Timber Supply Review

Analysis Report – Cascadia TSA

Version 1.5

DRAFT

Prepared by:
Forest Ecosystem Solutions Ltd
227 – 998 Harbourside Drive
North Vancouver, BC
V7P 3T2
604-998-2222
amakitalo@forestecosystem.ca

Prepared for:

Prepared for:
Cariboo-Chilcotin, Kootenay, Okanagan-Columbia and Skeena Business Areas
BC Timber Sales
Cascadia TSA

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Executive Summary

This report describes the timber supply analysis for the Cascadia Timber Supply Area (TSA). The analysis involves testing and reporting on a variety of assumptions and management strategies. The purpose of this report is to provide the Chief Forester with sufficient information to make an informed Allowable Annual Cut (AAC) determination.

The following are described in this report:

- Base Case harvest forecast for each Business Area (BA) – the Base Case models current management and tree growth in the Cascadia TSA;
- Sensitivity analyses for each BA – used to assess the risk associated with Base Case assumptions;
- Alternate harvest flows for each BA investigating the impacts of alternate initial harvest levels;
- A TSA level forecast, which is compared to an aggregated BA forecast

The Cascadia TSA consists of four Business Areas, Kootenay (TKO), Okanagan-Columbia (TOC), Cariboo-Chilcotin (TCC), and Skeena (TSK).

The Base Case harvest forecasts for each BA are illustrated in Figure 1, Figure 2, Figure 3 and Figure 4, while Table 1, Table 2, Table 3 and Table 4 provide forecast summaries for each BA.

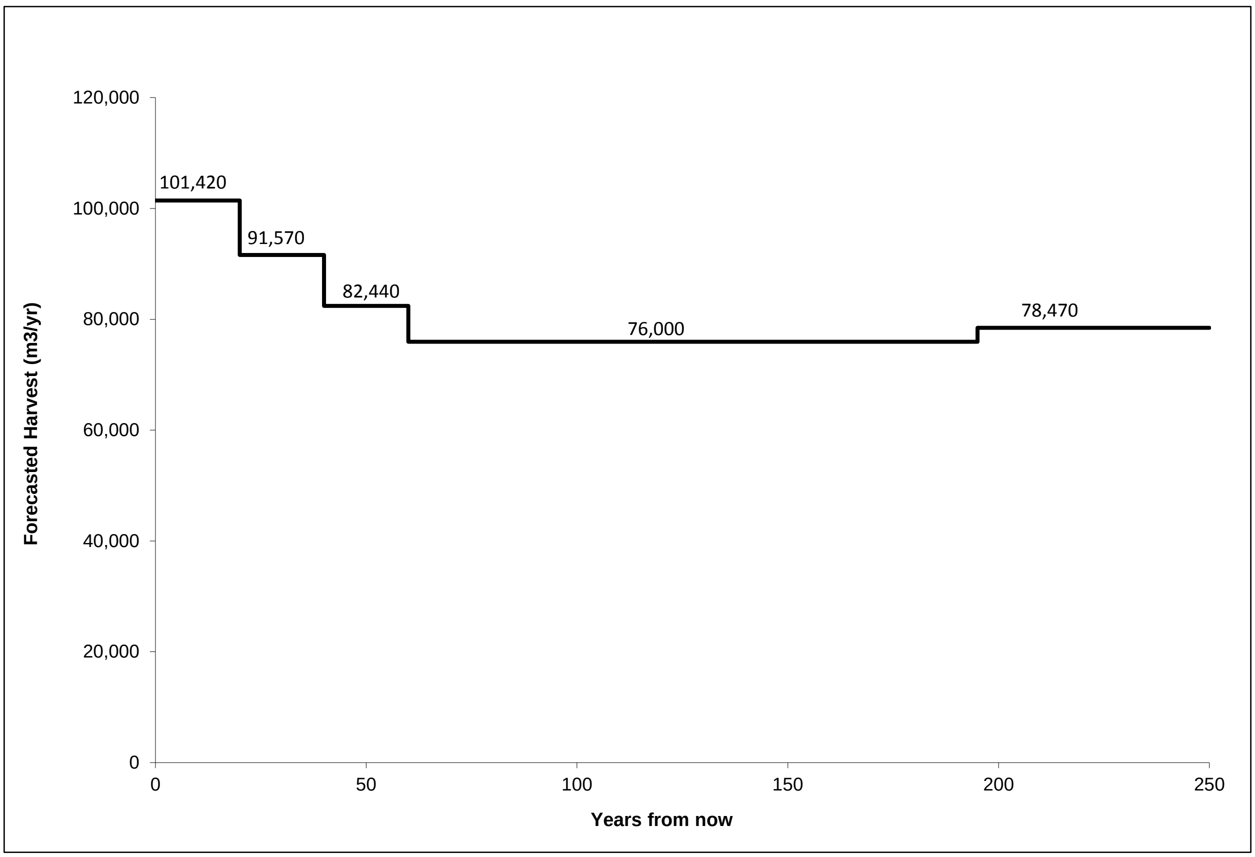


Figure 1: Base Case harvest forecast; TKO

Table 1: Harvest forecast summary, TKO

Period	Predicted Harvest (m^3 per year)	Unharvested THLB (ha)
Years 1 to 20:	101,420 m^3	1,262 ha (4.9%)
Years 21 to 40	91,570 m^3	
Years 41 to 60	82,440 m^3	
Years 61 to 195	76,000 m^3	
Years 196 to 250 (LTHL)	78,470 m^3	

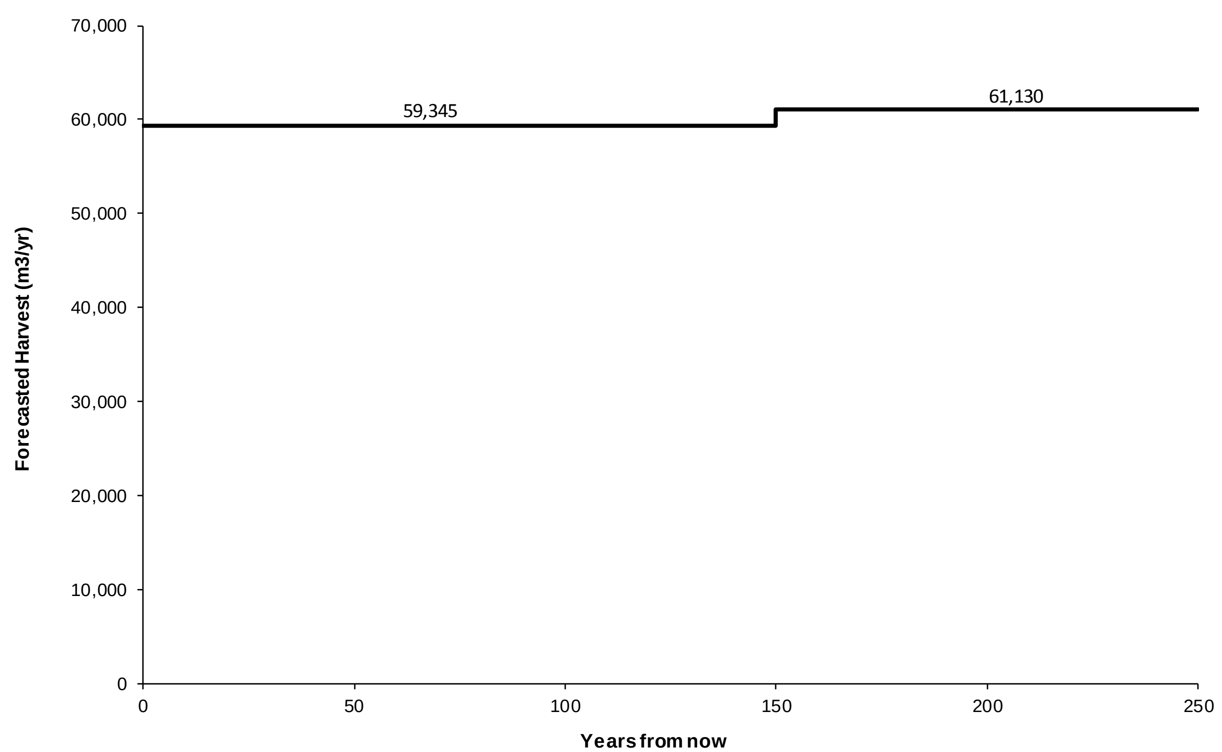


Figure 2: Base Case harvest forecast; TOC

Table 2: Harvest forecast summary, TOC

Period	Predicted Harvest (m^3 per year)	Unharvested THLB (ha)
Years 1 to 150:	59,345 m^3	1,325 ha (6.9%)
Years 151 to 250 (LTHL)	61,130 m^3	

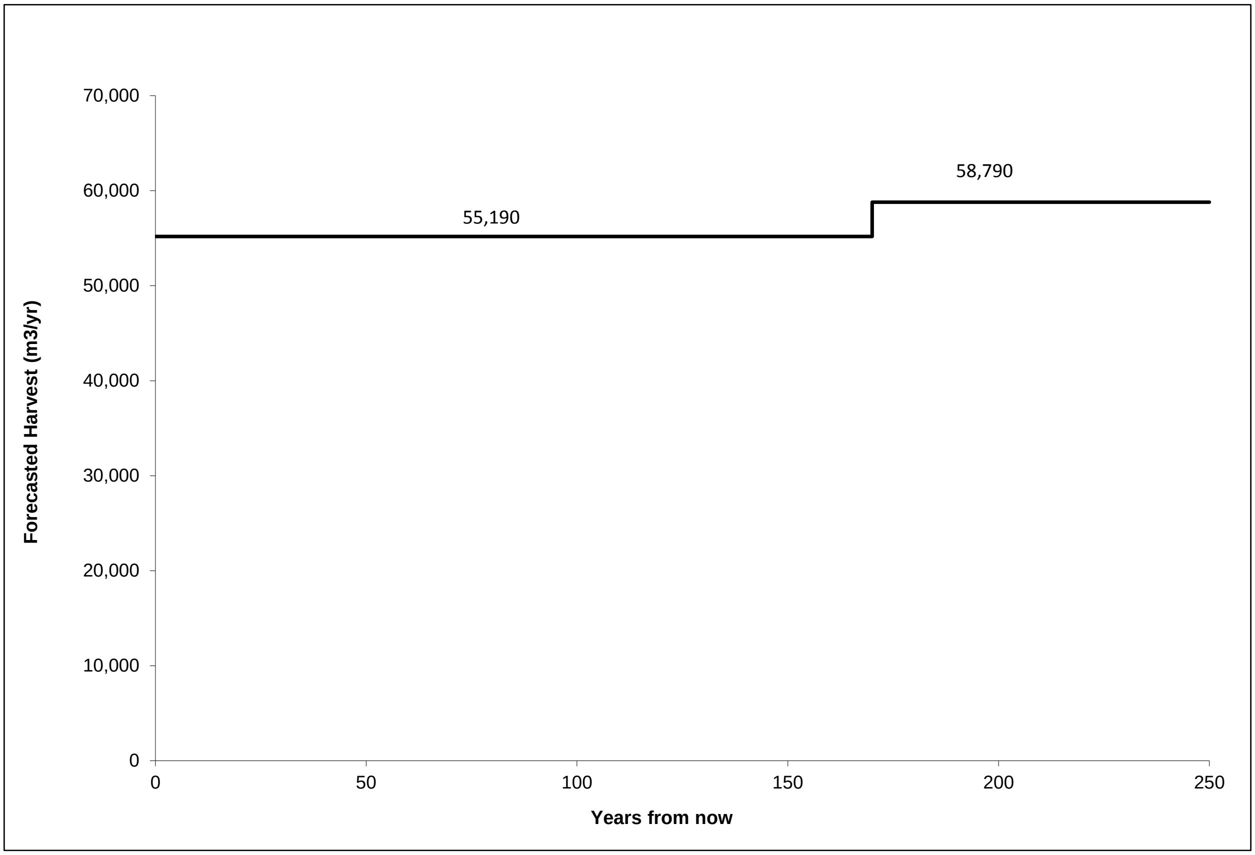


Figure 3: Base Case harvest forecast; TCC

Table 3: Harvest forecast summary, TCC

Period	Predicted Harvest (m^3 per year)	Unharvested THLB (ha)
Years 1 to 170:	55,190 m^3	282 ha (1.6%)
Years 171 to 250 (LTHL)	58,790 m^3	

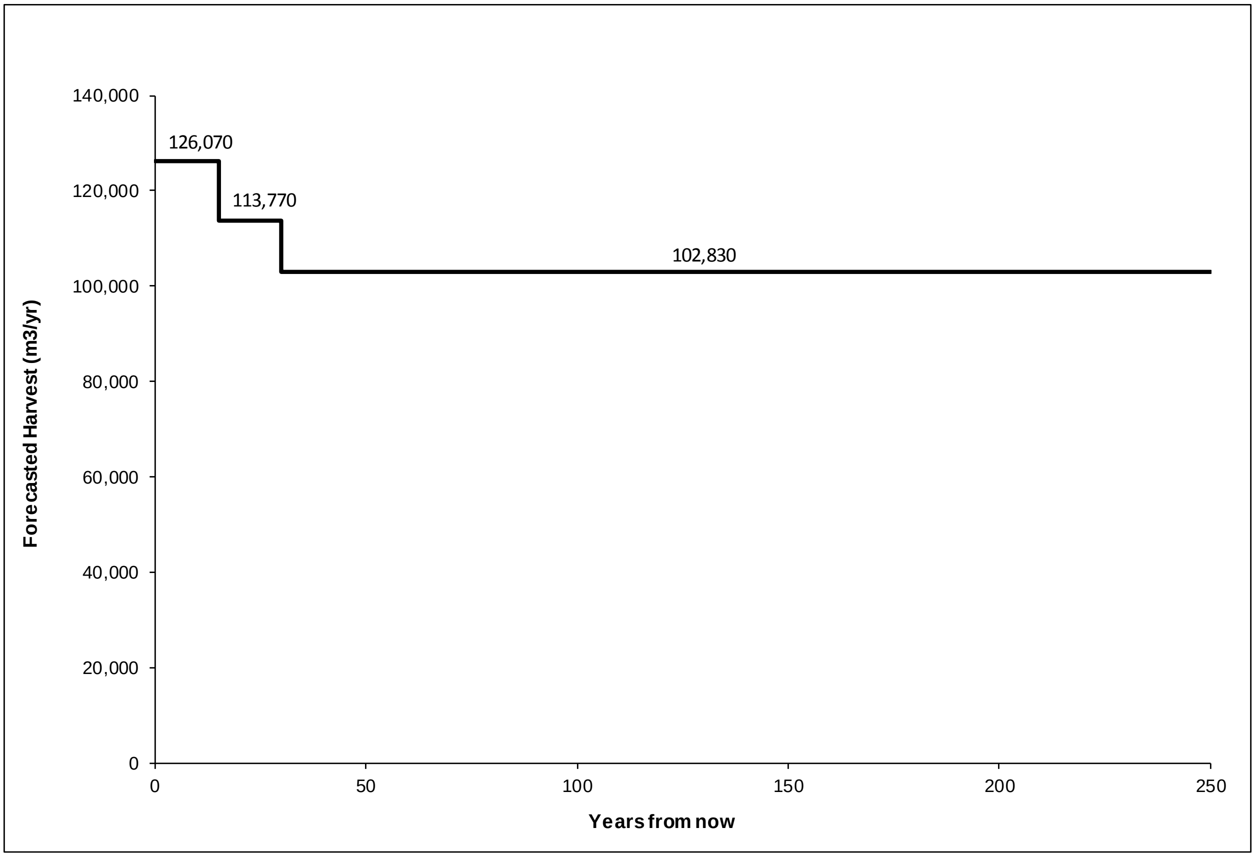


Figure 4: Base Case harvest forecast; TSK

Table 4: Harvest forecast summary, TSK

Period	Predicted Harvest (m^3 per year)	Unharvested THLB (ha)
Years 1 to 15:	126,070 m^3	3,222 ha (13.6%)
Years 16 to 30	113,770 m^3	
Years 31 to 250 (LTHL)	102,830 m^3	

Figure 5 illustrates the harvest forecast for the entire TSA. The initial harvest level 347,930 m^3 per year is 12.5% lower than the current AAC of 397,818 m^3 per year. Figure 6 compares the summed-up individual Business Area harvest forecasts to the TSA harvest forecast. The differences are small: in the first 60 years of the planning horizon, the TSA harvest forecast was 0.6% higher than the summed-up individual Business Area harvest forecasts. The midterm forecast in the TSA run was 1.1% higher, while the long-term harvest forecast was 0.6% higher.

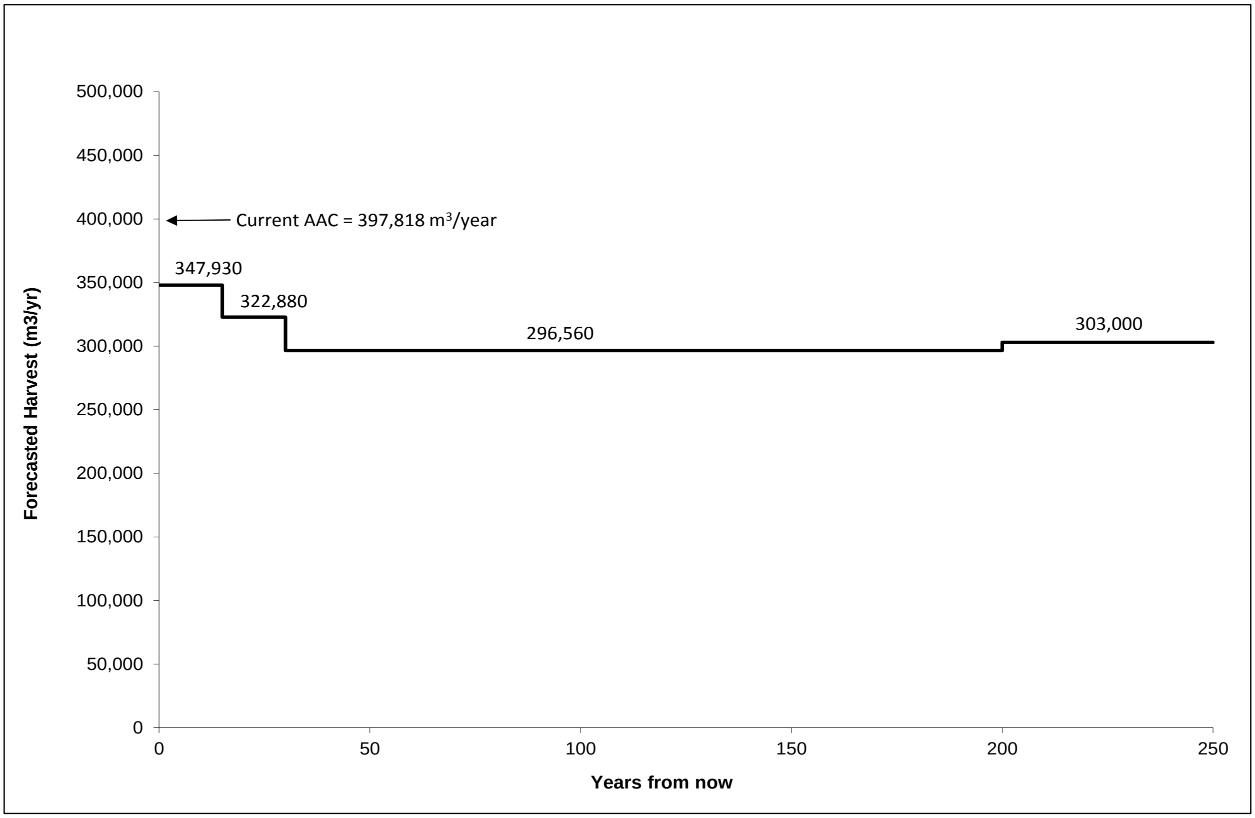
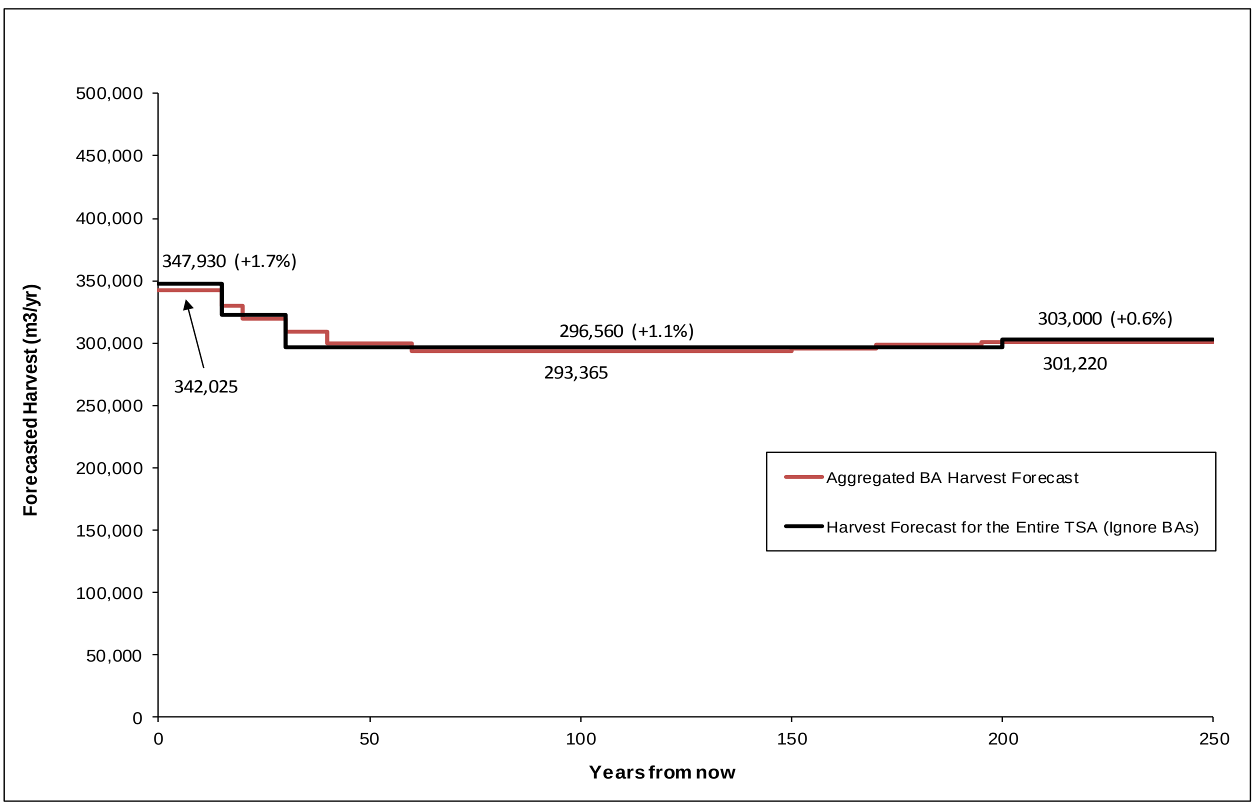


Figure 5: Harvest forecast for the entire Cascadia TSA; individual Business Areas are ignored



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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 analysis report is the second of three documents making up the TSR process summarizing the timber supply analysis results. The first document – the Information Package – documents the procedures, assumptions, data and model used in the analysis. The final document – the Rationale for AAC Determination – documents the Chief Forester's AAC determination and the rationale behind it. Section 8 of the *Forest Act* provides the legislative authority for AAC determinations and outlines the factors that must be considered by the Chief Forester during the process.

1.2 Timber Supply Analysis

This report describes the timber supply analysis for the Cascadia TSA. Timber supply analysis examines the availability of timber volume for harvesting over time. It involves testing and reporting on a variety of assumptions and management strategies. The timber supply analysis provides the Chief Forester with information about the relationship between current management and timber supply. The purpose of this report is to provide the Chief Forester with sufficient information to make an informed Allowable Annual Cut (AAC) determination.

Timber supply analysis is intended to ensure that current harvest levels do not threaten the availability of future timber volume. Sustainability is therefore the key concept in this report and in timber supply analysis in general. However, the main indicator of sustainability in timber supply analysis is the long-term stability of growing stock, and therefore the continuous availability of timber for harvest. This analysis does not attempt to evaluate sustainability in terms of the wider range of biological, social, or economic values that are affected by timber harvesting. Because of its limited definition of sustainability, timber supply analysis is only one aspect of a larger decision-making process used to set the AAC.

1.3 Timber Supply Forecasts

A single harvest forecast is not sufficient to depict the timber supply dynamics of the Cascadia TSA, or the individual Business Areas, due to the complexity of factors affecting timber supply. There are uncertainties about how well the analysis assumptions reflect the realities of timber supply and there are many options for setting harvest levels in response to the timber supply dynamics. Several forecasts are developed in this analysis to account for these uncertainties and options. The purpose of presenting different forecasts is to construct a complete understanding of the timber supply dynamics of the Cascadia TSA. The following forecasts are presented in this report:

Base Case: The Base Case is the standard against which other forecasts are compared when assessing the effects of uncertainty on timber supply. In most timber supply analyses, the Base Case reflects the best available knowledge about current management activities and forest development in a management unit. Base Cases are presented for all four Business Areas of the Cascadia TSA.

Sensitivity Analyses: Sensitivity analyses are used to determine the risk associated with uncertainties in the assumptions of the analysis. These forecasts isolate an area of uncertainty and test the implications of using a variety of assumptions.

Alternative Harvest Forecasts: Alternative harvest forecasts explore different decline rates, starting harvest levels, and potential trade-offs between short- and long-term harvests. Alternative forecasts enable the Chief Forester to assess short-, medium-, and long-term trade-offs.

