Timber Supply Review

Information Package – Cascadia TSA

Version 1.61

DRAFT

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Cascadia TSA

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1 Introduction

1.1 Context

BC Timber Sales (BCTS) is preparing a timber supply review (TSR) analyzing the strategic timber supply for the land base in the Cascadia TSA. This information package documents the procedures, assumptions, data and model to be used in the analysis. The information package is the first of three documents making up the TSR process. A separate document - the Analysis Report - summarizes the timber supply analysis results. The final document - the Rationale for AAC Determination - documents the Chief Forester's Allowable Annual Cut (AAC) determination and the rationale behind it.

In July 2011 the Cascadia Timber Supply Area (TSA) was established from an amalgamation of various tree farm license (TFL) areas taken back by the Province through the Forestry Revitalization Act (Bill 28, 2003). The Cascadia TSA consists of 11 Blocks located in the interior of British Columbia. The Blocks range in size from 2,000 ha to 83,000 ha.

BCTS is the sole operator in the Cascadia TSA, holding 100% of the AAC. The TSA is spread over four BCTS Business Areas (BAs): Kootenay (TKO), Okanagan-Columbia (TOC), Cariboo-Chilcotin (TCC), and Skeena (TSK). The volume targets for BCTS are currently established by Business Area and field team. Field teams are operated out of offices in Nelson and Castlegar (TKO), Vernon and Revelstoke (TOC), Williams Lake and Quesnel (TCC), and Terrace and Hazelton (TSK).

BCTS has engaged Forest Ecosystem Solutions Ltd. (FESL) to prepare this information package and complete the timber supply review on their behalf. Upon approval by the Forest Analysis and Inventory Branch (FAIB) of the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD), the assumptions detailed in this information package will be used to guide the development of the timber supply analysis.

The purpose of this information package is to:

- Provide a detailed account of the factors related to timber supply that the Chief Forester must consider under the Forest Act when determining an AAC and how these factors will be applied in the timber supply analysis;
- Provide a means for communication between staff from BCTS, FLNRORD, other government agencies, First Nations and stakeholders.
- Provide staff of the different ministries, First Nations and stakeholders with the opportunity to review data and information that will be used in the timber supply analysis before it is initiated;
- Ensure that all relevant information is accounted for in the analysis to an acceptable standard;
- Reduce the risk of having the analysis rejected because input assumptions and analysis methods were not agreed upon in advance.

This timber supply review will focus on current management practices in the TSA with some exceptions; in those cases where new rules or legislation are imminent, the analysis assumptions are consistent with the anticipated changes.

The current management scenario is called the base case. During the analysis, various sensitivity analyses, harvest flow alternatives, and management options will be tested to determine the influence of various factors on harvest levels. The combination of the base case and sensitivity analyses will provide the basis for discussions, public feedback and ultimately the Chief Forester’s AAC determination.

1.2 Study Area

The Cascadia TSA consists of 11 Blocks in the interior of British Columbia. Figure 1 shows the location of the Cascadia TSA Blocks. The TSA overlaps parts of three Natural Resource Regions - Kootenay/Boundary, Cariboo and Skeena - and three Natural Resource Districts - Selkirk (DSE), Quesnel (DQU) and Coast Mountains (DKM). The Blocks range in size from 2,000 ha to 83,000 ha. A summary of Blocks within each district and business area is shown in Table 1.

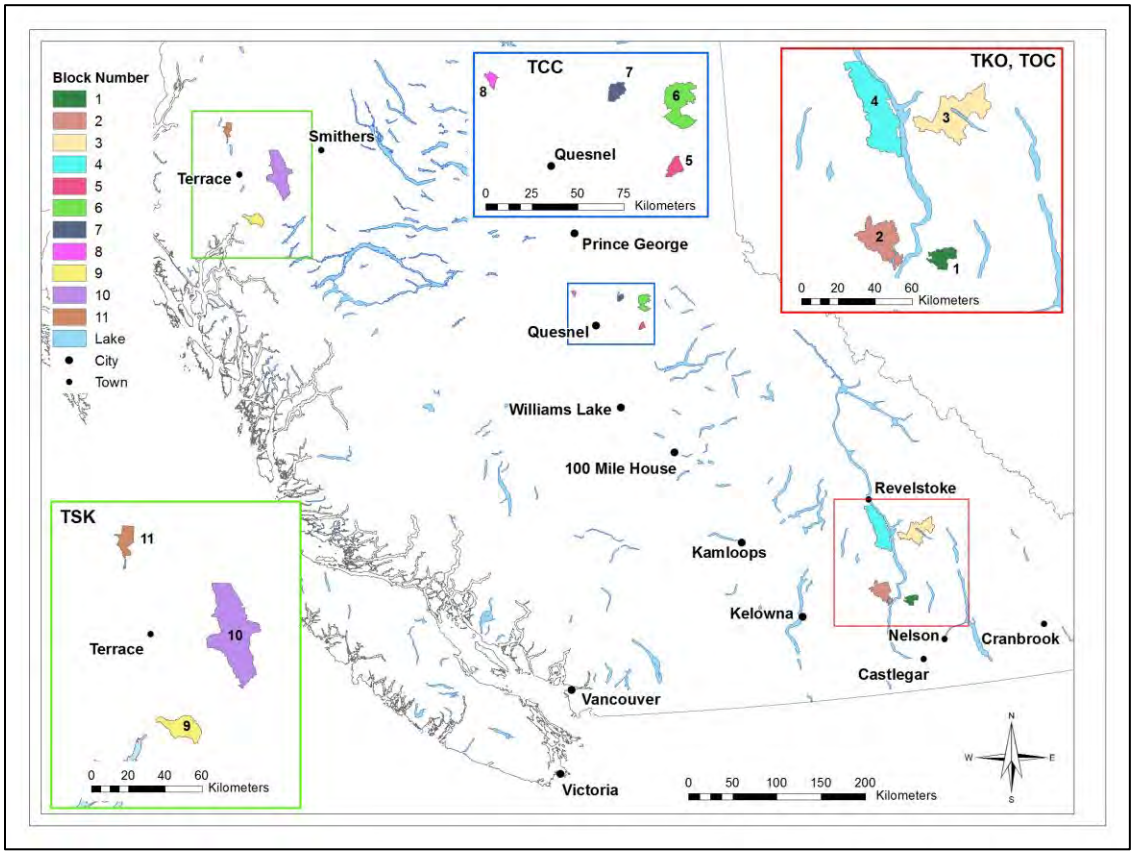

Figure 1: Cascadia TSA Blocks

Table 1: Cascadia TSA Blocks, Natural Resource Districts, and Business Areas

Block	District	Business Area	Area (ha)
1	DSE	TKO	11,734
2	DSE	TKO	35,072
3	DSE	TKO	55,226
4	DSE	TOC	73,517
5	DQU	TCC	3,662
6	DQU	TCC	17,319
7	DQU	TCC	4,208
8	DQU	TCC	2,015
9	DKM	TSK	19,754
10	DKM	TSK	83,268
11	DKM	TSK	10,854
Total			**316,630**

1.2.1 First Nations

Twenty-four First Nations or bands have asserted and/or established Aboriginal Interests within the Cascadia TSA as shown in Table 2.

Table 2: First Nations in the Cascadia TSA

Name	Type	Cascadia TSA Block
Neskonlith Indian Band	Band	1, 2, 3, 4, 5
Secwepemc RFA	First Nation Group	1, 2, 3, 4
Okanagan Nation Alliance	Tribal Council	1, 2, 3, 4
Okanagan Indian Band	Band	1, 2, 3, 4
Adams Lake Indian Band	Band	1, 2, 3, 4
Westbank First Nation	Band	1, 2, 3
Splats'in First Nation	Band	1, 2, 3, 4
Shuswap Indian Band	Band	1, 2, 3, 4
Little Shuswap Lake Indian Band	Band	4
Ktunaxa Nation Council	Tribal Council	1, 3
Tsilhqot'in - Engagement Zone A	Tribal Council	5, 6, 7, 8
Lhtako Dene Nation	Band	5, 6, 7, 8
Xats'ull First Nation	Band	5
Tsilhqot'in Nation - Notice of Civil Claim	First Nation Group	6, 7, 8
Nazko First Nation	Band	8
Kitsumkalum Band Council	Band	11
Gitxsan Hereditary Chiefs	Tribal Council	10, 11
Kitselas First Nation - Traditional Territory	Band	10

Name	Type	Cascadia TSA Block
Skin Tyee Nation	Band	10
Wet'suwet'en First Nation	Band	10
Metlakatla Band Council	Band	10
Lax Kw'alaams Band	Band	10
Office of the Wet'suwet'en	Tribal Council	10
Haisla Nation	Band	9

1.2.2 Land Use Plans

The Cascadia TSA contains several land use plans including the Kootenay-Boundary Higher Level Plan Order (KBHLPO), the Revelstoke Higher Level Plan Order (RHLPO), the Cariboo-Chilcotin Land Use Plan (CCLUP), and the Kalum Sustainable Resource Management Plan (KSRMP).

The TKO business area Blocks are managed under KBHLPO while the TOC business area (Block 4) is managed through RHLPO. All of the Blocks in the TCC business areas are managed under CCLUP, while in the TSK business area, the management direction comes from the KSRMP. Table 3 shows land use plans in force for each business area and Block.

Table 3: Land use plans in the Cascadia TSA

Block	Business Area	Land Use Plan / Order
1	TKO	KBHLPO
2	TKO	KBHLPO
3	TKO	KBHLPO
4	TOC	RHLPO
5	TCC	CCLUP
6	TCC	CCLUP
7	TCC	CCLUP
8	TCC	CCLUP
9	TSK	KSRMP
10	TSK	KSRMP
11	TSK	KSRMP

2 Timber Supply Scenarios and Sensitivity Analyses

This section briefly describes the management scenarios that will be presented in the Timber Supply Analysis Report.

2.1 Base Case

A timber supply analysis will be carried out using information outlined in this information package to support the AAC determination for the Cascadia TSA. This information includes data and information in three general categories: land base inventory, timber growth and yield and management practices. Using this information and a computer simulation model (as described under Section 3), a series of timber supply forecasts will be produced, reflecting different starting harvest levels, rates of decline or increase, and potential trade-offs between short and long term harvest levels. One of these forecasts will be chosen as the best reflection of current management in the Cascasdia TSA. This forecast will be presented as the base case harvest forecast, and will form the basis for comparison to assess the effects of uncertainty on timber supply.

The base case will be a non-spatial analysis using time-step simulation. The base case will reflect current management activities based on the following guidelines:

- Management activity as defined mostly by historical operations with emphasis on the last 5 years;
- *Forest and Range Practices Act* (FRPA);
- Forest cover inventory projected and updated to 2016;
- Apply inventory adjustments where appropriate;
- VDYP natural stand yields (NSYTs) for stands originating before 1976;
- Tree and Stand Simulator (TASS) managed stand yield tables (MSYTs) for all stands originating after 1975;
- Current utilization standards;
- Provincial site index layer to construct MSYTs;
- Genetic gains from tree improvement;
- Follow management direction from the Kootenay-Boundary Higher Level Plan Order (KBHLPO), the Revelstoke Higher Level Plan Order (RHLPO), the Cariboo-Chilcotin Land Use Plan (CCLUP), and the Kalum Sustainable Resource Management Plan (KSRMP) along with landscape unit (LU) plans.

2.2 Sensitivity Analyses

Sensitivity analyses provide an understanding of the contribution of specific data and assumptions to the timber supply dynamics of the base case. They also verify that the model is applying the harvesting constraints correctly. Table 4 presents the sensitivity analyses that are proposed to test the various uncertainties that exist in the base case data and assumptions. Additional sensitivities may be included, if new uncertainties are identified while completing the base case. Note that the base case will be run separately for each business area. As seen in Table 4, the TSA will be analyzed as an aggregate unit in a sensitivity analysis.

Table 4: Proposed sensitivity analyses

Issue	Sensitivity analysis	Notes
Generic Sensitivity Analyses		
Minimum harvestable age (MHA)	Increase and decrease MHA	BAs separately
Minimum volume/ha threshold	Increase and/or decrease minimum vol/ha	BAs separately
Volumes from existing natural stands	Increase and/or decrease existing natural stand volumes	BAs separately
Volumes from managed stands	Increase and/or decrease managed stand volumes.	BAs separately
Marginal timber	Include marginally economic areas in the harvest forecast as follows:	
	Include the Payne Creek area and helicopter operable area in the THLB	TKO
	Include helicopter operable area in the THLB	TOC
	Include helicopter operable area in Block 9 in the THLB.	TSK
	Include conventionally operable areas classified as low volume or uneconomic in the THLB in Blocks 10 and 11	TSK
Uncertainty regarding harvest of specific areas or specific species	Exclude specific areas or species from harvest.	BAs separately
Harvest rule	Use a different harvest rule; relative oldest first	BAs separately
Cascadia TSA Specific Sensitivity Analyses		
BCTS business area harvest	Run the analysis for the TSA as an aggregated unit.	Total aggregated harvest forecast and forecast by BA.
BEC version	Use different BEC versions	TKO, TOC
Armillaria impact in TKO and TOC. Pine forest health in TCC.	Use custom Operational Adjustment Factors (OAF 2) to test impact of Armillaria and Mountain Pine Beetle (MPB) on timber supply.	TKO, TOC (Armillaria) and TCC (MPB)
Deciduous in TCC	Control	TCC, if significant, consider controlling deciduous harvest in the base case
Green-up	33% maximum compared to 25%	All business areas
Agreement in Principle (AIP)	Remove AIP area from the THLB	TSK

2.3 Previous Timber Supply Reviews

There has been no formal timber supply review for the Cascadia TSA in the past. The current AAC for the TSA was established through a proportional allocation of the AACs of those TFLs that formed the Cascadia TSA. The current AAC for the TSA is 402,818 m^3 per year.

3 Model

Model Name: Forest Simulation and Optimization System (FSOS)

Model Developer: Dr. Guoliang Liu

Model Development: UBC, Hugh Hamilton Limited, Forest Ecosystem Solutions Ltd.

Model Type: Landscape Design Model

For this analysis Forest Simulation and Optimization System (FSOS) is used for modelling timber supply. FSOS uses C++ programming language. The model interfaces directly with Microsoft Access for data management. Although FSOS has both simulation and heuristic (pseudo-optimization) capabilities, the time-step simulation mode will primarily be used in this analysis. Time-step simulation grows the forest based on growth and yield inputs and harvests resultant polygons based on user-specified harvest rules and constraints that cannot be exceeded. Using these "hard" constraints and harvest rules instead of targets (as would be applied in the heuristic mode of FSOS) gives results that are repeatable and more easily interpreted.

From GIS overlay, the land base is divided into resultant polygons, each with a unique set of attributes. Constraints and harvest criteria are applied to each polygon based on these attributes. Constraints and harvest criteria can be defined by analysis unit, forest type, forest age, silviculture treatment, user allocation, site index, non-timber resource objectives or any other parameter.

FSOS uses individual stand ages to project the current age structure of stands in the analysis area. As stands age, they move into and out of age classes established as a basis for meeting target objectives. Generally, FSOS runs utilize 5-year periods, as the output is intended to be operationally applicable and reflect 5-year management plan objectives, but 1, 10 or 20 year periods can easily be assigned. The middle of the period (year 3 for 5-year periods) is used for reporting.

The planning horizon length can vary as required. FSOS can produce spatially and temporally explicit plans over 20 years or for multiple rotations. A unique feature of FSOS is its ability to integrate strategic, tactical and operational planning phases into one process. Analysis runs include harvest timing and location for each period, as well as long-term sustainable harvest levels.

The reporting functions of FSOS are extensive. The data for each period is easily accessible for any analysis unit, zone, polygon, LU, etc. and gives an overview of the forest state at any point in time. Species compositions, age structure, patch distribution, harvest scheduling, and many other variables are tracked and reported by period. Reporting functions are highly effective for the direct comparison of differing sensitivity analysis scenarios. FSOS is linked directly to the powerful ArcMap environment for high-quality map production.

4 Forest Inventory and Land Base Data

4.1 Data Sources

The majority of the data and assumptions for this project were downloaded from BC Geographic Warehouse (BCGW) or provided by BCTS. The base case of this analysis is considered to reflect current management in the Cascadia TSA. Table 5 lists all the spatial data layers used in the analysis, with their source and vintage.

Table 5: Spatial data sources

Layer Name	Description	Source	Vintage
arch_clip	Archeological Sites	BCTS	2017
bec_all	Provincial Biogeoclimatic Ecosystem Classification, versions 4, 7, and 10	BCGW	various
Cascadia_TSA	Cascadia TSA boundaries	BCTS	2017
cws	Community Watersheds	BCGW	2017
dws	Domestic Watersheds	BCTS (BCGW)	2017
kalum_grizzly	Draft Grizzly Bear WHAs	BCTS	2017
legal_beo	RHLPO Biodiversity Emphasis Option	BCGW	2001
legal_trail	CCLUP Buffered Trails	BCGW	2011
legal_corridors	KBHLPO Grizzly Bear Connectivity Corridors	BCGW	2002
legal_grizz_wshed	Kalum SRMP Grizzly Bear Identified Watersheds	BCGW	2006
legal_lakeshore	CCLUP Lakeshore Management Classes	BCGW	2011
legal_lu	RHLPO Landscape Units	BCGW	2001
lu_clip	Landscape Units	BCGW	2017
nonlegal_beo	KBHLPO Biodiversity Emphasis Option	BCGW	2002
ogma_final	Old Growth Management Areas	BCGW/BCTS	2017
own_final	Provincial ownership data	BCTS	2017
pod_buff	Points of Diversion, buffered 100m	BCGW	2017
psp_clip	Permanent Sample Plots	BCGW	2017
cascadia_rd_class_v2	Existing Roads	BCTS	2017
cascadia_proposed_rds	Proposed Roads	BCTS	2017
rec_polys_tko	Forest Tenures Recreation Areas	BCTS	2017
rec_trails	Forest Tenures Recreation Trails	BCTS	2017
rip_final	Riparian features and buffers	FESL/BCTS/BCGW	2017
slp60_blk10	Block 10 areas where slope is steeper than 60%	BCTS	2017
TCC_grizzly	Grizzly bear habitat capability classes	BCTS	2007
TSK_AIP	First Nation Agreement in Principal Lands	BCTS	2015
tsm_combine	Terrain Stability Mapping	BCGW	various
utilities_all	Pipelines, transmission lines, etc	BCTS	various

Layer Name	Description	Source	Vintage
uwr_clip	Ungulate Winter Range	BCGW	2017
VQO	Visual Quality Objective	BCGW	2017
wha_clip	Wildlife Habitat Areas	BCGW	2017
vri_all	Vegetation Resource Inventory	BCTS (FAIB)	2016
cons_cutblocks_2017	Consolidated Cutblocks	FAIB	2017
bcts_harvest_all	Harvested blocks	BCTS	2017
bcts_proposed_all	5-year plan proposed harvest	BCTS	2017
oper_final	Operability	FESL	2018
pem_tem	TEM and PEM site series	BCTS/BCGW	various

4.2 Forest Inventory and Depletions

The current forest inventory in the Cascadia TSA is a combination of a new Vegetation Resource Inventory (VRI) and non-standard TFL forest inventories. Each inventory was converted to VRI format by FAIB, projected to 2016, and then provided to FESL. FESL combined all these separate inventories into one consolidated VRI for the entire Cascadia TSA. The following issues were dealt with while processing the VRI.

4.2.1 Missing Data

Approximately 3,900 ha - mostly in Block 9 - contained no data in the VRI. SPOT imagery and the neighbouring polygons were used to assign attributes in the missing areas. BCTS provided SPOT imagery together with older black and white orthophotos for areas where the SPOT image was in deep shadow and difficult to interpret. Using these images, the missing areas were classified as alpine, avalanche tracks, gullies, wetlands, previous harvest, or forest. Those areas deemed to be forest were assigned the attributes from nearby polygons that appeared similar in the imagery.

In Blocks 5, 6, 7, 10, and 11, most of the polygons with missing data were around the edges, where the TFL data did not quite match the provincial TSA boundary. For these areas the neighbouring polygons were extended to fill in the gaps.

For Blocks 2 and 3, the polygons with missing data were assigned the attributes of a similar neighbouring polygon.

Once these polygons were given appropriate attributes, the data was mapped and sent to BCTS for review. Table 6 shows the areas of missing VRI data in the Cascadia TSA by Block.

Table 6: Missing VRI data summarized by Block

Block	Null Area (ha)
2	75
3	142
5	18
6	9
7	11
9	3,582
10	7
11	64
Total	**3,908**

4.2.2 Depletions

Depletion data for the Cascadia TSA originate from a number of different sources:

- Consolidated Cutblocks 2017;
- VRI harvest date;
- VRI age;
- BCTS business areas harvest data and proposed cutblocks;
- Manual changes by BCTS and FESL based on orthophotos

All these depletions were combined, mapped and spot-checked against orthophotos and Google Earth. BCTS reviewed the data and provided corrections and information on missing cutblocks.

The harvest data provided by each BA was used as the primary data source for depletions. The 2017 consolidated cutblocks data was used as the secondary source followed by the VRI harvest history. Furthermore, all stands with age less than or equal to 40 in 2016 were considered harvested, regardless whether a depletion record existed or not.

Once all updates were completed the final depletions dataset was added to the VRI.

4.2.3 Forest Management Land Base

The forest management land base field (FMLB) is a land classification provided in the VRI which is used to identify the forested part of the TSA land base that is capable of supporting a crop of trees for timber production. Areas not classified as FMLB will be excluded from the timber harvesting land base (THLB) as non-forest.

For the Cascadia TSA, the FMLB was updated for depletions, but otherwise unchanged from the source VRI. Previously harvested areas are considered to be forested and classified as FMLB.

A summary of FMLB is shown in Table 7.

Table 7: FMLB areas by Block

Block	Yes (ha)	No (ha)
1	10,380	1,354
2	33,387	1,685
3	41,583	13,643
4	51,110	22,407
5	3,597	65
6	16,523	797
7	4,127	82
8	1,950	66
9	9,804	9,950
10	40,379	42,889
11	8,723	2,131
Total	**221,563**	**95,068**

4.2.4 VRI Adjustments

All former TFLs had their inventories statistically adjusted using measurement of selected stand attributes collected from a sample of ground plots. The field sampling and inventory attribute adjustment were typically completed following the VRI Phase II process. Note that the VRI as provided by FAIB does not incorporate inventory adjustments.

4.2.4.1 Blocks 1, 2, 3 and 4

The former TFL 23 area (Blocks 1, 2, 3 and 4) has been re-inventoried and there is no need to incorporate inventory adjustments to the new inventory.

4.2.4.2 Blocks 5, 6, 7, and 8

Blocks 5 to 8 (TFL 52) had a VRI phase II adjustment completed before the Cascadia TSA was formed. The inventory adjustment was completed using VDYP7. In theory, this would make it relatively simple to adjust these inventories by simply using the inventory adjustment factors from the original adjustment project and applying them to the original reference inventory and then projecting the reference inventory to 2018.

However, as the adjustment factors were originally compiled using sample plot data over the entire TFL, they would be biased if utilized for adjusting the inventories on a fraction of the original area, i.e., Blocks 5, 6, 7, and 8. Consideration was given to recalculate the adjustment factors based on the portion of the plot data that fell on these Blocks. Unfortunately, Blocks 5, 6, 7, and 8 contained only 7 sample plots (out of 64 plots), with none in Blocks 5 and 8, 1 in Block 7 and 6 in Block 6. The number of sample plots was considered too low for a statistically valid adjustment.

4.2.4.3 Blocks 9, 10, and 11

Block 9 is located in the TSK business area. It used to be part of TFL 41. An inventory adjustment was completed for TFL 41 in 1998; however, due to the lack of original plot data it is not possible to adjust the inventory in an unbiased manner using VDYP 7.

The inventories for Blocks 10 and 11 (TFL 1) had a VRI phase II adjustment completed before the Cascadia TSA was formed. VDYP 6 was used to complete the inventory adjustment. As this analysis will use a different growth and yield model than the one used for the original inventory adjustment – VDYP 7 instead of VDYP 6 – to model natural stand yields, it would not be appropriate to utilize the adjustment ratios from the past adjustment. Rather, the original sample plot data is required to apply an adjustment to Blocks 10 and 11 inventories using procedures designed for VDYP 7.

The original sample plot data consisted of 150 plots distributed over the entire TFL. Only 12 plots fall within the Cascadia TSA (6 in each of Blocks 10 and 11). The number of sample plots was considered too low for a statistically valid adjustment.

4.2.5 Cascadia TSA LiDAR Enhanced Forest Inventory

BCTS acquired LiDAR data for the four business areas within the Cascadia TSA for operational planning purposes. This data was also seen as a potential tool to enhance the VRI for this TSR.

FAIB are using LiDAR to update forest inventory information throughout the province in high priority areas. LiDAR Enhanced Forest Inventory (LEFI) Tier 2 approach was used in this project; a set of

calibration plots were used to build parametric models and derive the inventory attributes from the LiDAR point cloud metrics.

In addition to stand height, these models predict basal area, diameter at breast height (DBH), [1]Lorey height, top height, and volume (net and gross). The LiDAR predictions were compared to variable radius ground (cruise) plots.

The LiDAR predictions can be used to update the VRI database provided that they mirror the parameter values and the variation measured on the ground. In this case only the prediction of average height and top height yielded satisfactory results. The VRI stand heights were updated using the LiDAR predictions prior to natural stand yield curve construction.

The LEFI approach used in this analysis is described in detail in Appendix 2 – Cascadia TSA LiDAR Inventory Update 2018.

4.2.6 Age Update

The depletion data were used to update the VRI stand ages in 2016; the following criteria were used:

- For depletions in 2007 or later, calculate stand age in 2016 as 2016 minus depletion year;
- For depletions between 1992 and 2006, the VRI may already be updated. An expected age was calculated as (2016 minus depletion year) and compared to the VRI projected age. If the VRI projected age was greater than the expected age plus 5 years, expected age was used, otherwise the VRI age was used;
- For older depletions, if the VRI age was null, the depletion year was used to calculate stand age, otherwise the VRI age was used;
- For all other stands, the VRI projected age was used;
- If a stand is classified as FMLB with the VRI age null and no depletion date (123 ha in the data set), it was assumed that the stand is non-sufficiently restocked (NSR) and the age in 2016 was set to 0.

4.3 Riparian Classification

Implementation of resource management objectives include establishment of riparian reserve zones and/or riparian management zones adjacent to water features. The width of these zones varies according to the water feature class. Under FRPA guidelines, water features are classified based on their size and whether or not they are fish habitat. This classification is straightforward for polygon features (lakes, wetlands, and large rivers), but not for smaller streams. Classified streams were available for Blocks 5, 6, and 7 in TCC, and for scattered areas elsewhere in the TSA. BCTS requested that FESL classify the streams in the remainder of the TSA. The source data for streams was the Freshwater Atlas. The following inputs were used:

- Freshwater Atlas Streams;
- Fish observation points ;

[1] Lorey height weights the contribution of trees to the stand height by their basal area. Lorey height is calculated by multiplying the tree height (h) by its basal area (g), and then dividing the sum of this calculation by the total stand basal area.

- DEM at 25m resolution, derived from TRIM elevation points, classified into slope greater than 20% or slope less than or equal to 20%.

