developing improved inventory information for TSR5. For planning purposes the landbase was divided into three key strata: mature green leading, dead-Pl leading, and PHR stands. The business needs identified are:

1. Determine the area, distribution and merchantable volume in mature green leading stands. The mature green component is generally regarded as the key strata in the short- and mid-term timber supply forecast.
    a. Complete the VRI Phase I on the mature green leading stands to current standards (completed December 2009).
    b. Assess the accuracy of the inventory estimates using VRI timber emphasis plots to complete an inventory audit style approach.
2. Update the inventory attribute information for MPB attacked stands to better reflect their current condition. A key decision for TSR5 will be how stands attacked by MPB are described and modelled in the yield curves. For those stands that will not be harvested, information about Pl mortality rates and the size, health, vigour and distribution of remaining live stems will be key components to creating yield curves for these stands. In particular:
    a. Identify the percentage of Pl that survived the attack.
    b. Identify year of death for MPB killed stands.

[1] West Fraser initiated a CMI program on TFL 52 in 2001 and has completed two measurements (2001-2003 and 2006 -2008) on 82 plots since then.

   c. Develop shelf-life projections for dead Pl.

   d. Project the non-Pl portion of the stands forward to the projection date for TSR 5.

   e. Develop projections of regeneration in non-salvaged MPB attacked stands.

3. Determine the actual growth of PHR stands to ensure that they are growing as projected in TSR.

   a. Determine MPB loss in Pl-leading PHR stands. Previous analyses assumed all stands less than 60 years old were not attacked.[2]

   b. Monitor the growth and yield of all PHR and naturally regenerating stands.

4. The sampling program should incorporate both Provincial (i.e., BC-National Forest Inventory [NFI]) and management unit information needs to best utilize inventory program investment.

[2] This is known to be incorrect. This information needs to be updated (the 2006 Type 2 Silviculture Strategy assumed 80% of managed Pl stands would incur a 30% volume loss).

3.0 SAMPLE DESIGNS

3.1 Overview

The program to address the identified business needs is described in the following three sections. Each section describes details of the sampling program proposed for that stratum. The three key strata are:

- PHR stands – all PHR stands between 15-47 years in the Forest Management Landbase (FMLB). This is the stratum where a Change Monitoring Inventory (CMI) program will be implemented using an intensification of the NFI grid.
- Mature green stands – these stands are largely those that are 48 years and greater and are not leading in Pl. The VRI Phase I program was implemented on 83 mapsheets, within which this stratum all resides. A VRI Phase II plot program will be implemented in this stratum to quantify the risk associated with the new Phase I inventory attributes. These plots are established so that they can be re-measured in future, if necessary.
- Dead-Pl - All Pl leading stands greater than 47 years in the vegetated-treed landbase that were delineated to Phase I standards (83 mapsheets), as well those mapsheets that did not have a VRI Phase I completed. A low intensity monitoring program is proposed for this population.

3.2 Data Assumptions

The sampling programs developed used the following principles and assumptions:

1. The inventory data used to derive the PHR program was downloaded from the LRDW March 10, 2009 and updated with harvest information.[3]
2. The December 2009 VRI Phase I data was used to derive the Mature Green program. This data was not validated by MFR but was acceptable to expedite the sample selection process.[4]
3. The NFI 20 km grid was chosen as the platform so that a subset of any grid size chosen will be NFI 20 km grid points. Where appropriate, BC-NFI plots should be installed across the entire TSA to support FAIB reporting needs.[5]

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[3] Gordon Nienaber, RPF, TSR4 timber supply analyst provided the harvest information and landbase definition on August 9, 2009.

[4] Use of this dataset was discussed with and approved by Gary Johansen in February 2010.

[5] Forest Analysis and Inventory Branch will provide the additional funding to complete plots to full BC-NFI standards.

4.0 PHR STAND SAMPLE DESIGN

4.1 Overview

The CMI sample design provides a set of representative sample points from a 5-km grid across PHR stands on the Quesnel TSA. The grid size was chosen to generate 50–100 points in PHR stands between 15 and 47 years of age in the first measurement period. This design will provide data to compare G&Y for all PHR stands in aggregate[6] and for Pl-leading stands (the most predominant). The sample size is not large enough to separately check G&Y estimates for stands with other leading species. The sample plots are 400-m^2 fixed-area permanent sample plots (PSPs). The measurements will follow NFI-BC standards and procedures[7] with some minor variances (Section 4.8). The intent is to remeasure the plots every five years, however, this and other elements of the CMI can be changed over time as necessary.

4.2 Objectives

The primary objectives of the CMI program are to:

1. Monitor the change in merchantable volume over time and compare this to predicted values used in timber supply analysis;
2. Check absolute values and stability of site index estimates over time and compare these to the values assumed in timber supply analysis;
3. Compare CMI plot data against selected inventory attributes and timber supply assumptions to detect relevant differences; and
4. Monitor and report on any forest health issues.

The secondary objectives of the CMI program are to:

1. Support certification requirements;
2. Provide information to the Provincial Government climate change reporting initiative;
3. Provide data to check that accurate inputs are being used in forest carbon projections; and
4. Use a flexible design that can be modified for future potential information needs.

4.3 Target Population

For the purposes of defining the PHR target population, stands were categorized into four species classes: Pl-leading, Conifer (non-Pl) -leading, Deciduous-leading and Unknown (no data) based on the greatest percent composition in the species label. Thus, a stand was Pl-leading if it was

[6] The question being asked is: over the entire TSA, are PHR stands on average growing as expected?

[7] BC Ministry of Sustainable Resource Management March 2005. National Forest Inventory – British Columbia. Change Monitoring procedures for provincial and national reporting. Version 1.4. 208pp. + appendices. (http://ilmbwww.gov.bc.ca/risc/pubs/teveg/nficmp05/nfi_cmp_2k5.pdf)

34% Pl, 33% Conifer, and 33% Deciduous. Stands were categorized into four age classes: Regen (0-14 years), PHR (15-47 years), Mature (48 years +), and Unknown (no data).[8]

The target population was defined using the Forest Managed Landbase (FMLB) with ages projected to 2009. The target population is all PHR stands between 15 and 47 years of age (since disturbance) in the FMLB. This age range is used to limit sampling to stands that have merchantable volume (thus the minimum of 15 years) and that are of post-harvest origin (thus the upper limit of 47 years). The target population can expand over time as new stands grow into the population definition, though the target population definition may change in future as business needs change.

4.4 Sample Location

A 5-km grid will be used to locate CMI plots over the target population. Plots will be systematically located in part because they cover practically as many conditions as random plots and are convenient since plot locations are automatically known once the grid size is defined.

4.5 Sample Size

The 5-km grid provides 61 plots in PHR stands as of 2009 and up to 132 PHR plots after 15 years (Table 1) (Appendix II).[9,10] The sample size is determined by the grid spacing and the area targeted for sampling in the target population area. The two main criteria influencing the choice of grid size is the sample size that will be achieved in the target area today, and how this sample size will increase over time as the target area expands (i.e., as natural stands are harvested, regenerated, and included in the PHR target population).

Table 1. Summary of 5 km grid points by leading species and age class.

	Age Class		
Leading Species	PHR (15-47)	Regen (0-15)	*Total*
Conifer	15	8	*24*
Deciduous	5	2	*7*
Pl	41	45	*87*
Unknown	0	15	*15*
Total	*61*	*70*	*132*

[8] The inventory data used was downloaded from the LRDW website March 10, 2009 and was updated with harvest information provided by Gordon Nienaber August 9, 2009. The FMLB definition along with ages projected to 2009 were used to define the target populations and is assumed to be the best available information. Any errors in this data will translate to errors in the summaries presented.

[9] One point already has a BC-NFI plot leaving 60 plots to be established.

[10] Prior to the second measurement the business needs and sample design will be reassessed and updated in a sample plan that will be submitted to MFR for review and approval.

4.6 Plot Design

The plot design follows the NFI-BC protocol for tree attributes (Figure 1). The main plot is 400 m^2 (11.28 m radius) where all trees greater than 9.0 cm are measured and tagged. Trees between 4 and 9 cm are measured and tagged in the small tree plot (100 m^2, 5.64 m radius), and all trees less than 4 cm dbh and greater than 30 cm tall are counted in the regeneration plot (19.6 m^2, 2.50 m radius). Some modifications to the standards have also been implemented (listed below).

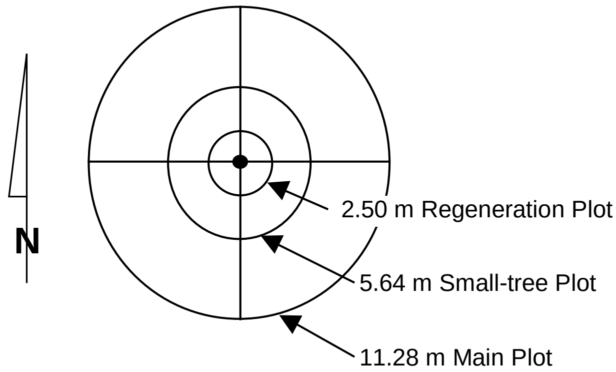

Figure 1. CMI sample plot.

