LIGNUM LTD.

INNOVATIVE FOREST PRACTICES AGREEMENT VEGETATION/TIMBER INVENTORY PLAN

Version 1

SUBMITTED: APRIL 1998

TABLE OF CONTENTS

INTRODUCTION

This Plan has been developed to provide more detailed information to the Ministry of Forest's (MoF), the Ministry of Environment, Lands and Parks and Forest Renewal BC regarding the Vegetation/Timber Inventory on the Lignum Ltd. Innovative Forest Practices Agreement (IFPA) Area. The Vegetation/Timber Inventory fits into the framework of Lignum's Forest Inventory Business Plan submitted April 1997.

It is intended that this plan be signed-off by the Director, MoF Resources Inventory Branch, the Regional Manager, Cariboo Forest Region and Lignum Ltd.

Background

Lignum's IFPA area is regarded as a Management Unit inventory. Management Unit inventories are typically timber emphasis. Besides providing detailed polygon information for day-to-day forest management, they can also be used to increase precision of the Provincial Vegetation Resources Inventory.

Lignum is responsible for the planning and implementation of this inventory using funding from Forest Renewal BC. The MoF Resources Inventory Branch requires Lignum to prepare an inventory business plan, which includes a sampling plan, for its approval. An inventory business plan defines the inventory needs, the information needed to meet the needs, and the methods for collecting the information. This business plan, once approved, will drive the timber inventory for Lignum's IFPA area.

Management activities such as tree planting and fertilization affect the way forests grow. Stand growth and timber yields are projected for each stand, based on current management. These projections are represented as timber yield curves that show the characteristics of a stand (e.g., timber volume per hectare, average stem diameter) at different ages.

Lignum's Innovative Forest Practices Agreement

Innovative Forest Practices Agreements were established in British Columbia in 1997 to provide forest companies, resource management agencies, and stakeholders with a means of testing new and innovative practices in forest resource management. New approaches to forest management planning, recovery of previously uneconomic timber, productivity improvements, trial-phase intensive silviculture treatments, innovations in ecosystem-based management, alternative harvesting practices - all are the types of projects the province is encouraging through these agreements.

The IFPA offers an important opportunity to demonstrate the effective management of forests for ecological and environmental values, as well as to meet the needs of a range of stakeholders. The returns afforded are expected to more than offset the

reductions experienced in recent years in the availability of timber and the annual allowable cut as the province has moved to protect representative ecosystems and regulate forest practices.

Lignum Limited is the first company in the province to sign an Innovative Forest Practices Agreement. Up to five other agreements will be established in the province.

Lignum has termed its agreement the "Innovative Resource Management Area," or IRMA.

IRMA's Objectives

Four main objectives have been set in establishing IRMA:

1. To achieve full timber production potential of the sites.
2. To maintain and enhance biodiversity across the forest estate covered by the management area.
3. To conduct forest management practices that do not adversely affect other resource users.
4. To create economic and social opportunities that contribute to the stability of the communities in the regions.

These objectives will be achieved through the practice of sustainable forest management.

Lignum's Commitment to Sustainable Forest Management

Balancing and maintaining ecological and economic values are basic tenets of sustainable forest management. In undertaking this initiative, Lignum has adopted the following definition of Sustainable Forest Management:

> *Sustainable forest management is the maintenance of the ecological integrity of the forest ecosystem while providing for social and economic values for the benefit of present and future generations.*

Approach to Sustainable Forest Management in IRMA

The company is now in the process of developing a sustainable forest management system. Though still in draft stage, this system adopts elements of a number of international and national voluntary environmental certification initiatives (e.g., the Forest Stewardship Council and the Montreal Process). It also attempts to reflect the broad range of views about the forest held by our employees, contractors, and customers, local communities, First Nations, the environmental community, and other forest users.

The key elements of our approach in pursuing sustainable forest management in IRMA are:

- Extensive Public Involvement;
- Co-operative Management;
- Ecosystem-based Management;
- Management for Results; and
- Use of Adaptive Management and Performance Monitoring.

