Tree Farm Licence 33 – Management Plan 10

INFORMATION PACKAGE

Version 1.1

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Project 11-244

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List of Acronyms

AAC	Allowable Annual Cut
AOA	Archaeological Overview Assessment
AU	Analysis Unit
BCLCS	BC Land Classification System
BEC	Biogeoclimatic Ecosystem Classification
CFLB	Crown Forested Land Base
CFP	Canoe Forest Products Ltd.
CMI	Change Monitoring Inventory
DBH	Diameter at Breast Height
ERR	Enhanced Riparian Reserve
ESA	Environmentally Sensitive Area
ESSF	Engelmann Spruce Sub-alpine Fir
FAIB	Forest Analysis and Inventory Branch
FLNRORD	Ministry of Forests, Lands, Natural Resource Operations and Rural Development
FSP	Forest Stewardship Plan
GAR	Government Actions Regulation
GIS	Geographic Information System
ICH	Interior Cedar Hemlock
IP	Information Package
LRMP	Land and Resource Management Plan
LU	Landscape Unit
MAI	Mean Annual Increment
MHA	Minimum Harvest Age
MOE	Ministry of Environment
MP	Management Plan
NDT	Natural Disturbance Type
NRL	Non-Recoverable Losses
OAF	Operational Adjustment Factor
OGMA	Old Growth Management Area
SIA	Site Index Adjustment
TFL	Tree Farm Licence
THLB	Timber Harvesting Land Base
TIPSY	Table Interpolation of Stand Yields
TSA	Timber Supply Area
TSR	Timber Supply Review
VAC	Visual Absorption Capacity
VDYP	Variable Density Yield Projection
VQO	Visual Quality Objective
WTP	Wildlife Tree Patch
WTR	Wildlife Tree Retention

Document Revision History

Version	Date	Description
1.0	January 2020	Initial Information Package submitted to FAIB for review.
1.1	February 2020	Revisions completed as a result of initial review by FAIB. These included additional clarifications and/or supporting information.

1 Introduction

Canoe Forest Products Ltd. (CFP) is the holder of Tree Farm Licence 33 (TFL 33), and is currently in the process of preparing Management Plan (MP) #10. This Information Package (IP) outlines the basic information and assumptions used to prepare the timber supply analysis that will become part of MP #10. The purpose of the timber supply analysis is to examine the short- and long-term effects of current forest management practices on the availability of timber for harvesting.

A review of this type is normally completed at least once every ten years in order to capture changes in data, practices, policy, or legislation influencing forest management in the TFL. The last timber supply analysis for TFL 33 was completed in the year 1999 when Management Plan #8 was prepared. An updated timber supply analysis was not completed when Management Plan #9 was submitted in 2005. In March 2011, the Chief Forester of British Columbia made an Allowable Annual Cut (AAC) determination using the analysis completed in 1999, with consideration of factors that might change the timber supply since that analysis was completed. Based on the date of the last determination, the goal is to have a new AAC determination and approved MP in place by March 31, 2021.

Following acceptance of this Information Package by Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) staff the timber supply analysis will be completed and documented in a draft Timber Supply Analysis Report. A draft Management Plan and this draft Analysis report will then undergo public review and First Nations consultation.

The timber supply analysis will model timber harvest over a 300 year planning horizon. It will use forest inventory information that has been updated to reflect previous harvesting and reforestation activities, LiDAR generated attributes, CFPs current understanding of the land base where harvesting is likely to occur, and projected growth rates as the forest ages. The modelling will also consider non-timber objectives for the TFL, including wildlife, biodiversity, and visual landscape quality. The Base Case scenario will represent current management practices and legal requirements that influence timber supply. Additional scenarios will examine sensitivity to factors where there is uncertainty, such as growth and yield estimates.

Together, the sensitivity analyses and the Base Case form a solid foundation for discussions about future timber harvest levels. Once completed, the timber supply analysis will provide information to assist the Chief Forester of BC in determining an AAC for TFL 33.

1.1 TFL 33 LOCATION

TFL 33 covers an area of 8,396 hectares and is situated within the Columbia wet-belt on the western slopes of the Shuswap Mountain Range. It lies immediately to the north of the District Municipality of Sicamous adjacent to Shuswap Lake (see Figure 1). The elevation ranges from approximately 347 metres at lake level to approximately 1700 metres on Queest Mountain. There are six biogeoclimatic subzones in the TFL, including ICHmw2, ICHwk1, ICHdw4, ESSFwc2, ESSFwcp, and ESSF wcw.

Access through TFL 33 is important for both summer and winter sports (mountain biking, hiking, ATV'ing, and snowmobiling. Hunters also utilize the access through the TFL in the fall. Access along the foreshore adjacent to the TFL is by boat only, and houseboats use the Provincial Park system for moorage during the summer. Visual quality of TFL 33 as seen from Shuswap Lake is an important management consideration.

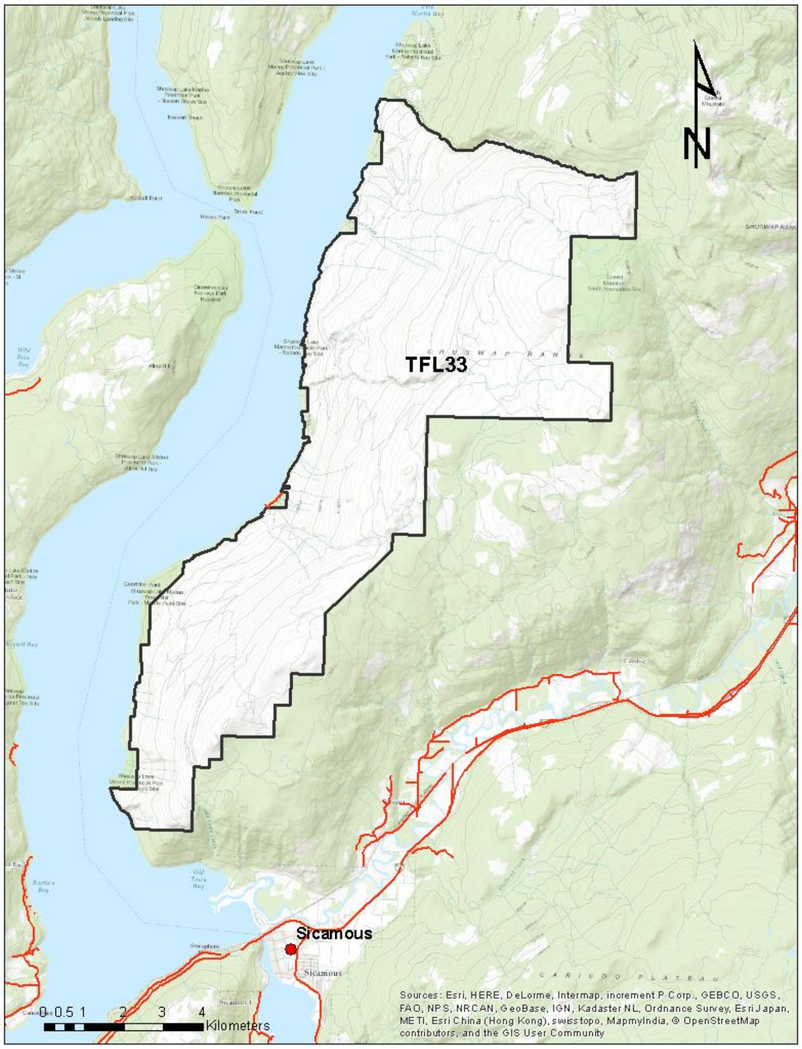

Figure 1 TFL 33 overview map

2 Process

This Information Package has been prepared to meet the requirements outlined in the draft "*Provincial Guide for the Submission of Timber Supply Analysis Information Packages for Tree Farm Licences, Version 5, June 2013*" document. Current forest and non-forest inventories, legal requirements, and non-legal management direction were used to categorize the land base and outline proposed modelling parameters that will be used to complete a Base Case scenario and additional sensitivity analyses.

2.1 MISSING DATA

There is no missing data for this version of the Information Package.

3 Response to 2011 AAC Determination Implementation Requests

The Chief Forester did not provide any specific implementation requests in the 2011 AAC determination. However, he did recognize that there was uncertainty in a number of factors. These factors and responses to how they have been addressed in the current analysis are outlined below.

3.1 SITE PRODUCTIVITY

Description of Uncertainty: Studies in 2003 and 2006 support localized site indices for post-harvest regenerated stands that are significantly higher than indicated for natural stands in the inventory. In the absence of a new timber supply analysis, the impact on the harvest forecast has not been quantified. For this determination, the new information on site productivity indicates that the mid- and long-term timber supply is underestimated by an unquantified but potentially significant amount.

Response: The Base Case scenario will use the results from the 2003 study completed by J.S. Thrower and Associates Ltd. that developed estimates of managed stand site indices for TFL 33. The Provincial Site Productivity Layer does not contain complete information for TFL 33 so it cannot be used for comparison purposes. A review of results from Change Monitoring Inventory plots and LiDAR derived heights is included.

3.2 GENETIC IMPROVEMENT

Description of Uncertainty: Genetic gains are expected to be higher than assumed in the base case. As a result mid- and long-term timber supply is underestimated by an unquantified amount.

Response: Genetic gains for existing managed stands were developed using planting records for TFL 33 and provincial genetic worth estimates by seedlot.

3.3 CARIBOU WINTER RANGE

Description of Uncertainty: Recent reductions in the amount of caribou habitat identified on TFL 33 have removed significant constraints from timber harvesting. I conclude that the short and mid-term timber supply is underestimated by 10 percent to 20 percent.

Response: This analysis incorporates direction from Government Actions Regulation (GAR) #u-8-004 which provides management requirements for mountain caribou habitat within TFL 33.

3.4 DEER WINTER RANGE

Description of Uncertainty: In 2006, the area identified as deer winter range was reduced but more intense management was required resulting in a risk of an unquantified but minor overestimation in the mid-term timber supply.

Response: This analysis incorporates direction from GAR order #u-8-001 which provides management requirements for mule deer within TFL 33.

3.5 OPERATIONAL ADJUSTMENT FACTORS

Description of Uncertainty: While I accept that the OAF assumptions used in the base case are currently the best available, significant uncertainty is demonstrated by the licensee's survey suggesting the assumed OAF 1 may be high, and the emerging science about the impact of root disease suggesting the assumed OAF 2 may be low. I view the risk associated with OAF 2 as significant as it could result in an overestimation of the mid- and long-term timber supply.

Response: Canoe Forest Products Ltd. uses stump removal techniques in stands where root disease is present and terrain conditions permit. In addition, mixed species planting is routinely used. Because these strategies reduce the potential impacts from root disease, CFP believe the standard OAFs to be appropriate. However, the Base Case will use an OAF2 of 10% in Douglas-fir and Cedar leading stands to be consistent with the approach used in the 2017 Okanagan TSA Timber Supply Review Data Package. A sensitivity analysis will explore the timber supply implications of using the standard OAF2 of 5%.

4 Timber Supply Forecast/Options/Sensitivity Analysis

4.1 BASE CASE

The Base Case is considered to be representative of current management practice on TFL 33. There have been a number of changes incorporated into this analysis when compared with the analysis completed in 1999. The most significant of these include the following:

- Inventory attributes updated using LiDAR. Although this update did not follow published FLNRORD standards, it appears that current volumes may be better represented than if the original inventory had simply been projected. Sensitivity analyses will provide insight into the timber supply implications due to uncertainty in growth and yield projections.
- Development of improved site index estimates for managed stands
- Updated version of VDYP used for natural stand yield tables
- Updated version of TIPSY used for managed stand yield tables
- Approval of a Government Actions Regulation (GAR) Order to guide caribou management
- Approval of a GAR Order to guide mule deer management
- Completion of terrain stability mapping, to be used instead of ESA mapping
- Use of Old Growth Management Areas to meet landscape level biodiversity objectives
- Use of a heuristic timber supply model rather than a simulation model

4.2 SENSITIVITY ANALYSIS

Sensitivity analyses provide a measure of the reasonable upper and lower bounds of the harvest forecast, reflecting the uncertainty of assumptions made in the Base Case. The magnitude of the increase and decrease in the sensitivity variable reflects the degree of uncertainty surround the assumption associated with that given variable. By developing and testing a number of sensitivity analyses, it is possible to determine which variable most influence results. To allow meaningful comparison of sensitivity analyses, they are usually performed using the Base Case and varying only the assumption being tested. An overview of the anticipated sensitivity analyses that will be carried out is summarized in Table 1, with further details provided in Section 13.

Table 1 Sensitivity analyses

Category	Sensitivity
Land Base Definition	THLB Area +/- 10%
Growth and Yield	Natural Stand Yields +/- 10%
	Managed Stand Yields +/- 10%
	Minimum Harvest Ages +/- 10 years
	Standard OAF2 of 5%
Integrated Resource Management	None anticipated at this time
Timber Harvesting	Turn off cutblock aggregation (no minimum cutblock size)

4.3 ALTERNATE HARVEST FLOWS

Non-timber management objectives, existing stand volumes, and the growth capacity of the Timber Harvesting Land Base (THLB) will determine the harvest flow options that will be considered. In general, the choice of harvest flow for the Base Case will strive to balance current and future harvest rates using the following objectives:

- Avoid any large or abrupt disruptions in timber supply during transitions from short to mid to long-term periods (generally increases and decrease in steps of 10% per decade)
- Achieve a stable long-term harvest level over a 300 year planning horizon
- Ensure that the growing stock on the THLB does not decline during the last 50 years of the planning horizon.

Options for alternative harvest flows will become more evident after the initial timber supply model is built and the timber supply dynamics for the TFL 33 land base become evident. Examples of potential options include maintaining the current allowable annual cut for as long as possible or minimizing the length of a mid-term harvest reduction if one exists. CFP will explore and include alternative harvest flow options in the analysis report, and present the recommended option as the Base Case.

4.4 OTHER OPTIONS

There are not additional scenarios beyond the Base Case and sensitivity analyses identified at this time.

5 Model

The PATCHWORKS ™ modeling software will be used for forecasting and analysis. This suite of tools is sold and maintained by Spatial Planning Systems Inc. of Deep River, Ontario (www.spatial.ca).

PATCHWORKS is a fully spatial forest estate model that can incorporate real world operational considerations into a strategic planning framework. It utilizes a practical goal seeking approach to simulate forest growth and schedule activities such as harvesting and silviculture across the land base to find a solution that best balances the targets/goals defined by the user. Realistic spatial harvest allocations can be optimized over long-term planning horizons because PATCHWORKS integrates operational-scale decision making within a strategic analysis environment.

The PATCHWORKS model continually generates alternative solutions until the user decides a stable solution has been found. Solutions with attributes that fall outside of specified ranges (targets) are penalized and the goal seeking algorithm works to minimize these penalties, resulting in a solution that reflects the user objectives and priorities.

Targets can be applied to any aspect of the problem formulation. For example, the solution can be influenced by issues such as desired mature/old forest retention levels, young seral disturbance levels, patch size distributions, conifer harvest volume, growing stock levels, and visual quality objectives. For this analysis, PATCHWORKS will be configured to consider the range of non-timber values that exist on TFL 56 while evaluating possible harvest flows.

6 Data Sources

To ensure that all forest management objectives are appropriately considered a broad set of timber and non-timber forest resource datasets have been compiled. Table 2 describes the data used to build the TFL 33 resultant file which is stored within an ArcGIS geodatabase and will be used to support forest estate modelling.

Table 2 Spatial data sources

Description	Source File Name	Source	Year
TFL Boundary	FADM_TFL	BCGW*	2019
Existing Roads	TFL33_Roads	CFP	2019
Streams from CP Development	TFL33_cutblock_streams	CFP	2019
Streams from LiDAR	Streams_1, Streams_2, Streams_3, Streams_4	Forsite	2015
Freshwater Atlas Streams	FWA_STREAM_NETWORKS_SP	BCGW	2019
Enhanced Riparian Reserves	TFL33_ERR	CFP	2019
LiDAR Digital Elevation Model	DEM	Forsite	2015
LiDAR Slopes	Slope_pct_20m	Forsite	2015
Old Growth Management Areas	TFL33_OGMA	CFP	2019
Biogeoclimatic Ecosystem Classification (BEC) version 5	BECv5	BECweb	2003
Biogeoclimatic Ecosystem Classification (BEC) version 6	BECv6	BECweb	2006
Biogeoclimatic Ecosystem Classification (BEC) version 11	BECv11	BCGW	2019
Shuswap Lake Lakeshore Management Zone	Shuswap_LMZ	Forsite	2019
Recreation Line Features	WHSE_FOREST_TENURE_FTEN_RECREATION_LINES_SVW	BCGW	2019
Visual Landscape Inventory	WHSE_FOREST_VEGETATION_REC_VISUAL_LANDSCAPE_INVENTORY	BCGW	2019
Terrain Stability	TFL33_Terrain_Stability_2001	CFP	2019
Caribou GAR	Tuwra_u-8-004.shp (downloaded from http://www.env.gov.bc.ca/wld/frpa/uwr/approved_uwr.html	MOE	2019
Mule Deer Winter Range GAR	Tuwra_u-8-001.shp (downloaded from http://www.env.gov.bc.ca/wld/frpa/uwr/approved_uwr.html)	MOE	2019
Forest Inventory	TFL33_Inventory_20191216	Forsite	2019
Wildlife Tree Patches	TFL33_WTP_20191213.shp	CFP	2019
Proposed Cutblocks	Proposed_blks	CFP	2019

* BC Geographic Warehouse (BCGW)

7 Current Forest Cover Inventory

TFL 33 has not had an entirely new inventory completed since 1977. However, there have been periodic updates for disturbance and silviculture since then, along with updated projections of age, height and volume. Recognizing the older vintage of the inventory, Canoe Forest Products elected to use LiDAR to improve the inventory for use in this Management Plan.