4.7 Remeasurement Period

We recommend a five-year re-measurement period, or as appropriate for the information needs of the Quesnel TSA. A 10-year re-measurement period has a high risk of plots being damaged and data lost.

4.8 Plot Measurements

4.8.1 Overview

The NFI-BC plot protocol will be used. Information that will not be collected includes:

1. Ecological data plots (10 m radius). However, a visual estimate of the biogeoclimatic site series will be recorded on the Ecology Header (EH) card.
2. Forage production micro plots.
3. Soils data.
4. Old growth data.

Protocols that will be modified include those for tag placement, coarse woody debris (CWD), photos and site tree selection as described below.

4.8.2 Plot Establishment

Navigation to the plot and establishment methods will follow the NFI-BC standards and procedures.

4.8.3 Tree Tags

Blue tree tags will be affixed at breast rather than at stump height as recommended in the protocol. This should simplify the work without making the plot unduly visible.

4.8.4 Plot Cards

The MFR VRI plot cards will be used for the CMI sample (as they are used for the NFI-BC). Some modification of the VRI cards is needed to accommodate information that is not taken in VRI (e.g., information on more site trees, quadrant of main plot, etc.).

4.8.5 Top Height Tree

The height and age of the largest diameter tree (regardless of species) in the NE quadrant will be measured and recorded as per the standard. This tree is the top height tree as identified in the standards and will be recorded as the "T" tree.

4.8.6 Site Trees

The height and age of the largest diameter tree of each species in each quadrant will be measured. These trees will be coded temporarily as "O" trees and will be recorded as required if they do or do not have suitable height and age measurements. The leading and second species will be determined and the site trees for the species will be changed from "O" to "L" and "S" trees prior to data entry into TIMVEG. "O" trees in TIMVEG are only "other species" (not "L" or "S" species) that are more than 20% of the plot basal area.

If the largest diameter tree of a given species is not a suitable site tree, the next largest diameter tree will be assessed for both suitable height and age. If acceptable for estimating site index, height and age will be recorded and this tree noted as "X" tree. If the second largest diameter tree is not acceptable, no further measurements will be taken. "V" trees are a representative residual tree from the 11.28m plot if present. "T" trees will be the top height from the 5.64 fixed radius plot. This procedure produces more height and age measurements and also ensures that all data required under the standard is collected. Using this approach, only "X" trees can be step-down trees.

If a site tree is between 4 and 9 cm and in the 11.28 m radius plot, but outside the 5.64 plot it will be tagged.[11]

4.8.7 Coarse Woody Debris

CWD transects will be done to NFI-BC standards, with one exception. On the last 10 m only pieces 7.6 cm and larger will be measured. So the procedure will be modified slightly from section 8.1 in the NFI-BC manual (modifications **highlighted**):

1. Establish the first line at a pre-assigned random azimuth from the IPC.
2. Measure out along the random azimuth with a tape to 30.0 m, correcting the distance to horizontal.
3. **Mark both ends of the transect with pins**.
4. Mark along the line with logging paint the intersection of the line transect with potential small and coarse woody debris.

[11] Trees between 4 and 9 cm diameter are not normally tagged in the outer "donut" of the 11.28 m plot.

5. Number a few of the large CWD with log marking paint to aid re-measurement and quality control.
6. Establish the second line at plus 90° from the first transect commencing at the IPC.
7. Record the azimuth of each line on the Coarse Woody Debris (EW) and (EC) Field Cards.
8. Measure the following pieces of coarse and small woody debris along the transect:
    a. From the IPC to 10.0 metres measure all CWD greater than 30.0 cm.
    b. **From 10.0 metre to 30.0 metres measure all CWD equal to or greater than 7.6 cm.**

4.8.8 Photos

If possible, crews should take at least one generic plot photo and one that shows the area around the IPC to help future re-location if necessary.

4.9 Data Management

Data entry, error checking and management will use the same processes used for the NFI-BC plots.

4.10 Analysis & Interpretation

The overall goal of the CMI analysis is to determine whether any significant differences exist between the attributes measured in the field and those modelled in timber supply (i.e. "are the timber supply analysis assumptions reasonable?"). The CMI analysis results serve as an early warning system should the modelled assumptions not be achieved on the ground.

Point in time estimates of site index and merchantable volume will be provided after the first measurement. These estimates can be compared to the values assigned to the forested polygons where the plots land. Change can be estimated when two or more measurements are completed and differences between the measured and predicted attributes of interest can be estimated. Graphical analysis will include plotting actual versus predicted values and plotting differences (actual-predicted) versus stand age or any other chosen variables to examine trends. The statistical analysis will include the average differences and associated confidence intervals.[12]

The graphical and statistical analysis methods are intended as tools to examine the data for possible overall trends of over- or under-prediction – these analyses are not meant as definitive tests. If the analyses suggest over- or under-prediction, then possible sources of the differences should be identified. For example, when considering volume estimates, potential factors to consider as sources of mean error are the differences between the inventory inputs to the model and the actual stand attributes. Potential inventory attributes to examine include stocking, site index, treatment, species composition, stand structure, and pest or disease incidence.

[12] The specific features to be analyzed will be discussed with MFR prior to analysis.

When using models for prediction there are two main sources of error. The first is errors within the model; the model produces inaccurate results despite being supplied with accurate inputs. When developing models, the modelers use model validation techniques to minimize these errors. Model validation often uses data from plots purposely located across a range of conditions (response surface) to ensure the model is performing correctly. The second is model application error. Model application error can result from incorrect inputs being supplied to the model or model results being extrapolated to situations the model has not been calibrated for. If, for example, the monitoring data detects significant differences between the merchantable volumes predicted for a specific stand type and that observed on the ground, the differences could be due to model errors, or model application errors. The intent of the analysis is to “raise a red flag” that something is wrong. Given the limited sample sizes, and the inability of the sampling design to definitively determine cause and effect, the ultimate cause of the problem may not always be discernable from the monitoring data. However, previous experience in analyzing CMI data has demonstrated that when significant prediction errors are present it is due to incorrect inputs such as species, stand initialization planting versus natural), and potentially OAFs not correctly reflecting insect and disease damage.

4.11 Future Modifications

Prior to the second measurement, the business needs and sample design will be revisited. Any changes will be updated in the sample plan and submitted to MFR for approval. Future modifications to the CMI program could include:

1) **Managing sample size**

The CMI target population will increase as more natural stands are harvested, regenerated, and brought to the minimum age of 15 years from disturbance. Though the target population will grow, the future sample size can be increased or decreased based on the business needs at that time.

2) **Increasing measurement period**

The five-year measurement period has traditionally been recommended because it corresponds with the TSR schedule and there is limited risk that plots will be damaged or data lost. However, this recommended time interval could change if the there is a higher level of comfort in PHR yield estimates, or if program costs need to be decreased. The advantage of an increased measurement period is lower costs, however, the disadvantage is that less information can be obtained from the data, and linking previous measurements will be more complicated.

3) **Expanding the CMI program to naturally regenerated stands**

Currently this proposed program focuses on post-harvest stands. Given the MPB attack there will be naturally regenerating stands on the TSA that should be observed. Whether or not these stands are sampled in the future under this program or under the umbrella of sampling the mature Pl is largely an issue of semantics.

4) **Expanding the program into older stand types**

The need to monitor carbon stocks on a management unit is emerging as a business need. The CMI program design is perfectly suited to provide statistically valid estimates of carbon stocks across a management unit. In these instances, a plot program is expanded outside the traditional CMI target population, but likely with a far reduced sampling intensity.

5) **Adding other information**

New tree measurements can be added to the CMI program at any time in the future. For example, measurements of branch size, tree taper, or wood quality could be included in the next measurement cycle. This would provide the same representative sample, but change estimates could not be computed until two or more measurements of the same attribute were taken.

5.0 MATURE GREEN SAMPLE DESIGN

5.1 Overview

The mature green stratum will provide the majority of short- and mid-term timber supply in TSR5, and is the most important strata. Therefore, it is vital that the inventory estimates describing stands in the mature green be reliable. A moderate degree of uncertainty in the inventory attributes can create a high degree of uncertainty in the timber supply forecast.

A new VRI Phase I was completed in December 2009. The business need is to determine the area, distribution, and merchantable volume in mature green leading stands and to obtain a precise ground based estimate of the volume in these stand types.

5.2 Objectives

The objective of the mature green sampling program is to assess the accuracy of the inventory using VRI timber emphasis plots.

5.3 Landbase Netdown

The 83 mapsheets recently completed as part of the VRI Phase I program represented approximately 707,000 ha (Table 2). The majority of the land base is between 100 – 250 years of age. Table 3 shows the species and age distribution within the TSA as represented by the portion of the target population as defined in Section 5.4.