Lignum Area

IRMA is located within the Cariboo Forest Region on the traditional operating area of the company in the Williams Lake and 100 Mile House Timber Supply Areas. It covers 619,841 ha and is located within Lignum's traditional operating areas of Williams Lake (442,124 ha) and the 100 Mile House (177,717 ha) TSA's. See Appendix 1 for reference map of Lignums's IFPA area.

The area is a mixture IDF, SBPS and MS biogeoclimatic zones. The IFPA does not contain any ecological reserves or parks.

Former Inventories

The most recent reinventory for the area was conducted in 1973 for the Williams Lake TSA portion and in 1972 for the 100 Mile House TSA. The Horsefly Forest District was updated for depletion in 1991 and the Chilcotin Forest District was last update in 1992.

Inventory audit's have been conducted for both the Williams Lake and 100 Mile House TSA's. The 1995 audits checked the accuracy of the mature timber volume. The initial audit results for the Williams Lake TSA were inconclusive**.** The completion date for the Williams Lake Inventory Audit is March 1998[1].

For the 100 Mile House TSA Audit there was no statistically significant difference within the acceptable confidence limits of the sample size observed between the overall mean audit volume (220 m^3/ha) and the map label volume (247 m^3/ha). However, for the operable land base, the difference between the mean audit volume (225 m^3/ha) and the map label volume (261 m^3/ha) was significant. This suggests, according to the 100 Mile House TSA Inventory Audit, "that the majority of the total

[1] The results of the 1997 Williams Lake TSA audit are not available at the time of submitting this Inventory Plan.

bias in the inventory for operable forested areas is associated with the classification of attributes".

BUSINESS ISSUES

Forest Management and Inventory Issues

Lignum has identified specific business concerns that that are important in developing an inventory strategy for the IRMA. Lignum requires:

- accurate timber volume on the IRMA landbase.
- accurate representation of forest structural information (by polygon).
- geographic representation of species, basal area and site index.
- seral stage definitions and representation in the IRMA.
- an accurate timber base from which to project habitat.
- increase Lignum's ability to effectively plan cut blocks and develop enhanced forestry treatments consistent with the Forest Practices Code of BC Act and the Cariboo-Chilcotin Land Use Plan.

The most recent Timber Supply Review identified specific issues and information needed to improve the timber inventory. These include:

- uncertainty in the accuracy of the mature timber volumes.
- green-up age estimations may not be achieved over time.
- identification of PFTs.
- uneven-aged (dry-belt Douglas-fir IDF stands) management issues: top height and age measurements (which are almost meaningless attributes in these complex stands); potentially incorrect volumes; and inaccurate estimates of wildlife-related attributes (e.g., crown closure, which is critical for mule deer management).
- decay factors for spruce-balsam stands, cedar-hemlock stands, and sub-alpine fir stands are too low.
- wildlife (caribou) habitat area delineation.
- old-growth (seral stage) forest cover biodiversity requirement; there is a perception that the old-growth forest is under-represented.
- uncertainty in regenerated stand volumes.
- riparian habitat areas need to be better defined.

- Salvage of non-recoverable losses.

OBJECTIVES

The Lignum Vegetation/Timber Inventory will specifically address Lignum's business concerns and assist in addressing the concerns identified in the Timber Supply Reviews by:

1. Installing a representative number of Provincial VRI Phase II ground sampling clusters within the IRMA to address provincial reporting requirements and to assist with the Criterion and Indicators inventory as well as reporting.
2. Improve the accuracy of the timber inventory in the IRMA stands by providing geographically explicit and polygon specific information such as volume, age, height, species and basal area information. It is expected to achieve a target sampling error of ± 10% for at least the volume attribute. This information will be used to adjust the polygon attributes where appropriate.
3. Improve estimates of tree net volume from the net factoring process for the IRMA stands.
4. Provide consistent Phase I photo estimation for the IRMA.