Data sources used to improve the inventory included LiDAR acquired in 2015, recent photography, spatial depletion layers, and silviculture records. The general approach used was:

- Update polygon boundaries where they were obviously incorrect using the LiDAR canopy height model and recent photography
- Update for depletions
- Update ages and species for new openings using silviculture records
- Update stand height using LiDAR
- Update crown cover using LiDAR
- Update stems per hectare using LiDAR and silviculture records
- Update site index for stands greater than 20 years old using LiDAR heights and inventory ages

Further details concerning the approach used to improve the inventory are provided in Appendix 1. In order to provide confidence that this updated inventory is suitable for use in the preparation of the new TFL Management Plan, a comparison of operational cruise volume to volumes predicted by VDYP 7 was completed for both the updated inventory and the original inventory. This analysis suggests that the updated inventory provides a much better estimate of volume than the original inventory. Overall, the volumes predicted by VDYP for the updated inventory were 98.1% of those estimated in the cruises. However, there were differences observed for the two biogeoclimatic zones in the TFL. The VDYP volumes were 5.9% higher than the cruise volumes in the ICH, and only 80.2% of the cruise volumes in the ESSF. Further details regarding this analysis are provided in Appendix 2.

8 Description of the Land Base

This section describes the land base data and assumptions used to define the crown forested land base (CFLB) and timber harvesting land base (THLB) in TFL 33. The THLB is designated to support timber harvesting while the CFLB is identified as the broader productive forest that can contribute toward meeting non-timber objectives such as wildlife habitat and biodiversity.

8.1 TIMBER HARVESTING LAND BASE

The timber harvesting land base definition begins with the total land area within the TFL boundaries, and applies the various legal, regulatory and operational classifications necessary to determine the CFLB and the THLB. Land base reductions often overlap on the same area. Although it is important to know the entire area within each reduction category, it is also important to account appropriately for these overlaps when determining the net area available for forest management activities. Table 3 summarizes the area reductions made to the total area of TFL 33 to determine the THLB. Reductions are applied in the order presented in the table using a step wise process to ensure that area is only removed once. In the table, gross area refers to the total area covered by the item, and net area refers to the incremental reduction after considering areas that were removed in previous lines in the table. Detailed descriptions of these reductions are provided in subsequent sections of this Information Package.

Table 3 TFL 33 land base area summary

Land Base Element	Gross Area (ha)	CFLB Area (ha)	Net Area (ha)	Percent of Total Area (%)	Percent of CFLB (%)
Total area	**8,396**		**8,396**	**100.0%**	
Less:					
Non-Forest	180		180	2.1%	
Existing Roads, trails and landings	176		172	2.0%	
Crown Forested Land Base (CFLB)			**8,044**	**95.8%**	**100.0%**
Less:					
Caribou Habitat	22	1	1	0.0%	0.0%
Queest Mountain Snowmobile Trail	14	10	10	0.0%	0.1%
Unstable Terrain	911	882	565	6.7%	7.0%
Riparian Management Areas	83	79	60	0.7%	0.7%
Enhanced Riparian Reserves	66	66	49	0.6%	0.6%
Non-Merchantable Deciduous Leading	60	59	46	0.5%	0.6%
Non-Merchantable Conifer Leading	301	271	188	2.2%	2.3%
Old Growth Management Areas	304	303	246	2.9%	3.1%
Existing Wildlife Tree Patches	133	131	106	1.3%	1.3%
Timber Harvesting Land Base (THLB) - Current			**6,774**	**80.7%**	**84.2%**
Less:					
Future Wildlife Tree Retention			363	4.3%	4.5%
Less:					
Future Roads and Landings (aspatial)			68	0.8%	0.8%
Future Timber Harvesting Land Base			**6,343**	**75.6%**	**78.9%**

Figure 2 provides a map of the land base classification. It can be seen that only a small portion of TFL 33 (~ 4%) is excluded from the CFLB, and that the majority of the CFLB (~86%) is considered to be THLB.

In comparison with the previous Information Package completed in 1999, the CFLB is 366 hectares (4.8%) larger. This is the result of changing the definitions for non-productive forest to be consistent with those currently used for other timber supply analyses in British Columbia. There have been a number of changes to inputs and assumptions that are used to determine the THLB (e.g. old growth management areas, terrain stability, etc.) since 1999. The net result is a reduction in THLB of 205 hectares (2.9%) when compared to the 1999 analysis.

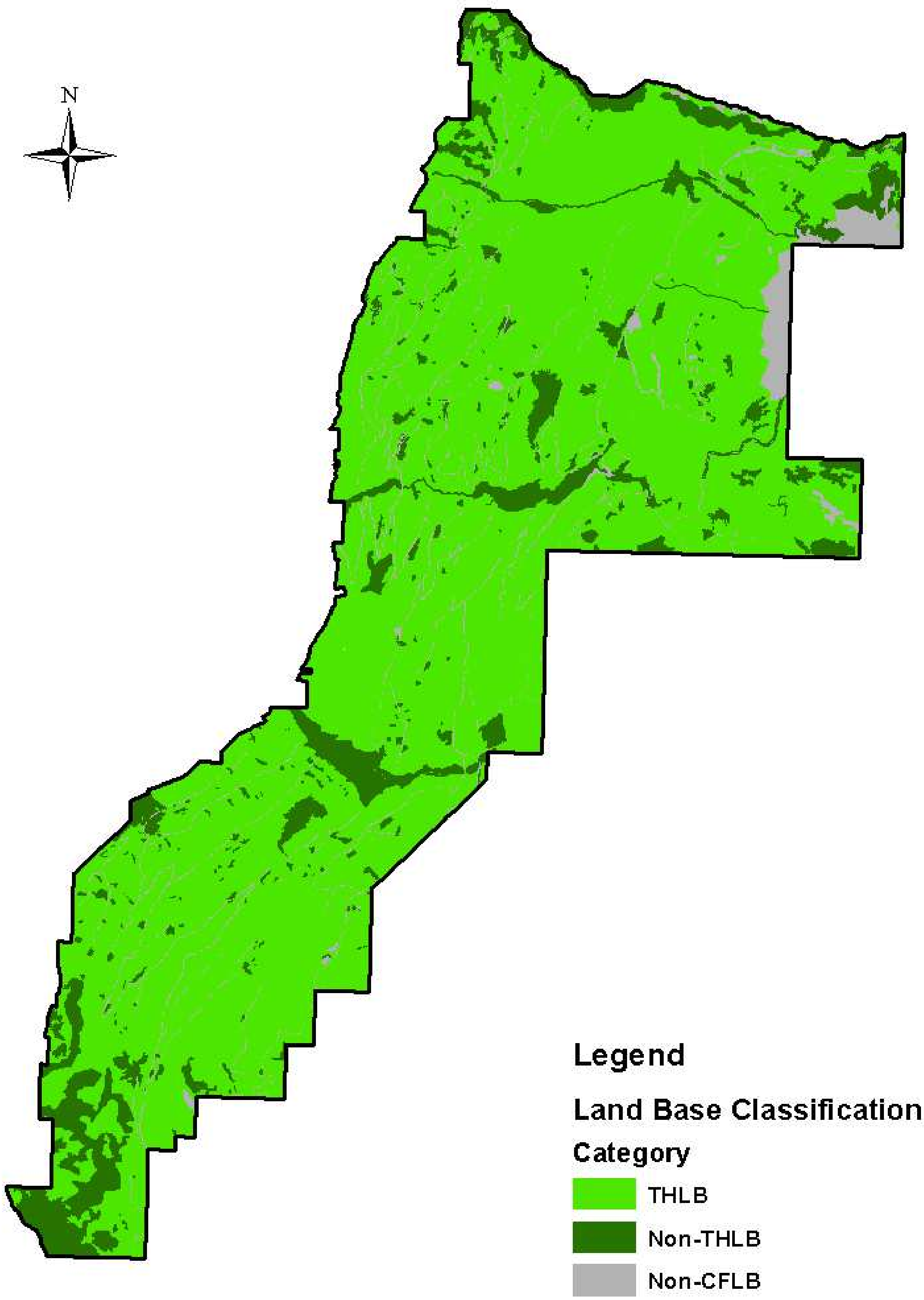

Figure 2 TFL 33 Land base classification

8.1.1 AGE CLASS DISTRIBUTION

The current age class distribution for TFL 33 is summarized in Table 4 and illustrated in Figure 3. Roughly 48% of the THLB is less than 60 years old, reflecting the harvest history on the TFL. In contrast, roughly 97% of the non-THLB is at least 80 years old, and about 84% is at least 120 years old.

Table 4 Age class distribution

Age Class (years)	THLB Area (ha)	Non-THLB Area (ha)	Total CFLB Area (ha)
< 10	784	2	786
10- 19	324	13	338
20- 29	665	2	667
30- 39	1,030	2	1,032
40- 49	365	1	366
50- 59	110	0	110
60- 69	376	12	388
70- 79	95	4	99
80- 89	559	104	663
90 - 99	7	56	63
100-109	11	6	17
110-119	23	3	26
120-129	104	41	145
130-139	86	42	128
140-149	191	85	276
150-159	370	163	533
160-169	181	141	321
170-179	400	217	618
180-189	468	168	636
190-199	137	19	156
200-209	4	15	20
210-219	267	78	345
220-229	21	6	26
230-239	162	25	187
240-249	0	0	2
>= 250	34	64	98
Total	**6,774**	**1,270**	**8,044**

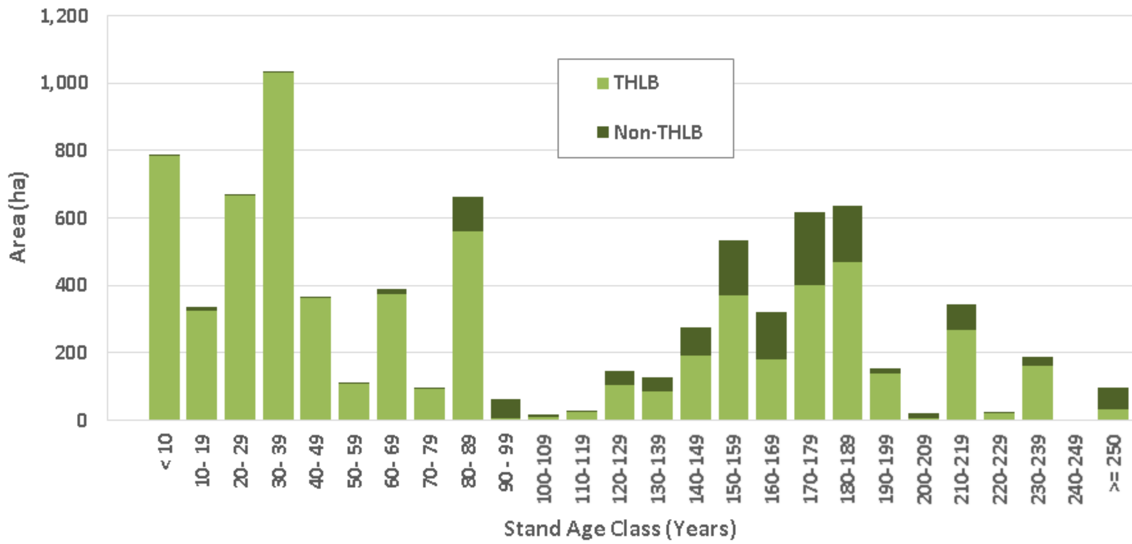

Figure 3 Age class distribution

8.1.2 SPECIES COMPOSITION

The species composition derived from individual stand composition percentages for the THLB and non-THLB area is shown in Figure 4. Douglas-fir (27.2%) is the predominant species on the THLB. Spruce (16.4%), cedar (15.9%), subalpine fir (14.7%), and hemlock (10.4%) are the next most common species on the THLB. Larch, lodgepole pine, white pine and deciduous species are all present in smaller amounts.

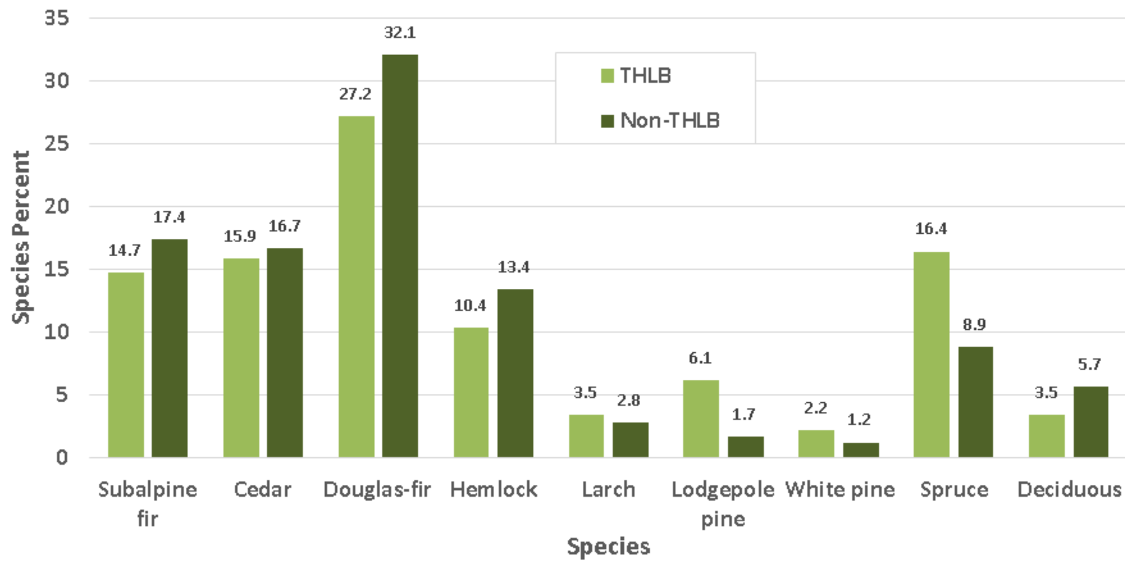

Figure 4 Overall species composition derived from individual stand composition percentages

8.1.3 BIOGEOCLIMATIC CLASSIFICATION

The area distribution of biogeoclimatic classifications and natural disturbance types (NDT) for the THLB, non-THLB, and non-CFLB are shown in Figure 5, and the spatial distribution of BEC variants is shown in Figure 6. The majority of the TFL is in the Interior Cedar Hemlock zone (ICH), with similar representation in three different ICH variants. The remainder of the TFL is in the Engelmann Spruce Subalpine Fir (ESSF) biogeoclimatic zone.