Table 2. Quesnel VRI Phase I target population net down

Land Classification	**Area**	**% of TSA**
TSA (83 mapsheets)	***706,748***	***100.0***
TFLs (52 and 53)	78	0.0
Indian Reserves	2,727	0.4
Parks	2,112	3
Woodlots and Community Forests	44,607	6.3
Maps in West of TSA (16)	166,992	23.6
Area of Interest (67mapsheets)	***490,231***	***69.4***
Pl Leading	72,988	10.3
Stands < 48 years (in 2009)	149,270	21.1
Non Vegetated Treed	15,957	2.3
Target Population	***252,017***	***35.7***

Table 3. Species distribution by MFR age class as % of target.

	Age Class							
Species	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
S	0.8	1.2	2.8	4.5	7.4	15.2	1.7	33.5
Fd	1.5	2.8	4.8	6.2	8.4	5.7	0.3	29.7
Bl	0.1	0.3	0.4	0.9	1.2	11.9	0.4	15.2
At	0.8	1.9	4.0	5.2	1.9	0.2	0.0	13.9
Ep	0.3	0.7	1.8	1.6	0.5	0.0	0.0	4.9
Cw	0.0	0.0	0.0	0.0	0.0	0.6	0.6	1.2
Act	0.1	0.0	0.1	0.3	0.3	0.2	0.0	1.0
Sb	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.3
Hw	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.3
Total	***3.6***	***6.9***	***13.9***	***18.8***	***19.9***	***33.9***	***3.0***	***100.0***

5.4 Target Population

The mature green stratum target population was defined as those polygons in the 67 mapsheets of interest where:

- Pl was not the leading species,
- Stands were 48 years[13] or older in 2009
- Polygons were vegetated-treed as defined by the BC land classification system (Table 4, Figure 2).

Table 4. Quesnel TSA mature green target population.

Land Classification	Area	% of TSA
Area of Interest (67 mapsheets)	***490,231***	***69.4***
Pl Leading	72,988	10.3
Stands < 48 years (in 2009)	149,270	21.1
Non Vegetated Treed	15,957	2.3
Target Population	***252,017***	***35.7***

The target population represents approximately 252,000 ha (or 36% of the area where the Phase I was completed [83 mapsheets]).

5.5 Stratification

Stratification of the target population improves the sampling efficiency by grouping similar sub-populations that might exist within a general population. Strata were created based on similarity of sub-populations while considering the number of samples being established. Using these criteria, the target population was stratified based on age (Table 5). The strata were defined as follows:

Table 5. Quesnel TSA mature green stratification.

Stratum	Sub - Stratum	Area (ha)	%	
			Target	Stratum
Young (48-120 yrs)	S & Bl	27,677	11%	25%
	Fd	38,404	15%	35%
	Other	42,773	17%	39%
	Total	108,854	43%	100%
Old (121 yrs+)	S & Bl	95,249	38%	67%
	Fd	36,335	14%	25%
	Other	11,579	5%	8%
	Total	143,163	57%	100%
Total		***250,017***	***100%***	

1. Young – Those stands in the target population between 48 and 120 years in 2009.
2. Old – Those stands in the target population greater than 120 years of age in 2009.

Final analysis results will be reported at the stratum level, and the strata may change based on the data and the variability observed during the analysis.[14] The strata were subdivided into sub-strata to ensure a representative distribution of samples within each stratum. The sub-strata were based on species group using the species that were most abundant and/or most important for future timber supply in the area. Sub-stratification is critical for spatial distribution of plots.

[13] The CMI target population included stands 15 - 47 years in 2009. The VRI and CMI target populations do not overlap.

[14] Upon examination of the final data, some post stratification may be necessary. Decisions regarding appropriate analysis scenarios will be discussed with MFR and TSA stakeholders.

Analyses will use the substrata level information for variance and means calculation and be rolled up, using the appropriate weights, for reporting at the stratum level. The results will be applied at the stratum level as these sampling groups have sample sizes that allow for the most meaningful results.

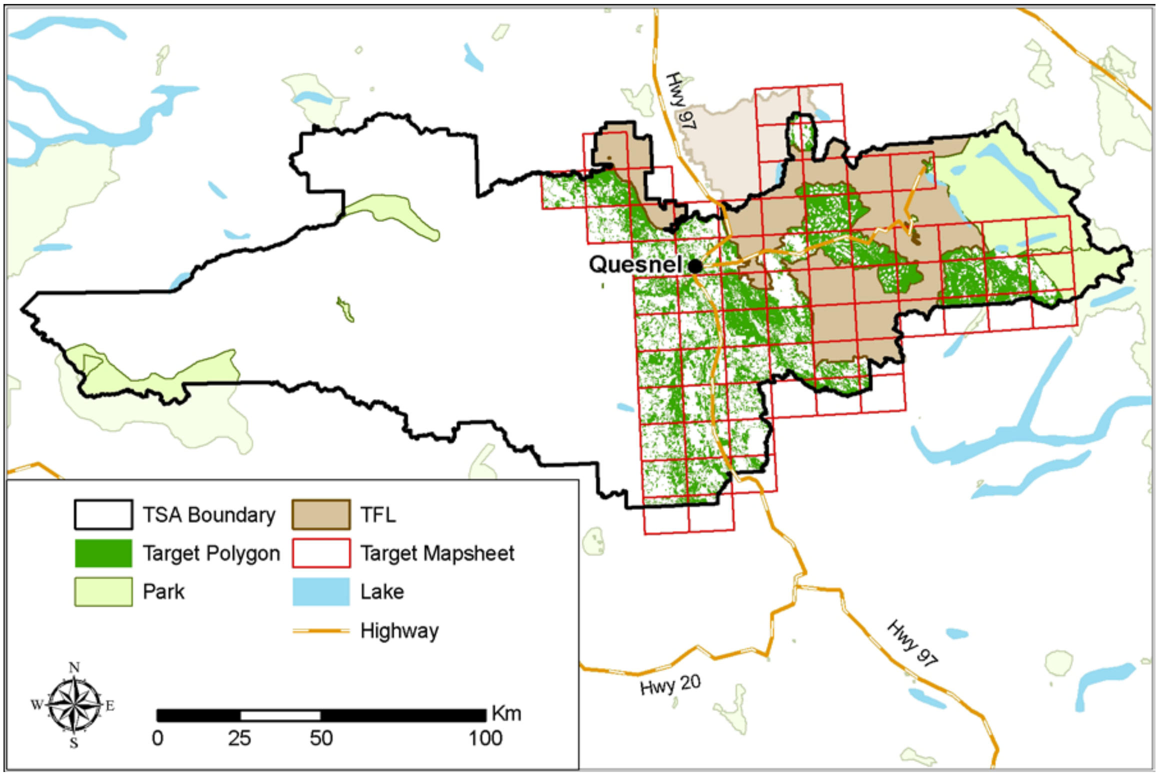

Figure 2. Quesnel TSA mature green target population distribution.

5.6 Phase II Program

5.6.1 Sampling Objectives

The primary objective is to install 50 samples in the target population to determine whether a sufficient level of comfort exists to use the Phase I in TSR5.

Sampling will follow a two-pass approach, whereby the first batch of 50 samples will be installed and an interim analysis will be completed. If the results appear reasonable, no further sampling is required.[15]

If significant differences exist between the Phase I and Phase II plot estimates, a second pass will occur and additional samples will be installed in the target population. If, after the second batch is installed, there are still significant differences between the Phase I attributes and Phase II ground

[15] The MFR and lead proponent will determine whether additional samples are required.

plot data, a decision will be made in conjunction with MFR to accept the differences, or statistically adjust the Phase I attributes with the Phase II ground sample data.

5.6.2 Sample Selection

Sample polygons were selected using probability proportional to size with replacement (PPSWR). Each polygon in the target population was listed once and size was total area of the polygon. The sample points within the sample polygons were selected from the provincial 100m grid in the Geographic Information System (GIS) using the simple random sampling (SRS) method. Appendix III lists the 50 samples with their locations and label for NVAF enhancement.

5.6.3 Sample Size

Fifty (50) samples were selected from the target population and will be installed in the two strata. The sample distribution is approximately equal to the area distribution of the strata. Twenty (20) samples will be established in the Young stratum and 30 samples will be established in the Old stratum (Table 6).

Table 6. Quesnel TSA mature green sample size by stratum

Stratum	Sub - Stratum	Area (ha)	No. Plots	Sampling Weight (ha)
Young (48-120 yrs)	S & Bl	27,677	5	5535
	Fd	38,404	7	5486
	Other	42,773	8	5347
	Sub-Total	***108,854***	***20***	***5443***
Old (120 yrs+)	S & Bl	95,249	20	4762
	Fd	36,335	8	4542
	Other	11,579	2	5790
	Sub-Total	***143,163***	***30***	***4772***
	Total	***250,017***	***50***	***5,000***

The sample and target population were compared by all variables potentially adjusted for, and used in VDYP7 including: height class, age class, basal area class, density class, Lorey height class, and volume class (Appendix IV).