JUSTIFICATION AND RATIONALE

Photo Estimation

The photo estimation in the Lignum IRMA area will need to be improved for more localized planning. This is required to provide consistent estimates of timber information across the landbase. Several stand types exist in the IRMA including dry belt fir, Lodgepole Pine, Spruce-Balsam and deciduous. With an inventory that is over 25 years old, it is unlikely that these stands have remained constant.

The development of a consistent and accurate geographic polygon representation will address Lignum's objectives for an accurate representation of forest structural information. The new photo estimation will provide a geographic representation of species basal area and site index, provide a seral stage representation and provide an accurate vegetation/timber base for the IRMA.

To address the Phase I requirements, Lignum will:

- complete the Vegetation Resources Inventory Phase I to RIC standards for the IRMA by completing contiguous photo estimation across the IRMA area.

- explore techniques such as radar altimetry for determining stand heights, 70mm photography for assisting with classification in the dry belt fir stands and computer aids for developing logical interpretation scenarios.
- adjust various Phase I attributes such as volume, site index and basal area with the ground sample information.

Ground Sampling

Lignum needs accurate information on the timber component of its IRMA. VRI definitions and procedures will be adapted and used for the timber component of these plots to minimize expense and ensure the data is compatible with other Resource Inventory Committee processes. The VRI was specifically designed for gathering extra information on any of the components of standard fieldwork, including the timber component.

Consistent with the VRI design, our objectives of the ground sampling are to:

1. estimate overall attribute totals and averages for the IRMA;
2. provide initial conditions for measuring indicators of sustainable management;
3. ensure that there is a sufficient number of ground samples to enable post stratification of the IRMA; and
4. provide a framework for further ground sampling, if required.

The number of samples in a Management Unit Inventory generally depends on several factors including theoretical considerations, available funds, available staff, timelines, and length of field season. Calculation of a theoretical target sample size requires:

- An estimate of variation in the key attributes of interest under the proposed sampling procedures [often expressed as the coefficient of variation (CV)]; and
- A statement of the precision desired in the attributes[2].

For the Lignum IFPA area, no information is available to make the theoretical calculations. However, an estimated CV of 90% (for timber volume) and a target sampling error of ± 10% are assumed. In addition, a large number of samples are required to allow Lignum to post stratify and obtain reliable statistics without having to resample. Approximately 350 plots[3] distributed over Lignum's landbase are

[2] The desired attribute for the Lignum IFPA include several key attributes found in the Biodiversity Conservation Strategy referenced by the Cariboo-Chilcotin Land Use Plan including number of dead standing trees, density of large (for the site) living trees, tree species diversity and structural diversity (both verticle and horizontal, including patchiness).

[3] Sample Size = $(CV\%/SE\%)^2$

considered sufficient for the timber emphasis inventory and other attributes. This large sample size should provide overall volume estimates with good precision, and strata volumes with reasonable sampling error. Assessments will be made allowing for post stratification and confirmation of sample size as required.

The same five-point VRI cluster will be used for ground sampling. This cluster consists of a full-measured plot in the center of the point cluster, with four count plots 50 m at cardinal directions. For Lignum's IRMA, all auxiliary plots will be located, established and completed regardless of the type lines in existence on the current inventory.

The polygons have been chosen using the sorted polygon list process of the VRI, and have been restricted to forested (treed) polygons.

The following plot cards should be used in whole or in part:

- #1 Header Card.
- #2 Compass Card.
- #3 Cluster Layout Card.
- #8 Tree Detail Card.
- #10 Small Tree and Stump Card.

Some items from the VRI process related to trees should be gathered on the TEPs, including:

1. The Secondary Top Height measurement.

2. Tree Loss Indicator Card (TL,#9) (except as a worksheet to calculate “percent sound” on the Tree Detail Card, if necessary).

3. The small tree card will only use the tally from 1.3m height to 4cm dbh. Stump information should not be taken.

4. Slope, aspect, elevation, and old-growth (Yes or No) should be gathered, but perhaps not on the cards on which they now are entered.