2 Study Area

The Cascadia TSA consists of 11 Blocks in the interior of British Columbia. Figure 7 shows the location of the Cascadia TSA Blocks. 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).

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 5.

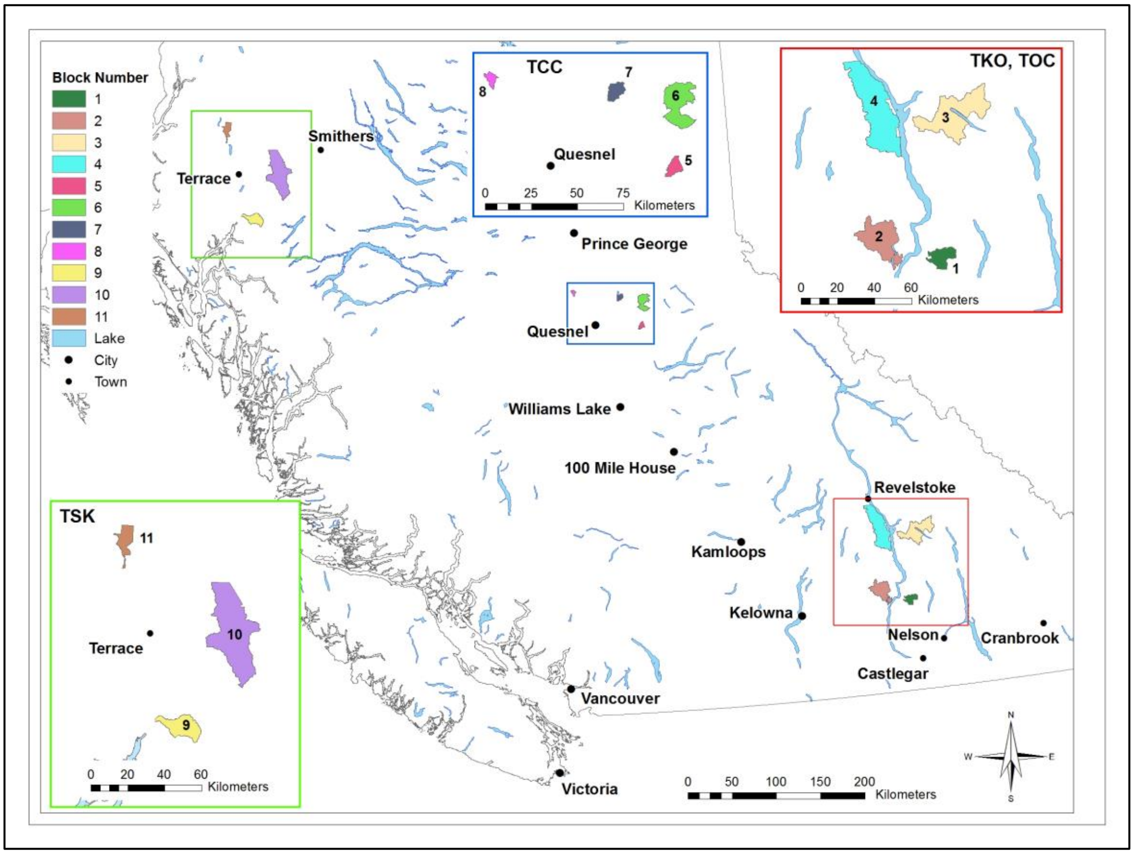

Figure 7: Cascadia TSA Blocks

Table 5: 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**

Twenty-four First Nations or bands have asserted and/or established Aboriginal Interests within the Cascadia TSA as shown in Table 6. These First Nations have been consulted throughout the TSR process, and will continue to be consulted regarding potential impacts to their rights and interests before the AAC determination by the Chief Forester.

Table 6: 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

Name	Type	Cascadia TSA Block
Kitselas First Nation - Traditional Territory	Band	10
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

2.1 Forest Inventory

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. See the Information Package for a more detailed description of the inventory.

2.2 Land Base Classification

2.2.1 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 considered to be physically, environmentally, economically and socially available for timber harvesting. It is productive forest land that is harvestable according to current forest practices and legislation.

Non-Harvestable Land Base (NHLB) – this is the portion of the CFLB where harvesting is not expected to occur according to current forest practices and legislation. 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 7; the netdowns for each of the four Business Areas are shown in Table 8, Table 9, Table 10, and Table 11. The netdown reductions are described in the Information Package. In these tables, the gross area is the total area of a netdown item (e.g. Wildlife Habitat Areas), and the net area is the remaining area after previous netdown items have been removed from the land base.

Table 7: 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	4,327	11,421
Archeological Sites	55	103
WTP	1,676	1,795
NHLB Area	**128,153**	
THLB Area	**87,285**	
Future Roads	1,026	
Future THLB	**86,258**	

Table 8: TKO netdown summary

Netdown Category	Net Area (ha)	Gross Area (ha)
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	1,185	4,198
Archeological Sites	1	29
WTP	470	506
NHLB Area	**56,610**	
THLB Area	**26,085**	
Future Roads	182	
Future THLB	**25,903**	

Table 9: TOC netdown summary

Netdown Category	Net Area (ha)	Gross Area (ha)
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	2,398	3,491
Archeological Sites		
WTP	599	652
NHLB Area	**30,544**	
THLB Area	**19,328**	
Future Roads	115	
Future THLB	**19,213**	

Table 10: TCC netdown summary

Netdown Category	Net Area (ha)	Gross Area (ha)
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	452	2,297
Archeological Sites	10	16
WTP	212	224
NHLB Area	**7,595**	
THLB Area	**17,813**	
Future Roads	330	
Future THLB	**17,483**	

Table 11: TSK netdown summary

Netdown Category	Net Area (ha)	Gross Area (ha)
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	293	1,435
Archeological Sites	44	58
WTP	395	413
NHLB Area	**33,405**	
THLB Area	**24,059**	
Future Roads	399	
Future THLB	**23,660**	

2.3 Current Forest Conditions

2.3.1 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 8). However, there are distinct differences between the Business Areas, as shown in Figure 9, Figure 10, Figure 11, and Figure 12.

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.

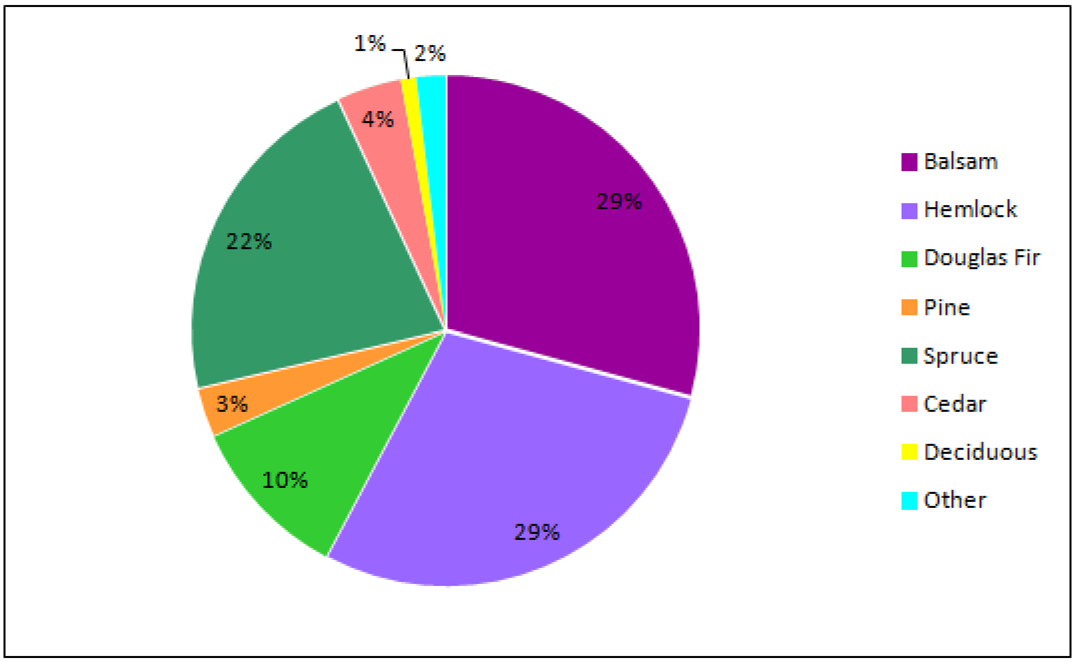

Figure 8: Leading species in the CFLB, Cascadia TSA

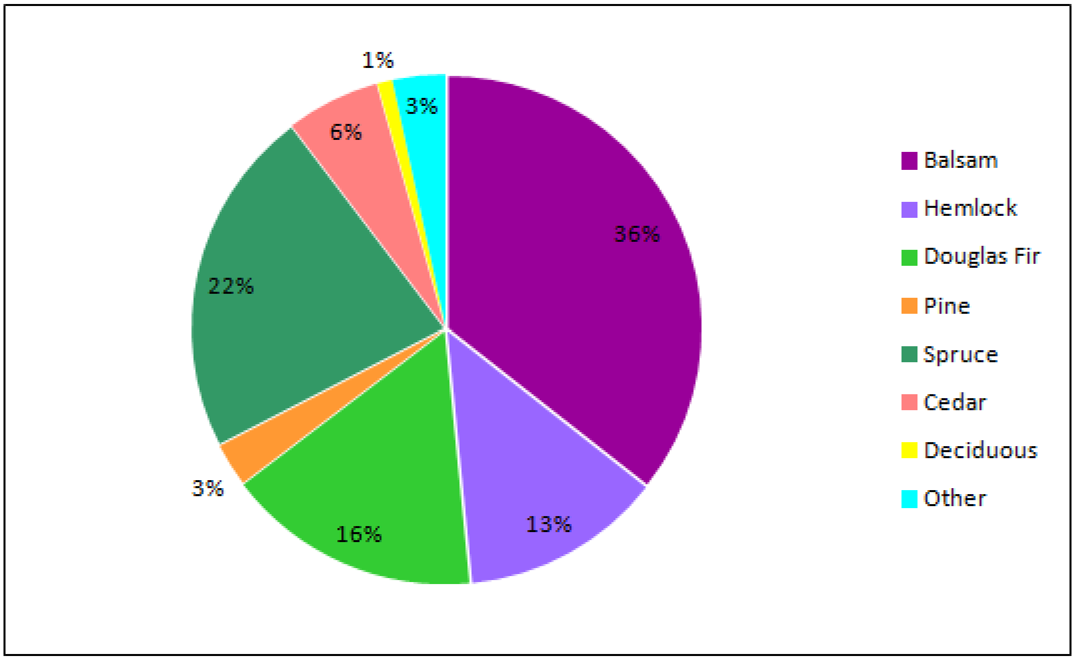

Figure 9: Leading species in the CFLB, TKO

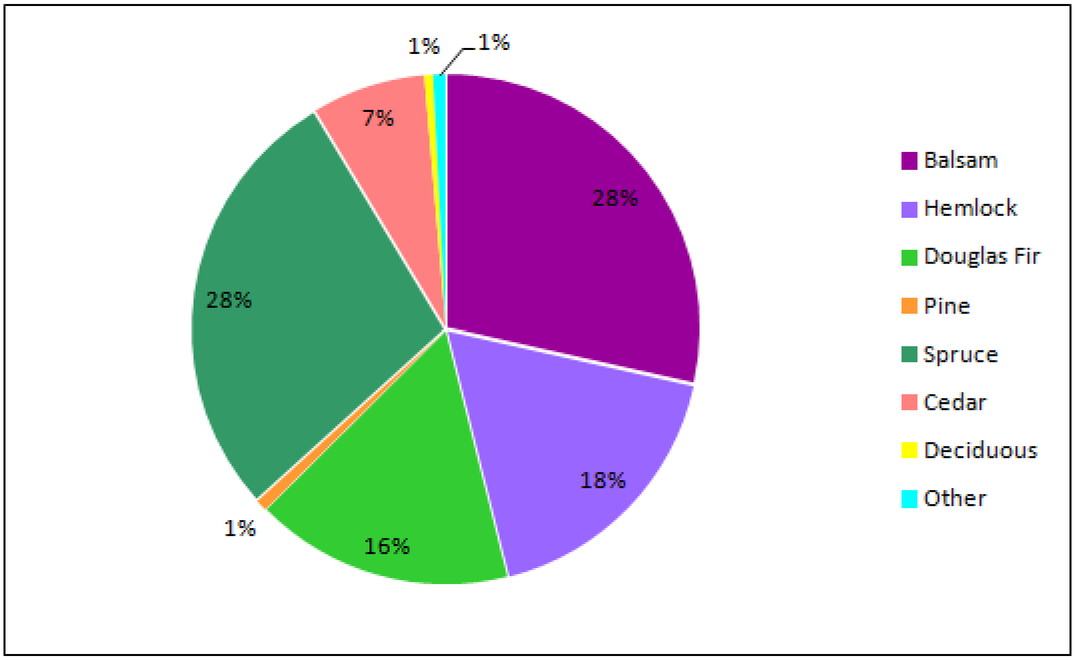

Figure 10: Leading species in the CFLB, TOC

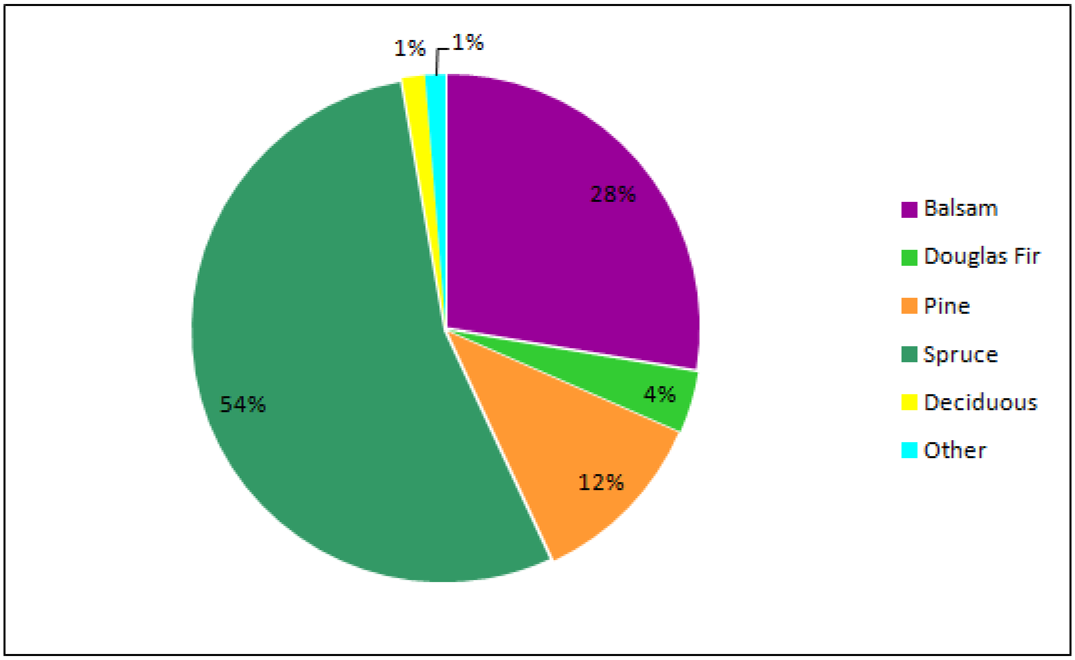

Figure 11: Leading species in the CFLB, TCC

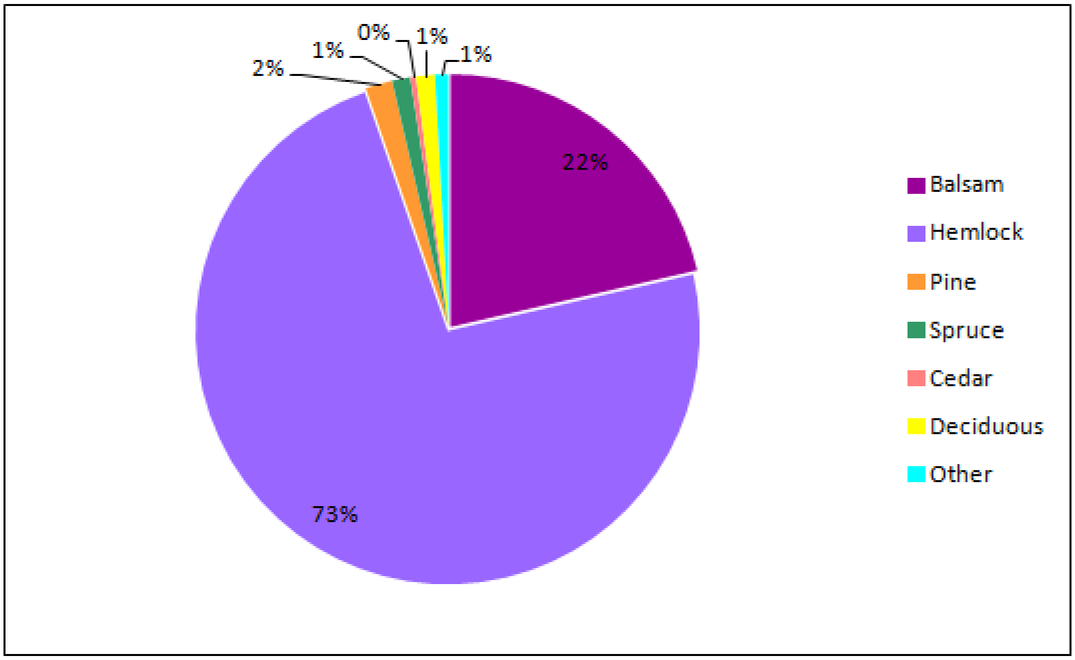

Figure 12: Leading species in the CFLB, TSK

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 13). The leading species in the THLB for each Business Area are shown in Figure 14, Figure 15, Figure 16, and Figure 17.

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.