Freshwater Atlas streams form a clean, continuous network with no gaps and the stream order is included in the attributes. The processing methodology was as follows:

1. Stream segments were divided based on slope greater than 20%, or slope less than or equal to 20%;
2. Fish observation points were linked to nearest stream;

The following rules were used to assign stream classes:

1. All segments downstream of a fish observation point are fish-bearing;
2. All segments upstream of a fish barrier (slope > 20%) are not fish-bearing;
3. All fourth order or higher streams are assumed to be fish-bearing;
4. All streams within a community watershed are considered fish-bearing;
5. First and second order streams are classified as S4 if fish-bearing, and S6 if not;
6. Third order streams are S3 if fish-bearing, S5 if not;
7. Fourth order streams are classified as S2;
8. Fifth order and above are classified as S1;

The classified streams were mapped and forwarded to BCTS for verification. Some changes were made based on field knowledge.

4.3.1 Polygon Water Features

Rivers, lakes, and wetlands from the Freshwater Atlas were classified according to size as per the Riparian Management Guidebook. For rivers, the width of these polygons was calculated as:

Width = Area / (Perimeter / 2)

Rivers wider than 100 m are S1A, rivers between 20 and 100 m wide are S1B, rivers less than 20 m wide are S2. A manual check of the rivers was also performed and compared with the stream classification. Some corrections were made to ensure that the classification was consistent. Lakes and wetlands were classified based on size.

Table 8 summarizes the total areas and lengths of the riparian classes within the Cascadia TSA.

Table 8: Riparian classes in the Cascadia TSA

Riparian Class	Definition	Length (km)	Area (ha)
S1A	>=100m wide	3	
S1B	20-100m wide	118	729
S2	5-20m wide	429	34
S3	1.5-5m wide	212	4
S4	<1.5m wide	478	
S5	> 3m wide, no fish	452	12
S6	<= 3m wide, no fish	5,388	
L1 large	>1000 ha		1,235
L1	5-1000 ha		747
L3	1-5 ha		183
NCL	small lake		151

Riparian Class	Definition	Length (km)	Area (ha)
W1	>5 ha		724
W3	1-5 ha		227
W5	wetland complex		338
NCW	small wetland		97

5 Description of the Land Base

5.1 Timber Harvesting Land Base

Land base assumptions define the land base classification in the Cascadia TSA. The different classes are a result of a land base netdown. The netdown is an exclusionary process. Once an area has been removed, it cannot be deducted further along in the process. For this reason, the gross area of netdown factors (e.g. inoperable) is often greater than the net area removed; a result of overlapping resource issues.

The TSA is classified in the following classes:

Excluded Land Base (EXLB) – private lands, non-forested areas and roads are excluded from the land base. These areas are excluded because they do not contain forest or are not managed by the Crown.

Crown Forested Land Base (CFLB) – the CFLB is identified as the broader land base that contains forest and can contribute towards meeting both timber and non-timber objectives (i.e. biodiversity).

Timber Harvesting Land Base (THLB) – the THLB is the portion of the CFLB where timber harvesting can occur. It is productive forest land that is harvestable according to current forest practices and legislation.

Non-Harvestable Land Base (NHLB) – the portion of the CFLB where harvesting will not occur according to current forest practices. The NHLB includes some areas that are currently not harvestable due to economic considerations. There is a possibility that some or all of these areas could become harvestable under different economic conditions.

The land base netdown for the entire TSA is shown in Table 9, and the netdowns for each business area are shown in Table 10, Table 11, Table 12, and Table 13 with each reduction described below.

Table 9: Cascadia TSA netdown summary

Netdown Category	Net Area (hectares)	Gross Area (hectares)
Total Area		**316,630**
Non-Crown land	1,494	1,494
Non-forest	95,518	95,757
Roads and Utility Corridors	4,180	4,882
CFLB Area	**215,437**	
Ungulate Winter Range	37,061	52,939
Wildlife Habitat Areas	712	1,109
Riparian	5,782	8,174
Points of Diversion	13	35
Old Growth Management Areas	20,483	43,483
Terrain Stability	12,374	28,506
Recreation	268	666
Permanent Sample Plots	178	195
Inoperable	43,143	190,259
Problem Forest	2,079	13,288
Unmerchantable	4,027	6,382
Archeological Sites	55	103
WTP	1,681	1,800
NHLB Area	**127,857**	
THLB Area	**87,580**	
Future Roads	1,028	
Future THLB	**86,552**	

Table 10: TKO netdown summary

Netdown Category	Net Area (hectares)	Gross Area (hectares)
Total Area		**102,032**
Non-Crown land	1,329	1,329
Non-forest	16,797	16,969
Roads and Utility Corridors	1,212	1,289
CFLB Area	**82,695**	
Ungulate Winter Range	35,655	50,116
Wildlife Habitat Areas		
Riparian	1,085	2,234
Points of Diversion	12	34
Old Growth Management Areas	6,894	26,974
Terrain Stability	3,908	14,309
Recreation	40	183
Permanent Sample Plots	143	150
Inoperable	6,328	57,801
Problem Forest	889	6,651
Unmerchantable	1,061	2,133
Archeological Sites	1	29
WTP	471	507
NHLB Area	**56,486**	
THLB Area	**26,208**	
Future Roads	183	
Future THLB	**26,025**	

Table 11: TOC netdown summary

Netdown Category	Net Area (hectares)	Gross Area (hectares)
Total Area		**73,517**
Non-Crown land	26	26
Non-forest	22,531	22,531
Roads and Utility Corridors	1,089	1,182
CFLB Area	**49,872**	
Ungulate Winter Range		
Wildlife Habitat Areas		
Riparian	942	1,110
Points of Diversion	1	2
Old Growth Management Areas	6,096	6,849
Terrain Stability	5,476	9,243
Recreation		
Permanent Sample Plots	12	14
Inoperable	14,117	46,803
Problem Forest	903	5,787
Unmerchantable	2,313	2,874
Archeological Sites		
WTP	601	653
NHLB Area	**30,461**	
THLB Area	**19,411**	
Future Roads	115	
Future THLB	**19,295**	

Table 12: TCC netdown summary

Netdown Category	Net Area (hectares)	Gross Area (hectares)
Total Area		**27,205**
Non-Crown land	70	70
Non-forest	1,077	1,110
Roads and Utility Corridors	651	821
CFLB Area	**25,407**	
Ungulate Winter Range		
Wildlife Habitat Areas	1	1
Riparian	1,580	1,767
Points of Diversion		
Old Growth Management Areas	3,492	3,945
Terrain Stability	1,456	2,297
Recreation	224	434
Permanent Sample Plots	24	31
Inoperable		
Problem Forest	142	270
Unmerchantable	431	1,112
Archeological Sites	10	16
WTP	212	224
NHLB Area	**7,574**	
THLB Area	**17,833**	
Future Roads	330	
Future THLB	**17,503**	

Table 13: TSK netdown summary

Netdown Category	Net Area (hectares)	Gross Area (hectares)
Total Area		**113,876**
Non-Crown land	70	70
Non-forest	55,114	55,147
Roads and Utility Corridors	1,228	1,590
CFLB Area	**57,463**	
Ungulate Winter Range	1,406	2,823
Wildlife Habitat Areas	711	1,107
Riparian	2,176	3,063
Points of Diversion		
Old Growth Management Areas	4,000	5,716
Terrain Stability	1,533	2,656
Recreation	4	49
Permanent Sample Plots		
Inoperable	22,698	85,654
Problem Forest	145	580
Unmerchantable	221	262
Archeological Sites	44	58
WTP	397	416
NHLB Area	**33,336**	
THLB Area	**24,128**	
Future Roads	399	
Future THLB	**23,729**	

5.1.1 Not Managed by the Crown (Ownership)

Private lands, federal parcels, miscellaneous reserves, municipal parcels, miscellaneous leases and other areas not under the ownership of the Crown are excluded from management. These areas are shown in Table 14.

Table 14: Lands not managed by the Crown

Ownership Code	Description	TKO Area (ha)	TOC Area (ha)	TCC Area (ha)	TSK Area (ha)	TSA (ha)
40-N	Private land	1,033	26	66	70	1,195
54-N	Federal Parcels	0	0	0.1	0	0.1
69-N	Misc Reserves	13	0	0	0	13
80-N	Municipal parcels	0	0	4	0	4
91-U	Unknown ownership	282	0	0	0	282
99-N	Misc Lease	0.2	0	0	0	0.2
Total		**1,329.2**	**26**	**70.1**	**70**	**1,494**

5.1.2 Non-Forest

Non-forest is defined using the updated VRI field FMLB, which indicates the productive forest based on site index, non-productive descriptor and logging history. All records where FMLB is "N" are removed as non-forest. Any water features identified in the Freshwater Atlas (lakes, rivers and wetlands) that do not

exist in the VRI are also removed as non-forest. The total area of non-forest in the Cascadia TSA is 95,518 ha.

5.1.3 Roads and Utility Corridors

Road data was provided by BCTS as lines, which were buffered as shown in Table 15.

Existing and planned roads were classified into types (highway, mainline, operational) and each business area provided an average width for each type based on local surveys. Proposed roads were given the same width as operational roads. Table 15 shows the road classes and their widths in different business areas. Road areas after buffering are shown in Table 16. The total existing road area is 4,347 ha.

Table 15: Road widths in the Cascadia TSA

Business Area	Road Width (m)		
	Highway	Mainline	Operational
TKO	25	20	12
TOC	40	20.8	20.8
TCC	50	23	15
TSK	20	15	15

Table 16: Road areas after buffering

Road Type	TKO (ha)	TOC (ha)	TCC (ha)	TSK (ha)	Total (ha)
Highway	45	97	37	16	**195**
Main	406	16	187	223	**833**
Operational	788	1,043	596	892	**3,319**
Proposed	28		99	223	**350**
Total	**1,267**	**1,156**	**920**	**1,354**	**4,697**

Data for utilities was provided by BCTS. The data originates from TRIM, BC Hydro and Fortis BC. Also, Tantalis Right-of-Way data was downloaded from BCGW. BC Hydro transmission lines in Blocks 2, 10, and 11 were used and buffered creating a 75m wide right-of-way (37.5m buffer on each side of the line).

The remaining powerlines in other Blocks generally followed roads, and were included in the road widths. From the Tantalis Right-of-Way data, a gas pipeline in Block 10 and penstock and powerline right-of-way in Block 4 were used. The Tantalis data includes permits for proposed infrastructure projects that have not been initiated yet. These proposed areas were not included in the analysis. One known pipeline in Block 4 was taken from TRIM and buffered 10 m each side. Utilities data is summarized in Table 17.

Table 17: Utility corridors

UTILITY	TKO (ha)	TOC (ha)	TCC (ha)	TSK (ha)	Total (ha)
Gas Pipeline ROW				122	**122**
Hydro Line Corridor 75m width	54			386	**441**
Penstock ROW		6			**6**
Power Line ROW		38			**38**
TRIM pipeline 20m width		2			**2**
Total	**54**	**46**	**0**	**508**	**609**

5.1.4 Ungulate Winter Range (UWR)

There are six legally established ungulate winter ranges that occur within the Cascadia TSA. Two are no harvest zones, while four allow harvest as long as cover constraints and specific operational conditions are met. The no harvest area netdowns are shown in Table 18. The units that allow harvest are also included in Table 18. The modelling details of these units are presented later in this document under Section 6.3.5. The total area of no harvest UWR is 52,939 ha.

Table 18: Ungulate winter ranges

Business Area	UWR Number	Species	Area (ha)	Netdown Area (ha)
No harvest units				
TKO	u-4-014	Mountain Caribou	50,116	50,116
TSK	u-6-001	Mountain Goat	2,823	2,823
Total			**52,939**	**52,939**
Conditional Harvest Units				
TKO	u-4-001	Elk, Mule Deer, White-tailed Deer and Moose	6,284	0
TOC	u-8-012	Mountain Caribou	17,653	0
TOC	u-4-001	Elk, Mule Deer, White-tailed Deer and Moose	5,859	0
TSK	u-6-009	Moose	5,980	0
Total			**35,776**	**0**

5.1.5 Wildlife Habitat Areas (WHA)

Wildlife habitat areas (WHA) have been legally established for coastal tailed frog and mountain caribou. The WHAs contain no harvest zones and zones where harvest is allowed as long as cover constraints and specific operational conditions are met. The WHA 6-063 in TSK is for coastal tailed frog. The order establishing this WHA allows for some harvest as long as 70% of the residual volume is maintained. The order further sets operational restrictions regarding interior forest condition, connectivity, maintenance of snags etc. Rather than setting up harvest constraints for this WHA, 70% of its forested area is removed from the THLB. The modelling details for the rest of these units are presented later in this document under Section 6.3.5.

There are also draft WHAs for grizzly bear. For this TSR, the draft grizzly WHAs that meet the intent of the FPPR Section 7 species at risk notice are treated as legal and removed from the THLB reflecting current practice. The total area removed for WHAs is 1,109 ha. The WHAs and their areas are summarized in Table 19.

Table 19: Wildlife habitat areas in Cascadia TSA

Business Area	WHA Number/Name	Species	Area (ha)	Netdown Area (ha)
No harvest units				
TCC	5-099	Mountain Caribou	1	1
TSK	6-063	Coastal Tailed Frog	80	80
TSK	Fiddler Nelson LU GB draft WHA	Grizzly Bear	118	118
TSK	Kitimat-Dala-Kildala draft WHA	Grizzly Bear	755	755
Total			**955**	**955**
Conditional Harvest Units				
TCC	5-088	Mountain Caribou	195	n/a
TCC	5-089	Mountain Caribou	2,028	n/a
TSK	6-063	Coastal Tailed Frog	220	154
Total			**2,443**	**154**

5.1.6 Northern Goshawk Management

Northern Goshawk nests are managed by targeted retention of nest trees and buffer areas. Because these retention areas are intended to be captured by WTRA, OGMA or other netdown classes, no THLB reductions are incorporated in this TSR.

5.1.7 Marbled Murrelet (MAMU)

Marbled Murrelet (MAMU) habitat exists in TSK. Habitat for MAMU is managed at the landscape level through OGMAs and through patch and seral targets identified in the Kalum SRMP. No THLB reductions are incorporated in this TSR.

5.1.8 Riparian Management Areas

Riparian management objectives have been established to minimize or prevent impacts of forest and range management directly on these aquatic resources values (e.g., water quality, aquatic ecosystem) and on the values within the surrounding area (e.g., wildlife habitat). Implementation of objectives include placement of riparian reserve zones and/or riparian management zones. Trees in riparian reserves are generally fully retained during harvesting, while trees within riparian management zones are partially retained at levels that vary according to the water feature class.

The riparian reserve zone and riparian management zone widths for lakes, rivers, wetlands and streams were set as per the Riparian Management Guidebook with one exception: in TOC the riparian management zone width of 100 m was used for L1 lakes instead of 0 m. The percent retention within the management zone buffers is different for each BA. The buffer widths and percent retention are shown in Table 20.

The riparian management area is defined as the combined riparian reserve zone buffer plus the percent retention of the management zone buffer. For example, an S3 stream in TKO requires a 20 m reserve

zone, and a 20 m management zone, with 50% retention in the management zone. This gives a riparian management area buffer of 20m + (20m * 0.5) = 30m. The total area of FRPA RMA reduction within the Cascadia TSA is 8,174 ha.

Table 20: Riparian management areas

Riparian Class	Reserve Zone (m)	Management Zone (m)	TKO		TOC		TCC		TSK	
			Percent retention	RMA width (m)	Percent retention	RMA width (m)	Percent retention	RMA width (m)	Percent retention	RMA width (m)
S1A (>=100m wide)	0	100	50%	50	20%	20	20%	20	20%	20
S1	50	20	50%	60	20%	54	20%	54	20%	54
S2	30	20	50%	40	20%	34	20%	34	20%	34
S3	20	20	50%	30	20%	24	20%	24	20%	24
S4	0	30	25%	7.5	10%	3	35%	10.5	10%	3
S5	0	30	25%	7.5	10%	3	10%	3	10%	3
S6	0	20	5%	1	0%	0	5%	1	0%	0
L1A (>1000 ha)	0	0	0%	0	0%	0	0%	0	10%	0
L1	10	0 (100 in TOC)	0%	10	10%	20	0%	10	10%	10
L3	0	30	25%	7.5	10%	3	10%	3	10%	3
W1	10	40	25%	20	10%	14	50%	30	10%	14
W3	0	30	25%	7.5	10%	3	20%	6	10%	3
W5	10	40	25%	20	10%	14	50%	30	10%	14

5.1.9 Water Licence Points of Diversion

Points of Diversion (POD) are locations where a license has been issued to remove water from a creek or river. These licenses may be for industry, agriculture, or domestic drinking water. Only active domestic PODs are considered for this analysis. There are 30 active domestic licenses, 29 of them are in Block 3 (TKO), and 1 in Block 4 (TOC); however, some of these are multiple licenses in the same location. These points were buffered by 100 m and the buffered area was removed from the THLB. The total area of POD buffers is 35 ha.

5.1.10 Old Growth Management Areas (OGMA)

OGMAs have been delineated in all of the Cascadia TSA landscape units. There are legal and non-legal OGMAs in the TSA. Legal OGMAs are spatially defined and legally established spatial areas. Non-legal OGMAs are not legally established, but have a notice stating that they meet the requirements of Section 8 in the Order Establishing Provincial Non-Spatial Old Growth Objectives (Old Growth Order). According to BCTS their current practice accounts for all OGMA types. All OGMAs will be removed from the THLB for the analysis. The OGMA areas are summarized in Table 21.

Table 21: OGMAs in Cascadia TSA

Business Area	Legal/Non-legal	Area ha
TKO	Non-legal	26,974
TOC	Non-legal	6,849
TCC	Legal	3,945
TSK	Legal	5,716
Total		**43,483**

5.1.11 Unstable Terrain

Terrain stability mapping (TSM) is available for the majority of the Cascadia TSA, including TKO, TOC and TCC. In TSK TSM covers almost the entire Block 11, while in Block 9 the mapping is available for valley bottoms only. Some TSM is available for Block 10 and those areas in Block 10 without TSM are managed under a system where all slopes greater than 60% are mapped and treated as class 4 terrain. Table 22 shows the total area of these classes and the area removed in the netdown.

Note that terrain stability class IV areas that have been previously harvested are not removed from the THLB. For terrain stability class V, areas harvested after 1995 remain in the THLB. Older harvest areas, harvested in 1995 or earlier, were removed from the THLB. The year 1995 was chosen as a cut-off because the majority of terrain stability mapping in BC was carried out in the late 1990's. It was assumed that any harvest in class V terrain after the mapping was completed has been assessed by a professional engineer or a professional geoscientist.

The area removed in the netdown for terrain stability is 28,506 ha. The netdown percentages reflect current practise in the TSA.

Table 22: Terrain stability in Cascadia TSA

Business Area	Class	Reduction	Area (ha)	Netdown Area (ha)
TKO	IV	13%	12,889	1,676
	V	80%	15,792	12,634
TOC	IV	13%	7,755	1,008
	V	80%	10,294	8,235
TCC	IV	50%	3,156	1,578
	V	100%	719	719
TSK	IV	10%	2,529	253
	V	100%	1,385	1,385
	Slope > 60%	10%	10,176	1,018
Total			**64,695**	**28,506**

5.1.12 Recreation Trails and Areas

Recreation data for the Cascadia TSA include Recreation Sites and Trails BC (RSTBC) recreation areas. The recreation features contained in the TSA consist of hiking, biking and skiing trails, and lakeshore and mountain camping areas.

Trails were buffered as per Table 23. According to BCTS, current practice has been to log around the established recreation areas in TKO. In the remainder of the BCTS areas, this is not the case, and the corresponding recreation areas have not been excluded. The total area of recreation areas and buffered trails removed from the THLB is 666 ha.

Table 23: Recreation trails and areas

Trails			
Business Area	**Buffer Width (m)**	**Total Width (m)**	**Area (ha)**
TKO	20	40	53
TCC	50	100	434
TSK	10	20	49
Areas			
TKO	Recreation Reserve		35
	Recreation Site		95
Total			**666**

5.1.13 Permanent Sample Plots

The FLNRORD maintains a network of growth and yield permanent sample plots (PSPs) across the province for the purposes of understanding forest growth and the calibration of growth and yield models. Active PSPs are removed from the THLB. The areas are shown in Table 24. The total area removed from the THLB is 195 ha.

Table 24: Permanent sample plots

Business Area	Installation	Area (ha)
TKO	Active	150
TOC	Active	14
TCC	Active	31
Total		**195**

5.1.14 Operability

The amount of productive forest land that is economically accessible by forestry operators using conventional and non-conventional harvesting systems is a key consideration in determining the available timber supply in a TSA.

Areas in the Cascadia TSA are considered inoperable where harvesting is limited by physical barriers or where there are other constraints that limit timber harvesting. The constraints may be economic or environmental; hauling distance, steep slopes, leading species, or timber size and quality are examples of these constraints.

Forest product market fluctuations can impact the size of the operable land base. In good markets it may be feasible to harvest marginally economic timber while the opposite is true during poor markets. This analysis attempts to reflect average market conditions; the timber supply impact of including marginally economic areas in the analysis will be tested via sensitivity analysis.

Note that all previously harvested areas are considered operable.

5.1.14.1 Physically Inoperable Areas

In TKO, operability mapping was completed in 1991. BCTS considers this classification and the one completed for TOC in 2008 still valid. In TCC, no physical limitations exist for harvesting, while in TSK operability classifications and total chance plans from 2002 (Blocks 10 and 11), 2006 (part of Block 9) and 1998 (remainder of Block 9) are used as a guideline to classify operable areas. All areas classified as inoperable, or areas with no classification, were removed from the THLB (Table 25).

Table 25: Areas classified as inoperable

Business Area	Area (ha)
TKO	50,725
TOC	44,908
TCC	0
TSK	80,738
Total	**176,371**

5.1.14.2 Inoperable Areas due to Steep Slopes or Harvest Method

Some helicopter harvest areas in the TSA are considered marginally economic to harvest and are removed from the THLB. Their impact on timber supply will be tested through sensitivity analyses.

Harvesting in steep cable harvesting areas in TKO and TOC is not considered feasible due to the steepness of the terrain. These steep cable harvest areas are removed from the THLB. The THLB reductions are shown in Table 26.

Table 26: THLB reductions due to harvest method and steep slopes

Business Area	Block	Harvest Method	Area (ha)	Notes
TKO	All	Cable, slope > 80%	35	
	All	Helicopter	4,346	Considered marginal. Impact will be tested through sensitivity analysis
TOC	All	Cable, slope >70%	210	
	All	Helicopter	1,192	Considered marginal. Impact will be tested through sensitivity analysis
TSK	9	Helicopter	542	Considered marginal. Impact will be tested through sensitivity analysis
	10, 11	Helicopter	891	Considered inoperable
	10,11	Conventional, low volume and uneconomic	3,484	Considered marginal. Impact will be tested through sensitivity analysis
Total			**10,699**	

5.1.14.3 Payne Creek Area (TKO, Block 3)

The Payne Creek area in Block 3 of the TKO BA is considered marginally economically operable. It is removed from the THLB in the base case. The total THLB reduction is 1,215ha.

The impact on timber supply of including the Payne Creek area in the THLB will be tested along with other marginally economic areas through sensitivity analyses.

5.1.14.4 Problem Forest Types

Stands that are physically operable but are not currently utilized are called problem forest types; they are excluded from the THLB. The various problem forest types and the associated THLB netdown are shown in Table 27. Note that deciduous volumes are also removed from all conifer leading stand yield curves, because they are generally not utilized.

Table 27: Problem forest types and associated THLB reductions in the Cascadia TSA

Business Area	Leading Species	Age	Harvest Method	Reduction %	Total Area (ha)	Netdown Area (ha)
TSK	Deciduous	All	All	100%	580	580
TCC	Deciduous except birch	>80	All	100%	115	115
	Birch	All	All	100%	155	155
TKO, TOC	Pure Hemlock >=80%	>140	Ground	80%	536	429
			Cable	100%	406	406
	Hemlock <80%	>140	Ground	40%	3,300	1,320
			Cable	100%	1,613	1,613
	Balsam	>250	All	100%	730	730
		141 to 250	All	25%	28,937	7,234
	Deciduous	All	All	100%	706	706
Total					**37,078**	**13,228**

5.1.14.5 Stands with Low Timber Growing Potential

In the course of this TSR, BCTS operational staff in different BAs were consulted to determine the minimum volume per ha currently harvested in operations. Stands that do not reach this minimum merchantable volume per hectare by age 150 are removed from the THLB. In the analysis file, stands older than 150 years that do not meet the criteria shown in Table 28 were first removed from the THLB. Younger natural stands were projected to age 150 using VDYP. Those stands that did not meet the Table 28 criteria were also removed from the THLB.

Table 28: Minimum volume per ha criteria

Business Area	Minimum Volume by Harvest Method (m^3/ha)		Area (ha)
	Cable	Ground	
TKO	200	150	2,133
TOC	250	200	2,874
TCC	200	110	1,112
TSK	250	250	262
Total			**6,382**

5.1.14.6 Marginally Operable (Economic) Areas

All marginally operable areas will be added back to the THLB to test their impact on the Cascadia TSA timber supply. These areas are summarized in Table 29.

Table 29: Marginally economic areas tested through sensitivity analyses

Business Area	Block	Marginal Area	Area (ha)
TKO	3	Payne Creek	1,215
	All	Helicopter operable area	4,346
TOC	All	Helicopter operable area	1,192
TSK	9	Helicopter operable area	542
TSK	10, 11	Conventional Areas classified as low volume or uneconomic	3,484
Total			**10,779**

5.1.15 Archeological Sites

Archaeological sites, including culturally modified trees (CMT) that pre-date 1846, are protected from timber harvesting under the *Heritage Conservation Act.* There are 29 known archeological sites within the Cascadia TSA. All sites will be buffered by 25 m in the analysis with the total area covering 103ha. This area will be removed from the THLB.

5.1.16 Cultural Heritage Resources

Cultural Heritage resources are managed in accordance with legal requirements and with the participation of First Nations. Reviews of proposed harvesting by First Nations may result in recommendations to conserve or protect specific sites. The values that are protected by reserving trees or specifying certain management practices are varied, but they can almost always be accommodated within reserve areas such as wildlife tree retention areas (WTRA), riparian reserves and OGMAs. Therefore, an additional netdown for Cultural Heritage Resources is not considered necessary in this analysis.

5.1.17 Agreements in Principle (AIP)

Kitsumkalum First Nation in TSK (Block 11) have proceeded to the Agreement in Principle (AIP) stage in their treaty process. The AIP area will be incorporated in the analysis file to facilitate further analysis; however, the area will remain in the THLB. The impact of removing the AIP area will be tested through sensitivity analysis.

5.1.18 Wildlife Tree Retention

An aspatial reduction for wildlife tree retention (WTRA) will be applied at the end of the netdown to the THLB. The reduction percent is 7% in TKO and TOC. In TCC the CCLUP sets the targets by landscape unit and BEC (Table 30) and in TSK the WTRA requirements are provided by the Kalum SRMP. It is assumed that WTRA requirements are already met in the THLB areas that are located within 200 m of any NHLB. The WTRA reduction from Table 30 was applied to all the remaining THLB polygons more than 200 m from the NHLB. WTRA areas can overlap with other partial reductions such as terrain stability; to account for this, the WTRA reduction in the netdown will be the difference between the WTRA target and the previous netdown reductions. For example, if the WTRA target is 11%, and the

polygon has already been reduced by 10% for terrain, the additional WTRA netdown in that polygon would be 1%.