These changes and any operational concerns were discussed with Nona Phillips, Regional Vegetation Inventory Officer of the Cariboo Forest Region, to ensure that the work was well coordinated with MOF.

There are no anticipated deviations from the processes and procedures described in Resources Inventory Committee publication #214 *“Vegetation Resources Inventory Ground Sampling Procedures.”* The main differences will be in the data selected for completion. There may be unforeseen problems that must be solved during the project. In these cases, Nona Phillips and Kim Iles (consultant to Lignum Ltd.) will coordinate technical issues.

Net Volume Adjustment Factor

Net volume for the Vegetation Resources Inventory (VRI) will be estimated by using net factoring and Net Volume Adjustment Factor (NVAF) sampling. Net factoring provides an initial net volume estimate of ground samples after a cruiser applies either individually or in combination a set of estimation and measurement rules to individual trees with visible decay. NVAF sampling provides an estimate of actual net merchantable volume based on felled tree measurements. It will be used to statistically adjust the cruiser's net merchantable volume of Phase II ground samples and will correct for possible taper equation error, net factor rule error, hidden decay in trees with no loss indicators or with no visible decay, and hidden loss indicators. The NVAF is calculated as a ratio of the actual net merchantable volume (based on NVAF stem analysis samples) to the cruiser's net merchantable volume (based on a check cruiser's estimate of the net merchantable volume of the stem analysis sample trees). The NVAF is then used to adjust the initial net volume Phase II estimate for the sampling unit.

NVAF sampling is a two-step operation. In the first step, the auxiliary plots of a random sub-sample of VRI plots are cruised. In the second step, the cruised trees are loaded into a sampling matrix and a random selection of trees is taken from each cell. All trees are selected with a known probability.

The objectives for the NVAF are as follows:

- To obtain a check cruiser's estimate of the net merchantable volume of sample trees.
- To obtain the actual net merchantable of trees cruised by a check cruiser.
- To calculate an unbiased NVAF estimate.

The MoF Resources Inventory Branch recommends a minimum of 75 sample trees be selected from the timber inventory samples for NVAF stem analysis. These sample trees should be distributed over 15 polygons.

IMPLEMENTATION STRATEGY

Implementation Process

The steps to complete the Lignum IFPA Inventory are:

1. Install a large number of the Timber Emphasis samples (e.g. over 60) and half of the 24 full Provincial VRI sample clusters over the Lignum IFPA area in the first field season (1997). This will provide the experience to refine the process for the second field season and will provide information to calculate the required number of remaining sample clusters.

2. Install the remaining sample clusters in the second field season (1998).

3. Install the NVAF samples in the second field season (1998). Note, if all of NVAF samples are unable to be completed during the 1998 field season, the remaining NVAF samples will be installed in the third field seasons (1999).

4. Begin the Phase I inventory in April 1998 and complete by December 1999.

Milestones, Scheduling, Responsibility

The following table (Table 1) outlines the milestones, anticipated schedule and responsibility for implementation of the Lignum IRMA inventory. Work that has been completed has been identified as "completed".

Table 1: Milestones, scheduling and responsibility for Lignum's IRMA Vegetation/Timber Inventory

Milestones	Schedule	Responsibility
Phase II - Ground Sampling		
First Field Season - 1997		
♦ Obtain Provincial VRI sample cluster information from the Resources Inventory Branch	April, 1997	Resources Inventory Branch (RIB)
♦ Assemble all District polygons	April, 1997	RIB
♦ Sort polygon list	April, 1997	RIB
♦ Select a large number of potential sampling points from list	April, 1997	RIB
♦ Select first year sample clusters from list	April, 1997	Lignum/RIB
♦ Plan for field sampling	April, 1997	Lignum
♦ Operational Support of Package Preparation	June-August, 1997	MoF Region
♦ Prepare field sampling plan with plot locations	August, 1997	Lignum
♦ Determine IPC Locations	July, 1997	MoF Region
♦ Locate and measure sample clusters (24 Full VRI Clusters and 60 Timber Emphasis Plots)	May-September, 1997	Lignum
♦ Operational Support of Field Sampling	August-October, 1997	MoF Region/Lignum
♦ Monitor QA of field data and procedures	May-September, 1997	MoF Region, Lignum
♦ Compile data from completed batches	Not Applicable	
Second Field Season – 1998		
♦ Plan for field sampling	January- March, 1998	Lignum
♦ Assemble all District polygons	March, 1998	RIB
♦ Sort polygon list	March, 1998	RIB