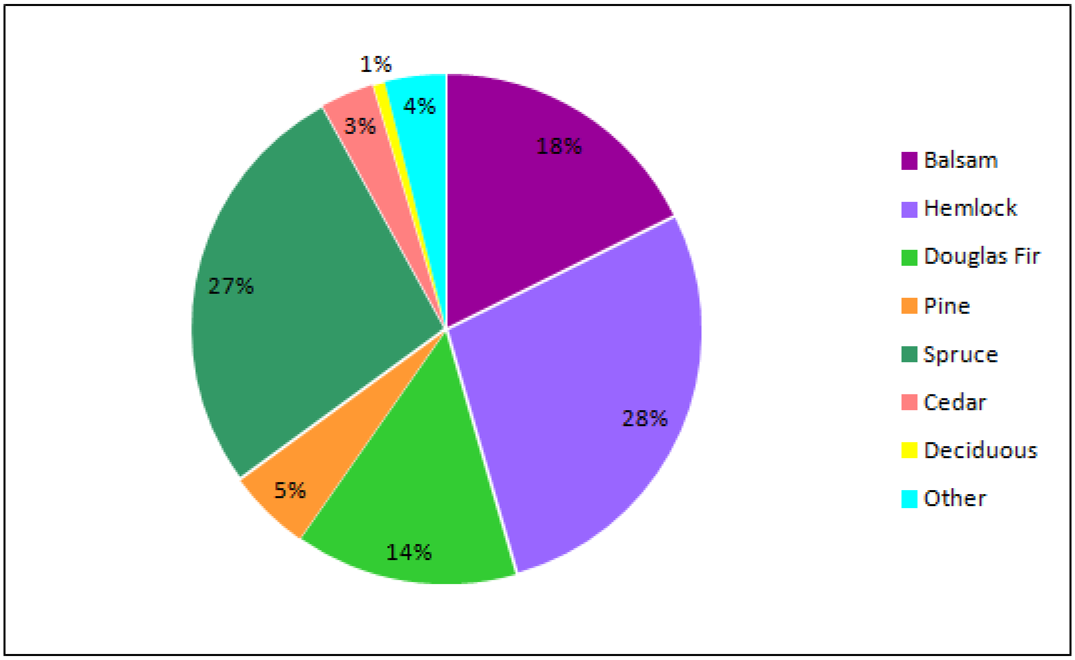

Figure 13: Leading species in the THLB, Cascadia TSA

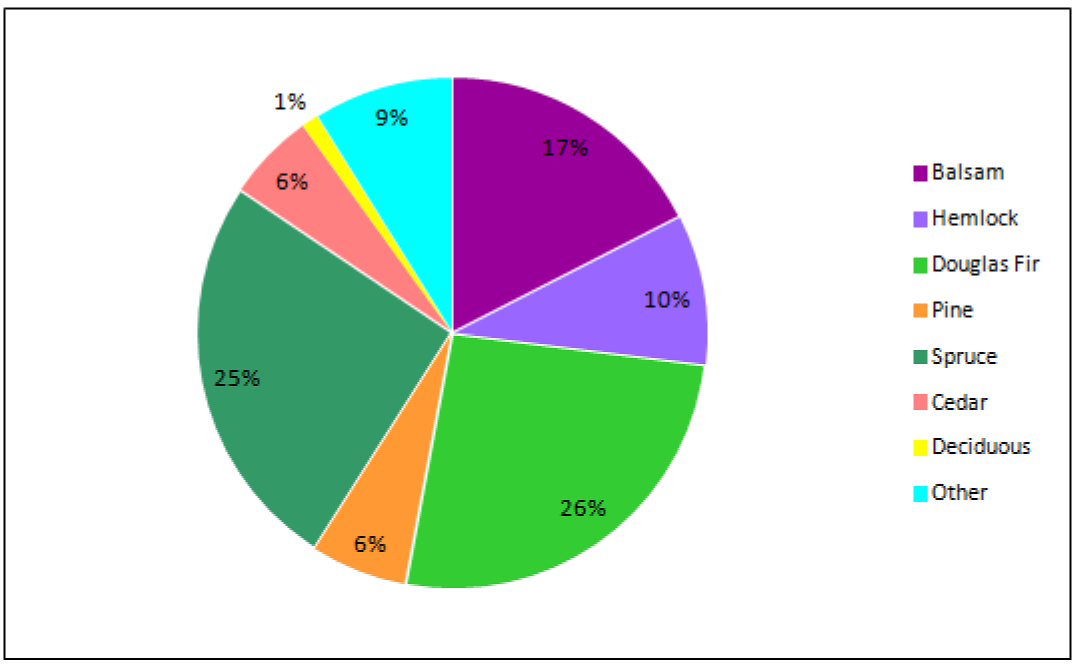

Figure 14: Leading species in the THLB, TKO

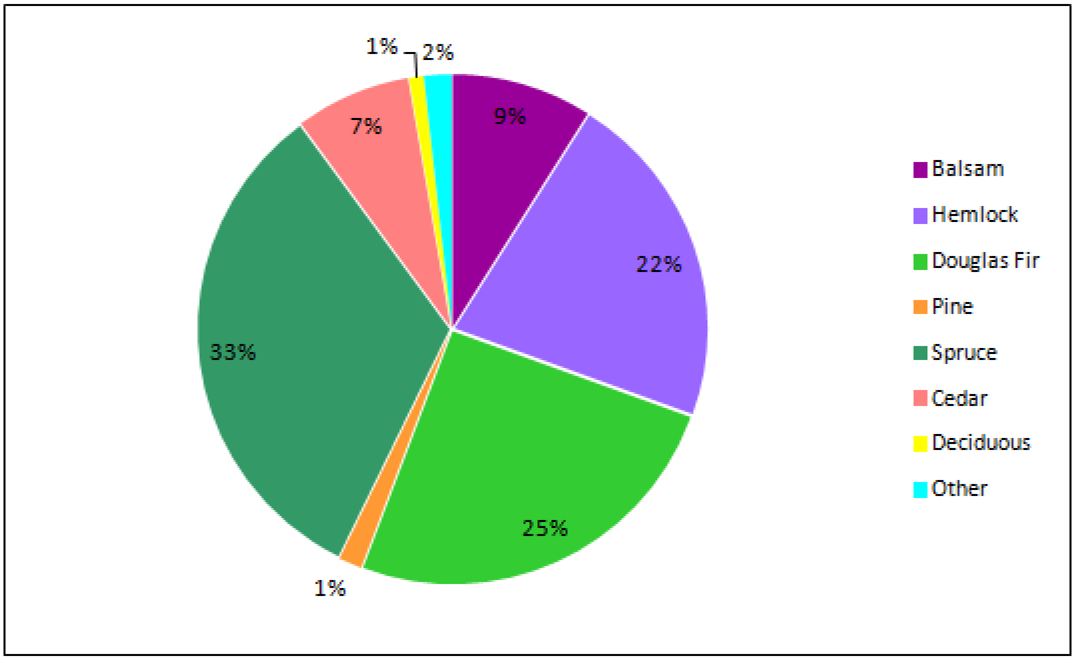

Figure 15: Leading species in the THLB, TOC

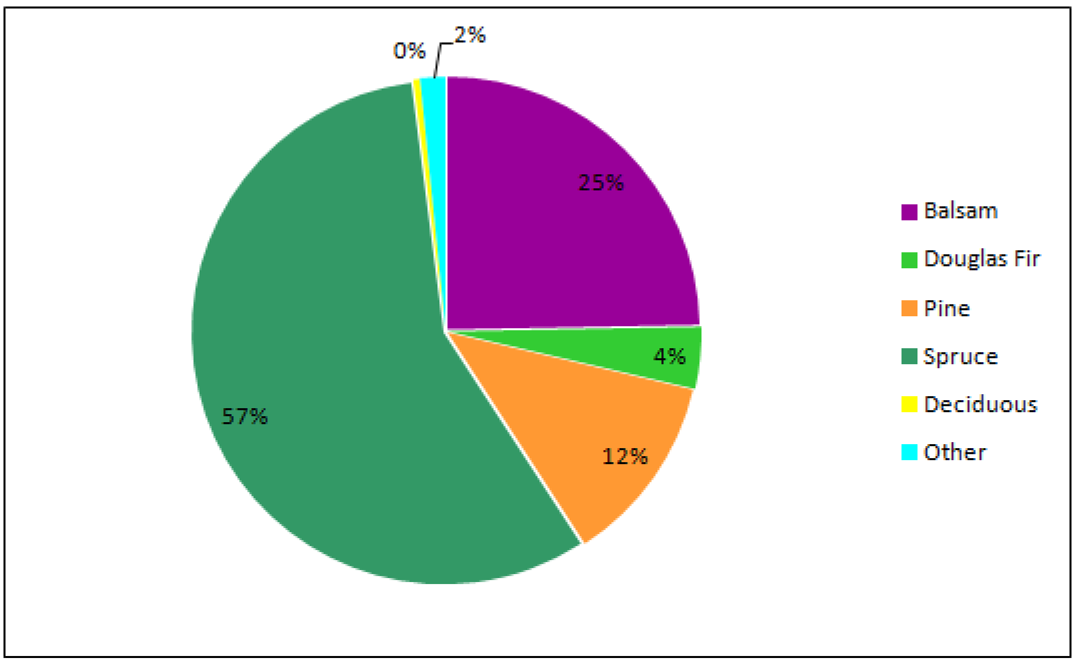

Figure 16: Leading species in the THLB, TCC

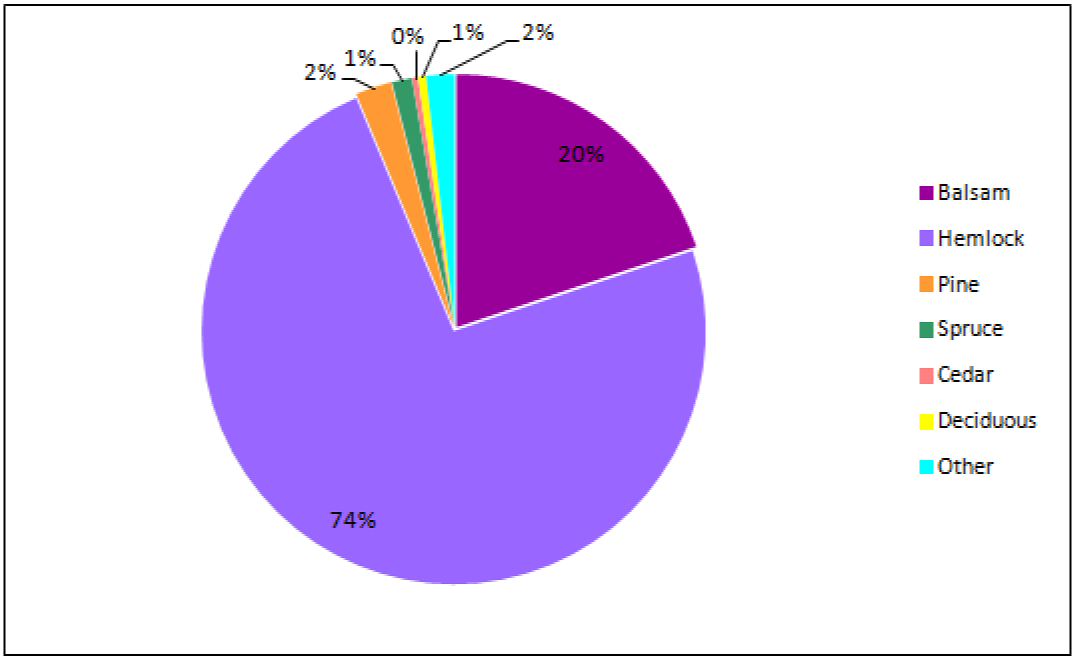

Figure 17: Leading species in the THLB, TSK

2.3.2 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 18).

The age class distributions for each Business Area are shown in Figure 19, Figure 20, Figure 21 and Figure 22. 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).

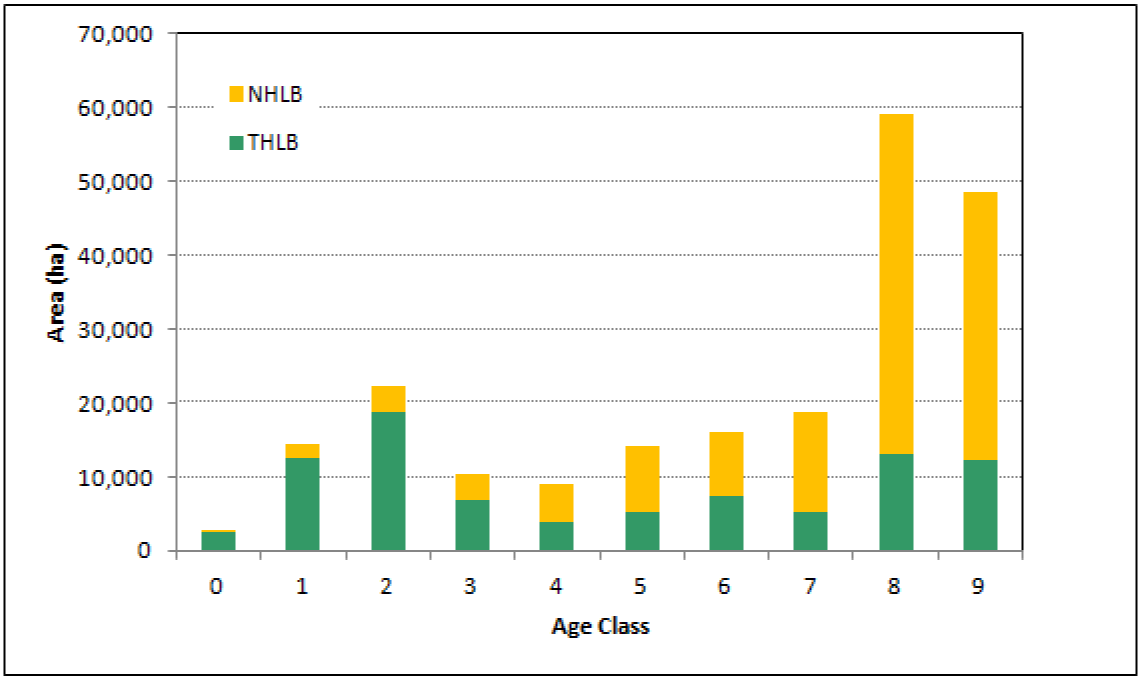

Figure 18: Age class distribution in the Cascadia TSA

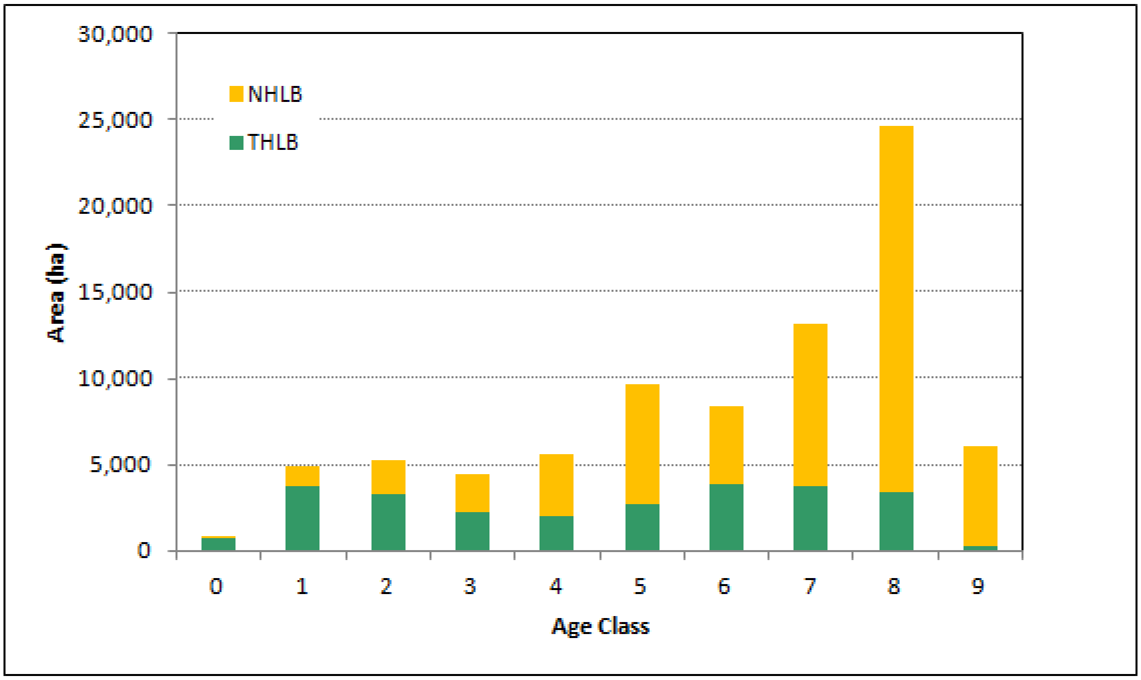

Figure 19: Age class distribution, TKO

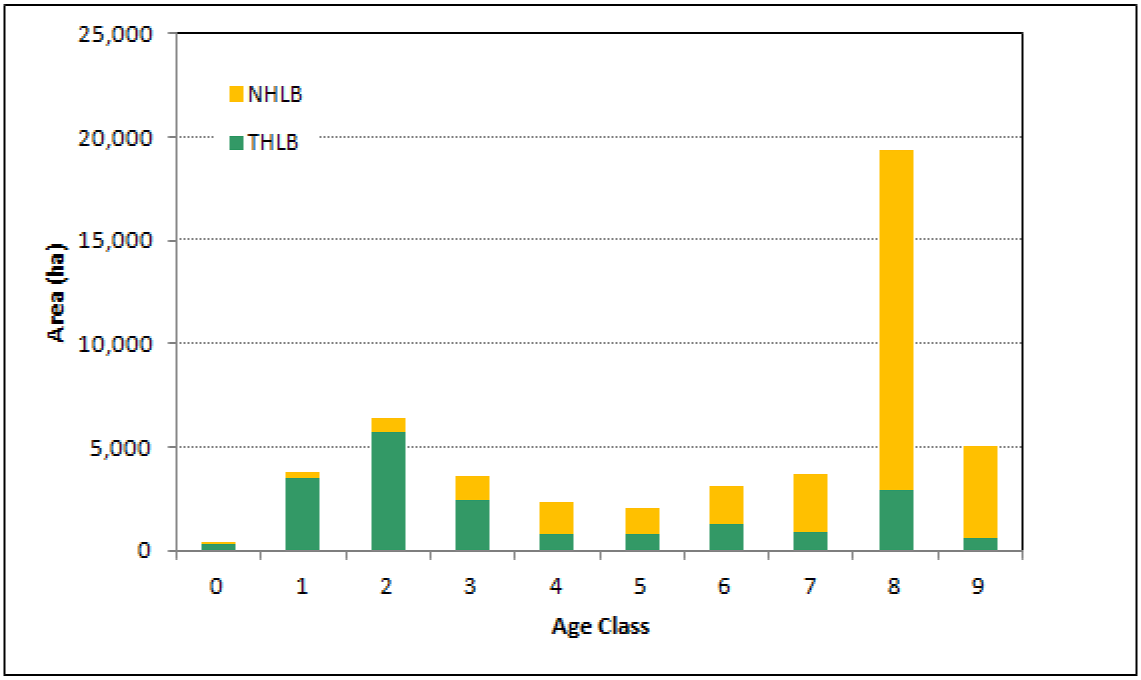

Figure 20: Age class distribution, TOC

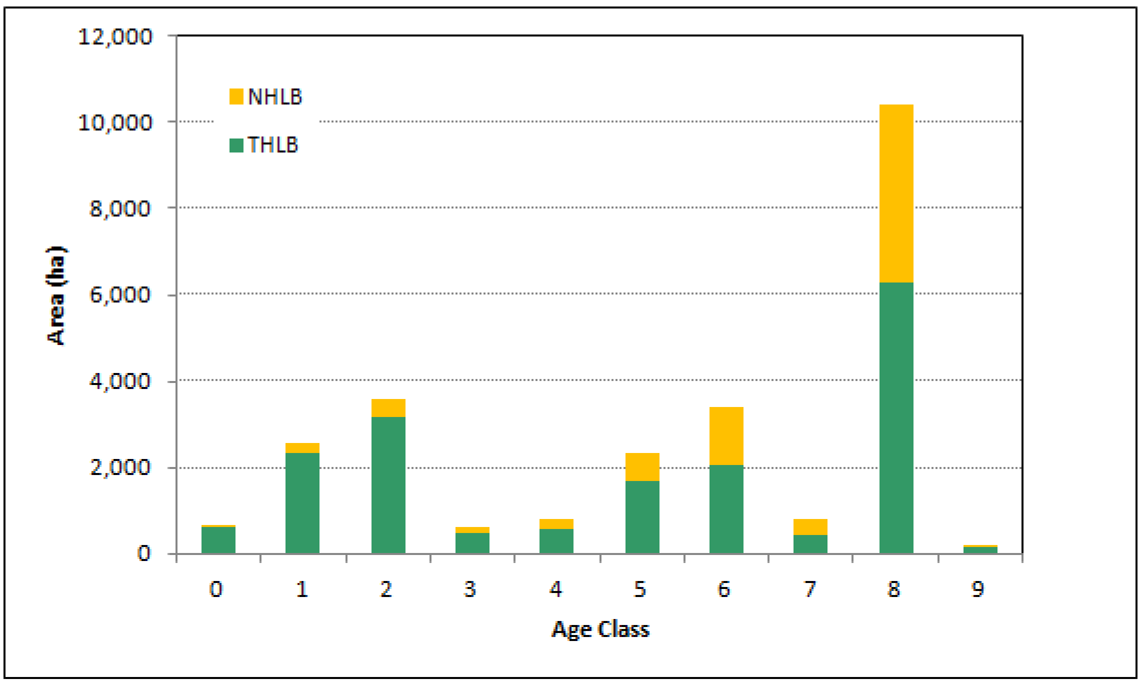

Figure 21: Age class distribution, TCC

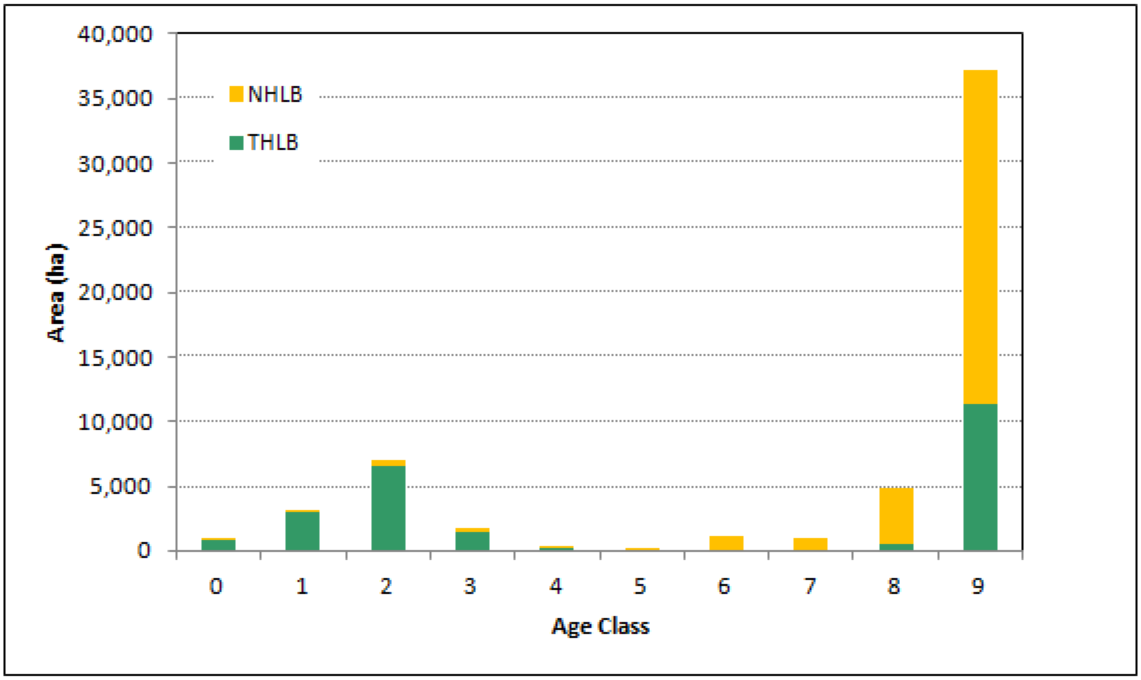

Figure 22: Age class distribution, TSK

2.3.3 Growing Stock

Table 12 shows the total merchantable growing stock by species for the Cascadia TSA. The estimate is based on the VRI species volumes for each stand in the TSA. The total merchantable growing stock is estimated at 18 million m^3. Hemlock (6.8 million m^3, 38%) and balsam (4 million m^3, 22%) volume forms the majority of the merchantable growing stock at around 10.8 million m^3 (60%). The shares of spruce and Douglas-fir volume are significant at 3 million m^3 (16%) and 2 million m^3 (11%) correspondingly (Table 12).

A large portion of the merchantable growing stock is older than 250 years (age class 9, 43%) most of it hemlock or balsam located in TSK (Figure 23 and Table 12).

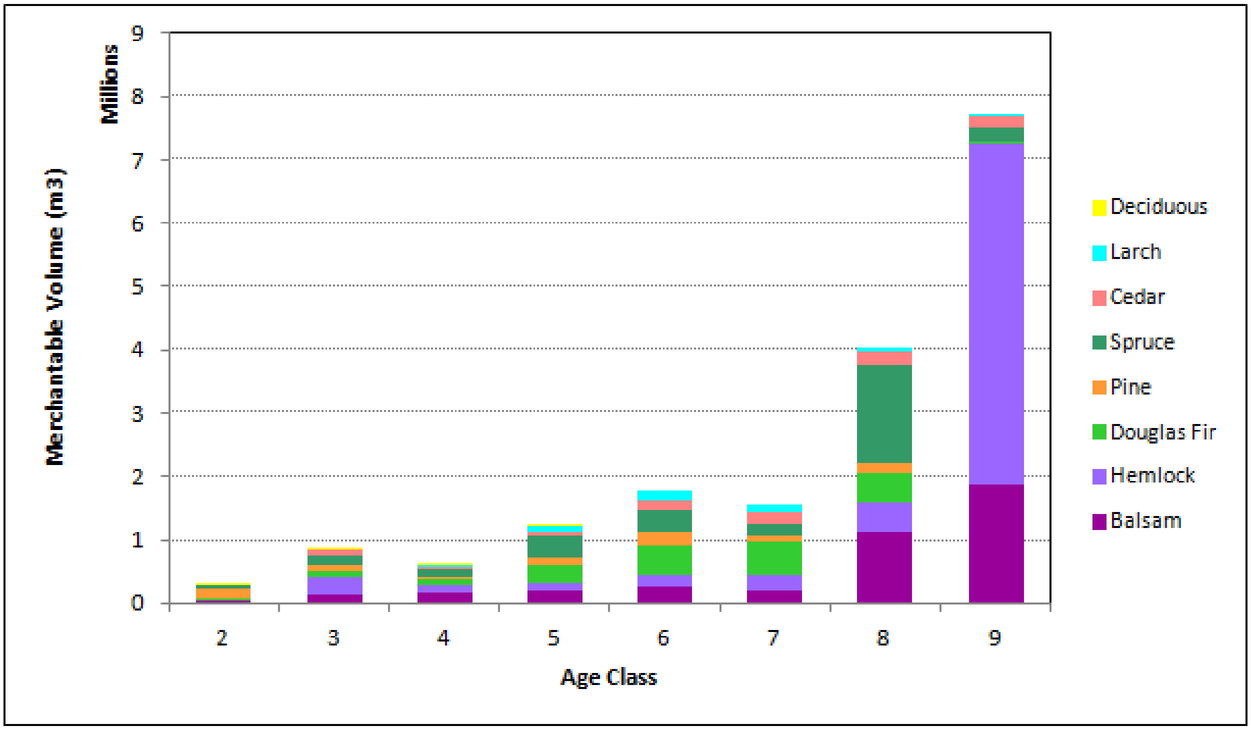

Figure 23: Merchantable growing stock by species and age class in the Cascadia TSA

Table 12: 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	736,071	427,330	1,132,106	591,525	472,518	426,473	821,283	0	**4,607,306**
TOC	218,761	396,068	666,011	635,521	16,209	42,913	488,081	0	**2,463,564**
TCC	918,957	0	185,928	0	0	360,070	1,482,923	2,112	**2,949,990**
TSK	2,097,856	117,003	0	5,623,179	0	17,893	172,800	0	**8,028,731**
Total	**3,971,644**	**940,402**	**1,984,045**	**6,850,225**	**488,727**	**847,349**	**2,965,087**	**2,112**	**18,049,591**

3 Assumptions and Methods

This section briefly describes the inputs and assumptions to the timber supply analysis. A full description of these issues is provided in the Cascadia TSA Timber Supply Review Information Package.

3.1 Timber Supply Model

All analysis presented in this report was conducted using Forest Simulation and Optimization System (FSOS), a proprietary forest estate model developed by FESL. FSOS has both simulation and heuristic (pseudo-optimization) capabilities. The time-step simulation mode was primarily used in this analysis. Time-step simulation grows the forest based on growth and yield inputs and harvests units of land area based on user-specified harvest rules and constraints that cannot be exceeded.

3.2 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.).

3.3 Site Index

The provincial site productivity data layer was 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 was modeled using the inventory site index.

3.4 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.

3.4.1 Natural Stands

Stands established prior to 1976 are considered natural stands in this analysis. Their growth and yield were 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.

3.4.2 Managed Stands

Stands established in 1976 and later are considered managed stands in this analysis. Their growth and yield were 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. In addition, managed stands were split by era.

Regeneration assumptions and detailed inputs to TASS are presented in the Information Package.

3.4.2.1 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.

3.4.2.2 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.

3.4.2.3 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.

3.5 Integrated Resource Management

3.5.1 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 the Information Package. 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.

3.5.2 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 60Table 13 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 13: Management zones – base case

Business Area	Resource Objective	Condition	Cover Requirement	Land Base	Notes
All	Cutblock Adjacency	Green-up height	Max 25%	THLB/LU	
	Visual Quality	Visually effective green-up height	Varies	CFLB in each VQO polygon.	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.
	Landscape Level Biodiversity	Old	Met through spatial OGMAs	Non-legal OGMAs	
		Mature and Old	Min targets	CFLB by LU/BEC	Targets are specified by LU/BEC.
		Mature and old	Min targets	CFLB by LU/BEC in connectivity corridors.	The above targets must be met first in connectivity corridors.
	Ungulate Winter Range	Forest cover	Max and min targets	CFLB in UWR tag/management unit	
TOC	Landscape Level Biodiversity	Old	Met through spatial OGMAs	Non-legal OGMAs	
	Ungulate Winter Range	Forest cover	Max and min targets	CFLB in UWR tag/management unit	
TCC	Landscape Level Biodiversity	Old	Met through spatial OGMAs	Legal OGMAs	
		Mature and Old	Min targets	CFLB by LU/BEC	Targets are specified by LU/BEC.
	Wildlife Habitat Area (Mountain Caribou)	Forest cover	Entry allowed once in 80 years for 30% of area	CFLB in WHA polygon	
TSK	Landscape Level Biodiversity	Old	Met through spatial OGMAs and aspatial targets	Legal OGMAs plus CFLB by LU/BEC.	Targets are specified by LU/BEC
		Mature and Old	Min targets	CFLB by LU/BEC	Targets are specified by LU/BEC.
		Early	Max targets	CFLB by LU/BEC	Targets are specified by LU/BEC.
	Ungulate Winter Range	Forest cover	Min targets	CFLB in UWR tag/management unit	
	Grizzly bear	Forest cover	Max target	CFLB in identified grizzly bear watershed (Copper)	

3.6 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 14 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 14: Annual non-recoverable losses

Forest Health Factor	Average Annual losses (m^3/year)			
	TKO	TOC	TCC	TSK
Douglas-fir bark beetle	600	562	210	
Fire	1469	358	500	103
Mountain Pine beetle	500			
Spruce bark beetle			331	
Western Balsam bark beetle			1000	617
Drought				437
Flooding				88
Total	**2569**	**920**	**2041**	**1245**

3.7 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 95% of the mean annual increment culmination is reached and the age the stand is predicted to reach a volume as described in Table 15. Both conditions must be met. The resulting harvest 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 15: Minimum harvest criteria

Business Area	Minimum Volume by Harvest Method (m^3/ha)		Age at which 95% of MAI Culmination is Reached
	Cable	Ground	
TKO	200	150	Must also be met
TOC	250	200	Must also be met
TCC	200	110	Must also be met
TSK	250	250	Must also be met

3.8 Minimum Periodic Volume

Minimum volume requirements can be set for an area, when it is known that the financial viability of the harvest from that area requires a minimum harvestable volume. The following table shows all the TSA woodsheds that are subject to minimum volume requirements in the base case. The requirements are applied to a period of 5 years. All the woodsheds that require a minimum periodic harvest volume are in the TKO BA.

Table 16: Minimum 5-year harvest volume requirements, TKO only

Woodshed	Minimum Periodic Target (m^3 in 5 Years)
Block 1	35,000
Block 3	35,000

3.9 Harvest Scheduling 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 can 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 was used in this analysis for all Business Areas, except TCC. According to the BCTS staff in TCC, relative oldest harvest rule best reflects operations in that Business Area.