Table 30: Wildlife tree retention areas

Business Area	Block	Landscape Unit	BEC	% WTRA
TKO	1	Woden	ESSFwc4	7%
TKO	1	Woden	ESSFwcp	7%
TKO	1	Woden	ESSFwcw	7%
TKO	1	Woden	ESSFwh1	7%
TKO	1	Woden	ICHmw2	7%
TKO	2	Barnes - Whatshan	ESSFdc1	7%
TKO	2	Barnes - Whatshan	ESSFdcw	7%
TKO	2	Barnes - Whatshan	ESSFmh	7%
TKO	2	Barnes - Whatshan	ESSFwc4	7%
TKO	2	Barnes - Whatshan	ESSFwcp	7%
TKO	2	Barnes - Whatshan	ESSFwcw	7%
TKO	2	Barnes - Whatshan	ESSFwh1	7%
TKO	2	Barnes - Whatshan	ICHdw1	7%
TKO	2	Barnes - Whatshan	ICHmw2	7%
TKO	2	Barnes - Whatshan	ICHmw5	7%
TKO	2	Eagle	ICHmw5	7%
TKO	2	Vipond	ICHdw1	7%
TKO	2	Vipond	ICHmw2	7%
TKO	3	Halfway	ESSFwc4	7%
TKO	3	Halfway	ESSFwcp	7%
TKO	3	Halfway	ESSFwcw	7%
TKO	3	Halfway	ESSFwh1	7%
TKO	3	Halfway	ICHmw2	7%
TKO	3	Halfway	ICHwk1	7%
TKO	3	Trout	ESSFwc4	7%
TKO	3	Trout	ESSFwcp	7%
TKO	3	Trout	ESSFwcw	7%
TKO	3	Trout	ESSFwh1	7%
TKO	3	Trout	ICHmw2	7%
TKO	3	Trout	ICHvk1	7%
TKO	3	Trout	ICHwk1	7%
TOC	4	Cranberry	ESSFwc4	7%
TOC	4	Cranberry	ESSFwcp	7%
TOC	4	Cranberry	ESSFwcw	7%
TOC	4	Cranberry	ESSFwh1	7%
TOC	4	Cranberry	ICHmw2	7%
TOC	4	Cranberry	ICHmw3	7%
TOC	4	Cranberry	ICHwk1	7%
TOC	4	Fosthall	ICHmw2	7%
TOC	4	Mulvehill	ESSFwc4	7%
TOC	4	Mulvehill	ESSFwcp	7%
TOC	4	Mulvehill	ESSFwcw	7%
TOC	4	Mulvehill	ESSFwh1	7%
TOC	4	Mulvehill	ICHmw3	7%
TOC	4	Mulvehill	ICHvk1	7%
TOC	4	Mulvehill	ICHwk1	7%

Business Area	Block	Landscape Unit	BEC	% WTRA
TOC	4	Pingston	ESSFwc4	7%
TOC	4	Pingston	ESSFwcp	7%
TOC	4	Pingston	ESSFwcw	7%
TOC	4	Pingston	ESSFwh1	7%
TOC	4	Pingston	ICHmw2	7%
TOC	4	Pingston	ICHwk1	7%
TCC	5	Swift	ESSFwc3	3%
TCC	5	Swift	ESSFwk1	8%
TCC	5	Swift	SBSwk1	9%
TCC	6	Antler	ESSFwk1	8%
TCC	6	Big Valley	ESSFwc3	7%
TCC	6	Big Valley	ESSFwk1	8%
TCC	6	Big Valley	SBSwk1	9%
TCC	6	Jack of Clubs	ESSFwc3	5%
TCC	6	Jack of Clubs	ESSFwk1	6%
TCC	6	Jack of Clubs	SBSwk1	7%
TCC	7	Umiti	ESSFwc3	4%
TCC	7	Umiti	ESSFwk1	10%
TCC	7	Umiti	SBSwk1	10%
TCC	7	Willow	ESSFwk1	8%
TCC	7	Willow	SBSwk1	9%
TCC	8	Abhau	SBSmh	3%
TCC	8	Abhau	SBSmw	6%
TSK	9	Hirsch	CWHvm1	5%
TSK	9	Hirsch	CWHvm2	5%
TSK	9	Hirsch	CWHws1	11%
TSK	9	Hirsch	CWHws2	11%
TSK	9	Hirsch	MHmm1	0%
TSK	9	Hirsch	MHmm2	0%
TSK	9	Hirsch	MHmmp	0%
TSK	9	Kitimat	MHmm2	0%
TSK	9	Kitimat	MHmmp	0%
TSK	10	Clore	CWHws1	6%
TSK	10	Clore	CWHws2	6%
TSK	10	Clore	MHmm2	3%
TSK	10	Clore	MHmmp	3%
TSK	10	Kleanza - Treasure	CWHws1	7%
TSK	10	Kleanza - Treasure	CWHws2	7%
TSK	10	Kleanza - Treasure	MHmm2	2%
TSK	10	Kleanza - Treasure	MHmmp	2%
TSK	11	Beaver	CWHws1	8%
TSK	11	Beaver	CWHws2	8%
TSK	11	Beaver	MHmm2	0.5%
TSK	11	Beaver	MHmmp	0.5%
TSK	11	Nelson - Fiddler	CWHws1	8%
TSK	11	Nelson - Fiddler	CWHws2	8%
TSK	11	Nelson - Fiddler	MHmm2	2%
TSK	11	Nelson - Fiddler	MHmmp	2%
TSK	11	Tseaux	CWHws1	4%
TSK	11	Tseaux	CWHws2	4%

Business Area	Block	Landscape Unit	BEC	% WTRA
TSK	11	Tseaux	MHmm2	0%
TSK	11	Tseaux	MHmmp	0%

5.1.19 Future Roads

A future road reduction is applied to the THLB after the first harvest in the model. For the Cascadia TSA, each BA provided their proposed roads in a digital format. These roads were buffered as described in Section 5.1.3 and added to the resultant. The total area of known future roads is 350 ha.

All current and proposed roads were buffered by the maximum skidding distance provided by each BA to estimate the percent reduction for future roads. This buffered area is considered "roaded", while all operable areas beyond the buffer are considered "unroaded". Within the roaded area, the percent of roads was calculated as road area divided by operable area. This percentage is applied to the unroaded THLB area to estimate the future road reduction. Table 31 shows the percent road used for each BA.

Table 31: Future road percentage calculation

BA	Skid Distance (m)	Operable Roaded Area (ha)	Road Area (ha)	Percent Road
TCC	275	16,362	734	4.49%
TKO	400	32,054	1,152	3.59%
TOC	500	20,489	976	4.76%
TSK	350	22,719	1,184	5.21%
Total		**91,624**	**4,046**	**4.42%**

5.2 Land Base Statistics

5.2.1 Biogeoclimatic classification

The Cascadia TSA is widely spread over the province of BC, in three distinct regions. Blocks 1-4 (TKO and TOC) are in the West Kootenay, in the wet interior. Blocks 5-8 (TCC) are in the Cariboo-Chilcotin, in the dry interior plateau. Blocks 9-11 (TSK) are more coastal in the transition zone between the Coast Mountains and the interior.

A summary of the Biogeoclimatic (BEC) variants in the Cascadia TSA is shown in Table 32. The BEC zones in TCC are Sub-Boreal Spruce (SBS) and Englemann Spruce/Sub-alpine Fir (ESSF). In TKO and TOC, the BEC zones are Interior Cedar Hemlock (ICH) and ESSF, while in TSK the climate is more coastal with the BEC zones of Cedar/Western Hemlock (CWH) and Mountain Hemlock (MH).

Table 32: Biogeoclimatic variants in the Cascadia TSA

Business Area	BEC Variant	CFLB (ha)	Percent of BA
TKO	ESSFdc1	7	0%
TKO	ESSFdcw	7	0%
TKO	ESSFmh	312	0%

Business Area	BEC Variant	CFLB (ha)	Percent of BA
TKO	ESSFwc4	20,597	25%
TKO	ESSFwcp	2,759	3%
TKO	ESSFwcw	9,259	11%
TKO	ESSFwh1	13,517	16%
TKO	ICHdw1	1,239	1%
TKO	ICHmw2	16,192	20%
TKO	ICHmw5	3,816	5%
TKO	ICHvk1	1,718	2%
TKO	ICHwk1	13,234	16%
TKO	IMAun	37	0%
Total TKO		**82,695**	
TOC	ESSFwc4	8,346	17%
TOC	ESSFwcp	1,073	2%
TOC	ESSFwcw	4,518	9%
TOC	ESSFwh1	8,856	18%
TOC	ICHmw2	5,366	11%
TOC	ICHmw3	4,826	10%
TOC	ICHvk1	2,292	5%
TOC	ICHwk1	14,537	29%
TOC	IMAun	57	0%
Total TOC		**49,872**	
TCC	ESSFwc3	2,452	10%
TCC	ESSFwk1	14,894	59%
TCC	SBSmh	622	2%
TCC	SBSmw	1,262	5%
TCC	SBSwk1	6,177	24%
Total TCC		**25,407**	
TSK	CWHvm1	897	2%
TSK	CWHvm2	3,033	5%
TSK	CWHws1	10,024	17%
TSK	CWHws2	22,179	39%
TSK	MHmm1	4,105	7%
TSK	MHmm2	15,135	26%
TSK	MHmmp	2,092	4%
Total TSK		**57,463**	
Grand Total		**215,437**	

5.2.2 Species Profile

The CFLB in the overall Cascadia TSA is dominated by western hemlock (Hw), various balsam fir species (Ba/Bl) and Spruce (Ss/Sx), with some Douglas Fir (Fd). The hemlock/balsam leading stands constitute approximately 58% of the CFLB. The share of spruce-leading stands is 22% while Fd is the leading species on 10% of the land base (Figure 2). However, there are distinct differences between the Business Areas, as shown in Figure 3, Figure 4, Figure 5, and Figure 6.

In TKO, the dominant species are sub-alpine fir (Bl) and spruce (Sx) with some hemlock (Hw) and Douglas Fir (Fd). The distribution is similar in TOC with a higher proportion of Sx.

In TCC, the majority of the area (54%) is spruce-leading. There is no hemlock or cedar in TCC.

In TSK, hemlock is the dominant species (73%), with some balsam (Ba). There is no Fd in TSK.

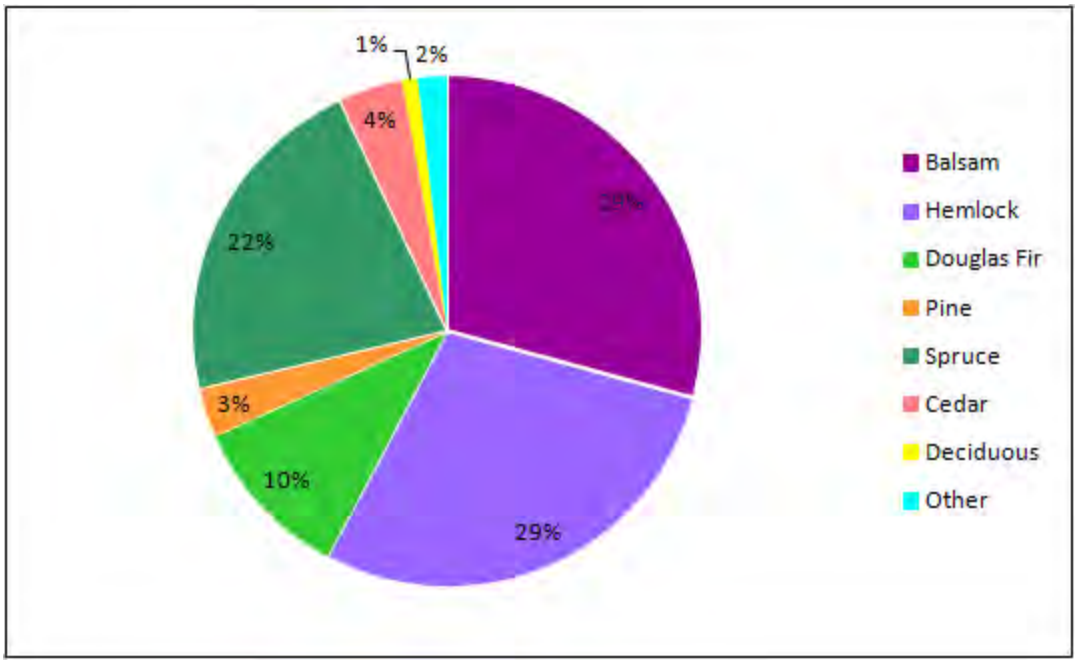

Figure 2: Leading species in the CFLB, Cascadia TSA

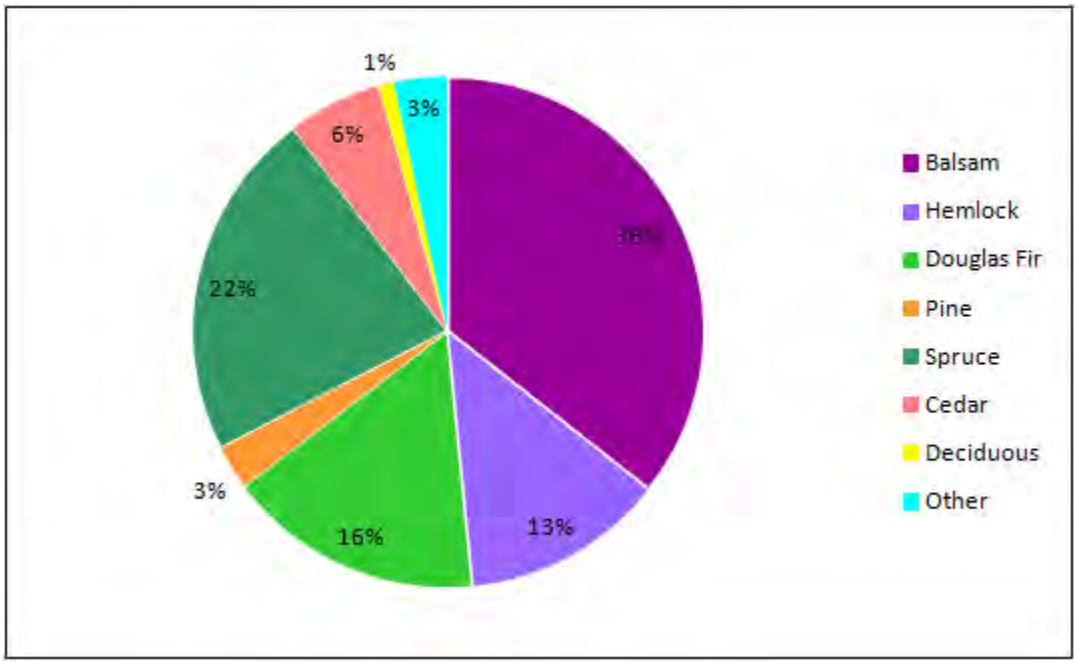

Figure 3: Leading species in the CFLB, TKO

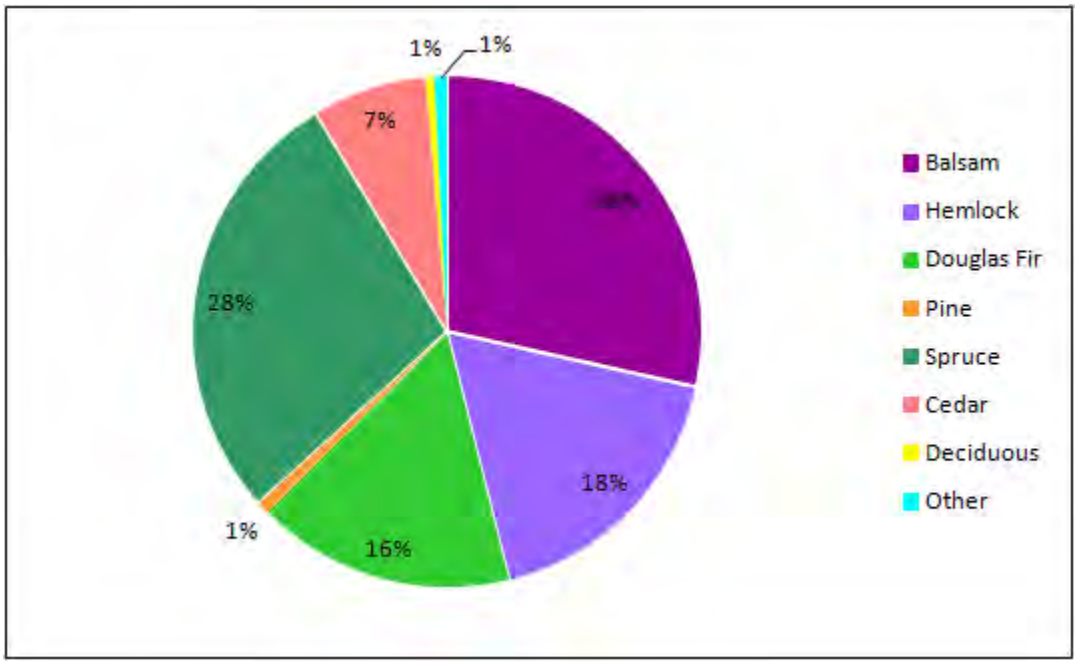

Figure 4: Leading species in the CFLB, TOC

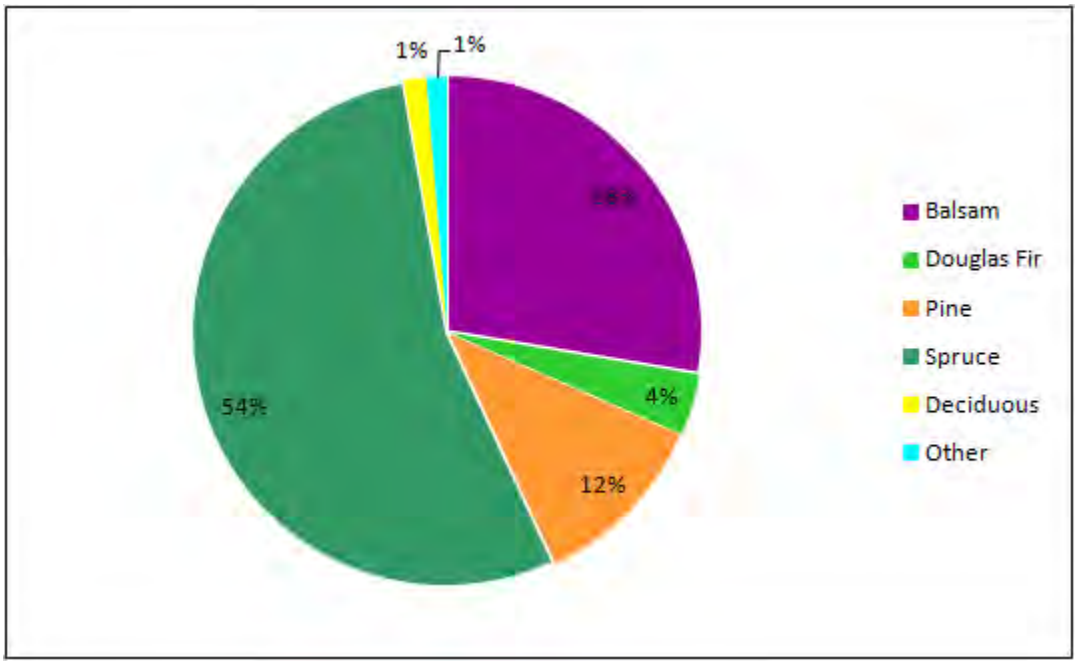

Figure 5: Leading species in the CFLB, TCC

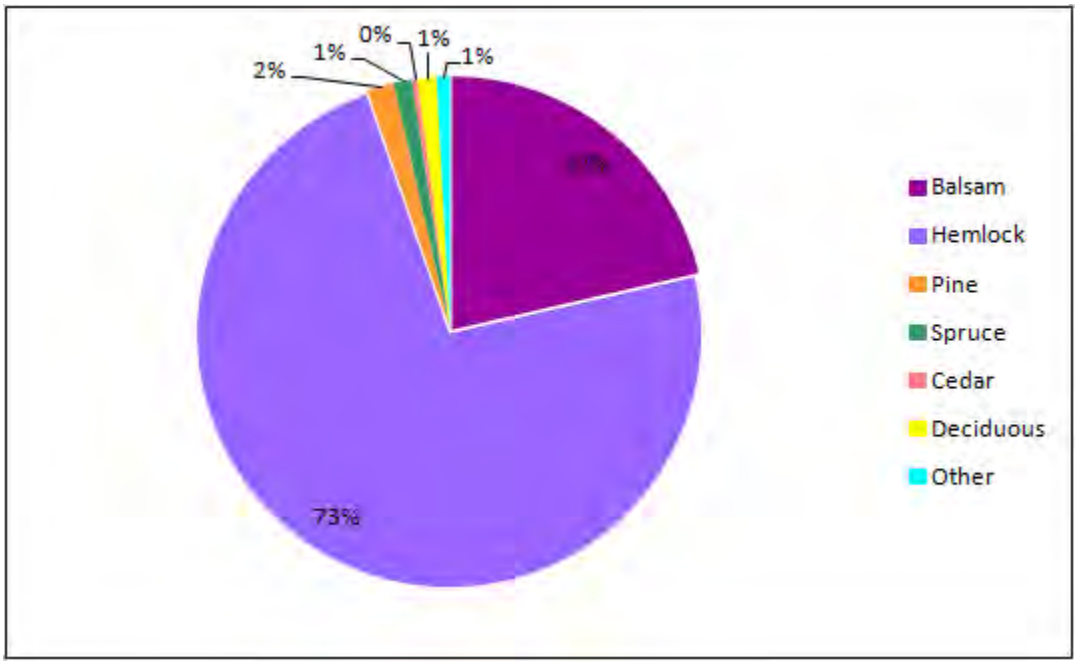

Figure 6: Leading species in the CFLB, TSK

In the THLB, the distributions are similar, but the amount of balsam drops considerably, such that the dominant species in the TSA are hemlock and spruce at 28% and 27% respectively. Balsam makes up 18% and Douglas fir 14% (Figure 7). The leading species in the THLB for each Business Area are shown in Figure 8, Figure 9, Figure 10, and Figure 11.

In TKO and TOC, the percentage of balsam and hemlock is reduced compared to the CFLB, and the majority of the area is spruce or Douglas fir leading. In TCC, spruce is still the dominant species, but with

a slightly higher percentage at 57% in the THLB compared to 54% in the CFLB. In TSK, the distribution is very similar to the CFLB with almost three quarters of the area hemlock-leading.