The distribution of the sample best represents the age class, volume class, Lorey height class, and stems per hectare class distributions of the target population. The sample does represent the height class distribution; however the 20m and 35m classes are slightly over-represented and the 15m class is slightly under-represented. The sample also represents basal area distribution within the target population; however the 10m^2/ha will have a high intensity of plots and the 40m^2/ha class will have a low intensity of plots.[16]

[16] While it is ideal that a sample represents the distribution of all variables of interest, it should be expected that some classes in some variables would have slight skewing of distribution when drawing a random sample of a small size. The sample distributions for height class and basal area class pose a small risk to the outcome of the overall Phase II program and the sample does represent the target population well for four of six variables of interest.

5.7 Net Volume Adjustment Factor Sampling

One VRI plot for every three trees destructively sampled will be enhanced to provide information for developing the NVAF tree matrix. Typically the NVAF target sampling error for live tree volume was ±7.5% (95% confidence), however the intent of this program is simply to provide a level of comfort and not attempt to achieve a target sampling error.

Table 7. NVAF maturity and weights.

Maturity	Area (ha)	Plots	Plot weight (ha/plot)
Immature	108,854	5	21,771
Mature	143,163	8	17,895
Total	***250,017***	***13***	***19,232***

Thirteen (13) VRI Phase II plots (5 immature and 8 mature)[17] (Table 7) were selected to be NVAF-enhanced (one plot for every three trees being destructively sampled). The VRI Phase II plots were sorted by NVAF stratum and sub-stratum and plots were selected using a systematic sampling design with a random start. Net-factoring and call-grading will be completed on all auxiliary plots for the NVAF-enhanced plots.

The NVAF sample size and species distribution will be finalized following review of the Phase II field data. All trees will be selected following the MFR standards at the time of selection.

5.8 Field Implementation

5.8.1 Sample Packages

Field sample packages include at a minimum:

1. An ortho-photo (1:5,000) showing plot location and its GPS points;
2. An ortho-photo (1:10,000) showing plot location and access;
3. A forest cover map (1:10,000) showing target polygon and plot locations with roads, contours and water features.
4. Overview map (approx 1:100,000) for general polygon location.

5.8.2 Field Crews

A project pre-work meeting will be held on the first day and sampling should begin immediately thereafter. All plots will be installed at the random locations selected by the GIS. If a plot location is unsafe or is no longer part of the target population (due to harvesting or fire), the project manager will work with the MFR representatives to locate an alternate location. If an alternate location cannot be found, the plot will be dropped as per ground sampling procedures at the time of contract signing.

[17] Stands 48 to 120 years in 2009 were considered immature. Stands 121+ years were considered mature.

5.8.3 VRI Measurements

The project priority is to measure timber attributes and CWD at each plot. Data will be collected to provincial VRI ground sampling standards at the time of contract signing. Additional attributes beyond VRI requirements will be measured. Certified crews will gather the data using VRI Card Types 1, 2, 3, 6, 7, 8, 9, 10, and 11.

5.8.4 Non-Standard VRI Data

Additional, non-standard VRI data will be collected to supplement the information normally provided by the VRI Phase II sampling. Collection of this data will allow the plots to be re-measured over time, should this re-measurement become an inventory priority. Additional measurements will include:

1. Measure the distance from the sample point to the tree in the auxiliary plots.
2. Measure the distance from the sample point to trees just outside the auxiliary plots.

5.8.5 Core Counting

Tree ages from sample cores will be counted by the field contractor completing the plot. Ages will be counted in the lab using a microscope and entered into the MFR data entry program, TIMVEG.

5.8.6 Data Entry

Standard VRI field data will be entered into the MFR data entry program TIMVEG. Validation reports will be generated for each plot to ensure data integrity. All standard VRI data will be provided to the MFR to be included in the provincial VRI database. Non-standard data will also be provided to the MFR in a digital format.

GPS data will be post-processed by the field contractors.

5.8.7 Pre-work and Quality Assurance

All field crews should attend a pre-work session with the client and auditor to review the plot methods and ensure that all questions are resolved at the beginning of the project. The client will hire a Phase II certified third party auditor to audit a minimum of 10% of all plots following the VRI Ground Sampling Quality Assurance Standards at the time of contract signing. Auditing will be done by batch, and failed plots may result in a failed batch. Crews may be required to revisit failed plots at their own expense.

5.8.8 Plot Supplies

Supplies such as aluminum stakes, field maps, field equipment, photos, plot cards, handheld data recorders, GPS units, and other required equipment will be supplied by the field contract crews. The MFR will supply VRI tags for each sample.

5.8.9 Net Volume Adjustment Factor Sampling

Upon completion of the 50 Phase II plots, all trees in the NVAF-enhanced plots with a diameter at breast height 12.5 cm or larger will be included in the sampling frame to develop the tree matrix. The proposed strata for the NVAF program are as follows (no dead trees will be sampled):

1. Immature – 48 to 120 years in 2009.
2. Mature – 121+ years in 2009.

The MFR Volume and Decay Officer assigned a sample size of 40 trees based on the species distribution in the target area (Table 8). Once the tree list is finalized a NVAF-certified crew(s) will be hired to complete destructive sampling.

Table 8. Preliminary NVAF sample size[a]

Stratum	Spp	% of Land base		No. Trees	
		Total	Group	Total	Group
Immature	S & B	11	25	4	25
	Fd	15	35	5	35
	Other	17	40	6	40
	Total	***43***	***100***	***15***	***100***
Mature	S & B	38	67	17	67
	Fd	14	24	6	25
	Other	5	9	2	8
	Total	***57***	***100***	***25***	***100***
Total		***100***		***40***	

[a] The distribution was based on the area represented by each species and will likely vary once the field data is collected and analyzed.

The NVAF program will follow MFR VRI standards at the time of contract signing, which likely includes five steps:

1. Create a tree matrix using data from the enhanced Phase II plots.
2. Select sample trees from the tree matrix.
3. Complete stem analysis of the sampled trees.
4. Complete a third-party audit of the sample trees.
5. Analyze the data to develop net volume adjustment factors.

The client will hire a third party auditor to audit a minimum of 10% of all trees following NVAF quality assurance standards at the time of contract signing.

5.9 Inventory Assessment

5.9.1 Data Compilation and Analysis

The licencees will use the MFR SAS compiler to compile all Phase II plots and NVAF trees and will complete the Phase II data analysis. This analysis will:

- Use an approach similar to the Inventory Audit Procedures (or equivalent) for comparing estimates of volume to determine if there are significant differences between the key inventory attributes.
- Calculate ground sample average volumes and inventory volumes for the target population.

If required, use the VRI Interim Procedures and Standards for Statistical Adjustment of Baseline VRI Timber Attributes, including:

- Adjust inventory height, age, basal area, and stems per hectare.
- Generate new VDYP7 volumes using the adjusted attributes.
- Adjust ground volumes using NVAF ratios.
- Adjust new volume estimates and Lorey height with the NVAF-adjusted ground volumes using the ratio of means method.
- Compute sampling errors and complete significance tests for the Quesnel TSA.

The ground samples were selected using recently completed Phase I data that had not been processed by the MFR. This was done to expedite the sample selection process. At the time of final adjustment the most recent data available will be used. It is anticipated that the data will have been processed by the MFR at this time and will be available through the LRDW.

5.9.2 NVAF Analysis and Ratio Calculation

Upon completion of the destructive sampling program, data analysis will be completed and new NVAF ratios will be generated. All NVAF stem analysis will follow the MFR standards and the “model based” approach for generating the ratios will be used as the samples were selected with approximately equal intensity by stratum.

6.0 DEAD PL SAMPLING OPTIONS

6.1 Background

The PHR and mature green programs detailed in this sample plan cover approximately one-third of the TSA area; the remaining area is within the "dead-Pl" stratum (approximately 700,000 ha).[18] This stratum is where the MPB epidemic caused the greatest change to the forests and is where the majority of the Pl salvage has occurred. As a result of these two factors, this is also the area where the inventory labels used to describe the forest characteristics are very unreliable.

The dead-Pl stratum is likely to have short-term relevance in TSR5 as it continues to support the short-term AAC. This diminishes significantly in the mid-term timber supply forecast which becomes sustained by the mature green stratum and, increasingly, the PHR stratum.

The challenge is to develop a program that addresses the short-term information needs of existing forest licensees, TSR5 information needs, and future investment needs from the forest resource with increasingly scarce financial resources.

6.2 Proposed Program

Stands within the dead-Pl stratum will undergo a high degree of change over the next few decades. These stands will be characterized be a mix of standing mature non-Pl, large areas of decayed Pl and an increasing presence of understory. Timber supply modelling efforts continue to incorporate gross assumptions around shelf-life and crude attempts at describing stand dynamics. The end result is a high degree of uncertainty in existing and future stand types.