4 Base Case Harvest Forecast

The Base Case is the foundation for comparison between timber supply forecasts. Base Case assumptions are described in the Information Package. The Base Case assumptions determine how the land base is expected to respond to the current management regime over time. The purpose of the Base Case is to understand the implications of current management to future timber supply, including short-, medium- and long-terms. This section explains how a sustainable harvest level is determined, presents the Base Cases for each Business Area, and describes the predicted development of selected attributes associated with the chosen sustainable harvest level. The Base Case is the point of comparison for all sensitivity analyses.

4.1 Sustainable Harvest Level

Base case forecast is designed to avoid both excessive changes from decade to decade and significant timber shortages in the future, while ensuring the long term productivity of forest lands. A reliable and objective indicator of sustainability is required to differentiate sustainable harvest levels from unsustainable harvest levels in timber supply analysis. Crashes in timber supply occur at pinch points when there is insufficient merchantable volume to satisfy the target harvest level. Timber supply analysts commonly use these crashes as an indicator of non-sustainable harvest levels. However, pinch points are directly related to how minimum harvest criteria are defined and may not reflect true constraints on timber supply.

Pinch points are only useful as indicators of sustainability if minimum harvest ages are equal or close to the culmination ages of mean annual increment (MAI). When minimum harvest ages are set close to culmination age, pinch points indicate that the model is attempting to harvest stands below culmination age. Pinch points are less effective indicators of sustainability when minimum harvest ages are set using other criteria, such as volume per ha and 95% MAI culmination, as in this analysis. The stable long-term growing stock is the sole indicator of sustainability in this timber supply analysis. Short- and medium-term harvest levels are considered sustainable if they do not compromise growing stock in the long term.

4.2 Determining the Base Case Harvest Level

Growing stock becomes stable when the rate of harvest equals the rate of growth of the forest. At low harvest levels stands are harvested after their MAI culmination age – if they have achieved their minimum harvestable volume – and the growing stock accumulates until an equilibrium is reached, often way into the future. If the harvest level is too high, the stands are harvested below their culmination age. This often causes a rapid decline of the growing stock until it can no longer support the desired harvest level.

In this analysis, a maximum sustainable even flow was established first. After this, the short-term harvest was elevated as high as possible without compromising the mid and long-term sustainability of the harvest forecast, i.e. the mid and long-term harvest level of the maximum sustainable even flow. The transitions to lower harvest levels were not allowed to exceed 10% per decade. If possible, the long-term harvest was elevated after the short-term harvest level was established.

4.3 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 harvest constraints correctly. Furthermore, sensitivity analyses also test the impact and risk of data uncertainties and modeling assumptions to the harvest level, particularly in the short-term.

In this TSR, there were several standard sensitivity analyses that were completed for each BCTS Business Area. In addition, each Business Area requested a set of sensitivity analyses that were of interest to them. For this reason, the number and kind of sensitivity analyses presented in this report vary from one Business Area to the other.

4.4 Alternative Harvest Forecasts

Because the Base Case represents only one in a number of theoretical forecasts, alternative harvest forecasts are also presented. Alternative harvest forecasts go hand-in-hand with the Base Case in that they are generally designed to support the base case as the most suitable depiction of future harvest in the TSA. They also make it easier to understand the timber supply dynamics in the TSA while providing a series of options that could be considered as alternatives to the base case.

Often alternative harvest forecasts investigate alternate ways of transitioning from the short term to the medium term and finally to the long term. Many analyses also include a maximum even flow as one of the alternative harvest forecasts.

5 Base Case, TKO

5.1 TKO Business Area

The analysis was completed separately for each BA. Blocks 1, 2 and 3 in Figure 24 depict the TKO BA.

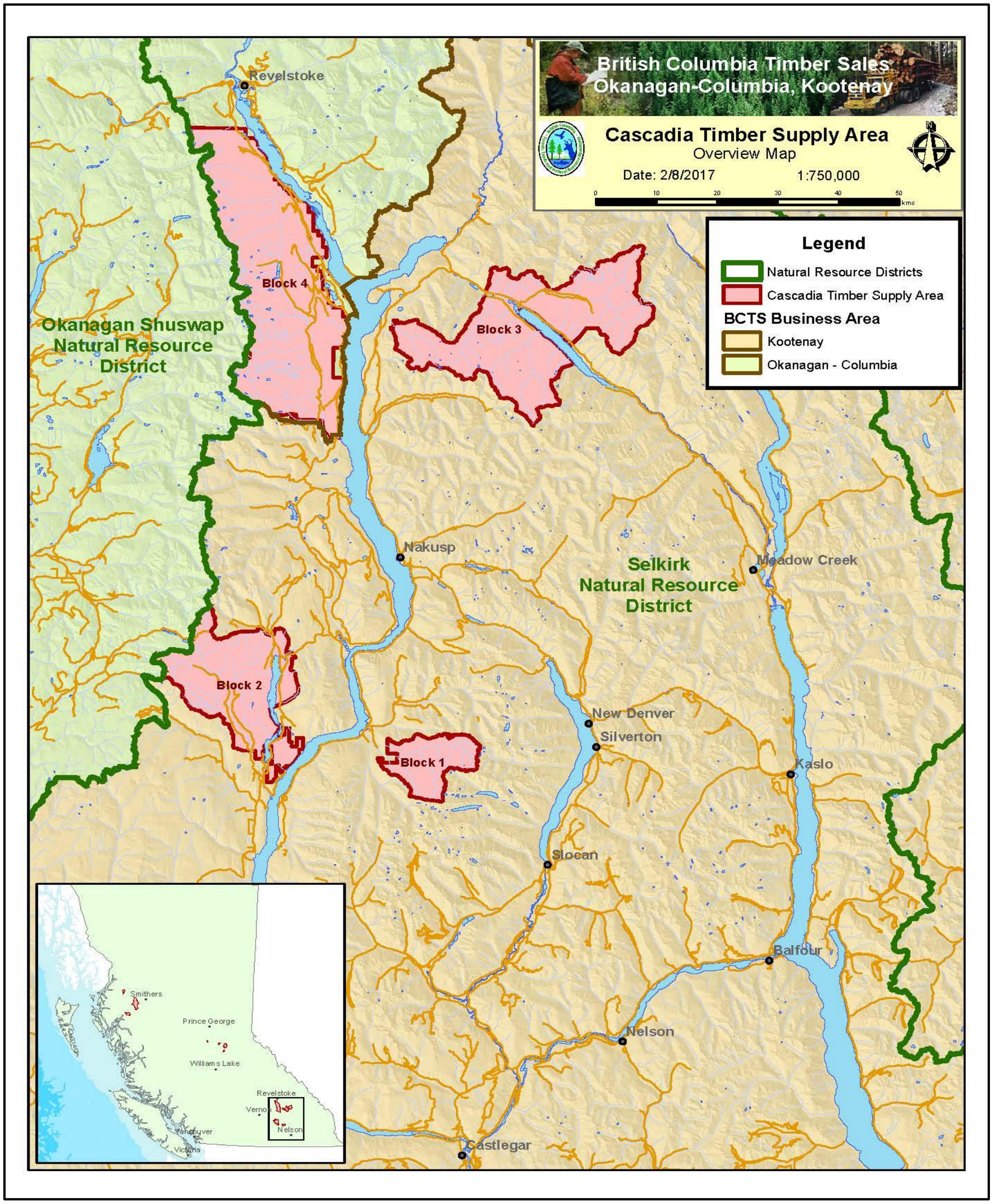

Figure 24: TKO BA: Blocks 1, 2 and 3

5.2 Harvest Forecast

The Base Case harvest forecast is illustrated in Figure 25. The initial harvest level of 101,450 m^3 per year is 9.9% less than the current AAC of 112,650 m^3 per year. The initial harvest level is maintained for 20 years, before the harvest is reduced by 10% to 91,570 m^3 per year for another 20 years. Two more steps are required until the mid-term harvest level of 76,000 m^3 per year is reached at year 61. The long-term harvest level of 78,470 m^3 per year is reached at year 196. In the Base Case 1,262 ha of the THLB (4.9%) remained unharvested at the end of the planning horizon. The highest volume first harvest rule selects stands for harvest based on their volume per ha. This harvest rule leaves some of the lower volume stands out of the harvest queue by "recycling" the more productive stands at their expense. Table 17 summarizes the TKO Base Case.

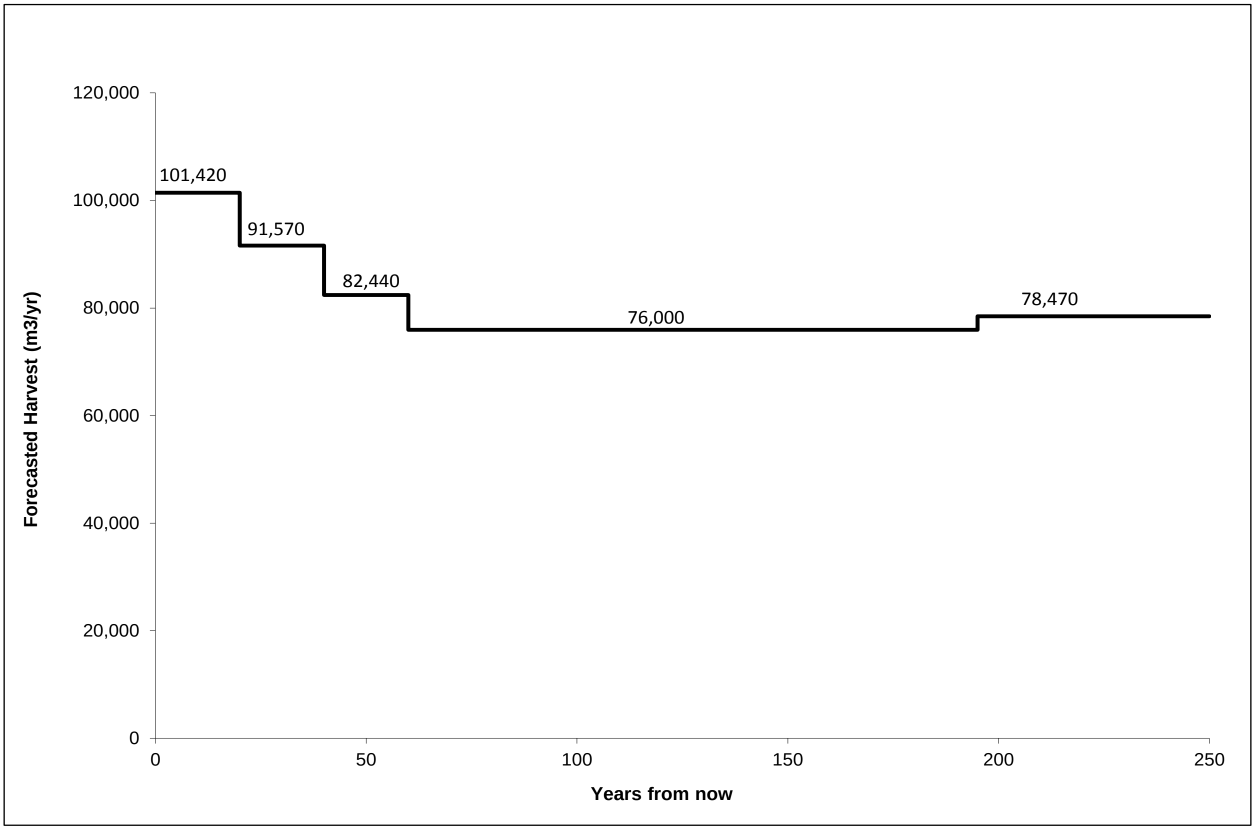

Figure 25: Base Case harvest forecast; TKO

Table 17: Harvest forecast summary, TKO

Period	Predicted Harvest (m^3 per year)	Unharvested THLB (ha)
Years 1 to 20:	101,420 m^3	1,262 ha (4.9%)
Years 21 to 40	91,570 m^3	
Years 41 to 60	82,440 m^3	
Years 66 to 195	76,000 m^3	
Years 195 to 250 (LTHL)	78,470 m^3	

5.3 Growing Stock

Figure 26 depicts the predicted growing stock for the TKO Base Case. The merchantable or mature growing stock remains relatively high. This suggests that harvest is not limited by lack of timber, but by constraints such as VQOs, seral targets, habitat targets etc.

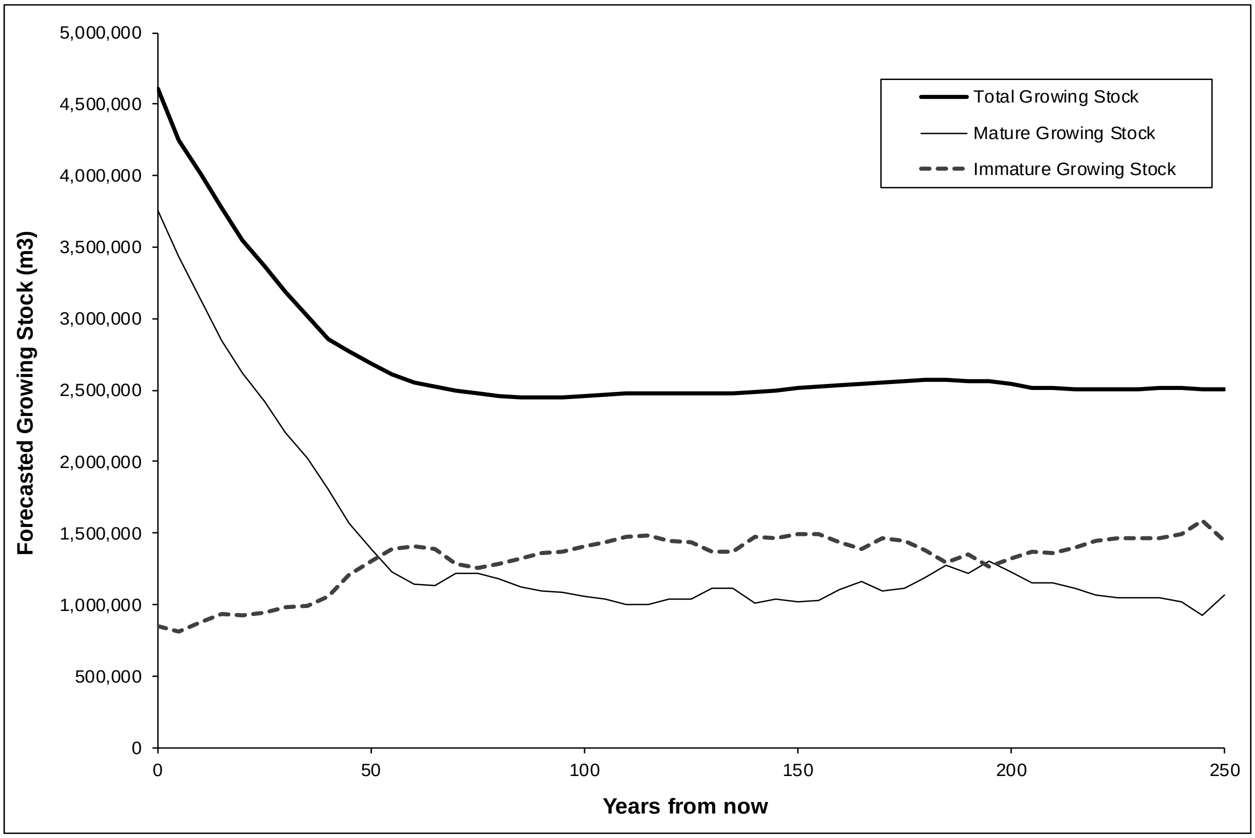

Figure 26: Predicted growing stock development; Base Case, TKO

5.4 Harvest Age, Harvest Volume and Harvest Area

Figure 27 shows the TKO harvest forecast by age class. Almost the entire harvest is predicted to come from stands older than 80 years during the first 40 years of the planning horizon. The harvest of age class 4 stands (age between 61 and 80) is expected to increase starting in year 41 and in the medium and long term these stands are predicted to form most of the future harvest. In the long term, almost the entire harvest is predicted to come from age class 4 and age class 5 stands. Figure 28 illustrates the average harvest age for the TKO Base Case, which settles at around 80 years in the long term.

Figure 29 shows the TKO harvest forecast by vol/ha class. In the medium and long terms up to 80% of the harvest is predicted to come from stands with the volume between 200 and 300 m^3 per ha. This corresponds with predicted average harvest volume of around 250 m^3 per ha in the long term (Figure 30). The annual average harvest area is predicted to be just above 300 ha with some fluctuations (Figure 31).