♦ Select a large number of potential sampling points from list for remaining samples	March, 1998	RIB
♦ Operational Support of Package Preparation	March - October, 1998	MoF Region
♦ Determine IPC Locations	March - April, 1998	MoF Region
♦ Locate and measure sample clusters (measuring only some tree attributes and site series)	April-September, 1998	Lignum
♦ Operational Support of Field Sampling	April-September, 1998	Lignum/MoF Region
♦ Monitor QA of field data and procedures	April-September, 1998	Lignum/MoF Region
♦ Compile data from completed samples	October - November, 1998	RIB

Net Volume Adjustment Factor		
♦ NVAF Ground Sample Selection	April, 1998	RIB
♦ Capture Auxiliary Plot Data	May - June, 1998	Lignum
♦ Validate Auxiliary Plot Data	July, 1998	MoF Region
♦ Select Trees	August, 1998	RIB
♦ Capture Stem Analysis Sample Data	September, 1998	Lignum
♦ QA Stem Analysis Sample Tree Data	September - October, 1998	RIB
♦ Compile Cruisers Standing Net Volume	October - December, 1998	RIB
♦ Compile Stem Analysis Sample Data	October - December, 1998	RIB
♦ Calculate NVAF	October - December, 1998	RIB

Phase I - New Photo Estimation		
♦ Develop Technical Plan (IFPA)	April - May, 1998	Lignum
♦ Evaluate Technical Plan (IFPA)	June, 1998	Lignum, MoF Region/RIB
♦ Delineate and Interpret Aerial Photos	September 1998 - March 1999	Lignum
♦ Capture and Validate Data	October 1998 - April 1999	Lignum
♦ Digitize Photos	October 1998 - April 1999	Lignum
♦ Integrate Data (i.e. Ancillary Data)	May 1998 - June 1999	Lignum. MoF Region
♦ Derive Slope, Elevation and Aspect	June 1999	Lignum

♦ Derive Additional Attributes	June - July 1999	Lignum
♦ Debriefing of Ministry of Forests	August 1999	Lignum, MoF Region, RIB

Adjust		
♦ Identify Adjustment Relationships	June - October, 1999	RIB
♦ Adjust Photo Estimation Data	June - October, 1999	RIB

Report		
♦ Prepare Report for Management Unit Inventory	October - November, 1999	Lignum

COST

The cost for the project is estimated as follows:

Table 2: Cost Requirements for Project

Milestone	# of Units	Cost/Unit $	Cost ($)
VRI Ground Sampling	24	5,300	127,200
IFPA Timber Emphasis Plots	350	2,350	822,500
Net Volume Adjustment Factor	75	650	48,750
Localization	619,841ha	1.25	774,801
Report	1	20,000	20,000
Total Cost			1,793,251

***** The cost and time deadlines are estimates based on Lignum's and MoF experience. If any revisions are to be made they will be done so under the Lignum Ltd. MYA (Multi-Year Agreement) on an annual basis.

POTENTIAL ISSUES OR CONSTRAINTS

At this time there are no issues or constraints.

APPROVAL/SIGNING

I have read and concur with the Lignum IFPA Inventory Plan, March 31, 1998. Modifications to this plan need to be reviewed and approved by the signatories.

Regional Manager, Cariboo Forest Region	Date
Director, Resources Inventory Branch	Date
Manager, Lignum Ltd	Date

Appendix 1: Map of Lignum's IFPA Area