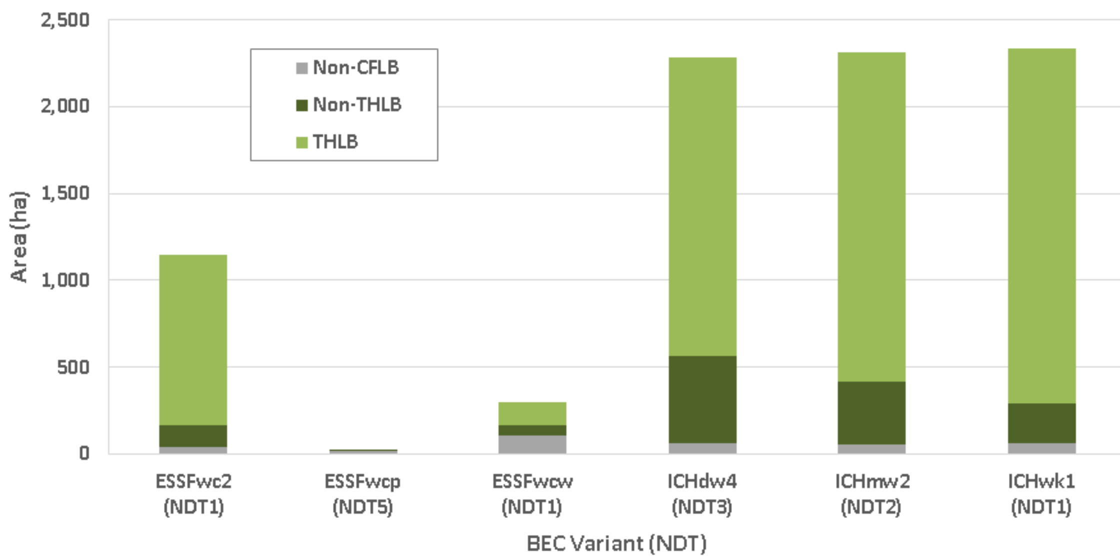

Figure 5 Area distribution of BEC (version11) variants

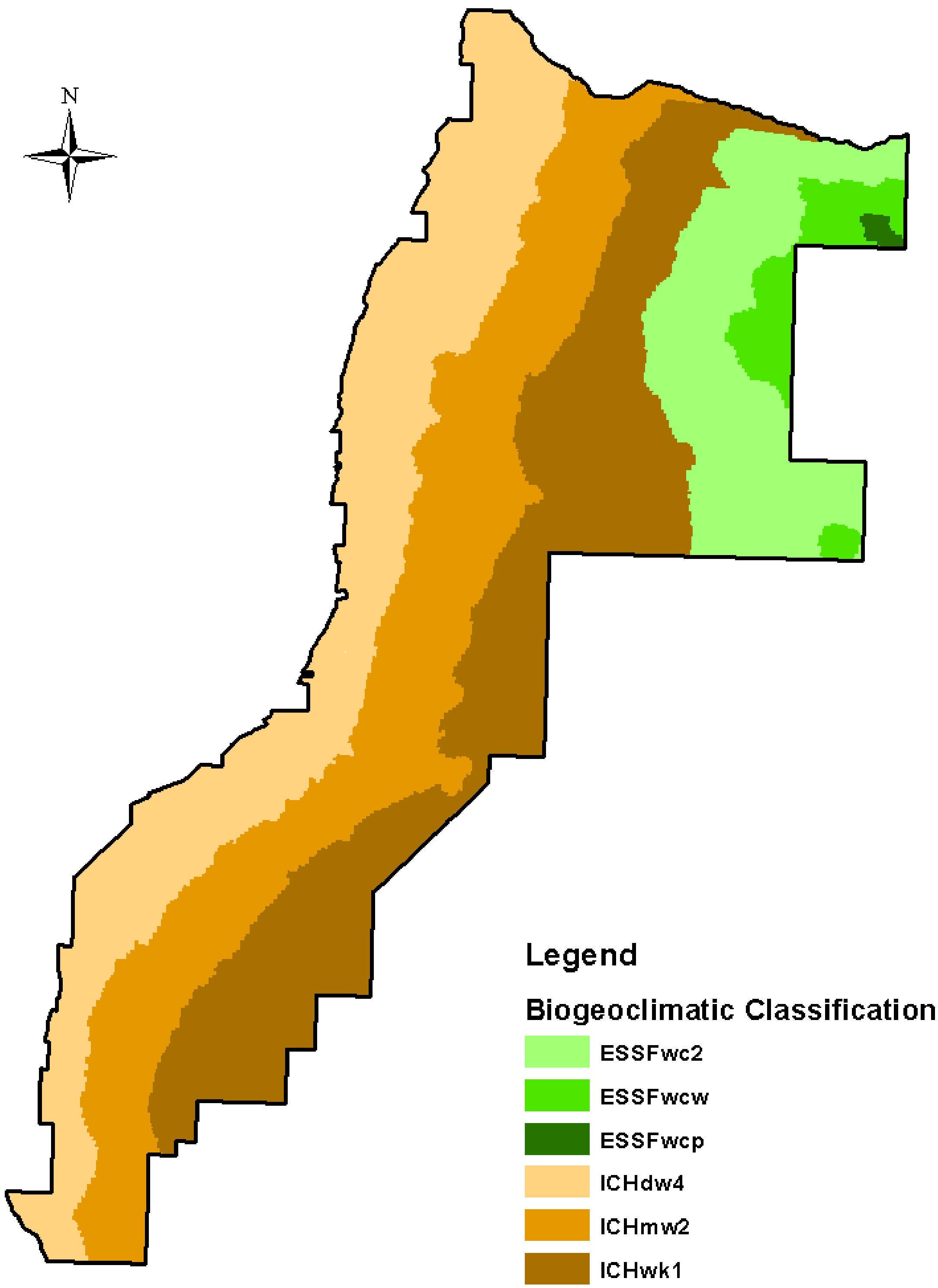

Figure 6 Spatial distribution of BEC variants

8.2 TOTAL AREA

The gross area within the mapped TFL 33 boundary is 8,396 hectares. This is an increase of 30 hectares from the area reported in the Information Package completed in 1999 for Management Plan #8. The boundary used in 1999 is no longer available to allow a detailed comparison of the source of the difference. However, as there have been no additions or deletions from the TFL since 1999, the difference is most likely the result of evolving digital mapping standards and data over time.

8.3 NON-CROWN LANDS

There is no non-Crown land within the TFL 33 boundary.

8.4 NON-FOREST/NON-PRODUCTIVE FOREST

BC Land Cover Classification (BCLCS) attributes are not available in the updated forest inventory. Therefore, the "*NPFORESDE*" attribute was used to identify non-forested polygons. This attribute was largely carried over from the original inventory with only a few changes where imagery and LiDAR data indicated the polygon is forested.

In addition to using this the "*NPFORESDE*" attribute, polygons with a site index less than or equal to five metres were also classified as non-forest. Table 5 summarizes the areas considered to be non-forested and removed from the CFLB.

Table 5 Non-forest area summary

Non-Forest Description	Criteria	Gross Area (ha)	Removed Area (ha)
Alpine	NPFORESTDE = "A"	133.1	133.1
Lake	NPFORESTDE = "L"	1.0	1.0
Rock	NPFORESTDE = "R"	9.4	9.4
Wetland	NPFORESTDE = "SWAMP"	2.6	2.6
Low Site Index	SI2019 <= 5.0	33.4	33.4
No Typing Available	POLY_ID = 0 (forest inventory data missing)	0.2	0.2
Total		**179.7**	**179.7**

8.5 ROADS TRAILS AND LANDINGS

8.5.1 EXISTING ROADS, TRAILS AND LANDINGS

Canoe Forest Products Ltd. maintains a spatial road database for their operations, including the area covered by TFL 33. This data was reviewed by CFP staff and roads were classified into three different widths to represent the permanent non-productive area occupied by the roads. These roads were then buffered to account for the area not expected to grow trees in the future.

These road buffers were also compared to the roads identified in the RESULTs silviculture inventory layer. It was found that the roads from RESULTs were already included in the buffered road layer, and that road widths were generally the same regardless of the data source. However, the buffered roads from CFP's spatial road database provided a more complete representation of the road network (i.e. not all buffered roads were in the RESULTs data). Therefore, the roads from RESULTs were not included in the analysis as a separate data source. Table 6 summarizes the resulting netdown for existing roads within TFL 33.

Table 6 Existing road summary

Road Classification	Length (km)	Buffer (m)	Gross Area (ha)	Removed Area (ha)
Main: 13 metre	44.9	13.0	58.4	57.6
Secondary: 10 metre	104.6	10.0	104.6	101.2
Tertiary: 5 metre	27.8	5.0	13.9	13.3
Total	**177.3**		**176.9**	**172.1**

8.5.2 FUTURE ROADS, TRAILS, AND LANDINGS

The permanent road network on TFL 33 is well developed, with most of the TFL in close proximity to an existing road. Existing roads have been removed from the THLB and it can be assumed that all stands with a logging history will need no further area reduction for future roads. These roads can be used as the basis for determining the approximate area required to account for future roads, as follows:

The current THLB area with a logging history is 3,049.6 hectares. There are another 110.7 hectares within the permanent road buffers that do not overlap with another land base reduction and that have a logging history. Therefore, the proportion of THLB removed for permanent roads in stands with a logging history is 3.50%, calculated as:

Permanent road proportion = 110.7 ha / (3,049.6 ha + 110.7 ha) = 3.50%

The remaining THLB without a logging history is 3,361.5 hectares. However, there are already some existing access roads (i.e. roads between existing cutblocks) within this area. This area within permanent road buffers that does not overlap with another land base reduction and that does not have a logging history is 51.7 hectares. Therefore, the additional area required for future roads is 67.8 hectares, calculated as:

*Total future roads = 3.50% * (3,361.5 ha + 51.7 ha), less 51.7 ha = 67.8 ha*

This reduction will be applied as a yield table adjustment off 2.07% for future managed stands, calculated as:

Reduction factor = 67.8 ha / 3,361.5 ha = 2.02%

8.6 MOUNTAIN CARIBOU HABITAT

Government Actions Regulation (GAR) Order #u-8-004 was amended in December, 2009 and specifies General Wildlife Measures to manage for mountain caribou within a polygon that overlaps with TFL 33. These General Wildlife Measures indicate that harvesting cannot take place within sub-alpine parkland ecosystems. Accordingly, all ESSFwcp (BEC version 11) within the area covered by the GAR order was removed from the THLB. The gross area of ESSFwcp within caribou habitat in TFL 33 is 21.7 hectares, of which 0.7 hectares is productive forest and part of the CFLB. After accounting for other reductions to the land base, the net area removed from the THLB was 0.7 hectares.

8.7 RECREATION TRAILS

Portions of the Queest Mountain Snowmobile Trail pass through TFL 33. Although there is no legal objective for this trail, the CFP FSP indicates that depending on availability, 50% of the the pre-harvest basal area within 50 metres of the trail will be retained. To account for the requirements of this commitment, a 25 metre buffer on each side of the trail was removed from the THLB. The total area within this buffer is 13.8 hectares, of which 9.9 hectares is in the CFLB. The net area removed from the THLB after accounting for previous netdown categories is 9.9 hectares.

8.8 INOPERABLE/ INACCESSIBLE AREAS

Inoperable areas are those portions of the land base where harvesting is not feasible due to terrain characteristics or lack of access. Canoe Forest Products Ltd. considers all of TFL 33 to be operable and accessible, and has demonstrated harvest performance relative to the profile in all slope classes, as summarized in Table 7. Therefore, no reductions will be made to account for inoperable or inaccessible areas.

Table 7 Harvest area by slope class from 2005 to 2019

Slope Class	Area by Harvest System (ha)				Harvest Percent	THLB Percent	TFL Percent
	Conventional	Hoe Chuck	Cable	Total			
0 – 10%	27.6	1.1	0.4	29.1	3.7%	6.9%	9.9%
10 – 20%	148.1	5.4	2.5	156.0	19.8%	20.9%	24.8%
20 – 30%	181.9	17.2	6.3	205.4	26.1%	24.2%	23.6%
30 – 40 %	126.0	45.8	23.5	195.3	24.8%	21.3%	18.5%
40 – 50%	36.5	29.8	43.7	110.0	14.0%	13.9%	11.1%
50 – 60%	6.2	7.1	43.0	56.3	7.2%	7.3%	6.3%
60 – 70%	1.0	0.8	23.7	25.5	3.2%	3.3%	3.2%
> 70%	-	0.1	8.7	8.8	1.1%	2.2%	2.6%
Total	**527.3**	**107.3**	**151.8**	**786.4**	**100.0%**	**100.0%**	**100.0%**

8.9 UNSTABLE TERRAIN

Section 37 of the Forest Planning and Practices Regulation requires that a primary forest activity does not cause a landslide that has a material adverse effect. One of the tools that forest companies use to address this requirement is terrain stability mapping that identifies areas where there is potential for landslides.

Level C (detailed) terrain stability mapping has been completed for the entire TFL 33 land base and was used for this analysis. A review of harvesting history for the last 10 years shows very little harvesting in terrain class V and that harvesting in terrain class IV is approximately 56% of the expected amount if it was all accessible. Accordingly, all terrain class V and 50% of terrain class IV area will be removed from THLB with the exception of previously logged stands which will remain in the THLB.

Table 8 summarizes the area removal to account for unstable terrain. The total area contained within terrain stability class IV and V polygons that have not been logged is 910.7 hectares, of which 881.8 hectares is forested and part of the CFLB. The net area removed from the THLB after accounting for area removed as a result of previous netdown categories and the partial netdown for terrain class IV is 565.3 hectares.

Table 8 Unstable terrain summary

Terrain Class	Criteria	Gross Area (ha)	CFLB Area (ha)	Removed Area (ha)
IV	20% Aspatial reduction for unlogged areas	548.9	522.8	206.3
V	100% Spatial reduction for unlogged areas	361.8	359.0	359.0
Total		**910.7**	**881.8**	**565.3**

8.10 RIPARIAN MANAGEMENT AREAS

Riparian management areas are designed to minimize the impacts of harvesting in areas immediately adjacent to water bodies, including streams, lakes, and wetlands. A riparian management area consists of a riparian management zone in which harvesting activity is restricted through basal area retention requirements, and depending on the water body classification may also include a riparian reserve zone immediately adjacent to the water body. Harvesting is fully excluded within the reserve zone. Riparian classifications were assigned to water features using the following approach:

8.10.1 STREAM CLASSIFICATION

CFP maintains a spatial GIS layer that contains classifications for stream segments associated with cutblocks, where stream classifications are determined at the time of cutblock layout. Streams generated using LiDAR data were then used to fill in the gaps between these stream segments. For areas of the TFL where there is little recent development, streams from the provincial Fresh Water Atlas were used to identify additional LiDAR based streams that should be incorporated. Maps from Reconnaissance Fish and Habitat Inventories completed in 2000 were also referenced to verify stream class where possible. As a final check, staff from Canoe Forest Products reviewed the stream classification and made minor adjustments based on their local knowledge of the TFL.

8.10.2 LAKE CLASSIFICATION

Lakes were extracted from the forest cover inventory using the "*NPFORESTDE*" attribute and cross referenced with lakes from the provincial Fresh Water Atlas. There was only one small lake identified within the TFL, and it was too small to be classified (i.e. less than one hectare) as a lake requiring a riparian buffer.

8.10.3 WETLAND CLASSIFICATION

Wetlands were extracted from the forest cover inventory using the "*NPFORESTDE*" attribute and cross referenced with wetlands from the provincial Fresh Water Atlas. Although there were seven small wetlands identified within the TFL, they were all less than the minimum size (i.e. less than one hectare) to be classified as a wetland requiring a riparian buffer.

8.10.4 RIPARIAN NETDOWN

CFPs management of riparian management areas follows the practices outlined in their approved Forest Stewardship Plan (FSP). An equivalent riparian management area width was calculated for each riparian class by considering the widths of the riparian reserve zone and riparian management zone, along with the percentage basal area retention within the management zone. Buffer polygons were then generated around the riparian features and removed from the THLB.

Table 9 summarizes the buffer widths and area reductions for riparian features. The total area contained within riparian management area buffers is 82.6 hectares, of which 79.3 hectares is forested and part of the CFLB. The net area removed from the THLB after accounting for area removed as a result of previous netdown categories is 59.9 hectares.

Table 9 Riparian buffers

Riparian Class	Reserve Zone (m)	Management Zone (m)	RMZ Basal Area Retention (%)	Equivalent RMA Buffer (m)	Gross Area (ha)	CFLB Area (ha)	Removed Area (ha)
S1 streams	50	20	50	60	-	-	-
S2 streams	30	20	50	40	25.9	24.2	17.1
S3 streams	20	20	50	30	15.2	15.0	11.5
S4 streams	-	30	33	10	7.4	6.8	6.8
S5 streams*	10	20	25	15	34.1	33.3	24.5
S6 streams (>= 1.5m)	-	20	50	10	-	-	-
S6 streams (< 1.5m)	-	20	-	-	-	-	-
Total					**82.6**	**79.3**	**59.9**

*** CFP FSP specifies 10 metre reserve, while FPPR does not require a reserve**

8.11 ENHANCED RIPARIAN RESERVES

The Okanagan Shuswap Land and Resource Management Plan identified an additional budget of 9,300 hectares within the THLB in the Okanagan TSA and associated TFL's be designated as enhanced riparian reserves (ERRs). Spatial locations of ERRs within TFL 33 have been identified by Canoe Forest Products and removed from the THLB in this analysis. The total area of these ERRs within TFL 33 is 66.2 hectares, of which 66.1 hectares is forested and part of the CFLB. The net area removed from the THLB after accounting for previous netdown categories is 48.6 hectares.