Completing a traditional Phase I across this stratum makes neither financial nor technical sense until the level of change in the forest has somewhat slowed. Instead a ground-based audit and monitoring program should be initiated within the next two years to meet the following objectives:

- Obtain a more reliable estimate of current volume, stand structure (including understory) to support the development of yield curves for these stand types;
- Obtain a more reliable estimate of current volume and merchantability in mature Pl-leading stands to support emerging information needs for sawlog, chips and bio-energy investment opportunities;
- Confirm the reliability and accuracy of the MFR Satellite Mountain Pine Beetle Attack Mapping for attack level/intensity; and
- Provide feedback to guide investment decisions on a new full phase VRI program.

The monitoring program would have 10 year remeasurement periods, or as the business case requires. There is uncertainty about the structure and variability of these stand types that limits the current ability to select an appropriate plot design (this includes looking at options of establishing plot clusters). A light reconnaissance of the affected area should be completed prior to developing the sample plan to ensure the plot design captures the key information needs.

[18] To some degree "dead-Pl" is a misnomer. The VRI Phase I program has identified significant amounts of area where live-Pl still exist. The majority of this stratum, however, can be described as having high components of dead-Pl.

Following reconnaissance, this document will be amended to describe the proposed sample methods.

6.3 Target Population

The target population is all Pl leading stands greater than 47 years in the vegetated-treed landbase on the TSA.

6.4 Sample Size

The sample size chosen will be dependent on the desired sampling error and available funding.

7.0 CMI AND VRI PHASE II IMPLEMENTATION

7.1 Schedule

7.1.1 PHR Sampling Schedule

The Quesnel TSA licensees tendered the field portion of the CMI program in the summer of 2009 based on the plot design presented in this sample plan. Northview Resource Logistics won the tender and installed one-half of the CMI plots in October 2009. Nona Phillips completed the field audit. Funding permitting, the remaining plots will be installed in the 2010 field season.

7.1.2 Mature Green Sampling Schedule

Sampling will begin in the 2010 field season, immediately following the pre-work meeting. The intent is to complete sampling in the 2010 field season. Crews will be audited at the start of the project and as the auditor deems necessary throughout the project. Data will be entered into TIMVEG and non-standard data entered into a database or spreadsheet.

Upon completion of the Phase II program the NVAF tree matrix, sample size, and sample plan update will be completed. The NVAF program (destructive sampling and data entry) will be completed early in the 2011 field season. Final data compilation, inventory assessment, and reporting will be completed before December 31, 2011.

Activities	2009-2010				2011			
	Sept.-Mar	Apr.-June	July–Sep.	Oct.-Dec.	Jan.-Mar	Apr.-June	July–Sep.	Oct.-Dec.
1. Sample Planning (CMI & Phase II)								
2. Select sample locations								
3. Approve sample plan								
4. CMI Sampling								
5. CMI QA								
6. Phase II Sampling								
7. Phase II QA								
8. NVAF sample selection								
9. Approve sample plan								
10. NVAF sampling								
11. NVAF QA								
12. Compilation and analysis								
13. Complete final report								

Quesnel Licensees

MFR

Sampling Contractors

Figure 3. Proposed 2010 and 2011 implementation schedule.

7.2 Proposed budget

The proposed budget for all activities on the Quesnel TSA should cost approximately $300,000, including audit, quality control, helicopter costs and the compilation and analysis.

Table 9. Proposed program field activities cost.

Phase	Cost	% of Phase	% of Total
CMI			
Field Sampling	$85,500	70	29
Helicopter[b]	$10,000	8	3
Field Audit	$7,000	6	2
Quality Control and Analysis[c]	$20,000	16	7
Subtotal	*$122,500*	*100*	*42*
Phase II			
Field Sampling[a]	$75,000	60	26
Helicopter[b]	$10,000	8	3
Field Audit	$10,000	8	3
Quality Control and Analysis[c]	$30,000	24	10
Subtotal	*$125,000*	*100*	*43*
NVAF			
Field Sampling[a]	$28,000	62	9
Helicopter[b]	$5,000	11	2
Field Audit	$5,000	11	2
Quality Control and Analysis[c]	$7,000	17	2
Subtotal	*$45,000*	*100*	*15*
Total	*$292,500*		*100*

[a] Costs are based on a field crew rate of $1,500/day.
[b] Helicopter costs are estimates based on generally good road access throughout the TSA.
[c] Quality control includes technical support, and ground sampling program management, VPIP update, extra sample selection, etc.

7.3 Roles and Responsibilities

Quesnel TSA licencees

- Develop and update sample plan.
- Coordinate project activities.
- Select sample points, polygons, and locations within polygons.
- Prepare sample packages.
- Select field crews.
- Ensure audit program is implemented.
- Check data after initial compilation
- Validate and compile data.

- Provide data to MFR.
- Complete data analysis and report and submit to MFR for review.

Field Contractors

- Complete field sampling.
- Enter the standard data (including trees cores and GPS) into TIMVEG and non-standard data into a database or spreadsheet and submit to the licencees.
- Complete internal quality control and submit data to the licencees at the conclusion of field sampling.

CMI and Phase II Auditor

- Third party Phase II certified auditor will audit a minimum of 10% of the Phase II samples.

NVAF Field Contractors

- Complete destructive sampling.
- Enter the sample data and provide to the licencees.

NVAF Auditor

- NVAF-certified auditor will audit a minimum of 10% of the NVAF sample trees.

MFR

- Review and approve the sample plan.
- Review and approve the final analysis.
- Be the custodian of the VRI standard and non-standard sample and population data.
- Audit the VRI process to ensure sample plan commitments are achieved and MFR standards are met.
- Review QA reports for acceptance.

7.4 MFR Deliverables

The deliverables for the MFR upon completion of the ground sampling program include:

1. Sample plan and individual sample packages.
2. Plot cards, validated TIMVEG ground sampling field data and analysis data.
3. NVAF destructive sampling data in a digital format accepted by the MFR.
4. Corrected GPS data.
5. Individual quality assurance reports.
6. Final analysis and report, including description of data and analysis issues

APPENDIX I - QUESNEL TSA LANDBASE

The Quesnel TSA is located in the northern part of the Southern Interior Forest Region, lying in the Fraser Basin and the Interior Plateau between the Coast Mountains on the west and the Cariboo Mountains on the east. The TSA covers about 1.6 million hectares in total, of which approximately 1.3 million hectares is productive Crown forest. The timber harvesting land base comprises about hectares 1.0 million hectares. [19]

The climate, terrain and forests of the TSA are varied. West of the Fraser River, the forests are predominately lodgepole pine, while east of the Fraser River, the forests contain more spruce and balsam. Overall, the TSA is covered by stands of lodgepole pine (85 percent), spruce (10 percent), and Douglas-fir (3 percent) with hemlock and balsam, and deciduous species forming minor components.

The Biogeoclimatic Ecosystem Classification zones present are the sub-boreal pine-spruce; sub-boreal spruce; montane spruce; Engelmann spruce-subalpine fir; interior Douglas-fir; interior cedar-hemlock; and alpine tundra.

Table 10. Area distribution by BEC subzone in the Quesnel TSA.

BEC Zone, Sub-zone, Variant	Quesnel Area (ha.)	Quesnel (%)
AT	9,846.6	0.62%
AT All	**9,846.6**	**0.62%**
BG xh		
BG xw		
BG All		
CWH ds		
ESSFmv1	783.9	0.05%
ESSF mw		
ESSFwk1	65,200.0	4.07%
ESSFwc3	32,400.0	2.02%
ESSFxv	17,127.9	1.07%
ESSF All	**115,511.8**	**7.22%**
ICH mk3		
ICH wk2		
ICHwk4	21,600.0	1.35%

[19] BC Ministry of Forests. 2004. Quesnel Timber Supply Area Rationale for Allowable Annual Cut (AAC) Determination. 59p.