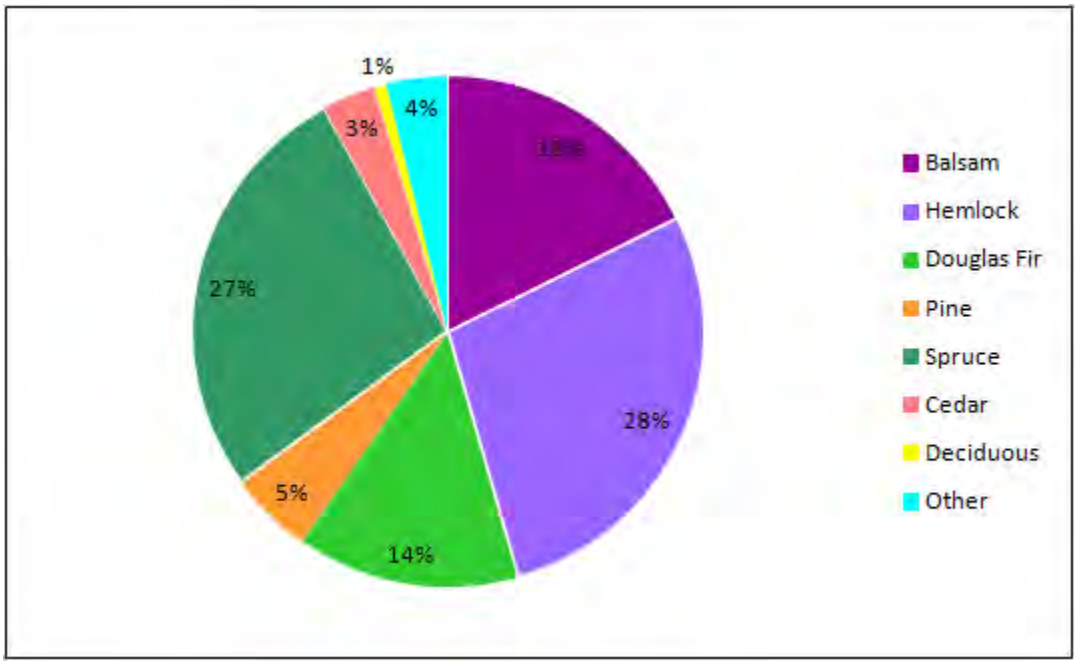

Figure 7: Leading species in the THLB, Cascadia TSA

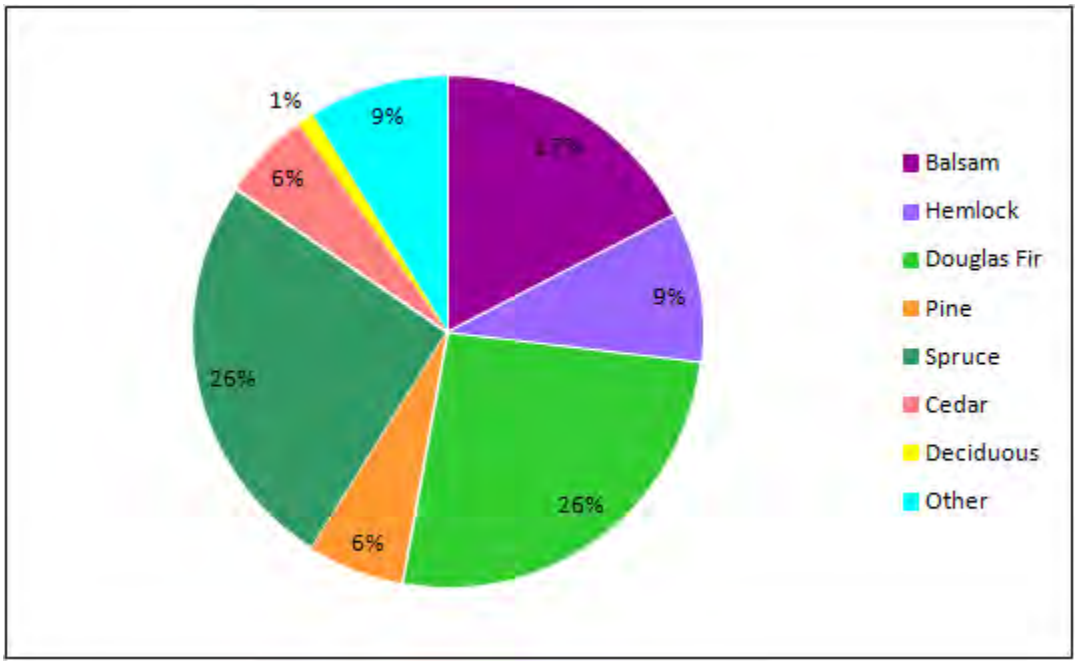

Figure 8: Leading species in the THLB, TKO

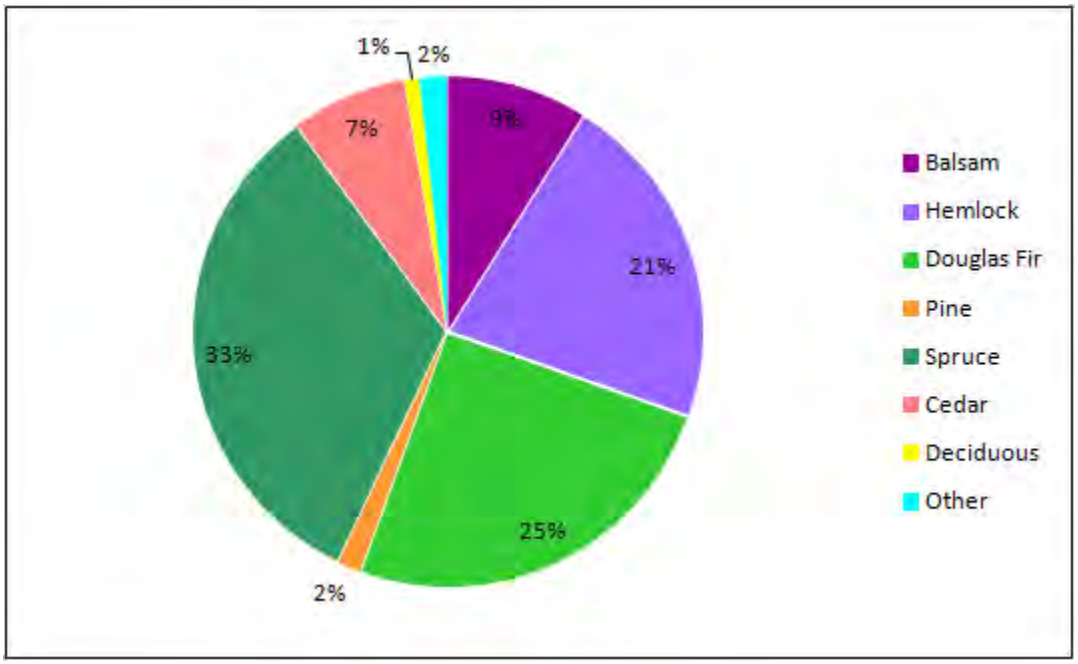

Figure 9: Leading species in the THLB, TOC

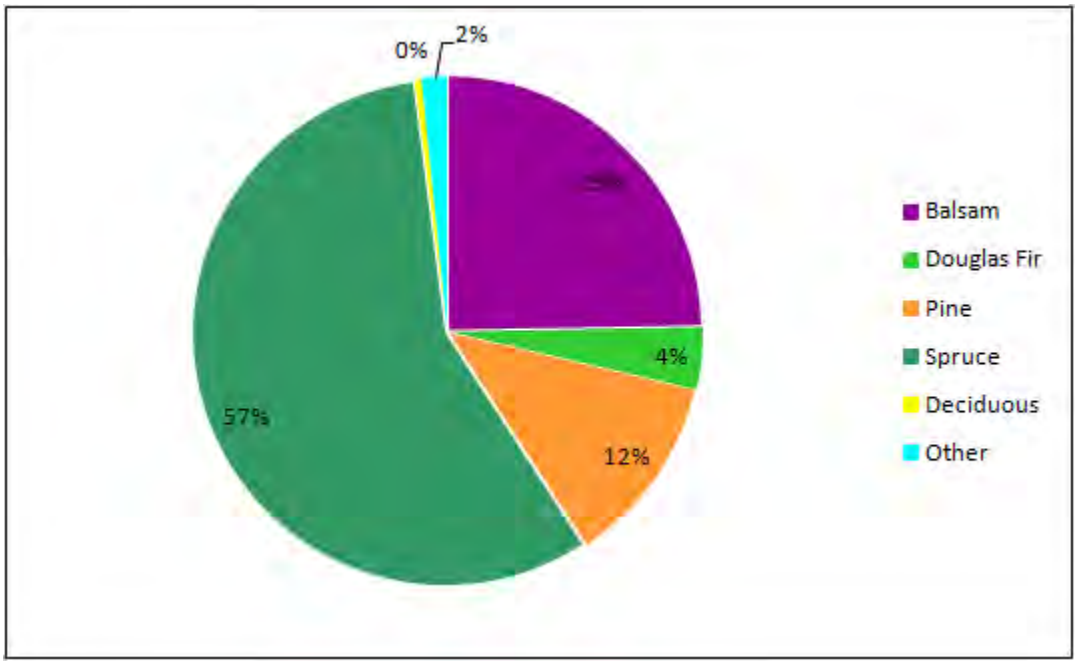

Figure 10: Leading species in the THLB, TCC

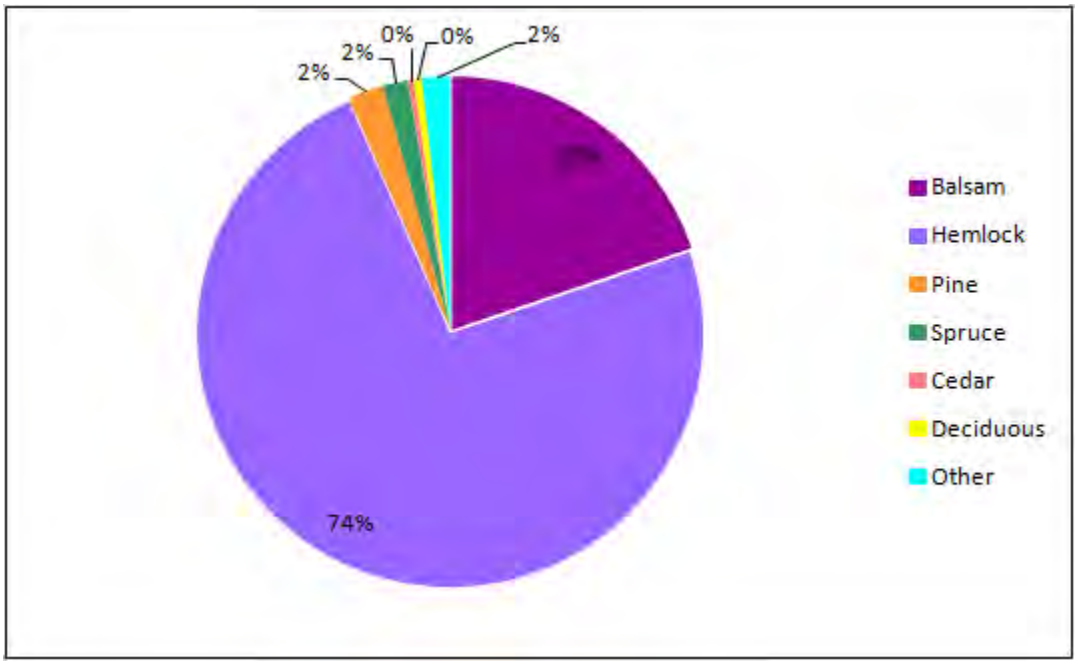

Figure 11: Leading species in the THLB, TSK

5.2.3 Stand Age Class Distribution

While older age classes dominate the productive forest in the TSA, younger age classes are more prevalent in the THLB. Approximately 50% of the productive forest is older than 140 years; however only 29% of the THLB is older than 140 years. Approximately 40% of the stands in the THLB are younger than 40 years (Figure 12).

The age class distributions for each Business Area are shown in Figure 13, Figure 14, Figure 15 and Figure 16. The age class pattern in each BA generally mirrors that of the TSA, with the majority of the NHLB in older age classes and a great portion of the THLB younger than 40. Some notable differences are that most of the age class 9 in the TSA occurs in TSK; the other Business Areas have large areas of age class 8 but little age class 9. Also, in TCC, 35% of the THLB is in age class 8 (however note that TCC has a much higher proportion of THLB than the other BAs – 70% of the forested land, compared to 37% THLB in rest of the TSA).

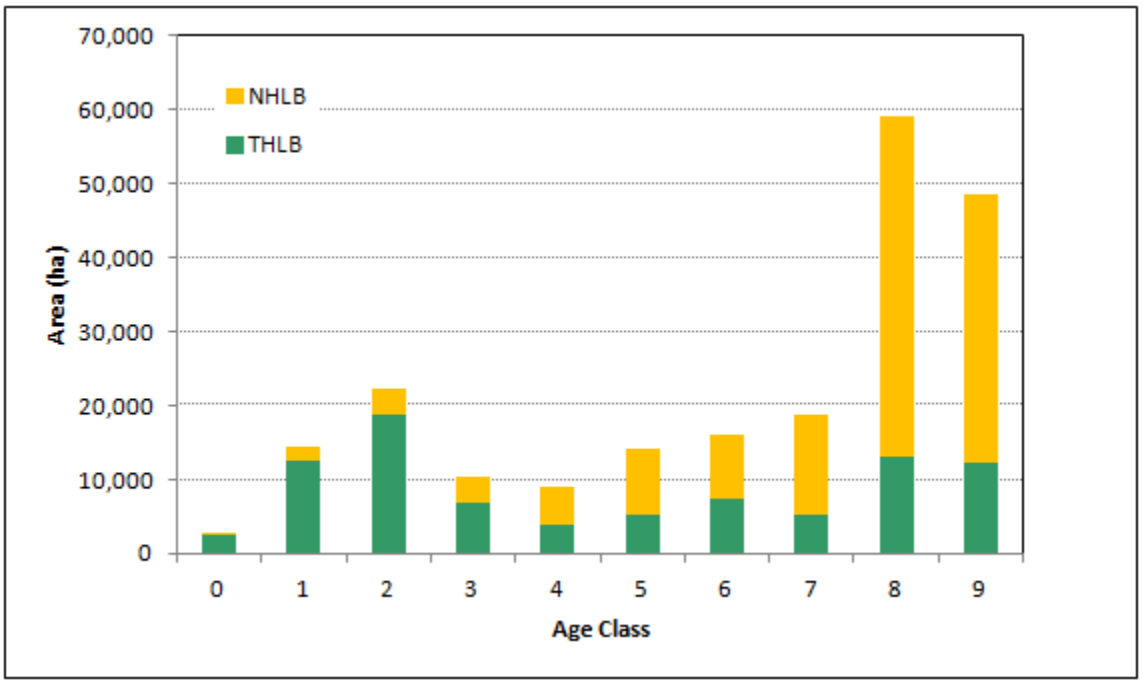

Figure 12: Age class distribution in the Cascadia TSA

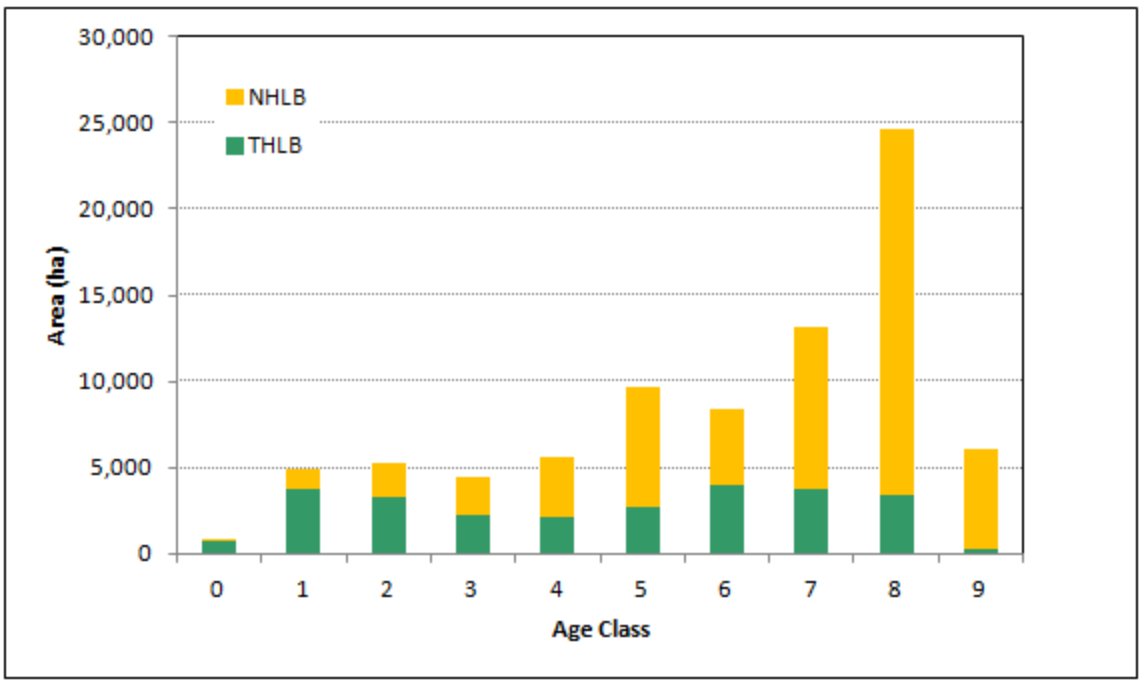

Figure 13: Age class distribution, TKO

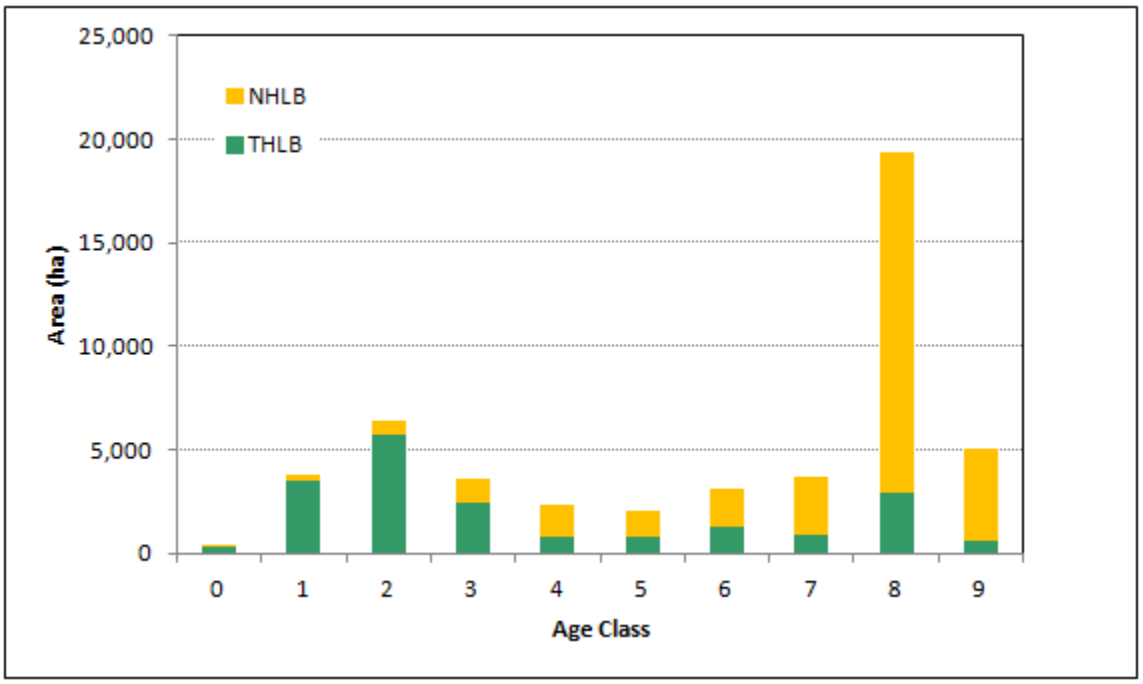

Figure 14: Age class distribution, TOC

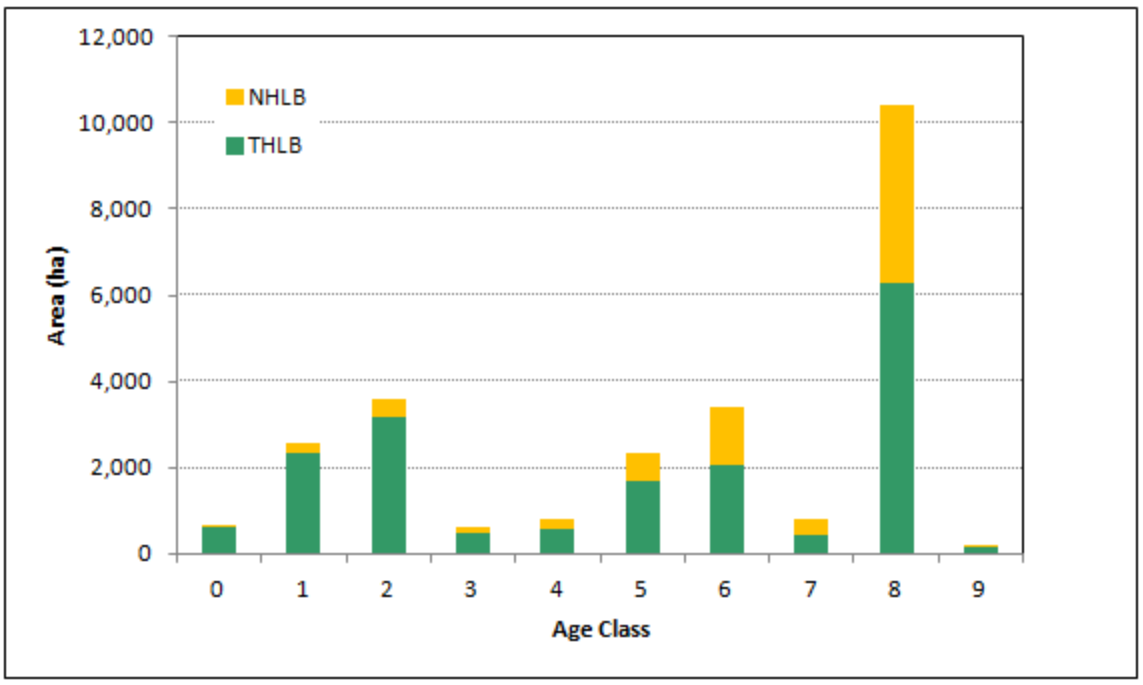

Figure 15: Age class distribution, TCC

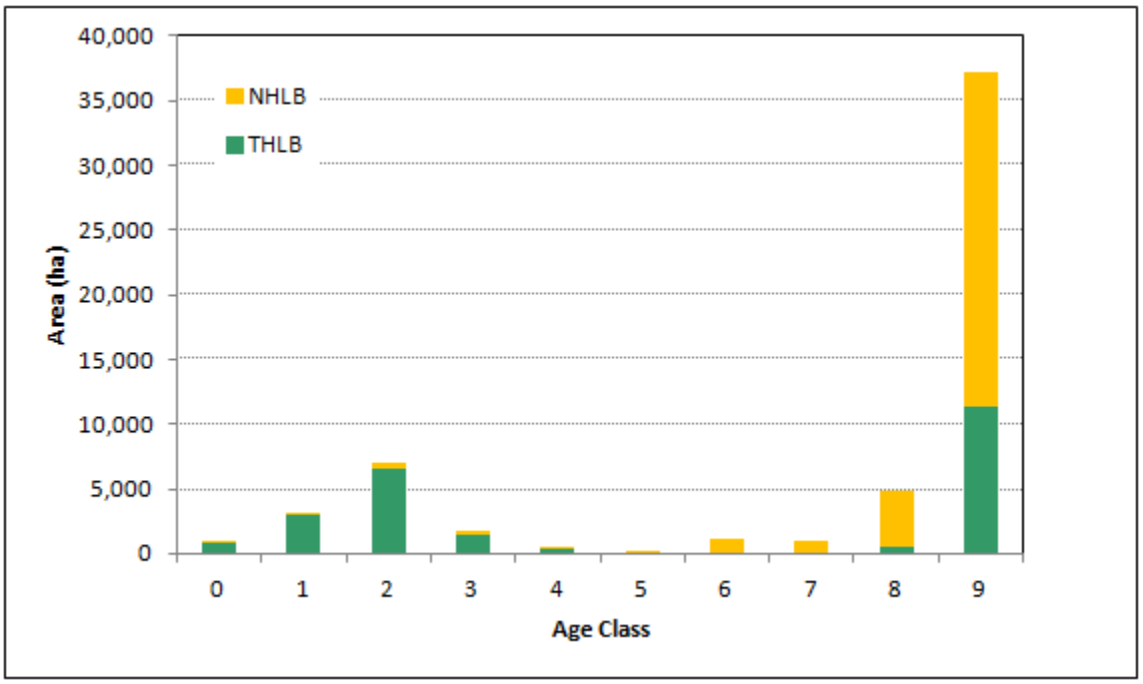

Figure 16: Age class distribution, TSK

5.2.4 Growing Stock

The total merchantable growing stock in the Cascadia TSA is estimated at 16.4 million m^3. Hemlock (6.4 million m^3, 39%) and balsam (3.6 million m^3, 22%) volume forms the majority of the merchantable growing stock at around 10 million m^3 (61%). The shares of spruce and Douglas-fir volume are significant at 2.6 million m^3 (16%) and 1.8 million m^3 (11%) correspondingly (Table 33).

A large portion of the merchantable growing stock is older than 250 years (age class 9, 44%) most of it hemlock or balsam located in TSK (Figure 17 and Table 33).

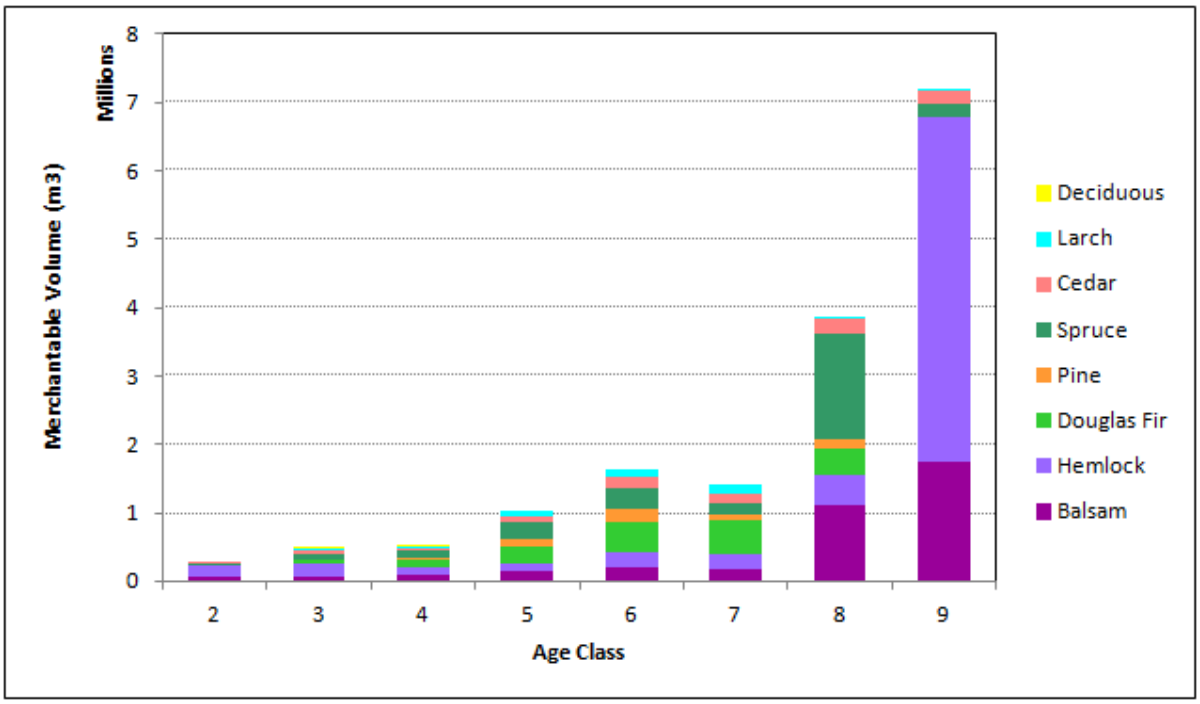

Figure 17: Merchantable growing stock by species and age class in the Cascadia TSA

Table 33: Merchantable growing stock in cubic metres by species and business area in the Cascadia TSA

BA	Balsam	Cedar	Douglas Fir	Hemlock	Larch	Pine	Spruce	Deciduous	Total
TKO	624,410	397,959	1,067,761	561,500	455,259	306,244	721,527		**4,134,659**
TOC	144,703	351,722	565,561	564,483	14,327	24,438	347,632		**2,012,866**
TCC	869,491		170,919			255,954	1,434,955	965	**2,732,284**
TSK	1,974,732	108,300		5,300,411		3,091	103,272		**7,489,805**
Total	**3,613,335**	**857,980**	**1,804,241**	**6,426,394**	**469,586**	**589,728**	**2,607,386**	**965**	**16,369,614**

6 Integrated Resource Management

This section provides details on how non-timber resource values are integrated with timber objectives in modeling.

6.1 Land Use Direction

FRPA's Forest Planning and Practices Regulation (FPPR) and other legislation set objectives for integrated resource management. Several land use plans exist within the Cascadia TSA, as described in Section 1.2.2. Resource management in the TSA is directed by these plans; the land base under each plan is divided into management zones with set management objectives for each zone. Outside of the plan areas, or management zones, FRPA's Forest Planning and Practices Regulation (FPPR) and other legislation set objectives for integrated resource management.

6.2 Management Zones and Multi-Level Objectives

Management zones are geographically specific areas that require unique management considerations. Areas requiring the same management regime or the same forest cover requirements are grouped into management zones. Table 34 lists the management zones for the Cascadia TSA and the rationale used to define these zones. Multiple resource issues may be present in the same forest area. For example, a management zone that requires a minimum area of mature and old seral forest may also have areas that are visually sensitive and require specific visual objectives. Forest estate models can accommodate multiple overlapping resource layers by establishing target levels for each layer. The models then schedule harvest units which best meet the target levels for all resource layers together.

Table 34: Management zones – base case

Business Area	Resource Objective	Condition	Cover Requirement	Land Base	Notes
All	Cutblock Adjacency	Green-up height	Max 25%	THLB/LU	See Section 6.3.1
	Visual Quality	Visually effective green-up height Table 37.	Varies, see Table 38	CFLB in each VQO polygon.	See section 6.3.2. Targets are applied to each VQO polygon separately. Visual green-up heights are based on slope.
TKO	Community Watersheds and Domestic Watersheds	ECA	Max 30%	CFLB within a watershed or a basin	Limit harvest to meet designated ECA. See Section **Error! Reference source not ound.**
	Landscape Level Biodiversity	Old	Met through spatial OGMAs	Non-legal OGMAs	
		Mature and Old	Min targets, see Table 40	CFLB by LU/BEC	See Section 6.3.4.1. Targets are specified by LU/BEC.
		Mature and old	Min targets, see Table 41	CFLB by LU/BEC in connectivity corridors.	See Section 6.3.4.1. The above targets must be met first in connectivity corridors.
	Ungulate Winter Range	Forest cover	Max and min targets, see Table 47	CFLB in UWR tag/management unit	See Section 6.3.5.2
TOC	Landscape Level Biodiversity	Old	Met through spatial OGMAs	Non-legal OGMAs	
	Ungulate Winter Range	Forest cover	Max and min targets, see Table 47	CFLB in UWR tag/management unit	See Section 6.3.5.2
TCC	Landscape Level Biodiversity	Old	Met through spatial OGMAs	Legal OGMAs	
		Mature and Old	Min targets, see Table 42	CFLB by LU/BEC	See Section 6.3.4.3. Targets are specified by LU/BEC.
	Wildlife Habitat Area (Mountain Caribou)	Forest cover	Entry allowed once in 80 years for 30% of area, see Table 46	CFLB in WHA polygon	See section 6.3.5.1
TSK	Landscape Level Biodiversity	Old	Met through spatial OGMAs and aspatial targets	Legal OGMAs plus CFLB by LU/BEC.	See Section 6.3.4.4. Targets are specified by LU/BEC
		Mature and Old	Min targets, see Table 45	CFLB by LU/BEC	See Section 6.3.4.4. Targets are specified by LU/BEC.
		Early	Max targets, see Table 43	CFLB by LU/BEC	See Section 6.3.4.4. Targets are specified by LU/BEC.
	Ungulate Winter Range	Forest cover	Min targets, see Table 47	CFLB in UWR tag/management unit	See Section 6.3.5.2
	Grizzly bear	Forest cover	Max target, see Table 49	CFLB in identified grizzly bear watershed (Copper)	See Section 6.3.5.3

6.3 Forest Cover Requirements

Modern natural resources management requires that multiple forest characteristics are retained across the landscape. These multiple characteristics are often referred to as forest cover objectives or requirements. It is important to identify how the THLB, and the productive forest which does not contribute to the THLB, are accounted for in the forest cover requirements. The most common way to express forest cover requirements is through maximum allowable disturbance or minimum area retention.