8.12 NON-MERCHANTABLE FOREST TYPES

Non-merchantable forest types are stands that contain tree species not currently utilized, or timber of low quality, small size, or low volume. In general, Canoe Forest Products Ltd. will harvest all stands provided there is at least 200 m^3/hectare of conifer volume.

Table 10 summarizes the areas in TFL 33 that are not expected to attain 200 m^3/hectare of conifer volume at any point in the future based on the yield tables used for the analysis. The total area of these non-merchantable forest types within TFL 33 is 360.8 hectares, of which 329.7 hectares is part of the CFLB. The net area removed from the THLB after accounting for previous netdown categories is 233.6 hectares.

Table 10 Non-merchantable forest types

Leading Species	Criteria	Gross Area (ha)	CFLB Area (ha)	Removed Area (ha)
Deciduous	Yield table indicates the stand will not achieve 200 m^3/hectare of conifer at any time	59.5	58.9	45.9
Conifer	Yield table indicates the stand will not achieve 200 m^3/hectare of conifer at any time	301.3	270.8	187.7
Total		**360.8**	**329.7**	**233.6**

8.13 OLD GROWTH MANAGEMENT AREAS

Non-legal, spatial Old Growth Management Areas (OGMAs) have been established as part of the Okanagan-Shuswap Land and Resource Management Plan (OSLRMP) process in order to manage for the old growth requirements outlined in the *Order Establishing Provincial Non-Spatial Old Growth Objectives, June 2004*. All OGMAs within the TFL 33 boundary were excluded from the THLB. The gross area of OGMAs within TFL 33 is 303.5 hectares, of which 302.7 hectares is forested and part of the CFLB. The net area removed from the THLB after accounting for previous netdown categories is 246.1 hectares.

8.14 WILDLIFE TREE RETENTION

8.14.1 EXISTING WILDLIFE TREE RETENTION

Wildlife tree patches (WTPs) are identified during cutblock layout to meet Canoe Forest Products Ltd. Forest Stewardship Plan requirements (see Section 8.14.2) and are maintained spatially in CFPs geographic information system. These existing WTPs were excluded from the THLB. The gross area of existing WTPs within TFL 33 is 132.5 hectares, of which 130.8 hectares is forested and part of the CFLB. The net area removed from the THLB after accounting for previous netdown categories is 105.6 hectares.

8.14.2 FUTURE WILDLIFE TREE RETENTION

Existing wildlife tree retention is generally associated with cutblocks that have been developed since 1995 (i.e. stands less than 25 years old). For stands that are at least 25 years of age or older, it is necessary to account for future wildlife tree retention in the timber supply analysis.

As a number of proposed cutblocks and their associated wildlife tree patches were included in the modelling dataset, it was possible to exclude these proposed WTPs spatially from the THLB, which resulted in a net THLB reduction of 7.7 hectares. An aspatial reduction was developed for the remaining THLB (i.e. stands >= 25 year old that are not in a proposed cutblock) as outlined below.

Because a portion of required future retention can overlap with areas that are already excluded from the timber harvesting land base, an analysis of existing and planned wildlife tree patches was used to estimate the incremental THLB reduction. The gross area of spatially located existing and planned WTPs is 140.7 hectares, and the net THLB reduction (i.e. does not overlap with another THLB reduction factor) is 113.3 hectares. Therefore, the net THLB reduction for future wildlife retention is 80.6% (113.3 ha / 140.7 ha) of the total required area for future wildlife tree patches.

This factor was combined with the direction outlined in the Canoe Forest Products Ltd. Forest Stewardship Plan which provides wildlife tree retention targets by biogeoclimatic subzone (Version 6) and landscape unit. TFL 33 falls within the Anstey-TFL landscape unit and the resulting aspatial netdown factors by biogeoclimatic subzone are summarized in Table 11.

Table 11 Future WTP THLB reduction factors

Landscape Unit	BEC subzone	Total FSP WTR requirement	THLB proportion	THLB reduction
Anstey-TFL	ICHmw	8%	80.6%	6.45%
Anstey-TFL	ICHwk	10%	80.6%	8.06%
Anstey-TFL	ESSFwc	9%	80.6%	7.25%

In summary, the total THLB reduction for future wildlife tree retention is 363.1 hectares, as follows:

- Spatial (associated with proposed cutblocks): 7.7 hectares
- Aspatial (to be applied within the model): 355.3 hectares

9 Inventory Aggregation

Aggregation of individual forest stands is commonly used to reduce complexity of the inventories for purposes of timber supply modelling.

9.1 ANALYSIS UNITS

Stands are often grouped into analysis units (AUs) to reduce the number of yield tables required with the model. Because the area within TFL 33 is relatively small, each individual forest inventory polygon will have its own unique analysis unit that uses its polygon number (1 to 1469) as its base. Analysis units within the model will be assigned to each polygon by adding an offset to the base depending on its management status and current age. Table 12 summarizes the analysis units that will be used in the model.

Table 12 Modelling analysis units and regeneration transitions

Analysis Unit	Description	Regeneration Analysis Unit
1 – 1469	Existing Natural Stands	22001 – 23469
2001 – 3469	Existing Managed Stands (37 to 52 years)	20001 – 21469
4001 – 5469	Existing Managed Stands (33 to 36 years)	20001 – 21469
6001 – 7469	Existing Managed Stands (15 to 32 years)	20001 – 21469
8001 – 9469	Existing Managed Stands (6 to 14 years)	20001 – 21469
10001 – 11469	Existing Managed Stands (1 to 5 years)	20001 – 21469
20001 – 21469	Future Managed Stands (No future road reduction)	20001 – 21469
22001 – 23469	Future Managed Stands (With road reduction)	22001 – 23649

9.2 NON-TIMBER RESOURCES

The forest estate model used for this analysis (PATCHWORKS™) does not require that unique, mutually exclusive zones be established to model non-timber resource objectives. Rather, stands are assigned to non-timber values based on their geographic location to allow objectives to be formulated for those values in the modelling framework. In general, a single stand will often belong and contribute to the status of more than one non-timber resource.

Table 13 provides an overview summary of the aggregations that will be used in this analysis to model non-timber resource requirements. Further details concerning the aggregation and model formulation are found in the sections of this report cross referenced in the table.

Table 13 Aggregation for non-timber resources

Non-timber Resource	Aggregation Level	Objective Type	Section Cross Reference
Visual Quality	Visual Landscape Inventory Polygon	Maximum Disturbance	Section 12.2.2
Mule Deer Winter Range	Mule Deer Winter Range Planning Cell	Minimum Retention	Section 12.2.3
Adjacency	Unconstrained THLB	Maximum Disturbance	Section 12.2.10

10 Growth and Yield

Forest estate modelling requires estimates for attributes such as net volume, species composition, and diameter for different stand types over time as the stands grow older. Growth and yield assumptions describe how these attributes are developed and incorporated into the model for natural and managed stands.

10.1 SITE INDEX

Site index for natural stands was updated using FLNRORD site index equations, LiDAR derived heights and the inventory age as part of the improvement to the inventory (see Section 7 and Appendix 1).

A site index adjustment (SIA) study was completed in 2003 by J.S. Thrower & Associates Ltd. that developed a relationship between elevation and post-harvest regenerated (i.e. managed) stand site index. The results from this study will be used to estimate site index of managed stands for the Base Case, as follows:

- Douglas-fir: SI (m) = 31.2 – 0.00392 x Elevation (m)
- Lodgepole pine: SI (m) = 29.5 – 0.00534 x Elevation (m)
- Spruce: SI (m) = 37.2 – 0.00933 x Elevation (m)

Site indices for other species will be calculated using the following conversion equations developed by FLNRORD:

- Sub-alpine fir: SI (m) = 1.680 + 0.860 x SI(Spruce)
- Hemlock: SI (m) = -5.140 + 1.130 x SI(Douglas-fir)
- Larch: SI (m) = 0.702 + 1.017 x SI(Douglas-fir)

Site index conversion equations are not available for western red cedar, white pine, or deciduous species. Therefore, the inventory site index will be used for these species if they are leading in the inventory, or the managed stand site index of the leading species if they are not the leading species.

FLNRORD maintains a site productivity layer containing managed stand site index estimates for much of the province. However, there is incomplete data for the area covered by TFL 33 so it is not possible to use the provincial layer to validate the SIA estimates. Therefore, alternate validation approaches were used and are discussed below.

A Change Monitoring Inventory (CMI) program was implemented on TFL 33 with forty sample plots established in managed stands between 15 and 39 years old in the 2005 and 2006 field seasons. The summary report for these initial measurements included a comparison of measured site index with those predicted by the 2003 Thrower SIA report. The average differences indicated that Douglas-fir SIA estimates were 1.3 metres higher than CMI plot site index, and Spruce SIA estimates were 1.1 metres higher than CMI plot site index. However, neither difference was significant. It was also concluded that differences in site tree collection standards between CMI and SIA programs may partially account for the observed site index differences.

The updated inventory using LiDAR generated heights provides another opportunity to validate the managed stand site index generated using the SIA estimates. As part of this update, a new site index was calculated for stands older than 20 years using the LiDAR heights and stand ages. There is a high degree of confidence in the ages of polygons up to 52 years of age (i.e. managed stands) as the age generally originated from harvest or silviculture records. Because there is also a high degree of confidence in the LiDAR height for each polygon, the calculated inventory site index for these managed stands is expected to be quite accurate. Figure 7 compares the updated inventory site index with the SIA generated managed stand site index for these 20 to 52 year old stands. Although there is some variation between individual species, the overall weighted managed stand site index is slightly lower (25.1metres) than the weighted inventory site index (25.6 metres) which suggests that the SIA estimates provide a reasonable estimate of managed stand site index.

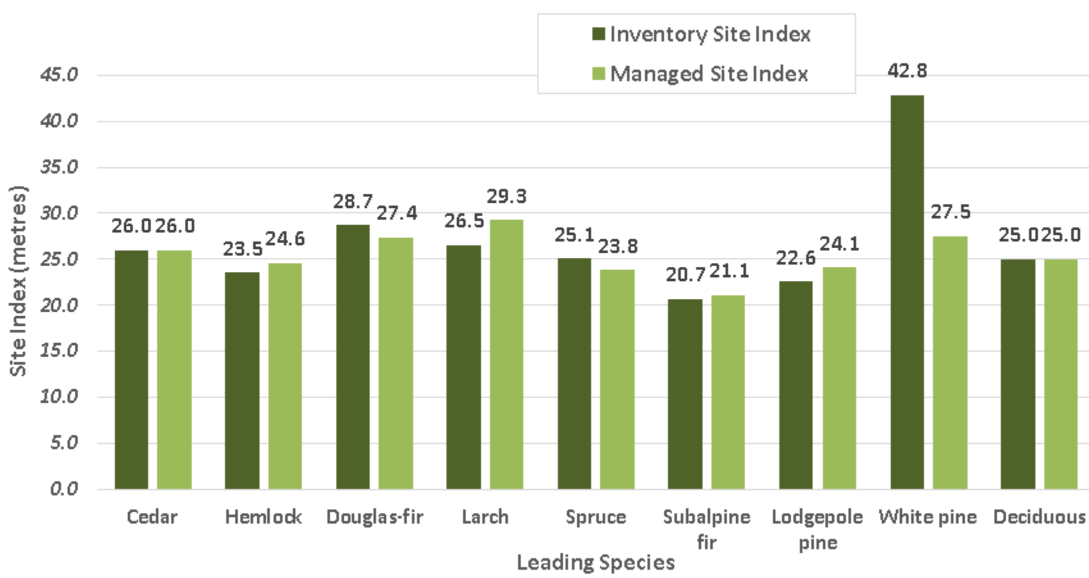

Figure 7 Inventory site index versus managed stand site index for stands 20 to 52 years old

The TIPSY yield tables for existing managed stands (Section 10.7) provide another opportunity to validate the SIA estimates. The LiDAR estimated heights for stands between 20 years and 52 years old in the inventory were compared to the top heights predicted by TIPSY for each forest inventory polygon. Figure 8 shows a comparison of the heights predicted by TIPSY with the LiDAR heights from the inventory for stands between 20 and 52 years old. Based on this, it appears that the TIPSY heights generated with TIPSY using the SIA site indices are generally less than the actual heights measured determined with LiDAR, particularly as the trees get taller and become merchantable.

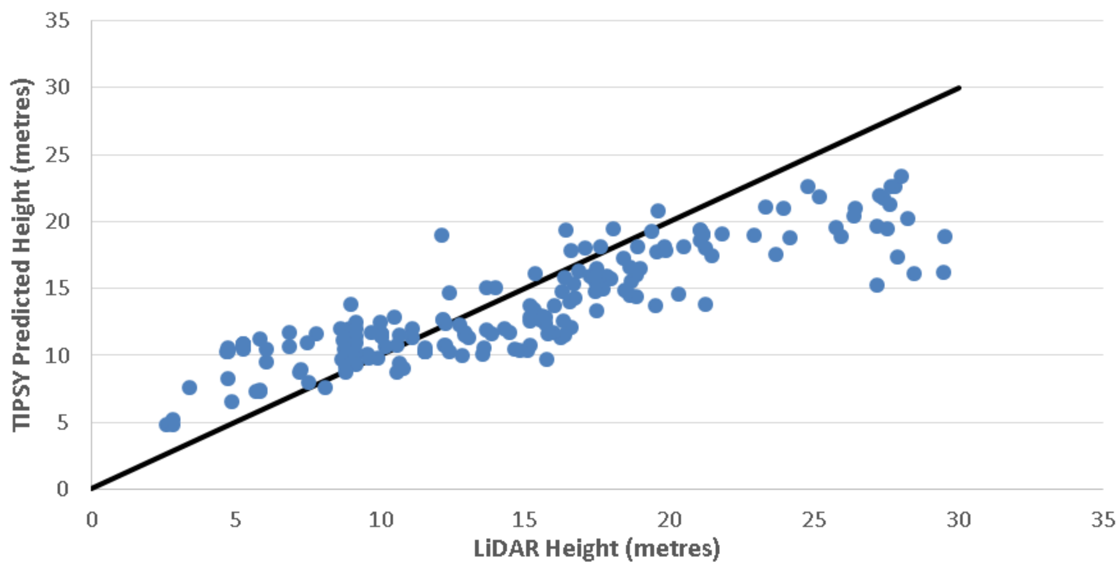

Figure 8 TIPSY predicted heights versus LiDAR inventory heights for stands 20 to 52 old

Based on the above information, we conclude that the managed stand site indices generated using the elevation based SIA estimates provide a good estimate of the expected growth potential for managed stands and can be used for the remainder of the TFL. Figure 9 provides a comparison of the leading species managed stand site index with the inventory site index for all stands in TFL 33.

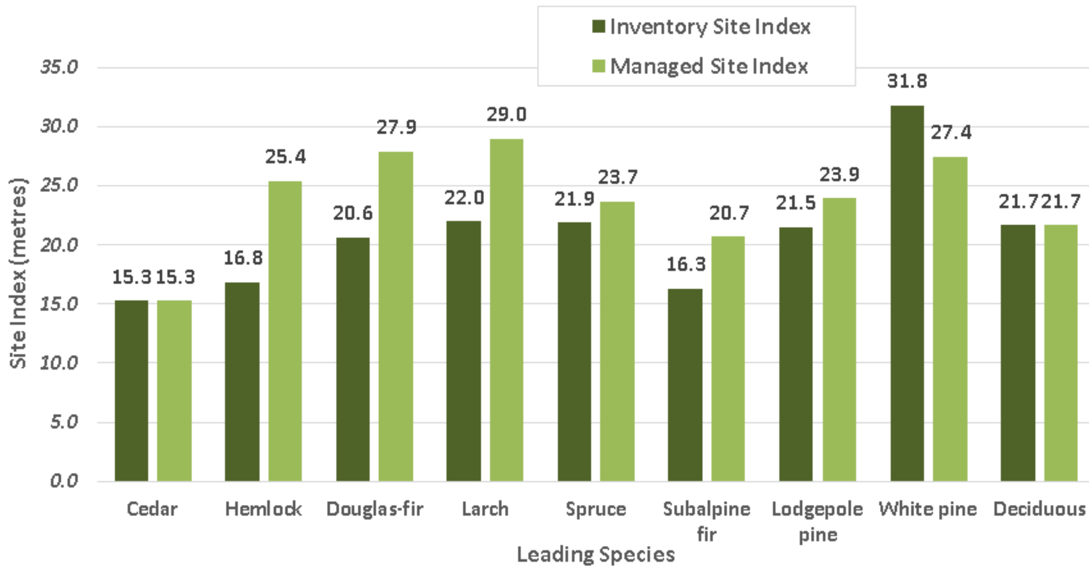

Figure 9 Site index comparison by species for all stands

10.2 UTILIZATION LEVELS

Utilization levels define the portion of the tree that is considered to be merchantable volume. Table 14 outlines the minimum merchantable timber specifications that will be used for all species when developing the yield tables for this analysis.