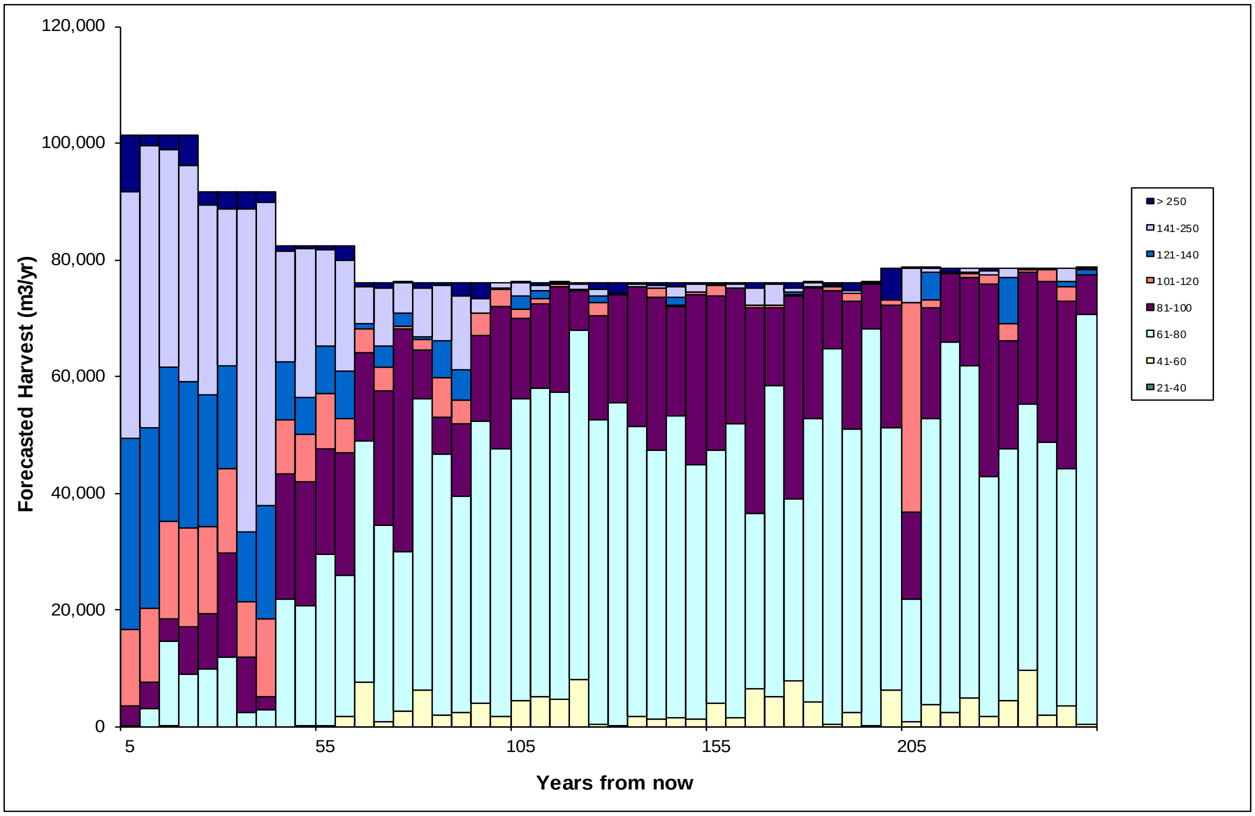

Figure 27: Base Case harvest forecast by age class; TKO

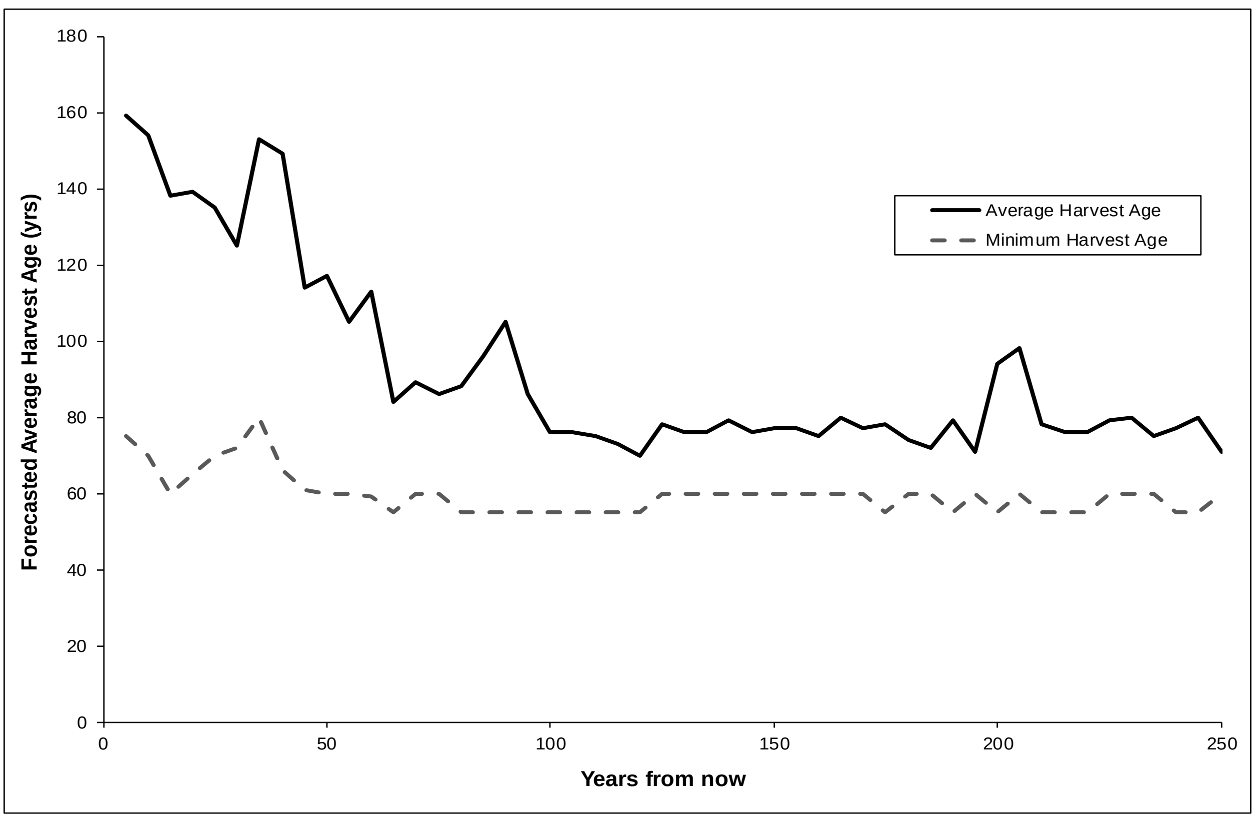

Figure 28: Average harvest age: Base Case; TKO

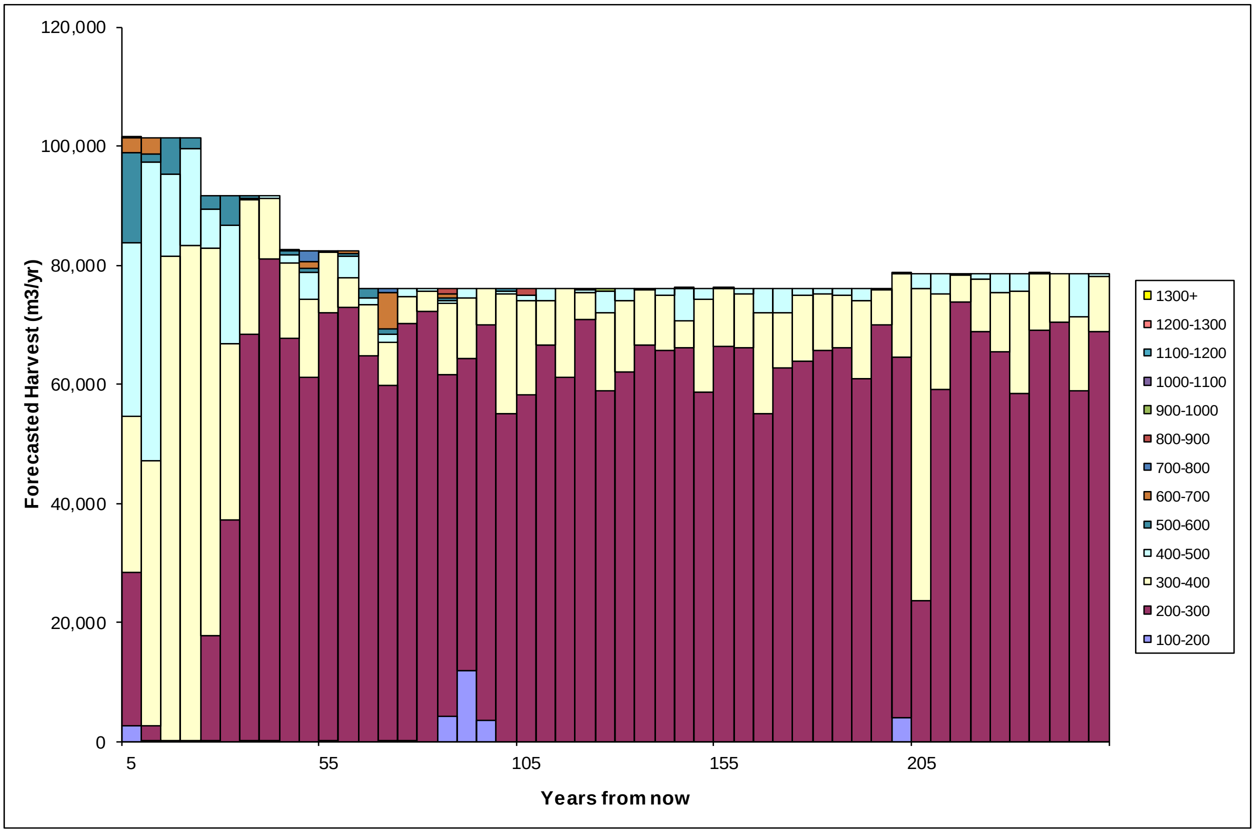

Figure 29: Base Case harvest forecast by volume per ha class; TKO

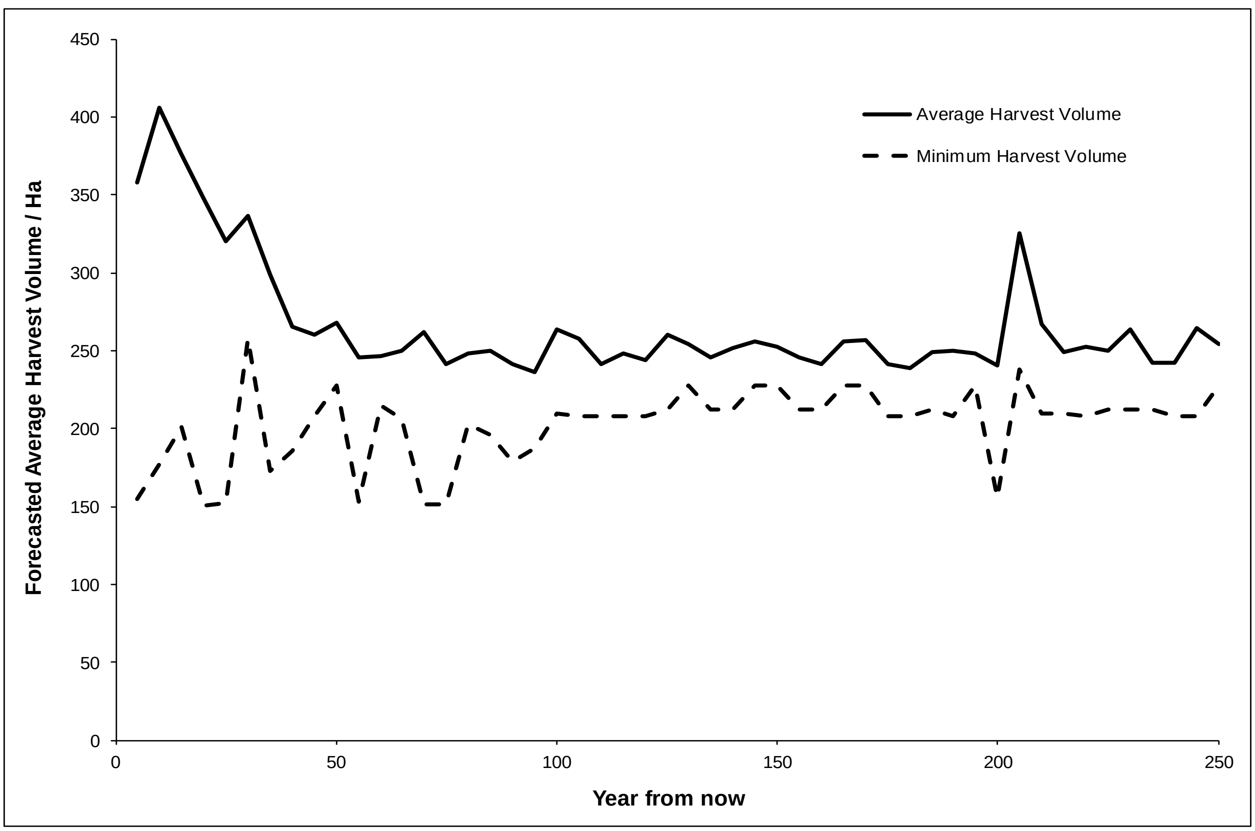

Figure 30: Average harvest volume per ha; Base Case; TKO

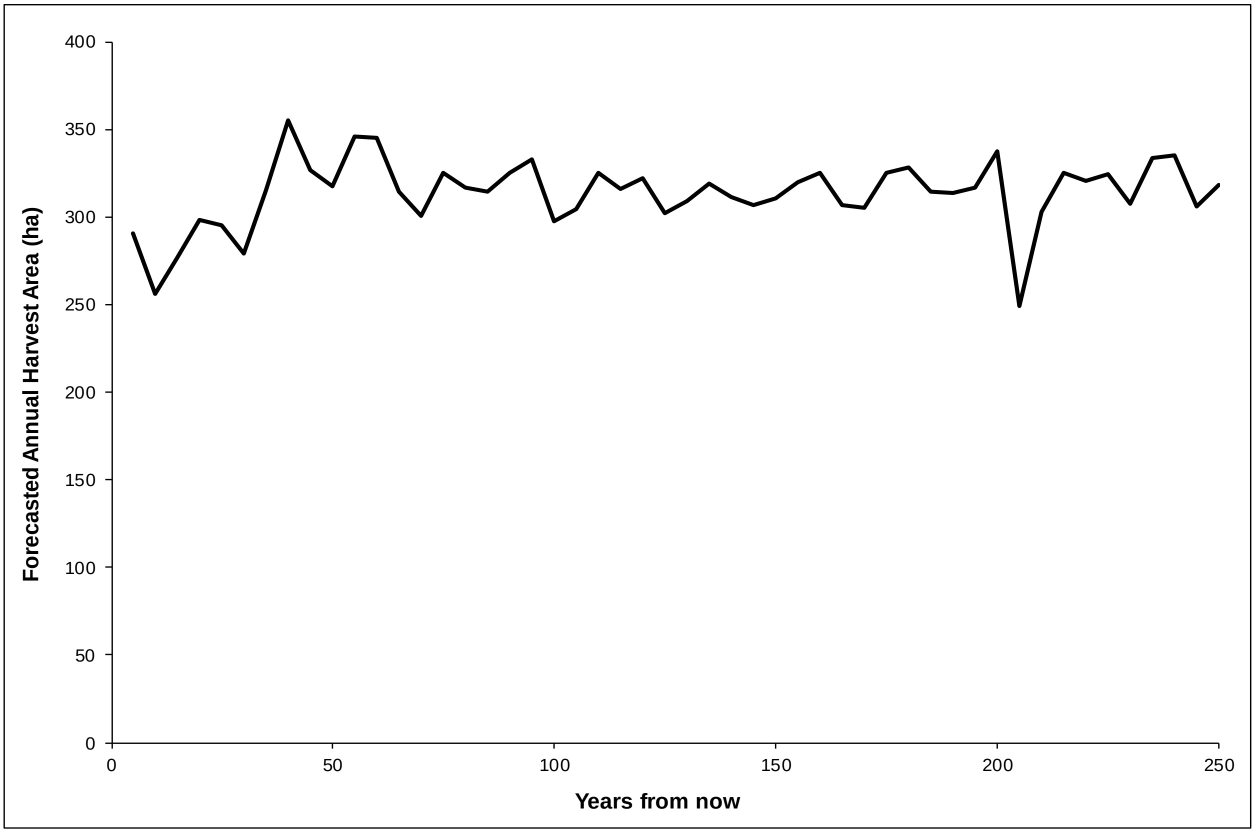

Figure 31: Average annual harvest area (ha); Base Case; TKO

5.5 Composition of Harvest by Yield Type, Species and Block

Figure 32 illustrates the TKO Base Case harvest forecast by yield type. The transition to managed stands is predicted to start after 35 years and by year 100 almost the entire harvest is predicted to come from managed stands.

Figure 33 provides the harvest forecast by species. Note that while the species composition of the predicted harvest from natural and existing managed stands is based on the forest cover inventory, the future species profile reflects general assumptions about current regeneration and planting practices within the TKO Business Areas in the Cascadia TSA. The predicted species profile for the first 50 or so years of the planning horizon is therefore more reliable than that of the long-term.

Figure 34 shows the Base Case harvest forecast by Block.

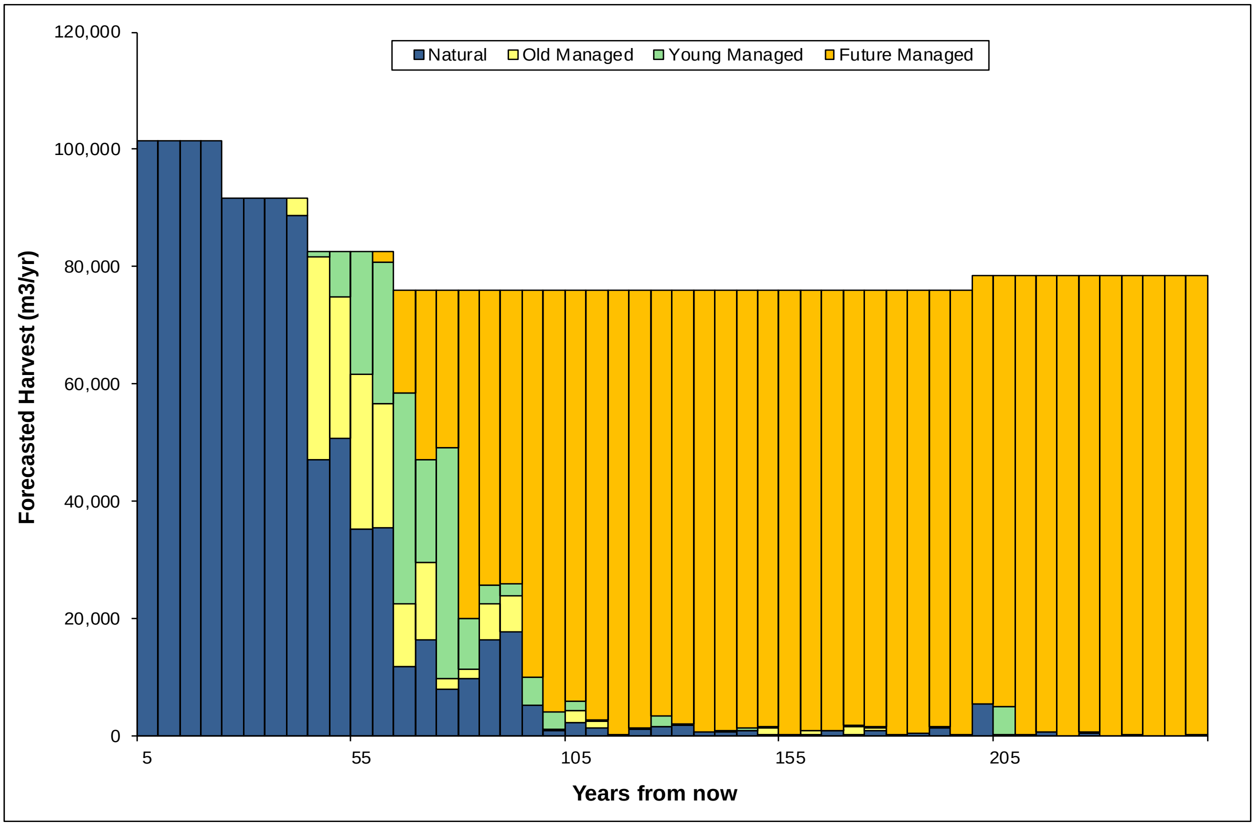

Figure 32: Base Case harvest forecast by yield type; TKO

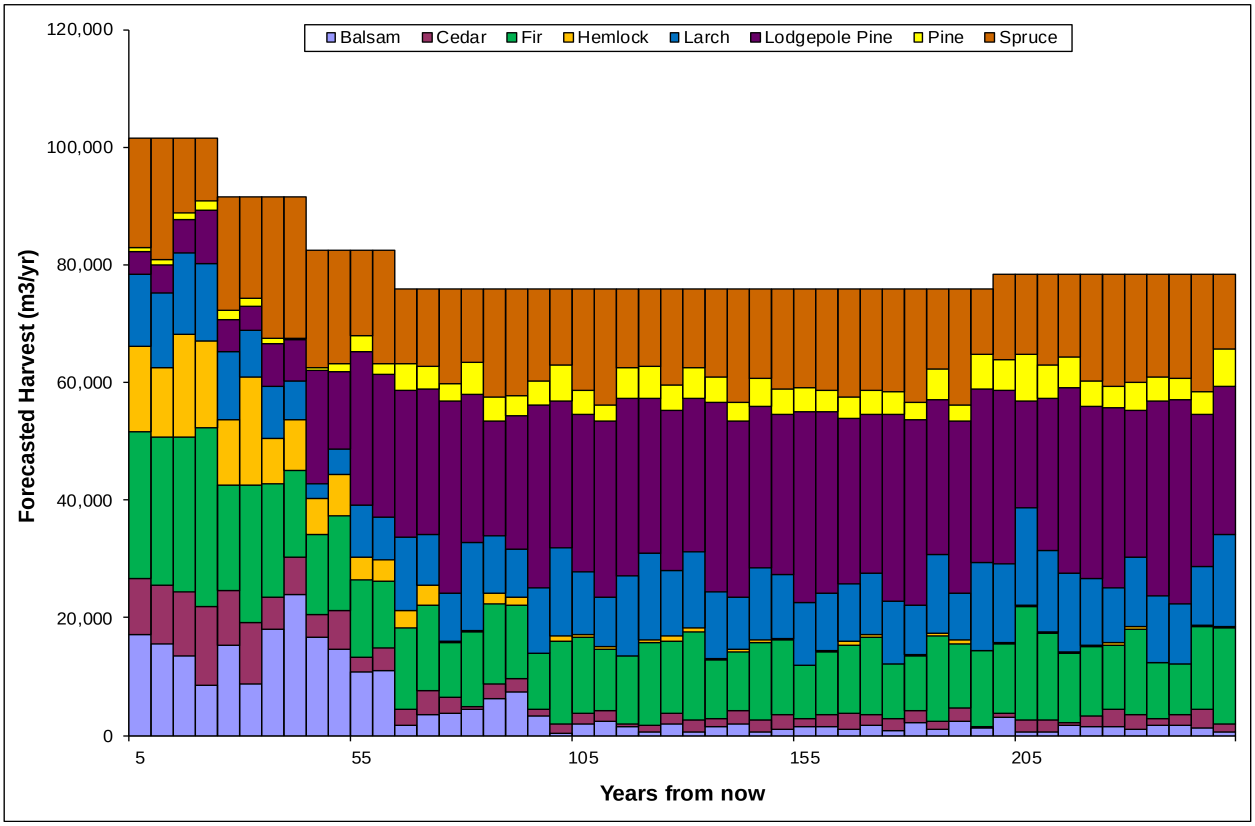

Figure 33: Base Case harvest forecast by species; Base Case; TKO

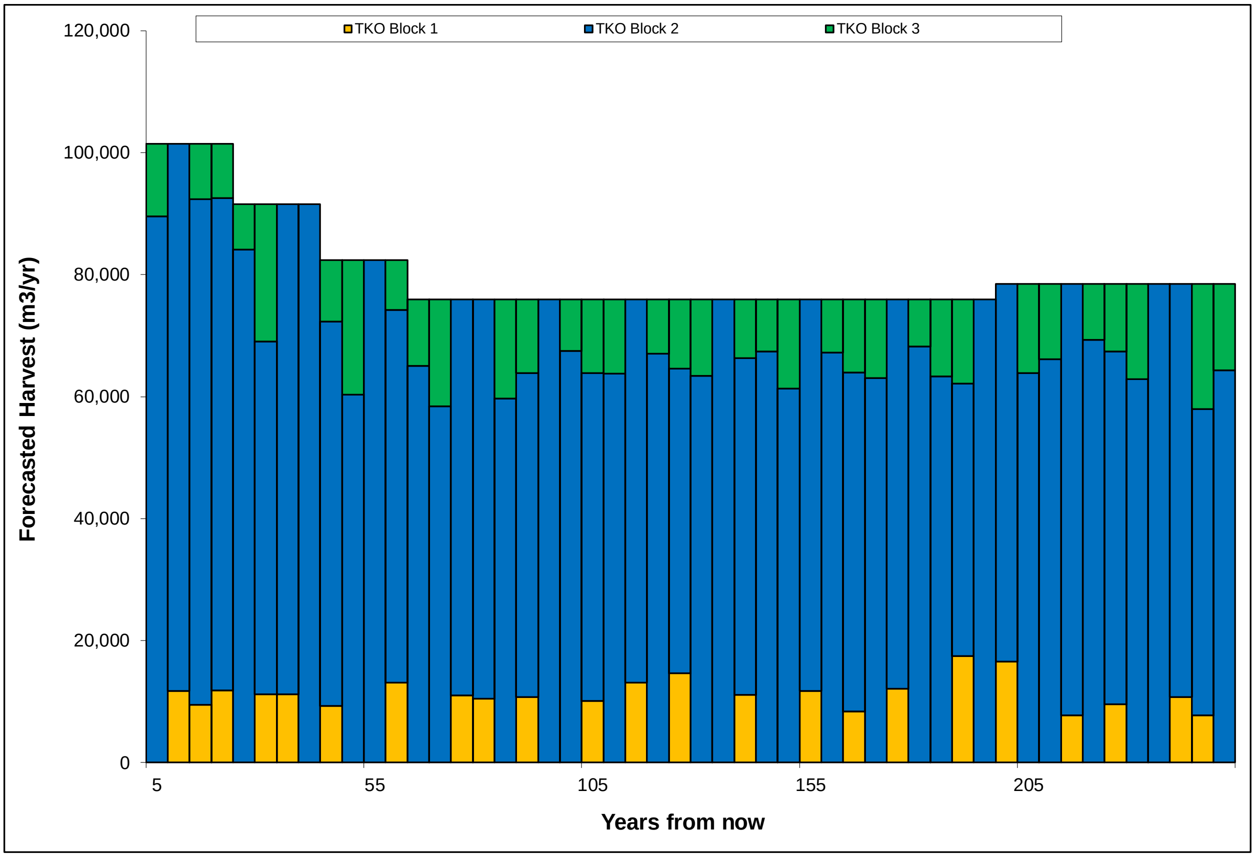

Figure 34: Base Case harvest forecast by Block; TKO

5.6 Age Structure

Figure 35, Figure 36, Figure 37, Figure 38, Figure 39 and Figure 40 illustrate the projected age class structure of the forest, should the Base Case harvest schedule be followed. In the course of time, most of the NHLB will become late seral (over 250 years of age). The harvest would occur in the THLB, which would not generally age much beyond 100 years. Most of the harvest is expected to come from age class 4 and 5 stands in the long run.