BEC Zone, Sub-zone, Variant	Quesnel Area (ha.)	Quesnel (%)
ICH All	**21,600.0**	**1.35%**
IDFdk3	7,118.8	0.44%
IDF dk4		
IDF dw, unv		
IDFxm	2,186.8	0.14%
IDF All	**9,305.6**	**0.58%**
MS dc		
MS dv		
MS xk		
MSxv	339,119.6	21.19%
MS All	**339,119.6**	**21.19%**
SBPSdc	263,518.1	16.47%
SBPSmc	47,715.8	2.98%
SBPSmk	173,413.4	10.84%
SBPSxc	80,448.4	5.03%
SBPS All	**565,095.7**	**35.32%**
SBSdk	536.0	0.03%
SBSdw1	110,306.2	6.89%
SBSdw2	167,209.1	10.45%
SBSmc1	9,200.0	0.57%
SBSmc2	82,237.7	5.14%
SBSmc3	14,885.5	0.93%
SBSmh	78,363.3	4.90%
SBSmw	58,800.0	3.67%
SBSwk1	18,000.0	1.12%
SBS All	**539,537.8**	**33.72%**
TSA Total	**1,600,017.1**	**100.00%**

APPENDIX II – PHR CMI SAMPLE LIST

Table 11. Quesnel TSA CMI sample list**.**

Plot Number	UTM Easting	UTM Northing	MAP_ID	Leading Species
446-5924	446,020	5,923,718	093G041	Conifer
446-5919	445,807	5,918,716	093G041	Pl
566-5914	565,852	5,913,592	093G040	Conifer
416-5915	415,584	5,914,987	093F039	Pl
420-5910	420,373	5,909,773	093F040	Conifer
460-5898	459,960	5,898,071	093G023	Pl
580-5888	579,784	5,887,939	093H011	Conifer
565-5884	564,564	5,883,582	093G010	Conifer
459-5883	459,322	5,883,067	093G002	Pl
484-5882	484,329	5,882,003	093G004	Pl
539-5880	539,343	5,879,653	093G008	Pl
564-5879	564,350	5,878,581	093G010	Pl
574-5878	574,352	5,878,151	093H001	Conifer
579-5878	579,354	5,877,936	093H001	Conifer
589-5878	589,356	5,877,506	093H002	Conifer
624-5876	624,369	5,875,995	093H005	Pl
504-5876	504,120	5,876,149	093G006	Pl
609-5872	609,148	5,871,642	093A094	Conifer
619-5871	619,152	5,871,210	093A094	Conifer
629-5871	629,155	5,870,778	093A095	Conifer
634-5871	634,157	5,870,561	093A095	Conifer
559-5869	558,919	5,868,793	093B100	Pl
439-5869	438,680	5,868,913	093B091	Pl
559-5864	558,704	5,863,792	093B100	Conifer
564-5864	563,705	5,863,577	093B100	Conifer
428-5864	428,466	5,864,336	093C100	Pl
438-5864	438,468	5,863,912	093B091	Pl
448-5863	**448,470**	**5,863,487**	**093B092**	**Pl**
518-5861	518,482	5,860,505	093B087	Pl
443-5859	443,257	5,858,698	093B081	Pl
463-5858	463,261	5,857,849	093B083	Pl
478-5857	478,263	5,857,211	093B084	Pl
488-5857	488,264	5,856,786	093B085	Pl
493-5857	493,265	5,856,572	093B085	Pl
508-5856	508,267	5,855,932	093B086	Pl
523-5855	523,269	5,855,290	093B087	Pl
528-5855	528,270	5,855,077	093B088	Decid
543-5854	543,272	5,854,434	093B089	Decid
433-5854	433,043	5,854,122	093B081	Pl
438-5854	438,044	5,853,910	093B081	Pl
483-5852	483,051	5,851,998	093B084	Pl
553-5849	553,059	5,849,004	093B079	Pl
423-5850	422,829	5,849,544	093C080	Pl

448-5848	447,834	5,848,485	093B072	Pl

Bolded is a BC-NFI plot that has already been established.

Plot number	UTM Easting	UTM Northing	MAP_ID	Leading Species
563-5844	562,845	5,843,574	093B080	Decid
423-5845	422,617	5,844,543	093C080	Pl
438-5844	437,620	5,843,908	093B071	Pl
583-5838	582,633	5,837,712	093A062	Pl
482-5837	482,412	5,836,996	093B064	Pl
547-5834	547,415	5,834,218	093B069	Pl
497-5826	496,986	5,826,357	093B055	Pl
502-5826	501,986	5,826,143	093B056	Pl
522-5825	521,985	5,825,288	093B057	Pl
547-5824	546,986	5,824,217	093B059	Pl
477-5822	476,774	5,822,208	093B054	Pl
522-5820	521,771	5,820,288	093B057	Conifer
542-5819	541,772	5,819,431	093B059	Pl
487-5817	486,560	5,816,783	093B055	Pl
517-5816	516,558	5,815,502	093B047	Decid
522-5815	521,557	5,815,288	093B047	Pl
521-5805	521,130	5,805,289	093B037	Decid

APPENDIX III – GREEN MATURE SAMPLE LIST

Table 12. Mature Green Sample List.

Plot No	NVAF	Stratum	Sub Stratum	Mapsheet	Polygon	Area (ha)	Ht (m)	Age (yrs)	Vol (m3/ha)	SPH	BA (m2/ha)	Lor. Ht. (m)	SI (m)	UTM Zone	UTM North	UTM East
1		1	1	093B047	708	36.2	24.7	104	107	308	13.4	24.2	16.0	10	5807499	523432
2		1	1	093B057	670	22.3	19.3	112	154	668	31.4	16.5	11.0	10	5821200	514602
3	Y	1	1	093B077	301	57.9	30.4	105	396	778	48.4	25.4	20.6	10	5844872	525633
4		1	1	093B078	727	43.6	18.1	58	135	856	26.9	16.9	19.7	10	5849793	530052
5		1	1	093B100	405	114.7	21.6	83	267	946	46.7	19.1	16.7	10	5861858	557122
6		1	2	093B048	548	17.5	19.3	113	122	790	25.5	16.7	12.5	10	5814118	534935
7	Y	1	2	093B048	715	155.3	25.5	114	93	224	12.8	23.8	16.4	10	5815734	532300
8		1	2	093B059	122	87.9	18.8	74	136	1,811	34.5	15.1	15.9	10	5818469	540932
9		1	2	093B099	448	40.5	37.8	106	668	420	72.0	32.4	25.2	10	5867687	545047
10		1	2	093G007	903	18.5	20.7	84	145	984	31.2	17.2	16.0	10	5880115	523935
11	Y	1	2	093G018	6	3.6	19.3	54	119	1356	32.9	14.8	20.4	10	5883554	530195
12		1	2	093G026	41	12.6	21.6	73	157	739	25.9	18.9	18.4	10	5895179	506742
13		1	3	093A061	242	5.9	25.3	119	100	209	16.4	24.3	16.7	10	5838635	568248
14		1	3	093A071	135	67.8	26.3	108	41	118	6.4	26.0	18.3	10	5840095	576226
15	Y	1	3	093B089	321	14.6	18.6	63	75	847	16.3	18.0	16.6	10	5853239	547834
16		1	3	093B097	244	26.4	27.4	104	206	574	35.9	24.7	19.6	10	5863795	518928
17		1	3	093B098	267	9.6	21.5	94	94	410	20.7	18.5	15.4	10	5863500	532843
18	Y	1	3	093G007	1167	12.9	22.7	69	239	1,244	42.0	20.6	19.6	10	5883393	517562
19		1	3	093G017	508	50.1	25.4	99	272	957	40.7	23.1	18.4	10	5888540	514375
20		1	3	093G018	452	26.6	22.4	83	203	1,136	31.0	22.5	17.4	10	5888281	529796
21		2	1	093A071	176	17.7	33.3	133	207	171	22.2	30.6	19.9	10	5841217	575773
22	Y	2	1	093A092	51	63.0	23.1	233	235	998	40.0	18.0	6.2	10	5867184	591722
23		2	1	093A094	105	109.5	18.2	203	109	501	25.0	14.8	5.6	10	5864176	608027
24		2	1	093A094	156	11.3	32.1	263	407	648	50.0	26.8	10.9	10	5866568	619955

Plot No	NVAF	Stratum	Sub Stratum	Mapsheet	Polygon	Area (ha)	Ht (m)	Age (yrs)	Vol (m3/ha)	SPH	BA (m2/ha)	Lor. Ht. (m)	SI (m)	UTM		
														Zone	North	East
25		2	1	093A095	471	28.2	25.2	233	319	824	50.0	20.6	8.6	10	5866262	633973
26	Y	2	1	093A095	413	36.6	28.3	183	196	261	30.0	24.0	11.6	10	5872695	633550
27		2	1	093B067	26	63.6	24.4	123	197	343	30.3	20.7	13.5	10	5828193	517406
28		2	1	093B067	524	42.6	32.6	149	79	70	8.0	30.0	17.8	10	5835311	519614
29		2	1	093B080	858	12.6	32.4	144	94	70	10.1	29.9	18.1	10	5848674	565473
30	Y	2	1	093G010	528	70.2	18.3	153	190	1,335	40.3	15.6	7.7	10	5883045	565447
31		2	1	093G020	20	21.8	23.3	179	280	1,096	44.7	18.6	8.6	10	5884403	566507
32		2	1	093H001	156	34.3	30.1	223	246	220	30.0	26.7	11.0	10	5878475	573869
33		2	1	093H002	127	50.4	30.3	174	81	81	10.0	26.2	13.9	10	5874748	583629
34	Y	2	1	093H002	110	16.0	23.4	144	301	1,077	50.3	19.0	11.7	10	5875242	590766
35		2	1	093H002	346	29.7	33.3	199	542	772	55.9	28.1	15.0	10	5879461	581227
36		2	1	093H011	102	34.9	24.2	173	243	675	39.9	19.7	10.5	10	5885527	579984
37		2	1	093H011	439	43.5	20.2	178	116	452	20.0	18.3	7.6	10	5890808	573697
38	Y	2	1	093H011	671	82.4	23.4	174	58	130	9.9	19.7	8.8	10	5890441	577590
39		2	1	093H011	536	133.6	18.2	173	170	477	29.8	18.9	6.7	10	5891840	575345
40		2	1	093H031	71	48.1	23.2	188	269	875	44.9	18.9	9.0	10	5914401	570400
41	Y	2	2	093B037	72	5.3	32.1	233	83	94	12.0	24.5	15.4	10	5803225	522648
42		2	2	093B058	609	33.4	29.3	184	102	198	14.0	24.0	15.1	10	5819015	530537
43		2	2	093B067	519	85.3	25.3	133	70	110	10.2	22.9	15.0	10	5834364	520675
44		2	2	093B090	1002	136.9	34.3	122	531	537	53.3	30.8	21.3	10	5858517	562590
45	Y	2	2	093G007	916	17.0	28.4	134	325	891	45.5	23.3	16.8	10	5880455	513628
46		2	2	093G007	988	12.5	34.4	133	631	638	70.4	29.9	20.5	10	5881525	514376
47		2	2	093G026	58	28.0	35.3	163	674	621	74.8	30.3	19.3	10	5895223	512756
48		2	2	093G026	514	27.6	34.3	163	481	642	59.8	28.1	18.7	10	5897041	507723
49	Y	2	3	093B099	72	12.0	25.3	124	140	312	25.2	23.1	16.4	10	5861790	551708
50		2	3	093G026	414	127.5	30.2	123	321	678	45.3	27.4	20.6	10	5902350	505445