Table 14 Utilization levels

Species	Minimum Diameter at Breast Height	Maximum Stump Height	Minimum Top Diameter Inside Bark
Lodgepole pine	12.5 cm	30.0 cm	10.0 cm
Other Conifer	17.5 cm	30.0 cm	10.0 cm

10.3 DECAY, WASTE, AND BREAKAGE

For natural stands, default reductions to stand volume for decay, waste and breakage will be applied in the Variable Density Yield Projection (VDYP 7) model. Within the TIPSY model used for managed stands, the default Operational Adjustment Factor 2 (OAF2) will be applied to account for merchantable volume losses due to decay, waste, and breakage (Section 10.4).

10.4 OPERATIONAL ADJUSTMENT FACTORS FOR MANAGED STANDS

Operational Adjustment Factors (OAFs) will be applied in order to adjust potential yields generated by the TIPSY growth and yield model to reflect net operational volumes. This includes reduction for such things as gaps in stands, decay/waste/breakage, and endemic forest health losses.

There are two type of OAFs used in the TIPSY model. OAF 1 is a constant percentage reduction to account for openings in stands, distribution of stems or clumpiness, endemic pests and diseases, and other risks to potential yield. OAF2 is an increasing percentage reduction that can be applied to account for decay, waste and breakage or forest health losses that increase with age. OAF 2 is applied after OAF 1 and increases linearly over time from zero percent at age zero to the specified percentage at 100 years of age.

The provincial default values of 15% for OAF 1 and 5% for OAF 2 will be used in this analysis, except for Douglas-fir and cedar leading stands which will have an OAF 2 of 10% to account for losses due to root disease. This is consistent with the approach documented in the 2017 Okanagan TSA Timber Supply Review Data Package.

10.5 VOLUME REDUCTIONS

Deciduous volumes were removed from all yield tables. For natural stands, this was done directly using the VDYP output by not including reported deciduous volumes in total merchantable volume. For managed stands, deciduous volumes were removed by adjusting the total volume to account for deciduous volumes obtained in a separate, complimentary deciduous only yield table. This is required because of the short life-span of deciduous species and the lack of individual species information in the TIPSY output.

In addition, future managed stand yield tables for existing natural stands will be reduced by 2.02% in the model to account for future roads (see Section 8.5.2).

10.6 YIELD TABLES FOR NATURAL STANDS

Stands younger than 53 years old have had at least some degree of management and are considered to be managed stands. Stands that 53 years and older are considered natural stands for purposes of this analysis. Age, height, crown closure, stems per hectare and species composition for each forest inventory polygon were used as inputs to the VDYP 7 console processing program to create the yield tables used in this analysis.

10.7 YIELD TABLES FOR MANAGED STANDS

Managed stands for this analysis are considered to be stands that are 52 years old and younger. This age was chosen as previous management plans have identified that there has been at least some level of management that has occurred since establishment on stands of this age. Yield tables were created for each individual existing managed stand and future managed stand using the Table Interpolation for Stand Yields (TIPSY) model, version 4.4.

10.7.1 SILVICULTURE MANAGEMENT REGIMES

In 2005, J.S. Thrower & Associates Ltd. developed yield tables in preparation for Management Plan #9. This report identified three historical silviculture eras that reflected different silviculture strategies. From 1972 to 1982, the usual strategy was to broadcast burn sites and wait five to six years for natural regeneration to establish, followed by planting to 1,600 stems per hectare in the ICH biogeoclimatic subzones. ESSF sites were generally not planted. From 1983 to 1987, target stocking remained the same but the planting delay was reduced to four years, and planting was undertaken in the ESSF. Starting in 1987, regeneration delay was reduced to two years.

A review of planting records since 2005 for TFL 33 shows that there was a noticeable increase in genetic worth starting in 2014 (see Section 10.7.3). Consideration of this information resulted in the identification of two additional historic silviculture eras, plus an additional era to represent future managed stands.

In 2011, CFP reduced their planting density to 1,400 stems per hectare. Accordingly, the initial stand density for the 2005 to 2013 silviculture era for use in this analysis was reduced to 1,575 based on the planting records during this transition.

Table 15 lists the silviculture eras, age ranges, planting densities, and regeneration delay that will be used for the current analysis.

Table 15 Silviculture eras

Silviculture Era	Age Range	THLB Area (ha)	Planting Density (sph)	Regeneration Delay (yrs)
Pre – 1983	37 to 52 years	567.8	1600*	6
1983 - 1986	33 to 36 years	467.6	1600	4
1987 - 2004	15 to 32 years	1,276.7	1600	2
2005 - 2013	6 to 14 years	237.6	1575	2
2014 - 2018	1 to 5 years	501.7	1400	2
Existing Natural/Future Managed		3,846.5	1400	2

* ICH stands will be modelled as planted, and ESSF stands will be modelled as natural in TIPSY for the Pre-1983 silviculture era

10.7.2 REGENERATION ASSUMPTIONS

Each existing natural and existing managed stand will be regenerated to a corresponding future managed stand as described in Table 12 within Section 9.1. Natural stands will regenerate to future managed stands with a volume reduction to account for future roads (See Section 8.5.2), while existing managed stands will regenerate to future managed stands that do not have a reduction for future roads.

The existing inventory species composition for each individual forest inventory polygon will be used as the TIPSY species input for all existing managed stands. Future managed stands will use species compositions that reflect current CFP silviculture practices by BEC subzone, as follows:

- ICHmw2/ICHdw4: Fd55 Lw15 Cw15 Pw10 Pl5
- ICHwk1: Fd55 Cw30 Pw10 Sx5
- ESSF: Se80 Bl20

Managed stand site index will be calculated for each species by forest inventory polygon using the elevation based site index equations discussed in Section 10.1, and these site indices will be used as TIPSY inputs.

10.7.3 GENETIC IMPROVEMENT

Class A spruce seed was first planted in 1993 and has been planted exclusively since 1999. The 2005 Thrower yield tables did not consider any genetic worth for yield tables prior to 2005. Planting records since 2005 from the CFP silviculture system were combined with the genetic gain for each planted seedlot to evaluate the use of Class A seed in TFL 33. There was a noticeable increase in the overall genetic worth starting in 2014. This was used to differentiate between two different silviculture eras to be used in this analysis. The weighted genetic worth for each species was then calculated for each era, and is summarized in Table 16. These weighted values will be used when creating the TIPSY yield curves for existing managed stands. For future managed stands, the achieved genetic worth from 2014 to 2018 will be used on the assumption that there will be at least similar use of Class A seed performance in the future, and that average genetic worth will not decline.

Table 16 Genetic worth by species and silviculture era

Silviculture Era	2005 – 2013		2014 - 2018	
	Number Planted (Total/Improved)	Weighted GW (%)	Number Planted (Total/Improved)	Weighted GW (%)
Spruce	57,720/57,720	8.62	33,380/33,380	16.00
Douglas-fir	75,691/11,610	4.14	192,580/133,150	18.21
Larch	49,455/13,775	4.35	65,475/14,415	5.50
Lodgepole Pine	21,705/14,730	4.70	27,095/6,000	3.54

10.7.4 REGENERATION DELAY

Regeneration delay is the time elapsed between harvesting and the establishment of a new stand of trees, taking into account the age of the planted trees. Regeneration delays vary between two and six years depending on the silviculture era, as described in Section 10.7.1. For this analysis, regeneration delays will be applied in the yield tables when they are created using TIPSY.

10.7.5 NOT SATISFACTORILY RESTOCKED

Not satisfactorily restocked (NSR) is defined as a forested area that does not have a sufficient number of well-spaced trees of desirable species. Backlog NSR refers to stands disturbed prior to 1987 that are not declared as satisfactorily restocked. TFL 33 has no backlog NSR. Current NSR typically refers to stands recently disturbed (i.e. since 1987) that are not yet declared as being stocked.

Current NSR is addressed in the analysis as part of the regular regeneration assumptions described in Section 10.7.1, and through the inventory update undertaken during the data preparation for the analysis as described in Section 7.

11 Protection

11.1 UNSALVAGED LOSSES

Damage to timber caused by fire, wind, insects, diseases and other pests contribute to loss in harvestable volumes. This volume loss is difficult to quantify, although losses to insect and disease that are normally found in stands (i.e. endemic losses) are accounted for in yield table estimates. Depending on the type of damage and stand accessibility, losses due to catastrophic or epidemic events may be either salvageable or unsalvageable, and are not accounted for in the yield tables.

Average unsalvaged losses for the past 10 years were estimated for TFL 33 using aerial overview survey data obtained from DataBC. Table 17 summarizes these unsalvaged losses, and further details are provided in Appendix 3. Annual harvest volumes determined using the timber supply model will be reduced by this amount when harvest flows are reported.

Table 17 Unsalvaged losses

Loss Category	Annual Volume (m^3/year)
Fire Losses	0
Windthrow	0
Pests	571
Total	**571**

11.2 GRADE 4 CREDIT

Grade 4 logs are low quality logs that are generally not suitable for lumber production. Under the Cut Control Regulation, Grade 4 volume delivered to facilities other than sawmills or veneer plants (i.e. pulp, bioenergy, etc.) is not counted against cut control (i.e. AAC) if an application is submitted to and approved by government. This is known as the Grade 4 credit and the intent is to increase the utilization of low quality logs. CFP has not applied for a Grade 4 credit for TFL 33 to date.

12 Integrated Resource Management

12.1 FOREST RESOURCE INVENTORIES

The status of the non-timber resource inventories has previously been described in Section 6. If required, additional details will be provided in the individual sections provided below.

12.2 NON-TIMBER FOREST RESOURCE MANAGEMENT

12.2.1 BIODIVERSITY

Modelling landscape and stand-level biodiversity management objectives will be addressed through the retention of old forest cover and WTP retention. Details on how biodiversity objectives are integrated into the modelling environment are provided below.

12.2.1.1 LANDSCAPE-LEVEL BIODIVERSITY

Non-legal, spatial Old Growth Management Areas (OGMAs) have been established in order to manage for the old growth requirements outlined in the *Order Establishing Provincial Non-Spatial Old Growth Objectives, June 2004*. This order provided old seral targets by landscape unit and BEC subzone (Version 5). In 2007, the Integrated Land Management Bureau confirmed that the spatial OGMAs meet the intent of this order.

The location of these OGMAs was determined through a collaborative approach led by government with input from forest industry and Environmental Non-governmental Organizations. In addition to the old growth requirements which were based on the LRMP objectives for Landscape Units and BEC subzones, OGMA locations were selected to consider other objectives such as the protection of rare ecosystems and sensitive areas. These OGMAs have been removed from the THLB as outlined in Section 8.13.

The 2004 Old Growth order allowed for a temporary reduction of the old seral target by up to 2/3 for landscape units with a low biodiversity emphasis. This reduction was applied for the TFL 33 portion of the Anstey landscape unit when the old seral targets were established in the order. The Landscape Unit Planning Guide (1999) indicates that where the old seral targets are initially reduced, a recruitment strategy must be developed to meet the target by the end of the third rotation, or 240 years. Therefore, as the order was established in 2004, the model will be configured to require full achievement of the specified target by the year 2245. Note that 2005 will be used as the reference year because the planning horizon starts in 2020 and the model will use 5 year periods. In addition, the model will be configured to require that 2/3 of the full target be achieved by the end of the second rotation (i.e. year 2165, or 160 years from 2005). Table 18 summarizes the old seral targets by BEC subzone (version 5).

Table 18 Old seral requirements

LU	Bio-diversity Emphasis	BEC (v5)	NDT	CFLB Area (ha)	Old Seral Age (years)	2004 Old Growth Order Target (ha)	Old Required by End of 3rd Rotation (%)
Anstey	Low	ESSFwc2	1	1,768	>250	92	19
TFL		ICHwk1	1	2,291	>250	99	13
		ICHmw2	2	1,780	>250	53	9
		ICHmw3	3	2,206	>140	105	14

12.2.1.2 STAND-LEVEL BIODIVERSITY

Wildlife tree retention targets consistent with Canoe's FSP have been addressed through spatial and aspatial THLB reductions as specified in Section 8.14. Therefore, no additional requirements will be implemented in the analysis.

12.2.2 VISUAL QUALITY

Scenic Areas with Visual Quality Objectives (VQO) for TFL 33 have been grand-parented under Section 180 of the Forest and Range Practices Act. These areas and objectives were established in October 2002 through District Manager Forest Development Plan direction. Three polygons with VQOs overlap TFL 33, as shown in Figure 10, and are a very important consideration for forest management in the TFL.

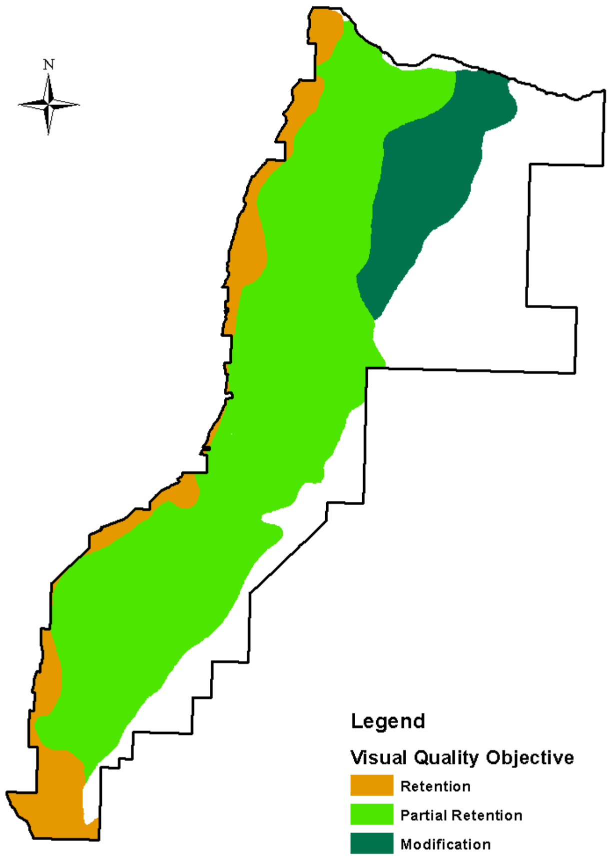

Figure 10 Visual quality objectives

Canoe Forest Products designs cutblocks and roads in Scenic Areas to meet the VQO using the following approach:

- Utilizing visual simulation techniques
- Designing openings consistent with natural landscape characteristics, with their location, shape and scale having regard for visual design principles
- Retaining trees in locations, sizes and shapes with regard for visual design principles.

The CFLP Forest Stewardship Plan defines visual design principles to be "visual landscape design elements and principals such as those described in the *OSLRMP Scenic Areas with Visual Quality Objectives Zone 1 Guidelines."* These guidelines are found in Appendix VI of the Okanagan Shuswap LRMP, and contain detailed guidelines regarding landscape design, visually effective green-up (VEG) heights, and allowable planimetric disturbances.

For purposes of this analysis, maximum disturbance targets within each Visual Landscape Inventory (VLI) polygon will be used to control the rate at which harvesting can occur in visually sensitive areas. The model will be configured to only allow harvest within a VLI polygon if the proportion of the CFLB that is shorter than a specified height is above a VQO dependent threshold. The guidance outlined by the Okanagan-Shuswap LRMP will be used to develop these minimum heights and thresholds.

Visually effective green-up height is the height that regenerating trees must attain before the stand is considered to be undisturbed for purposes of visual landscape management. The LRMP guidelines indicate that visual green-up will generally range from three metres to five metres, and where the slope is greater than 50% with either a low

Visual Absorption Capacity (VAC) or foreground viewing that a six metre VEG height should be used. For this analysis, a VEG height of five metres will be used for the Partial Retention and Modification VQO polygons, and six metres will be used for the Retention VQO polygon adjacent to Shuswap Lake.

The LRMP guidelines include procedures for determining the recommended planimetric disturbance thresholds based on cutblock size, silviculture system, VQO, VAC, and viewing distance. This analysis will use thresholds based on cutblocks between 5 and 10 hectares in size using the clearcut with reserves silviculture system. Using this guidance, the initial range for allowable harvest percent is 5 to 15% for Retention, 10 to 25% for Partial Retention, and 20 to 30% for Modification. These initial ranges are then adjusted based on the VAC and viewing distance for the individual polygon. Table 19 summarizes the VEG heights and disturbance thresholds that will be used to model visual quality objectives for the VQOs within TFL 33.

The status of the existing land base condition, including anticipated harvesting of recently developed cutblocks provides additional validation that the thresholds are appropriate for the modelling. The proportion of the CFLB that is below the visually effective green-up height or in recently developed blocks is included in Table 19 for comparison. Based on this, the proposed maximum thresholds appear to be appropriate.