6.3.1 Landscape Green-up

As a surrogate for spatial cutblock adjacency constraint, a landscape green-up constraint will be applied in the base case, specifying that no more than 25% of the THLB area in each landscape unit may be below the specified green-up height at any given time. The green-up heights vary by BA within the TSA (Table 35).

Table 35: Green-up heights by BA

Business Area	Greenup Height (m)
TKO	2.5 m
TOC	2.0 m
TCC	3.0 m
TSK	3.0 m

6.3.2 Visual Resources

Visual quality objectives are managed on 38,700 ha (18%) of the CFLB.

Table 36: VQO classes in the Cascadia TSA

Business Area	VQO Class Area (ha)			
	R	PR	M	Total
TKO	0	5,661	6,664	**12,324**
TOC	0	5,397	14,683	**20,080**
TCC	610	1,828	1,404	**3,842**
TSK	0	348	2,106	**2,454**
Total	**610**	**13,234**	**24,857**	**38,700**

Forest cover requirements for visual quality objectives are composed of two values:

- Visually Effective Greenup (VEG)—the stand height at which regeneration is perceived as a newly established forest, above which the stand is considered to have no visual impact; and
- Percent Planimetric Denudation—the maximum proportion of the productive area of a visual polygon that can be below the VEG height.

6.3.2.1 Visually Effective Greenup (VEG)

VEG is calculated according to the *Procedures for Factoring Visual Resources into Timber Supply Analyses (*BC Ministry of Forests *et al*. 1998*)*. The procedures specify VEG tree heights for slope classes to account for the effect of slope on visual impact. This timber supply analysis will use the area-weighted average slope to calculate VEG height for each visual quality polygon. Table 37 shows the overall area - weighted average VEG tree height for the different slope classes.

Table 37: Visual effective green-up heights (m) by slope

Slope (%)	0-5	5.1-10	10.1-15	15.1-20	20.1-25	25.1-30	30.1-35	35.1-45	45.1-50	50.1-55	55.1-60	>60
VEG (m)	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5

6.3.2.2 Percent Planimetric Denudation

The visual landscape inventory dataset field EVQO was used to determine the planimetric denudation limits. The limits are shown in Table 38. The targets are applied to the CFLB portion of each visual polygon separately. The allowable disturbance varies depending on the visual class and the visual absorption capability (VAC). The higher the VAC, the more disturbance is permitted.

Polygons with no VAC provided are treated as moderate (VAC = M).

Table 38: Visual classes and maximum allowable disturbance

Visual Class	Visual Absorption Capability (VAC)	Maximum Allowable Disturbance	Number of polygons	Total CFLB Area (ha)
Retention (R)	L	1.1%	3	32
	M	3.0%	2	577
	H	5.0%	0	0
Partial Retention (PR)	L	5.1%	16	2,732
	M	10.0%	33	9,061
	H	15.0%	4	1,441
Modification (M)	L	15.1%	27	5,098
	M	20.0%	63	16,370
	H	25.0%	17	3,389

6.3.3 Watersheds

6.3.3.1 Hydrological Recovery

The impact of timber harvesting on hydrological processes in watersheds is often estimated through the equivalent clearcut area (ECA). As noted below, in this analysis all community watersheds and domestic watersheds in TKO have a maximum ECA of 30%, i.e., a maximum of 30% of any watershed or watershed basin area can be in an unrecovered state. As a watershed consists of many stands that may be in different stages of development, the ECA for each stand within the watershed is determined. The timber supply model then calculates the weighted ECA for each watershed or watershed basin; if the weighted ECA is less than 30%, harvesting in the watershed may proceed until the limit of 30% is reached.

The equation commonly used for ECA is:

ECA = A x (1-HR)

A depicts the area of each stand within a watershed or basin, while HR stands for hydrological recovery. Timber supply analyses have traditionally used the Forest Practices Code Watershed Assessment Procedure Guidebook (Guidebook) from 1991 to guide the modelling of ECA. The Guidebook contains a default recovery curve (height curve) to aid modelling. In this analysis, the HR was modeled using the following equation by Winkler (Pers. Com):

HR (%) =100*(1-EXP(-0.24*(Ht-2)))^2.909

Ht is the average dominant/codominant tree height and 2 is the maximum snow depth in the stands for which the equation was derived. The above equation is considered to represent HR in TKO reasonably well. Figure 18 illustrates the resulting HR curve and its relationship to ECA. As can be observed from, Figure 18 in the example stand, a 30% ECA is reached when trees are 11 meters tall. Figure 18 also shows that a 30% ECA is reached at 70% HR.

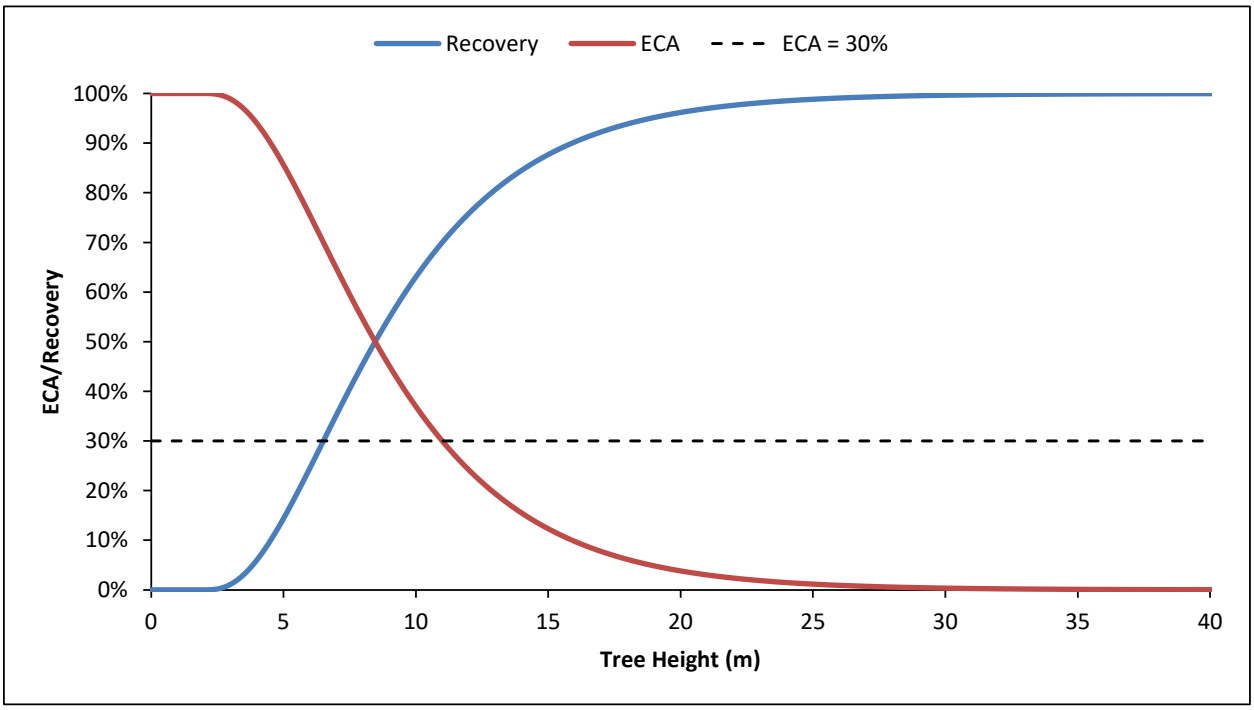

Figure 18: Recovery curve and ECA curve for a single stand in a TKO watershed

6.3.3.2 Community Watersheds

BCTS completes a hydrological assessment when proposing harvest in a community watershed (CWS). This assessment guides the harvest plan in each specific situation. There are two community watersheds within the Cascadia TSA: 340.011 (Batys) and 340.067 (Humphries), located in TKO, in Block 3. In the model, both watersheds have an ECA limit of 30%. An ECA of 30% is considered to be a moderate risk for peak flow hazard and a reasonable approximation of current practice. The total CFLB area in the community watersheds is 586 ha.

6.3.3.3 Domestic Watersheds

There are 16 domestic watersheds in TKO (Table 39), all with the maximum ECA of 30% as per current management by BCTS.

Table 39: Domestic watersheds in TKO

Watershed Name	Type	ECA Maximum (%)	CFLB (ha)
Andres Face	1	30%	111
Brittny Creek	1	30%	159
Canatain Creek	1	30%	88
Caribou South Face	1	30%	36
Daney Creek	3	30%	252
Daney Creek 1	3s	30%	109
Daney Creek 2	3s	30%	80
Elvidge Creek	2	30%	275
Ferguson Face	1	30%	68
Hladinec Brook	1	30%	32
Laughton Creek	3	30%	22
Marangie Creek	1	30%	189
Norwood Brook	1	30%	24
Payne Face	1	30%	84
Sawczuk Creek	1	30%	178
Summer Creek	2	30%	107
Total			**1,815**

6.3.4 Biodiversity

In the Cascadia TSA, landscape - level biodiversity is managed through OGMAs in all business areas, except for TSK, where aspatial targets are used in conjunction with OGMAs. KBHLPO, RHLPO, CCLUP and KSRMP provide additional direction for managing landscape level biodiversity.

6.3.4.1 KBHLPO Mature and Old Seral Requirements

The KBHLPO (October 26, 2002) establishes legal objectives and targets for old forest retention, mature and old forest retention, and landscape connectivity. As noted above, old growth targets are assumed to be met through OGMAs. The KBHLPO also establishes legal regional forest ecosystem connectivity corridors. Mature and old requirements must be preferentially located inside connectivity corridors.

This analysis sets the mature and old forest targets by LU and BEC as per the KBHLPO; the targets are required for only two LUs: Halfway and Trout (Table 40). Note that by applying the percent targets, the area targets are prorated to apply only to the Cascadia TSA portion of the LU and BEC.

The forest estate model is set to meet the mature and old targets first in the connectivity corridors as per Table 41. OGMAs – including younger recruitment areas - are considered to represent old forest and

account towards meeting the mature and old targets in full. Note that forested areas where the slope is greater than 80% are not considered for mature and old retention in the connectivity corridors. In most cases the area targets for connectivity corridors in Table 41 are greater than the forested areas. The targets were adjusted accordingly, i.e. they were set to be equal to the forested area within the connectivity corridor for each LU/BEC variant.

Table 40: Mature and old targets by LU/BEC

Landscape Unit	NDT	BEC Variant	Age of Mature	BEO	Forested Area (ha)	Mature and Old Target (%)	Mature and Old Target Area (ha)	Area in OGMA (ha)	Old and Mature outside OGMA (ha)	Mature and Old Current (ha)	Old and Mature Current (%)
Halfway	1	ESSFwc1	>120	H	692	>54%	374	171	388	559	81%
	1	ESSFwc4	>120	H	1,559	>54%	858	835	634	1,468	92%
Trout	1	ESSFwc4	>120	H	10,463	>54%	5,650	2,369	1,820	4,188	84%
	1	ESSFwc1	>120	H	4,962	>54%	2,680	5,791	3,211	9,001	86%
	1	ICHvk1	>100	H	1,718	>51%	876	513	966	1,479	86%
	1	ICHwk1	>100	H	9,814	>51%	5,005	3,188	3,731	6,920	71%
	2	ICHmw2	>100	H	3,090	>46%	1,422	381	1,064	1,446	47%

Table 41: Mature and old area targets applied to connectivity corridors in the model

Landscape Unit	NDT	BEC Variant	Age of Mature	BEO	Forested Area (ha)	Mature and Old Target Area (ha)	Target Used in the Analysis	Area in OGMA (ha)	Old and Mature outside OGMA (ha)	Mature and Old Current (ha)	Surplus/Deficit
Halfway	1	ESSFwc1	>120	H	343	374	343	154	124	278	-65
	1	ESSFwc4	>120	H	955	858	858	804	135	939	81
Trout	1	ESSFwc4	>120	H	3,310	5,650	3,310	1,388	53	1441	-86
	1	ESSFwc1	>120	H	1,527	2,680	1,527	2,987	242	3229	-266
	1	ICHvk1	>100	H	108	876	108	58	2	60	-48
	1	ICHwk1	>100	H	3,697	5,005	3,697	2,419	339	2758	-1,030
	2	ICHmw2	>100	H	512	1,422	512	122	91	213	-300

6.3.4.2 RHLPO Mature and Old Seral Requirements

The RHLPO (March 2005) specifies the amount of mature and old forest that must be maintained within each BEC variant within each Landscape Unit (LU). The RHLPO was amended in 2011, with the amendment removing mature seral requirements. As noted above, old growth targets are assumed to be met through OGMAs.

6.3.4.3 CCLUP Mature and Old Seral Requirements

The CCLUP Biodiversity Conservation Strategy (1996) defines landscape units and biodiversity emphasis options (BEO) for seral stage distributions. The age definitions for mature forest and the retention targets are summarized in Table 42. All landscape units are currently meeting their targets for mature and old except for Antler and Umiti.

Table 42: Mature and old seral forest cover targets in TCC

Landscape Unit	BEO	BEC Variant	NDT	Age of Mature	Forest Area (ha)	Mature and Old Target (%)	Mature and Old Target Area (ha)	Mature and Old Now (ha)	Mature and Old Now (%)
Abhau	L	SBSmh	3	>100	622	>11%	68	282	45%
		SBSmw			1,262		139	217	17%
Antler	I	ESSFwk1	1	>120	55	>36%	20	10	18%
Big Valley	L	ESSFwc3	1	>120	1,270	>19%	241	970	76%
		ESSFwk1			7,143		1,357	3,394	48%
		SBSwk1	2	>100	2,131	>15%	320	956	45%
Jack of Clubs	L	ESSFwc3	1	>120	1,089	>19%	207	909	83%
		ESSFwk1			3,459		657	1,802	52%
		SBSwk1	2	>100	904	>15%	136	608	67%
Swift	L	ESSFwc3	1	>120	92	>19%	17	92	100%
		ESSFwk1			2,342		445	747	32%
		SBSwk1	2	>100	982	>15%	147	278	28%
Umiti	I	ESSFwc3	1	>120	1	>36%	0	0	0%
		ESSFwk1			141		51	35	25%
		SBSwk1	2	>100	136	>31%	42	18	13%
Willow	L	ESSFwk1	1	>120	1,754	>19%	333	1,399	80%
		SBSwk1	2	>100	2,024	>15%	304	871	43%

6.3.4.4 KSRMP Seral Requirements

The KSRMP (2006) establishes seral stage targets for TSK. As noted before in this document, the old seral requirement in TSK are assumed to be met by OGMAs and aspatial old seral targets This analysis

also sets early, and mature and old forest targets by LU and BEC as per the KSRMP. The targets are shown in Table 43, Table 44, and Table 45. For all BEC variants in the KSRMP, early seral is defined as younger than 40 years, while old is defined as older than 250 years old. The definition of mature depends on the BEC variant.

Table 43: Early seral stage targets by LU/BEC

Landscape Unit name	BEO	NDT	BEC Variant	Forest Area (ha)	Early Target (%)	Early Target Area (ha)	Early Now (ha)	Early Now (%)
Beaver	I	1	MHmm2	129	22%	28	4	3%
		2	CWHws1	5,637	36%	2,029	2861	51%
			CWHws2	2,156	36%	776	709	33%
Clore	I	1	MHmm2	7,924	22%	1,743	321	4%
		2	CWHws1	1,736	36%	625	636	37%
			CWHws2	6,229	36%	2,242	2071	33%
Hirsch	I	1	CWHvm1	897	30%	269	466	52%
			CWHvm2	3,033	30%	910	1371	45%
			MHmm1	4,105	22%	903	315	8%
			MHmm2	29	22%	6	0	0%
		2	CWHws1	340	36%	123	101	30%
			CWHws2	195	36%	70	55	28%
Kleanza - Treasure	L	1	MHmm2	7,044	n/a			
		2	CWHws1	2,144	n/a			
			CWHws2	13,485	n/a			
Nelson - Fiddler	L	1	MHmm2	8	n/a			
		2	CWHws1	127	n/a			
			CWHws2	63	n/a			
Tseaux	I	2	CWHws1	39	36%	14	27	69%
			CWHws2	51	36%	18	0	0%

Table 44: Old seral stage targets by LU/BEC

Landscape Unit name	BEO	NDT	BEC Variant	Forest Area (ha)	Old Target (%)	Old Target Area (ha)	Old Now (ha)	Old Now (%)
Beaver	I	1	MHmm2	129	19%	24	124	97%
		2	CWHws1	5,637	9%	507	1,641	29%
			CWHws2	2,156	9%	194	1,382	64%
Clore	I	1	MHmm2	7,924	19%	1,506	4,474	56%
		2	CWHws1	1,736	9%	156	823	47%
			CWHws2	6,229	9%	561	3,567	57%

Landscape Unit name	BEO	NDT	BEC Variant	Forest Area (ha)	Old Target (%)	Old Target Area (ha)	Old Now (ha)	Old Now (%)
Hirsch	I	1	CWHvm1	897	13%	117	74	8%
			CWHvm2	3,033	13%	394	1,536	51%
			MHmm1	4,105	19%	780	3,494	85%
			MHmm2	29	19%	6	27	92%
		2	CWHws1	340	9%	31	55	16%
			CWHws2	195	9%	18	107	55%
Kleanza - Treasure	L	1	MHmm2	7,044	19%	1,338	6,522	93%
		2	CWHws1	2,144	9%	193	619	29%
			CWHws2	13,485	9%	1,214	11,139	83%
Nelson - Fiddler	L	1	MHmm2	8	19%	2	8	97%
		2	CWHws1	127	9%	11	43	34%
			CWHws2	63	9%	6	45	71%
Tseaux	I	2	CWHws1	39	9%	4	11	29%
			CWHws2	51	9%	5	51	100%

Table 45: Mature and old seral stage targets by LU/BEC

Landscape Unit name	BEO	NDT	BEC Variant	Forest Area (ha)	Age of Mature	Mature and Old Target (%)	Mature and Old Target Area (ha)	Mature and Old Now (ha)	Mature and Old Now (%)
Beaver	I	1	MHmm2	129	>120	36%	46	124	97%
		2	CWHws1	5,637	>80	34%	1,916	1,916	34%
			CWHws2	2,156	>80	34%	733	1,389	64%
Clore	I	1	MHmm2	7,924	>120	36%	2,853	7,455	94%
		2	CWHws1	1,736	>80	34%	590	909	52%
			CWHws2	6,229	>80	34%	2,118	3,925	63%
Hirsch	I	1	CWHvm1	897	>80	36%	323	193	22%
			CWHvm2	3,033	>80	36%	1,092	1,626	54%
			MHmm1	4,105	>120	36%	1,478	3,717	91%
			MHmm2	29	>120	36%	11	29	100%
		2	CWHws1	340	>80	34%	116	57	17%
			CWHws2	195	>80	34%	66	140	72%
Kleanza - Treasure	L	1	MHmm2	7,044	>120	19%	1,338	6,973	99%
		2	CWHws1	2,144	>80	17%	365	1,686	79%
			CWHws2	13,485	>80	17%	2,292	11,616	86%

Landscape Unit name	BEO	NDT	BEC Variant	Forest Area (ha)	Age of Mature	Mature and Old Target (%)	Mature and Old Target Area (ha)	Mature and Old Now (ha)	Mature and Old Now (%)
Nelson - Fiddler	L	1	MHmm2	8	>120	19%	2	8	97%
		2	CWHws1	127	>80	17%	22	44	35%
			CWHws2	63	>80	17%	11	45	71%
Tseaux	I	2	CWHws1	39	>80	34%	13	11	29%
			CWHws2	51	>80	34%	17	51	100%

6.3.5 Wildlife

Wildlife habitat areas for mountain caribou, grizzly bear habitat and coastal tailed frog designated as no harvest zones are reserved from harvest and accounted for in the land base netdown. The same applies to no harvest areas in legally established ungulate winter ranges for mountain goat and mountain caribou.

6.3.5.1 Wildlife Habitat Areas

There are three WHAs in the Cascadia TSA where harvest is allowed. The WHA 6-063 in TSK is for coastal tailed frog. The order establishing this WHA allows for some harvest as long as 70% of the residual volume is maintained. The order further sets operational restrictions regarding interior forest condition, connectivity, maintenance of snags etc. Rather than setting up harvest constraints for this WHA, 70% of its forested area is removed from the THLB, as described in Section 5.1.5.

The two other WHAs that allow harvest were established for mountain caribou (5-088 and 5-089). Both are located in TCC and along with many operational restrictions limit harvest to a maximum of 33% for each polygon within the WHA on an 80 harvest cycle.

Table 46: WHA units that allow harvest

Business Area	WHA	Species	Area (ha)	Maximum Area %	Age	Required Retention and Management
TSK	6-063	Coastal Tailed Frog	220	n/a, netdown	n/a, netdown	Maintain 70% of residual volume, other operational measures.
TCC	5-088	Mountain Caribou	195	33%	<81	Harvest max 33% of each stand on an 80 year cycle, other operational measures.
TCC	5-089	Mountain Caribou	2,028	33%	<81	Harvest max 33% of each stand on an 80 year cycle, other operational measures.

6.3.5.2 Ungulate Winter Range

There are three UWRs in the Cascadia TSA where harvest is allowed. UWR u-6-009 is for moose management and it is located in TSK. The General Wildlife Measures for this UWR require that a minimum of 30% of the forest cover in each UWR management unit is maintained in age classes 8 and 9

(>140 years old) throughout the planning horizon. Site specific operational measures are also noted in the order.

UWR u-8-012 is for mountain caribou and is located in TOC. It requires that mature and old forest cover is maintained for 70% of each UWR management unit.

UWR u-4-001 is for several ungulate species; however only moose and mule deer management units are located within the TSA (TKO and TOC). The retention targets are set for each species and BEC. Additional targets are set for forage cover (minimum target) and forest cover (maximum disturbance).

The modelling parameters are shown in Table 47. The targets and constraints are applied by UWR management unit, which are shown in Table 48.

Table 47: UWR units that allow harvest

Business Area	UWR	Species	BEC	Forest Cover	Age
TKO	u-4-001	Mule Deer	ICHdw	Min 30%	>80
TKO	u-4-001	Mule Deer	ICHmw	Min 40%	>100
TKO	u-4-001	Moose	All	Min 20%	>60
TKO	u-4-001	Forage, all species	All	Min 10%	>80
TKO	u-4-001	Forest cover, All Species	All	Max 40%	<21
TOC	u-8-012	Mountain Caribou	ESSF	Min 70%	>140
			ICH		
TOC	u-4-001	Mule Deer	ICHmw	Min 40%	>100
TOC	u-4-001	Moose	All	Min 20%	>60
TOC	u-4-001	Forage, all species	All	Min 10%	>80
TOC	u-4-001	Forest Cover, All Species	All	Max 40%	<21
TSK	u-6-009	Moose	All	Min 30%	>140

Table 48: UWR management units for conditional harvest in the Cascadia TSA

Business Area	UWR TAG	Management Unit	Species	Forested Area (ha)
TKO	u-4-001	101	Moose	1,696
TKO	u-4-001	114	Moose	1,129
TKO	u-4-001	128	Mule Deer	40
TKO	u-4-001	130	Mule Deer	57
TKO	u-4-001	131	Mule Deer	1,568
TKO	u-4-001	135	Mule Deer	1,400
TKO	u-4-001	142	Mule Deer	1
TKO	u-4-001	344	Mule Deer	22
TOC	u-4-001	41	Moose	440
TOC	u-4-001	42	Mule Deer	359
TOC	u-4-001	44	Moose	187
TOC	u-4-001	45	Moose	1,862
TOC	u-4-001	46	Mule Deer	200

Business Area	UWR TAG	Management Unit	Species	Forested Area (ha)
TOC	u-4-001	56	Moose	397
TOC	u-4-001	57	Mule Deer	32
TOC	u-4-001	60	Mule Deer	232
TOC	u-4-001	63	Moose	169
TOC	u-4-001	65	Moose	938
TOC	u-4-001	66	Mule Deer	538
TOC	u-4-001	72	Mule Deer	60
TOC	u-8-012	1	Mountain Caribou	1,282
TOC	u-8-012	2	Mountain Caribou	8,856
TSK	u-6-009	1	Moose	2,015
TSK	u-6-009	2	Moose	1,045
TSK	u-6-009	3	Moose	614
TSK	u-6-009	20	Moose	1,150
TSK	u-6-009	21	Moose	111

6.3.5.3 Grizzly Bear

As note earlier in this document, the draft grizzly WHAs that meet the intent of the FPPR Section 7 species at risk notice are treated as legal and removed from the THLB reflecting current practice. In addition to the removal of the draft WHAs from the THLB, forest cover constraints exist for the Copper grizzly bear identified watersheds as per the Kalum SRMP.

Table 49: Forest cover targets for grizzly bear in the Copper watershed

Business Area	Watershed	Forest Cover	Age	Forest Area (ha)
TSK	Copper	Max 30%	Between 25 and 100	7,788

6.3.5.4 Northern Goshawk

Nesting sites for Northern Goshawk (TSK) are co-located with OGMAs and other reserve areas, and do not require additional management actions.

6.3.5.5 Marbled Murrelet

Habitat for Marbled Murrelet (TSK) is managed at the landscape level through OGMAs and through patch and seral targets identified in the Kalum SRMP.

6.3.5.6 Migratory Birds

BCTS maintains a Migratory Birds SOP document for guidance on how to identify times and areas of concern for migratory birds, to incorporate migratory bird management strategies into operational plans,

and to implement the management strategies during harvesting activities. Strategies including scheduling harvest timing outside of nesting periods and leaving stand level retention are used in areas where risk ranking is high. Retention can usually be accommodated within existing reserve areas such as WTRAs, riparian reserves, OGMAs.

7 Timber Harvesting

7.1 Initial Harvest Level

In the course of building the base case, various options for a sustainable harvest forecast will be tested. A base case will be constructed for each BA separately, while a sensitivity analysis will test the impact of analyzing the TSA as one unit.