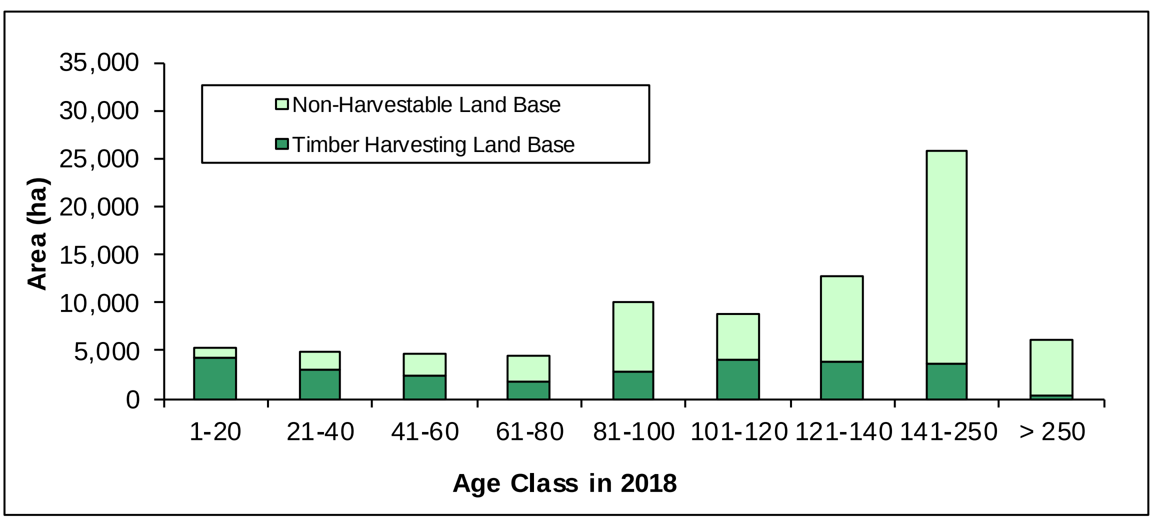

Figure 35: Current age class distribution, TKO

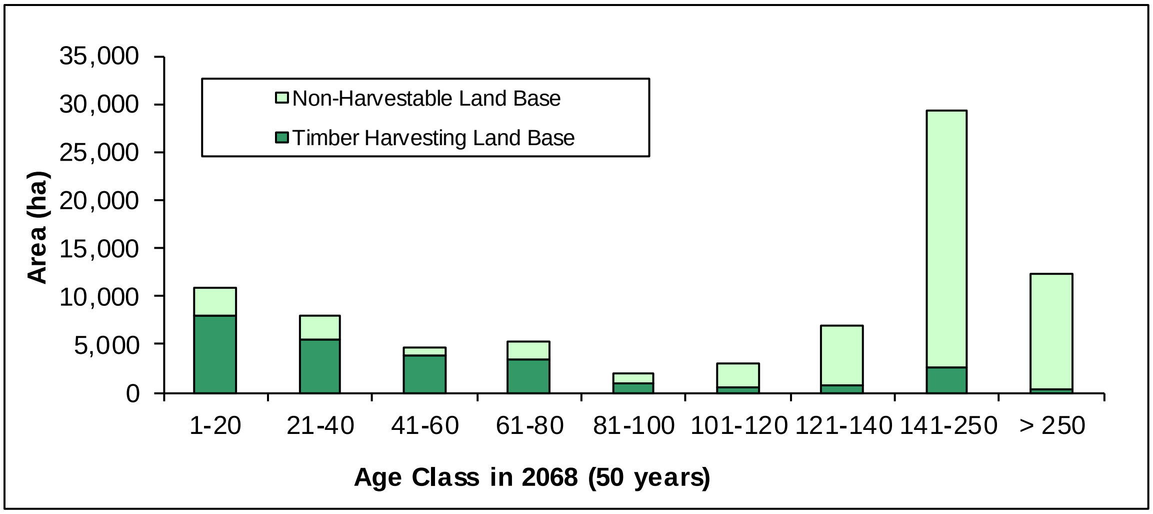

Figure 36: Projected age class distribution in 50 years, TKO

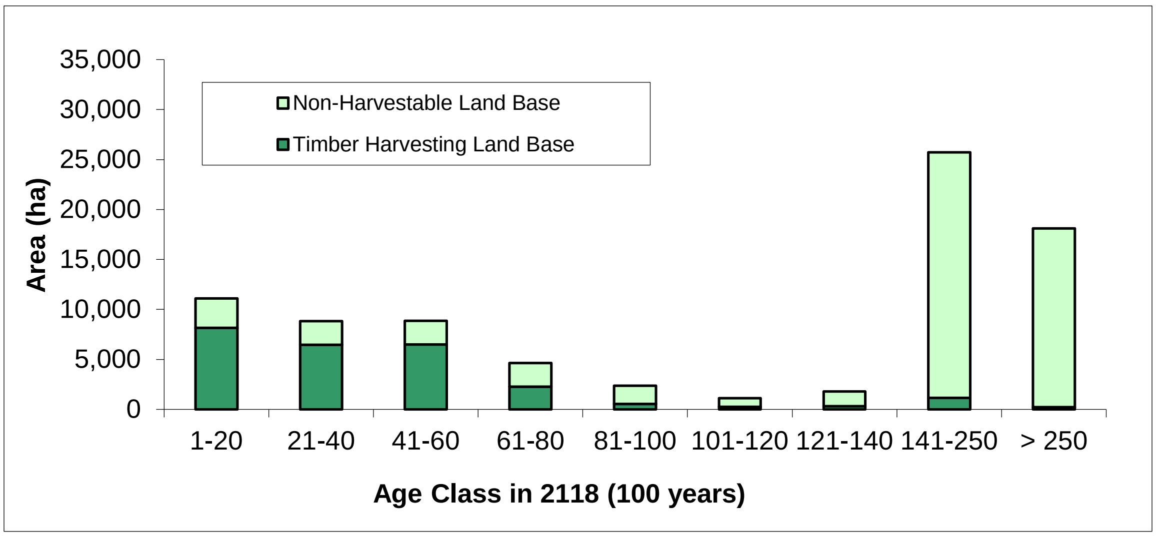

Figure 37: Projected age class distribution in 100 years, TKO

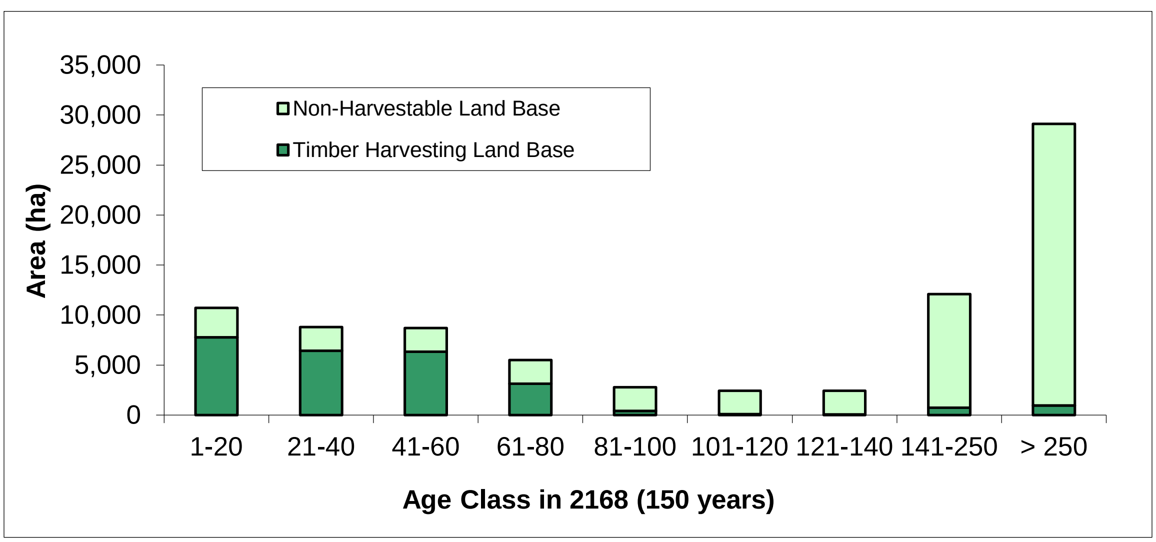

Figure 38: Projected age class distribution in 150 years, TKO

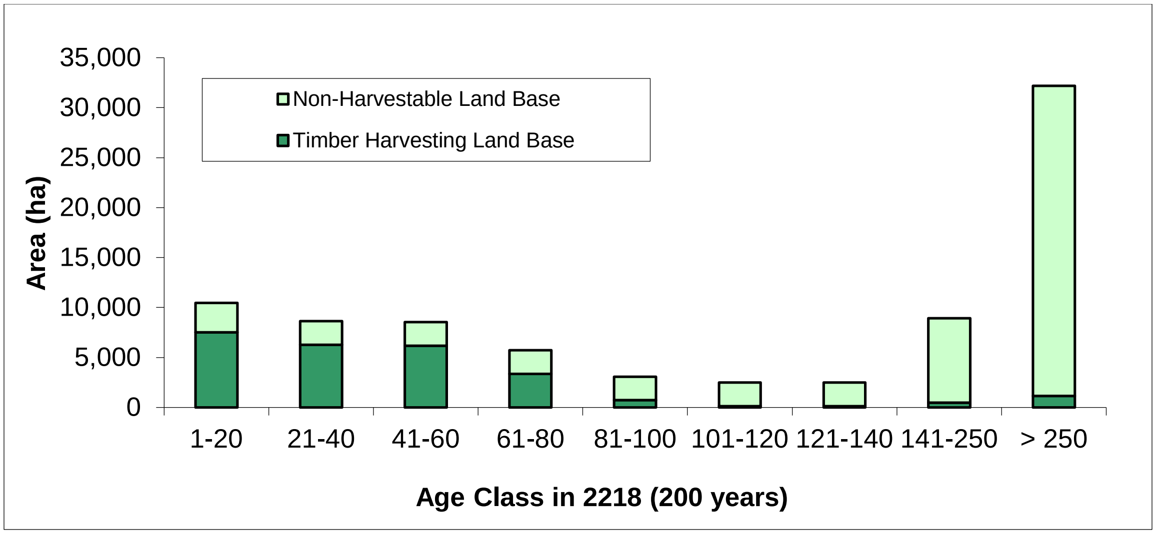

Figure 39: Projected age class distribution in 200 years, TKO

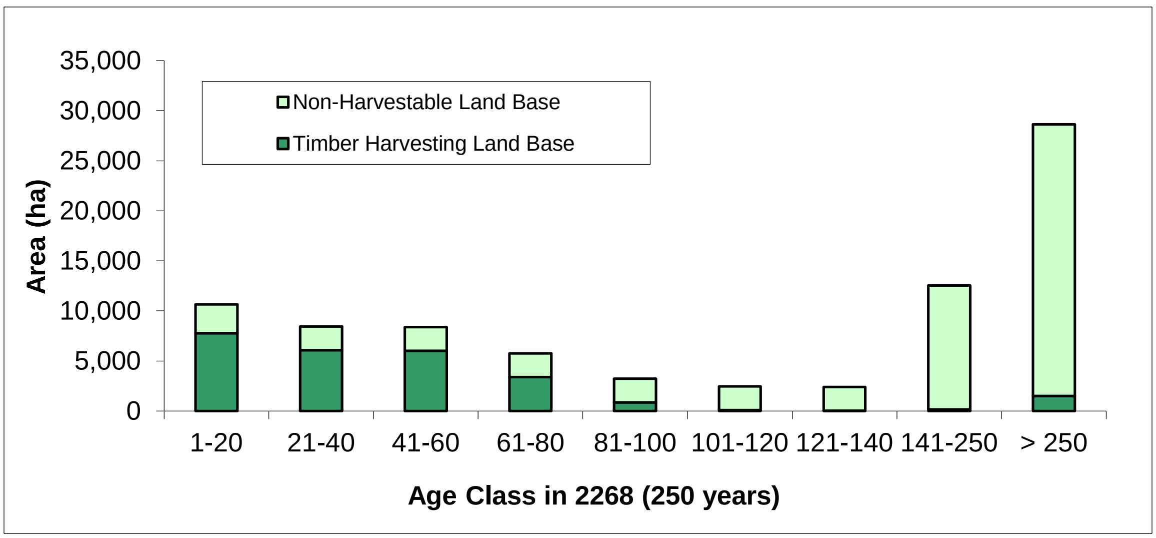

Figure 40: Projected age class distribution in 250 years, TKO

5.7 Sensitivity Analyses, TKO

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 harvest constraints correctly. Furthermore, sensitivity analyses also test the impact and risk of data uncertainties and modeling assumptions to the harvest level, particularly in the short-term. Table 18 presents a summary of the sensitivity analyses that were carried out to test the various uncertainties that exist in the Base Case data and assumptions.

Table 18: Summary of sensitivity analyses; TKO

Issue	Sensitivity analysis
Minimum harvest criteria	Consider only minimum harvest volume for **all** stands and remove the 95% MAI culmination rule.
	Increase minimum harvest volume (MHV) of **all** stands by 50 m^3 per ha, maintain 95% MAI culmination rule.
	Increase minimum harvest volume (MHV) of **all** stands by 100 m^3 per ha, maintain 95% MAI culmination rule.
	Decrease minimum harvest volume (MHV) of **all** stands by 50 m^3 per ha, remove 95% MAI culmination rule.
	Increase minimum harvest volume (MHV) of **managed** stands by 50 m^3 per ha, maintain 95% MAI culmination rule.
	Increase minimum harvest volume (MHV) of **managed** stands by 100 m^3 per ha, maintain 95% MAI culmination rule.
Volume of existing natural stands	Increase natural stand volumes by 10%
	Decrease natural stand volumes by 10%
Volume of managed stands	Increase managed stand volumes by 10%
	Decrease managed stand volumes by 10%
Marginal timber	Include the Payne Creek area and helicopter operable area in the THLB
Harvest rule	Use a relative oldest first harvest rule
BEC version	Use a different BEC version
Armillaria (root disease) impact	Remove custom operational adjustment factors (OAF 2) to test impact of not considering Armillaria
Green-up	Maximum 33% of THLB in each LU less than green-up height
	Maximum 20% of THLB in each LU less than green-up height
Woodsheds	Remove minimum periodic harvest requirements for woodsheds

5.7.1 Minimum Harvest Criteria

In the Base Case, the stands can be harvested once they reach a volume of 150 m^3 per ha for ground-based operations and 200 m^3 per ha for cable operations. The stands must also reach the age at which the mean annual increment (MAI) of the stand achieves a value of 95 percent of the maximum (culmination).

Minimum harvestable volumes may be lower in good market conditions and at times higher volumes may be required for the harvest to be economic. In these sensitivity analyses the minimum harvest volumes were increased and decreased. The 95% MAI culmination rule was maintained, unless otherwise noted.

5.7.1.1 Consider Only Minimum Harvest Volume for All Stands

In this sensitivity analysis, only the minimum harvest volume criteria were considered, while the 95% MAI culmination rule was ignored. This effectively reduced the earliest age at which stands – particularly managed stands – could be harvested. The mid-term timber supply was marginally impacted as illustrated in Figure 41; it was reduced by less than one percent. The long-term forecast decreased by 3.8%.

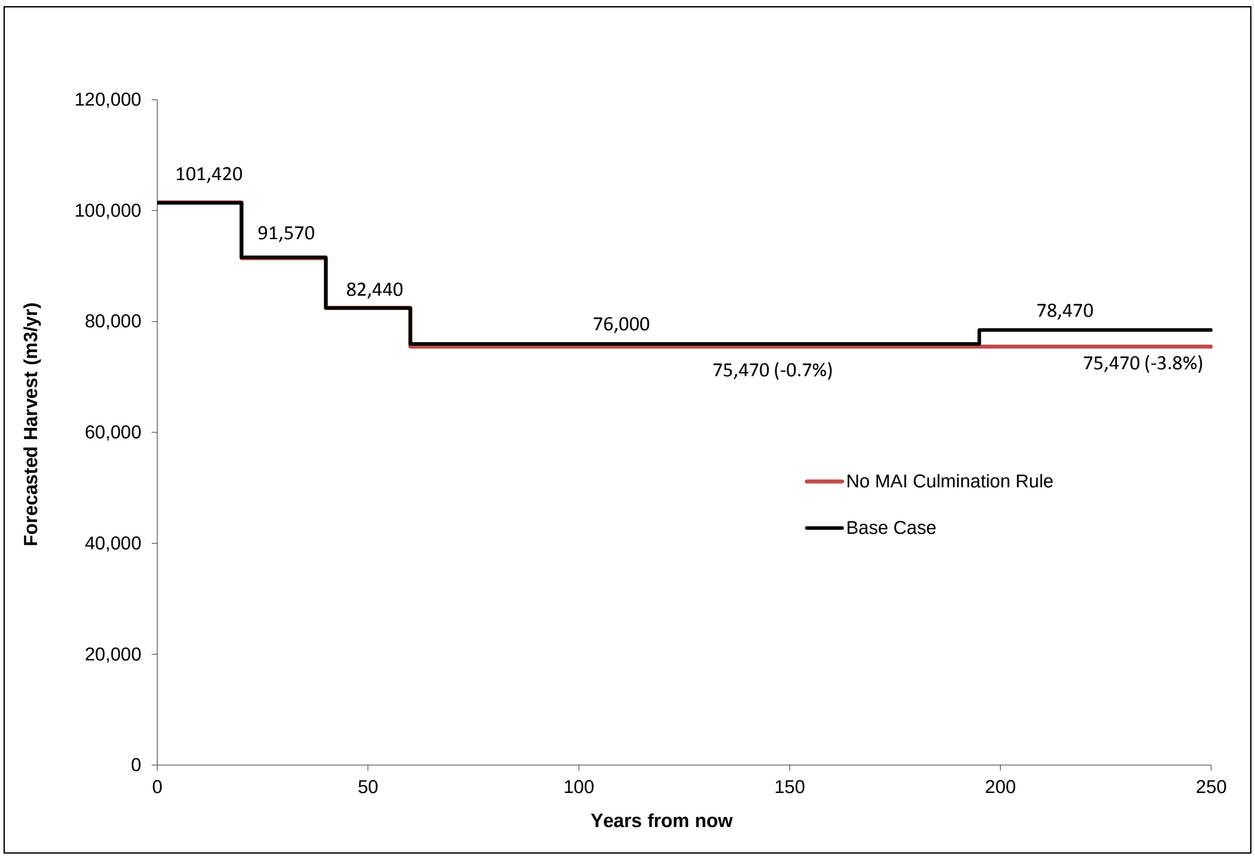

Figure 41:Sensitvity analysis; ignore MAI culmination rule, TKO

5.7.1.2 *Increase Minimum Harvest Volume of All stands by 50 m^3 per ha*

This sensitivity analysis increased the minimum harvest volume (MHV) of all stands by 50 m^3 per ha to 200 m^3 per ha for ground-based operations and 250 m^3 per ha for cable operations. The 95% MAI culmination rule was also enforced.

Increasing the MHV for all stands effectively removes some natural stands from the THLB, because they never meet the increased MHV. In the Base Case, 1,262 ha (4.9%) of THLB is never harvested. In this sensitivity analysis the model did not harvest 2,594 ha (10.0%) of the THLB during the planning horizon. The impact was significant (Figure 42). The short-term harvest was reduced by 19.6 %, while the mid-term reduction ranged from 1.9% to 18.7%. The long-term forecast was reduced by 5.1%.

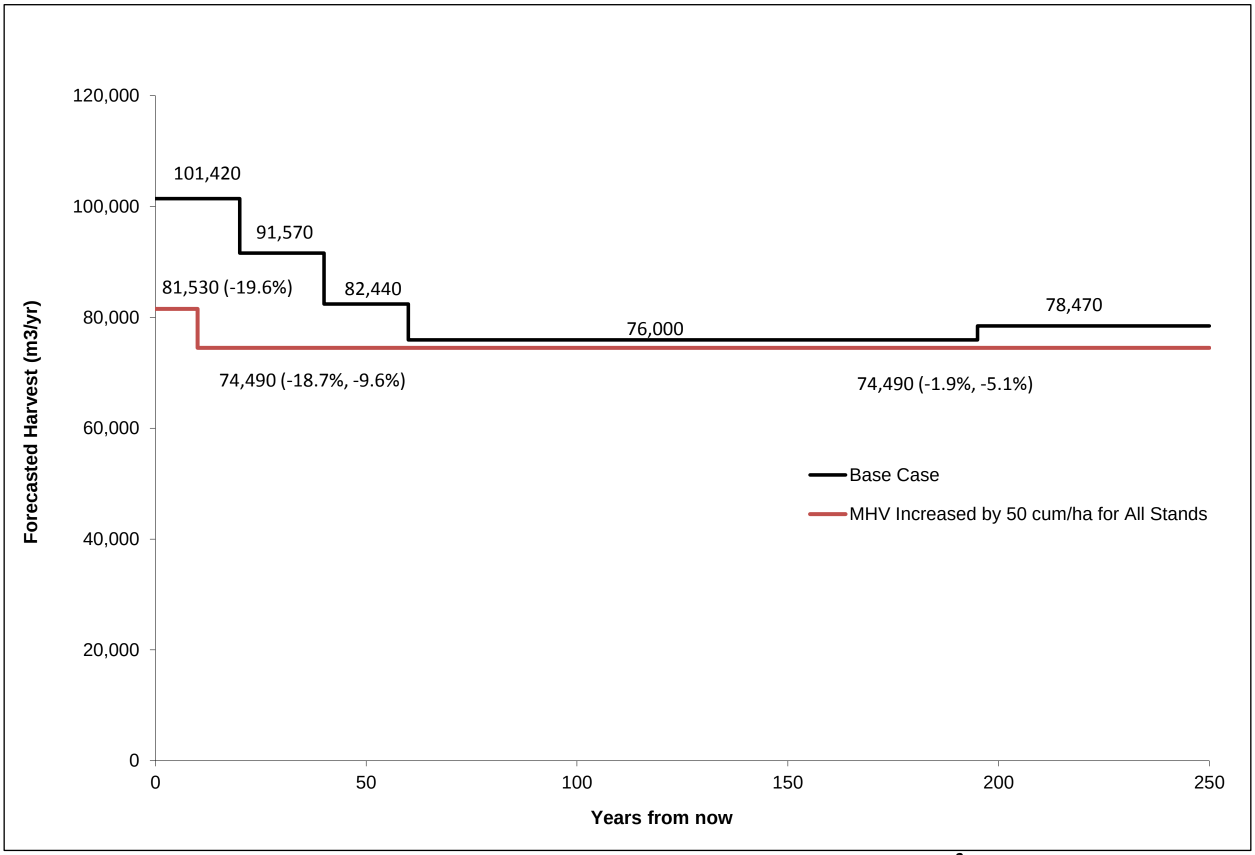

Figure 42: Sensitivity analysis; increase minimum harvest volume of all stands by 50 m^3/ha, TKO

5.7.1.3 Increase Minimum Harvest Volume of All stands by 100 m^3 per ha

This sensitivity analysis increased the MHV of all stands by 100 m^3 per ha to 250 m^3 per ha for ground-based operations and 300 m^3 per ha for cable operations. The 95% MAI culmination rule was also enforced.

In this sensitivity analysis, 4,955 ha (19.1%) of the THLB was left unharvested due to the high volumes required for harvesting. The short-term harvest was reduced by 29.5 %, while the mid-term reduction ranged from 11.2% to 26.3% (Figure 43). The long-term forecast was reduced by 14.0 %.

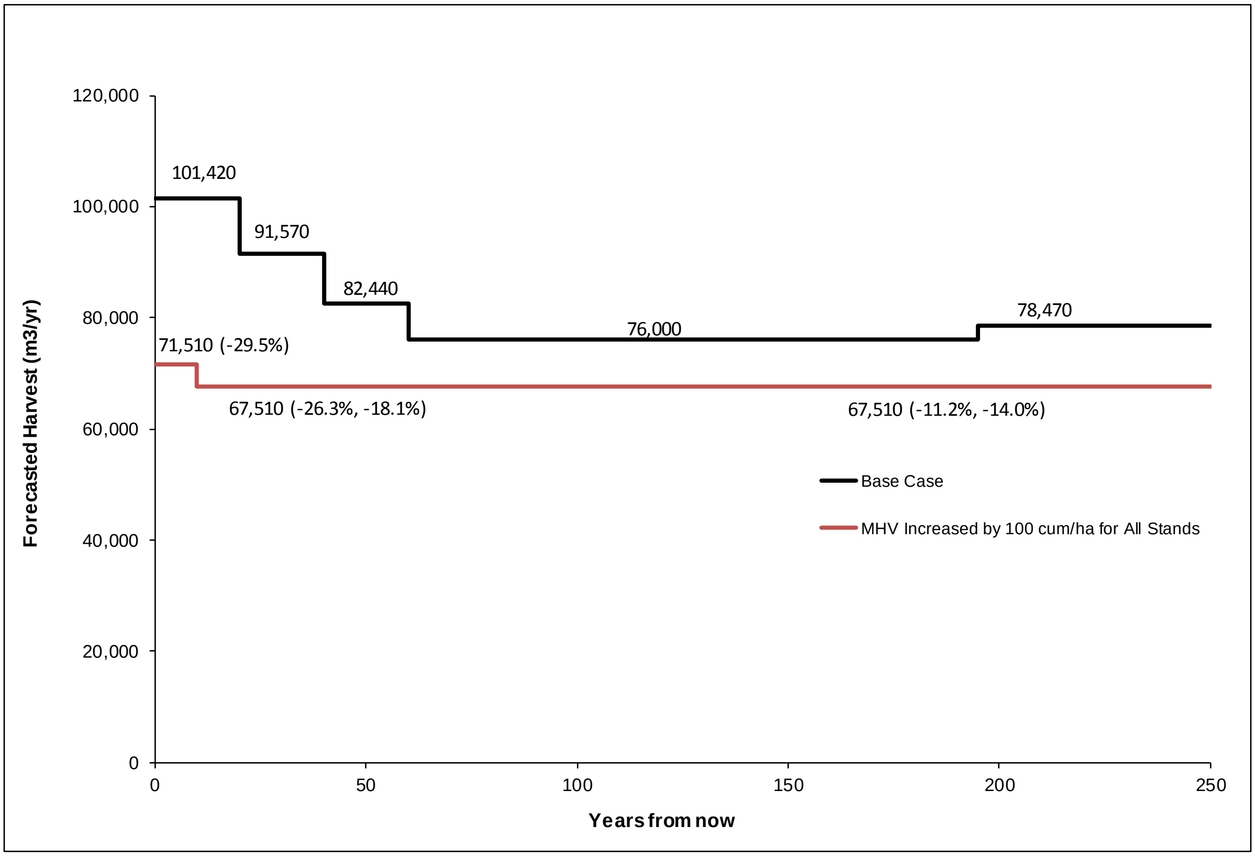

Figure 43: Sensitivity analysis; increase minimum harvest volume of all stands by 100 m^3/ha, TKO

5.7.1.4 Decrease Minimum Harvest Volume of All stands by 50 m^3 per ha

This sensitivity analysis decreased the MHV of all stands by 50 m^3 per ha to 100 m^3 per ha for ground-based operations and 150 m^3 per ha for cable operations. The 95% MAI culmination rule was ignored.

Reducing the MHV for all stands allowed the timber supply model to harvest young managed stands earlier than in the Base Case. In many cases, the harvest of these young stands occurs several years before their MAI culmination. This erodes the growing stock, forcing a lower harvest level in the long term and leading into a lower mid and long-term harvest forecast than in the Base Case. The mid-term harvest forecast and the long-term harvest forecast are reduced by 1.4% and 4.5% respectively (Figure 44).

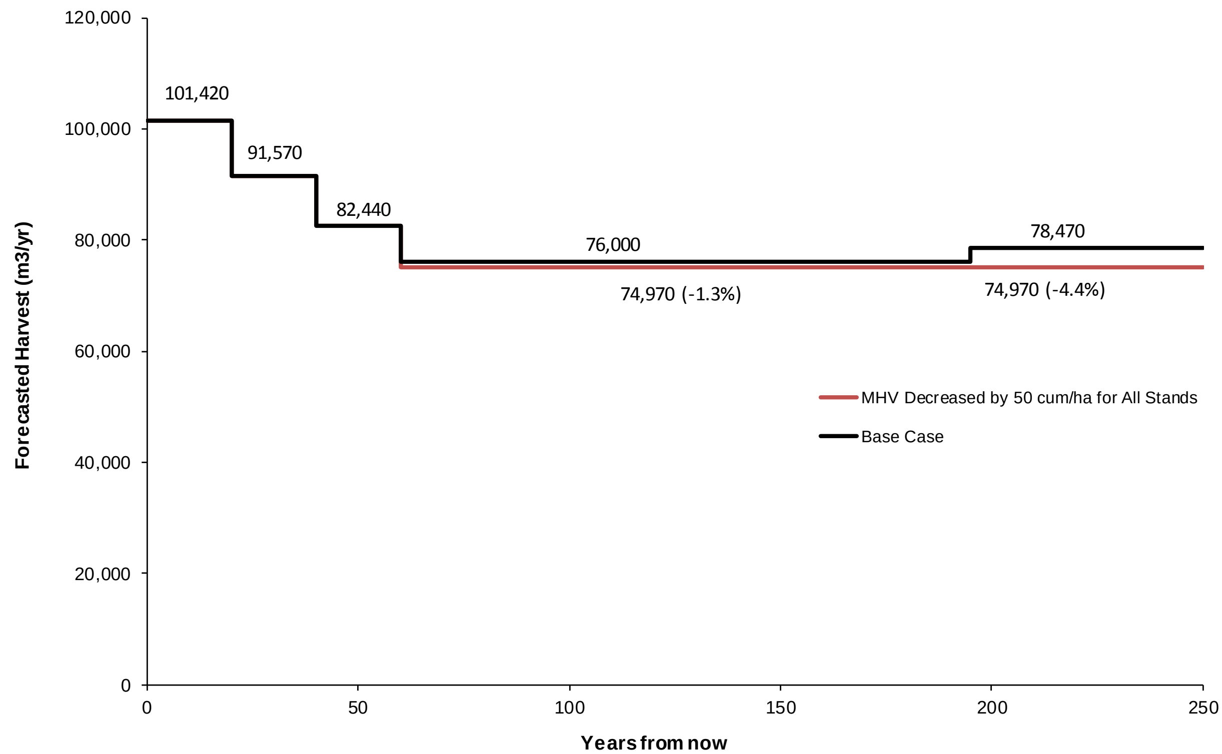

Figure 44: Sensitivity analysis; decrease minimum harvest volume of all stands by 50 m^3/ha, TKO

5.7.1.5 Increase Minimum Harvest Volume of Managed Stands by 50 m^3 per ha

This sensitivity analysis increased the MHV of managed stands by 50 m^3 per ha to 200 m^3 per ha for ground-based operations and 250 m^3 per ha for cable operations. The 95% MAI culmination rule was enforced.

There is adequate growing stock in the THLB to support the transition to managed stands even with the 50 m^3 per ha increase in the MHV for managed stands; the short-term harvest or the mid-term harvest were not impacted. The long-term harvest level was elevated by 2.6% (Figure 45), and the transition to the long-term harvest level occurred 20 years earlier than in the Base Case.