Table 19 VQO modelling parameters

VLI Polygon	CFLB Area (ha)	VQO	VAC	Viewing Distance	VEG Height (m)	Existing* % < VEG	Maximum % < VEG
101088	818.6	Retention	L	Fore-ground	6	7.7%	8.3%
100518	4,220.5	Partial Retention	M	Mid-ground	5	18.9%	20.0%
100565	812.2	Modification	M	Mid-ground	5	8.5%	26.7%
Total	**5,851.3**						

* Includes developed, unharvested cutblocks

12.2.3 MULE DEER WINTER RANGE

GAR order #u-8-001 signed October 1st, 2006 outlines the requirements for management of mule deer winter range in TFL 33. The General Wildlife Measures in the order specify the amount of snow interception cover (SIC) that must be retained within each mule deer winter range planning cell. Snow interception cover attributes are a function of snowpack zone, which is defined by BEC unit (Version 6).

For TFL 33, all of the mule deer winter range is in the ICHmw2 (i.e. Deep snowpack zone), which means that the attributes required in order to be considered SIC are:

- Predominantly Douglas-fir,
- At least 100 years old, and
- Crown closure at least 46%

For this analysis, SIC will be defined as all Douglas-fir leading stands that are 100 years or older. Crown closure will not be modelled because of yield table limitations. However, a review of the inventory indicates that mature Douglas-fir leading stands in the TFL generally meet the crown closure threshold.

The required SIC for each planning cell was determined by pro-rating the requirement for the entire planning cell by the proportion that is in TFL 33. Table 20 summarizes the resulting SIC requirements by planning cell. Note that planning cell 1165 will be combined with adjacent planning cell 1164 because only a small portion of it is in TFL 33.

Table 20 Required snow interception cover by planning cell

MDWR Planning Cell	Total Area* (ha)	SIC Required (ha)	TFL 33 Area (ha)	TFL 33 SIC Area (ha)
1158	115.3	72	113.2	70.7
1159	196.1	115	191.0	112.0
1164	487.4	263	376.6	203.2
1165**	370.2	204	9.3	5.1

* Excluding private land as the GAR order does not apply to private land

** Because only a small portion of planning cell 1165 is in TFL 33, it will be combined with the adjacent planning cell 1164 for this analysis

12.2.4 MOUNTAIN CARIBOU

GAR order #u-8-004 signed December 9th, 2009 outlines the requirements for management of mountain caribou in TFL 33. As the General Wildlife Measures indicate that harvesting is not permitted in subalpine parkland ecosystems, ESSFwcp was removed from the THLB as indicated in Section 8.6. In addition, the General Wildlife Measures specify that silviculture treatments will not result in the conversion of forest cover to pure spruce stands. This requirement has been incorporated into this analysis through the silviculture regimes used to create managed stand yield tables, as outlined in Section 10.7.1).

12.2.5 RECREATION SITES, TRAILS, AND INTERPRETIVE SITES

The CFP FSP indicates that 50 percent of the pre-harvest basal area within 50 metres of the Queest Mountain Snowmobile trail will be retained. For this analysis, an equivalent area has been removed from the THLB (see Section 8.7) and no further modelling considerations are required.

12.2.6 SHUSWAP LAKE LAKESHORE MANAGEMENT ZONE

There is no legal resource management zone or objective for management within a 200 metre lakeshore management zone (LMZ) adjacent to Shuswap Lake. However, licencees generally follow the intent of the Okanagan-Shuswap LRMP. The portion of this LMZ within TFL 33 is completely contained within the Retention VQO polygon and it is expected that the requirements of the VQO will meet the objectives within the LMZ. Therefore, no additional modelling requirements will be considered.

12.2.7 MARTEN AREAS

A portion of TFL 33 is within a marten area defined in the *Order Establishing Objectives set by Government in the Area Covered by the Okanagan-Shuswap Land and Resource Management Plan in the Okanagan Shuswap Forest District*. The objective for this area is to maintain forage, cover and connectivity for marten. Because this objective can be met operationally without an incremental timber supply impact, additional modelling requirements are not necessary and will not be considered.

12.2.8 FISHER AREAS

Most of TFL 33 is within a fisher area defined in the *Order Establishing Objectives set by Government in the Area Covered by the Okanagan-Shuswap Land and Resource Management Plan in the Okanagan Shuswap Forest District*. The objective for this area is to maintain forage, cover and connectivity for fisher. Because this objective can be met operationally without an incremental timber supply impact, additional modelling requirements are not necessary and will not be considered.

12.2.9 TOURISM AREAS

A portion of TFL 33 is within a tourism area defined in the *Order Establishing Objectives set by Government in the Area Covered by the Okanagan-Shuswap Land and Resource Management Plan in the Okanagan Shuswap Forest District*. The objective for this area is to maintain foreground visual quality from viewpoints on existing tourism areas, facilities, trails and natural features important for tourism. These requirements have been addressed in this analysis through the established visual quality objectives (Section 12.2.2).

12.2.10 CUTBLOCK ADJACENCY

Cutblock adjacency, or green-up, is a measure of tree height and site occupancy on a harvested site. The green-up height specified in the CFP FSP is 2 metres, and is the height that a harvested opening must achieve before adjacent areas may be harvested. There are situations when adjacency requirements are not applied, such as for salvage harvest and when applying patch size distributions consistent with the Biodiversity Guidebook.

Adjacency requirements will be implemented in the model by ensuring that no more than 30% of the THLB area that does not overlap another constraint (e.g. ungulate winter range, visual quality, etc.) can be less than two metres tall at any time.

12.2.11 CULTURAL HERITAGE RESOURCES

A cultural heritage resource is defined in the Forest Act as an object, site, or location of a traditional societal practice that is of historical, cultural or archaeological significance to the province, a community, or an aboriginal people. Cultural heritage resources are post-1846 and include archaeological sites, structural features, heritage landscape features and traditional use sites. Older cultural heritage resources are considered to be an archaeological resource and are protected under the Heritage Conservation Act.

Canoe Forest Products Ltd. refers all proposed development to First Nations prior to the application for a Cutting Permit. Based on this level of engagement with First Nations, there have not been any cultural heritage resources identified within TFL 33 that would warrant additional considerations within the timber supply analysis.

12.3 TIMBER HARVESTING

12.3.1 MINIMUM HARVEST AGE / MERCHANTABILITY CRITERIA

For this analysis, minimum harvest ages will be determined using the following criteria:

- At least 200 m^3/hectare of conifer volume, and
- At least 95% of maximum Mean Annual Increment (MAI) has been achieved

Within the timber supply model, a stand can be considered for harvesting once it meets the defined minimum harvest age. Note that these are minimum criteria, not the actual ages at which stands are forecast for harvest. Some stands may be harvested at the minimum thresholds to meet forest-level objectives (e.g. maintaining overall harvest levels for a short period of time or avoiding large fluctuations in harvest levels). However, other stands may not be harvested until older than these "optimal" timber production ages due to management objectives for other resource values.

Table 21 summarizes the weighted average minimum harvest ages, mean annual increment, and volume per hectare at MHA by silviculture era. In addition, the range of minimum harvest ages for individual stands within the silviculture era grouping is provided for reference. Note that many of the existing natural stands are already older than the minimum harvest age.

Table 21 Minimum harvest ages by silviculture era

Silviculture ERA	Minimum Harvest Age (years)		Mean Annual Increment (m^3/ha/yr)		Average Volume at MHA (m^3/ha)
	Range	Average	Maximum	At MHA	
Existing Natural	59 – 152	104	2.94	2.81	285.8
Existing Managed: Pre – 1983	62 – 93	79	5.40	5.14	400.3
Existing Managed: 1983 – 1986	58 – 91	71	5.62	5.36	373.6
Existing Managed: 1987 – 2004	47 – 151	68	5.75	5.48	367.1
Existing Managed: 2005 – 2013	52 – 149	78	5.17	4.92	378.1
Existing Managed: 2014 – 2018	59 – 82	71	6.35	6.05	422.4
Future Managed	66 - 86	72	6.57	6.25	449.1

12.3.2 HARVEST SYSTEMS

The harvest systems used in TFL 33 include conventional ground-based, hoe chuck, and cable systems. Three slope classes (0-35%, 35 – 60%, > 60%) will be used in the model as surrogates for these systems in order to report harvest volumes by harvest system.

12.3.3 SILVICULTURE SYSTEMS

This analysis will use clearcut with reserves as the silviculture system for modelling purposes. The reserves for wildlife tree retention will be accounted for using THLB reductions as outlined in Section 8.14.

12.3.4 CUT BLOCK AGGREGATION

Cut block aggregation will be used so that the analysis reflects operational reality by avoiding harvesting of small isolated units, or "slivers". Two forms of aggregation will be implemented.

- The individual polygons ("fragments") created by overlaying the various data input layers into the "resultant" layer will be aggregated into larger units called "blocks" prior to modelling. Within the model, blocks are the units that get harvested. Individual fragments that are adjacent, have the same analysis unit and are within 5 years age are potential candidates to be combined into blocks. The target size for these blocks will be 5 hectares, which may not be achieved in all cases due to the differing attributes of the initial fragments.
- During the model runs, the patching capabilities of the model will be used to control the spatial distribution of the harvested blocks. The model will be configured to prevent creating harvest patches less than 1 hectare in size, and avoid creating harvest patches less than 5 hectares in size if possible.

12.3.5 INITIAL HARVEST RATE

The current AAC for TFL 33 is 21,000 m^3 per year. The initial harvest level for the Base Case scenario will be set to 21,000 m^3 per year plus the allowance for unsalvaged losses. This level may be adjusted depending on the modelling results.

12.3.6 HARVEST RULES

The model used for this analysis does not explicitly use rules such as "oldest first" to rank stands for harvest. Rather, targets are set for harvest levels and individual non-timber resource requirements (e.g. maximum VQO disturbance, etc.). Each target in the model is assigned a relative weight that is used by the model to balance the achievement of the targets. Non-timber resource targets are typically assigned a very high weight so that the model will ensure they are achieved. Harvest volume is assigned a lower weight so that harvest is only attractive to the model when all other targets have been addressed.

The model will prioritize harvest of individual blocks to best achieve the overall harvest target subject to the non-timber resource targets being met. Stands will be harvested at the age that balances the requirements of all targets, including harvest.

12.3.7 HARVEST FLOW OBJECTIVES

Forest cover constraints and the growth capacity of the THLB will determine the harvest level options that will be considered. In general, the choice of harvest flow will reflect the following objectives:

- Avoid any large or abrupt disruptions in timber supply during transitions from short to mid to long-term periods (generally increases and decreases in steps of 10% per 10 year period)
- Manage the degree to which mid-term timber supply drops below the long-term sustainable harvest level, avoiding very deep mid-term reductions in harvest

- Achieve a stable long-term harvest level over a 300 year planning horizon
- Ensure that the growing stock on the THLB does not decline during the last 50 years of the planning horizon

13 Sensitivity Analyses

This section briefly describes the sensitivity analyses that are anticipated to be performed against the Base Case scenario. These analyses explore the stability of the base case relative to the uncertainty surrounding specific analysis assumptions. They also reflect the impact of alternative management or potential changes in forest practices. Additional sensitivity analyses may be completed as the analysis progresses.

13.1 LAND BASE DEFINITION

13.1.1 TIMBER HARVESTING LAND BASE +/- 10%

This sensitivity analysis will test the effect of moving land between the non-THLB and the THLB. This will be accomplished by increasing/decreasing the area of each THLB polygon by 10% when it is entered into the model. The area of each productive non-THLB polygon will have a corresponding proportional adjustment applied so that the total land base area remains the same, and that the area for each non-timber resource value remains the same.

13.2 GROWTH AND YIELD ASSUMPTIONS

13.2.1 NATURAL STAND YIELDS +/- 10%

This sensitivity analysis will test the uncertainty in the yields predicted by the VDYP 7 model used to generate natural stand yield tables. The volumes for each natural yield table will be increased/decreased by 10%. Other yield parameters used by the model (e.g. height, minimum harvest age) will remain unchanged.

13.2.2 MANAGED STAND YIELDS +/- 10%

This sensitivity analysis will test the effect of changes to the yield tables for managed stands. The volumes for each managed stand yield table will be increased/decreased by 10%. Other yield parameters used by the model will remain unchanged.

13.2.3 MINIMUM HARVEST AGES +/- 10 YEARS

This sensitivity analysis will test the effect of increasing/decreasing minimum harvest ages by 10 years for each analysis unit.

13.2.4 STANDARD OAF2 VALUE

This sensitivity analysis will test the effect of reducing the OAF2 value to the standard value of 5% for all Douglas-fir and cedar leading stands.

13.3 INTEGRATED RESOURCE MANAGEMENT ASSUMPTIONS

No sensitivity analyses related to non-timber objectives are anticipated at this time.

13.4 TIMBER HARVESTING ASSUMPTIONS

13.4.1 TURN OFF CUTBLOCK AGGREGATION

This sensitivity analysis will test the effect of relaxing the requirements for cutblock aggregation at the time of harvest so that there is no minimum cutblock size. The aggregation undertaken during data preparation prior to modelling will remain unchanged.

14 References

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Appendix 1 Inventory Update Using LiDAR

FORSITE
Forest Management Specialists

Memorandum

To: Graham Hawkins, FLNRORD-FAIB

From: Geoff Lawless, Anita Li, Forsite Consultants

Cc: Jeff Lipsett, Canoe Forest Products

Date: November 19, 2019

Subject: Forest Inventory Improvement using LiDAR data

BACKGROUND

The purpose of this project is to undertake improvements to the existing forest inventory for Tree Farm Licence 33 in order to complete a timber supply analysis and Management Plan to support a new AAC determination by March 2021.

APPROACH

Forsite proposes to update the existing VRI within TFL 33 using LiDAR data acquired in 2015, recent photography, GIS depletion layers, and silvicultural records. The described approach is to update:

- VRI polygon boundaries where visibly incorrect,
- Species labels for openings created since previous inventory (silviculture records)
- Ages (silviculture records for openings, adjust previous age to new inventory year)
- Crown Cover (from LiDAR)
- SPH (from silviculture records and LiDAR)
- Stand Height (from LiDAR), and
- Site Index for stands greater than 20 years old (using LiDAR heights)

I. <u>VRI polygon boundary updates using LiDAR Canopy Height Model (CHM)</u>

1.) Delineate any new openings not reflected in current inventory
    a. Use standard VRI specs when delineating (minimum size, location accuracy)
    b. Clip non-free growing RESULTS and FTA Blocks opening boundaries into inventory. (Note: Delineate according to Opening ID's, not just openings)
    c. Opening ID's can be inserted at a later date if required.

2.) Update existing polygon boundaries where polygon edges look to be ~5m out or more
    a. Use standard VRI specs - width of polygons and min size.
    b. Includes free growing RESULTS polygons

3.) Create new polygons where crown closure within an existing polygon appears obviously different.
    a. Common along edges of openings (assumption: blowdown)
    b. Maintain minimum size VRI specifications
    c. Keep species codes and ages the same as original VRI polygon, but calculate unique CC, SPH, and Height values.

II. <u>Species label updates</u>

1.) Species composition for mature stands will remain as per previous inventory because species will not be adjusted as part of this inventory unless obvious changes can be determined from available SPOT and ortho photography.

2.) Use up-to-date client silvicultural data (planting records, stocking/fg survey records, etc.) if available to update species species composition for new openings
3.) If client silviculture data is not available, assign existing VRI attributes to new openings
   a. Use the data from existing VRI polygon that has the largest area within new opening (Similar to procedures used to integrate RESULTS polygons when creating a new VRI)

III. Age Update (new RESULTS openings)

1.) Updated age for new openings using:
   a. Forest cover inventory surveys
   b. Client silviculture records
   c. RESULTS (higher priority than FTA block layers as per VRI specs)
      i. Use RESULTS layer from BCGW
      ii. Use newest planting age, ie PLNT1_DATE
      iii. PLNT2_DATE exists but is older than PLNT1. i.e. block needed replanting
      iv. If no plant date, then set 2015 age to equal age of adjacent opening if stem height / conditions looked similar.
      v. Assume stock 1 year old at planting (i.e. 1+0). No 2 yr.
   d. FTA Blocks (2nd priority)
      i. Use PLN_HRV_DT for age
      ii. Use most recent plant date if conflicting dates with RESULTS polygons
   e. Check and update age manually

IV. Crown Cover ("CC") and Stocking ("SPH") Update

1.) Determine CC using CHM
   a. Generate a 0.5m CHM for the AOI and then determine the % of cells (% area) that is taller than 40% of the height assigned to the inventory polygon. Crowns do expand below this height but ignoring this is meant to counterbalance the fact that 100% of the area of the 0.5m tiles above the height threshold are not always going to be crown (i.e. a corner of the tile may have crown and the rest is non crown). This metric was cross checked with a VRI interpreter using many examples.
   b. Ensure all logged openings have a CC of at least 10%. Note: this ensures polygons are considered forested in terms of VRI. If we assign CC < 10 within an opening, then block area may be removed from productive landbase during analysis.
2.) Predict stems per hectare (SPH) using TSI software (proprietary tree segmentation routine)
   a. Update SPH for recent openings from RESULTS and Canoe Forest Products silviculture data
   b. For mature stands, calculate associated polygon SPH for stands >5m tall.
   c. If TSI SPH > VRI SPH, and forested poly: then use TSI SPH; else: use VRI SPH
   d. TSI algorithms historically underrepresents SPH by approximately 20-30% depending on the forest type – but no plot data is available to correct the estimates. They are thus expected to be a conservative estimate of SPH for calculating yields.
   e. Manually update using CHM where needed for special cases as determined by analyst.