APPENDIX IV – MATURE GREEN TARGET AND SAMPLE COMPARISONS

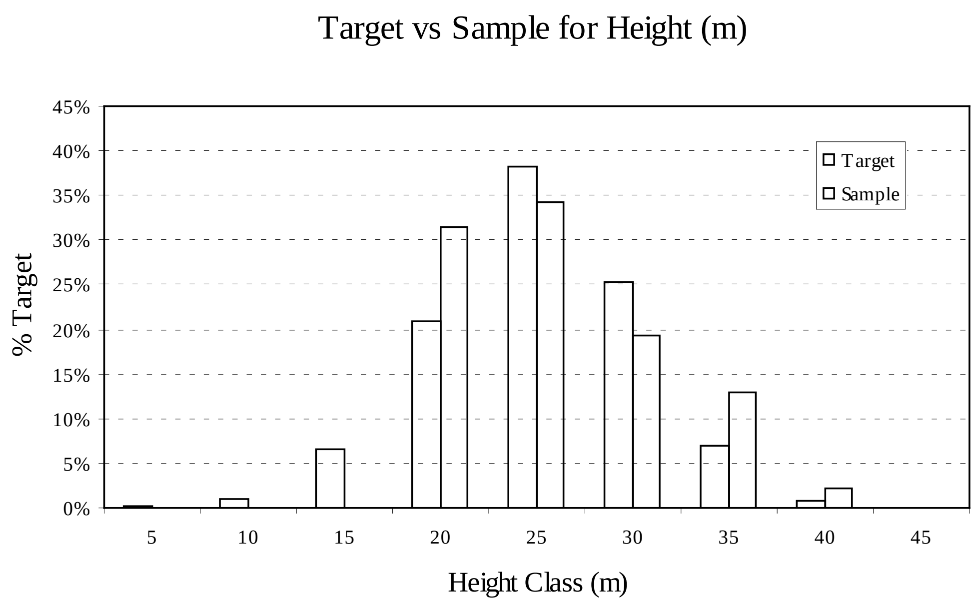

Figure 4. Quesnel TSA Mature Green Target vs. Sample for Height (m).

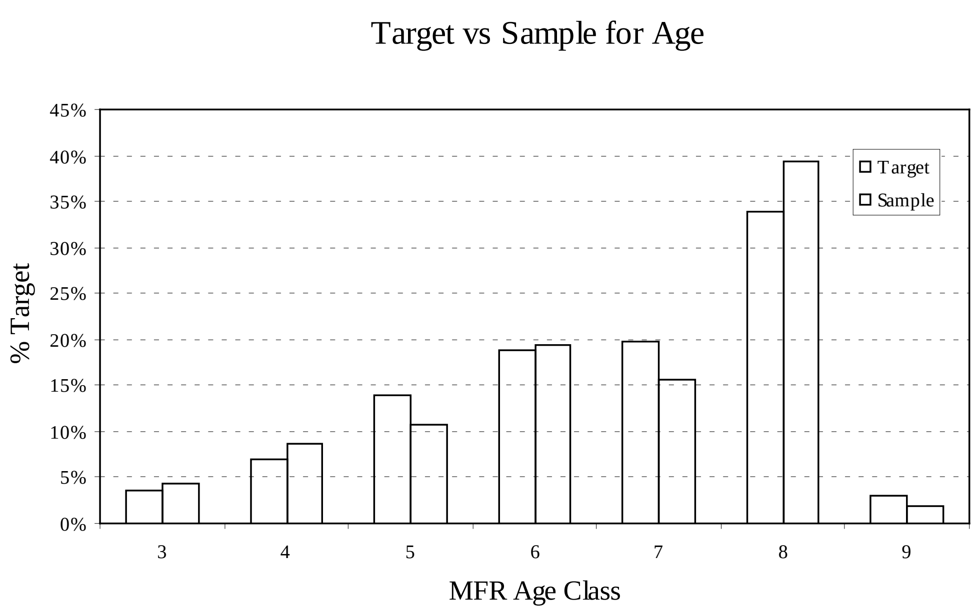

Figure 5. Quesnel TSA Mature Green Target vs. Sample for Age.

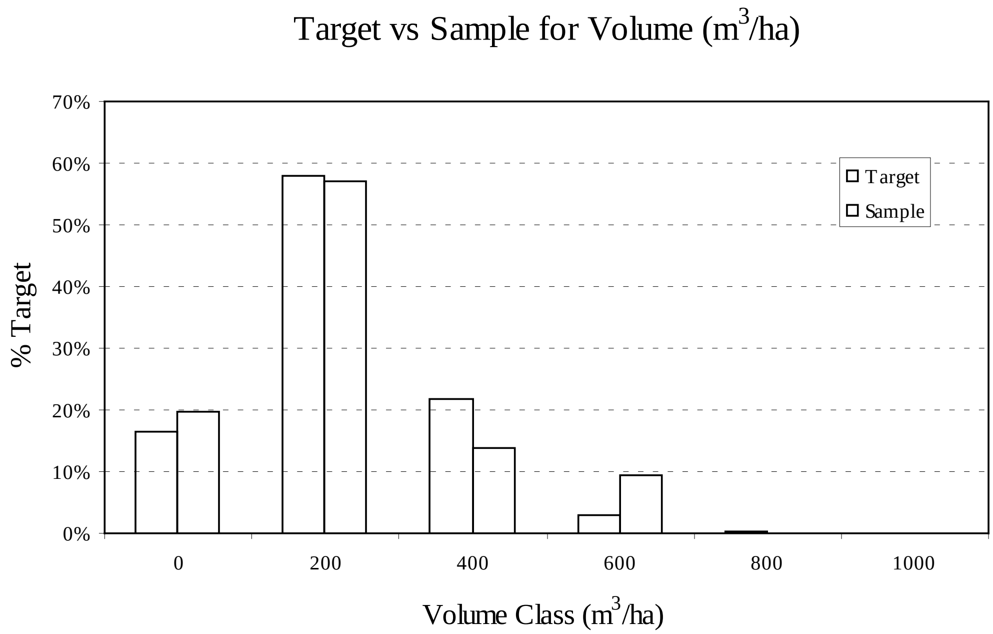

Figure 6. Quesnel TSA Mature Green Target vs. Sample for Volume (m^3/ha).

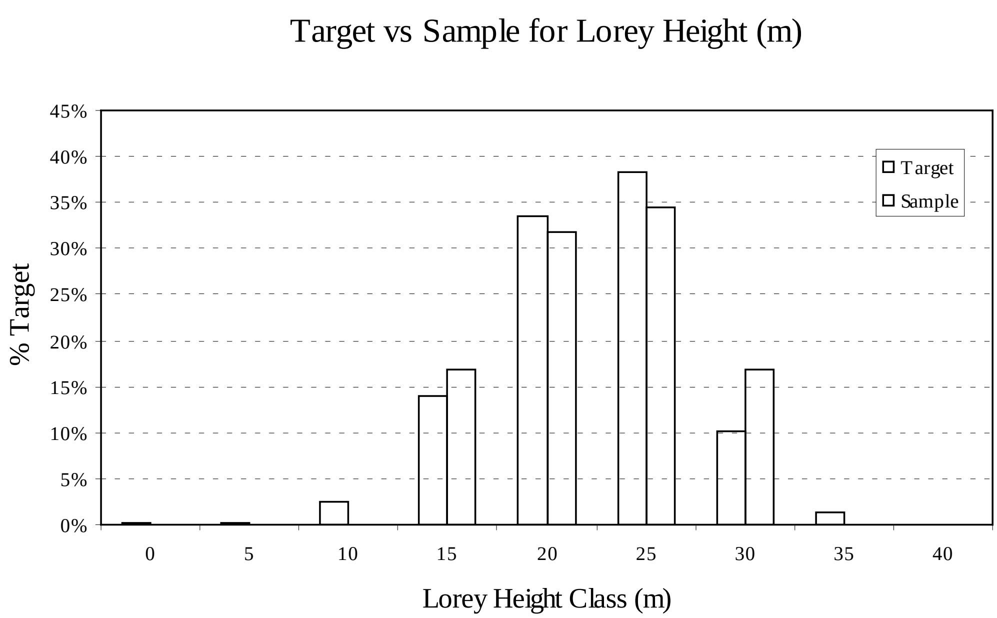

Figure 7. Quesnel TSA Mature Green Target vs. Sample for Lorey Height (m).