The first iterations in building the base case use the current TSA AAC of 402,818 m^3 per year as the initial harvest level. The AAC will be allocated to different BAs as per Table 50. The resulting timber supply forecasts for the medium term and the long term will then demonstrate whether the current AAC or some other harvest level is appropriate as the initial harvest level for the final version of the base case.

Table 50: Cascadia TSA AAC by BA

Business Area	AAC m^3/Year
TKO	112,650
TOC	66,566
TCC	81,986
TSK	141,616
Total	**402,818**

7.2 Harvest Rule

Simulation models are rule-driven, and require harvest scheduling rules to control the order in which stands are harvested. It is important that these rules are able to organize the harvest in a way that realizes the productive potential of the land base in a reasonable manner to understand the impacts of the timber supply assumptions and constraints.

The highest volume first harvest rule has been gaining popularity recently due to its ability to mimic operations more realistically than other commonly used harvest rules, such as oldest first or relative oldest first. In this rule, the stands that have the greatest volume per ha are given priority for harvest, subject to forest cover requirements. The highest volume first harvest rule will be used in this analysis.

7.3 Harvest Priority, Harvest Deferrals and Minimum Volume Requirements

7.3.1 Harvest Priority

Harvest priority can be used to override the harvest rule. It can be used in modelling to reflect situations when it is known that some areas will be targeted for harvesting. Such targeting may be required to address forest health issues as an example.

While no areas will be prioritized for harvest in the base case, the existing five-year plans will be incorporated into the timber supply model to ensure that planned blocks are included in the harvest forecast.

7.3.2 Partitions

Partitions are used when a specific level of harvest is required from a geographic area. The partition can be a minimum or maximum. Minimums are often used to promote harvest when it is uncertain whether harvest in an area will occur at all. An example of this would be marginally economic harvest areas within the THLB containing less valuable species such as hemlock and balsam. Maximums are used when there is a need to limit the rate of cut from a geographic area within a TSA.

Partitions can also be non-spatial, i.e. not tied to specific geographic areas. An example would be a maximum volume of harvest of a specific species within a TSA. Non-spatial partitions are usually more difficult to implement and monitor.

7.3.3 Areas Classified as Marginally Economic

There are areas in the Cascadia TSA that are considered marginally economic as noted in Section 5.1.14.6. It is assumed that harvest in these areas would be economic only during exceptionally high log prices. The base case will exclude these areas from the THLB. Their impact on timber supply will be tested through sensitivity analysis

7.4 Utilization Levels

The utilization level defines the minimum top diameter (inside bark) and minimum diameter (dbh) of stems that must be removed from harvested areas. It also specifies the maximum height of stumps that may be left. These factors are used to determine the merchantable stand volume in the analysis.

The utilization levels used in this analysis are shown in Table 51. These levels are consistent with TSL specifications

Table 51: Utilization levels used in the analysis

Leading species	Utilization		
	Minimum dbh (cm)	Maximum stump height (cm)	Minimum top dib (cm)
All conifer, except pine	17.5	30	10
Pine	12.5	30	10

7.5 Volume Exclusions

One or more species may be non-merchantable in mixed-species stands. As an example, deciduous species may not be harvested in a predominantly coniferous stand; the unharvested portion should not contribute to the estimated stand volume. In the Cascadia TSA all deciduous species in conifer stands will be excluded from the estimation of stand volume. This reflects current utilization standards and performance.

7.6 Minimum Harvest Criteria

Minimum harvest criteria is the earliest age, volume per ha, or other criterion such as DBH at which stands become eligible for harvest within the timber supply model. Minimum harvest criteria can have a profound effect on modeled harvest levels by creating acute timber supply shortages, or “pinch points”, that constrain the rest of the planning horizon.

For this analysis, the minimum harvestable criteria for stands in each analysis unit is the age at which the stand is predicted to reach a volume as described in Table 52. These volumes reflect the current practise in the four BCTS business areas. In operations most forest stands are harvested beyond the minimum harvest criteria due to economic considerations and constraints on harvesting which arise from managing for other forest values.

Table 52: Minimum harvest criteria

Business Area	Minimum Volume by Harvest Method (m^3/ha)	
	Cable	Ground
TKO	200	150
TOC	250	200
TCC	200	110
TSK	250	250

7.7 Harvest Profile

The base case will not target a specific harvest profile.

8 Growth and Yield

Growth and yield assumptions define the net volumes that are realized when natural and managed stands are harvested. They also describe various tree and stand attributes over time (i.e., volume, height, diameter, presence of dead trees, etc.).

8.1 Site Index

The provincial site productivity data layer will be used in this TSR to model the growth and yield of managed stands. The provincial site productivity layer is considered a standard operating procedure (SOP) by FAIB and its use is recommended in all TSRs.

Where there is no data in the provincial layer, the SIBEC site index for the leading TEM/PEM site series will be used. If there is no site index in SIBEC, the inventory (VRI) site index will be used.

The growth and yield of natural stands will be modeled using the inventory site index.

8.2 Analysis Units

An analysis unit is a grouping of similar forest areas with the objective of simplifying the analysis and the interpretation of analysis results.

8.2.1 Natural Stands

Stands established prior to 1976 are considered natural stands in this analysis. Their growth and yield will be modeled using the Variable Density Yield Prediction (VDYP7) yield model. Inventory site index estimates are considered to be the most appropriate in modelling these stands.

The natural stand yield curves were not aggregated. Rather, the analysis file contains one natural stand yield curve for each forest cover polygon; there are 19,128 natural stand yield curves in total.

8.2.2 Managed Stands

Stands established in 1976 and later are considered managed stands in this analysis. Their growth and yield will be modeled using Tree and Stand Simulator (TASS) version II. TASS is a three dimensional growth simulator that generates growth and yield information for even aged stands of pure coniferous species of commercial importance in coastal and interior forests of British Columbia. Provincial site productivity layer estimates of site index are considered to be the best estimates of site productivity for modelling managed stands and were used for this project.

Analysis units for managed stands are based on BEC site series groupings using terrestrial ecosystem mapping (TEM) and predictive ecosystem mapping (PEM) data. In TSK, TOC and TKO minor BEC variants were amalgamated with the most similar larger BEC variants (Table 53). In addition, managed stands were split by era.

Table 53: Site series groupings, managed stands

Group #	Business Area	BEC Variant	Site Series	THLB Area (ha)
1	TKO	ESSFwh1/mh	101,102,103,104,105	4,121
2	TKO	ESSFwh1/mh	110,111,112,113	533
3	TKO	ESSFwc4/wcw/dc1/dcw	101,102,103,104,105	5,087

Group #	Business Area	BEC Variant	Site Series	THLB Area (ha)
4	TKO	ESSFwc4/wcw/dc1/dcw	110,111,112,113	509
5	TKO	ICHwk1/vk1	101,104	1,807
6	TKO	ICHwk1/vk1	102,103	99
7	TKO	ICHwk1/vk1	110,111,112,113,Fm02,Fm04	204
8	TKO	ICHmw2/mw5/dw1	101,102,103,104,105	12,439
9	TKO	ICHmw2/mw5/dw1	110,111,111,112,113,114,Fm01,Fm02,Fm03,Fm04	1,409
10	TOC	ESSFwh1	101,102,103,104	2,981
11	TOC	ESSFwh1	110,111	298
12	TOC	ESSFwc4/wcw	101,102,103	998
13	TOC	ESSFwc4/wcw	110,111,112	38
14	TOC	ICHwk1/vk1	101,104	7,537
15	TOC	ICHwk1/vk1	102,103	93
16	TOC	ICHwk1/vk1	110,111,112,113,Fm02,Fm04	849
17	TOC	ICHmw2	101,102,103,104	3,171
18	TOC	ICHmw2	110,111,112,113,114,Fm02,Fm03	264
19	TOC	ICHmw3	01,02,03,04,05	2,860
20	TOC	ICHmw3	06,07,08,09	322
21	TCC	ESSFwk1	01,02,03	8,783
22	TCC	ESSFwk1	04,05,06,07	418
23	TCC	ESSFwc3	01,02	1,942
24	TCC	ESSFwc3	03	110
25	TCC	SBSwk1	01,02,03,04,05	4,034
26	TCC	SBSwk1	06,07,08,09,10,11	837
27	TCC	SBSmh	01,02,03,04,05	246
28	TCC	SBSmh	06,07,08,09	28
29	TCC	SBSmw	01,02,03,04	897
30	TCC	SBSmw	05,06,07,08,09,10, 12, 13	539
31	TSK	CWHvm1	01,05	555
32	TSK	CWHvm1	03,04	4
33	TSK	CWHvm1	06,07,08,09,10,11,12,13,14	377
34	TSK	CWHws1	01,04, 01|05, 04|06	7,193
35	TSK	CWHws1	02,03	480
36	TSK	CWHws1	05,06,07,08,09,10,11	425
37	TSK	CWHvm2	all	3
38	TSK	CWHws2	01,04, 01|05, 04|06	11,858
39	TSK	CWHws2	02,03	19
40	TSK	CWHws2	05,06,07,08,09,10,11	152
41	TSK	MHmm1/2, ESSFmk	01,03, 01|04, 03|05	2,995
42	TSK	MHmm1/2, ESSFmk	02	1
43	TSK	MHmm1/2, ESSFmk	04,05,06,07,08,09	66

8.2.2.1 Era 1; Stands established between 1976 and 1995

Stands established between 1976 and 1995 are considered existing managed stands. Most of these stands were regenerated through planting with seedlings of no genetic worth (wild seed, not genetically improved) and natural ingress. Some units in TSK were naturally regenerated. In TCC the stands of this era for the main BEC units (SBSwk1 and ESSFwk1 site series 01 and drier) were further split into pine and spruce leading units. There are 18,813 ha of THLB in this Era, as shown in Table 54.

Table 54: Era 1 THLB area by BA

BA	THLB (ha)
TKO	3,296
TOC	5,758
TCC	3,165
TSK	6,594
Total	**18,813**

8.2.2.2 Era 2; Stands established between 1996 and 2016

Stands established between 1996 and 2016 are also considered existing managed stands. Most of these stands were regenerated through planting with seedlings of genetic worth (average productivity gains for the era were used) and natural ingress, with some analysis units in TSK assumed to be naturally regenerated. Table 55 shows the THLB area of Era 2 stands by BA.

Table 55: Era 2 THLB area by BA

BA	THLB (ha)
TKO	3,789
TOC	3,513
TCC	2,344
TSK	2,963
Total	**12,610**

8.2.2.3 Era 3; Stands established after 2016

Stands established after 2016 and those that will be established in the future are considered future managed stands. Most of these stands were regenerated through planting with seedlings of genetic worth (averages for 2013 to 2015 were used) and natural ingress, with some units in TSK assumed to be naturally regenerated. Some future stands in TCC and TSK with similar stand attributes as Era 2 were grouped together for modelling.

8.2.3 Operational Adjustment Factors in Managed Stand Yields

The yield tables generated by the Tree and Stand Simulator (TASS) are based on the data observed and collected in research plots established by FLNRORD and industry. Historically, this research has been carried out in fully stocked, even aged stands with no significant incidences of pests and diseases.

Operational adjustment factors (OAF) are usually applied to the TASS generated yields to reflect average operational growing conditions.

OAF 1 allows for yield reductions associated with non-productive areas in the stand, uneven spacing of crop trees (clumping), and endemic and random loss. The standard OAF1 of 15 % is considered a province-wide approximation of the difference between research plots and actual yields, and is composed of the following estimates:

- Espacement 4%
- Non-productive 4%
- Random risk 3%
- Endemic losses 4%

The standard OAF 1 of 15% will be applied to all yield curves generated by TASS.

OAF 2 allows for increasing volume losses towards maturity, attributable to decay, waste and breakage, disease and pest factors. The standard OAF2 of 5 % is also a province-wide approximation of the difference between research plot yields and actual yields. As this difference increases with age, the impact of OAF 2 also accelerates with age.

The standard OAF 2 of 5% will be applied to all yield curves generated by TASS.

8.3 Natural Disturbance Assumptions

8.3.1 Non-Harvestable Land Base

A disturbance function was used in the analysis to prevent the non-timber harvesting land base from continually aging and providing a disproportionate, and often improbable, amount of old forest cover conditions to satisfy landscape level biodiversity requirements. The document "Modeling Options for Disturbance Outside the THLB – Working Paper" (Forest Analysis Branch, 2003) provides direction for disturbing areas of the landscape outside of the THLB. The age reset by variant for the non-timber harvesting land base methodology was applied in this analysis. The methodology is as follows:

1. List the estimated return interval for disturbance and old seral age in each variant and NDT in the TSA (taken from the Biodiversity Guide Book or Landscape Unit Planning Guide Appendix 2).
2. Calculate the expected percent of the forest above the old seral age. This calculation uses a negative exponential distribution and assumes that the probability of disturbance is independent of forest age. The calculation is "percent forest greater than age t = exp(-[t/b])", where b is the average disturbance interval and t is the old seral age.
3. Calculate a rotation age based on the age distribution described in step 2 (old age / (1- % forest above seral age).
4. Divide the contributing non-THLB area in the variant by the calculated rotation age to determine the annual minimum disturbance target for each variant.

Table 56 identifies the target area to be disturbed annually within each BEC variant for the Cascadia TSA.

Table 56: Target NHLB area to be disturbed annually in each BEC variant

Business Area	BEC variant	NDT	Mean Disturbance Interval	Age of Old	Forest Above Old Seral Age (%)	Rotation Age	NHLB Area (ha)	Annual Disturbance (ha)	Annual Disturbance (%)
TKO	ESSFdc1	2	200	250	29%	350	3	0.01	0.29%
TKO	ESSFdcw	2	200	250	29%	350	2	0.00	0.29%
TKO	ESSFmh	2	200	250	29%	350	44	0.13	0.29%
TKO	ESSFwc4	1	350	250	49%	490	15,191	31.02	0.20%
TKO	ESSFwcw	1	350	250	49%	490	9,076	18.53	0.20%
TKO	ESSFwh1	1	350	250	49%	490	9,133	18.65	0.20%
TKO	ICHdw1	3	150	140	39%	231	479	2.07	0.43%
TKO	ICHmw2	2	200	250	29%	350	6,238	17.80	0.29%
TKO	ICHmw5	2	200	250	29%	350	680	1.94	0.29%
TKO	ICHvk1	1	250	250	37%	395	1,685	4.26	0.25%
TKO	ICHwk1	1	250	250	37%	395	11,158	28.21	0.25%
TOC	ESSFwc4	1	350	250	49%	490	7,333	14.97	0.20%
TOC	ESSFwcw	1	350	250	49%	490	4,477	9.14	0.20%
TOC	ESSFwh1	1	350	250	49%	490	5,584	11.40	0.20%
TOC	ICHmw2	2	200	250	29%	350	1,931	5.51	0.29%
TOC	ICHmw3	2	200	250	29%	350	1,646	4.70	0.29%
TOC	ICHvk1	1	250	250	37%	395	1,781	4.50	0.25%
TOC	ICHwk1	1	250	250	37%	395	6,579	16.64	0.25%
TCC	ESSFwc3	1	350	250	49%	490	960	1.96	0.20%
TCC	ESSFwk1	1	350	250	49%	490	4,516	9.22	0.20%
TCC	SBSmh	3	125	140	33%	208	349	1.68	0.48%
TCC	SBSmw	3	125	140	33%	208	192	0.92	0.48%
TCC	SBSwk1	2	200	250	29%	350	1,558	4.45	0.29%
TSK	CWHvm1	1	250	250	37%	395	370	0.93	0.25%
TSK	CWHvm2	1	250	250	37%	395	1,188	3.00	0.25%
TSK	CWHws1	2	200	250	29%	350	3,911	11.16	0.29%
TSK	CWHws2	2	200	250	29%	350	9,667	27.59	0.29%
TSK	MHmm1	1	350	250	49%	490	3,235	6.61	0.20%
TSK	MHmm2	1	350	250	49%	490	12,876	26.29	0.20%

The annual disturbance areas were randomly applied to stands in the NHLB by BEC Unit. When disturbed the stand age was reset to 0. The implementation only allowed stands to be disturbed once, which results in a lower than targeted disturbance in the SBS portions of the forest after 208 years and in ICHdw1 after 231 years.

8.3.2 Timber Harvesting Land Base, Non-Recoverable Losses

Non-recoverable losses provide an estimate of the average annual volume of timber damaged or killed within the THLB and not salvaged or accounted for by other factors. These losses result from natural events such as insects, diseases, wind, wildfires, etc.

BCTS received non-recoverable loss (NRL) data from FAIB for the last 19 years. They adjusted the data by removing the MPB related losses; MPB is no longer a factor in the Cascadia TSA. BCTS further adjusted the data by removing balsam bark beetle losses and by adding losses for fire and spruce beetle in TCC. The data for balsam bark beetle losses in TCC is skewed by a large spike in losses in 2003. Adding losses for fire in TCC accounted for the large fires in 2017. The values shown in Table 57 indicate the estimated annual volume that will not be salvaged. Non-recoverable losses are removed from the harvest volume for each timber supply forecast.

Table 57: Annual non-recoverable losses

Business Area	Average Annual Losses (m^3/yr)	Annual Losses Used in Analysis (m^3/yr)	Notes
TKO	2,728	2,500	Caribou UWR has reduced the THLB
TOC	921	900	
TCC	9,400	2,200	Balsam bark beetle removed. Add for fire and spruce beetle.
TSK	1,289	1,200	
Total	**14,338**	**6,800**	

8.4 Silviculture

8.4.1 Silviculture Systems and Harvesting Systems

Clear cut with reserves is the most common silvicultural system in the Cascadia TSA. Retention levels vary throughout the TSA. Trees are retained to meet riparian or wildlife habitat objectives or higher level plan objectives.

Reductions to account for retention are applied through a land base netdown as described in Section 5.1.18.

8.4.2 Regeneration activities in managed stands

Regeneration assumptions for existing managed stands and future managed sands were developed from RESULTS data and in cooperation with BCTS staff using the following approach:

1. Split the managed stands into Eras as described above in Section 8.2.2.
2. Silviculture free growing survey inventory and planting data were analyzed and summarize by BEC variant.

   Era 1; stands regenerated between 1976 and 1995: RESULTS planting data summarized to the BEC variant is not available for this era. Overall regional planting averages and professional input from BCTS staff were used to develop the average BEC variant planting inputs for this era.

   The average BEC variant natural ingress inputs were developed by deducting the average planted densities by species from the average free growing inventory densities by species.

RESULTs free growing inventory data with linkages to a BEC variant were used to come up with average BEC variant estimates for free growing stand compositions. VRI species composition summaries by BEC variant were compared with the RESULTS data and professional input from BCTS staff was used to finalize the average stand attributes for each BEC variant.

The BEC variant averages were assigned to PEM site series group dominated by site series 01. Professional input from BCTS staff was further used to adjust the site series 01 estimates to best reflect practices throughout the whole era and to develop BEC variant averages for the other PEM site series groups in the BEC variant.

3. Era 2; stands regenerated between 1995 and 2016: RESULTS planting data is only available for harvesting years 2002 to 2015 for BEC variant averages. It was used to develop average BEC variant estimates for the planted inputs for the era.

   For the harvesting period where both RESULTS planting and free growing survey data is available by BEC variant (between 2002 and 2006) the average BEC variant natural ingress inputs were developed by deducting the average planted densities by species (from the 2002 to 2006 period) from the average free growing inventory densities by species.

   The BEC variant averages were assigned to PEM site series group dominated by site series 01. Professional input from BCTS staff was used to adjust the site series 01 estimates to best reflect practices throughout the whole era and to develop BEC variant averages for the other PEM site series groups in the BEC variant.

4. Era 3; Stands regenerated from 2016 and into the future: regeneration assumptions for these stands were assumed to be the same by PEM site series group as those for Era 2. It was necessary to separate these stands from Era 2 stands due to the significant differences in the genetic worth of the planting stock.

Table 58, Table 59 and Table 60 present the regeneration assumptions that will be used in the analysis for modelling the growth and yield of managed stands. Genetic gain information for Eras 2 and 3 are provided in Table 61 and Table 62. Natural ingress delay is described in section 8.4.4.

Table 58: Regeneration assumptions for plantations established between 1976 and 1995

AU	BA	BGC Variant	Site Series	Leading Species	SI	Planted Density (sph)	Species Comp	Regen Delay	Ingress Density (sph)	Ingress Species Comp	Ingress Delay	OAF1	OAF2
101	TKO	ESSFwh1/mh	101,102,103, 104,105	Sx	18.4	900	Sx65Pli25Bl10	4	1900	Bl65Pli35	0	15	5
102	TKO	ESSFwh1/mh	110,111,111, 112,113	Sx	19.5	800	Sx70Pli20Bl10	4	1700	Bl70Pli30	0	15	5
103	TKO	ESSFwc4/wc w/dc1/dcw	all	Sx	15.2	900	Sx60Pli25Bl10Cw5	4	1750	Bl70Pli30	0	15	5
104	TKO	ICHwk1/vk1	101,102,103, 104	Sx	22.6	1200	Sx40Fd40Cw15Pw5	4	1300	Sx50Hw45At5	0	15	5
105	TKO	ICHwk1/vk1	110,111,112, 113,Fm02, Fm04	Sx	24.8	1100	Sx50Fdi30Cw20	4	1000	Hw70Fdi15Sx10At5	0	15	5
106	TKO	ICHmw2/mw5/ dw1	101,102,103, 104,105	Fdi	22	1200	Fdi50Pli20Sx20Lw10	4	2630	Pli35Fdi25Hw20Cw15 At5	0	15	5
107	TKO	ICHmw2/mw5/ dw1	110,111,111, 112,113,114, Fm01,Fm02, Fm04	Sx	24.3	1100	Sx50Fdi20Pli30	4	2400	Pli25Fdi25Hw25Cw20 At5	0	15	5
108	TOC	ESSFwh1	all	Sx	19.1	900	Sx100	4	1900	Bl50Sx30Hw20	0	15	5
109	TOC	ESSFwc4	all	Sx	16.6	900	Sx100	4	1750	Bl50Sx50	0	15	5
110	TOC	ICHwk1/vk1	101,102,103, 104	Sx	23.1	1000	Sx60Fd30Cw5Pw5	4	1500	Hw45Sx25Cw25At5	0	15	5
111	TOC	ICHwk1/vk1	110,111,112, 113,Fm02, Fm04	Sx	24.3	900	Sx65Fdi25Cw5Pw5	4	1200	Hw45Cw35Sx15At5	0	15	5
112	TOC	ICHmw2	101,102,103, 104	Fdi	22.8	1200	Fdi75Pli10Sx10Lw5	4	2630	Hw40Cw30Fdi25At5	0	15	5
113	TOC	ICHmw2	110,111,112, 113,114	Sx	23.2	1000	Sx50Fdi45Pw5	4	2500	Hw40Cw30Fdi25At5	0	15	5
114	TOC	ICHmw3	01,02,03,04, 05	Fdi	20.8	1200	Fdi75Sx20Pl5	4	1600	Hw50Cw30Fdi15At5	0	15	5
115	TOC	ICHmw3	06,07,08,09	Fdi	22.4	1000	Fdi50Sx50	4	1600	Hw50Cw30Fdi15At5	0	15	5
116	TCC	ESSFwk1	01,02,03	Pli	19.5	1600	Pli70Sx30	2	300	Bl20Sx35Pli40At5	1	15	5
117	TCC	ESSFwk1	01,02,03	Sx	16.8	1600	Sx90Pli10	2	300	Bl45Sx35Pli15At5	1	15	5
118	TCC	ESSFwk1	04,05,06,07	Sx	18.7	800	Sx60Pli40	2	100	Bl35Sx35Pli25At5	1	15	5
119	TCC	ESSFwc3	all	Sx	15.7	1600	Sx85Pli15	2	500	Bl55Sx25Pli15At5	1	15	5
120	TCC	SBSwk1	01,02,03,04, 05	Pli	20.7	1600	Pli70Sx20Fdi10	2	1500	Pli60Bl10Sx20At10	1	15	5
121	TCC	SBSwk1	01,02,03,04, 05	Sx	21.6	1600	Sx85Pli10Fdi5	2	1500	Sx50Bl25Pli15At10	1	15	5

AU	BA	BGC Variant	Site Series	Leading Species	SI	Planted Density (sph)	Species Comp	Regen Delay	Ingress Density (sph)	Ingress Species Comp	Ingress Delay	OAF1	OAF2
122	TCC	SBSwk1	06,07,08,09, 10, 11	Sx	21.4	950	Sx60Pli40	2	600	Sx40Pli30Bl20At10	1	15	5
123	TCC	SBSmh	all	Pli	22.4	1600	Pli60Sx25Fdi15	2	2600	Pli60Bl5Sx25At10	1	15	5
124	TCC	SBSmw	01,02,03,04	Pli	22.3	1600	Pli60Sx30Fdi10	2	2600	Pli60Bl5Sx25At10	1	15	5
125	TCC	SBSmw	05,06,07,08, 09,10	Sx	21.8	950	Sx60Pli40	2	800	Sx50Pli35Bl5At10	1	15	5
126	TSK	CWHvm1/vm2	01,03,04,05		23.9	0			6000	Hw55Ba25Cw10Ss10	1	15	5
127	TSK	CWHvm1	06,07,08,09, 10,11,12,13,1 4	Ba	27	1200	Ba40Cw10Ss30Hw20	2	5000	Hw70Ba30	1	15	5
128	TSK	CWHws1	01,04		21.4	0			5000	Hw55Ba35Cw5Ss5	1	15	5
129	TSK	CWHws1	02,03		21.9	0			5000	Hw55Ba35Cw5Ss5	1	15	5
130	TSK	CWHws1	05,06,07,08, 09,10,11	Ba	25.3	1230	Ba50Hw30Cw10Sx10	2	4000	Hw50Ba50	1	15	5
131	TSK	CWHws2	01,02, 03, 04		22.8	0			5400	Ba45Hw45Sx5Cw5	1	15	5
132	TSK	CWHws2	05,06,07,08, 09,10,11	Ba	23.2	1240	Ba45Hw40Cw10Sx5	2	4400	Ba55Hw45	1	15	5
133	TSK	MHmm1/2	all		19.9	0			4000	Ba50Hm25Hw25	1	15	5

Genetic gain = 0

Table 59: Regeneration assumptions for plantations established between 1996 and 2016