V. Stand Height Update (“Ht2015” and “Ht2019”)

1.) Generalize to a 5m CHM (tallest point in each 5x5m pixel).
    a. This is done to eliminate small natural gaps (ground points) from the data as long as there is a tree within 5m.
    b. When gaps are larger than this, we want to recognize them in the process as stocking would be getting below 400sph.
    c. Note that this value in the 5mx5m pixel is species indifferent.
2.) Segment out all trees in the AOI using TSI software.
    a. Define a 20mx20m grid and populate ‘Top Height’ (average of the tallest 4 trees) into each cell. Make grids into point dataset.
3.) Assign heights (“Ht2015”) to each polygon with the following logic:
    a. Assign each polygon the average of all top height points that fall within it.
    b. If the Coefficient of Variation of heights from CHM 5m is >40% or the difference between the median and mean (CHM 5m) is >10% of mean height (CHM 5m):
        i. Where crown cover >20% or age (2019) is <30, assign the median height of CHM 5m raster (height where 50% of the area is taller).
        ii. Where crown cover is 10-20%, assign the 5m CHM height where 20% of the area is taller.
        iii. Where crown cover is <10%, assign the 5m CHM height where 10% of the area is taller.
    c. If there are < 20 points in the polygon, assign the median height of 5m CHM raster.
    d. If Age 2015 is <= 0, “Ht2015” = 0 metres
4.) Project stand height from 2015 to 2019 (“Ht2019”) using Age 2019, Updated Site Index (from the step below). If Age 2019 = 0, Ht2019 =0

VI. Site Index Update (“SiteIndex”)

1. Use the latest version of Site Tools (v 4.1 – March 2018)
2. For stands <= 20 yrs; SI values from the old VRI were maintained. These stands will use site index from the the provincial site productivity layer to estimate yields when the timber supply analysis is being completed.
3. For stands > 20 yrs, use LiDAR height (Ht2015) and 2015 age to update Site Index using Site Tools. See below for examples of why age was maintained from the old VRI over SI.

RESULTS

Site Index

Figure 1 shows the comparison between updated SI and inventory SI for all polygons greater than 20 yrs and area larger than 2 hectares, and Figure 2 shows the distribution of updated site index in 5 metre classes within the TFL.

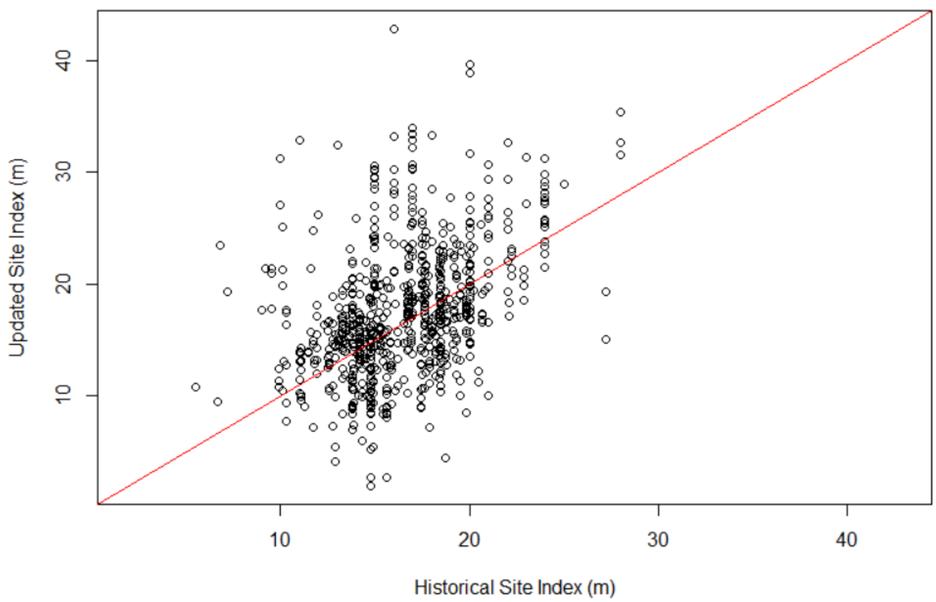


Figure 1 Comparison of updated SI vs historical SI

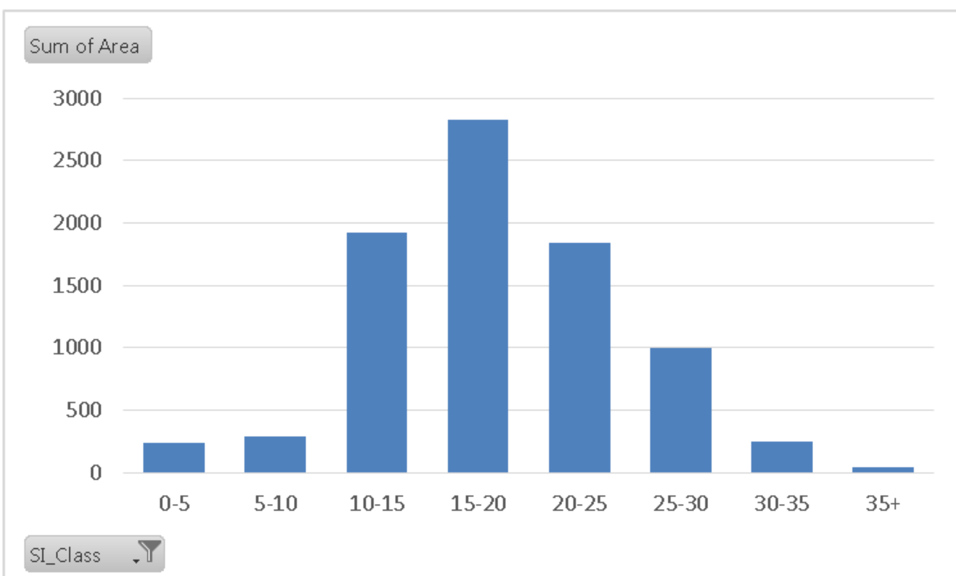
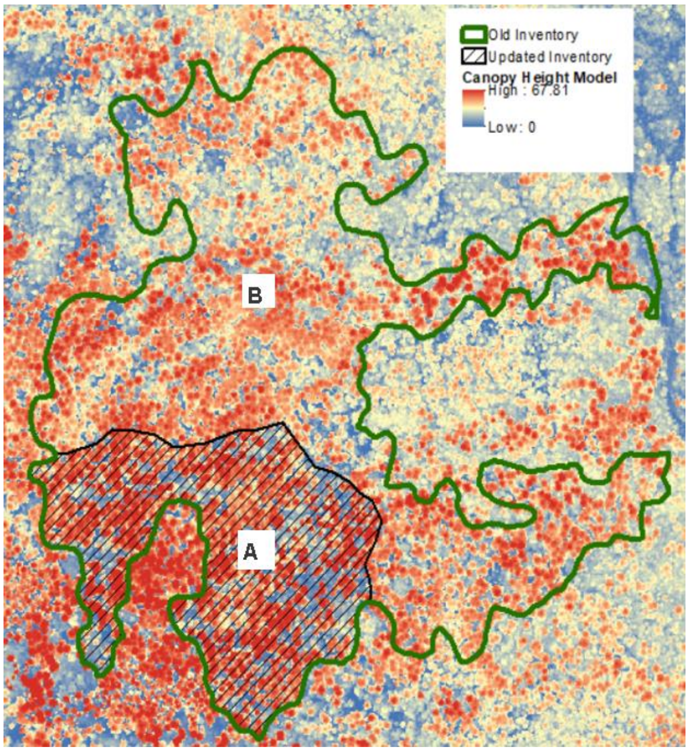


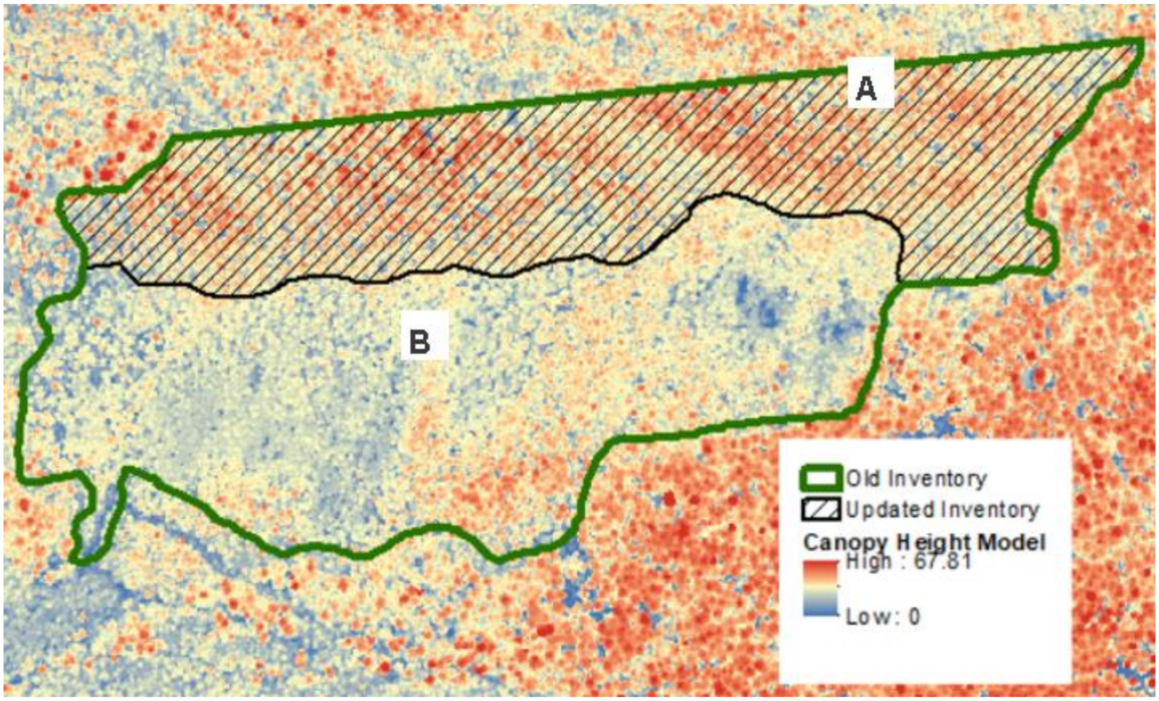
Figure 2 Site Index Distribution

The two examples below illustrate why Site Index was updated for mature stands rather than age. In these examples, the original inventory inventory polygons were split to better match the LiDAR attributes.



Example 1: Using new height to update SI (age stays the same) or Age (site index stays the same)

	PolyID	Species	Height	Age	SI	Or…	Age	SI
VRI	789	Fd	31.8	**176**	16.8		**176**	16.8
Part A	1430	Fd	43.3	**176**	23.1		**886**	16.8
Part B	1111	Fd	36.1	**176**	19.2		**271**	16.8



Example 2:

	PolyID	Species	Height	Age	SI	Or…	Age	SI
VRI	110	Fd	24.2	**184**	12.5		**184**	12.5
Part A	1363	Fd	31.9	**184**	16.6		**611**	12.5
Part B	261	Fd	25.9	**184**	13.4		**222**	12.5

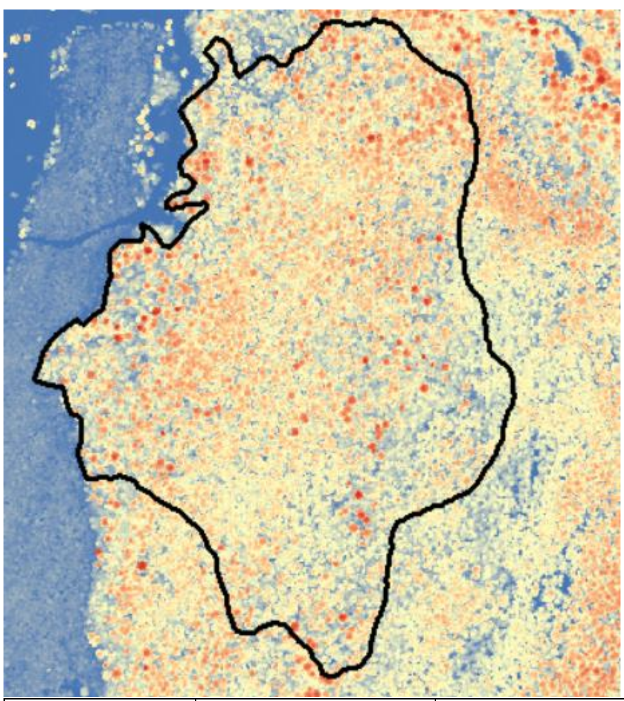
Crown Cover

The orginal inventory crown cover values were in 10% classes and seemed to bear very little resemblance to what the lidar data was showing. See below for examples.

Figure 3 illustrates the resulting crown cover distribution for the TFL when the approach using 40% of maximum height is used.

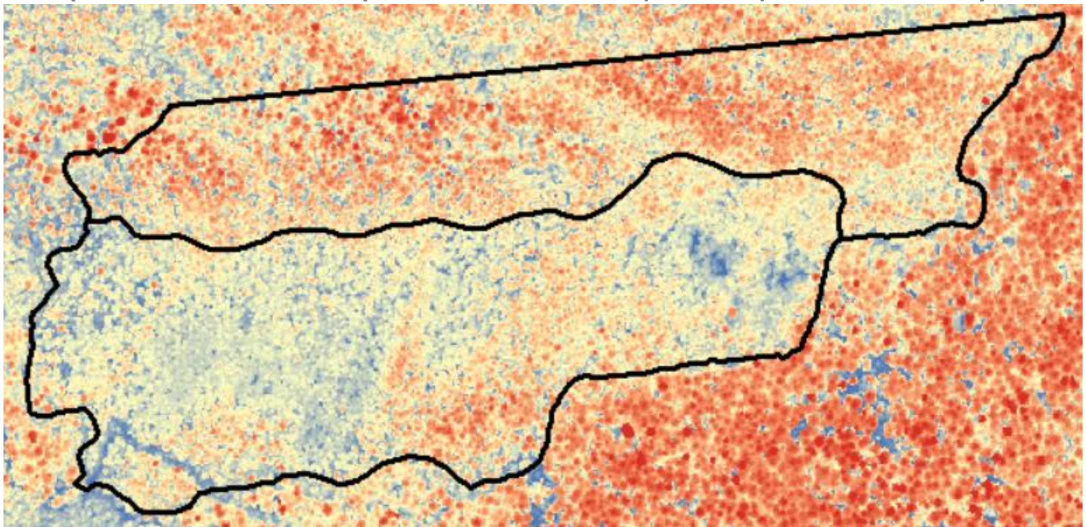
Example 3: Crown cover comparison between CHM (40% max) and old inventory value

POLY_ID	Old Inventory CC	CHM (40% poly Ht)
680	80	33

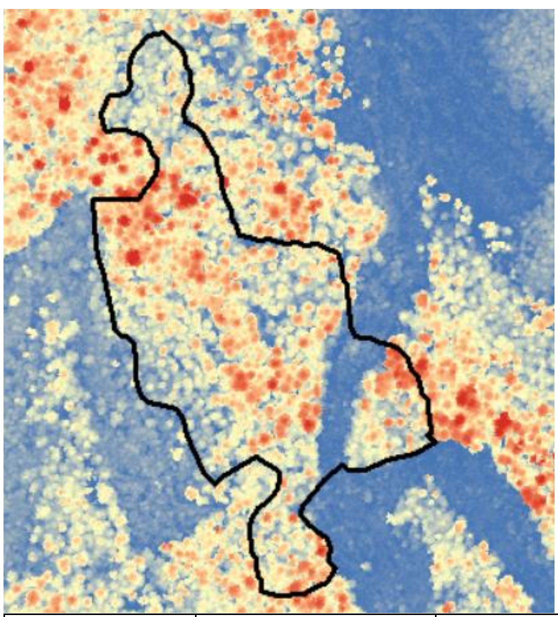


POLY_ID	Old Inventory CC	CHM (40% poly Ht)
686	20	64

Example 4: Crown cover comparison between CHM (40% max) and old inventory value



POLY_ID	Old Inventory CC	CHM (40% poly Ht)
261/1363	10	65 lower /70 upper



POLY_ID	Old VRI CC	CHM (40% poly ht)
750	70	51

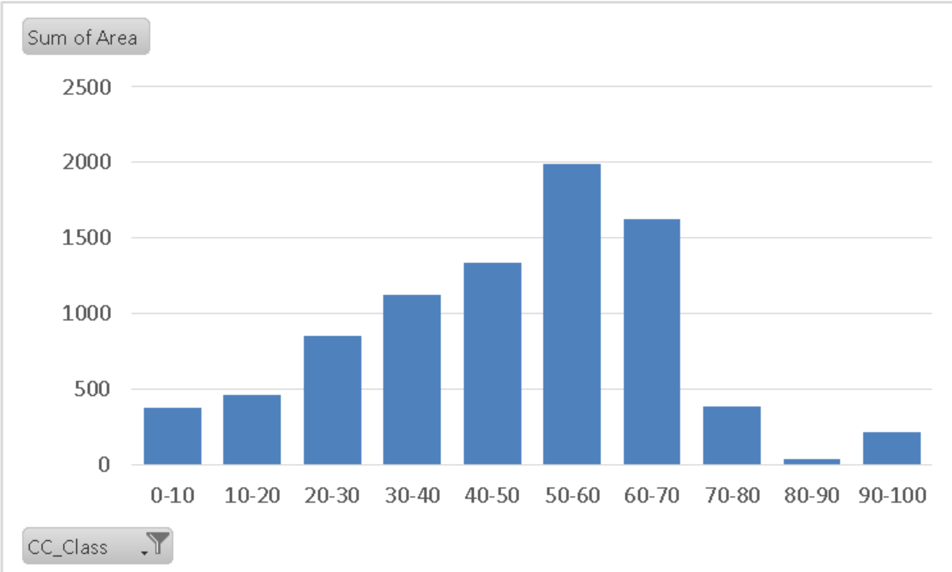


Figure 3 Crown Cover Distribution

Stems per Hectare

Figure 4 summarizes the distribution of stems per hectare assigned to the inventory polygons in the TFL.