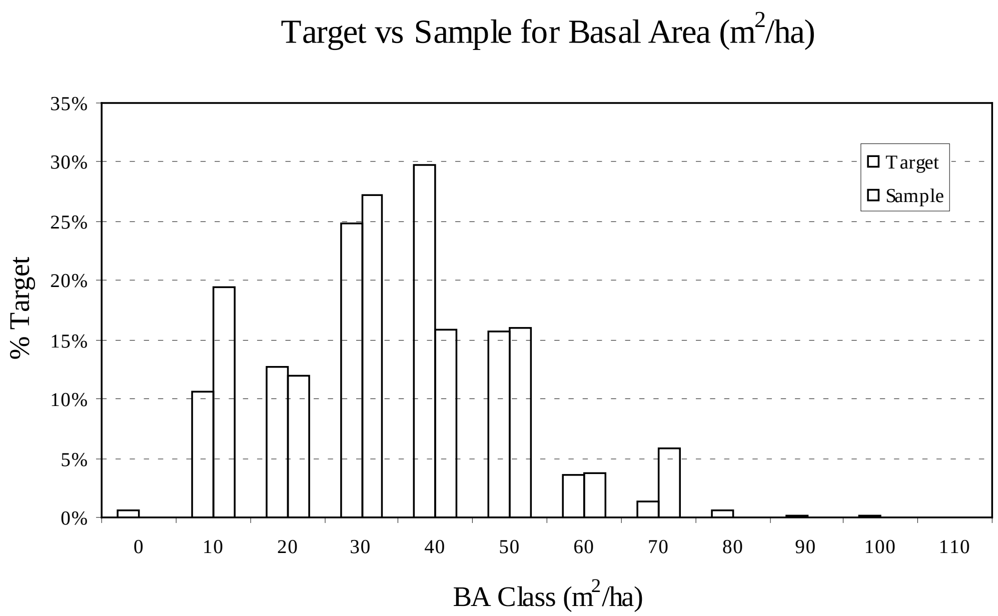

Figure 8. Quesnel TSA Mature Green Target vs. Sample for Basal Area (m^2/ha).

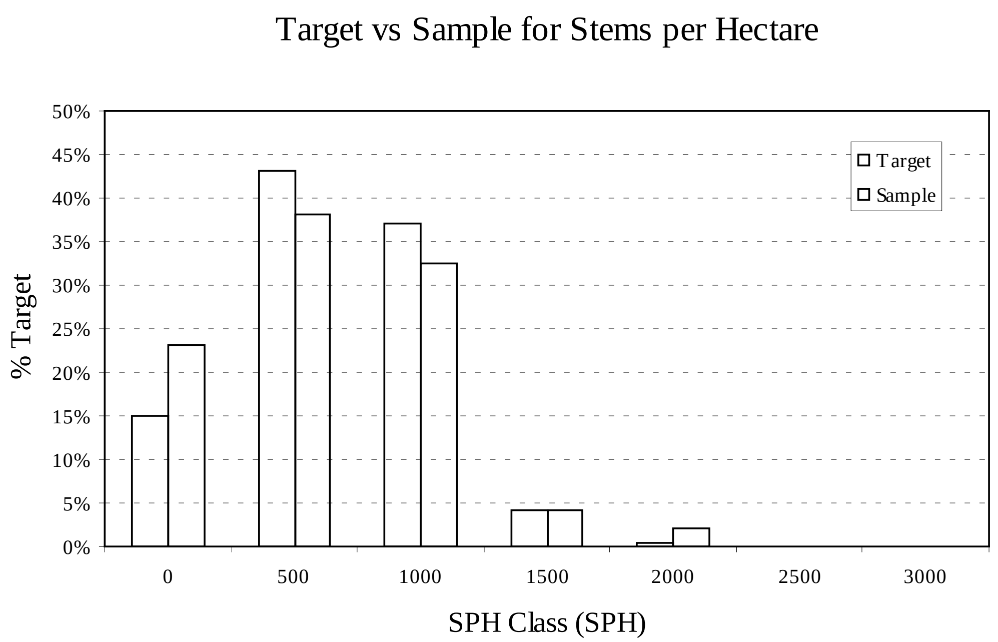

Figure 9. Quesnel TSA Mature Green Target vs. Sample for SPH.

APPENDIX V – MATURE GREEN SAMPLE DISTRIBUTION

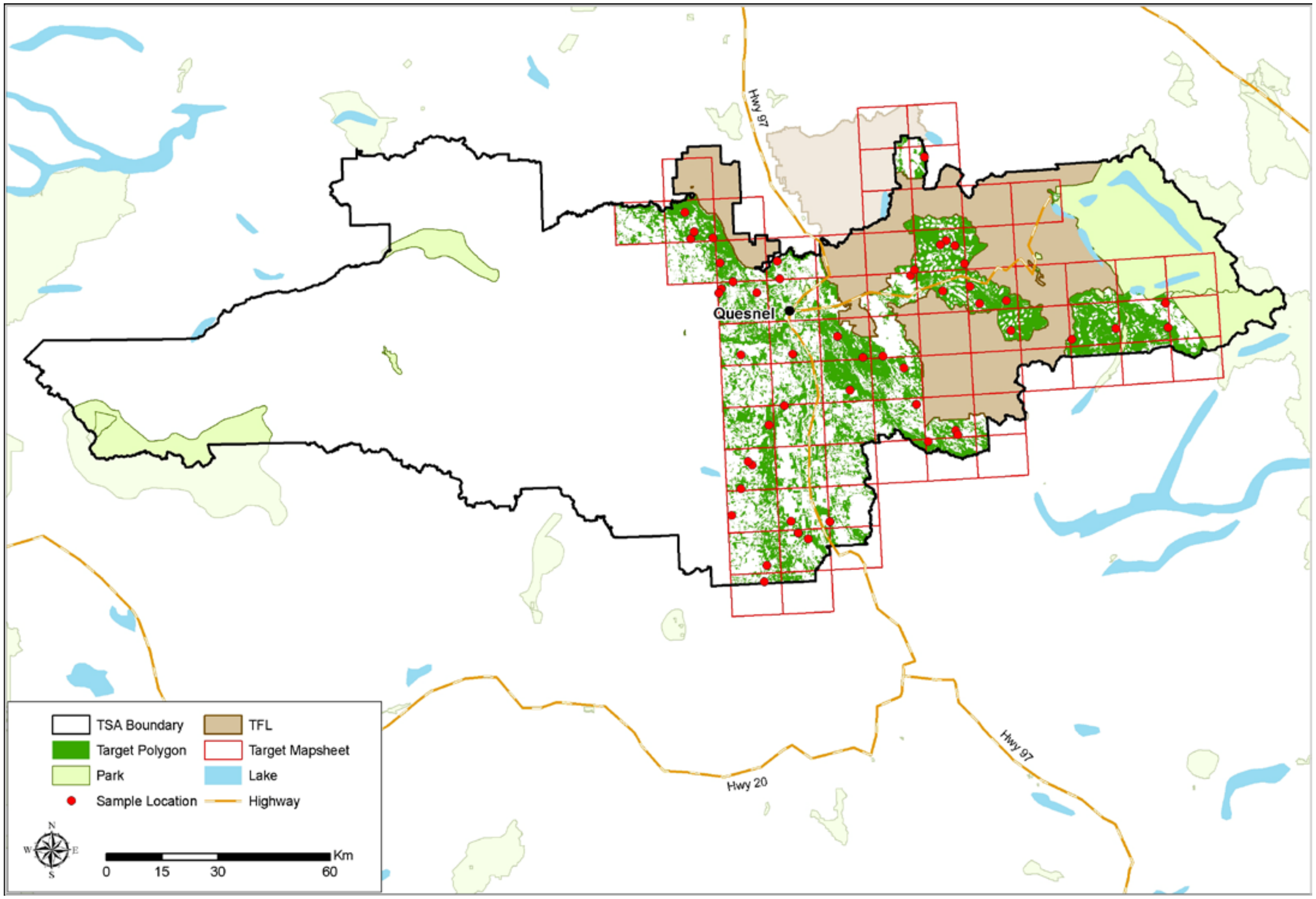

Figure 10. Quesnel TSA Phase II Sample Distribution.