AU	BA	BGC Variant	Site Series	Leading Species	SI	Planted Density (sph)	Species Comp	Regen Delay	Ingress Density (sph)	Species Comp	Ingress Delay	OAF1	OAF2
51	TKO	ESSFwh1/mh	101,102,103, 104,105	Sx	18.3	1200	Sx65Pli20Fdi10Lw5	2	2210	Bl65Pli35	0	15	5
52	TKO	ESSFwh1/mh	110,111,111, 112,113	Sx	19.5	1200	Sx65Pli25Bl10	2	2000	Bl70Pli30	0	15	5
53	TKO	ESSFwc4/wc w/dc1/dcw	101,102,103, 104,105	Sx	16.1	1400	Sx60Pli25Bl10Cw5	2	2155	Bl70Pli30	0	15	5
54	TKO	ESSFwc4/wc w/dc1/dcw	110,111,111, 112,113	Sx	16.6	1200	Sx60Pli25Bl10Cw5	2	1950	Bl75Pli25	0	15	5
55	TKO	ICHwk1/vk1	101,104	Sx	22.5	1500	Sx40Cw25Fdi25Pw5Lw5	2	1120	Hw75Fdi20At5	0	15	5
56	TKO	ICHwk1/vk1	102,103	Fdi	22.8	1500	Fdi40Cw30Sx25Pw5	2	1500	Hw70Fdi15Lw10At5	0	15	5
57	TKO	ICHwk1/vk1	110,111,112, 113,Fm02, Fm04	Cw	19.8	1400	Cw40Sx30Fdi25Pw5	2	800	Hw70Fdi15Lw10At5	0	15	5
58	TKO	ICHmw2/mw5 /dw1	101,102,103, 104,105	Fdi	22.1	1330	Fdi30Pli20Lw20Pw20Sx1 0	2	2630	Pli35Fdi25Hw20Cw15At5	0	15	5
59	TKO	ICHmw2/mw5 /dw1	110,111,111, 112,113,114, Fm01,Fm02, Fm04	Sx	24	1330	Sx30Fdi20Pli20Lw20Pw1 0	2	2630	Pli25Fdi25Hw25Cw20At5	0	15	5
60	TOC	ESSFwh1	all	Sx	18.6	1400	Sx90Cw7Bl3	2	2000	Bl50Sx30Hw20	0	15	5
61	TOC	ESSFwc4	all	Sx	16	1400	Sx90Bl10	2	2155	Bl50Sx50	0	15	5
62	TOC	ICHwk1/vk1	101,102,103, 104	Fdi	24	1500	Fdi35Cw30Sx25Pw10	2	1120	Hw45Sx25Cw25At5	0	15	5
63	TOC	ICHwk1/vk1	110,111,112, 113,Fm02, Fm04	Cw	20.4	1400	Cw35Sx30Fdi25Pw10	2	800	Hw45Cw35Sx15At5	0	15	5
64	TOC	ICHmw2	101,102,103, 104	Fdi	22.8	1500	Fdi60Lw20Pw15Cw5	2	2450	Hw40Fdi30Cw25At5	0	15	5
65	TOC	ICHmw2	110,111,112, 113,114	Cw	19.5	1500	Cw30Fdi30Lw20Sx10Pw1 0	2	2450	Hw40Cw30Fdi25At5	0	15	5
66	TOC	ICHmw3	01,02,03,04, 05	Fdi	21	1500	Fdi60Cw20Pw10Sx5Lw5	2	1400	Hw50Cw30Fdi15At5	0	15	5
67	TOC	ICHmw3	06,07,08,09	Fdi	22.1	1500	Fdi40Cw45Sx10Pw5	2	1400	Hw50Cw30Fdi15At5	0	15	5
68	TCC	ESSFwk1	01,02,03	Sx	17	1800	Sx80Pli20	2	825	Bl55Pli40At5	1	15	5
69	TCC	ESSFwk1	04,05,06,07	Sx	16.9	1200	Sx60Pli40	2	600	Bl55Sx20Pli20At5	1	15	5
70	TCC	ESSFwc3	01,02	Sx	16	1800	Sx95Bl5	2	1025	Bl75Pli20At5	1	15	5
71	TCC	SBSwk1	01,02,03,04, 05	Sx	21.1	1750	Sx55Pli45	2	3850	Pli60Bl25At5Fdi10	1	15	5
72	TCC	SBSwk1	06,07,08,09, 10,11	Sx	21.5	1400	Sx60Pli40	2	1000	Sx45Pli30Bl20At5	1	15	5

AU	BA	BGC Variant	Site Series	Leading Species	SI	Planted Density (sph)	Species Comp	Regen Delay	Ingress Density (sph)	Species Comp	Ingress Delay	OAF1	OAF2
73	TCC	SBSmh	all	Pli	22.4	1700	Pli60Sx35Fdi5	2	6700	Pl55At10Sx20Fd10Bl5	1	15	5
74	TCC	SBSmw	01,02,03,04	Pli	22.4	1700	Pli60Sx35Fdi5	2	6700	Pl55At10Sx20Fd10Bl5	1	15	5
75	TCC	SBSmw	05,06,07,08, 09,10	Pli	22.5	1400	Pli60Sx40	2	1500	Sx50Pli35Bl5At10	1	15	5
76	TSK	CWHvm1/ vm2	all		24	0		2	6000	Hw60Ba30Cw5Ss5	1	15	5
77	TSK	CWHws1	01,04,05,06, 07,08, 09,10,11		21.2	0		2	5200	Hw45Ba45Cw5Ss5	1	15	5
78	TSK	CWHws1	02,03		21.4	0		2	5200	Hw45Ba45Cw5Ss5	1	15	5
79	TSK	CWHws2	all		22.1	0		2	5800	Ba45Hw45Cw5Ss5	1	15	5
80	TSK	MHmm1/2	all		19.7	0		2	4000	Ba50Hm25Hw25	1	15	5

Genetic Gain, see Section 8.4.3, Table 61

Table 60: Regeneration assumptions for future managed stands

AU	BA	BGC Variant	Site Series	Leading Species	SI	Planted Density (sph)	Species Comp	Regen Delay	Ingress Density (sph)	Species Comp	Ingress Delay	OAF1	OAF2
1	TKO	ESSFwh1/mh	101,102,103, 104,105	Sx	18.7	1200	Sx65Pli20Fdi10Lw5	2	2210	Bl65Pli35	0	15	5
2	TKO	ESSFwh1/mh	110,111,111, 112,113	Sx	19.6	1200	Sx65Pli25Bl10	2	2000	Bl70Pli30	0	15	5
3	TKO	ESSFwc4/wcw /dc1/dcw	101,102,103, 104,105	Sx	16.1	1400	Sx60Pli25Bl10Cw5	2	2155	Bl70Pli30	0	15	5
4	TKO	ESSFwc4/wcw /dc1/dcw	110,111,111, 112,113	Sx	17	1200	Sx60Pli25Bl10Cw5	2	1950	Bl75Pli25	0	15	5
5	TKO	ICHwk1/vk1	101,104	Sx	22.6	1500	Sx40Cw25Fdi25Pw5Lw5	2	1120	Hw75Fdi20At5	0	15	5
6	TKO	ICHwk1/vk1	102,103	Fdi	23.6	1500	Fdi40Cw30Sx25Pw5	2	1500	Hw70Fdi15Lw10At5	0	15	5
7	TKO	ICHwk1/vk1	110,111,112, 113,Fm02, Fm04	Cw	20.4	1400	Cw40Sx30Fdi25Pw5	2	800	Hw70Fdi15Lw10At5	0	15	5
8	TKO	ICHmw2/mw5/ dw1	101,102,103, 104,105	Fdi	22.1	1330	Fdi30Pli20Lw20Pw20 Sx10	2	2630	Pli35Fdi25Hw20Cw15At5	0	15	5
9	TKO	ICHmw2/mw5/ dw1	110,111,111, 112,113,114, Fm01,Fm02, Fm04	Sx	24.1	1330	Sx30Fdi20Pli20Lw20Pw10	2	2630	Pli25Fdi25Hw25Cw20At5	0	15	5
10	TOC	ESSFwh1	101,102,103, 104	Sx	19	1400	Sx90Cw7Bl3	2	2000	Bl50Sx30Hw20	0	15	5
11	TOC	ESSFwh1	110,111	Sx	19.7	1400	Sx90Cw10	2	1800	Bl50Sx30Hw20	0	15	5
12	TOC	ESSFwc4	101,102,103	Sx	16.3	1400	Sx90Bl10	2	2155	Bl50Sx50	0	15	5
13	TOC	ESSFwc4	110,111,112	Sx	16.3	1400	Sx90Bl10	2	1750	Bl60Sx40	0	15	5
14	TOC	ICHwk1/vk1	101,104	Fdi	24	1500	Fdi35Cw30Sx25Pw10	2	1120	Hw45Sx25Cw25At5	0	15	5
15	TOC	ICHwk1/vk1	102,103	Fdi	23.5	1500	Fdi45Cw25Sx20Pw10	2	1500	Hw40Fdi20Cw20Sx15At5	0	15	5
16	TOC	ICHwk1/vk1	110,111,112, 113,Fm02, Fm04	Cw	20.2	1400	Cw35Sx30Fdi25Pw10	2	800	Hw45Cw35Sx15At5	0	15	5
17	TOC	ICHmw2	101,102,103, 104	Fdi	22.8	1500	Fdi60Lw20Pw15Cw5	2	2450	Hw40Fdi30Cw25At5	0	15	5
18	TOC	ICHmw2	110,111,112, 113,114	Cw	19.4	1500	Cw30Fdi30Lw20Sx10 Pw10	2	2450	Hw40Cw30Fdi25At5	0	15	5
19	TOC	ICHmw3	01,02,03,04,05	Fdi	20.8	1500	Fdi60Cw20Pw10Sx5Lw5	2	1400	Hw50Cw30Fdi15At5	0	15	5
20	TOC	ICHmw3	06,07,08,09	Fdi	22.3	1500	Fdi40Cw45Sx10Pw5	2	1400	Hw50Cw30Fdi15At5	0	15	5
21	TCC	ESSFwk1	01,02,03	Sx	16.8	1800	Sx80Pli20	3	825	Bl55Pli40At5	1	15	5
22	TCC	ESSFwk1	04,05,06,07	Sx	17.3	1200	Sx60Pli40	3	600	Bl55Sx20Pli20At5	1	15	5

AU	BA	BGC Variant	Site Series	Leading Species	SI	Planted Density (sph)	Species Comp	Regen Delay	Ingress Density (sph)	Species Comp	Ingress Delay	OAF1	OAF2
23	TCC	ESSFwc3	01,02	Sx	15.5	1800	Sx95Bl5	2	1025	Bl75Pli20At5	1	15	5
24	TCC	ESSFwc3	03	Sx	15.8	1200	Sx60Pli40	2	800	Bl70Sx15Pli10At5	1	15	5
25	TCC	SBSwk1	01,02,03,04,05	Sx	21.4	1750	Sx55Pli45	3	3850	Pli60Bl25At5Fdi10	1	15	5
26	TCC	SBSwk1	06,07,08,09,10, 11	Sx	21.4	1400	Sx60Pli40	3	1000	Sx45Pli30Bl20At5	1	15	5
27	TCC	SBSmh	01,02,03,04,05	Pli	22.3	1700	Pli60Sx35Fdi5	3	6700	Pl55At10Sx20Fd10Bl5	1	15	5
28	TCC	SBSmh	06,07,08,09	Pli	22.4	1400	Pli60Sx40	3	1500	Sx50Pli35Bl5At10	1	15	5
29	TCC	SBSmw	01,02,03,04	Pli	22	1700	Pli60Sx35Fdi5	3	6700	Pl55At10Sx20Fd10Bl5	1	15	5
30	TCC	SBSmw	05,06,07,08,09, 10	Pli	22	1400	Pli60Sx40	3	1500	Sx50Pli35Bl5At10	1	15	5
31	TSK	CWHvm1	01,05		24	0		2	6000	Hw60Ba30Cw5Ss5	1	15	5
32	TSK	CWHvm1	03,04		23.9	0		2	6000	Hw60Ba30Cw5Ss5	1	15	5
33	TSK	CWHvm1	06,07,08,09,10, 11,12,13,14	Ba	27	1000	Ba30Cw35Ss30Hw5	2	5000	Hw70Ba30	1	15	5
34	TSK	CWHws1	01,04		21.6	0		2	5200	Hw45Ba45Cw5Ss5	1	15	5
35	TSK	CWHws1	02,03		21.9	0		2	5200	Hw45Ba45Cw5Ss5	1	15	5
36	TSK	CWHws1	05,06,07,08,09, 10,11	Ba	27	830	Ba50Hw30Cw10Sx10	2	4200	Hw50Ba50	1	15	5
37	TSK	CWHvm2	01,02,03,04,05, 06, 08		22.2	0		2	6200	Hw55Ba20Cw15Ss8Dr2	1	15	5
38	TSK	CWHws2	01,04		22.1	0		2	5800	Ba45Hw45Cw5Ss5	1	15	5
39	TSK	CWHws2	02,03		21.1	0		2	5800	Ba45Hw45Cw5Ss5	1	15	5
40	TSK	CWHws2	05,06,07,08,09, 10,11	Ba	22.9	940	Ba45Hw40Cw10Sx5	2	4800	Ba50Hw50	1	15	5
41	TSK	MHmm1/2	01,03		19.8	0		2	4000	Ba50Hm25Hw25	1	15	5
42	TSK	MHmm1/2	02		19.6	0		2	4000	Ba50Hm25Hw25	1	15	5
43	TSK	MHmm1/2	04,05,06,07,08, 09	Ba	19.2	800	Ba100	2	3000	Ba40Hm30Hw30	1	15	5

Genetic Gain; see Section 8.4.3, Table 62.

8.4.3 Genetic Gain

Where available, class A seed from seed orchards is used for regeneration due to its advanced volume production. Genetic gain was applied to some yield curves of existing (Era 2) and future (Era 3) managed stands in TCC, TOC and TKO. No genetic gain was applied to older existing managed stands (Era 1) and any stand in TSK for any era.

For Era 2 (1996 to 2016) available RESULTS data was used to calculate the proportion of trees planted from genetically improved seed (class A) and the genetic gain for each seedlot was used to estimate the weighted average genetic worth for each species for each BEC variant. For the period of 1996 to 2002 RESULTS data does not include genetic worth and it was assumed that trees planted during this period had 0 genetic worth.

The weighted average genetic gain for each species and BEC variant for Era 2 are shown in Table 61.

Table 61: Genetic gain for existing managed stands established between 1996 and 2016

Business Areat	BEC Variant	Species	Weighted Average Genetic Gain (%)
TCC	ESSFwk1	Sx	15.3
TCC	ESSFwk1	Pli	5.3
TCC	SBSwk1	Sx	23.5
TCC	SBSwk1	Pli	5.9
TCC	SBSmh	Sx	5.5
TCC	SBSmw	Pli	4.1
TCC	SBSmw	Sx	21.7
TCC	SBSmw	Fdi	16.7
TKO/TOC	ESSFwh1/mh	Sx	13.6
TKO/TOC	ESSFwh1/mh	Pli	1.5
TKO/TOC	ESSFwh1/mh	Fdi	16.1
TKO/TOC	ESSFwh1/mh	Lw	23.3
TKO/TOC	ICHwk1/vk1	Sx	11.2
TKO/TOC	ICHwk1/vk1	Fdi	8.4
TKO/TOC	ICHwk1/vk1	Lw	18.8
TKO/TOC	ICHmw2/mw5/dw1	Fdi	10.6
TKO/TOC	ICHmw2/mw5/dw1	Sx	13.2
TKO/TOC	ICHmw2/mw5/dw1	Pli	6.0
TKO/TOC	ICHmw2/mw5/dw1	Lw	18.4

The same approach was used to estimate the genetic gain for future managed stands (Era 3). The genetic gain data and planting information from 2013 to 2015 was assumed to predict future genetic gains. The genetic gains applied in the analysis to future managed stands are shown in Table 62.

Table 62: Genetic gain for future managed stands (2017 forward)

Business Area	BEC Variant	Species	Weighted Average Genetic Gain (%)
TCC	ESSFwk1	Sx	15.3
TCC	ESSFwk1	Pli	5.3
TCC	SBSwk1	Sx	23.5
TCC	SBSwk1	Pli	5.9
TCC	SBSmh	Sx	5.5
TCC	SBSmw	Pli	4.1
TCC	SBSmw	Sx	21.7
TCC	SBSmw	Fdi	16.7
TKO/TOC	ESSFwh1/mh	Sx	13.4
TKO/TOC	ESSFwh1/mh	Pli	0
TKO/TOC	ESSFwh1/mh	Fdi	33.4
TKO/TOC	ESSFwh1/mh	Lw	22.6
TKO/TOC	ICHwk1/vk1	Sx	15.8
TKO/TOC	ICHwk1/vk1	Fdi	26.6
TKO/TOC	ICHwk1/vk1	Lw	26.5
TKO/TOC	ICHmw2/mw5/dw1	Fdi	23.9
TKO/TOC	ICHmw2/mw5/dw1	Sx	18.4
TKO/TOC	ICHmw2/mw5/dw1	Pli	9.6
TKO/TOC	ICHmw2/mw5/dw1	Lw	19.2

8.4.4 Regeneration Delay and Ingress Delay

Regeneration delays for planting and natural ingress (ingress delay) were applied to all managed stand yield curves based on RESULTS data and input from BCTS staff.

Ingress delay (0 or 1 in this analysis), as utilized in TASS, indicates the number of years since harvest before the first naturally regenerated trees arrive on site. For an ingress delay of 0, it is assumed that 4% of the naturally regenerated seedlings occupy the site during the first year, while the rest of the seedlings enter the site over a period of 8 years. For an ingress period of 1, all the seedlings are assumed to occupy the site in 9 years.

There are analysis units in the Cascadia TSA that generally contain significant components of natural infill of Hw, Ba and At. As some of this natural infill is advanced regeneration, it was considered reasonable to assume that 4% or more of the infill will be on site at the end of the first season after harvest.

8.4.5 Not satisfactorily restocked (NSR) areas

In this analysis all NSR is considered current. It is assumed to regenerate within the regeneration delays detailed under Section 8.4.4.

8.4.6 Fertilized, Pruned and Spaced Areas

Based on a review of RESULTS data and input from BCTS staff no allowances will be made in the yield curves to account for past or future incremental silviculture such as fertilization and juvenile spacing.

9 List of Acronyms

Acronym	Description
AAC	Annual Allowable Cut
AIP	Agreement in Principal
BA	Business Area
BCGW	BC Geographic Warehouse
BCTS	BC Timber Sales
BEC	Biogeoclimatic Ecosystem Classification
BEO	Biodiversity Emphasis Option
CCLUP	Cariboo-Chilcotin Land Use Plan
CFLB	Crown Forested Land Base
DBH	Diameter at Breast Height
DEM	Digital Elevation Model
DIB	Diameter inside bark
DKM	Coast Mountains Natural Resource District
DQU	Quesnel Natural Resource District
DSE	Selkirk Natural Resource District
ECA	Equivalent Clearcut Area
EXLB	Excluded Land Base
FAIB	Forest Analysis and Inventory Branch, Ministry of Forests, Lands, Natural Resource Operations and Rural Development
FC1	Former Forest Cover Inventory Standard
FESL	Forest Ecosystem Solutions Ltd.
FLNRORD	Ministry of Forests, Lands, Natural Resource Operations, and Rural Development
FMLB	Forest Management Land Base
FPPR	Forest Planning and Practices Regulation
FRPA	Forests and Range Practices Act
FSOS	Forest Simulation and Optimization System (model used for analysis)
FSP	Forest Stewardship Plan
FWA	Freshwater Atlas
GAR	Government Action Regulation
GBRO	Great Bear Rainforest Order (EBM)
GIS	Geographic Information Systems
HR	Hydrological Recovery
IRM	Integrated Resource Management
KBHLPO	Kootenay-Boundary Higher Level Plan Order
KSRMP	Kalum Sustainable Resource Management Plan
LEFI	LiDAR Enhanced Forest Inventory
LiDAR	Light Detection and Ranging
LRMP	Land and Resource Management Plan
LU	Landscape Unit
MAMU	Marbled Murrelet

Acronym	Description
MHA	Minimum Harvest Age
MPB	Mountain Pine Beetle
MSYT	Managed Stand Yield Table
NHLB	Non-Harvesting Land Base
NRL	Non-recoverable Losses
NSR	Not Sufficiently Restocked
NSYT	Natural Stand Yield Table
OAF	Operational Adjustment Factor
OGMA	Old Growth Management Area
PEM	Predictive Ecosystem Mapping
POD	Point of Diversion
PSP	Permanent Sample Plot
RHLPO	Revelstoke Higher Level Plan Order
RMA	Riparian Management Area
RMZ	Riparian Management Zone
RRZ	Riparian Reserve Zone
RSTBC	Recreation Sites and Trails BC
SIBEC	Site Index by BEC Site Series
SOP	Standard Operating Procedure
SRMP	Sustainable Resource Management Plan
TASS	Tree and Stand Simulator
TCC	BCTS Cariboo-Chilcotin Business Area
TEM	Terrestrial Ecosystem Mapping
TFL	Tree Farm License
THLB	Timber Harvesting Land Base
TIPSY	Table Interpolation for Stand Yields
TKO	BCTS Kootenay Business Area
TSA	Timber Supply Area or Timber Supply Analysis
TOC	BCTS Okanagan-Columbia Business Area
TRIM	Terrain Resource Information Management
TSK	BCTS Skeena Business Area
TSM	Terrain Stability Mapping
TSR	Timber Supply Review
UWR	Ungulate Winter Range
VAC	Visual Absorption Capability
VDYP	Variable Density Yield Projection
VEG	Visually Effective Green-up
VRI	Vegetation Resource Inventory
VQO	Visual Quality Objective
WHA	Wildlife Habitat Area
WTRA	Wildlife Tree Retention Area

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Appendix 1 – Yield Tables

In the following tables, the column headings are the analysis unit numbers.

Table 63: Managed stands established between 1976 and 1995

Table 64: Managed stands established between 1996 and 2016

Table 65: Managed stands established after 2016

Appendix 2 – Cascadia TSA LiDAR Inventory Update 2018

Cascadia TSA LiDAR Inventory Update 2018

By Christopher Butson

Version 3 April 12th, 2018

1.0 Introduction

Forest Analysis & Inventory Branch (FAIB) was tasked with updating the forest inventory covering four different business areas in the Cascadia Timber Supply Area (TSA). BC Timber Sales (BCTS) recently acquired LiDAR data for the business areas and require the inventory updates for the Timber Supply Review (TSR) process. FAIB are currently using LiDAR to update forest inventory information across the province in high priority forests. Through a hierarchical process the cell-based predictions were first created for the LiDAR data captured in each business area. Next, these LiDAR predictions were compared to variable radius ground (cruise) plots. Provided that the LiDAR predictions reflect the same magnitude and variation that was measured on the ground through the cruise plots, it is generally accepted that the cell-based LiDAR predictions can be used to update the provincial standard Vegetation Resources Inventory (VRI) database. If however, some or all of the LiDAR predictions do not show a strong positive correlation to the actual ground measurements then the LiDAR models would need to be revisited and the LEFI layers should not be used to update the VRI. In this particular case, the cell-based predictions of basal area, DBH, lorey height, gross volume and net volume did not perform very well but average height and top height did perform well. The recommendation based on these analyses performed to date was to update only the VRI stand heights using the cell-based LiDAR predictions for inventory update prior to the TSR. For the VRI stand height update, the 80^{th} percentile of the polygon height was used as the best estimate of height. Once the modelled stand height was calculated a subset of the data was extracted based on the RMSE calculated for that linear model. In TSK, an RMSE= +/- 6.82m resulted in the update of 1884 VRI polygons. In TOC, an RMSE=+/-5.8m resulted in the update of 2179 VRI polygons. In TKO, an RMSE=+/-5.9m resulted in the update of 1672 VRI polygons. Lastly, in TCC an RMSE=+/-5.61m resulted in the update of 3085 VRI polygons. The impact of these updates on stand volume will be presented as an addendum to this document.

2.0 Objectives

The primary objective of this work is to process the available LiDAR data for four BCTS business areas into LEFI cell-based predictions of forest inventory attributes. Once these layers were created, a hierarchical process was used;

1. To evaluate these LiDAR cell-based predictions of forest inventory attributes using variable radius ground plots and,
2. If 1 was successful, apply these cell-based predictions to the existing VRI polygons to generate a new LEFI inventory Tier 2 product. If unsuccessful, report on process, results and future recommendations.

3.0 Study Areas

Four business areas were considered for LiDAR enhanced forest inventory updates all located in the Cascadia Timber Supply Area (TSA), an area encompassing approximately 496,000 hectares. The business areas are highlighted in Figure 1. LiDAR data was captured for approximately 290,000 hectares of the TSA from 2013-2016.

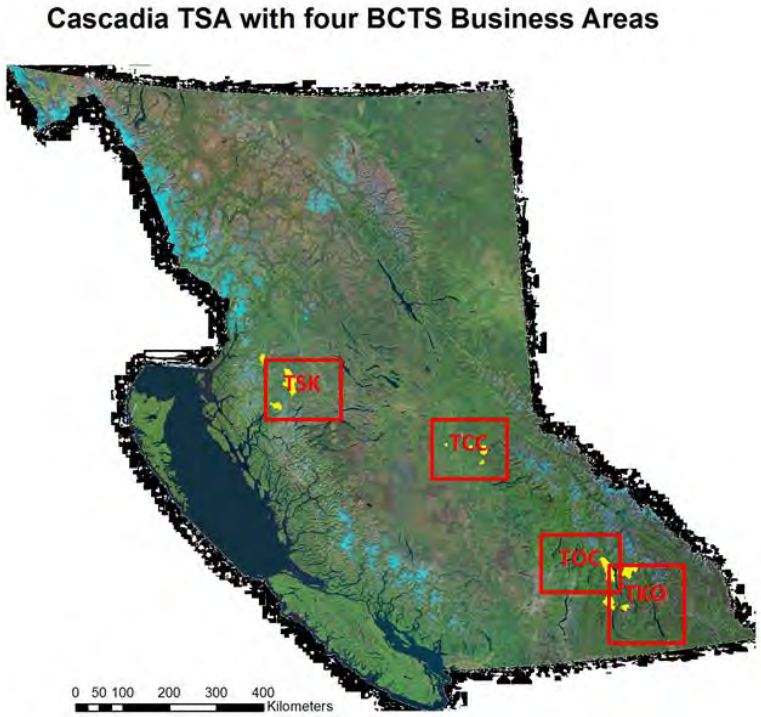

Figure 1 - Cascadia TSA overview with four business areas identified. TSK – Skeen, TCC- Cariboo-Chilcotin, TKO – Kootenay and, TOC- Okanagan-Columbia.

3.1 TSK- Skeena Business Area

The Skeena Business Area of BC Timber Sales geographically encompasses the Kalum, Skeena Stikine (portions formerly Kispiox and Cassiar) and North Coast forest districts. The area of interest for the LiDAR forest inventory update was the Copper River basin show in in Figure 2 covering an area of approximately 70,000 hectares.

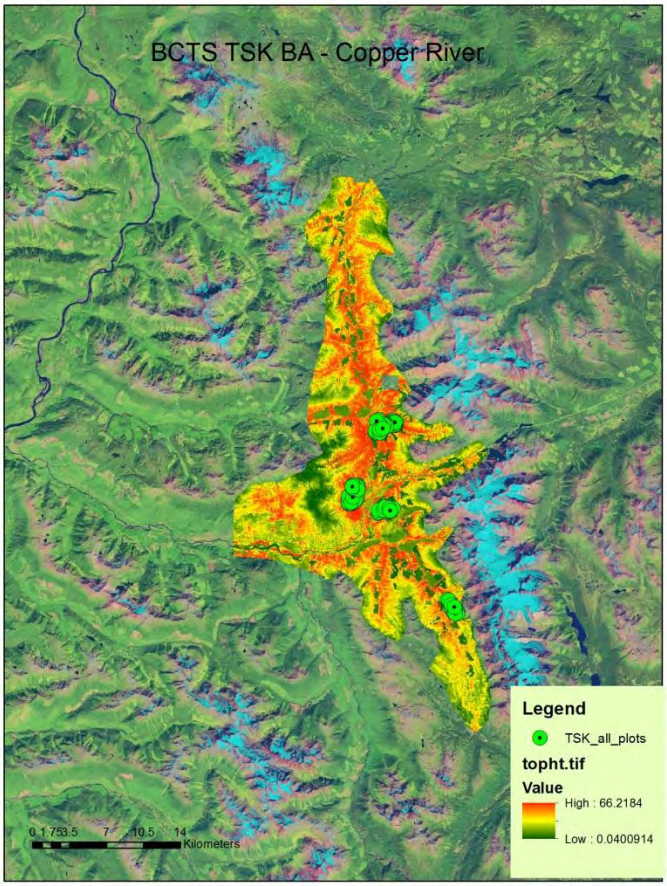

Figure 2 - Skeena area Copper River Basin showing LiDAR coverage and validation cruise plot locations (138 plots).