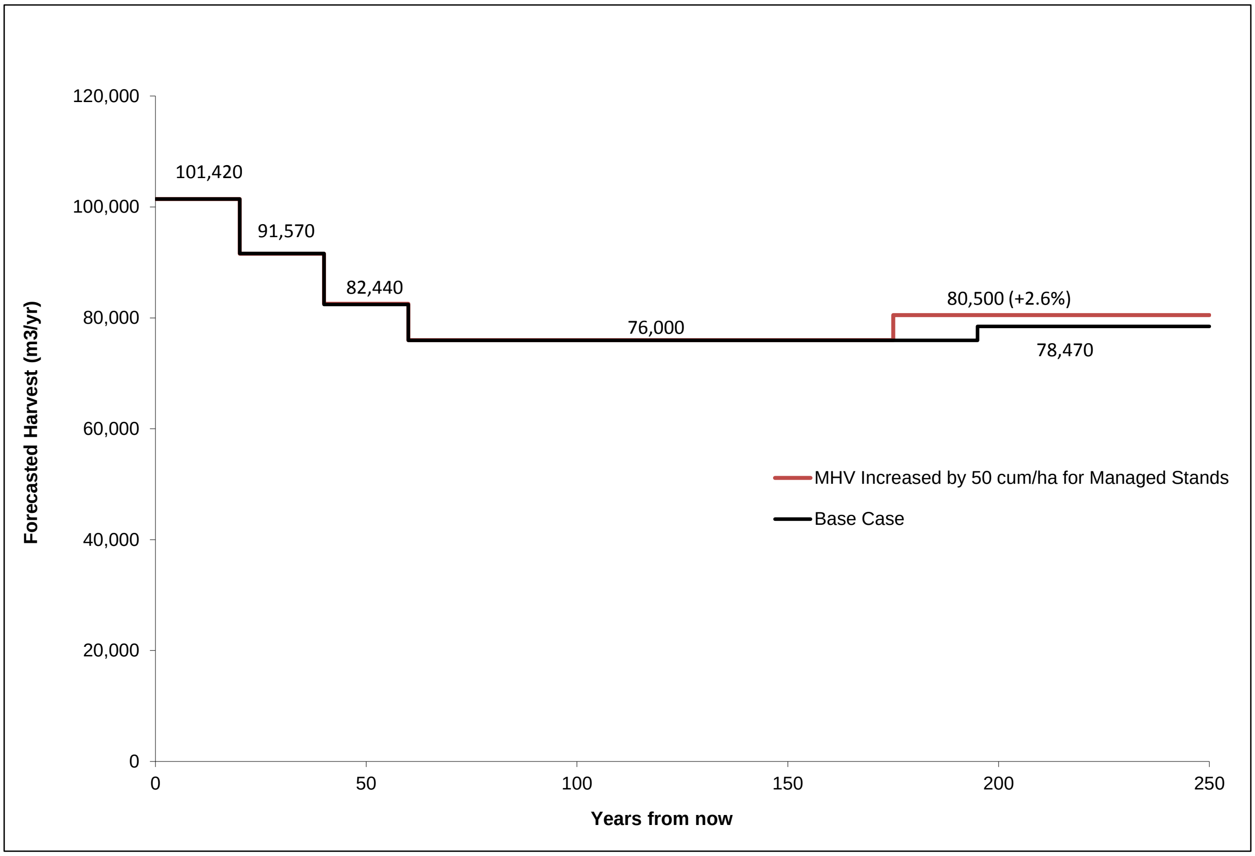

Figure 45: Sensitvity analysis; increase the MHV of managed stands by 50 m^3 per ha, TKO

5.7.1.6 Increase Minimum Harvest Volume of Managed Stands by 100 m^3 per ha

This sensitivity analysis increased the MHV of managed stands by 100 m^3 per ha to 250 m^3 per ha for ground-based operations and 300 m^3 per ha for cable operations. The 95% MAI culmination rule was enforced.

The harvest has to be reduced in the first 60 years, because the current growing stock is not high enough to support the transition to managed stands, if their MHV is increased as much as 100 m^3 per ha (Figure 46). Depending on the time period between 4.8% and 9.8% less timber is harvested in the first 60 years. However, starting at year 61, the predicted harvest level is 3.3% higher than in the Base Case. The long-term harvest level was elevated by 2.6%.

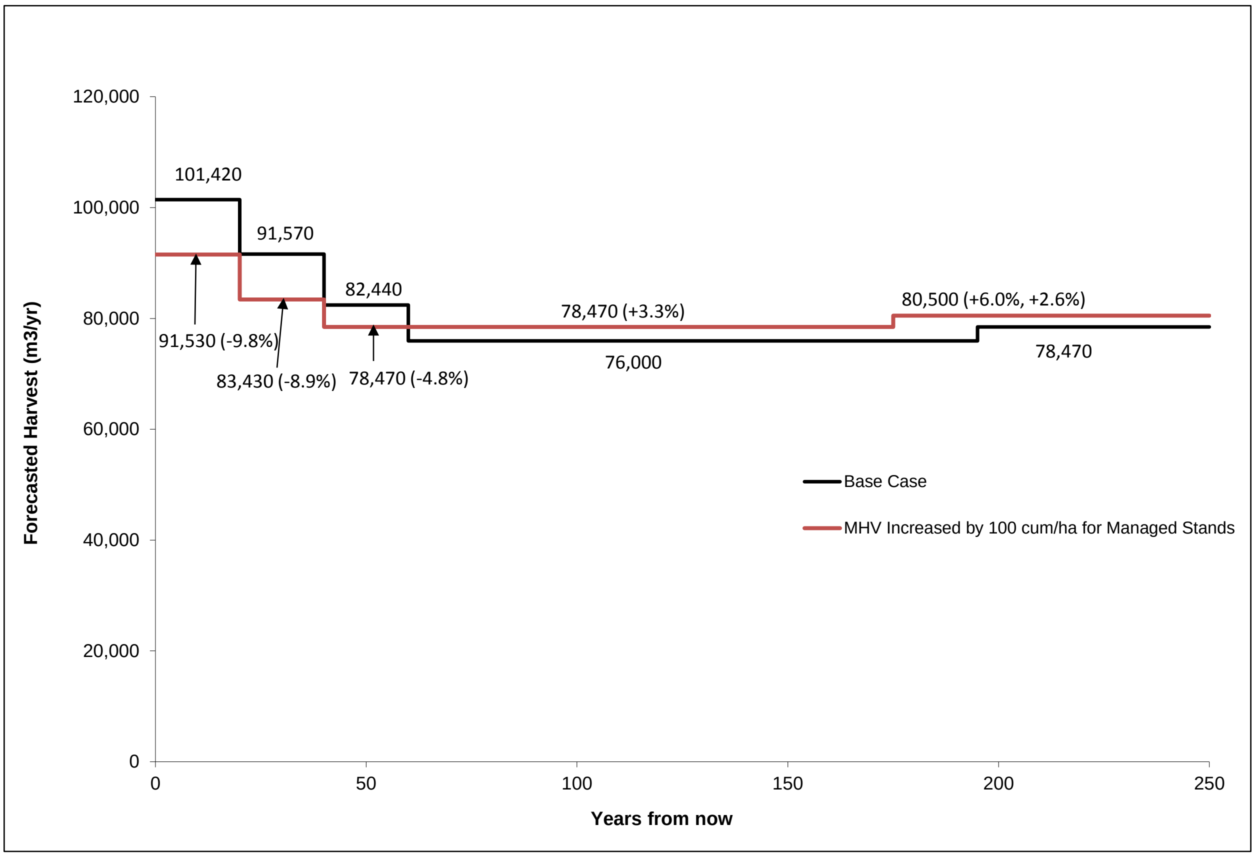

Figure 46: Sensitvity analysis; increase the MHV of managed stands by 100 m^3 per ha, TKO

5.7.2 Uncertainty of Predicted Inventory Volumes

The purpose of this sensitivity analysis is to test the risk associated with an overestimation in volumes predicted by the VRI. While underestimation of the inventory volumes poses no risk to timber supply, its impact was tested as well.

5.7.2.1 Increase Natural Stand Volumes by 10%

Increasing the natural stand volumes by 10% elevated the timber supply forecast by 11.0% in the first 15 years of the planning horizon (Figure 47) and by year 65 approximately 5.8% more timber is predicted to be harvested than in the Base Case. The long-term forecast was not impacted.

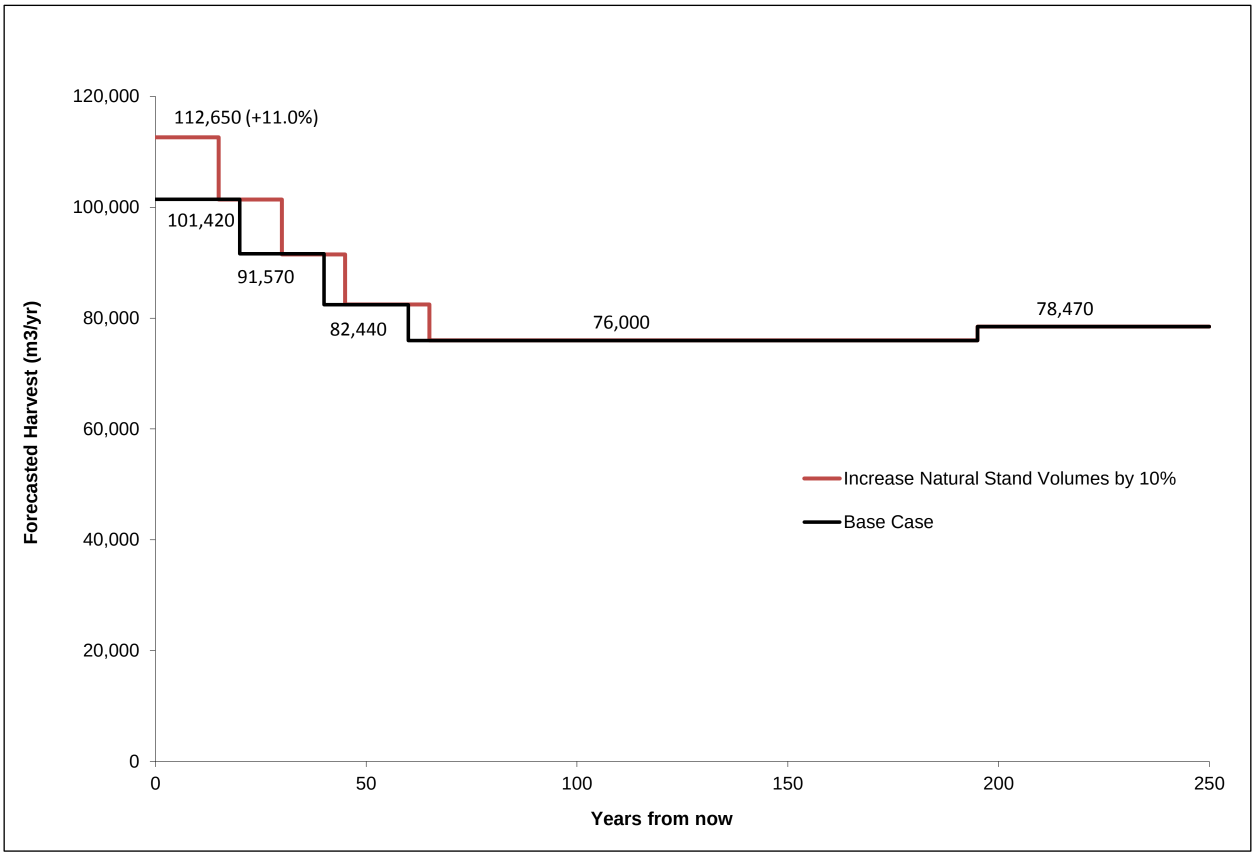

Figure 47: Sensitvity analysis; increase natural stand volumes by 10%, TKO

5.7.2.2 Decrease Natural Stand Volumes by 10%

Reducing the natural stand volumes by 10% decreased the timber supply forecast by 15.9% in the first 60 years of the planning horizon – between 10.6% and 20.7% depending on the period (Figure 48). The harvest forecast remained below the Base Case level in the medium term and the long-term forecast was reduced by 2.5% compared to the Base Case. Decreasing the natural stand volumes caused more THLB to remain unharvested than in the Base Case; in this sensitivity analysis 7.9% of the THLB was never harvested (4.9% in the Base Case). As less THLB was harvested, the long-term harvest level was impacted.

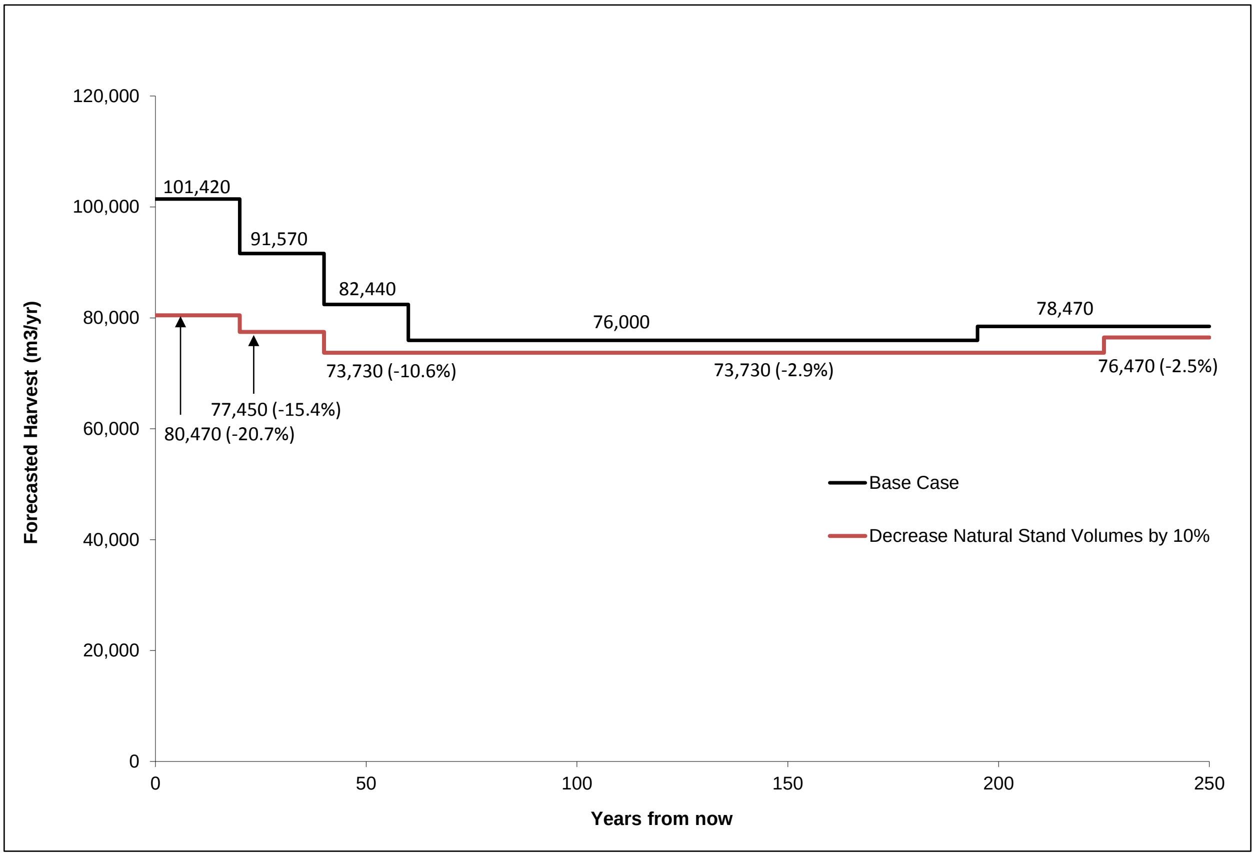

Figure 48: Sensitvity analysis; decrease natural stand volumes by 10%, TKO

5.7.3 Uncertainty of Predicted Growth and Yield of Managed Stands

Existing and future managed stands are the dominant source of volume in the medium and long terms. The purpose of this sensitivity analysis is to assess the impact associated with an over- or under-estimation in the growth of existing and future managed stands.

5.7.3.1 Increase the Volume of Managed Stands by 10%

Increasing the volume (yield) of managed stands by 10% increased the harvest forecast between years 61 195 by 8.5% (Figure 49). The long-term timber supply was increased by 7.7%.

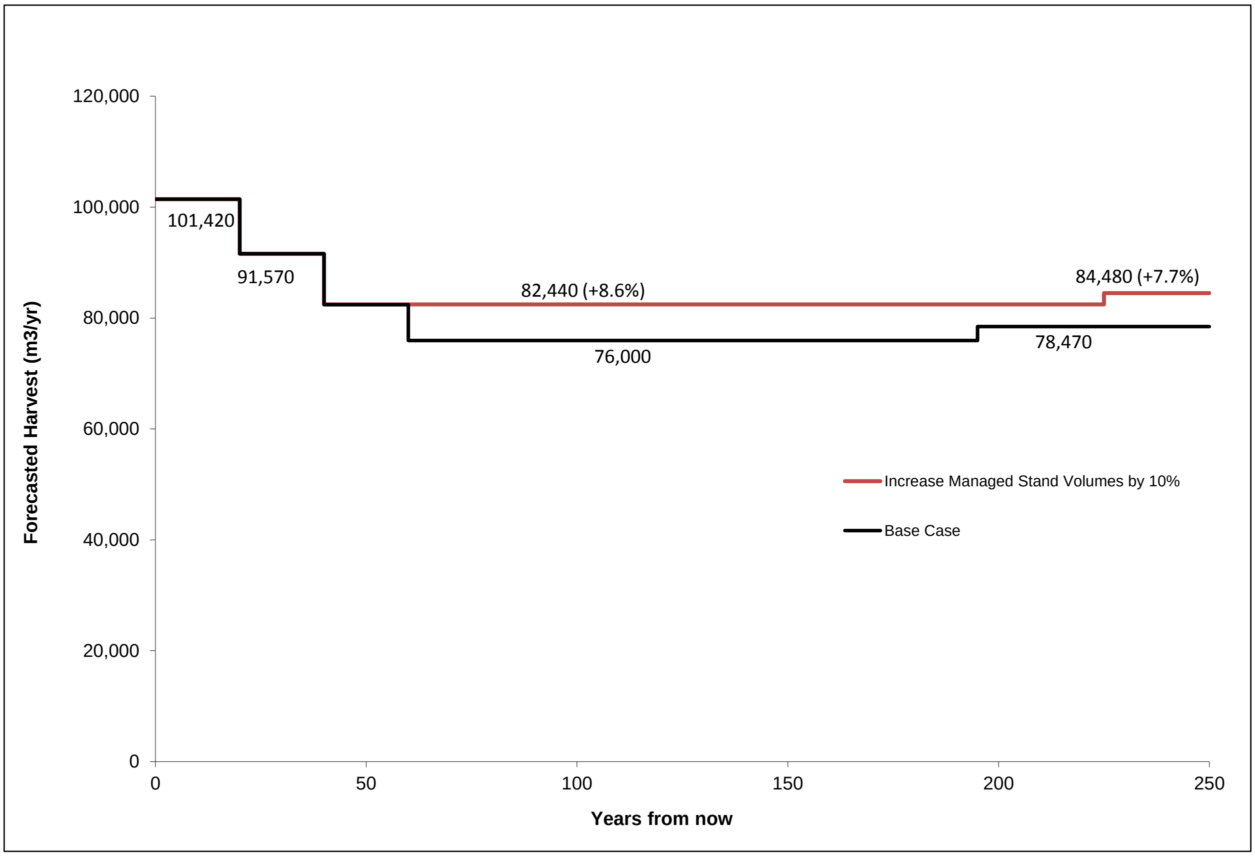

Figure 49: Sensitvity analysis; increase managed stand volumes by 10%, TKO

5.7.3.2 Decrease the Volume of Managed Stands by 10%

Decreasing the volume of managed stands by 10% impacted the timber supply at year 61 and into the late midterm and the long term. The timber supply was reduced by between 7.3% and 12.5% % in the midterm. The long-term harvest forecast was reduced by 10.2% compared to the Base Case (Figure 50).

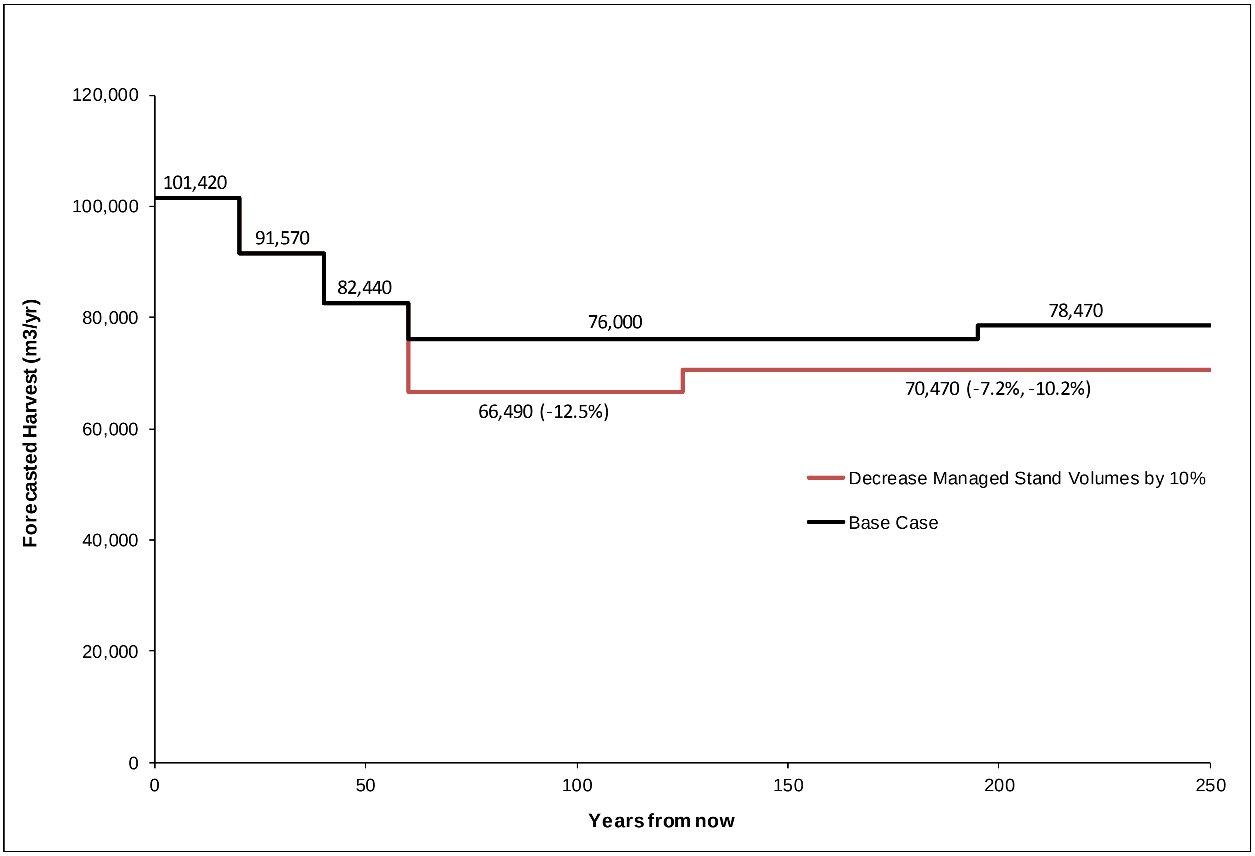

Figure 50: Sensitvity analysis; decrease managed stand volumes by 10%, TKO

5.7.4 Marginal Timber

5.7.4.1 Include the Payne Creek Area and Helicopter Operable Land Base in the THLB

This sensitivity analysis tested the impact of including the Payne Creek area and the helicopter operable land base in the THLB. The net increase in the THLB was only 64 ha. There was no timber supply impact.

Including the Payne Creek area in the THLB increased the THLB by 16 ha. The net increase is small, because other netdown factors are significant in Payne Creek; most of the area remains outside of the THLB because of the UWR.

Including the helicopter operable land base in the THLB increased the size of it by only 48 ha. Similarly, to the Payne Creek area, other netdown factors reduced the net area added to the THLB. The minimum harvest criteria for helicopter operations also contributed to the small increase in the THLB; according to the TKO Business Area, the minimum harvest criteria for helicopter operations is 400 m^3 per ha with the stand required to be either Fd or Cw leading.

5.7.5 Harvest Scheduling

This sensitivity analyses tested the impact of using the relative oldest first harvest rule as opposed to the highest volume first harvest rule that was employed in the Base Case.

Figure 51 illustrates the timber supply impact of using relative oldest first harvest rule. The late mid-term harvest forecast was increased by 5.9%, while the long-term was elevated by 2.6%. The impact comes mostly from a more efficient utilization of the THLB, i.e. less THLB is left unharvested than in the Base Case. In the Base Case 1,262 ha (4.9%) of the THLB was never harvested. In this sensitivity analysis only 243 ha of the THLB (0.9%) was never harvested throughout the planning horizon.