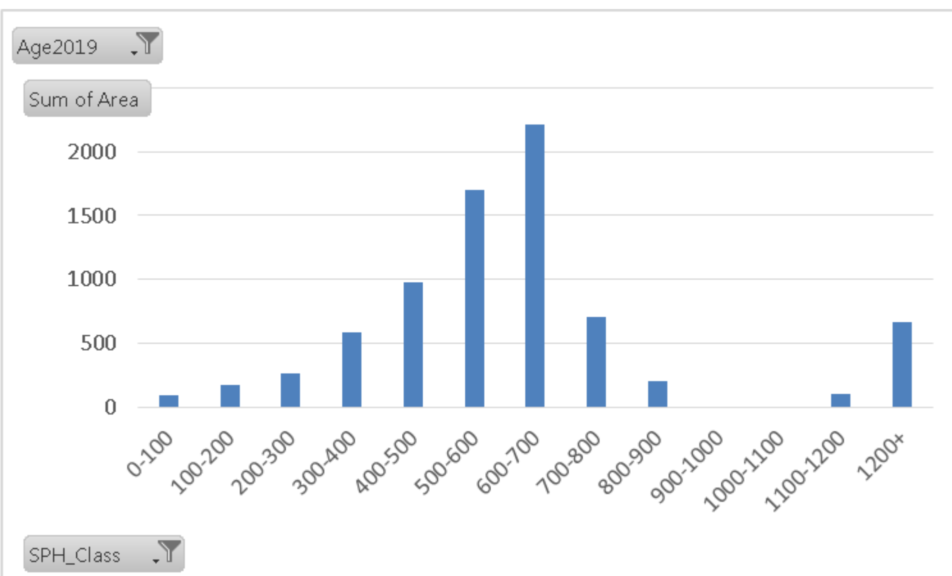


Figure 4 Stems per Hectare Distribution

Appendix 2 Cruise/VDYP comparison

Memorandum

To: Graham Hawkins, FLNRORD-FAIB

From: Rob Kennett

Cc: Jeff Lipsett, Canoe Forest Products

Date: December 10, 2019

Subject: Cruise/VDYP volume comparison

BACKGROUND

Forsite has created an updated version of an older non-VRI forest inventory for TFL 33 using LiDAR data to estimate height, crown cover, and stems per hectare for stands that have not been recently harvested. Species composition and ages for these stands were derived from the original inventory. Attributes for younger stands were updated using silviculture information where available.

In order to provide confidence that this updated inventory is suitable for use in the preparation of the new TFL Management Plan, a comparison of cruise volume to volumes predicted by VDYP 7 was completed for both the updated inventory and the original inventory.

APPROACH

Canoe Forest Products Limited provided operational cruise information for cutblocks that were cruised after the LiDAR was acquired (see Figure 1). These blocks fell into two broad categories:

- Blocks not identified as harvested in the updated inventory
- Blocks identified as harvested in the updated inventory that were still standing when the LiDAR was flown

VDYP volumes projected to 2019 were calculated for each block as follows:

- Unharvested blocks: Age, height, crown cover, and stems per hectare using the 2019 values in the updated inventory were used as inputs to VDYP.
- Harvested blocks: Height, crown cover, and stems per hectare for each block as of 2015 were created using the LiDAR metrics. Species composition and age in 2015 for each block were obtained by overlaying the 1998 inventory with the blocks. These 2015 values were input into VDYP 7 and projected to 2019.

Cruise areas and volumes were summarized for each block using the cruise reports. VDYP predicted volumes were summarized for each block using GIS areas and the indicated VDYP volumes per hectare.

In order to provide a reference against the original inventory, VDYP inputs were also created for each polygon in the original inventory using age, height, and crown closure in 1998. Stems per hectare were not available in this inventory. VDYP 7 was then used to create volumes projected to 2019 using these inputs. The cruised blocks were then intersected with the original inventory polygons to determine the area and weighted volume per hectare for each block.

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tel 250-832-3366 fax 1-888-273-0209 FORSITE.CA

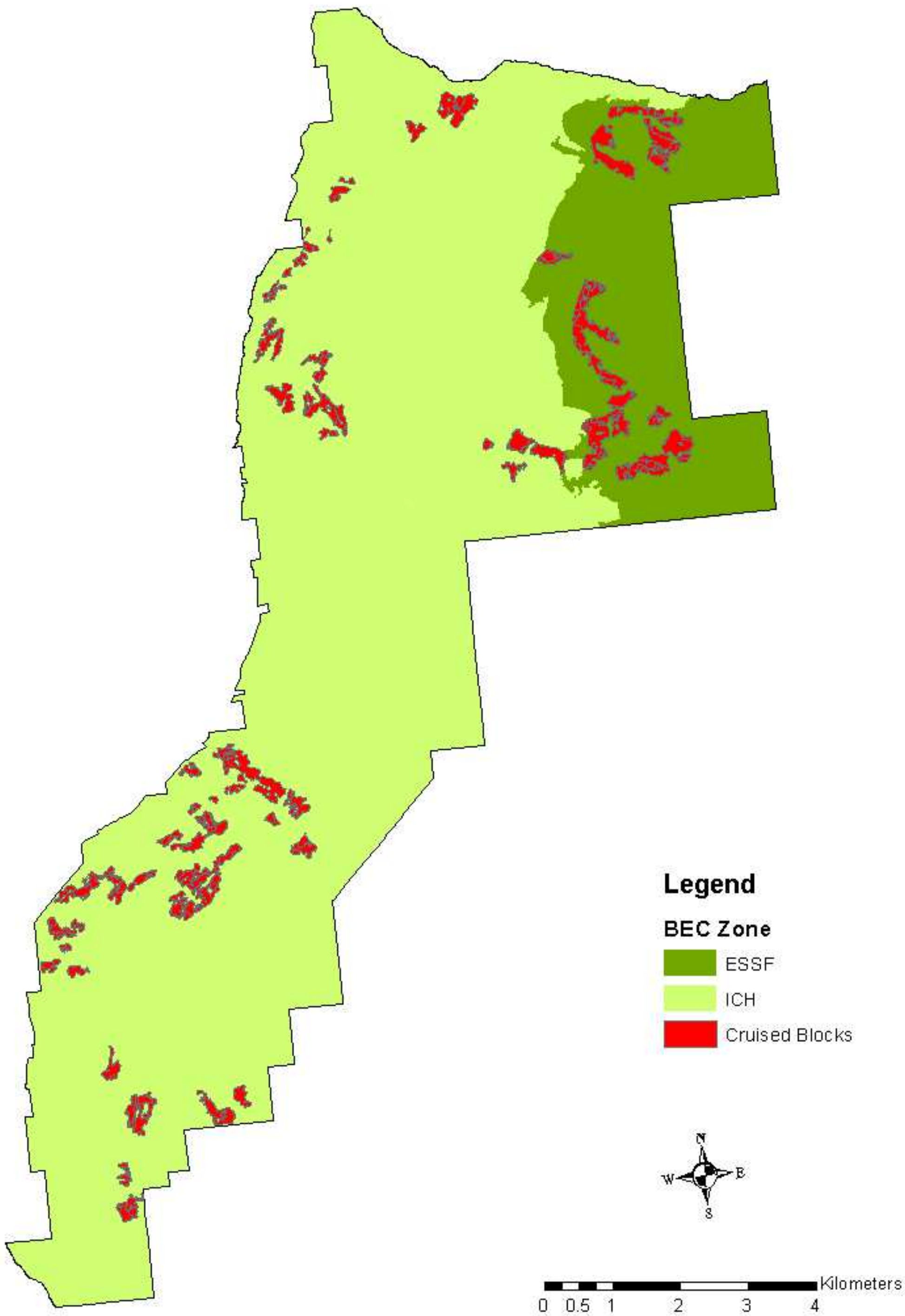

Figure 1 Location of cruised blocks

RESULTS

Table 1 summarizes the overall results from this analysis. It can be seen that the VDYP volumes derived using the updated inventory are slightly lower than those determined during the operational cruises. In comparison, the projected volumes using the original inventory attributes are significantly lower. Note that the small differences in area are the result of using areas from the cruise report versus using the polygon areas of mature forested polygons in the inventories.

Table 1 Cruise volume vs Inventory volumes

	Cruise			Updated Inventory (2019)				Original Inventory (2019)			
Block Type	**Area**	**Total Vol.**	**m^3 per ha**	**Area**	**Total Vol.**	**m^3 per ha**	**Ratio to Cruise**	**Area**	**Total Volume**	**m^3 per ha**	**Ratio to Cruise**
Not Harvested	167.9	74,362	**442.9**	173.3	74,594	**430.5**	97.2%	173.7	62,290	**358.6**	81.0%
Harvested	250.1	101,267	**404.9**	265.2	106,135	**400.2**	98.8%	273.1	99,383	**263.9**	89.9%
Total	**418.0**	**178,628**	**420.2**	**438.5**	**180,729**	**412.2**	**98.1%**	**446.8**	**161,673**	**361.8**	**86.1%**

It became apparent when completing this analysis that there were differences in results for blocks in the ICH vs blocks in the ESSF. Table 2 summarizes the results broken down by BEC zone. Overall, the updated inventory results in volumes that are 5.9% greater than cruise volumes in the ICH, and almost 20% lower than cruise volumes in the ESSF. Predicted volumes using the original inventory are still much lower than cruise volumes for both BEC zones. Note – ESSF makes up relatively small proportion of the TFL.

Table 2 Cruise volume vs inventory volumes by BEC zone

	Cruise			Updated Inventory (2019)				Original Inventory (2019)			
Block Type	**Area**	**Total Vol.**	**m^3 per ha**	**Area**	**Total Vol.**	**m^3 per ha**	**Ratio to Cruise**	**Area**	**Total Volume**	**m^3 per ha**	**Ratio to Cruise**
ICH - Not Harvested	100.2	48,824	**487.6**	104.9	56,853	**542.2**	111.3%	105.2	47,259	**449.2**	92.2%
ESSF – Not Harvested	67.7	25,538	**377..2**	68.4	17,741	**259.2**	68.7%	68.5	15,031	**219.4**	58.2%
ICH – Harvested	164.0	71,970	**438.8**	174.1	78,248	**449.5**	102.4%	179.6	67,860	**377.8**	86.1%
ESSF - Harvested	86.1	29,297	**340.3**	91.1	27,886	**306.1**	90.0%	93.5	31,524	**337.1**	99.1%
ICH – Total	**264.2**	**120,794**	**457.2**	**278.9**	**135,101**	**484.3**	**105.9%**	**284.8**	**115,119**	**404.2**	**88.4%**
ESSF- Total	**153.8**	**54.834**	**356.5**	**159.5**	**45,627**	**286.0**	**80.2%**	**162.0**	**46,554**	**287.4**	**80.6%**

Summary

Care must be taken when extrapolating these results to the entire inventory because cruised blocks do not represent an unbiased sample of the inventory. However, it appears that the new inventory represents current volumes on the land base far better than if the original inventory is simply projected to the current date using VDYP 7.

Appendix 3 Unsalvaged Losses

FORSITE
Forest Management Specialists

Memorandum

To: Jeff Lipsett, R.P.F.

From: Kat Gunion, R.P.F.

Cc:

Date: January 27, 2020

Subject: Non-Recoverable Losses

BACKGROUND

An estimate of non-recoverable loss (NRL) must be calculated for use in a timber supply review. These NRLs are used to reduce the harvest volumes estimated through the timber supply modelling.

This NRL estimation focused on three types of losses; wind throw, biotic-pests, and fire. They are presented in detail below.

APPROACH

Aerial overview survey (AOS) data, historical fire, and current fire data was obtained from DataBC (the current fire shape was empty for TFL33), and clipped to the timber harvesting landbase (THLB).

Polygons from AOS with a Capture Year greater than or equal to 2010 were selected. There were no Spruce Beetle, Wind throw, or historical Fire polygons during this period so these layers were omitted.

Table 1 Severity class and non-recoverable volume percent.

Severity Class	Percent of Trees in Polygon Recently Killed	Lost Volume
Trace	<1%	0.5%
Light	1-10%	5%
Moderate	11-29%	20%
Severe	30-49%	40%
Very Severe	>50%	75%

Individual Layers from AOS for Douglas-fir Beetle, and Mountain Pine Beetle were created. Their capture year and Severity were maintained and the layers were then unioned together. Where overlaps existed in the dataset between polygons for Douglas-fir Beetle, the one with the highest severity rating was retained.

The updated forest inventory was overlaid with this combined pest layer, and volumes for species one through species six were determined. Only polygons where there was no history of harvesting or planned harvesting were considered for the volume calculations. There were a few AOS polygons where most of the AOS polygon overlapped with previous or planned harvesting. These polygons were assumed to be fully addressed with any areas not covered by harvesting assumed to be due to inaccuracies in the AOS mapping.

Each severity class was assigned a lost volume percentage based on the midpoint of the class definition (Table 1.) The live volumes per hectare from the inventory were then multiplied by the area of the polygon and the lost volume percentages to get the total lost volume. For pests, only the volumes for the susceptible species were used (i.e. FDI volumes for Douglas-fir beetle, and PL, PW, and PA volumes for mountain pine beetle). These final volumes were then summed to give a ten year total, and then divided by ten to get the annual average.

RESULTS

Table 2 illustrates the total area and the associated volume lost for each of the pests for the 10 year period between 2009 and 2019.

Table 2 Total area and volume lost by severity from 2009-2019

Disturbance	Severity	Area (ha)	Volume (m^3)
Mountain Pine Beetle	Moderate	42	42
Total		42	42
Douglas-fir Beetle	Low	7	145
	Moderate	34	2,373
	Severe	15	1,080
	Very Severe	8	2,070
Total		64	5,668
Total		106	5,710

The final annual NRL values for TFL 33 are shown in Table 3. The total NRL per year is 571 m^3, which is an increase of 27% from the 450 m^3/year used in the 1999 analysis.

Table 3 Final NRL Values.

Disturbance	**Volume (m^3/yr)**
Pest	**571**
Mountain Pine Beetle	4
Douglas-fir Beetle	567
Total	**571**

Other non-recoverable losses on the landbase such as aspen leaf miners, pine needle cast and western balsam bark beetle were considered minimal and would be captured in our operational adjustments within the yield curves.