3.2 TCC –Cariboo Chilcotin Business Area

The Cariboo-Chilcotin Business Area of BC Timber Sales geographically encompasses the Central Cariboo, Chilcotin and Quesnel forest districts. The area of interest for the LiDAR forest inventory update was located in east Quesnel TSA show in in Figure 3 covering an area of approximately 32,000 hectares.

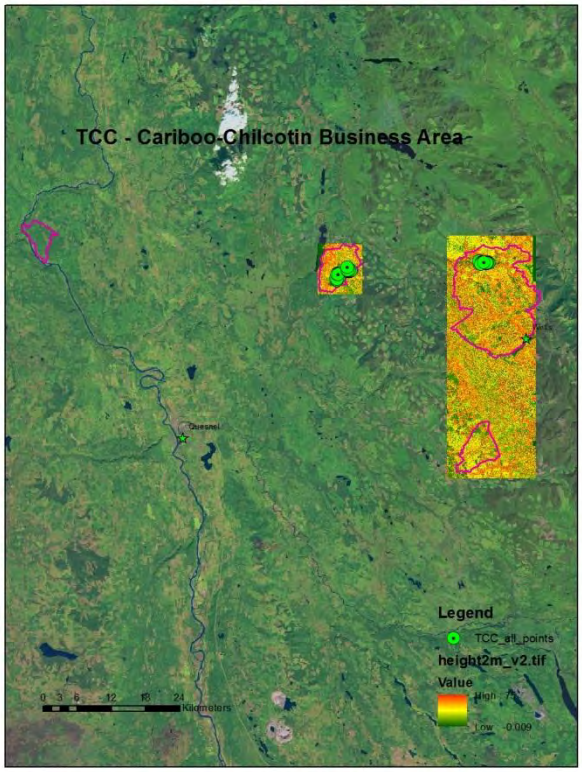

Figure 3 – TCC LiDAR forest inventory update was located in east Quesnel TSA.

3.3 TKO- Kootenay Business Area

TKO Kootenay Business Area of BC Timber Sales geographically encompasses the Arrow Boundary, Kootenay Lake and Rocky Mountain forest districts. The area of interest for the LiDAR forest inventory update was located surrounding Trout Lake in Figure 4 and southern areas including Barnes Creek, Whatshan and Burton. These areas combine to cover an area of approximately 100,000 hectares.

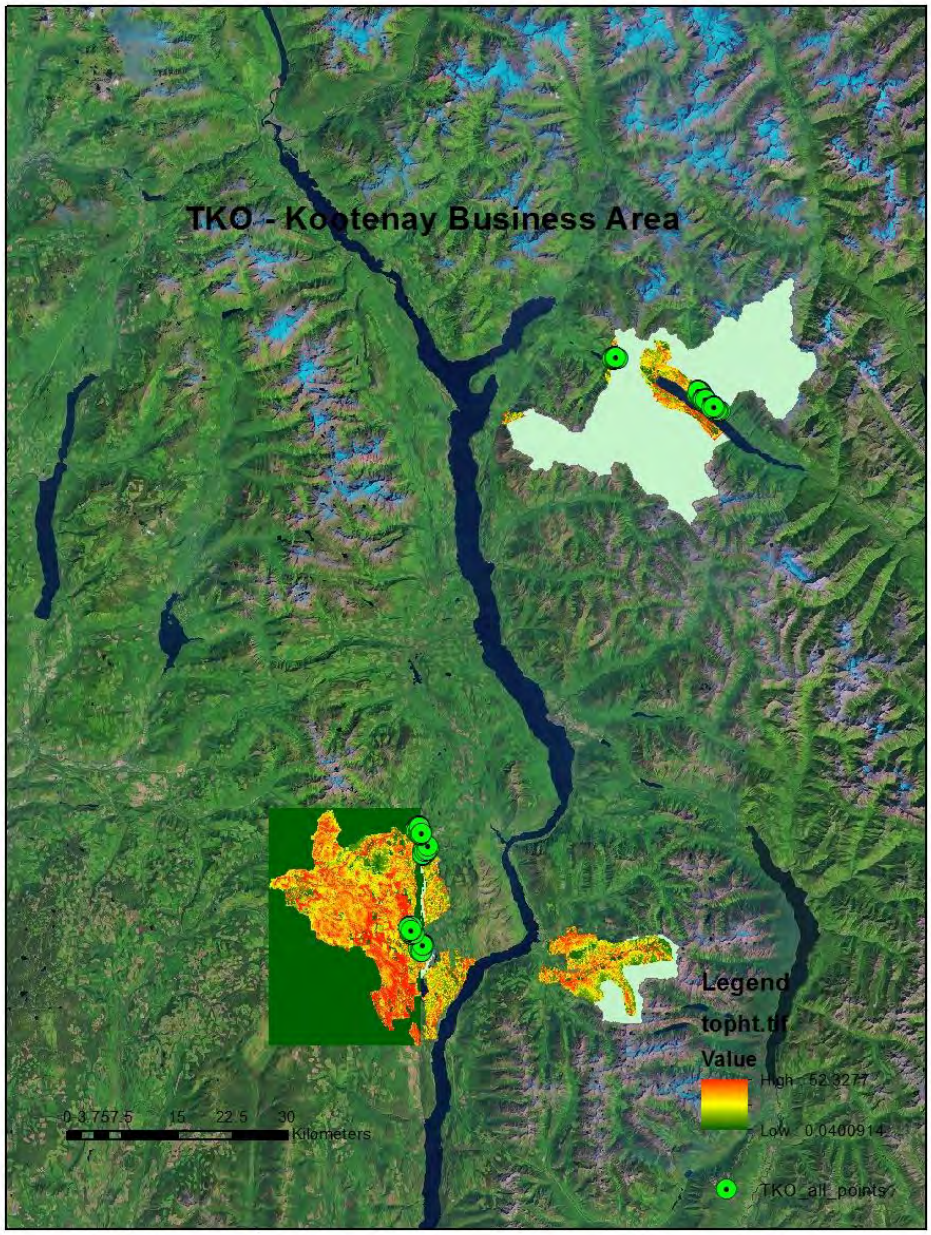

Figure 4 – BCTS Kootenay locations for LiDAR inventory update with 191 cruise plots. Note some of the mountain areas are not included as they are under a no-harvest order for Mountain Caribou.

3.4 TOC – Okanagan Columbia Business Area

TOC Okanagan Columbia Business Area of BC Timber Sales which geographically encompasses the Okanagan-Shuswap and Columbia forest districts. The area of interest for the LiDAR forest inventory update was located west of Arrow Lake in Figure 5 covering an area of approximately 74,000 hectares.

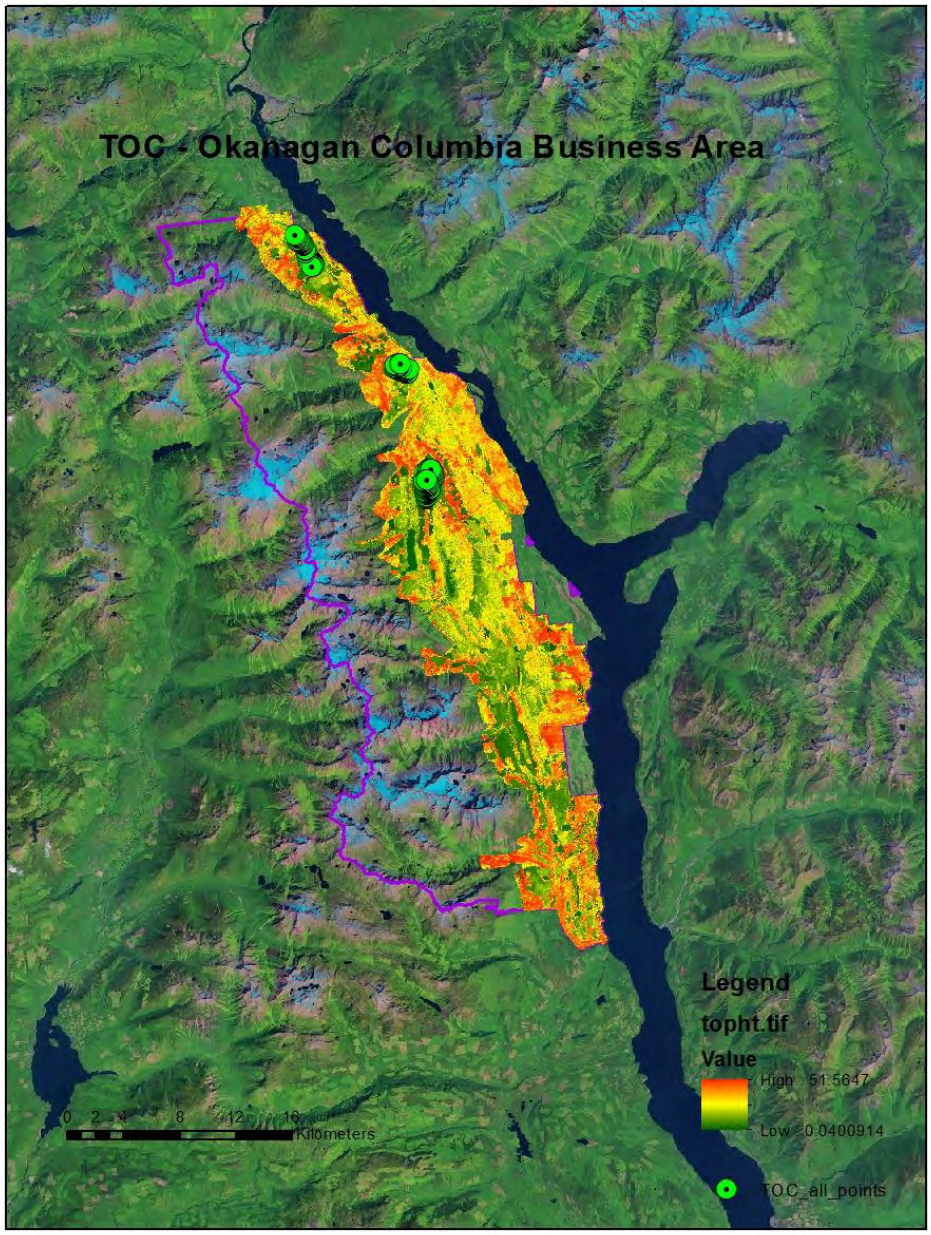

Figure 5 – BCTS Okanagan Columbia locations for LiDAR inventory update with 163 cruise plots.

4.0 Methods

The point cloud was normalized to remove the ground information. Next a LiDAR Canopy Height Model (CHM) at 1-2m spatial resolution was generated using a threshold height >3m. LiDAR metrics (i.e. p80 – 80th percentile of height) were then extracted from the normalized point cloud and our in-house models

were applied. These models were derived from a similar LiDAR project in the same relative location (Kamloops/Okanagan TSAs in 2015) and allow us to create cell based predictions (at 25m) of basal area, DBH, lorey height, top height, gross volume and net volume.

To validate the LiDAR cell-based predictions, cruise plot data was summarized to compare each of the inventory attributes which yielded summary statistics describing these comparisons for each BCTS business area. By evaluating r^2 and rmse calculations assumptions were then made as to the quality of the EFI layers. As a second evaluation, these EFI layers were summarized to the existing VRI polygons and stand level comparisons of these predictions were plotted against the VRI attributes. The following section describes the analysis and results for each of the four business areas under investigation.

5.0 Results

Validation comparisons were done between cruise plot level inventory attributes and the LiDAR-derived EFI inventory layers for:

1) Average Height,
2) Top Height,
3) Basal Area
4) Average DBH
5) Gross volume and,
6) Net volume

The results of this validation exercise are presented in the following tables and Figure 6 below. When the LiDAR inventory models were transferred to the TSK business areas as expected, forest inventory attribute models related to tree height performed best when compared to the cruise plots. As shown in Table 1, **top height** showed a strong positive correlation with R-square value equal to 0.93. The scatterplots (Figure 6) for these comparisons all show linear trends around the 1:1 blue line. **Basal area , gross and net volume** models performed quite poorly when compared to the cruise plot information as shown by the scatterplots in Figure 6 and statistics in Table 1.

TSK BCTS 2018

Attribute	r2	rmse	intercept	slope
Basal Area	0.23	31.58	68.47	0.03
Avg. Height	0.81	4.84	17.04	0.46
Top Height	0.93	6.5	13.12	0.551
Avg. DBH	0.69	24.42	22.73	0.25

Gross Vol	0.58	363.18	626.32	0.22
Net Vol	0.23	311.9	620.13	0.04
*Cruise data for 138 locations				

Table 1 – Tabular results for the comparison between cruise plots located in the TSK business area with the LiDAR-derived EFI layers. Average and top height LiDAR predictions (shown in Yellow) performed best across this business area.

TKO BCTS 2018

Attribute	r2	rmse	intercept	slope
Basal Area	0.54	30.03	55.53	0.113
Avg. Height	0.71	4.5	16.11	0.38
Top Height	0.79	5.26	19.06	0.37
Avg. DBH	0.43	12.35	22.62	0.13
Gross Vol	0.68	285.37	477.9	0.24
Net Vol	0.65	251.87	398.82	0.21
*Cruise data for 191 locations				

Table 2 – Tabular results for the comparison between cruise plots located in the TKO business area with the LiDAR-derived EFI layers. Average and top height LiDAR predictions (in Yellow) performed best across this business area.

TOC BCTS 2018				
Attribute	r2	rmse	intercept	slope
Basal Area	0.7	20.88	29.73	0.37
Avg. Height	0.76	4.62	13.48	0.43
Top Height	0.76	6.6	15.09	0.42
Avg. DBH	0.58	16.81	20.03	0.18
Gross Vol	0.81	187.5	203.68	0.55
Net Vol	0.74	167.87	199.97	0.5
*Cruise data for 163 locations				

Table 3– Tabular results for the comparison between cruise plots located in the TOC business area with the LiDAR-derived EFI layers. In this case, gross volume, average and top height LiDAR predictions (in yellow) performed best across this business area.

TCC BCTS 2018				
Attribute	r2	rmse	intercept	slope
Basal Area	0.22	14.87	38.66	0.24
Avg. Height	0.79	2.78	11.588	0.5325
Top Height	0.755	4.37	15.17	0.409
Avg. DBH	0.46	9.97	26.98	0.0809
Gross Vol	0.47	145.02	315.57	0.1512
Net Vol	0.51	112.13	250.51	0.193
*Cruise data for 51 locations				

Table 4– Tabular results for the comparison between cruise plots located in the TCC business area with the LiDAR-derived EFI layers. In this case, average and top height LiDAR predictions (in yellow) performed best across this business area. Note this area had a reduced sample size when compared to the other three business areas.

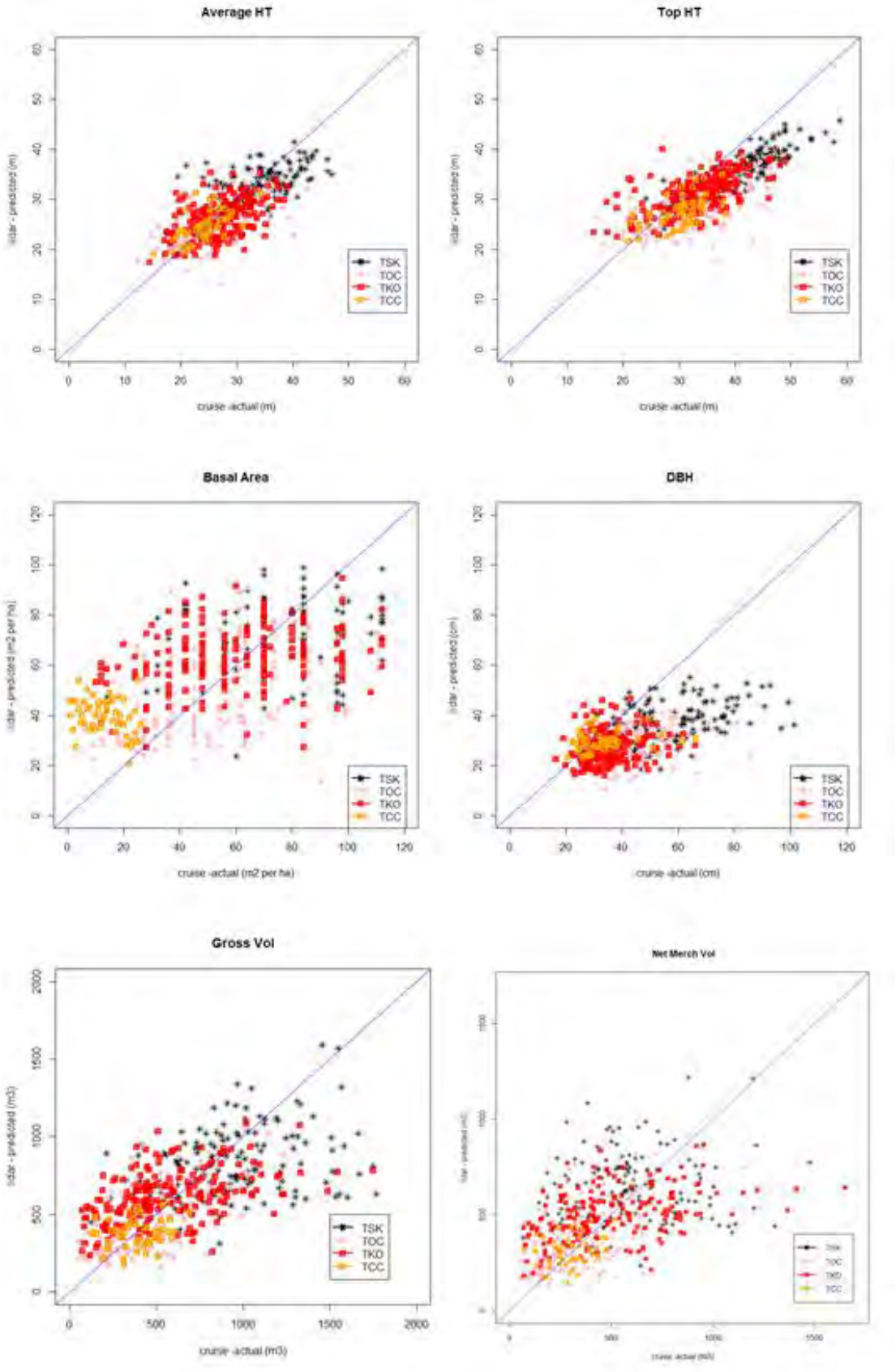
Average HT
Top HT
Basal Area
DBH
Gross Vol
Net Merch Vol
TSK
TOC
TKO
TCC
cruise -actual (m)
cruise -actual (m2 per ha)
cruise -actual (cm)
cruise -actual (m3)

Figure 6 – Scatterplots of cruise vs. LiDAR-predicted forest inventory attributes. Blue line is the 1:1 line.

The results of the TOC business area show similarities to the other business areas previously shown. Forest inventory attribute models related to tree height performed best when compared to the cruise plots. As shown in Table 3, both **top height and average height** showed a strong positive correlation with r^2 value equal to 0.76. The scatterplots (Figure 6) for these comparisons all show linear trends around the 1:1 blue line. **Gross volume** in this case was predicted fairly well with the LiDAR EFI models showing an r^2 equal to 0.81. **Basal area and DBH** models performed quite poorly when compared to the cruise plot information as shown by the scatterplots in Figure 6 and statistics in Table 2.

When the LiDAR inventory models were transferred to the TKO business areas as expected, forest inventory attribute models related to tree height performed best when compared to the cruise plots. As shown in Table 3, both **top height and average height** showed a strong positive correlation with r^2 value equal to 0.71 to 0.79. The scatterplots (Figure 6) for these comparisons all show linear trends around the 1:1 blue line. **Basal area and DBH** models performed modestly when compared to the cruise plot information as shown by the scatterplots in Figure 6 and statistics in Table 3.

Lastly, the LiDAR inventory models were transferred to the TCC business areas as expected based on the other business areas, forest inventory attribute models related to tree height performed best when compared to the cruise plots. As shown in Table 4, both **top height and average height** showed a strong positive correlation with r^2 value equal to 0.755 to 0.79. The scatterplots (Figure 6) for these comparisons all show linear trends around the 1:1 blue line. **Basal area and DBH** models performed poorly in the TCC business area when compared to the cruise plot information as shown by the scatterplots in Figure 6 and statistics in Table 4.

Based on these validation results, it is recommended that the forest inventory attributes relating to stand height could be updated (Stand height) with this new LEFI information whereas different parametric LiDAR models should be considered for updating basal area and average DBH.

6.0 Vegetation Resource Inventory (VRI) Update

This section describes the process used to take the LiDAR inventory output layers and update the information in the Vegetation Resource Inventory (VRI) provincial forest inventory. Since the former data are raster products (attribute grids or cells of spatial data) and the latter is polygonal/vector (1 attribute value per polygon), assumptions and rules are defined in this section to facilitate the overall process.

The rules governing the LiDAR update for VRI stand heights follow a few basic principles:

1. Only stands with BCLCS1='V' (vegetated) and BCLCS2='T' (treed).
2. Only stands over 10m in height based on PROJ_HT1.
3. Only stands containing species 1 taller than all other species in the polygon.

All other polygons not contained in the subset above used the original PROJ_HT1 value.

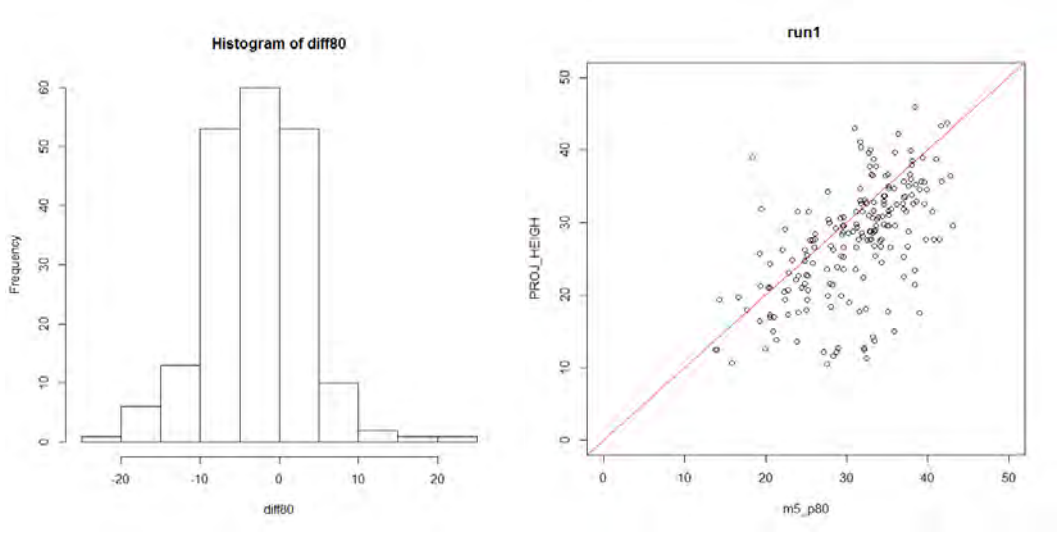

Figure 8 – Difference histogram of VRI PROJ_HT1-LiDAR-derived P80 (left). Scatterplot comparisons of VRI projected stand height (y-axis) versus LiDAR predictions of stand height based on P80 (right). X-axis percentiles in this case (i.e. p80) are the LiDAR raster percentiles summarized over the polygons, so for example p50 is the mean basal area for a particular polygon.

6.1 – VRI update for all business areas

Analysis was performed between the LiDAR-derived summaries of stand heights against the VRI polygons for all business areas. A consideration for stand height VRI updates was made based on minimizing both bias and root-mean-square errors between the LiDAR-derived stand height and VRI PROJ_HT1. Using a sample subset of data (~20%) it was determined in all cases that a linear model as Eq. 1 yielded the best predictions:

$$Y = MX + B \qquad \text{[Eq.1]}$$

Where;

Y= PROJ_HT1

M=slope

X = P80 (Lidar-derived)

B = bias (intercept)

Once the modelled stand height was calculated a subset of the data was extracted based on the RMSE calculated for that linear model. In TSK, an RMSE= +/-6.82m resulted in the update of 1884 VRI polygons. In TOC, an RMSE=+/-5.8m resulted in the update of 2179 VRI polygons. In TKO, an RMSE=+/-

5.9m resulted in the update of 1672 VRI polygons. Lastly, in TCC an RMSE=+/-5.61m resulted in the update of 3085 VRI polygons.

The linear model statistics are presented in Table 4 below.

Business Area	r2	rmse	intercept	slope
TSK	0.78	6.83	7.16	0.67
TKO & TOC	0.78	5.79	4.1	0.78
TCC	0.69	5.9	8.38	0.73

Table 4 – Linear regression statistics applied to adjust VRI stand height for each business area.

Methods to perform the VRI height update for these business areas are listed and described in detail below.

All steps require personal geodatabases created in ARCGIS. The work flow is as follows:

1. Start with original r1_poly MDB containing five blocks: blk9, blk10, blk11, blk1234, blk5678

2. For all blocks, add field "LIDARHT1" and populate with PROJ_HT1 values.

3. Since no LiDAR data was available for blk9 or blk11, copy these two files to OUTPUT_MDB

4. To do VRI HT updates create new update.MDB and copy blk10, blk1234 and blk5678 into this file.

5. Do r work and model HT1 using a linear model of p80 based on Eq.1.

6. Subset these LiDAR updates to +/- 1 RMSE or approximately 6m.

7. Add subsets to update_MDB

8. Use following SQL to update only specific Feature_IDs with new LIDARHT1:

UPDATE blocks10

inner join blk10_rmse_subset on

blocks10.feature_id=blk10_rmse_subset.FEATURE_ID

SET blocks10.LIDARHT1 = blk10_rmse_subset.LIDARHT1

9. Confirm updates are correct and copy output tables to OUTPUT_MDB.

7.0 Summary

Forest Analysis & Inventory Branch (FAIB) was tasked with updating the forest inventory covering four different business areas in the Cascadia Timber Supply Area (TSA). BC Timber Sales (BCTS) recently acquired LiDAR data for the business areas and require the inventory updates for the Timber Supply Review (TSR) process. Through a hierarchical process the cell-based predictions were first created from the LiDAR data captured in each business area. Next, these LiDAR predictions were compared to variable radius ground (cruise) plots. Based on the results presented in Section 5, it was determined that the models predicting stand height performed best in all business areas whereas existing models of basal area, DBH and volume needed more work. This is very common where the overall study area is very diverse in terms of forest types (simple to complex) and the forests contain varying vertical structures. Since the initial calibration models were derived from plot data in the Kamloops/Okanagan TSAs of BC it is no surprise that the best comparisons were found in the TOC business area as this area would have the most similar forest types to those which were used to calibrate the LiDAR models.