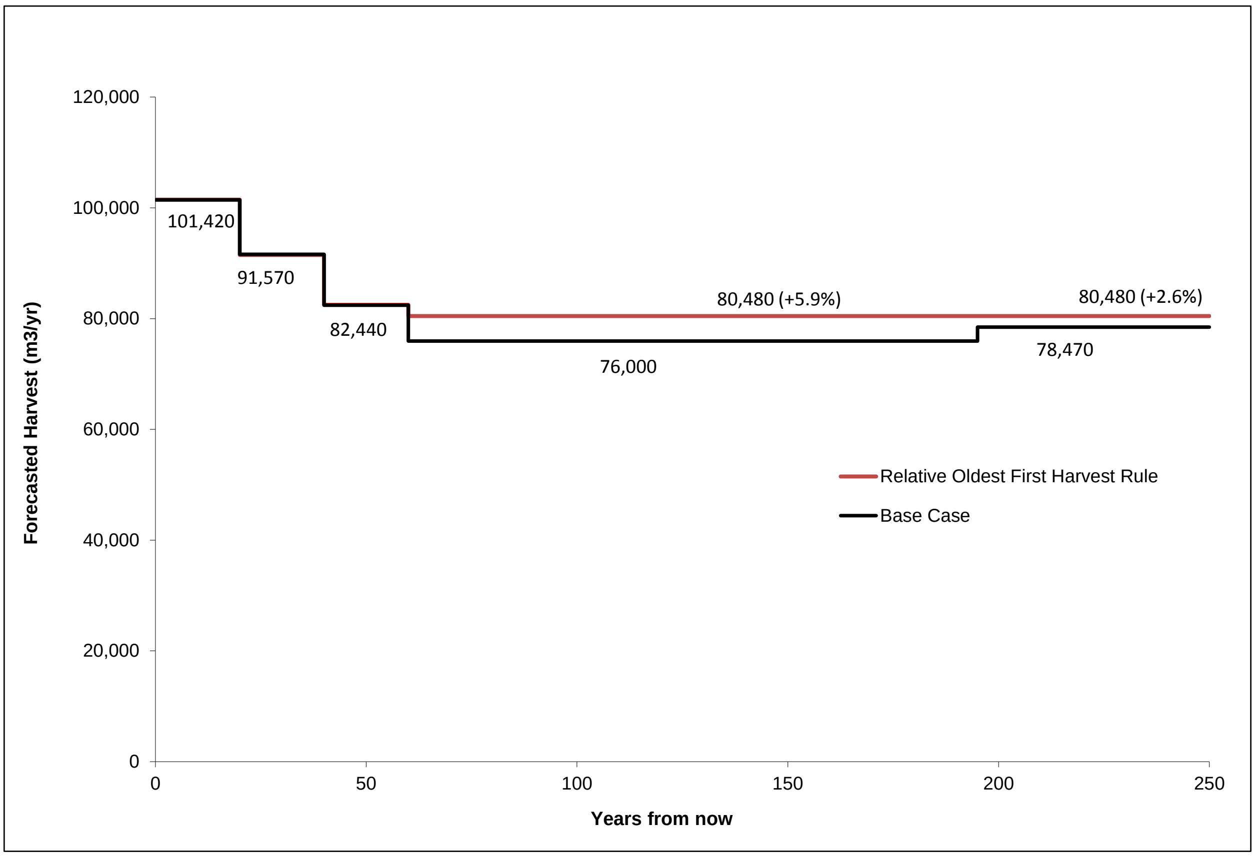

Figure 51: Sensitvity analysis; employ relative oldest first harvest rule, TKO

5.7.6 Biogeoclimatic Classification (BEC) Version

Kootenay-Boundary Higher Level Plan Order (KBHLPO, October 26, 2002) establishes legal objectives and targets for old forest retention, mature and old forest retention, and landscape connectivity. This analysis set aspatial mature and old forest targets by LU and BEC as per the KBHLPO; the targets are required for only two LUs: Halfway and Trout. In TKO landscape-level biodiversity is managed mostly through OGMAs.

The old forest retention, mature and old forest retention, and landscape connectivity targets are based on the version of the biogeoclimatic (BEC) classification in place at the time the KBHLPO was established in 2002. This version was also used in the Base Case.

Since then the BEC classification has changed resulting in area changes in BEC variants and seral stage target areas. This sensitivity analysis tested the impact of the latest BEC classification version (2016) on timber supply.

Utilizing the latest version of the BEC classification had a small impact on timber supply; the harvest forecast was reduced by 1% between years 61 and 195 (Figure 52).

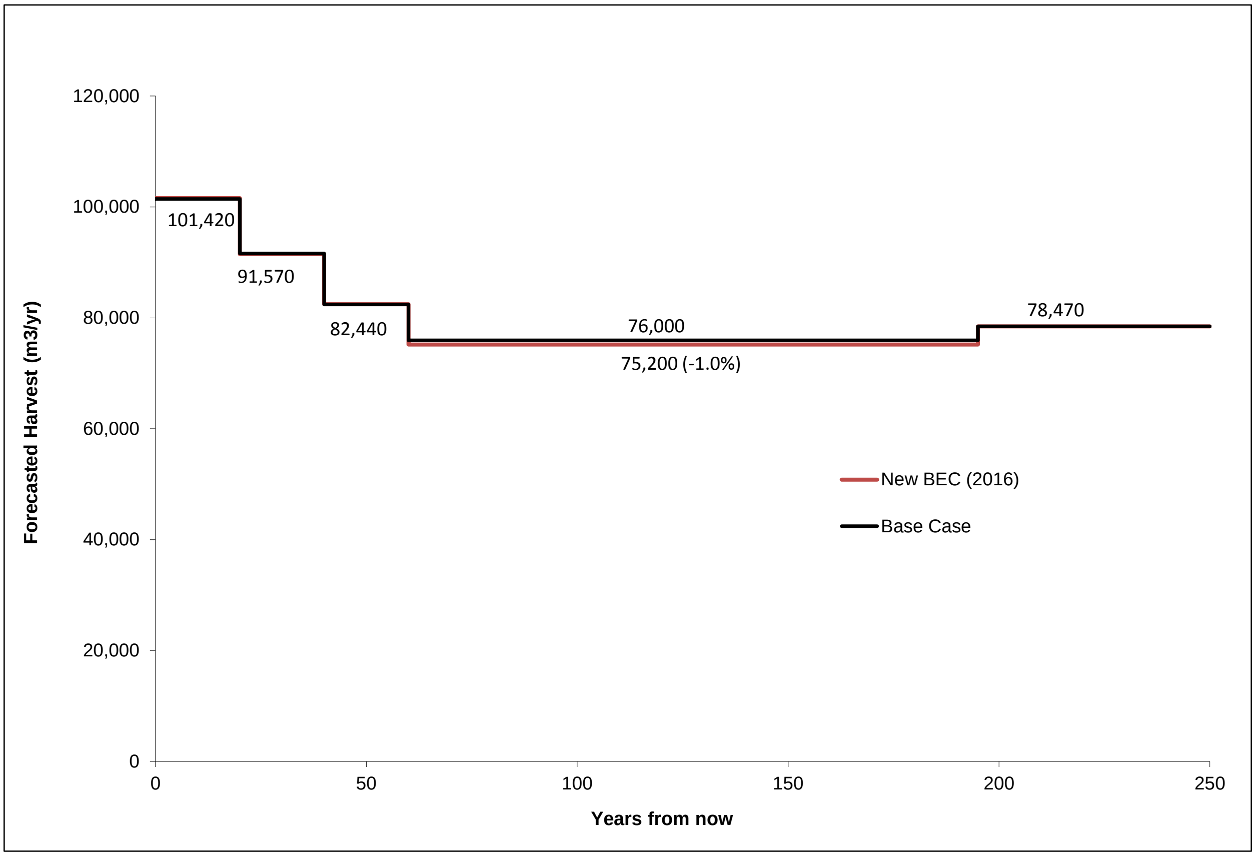

Figure 52: Sensitivity analysis; use new BEC (2016) for setting up seral stage targets, TKO

5.7.7 Armillaria Impact

The Base Case incorporated customized operational adjustment factors (OAF) – OAF2 in particular – in modelling the growth and yield of managed stands in TKO and TOC, to account for the impact of Armillaria root disease. Armillaria is a common forest health agent in the interior wet belt that affects tree growth and mortality. This sensitivity analysis tested the impact of using the default value of 5% OAF2 for managed stands.

Figure 53 illustrates the harvest forecast of this sensitivity analysis compared to the Base Case. The harvest forecast is 3.6% higher during the first 60 years of the planning horizon. The mid and long-term harvest forecasts are significantly higher than those in the Base Case with the mid-term harvest level predicted to be 15.1% higher and the long-term harvest forecast predicted to be 19.1% higher. The long-term harvest level is also reached at year 151, 45 years earlier than in the Base Case.

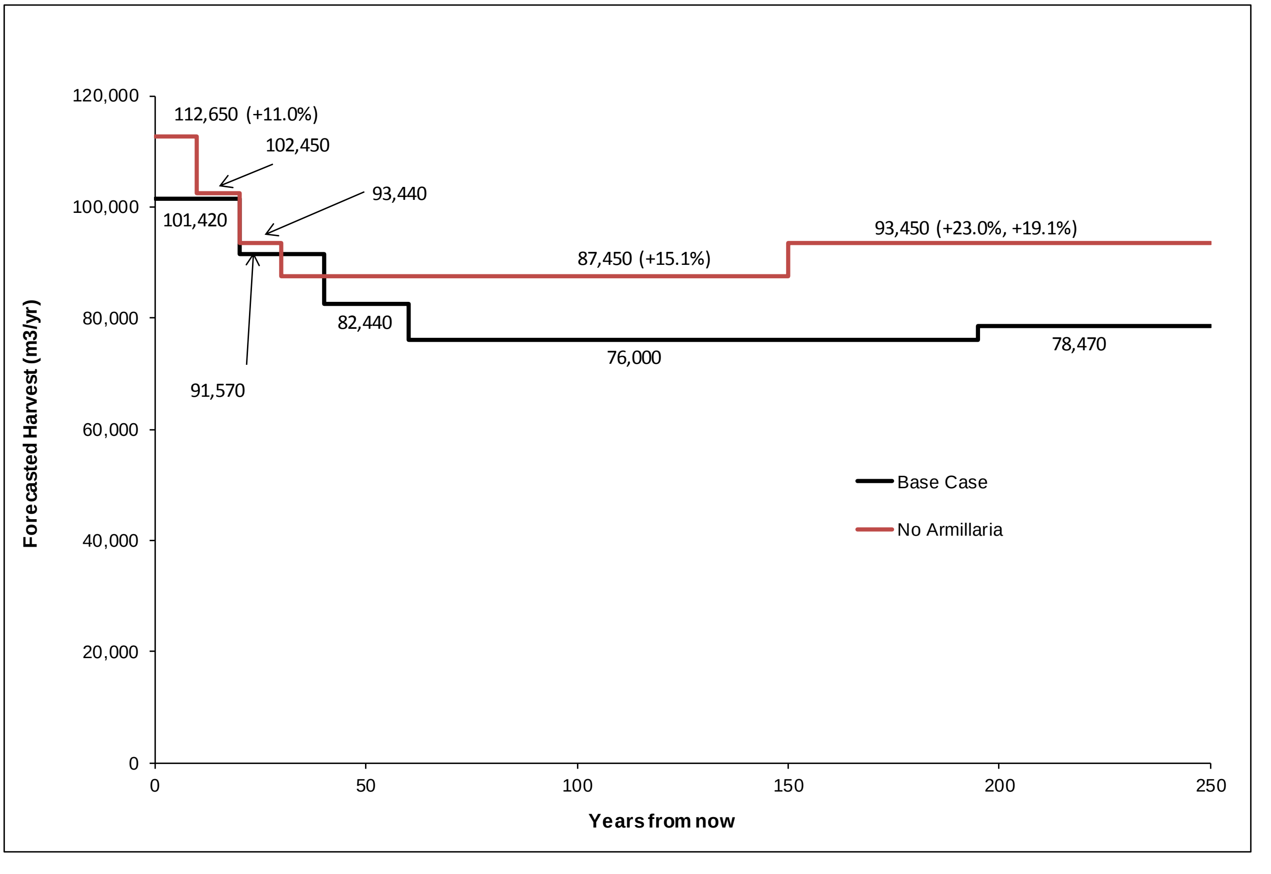

Figure 53: Sensitvity analysis; armillaria root disease, TKO

5.7.8 Green-Up

As a surrogate for spatial cutblock adjacency constraint, a landscape green-up constraint was applied in the Base Case, specifying that no more than 25% of the THLB area in each landscape unit outside of VQOs may be below the green-up height of 2.5 m at any given time.

Two sensitivity analyses were completed. One increased the maximum percentage of the THLB that could be below the green-up height to 33%, while the other decreased it to 20%.

Increasing the percentage to 33% had no impact on timber supply. However, reducing it to 20% had a small impact on the long-term harvest forecast; it was reduced by 1.4% (Figure 54).

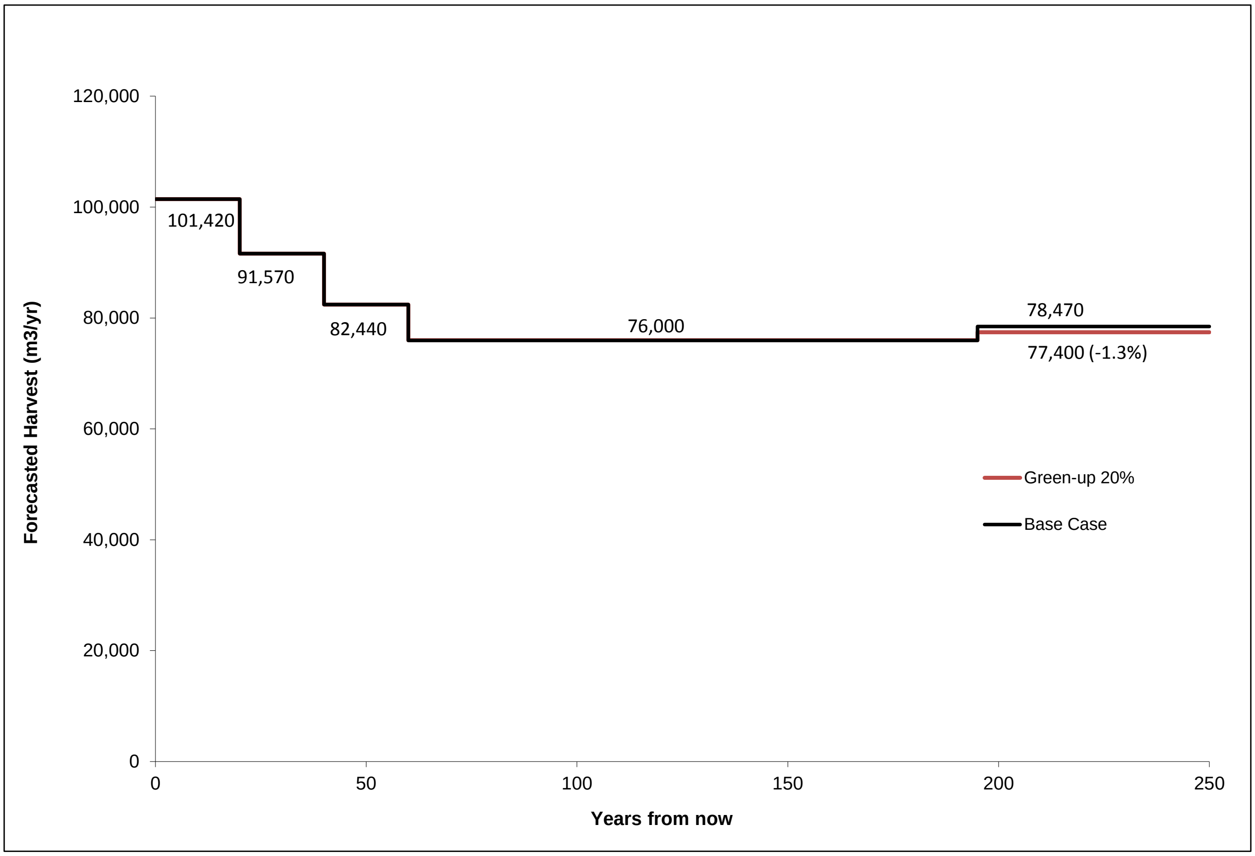

Figure 54: Sensitvity analysis; maximum 20% of THLB in LU less than green-up height, TKO

5.7.9 Woodsheds

This sensitivity analysis removed the minimum harvest volume requirements that were placed on various woodsheds in the Base Case. The harvest was impacted in the short- and early mid-term. The harvest forecast for the first ten years was increased by 11.0% (Figure 55). However, the overall impact was modest; the harvest forecast for the first 65 years of the planning horizon was only 3.2% more than that of the Base Case.

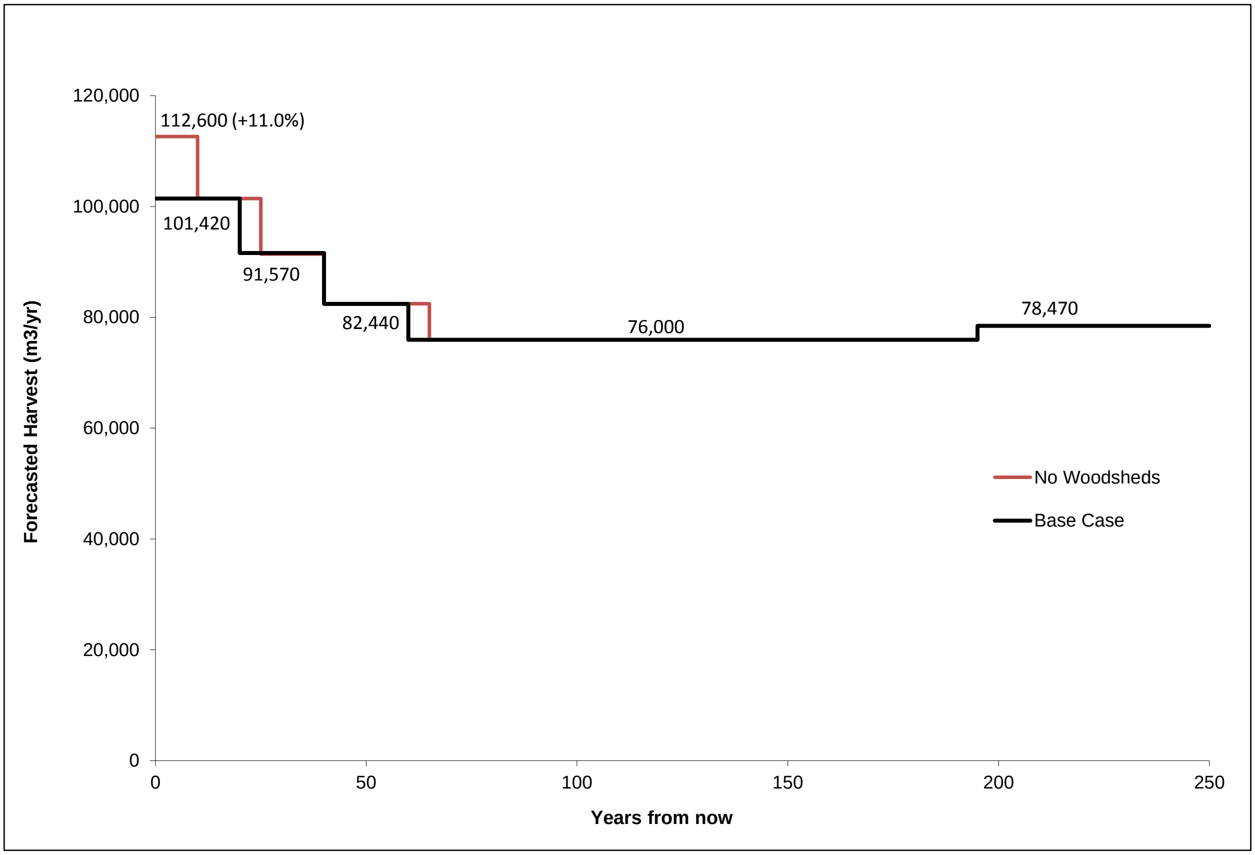

Figure 55: Sensitvity analysis; minimum volume requirements in woodsheds removed, TKO

5.8 Alternative Harvest Forecasts, TKO

Figure 56 illustrates the analysis results for two alternate harvest forecasts compared to the Base Case. The first alternate forecast set the initial harvest level at the current AAC of 112,650 m^3 per year. This harvest level is maintained for 10 years until the forecast is reduced by 11.1%. The mid-term forecast was also reduced between years 61 and 125 (by 4.7%), as was the long-term forecast, which decreased by 1.2%.

Figure 56 also presents the maximum non-declining even flow alternative; the highest possible even flow harvest level for TKO is 76,000 m^3 per year.

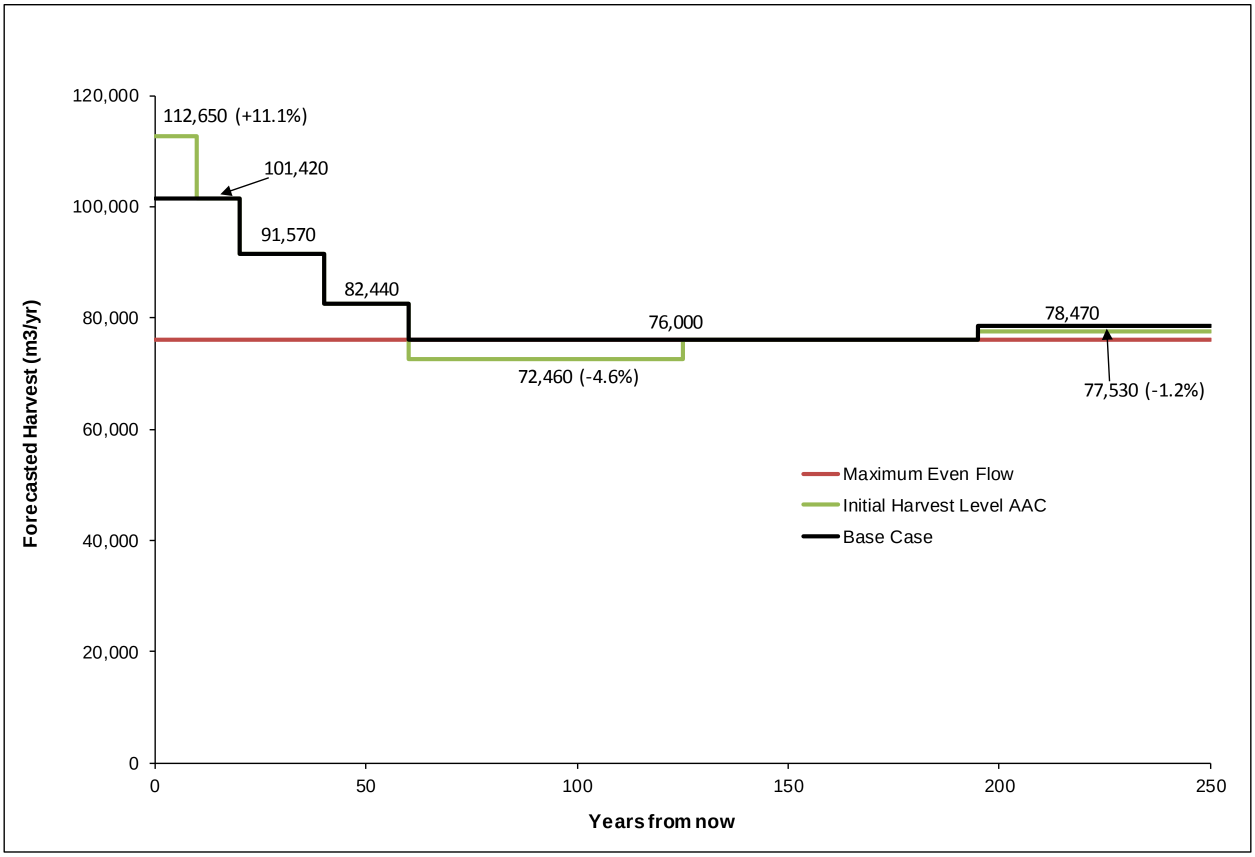

Figure 56: Alternative harvest forecasts; TKO

5.9 Discussion

The Caribou UWR and OGMA designations have reduced the THLB in TKO by approximately 30%, since 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). In this analysis, the growth and yield of managed stands was also reduced significantly due to the predicted impacts of Armillaria on tree growth. Furthermore, woodsheds were incorporated in this analysis; a minimum periodic (5 years) harvest volume was required for the harvest to occur at all.

For these reasons, the BCTS staff expected the TKO Base Case short-term harvest forecast to be significantly lower than the current AAC. However, the short-term harvest forecast of 101,450 m^3 per year is only approximately 10% lower than the current AAC of 112,600 m^3 per year. A sensitivity analysis revealed that turning off the woodshed constraint allows the current AAC to be maintained for 10 years.

The high site indices of managed stands in conjunction with exceptionally high genetic gain are the likely reasons for the higher than expected timber supply forecast for TKO, in spite of the reduced THLB and the predicted Armillaria impacts. The relatively large growing stock of natural stands allows for the maintenance of high harvest levels in the short term, while the productive managed stands make it possible for a controlled transition to the midterm to occur in 60 years.

The timber supply is sensitive to changes in the growth and yield assumptions of natural stands and managed stands. Reducing the natural stand volumes by 10% reduced the short-term harvest forecast between 15.4% and 20.7%. The mid-term and long-term forecasts were also reduced by 2.9% and 2.5% respectively. The impact comes from several sources: the reduced natural stand volumes force the transition of harvest to managed stands early. The managed stands are not ready for harvest and the short-term harvest must be reduced. The lower natural stand volumes also effectively remove THLB from the land base; some stand volumes fall so low that they no longer meet the minimum harvest criteria and are never harvested. The THLB impacts are reflected in the reduction of mid- and long-term harvest forecast.

Reducing the managed stand volumes by 10%, decreased the early mid-term harvest forecast by 12.5%; managed stands are not ready for harvest at the transition from natural stands to managed stands and the harvest request must be reduced. The lower assumed productivity (10%) of managed stands is reflected in the long-term harvest forecast, which is 10.2% lower than that of the Base Case.

Increasing the minimum harvest criteria had a comparable impact on the timber supply as did decreasing the growth and yield of stands. If the minimum harvest volume was increased for all stands, many natural stands remained unharvested and the timber supply impact was significant throughout the planning horizon. Increasing the minimum harvest criteria of managed stands by 50 m^3 per ha increased the long-term harvest level with no impact on the short term. If the increase was larger at 100 m^3 per ha, both the mid- and the long-term harvest forecast was increased, while the short-term harvest level had to be reduced.

Including the Payne Creek area and the helicopter harvestable timber in the THLB had no impact on timber supply, because the net increase in the THLB was negligible due to other netdown factors keeping most of these areas out of the THLB.

6 Base Case, TOC

6.1 TOC Business Area

The analysis was completed separately for each BA. Block 4 in Figure 57 depicts the TOC BA.

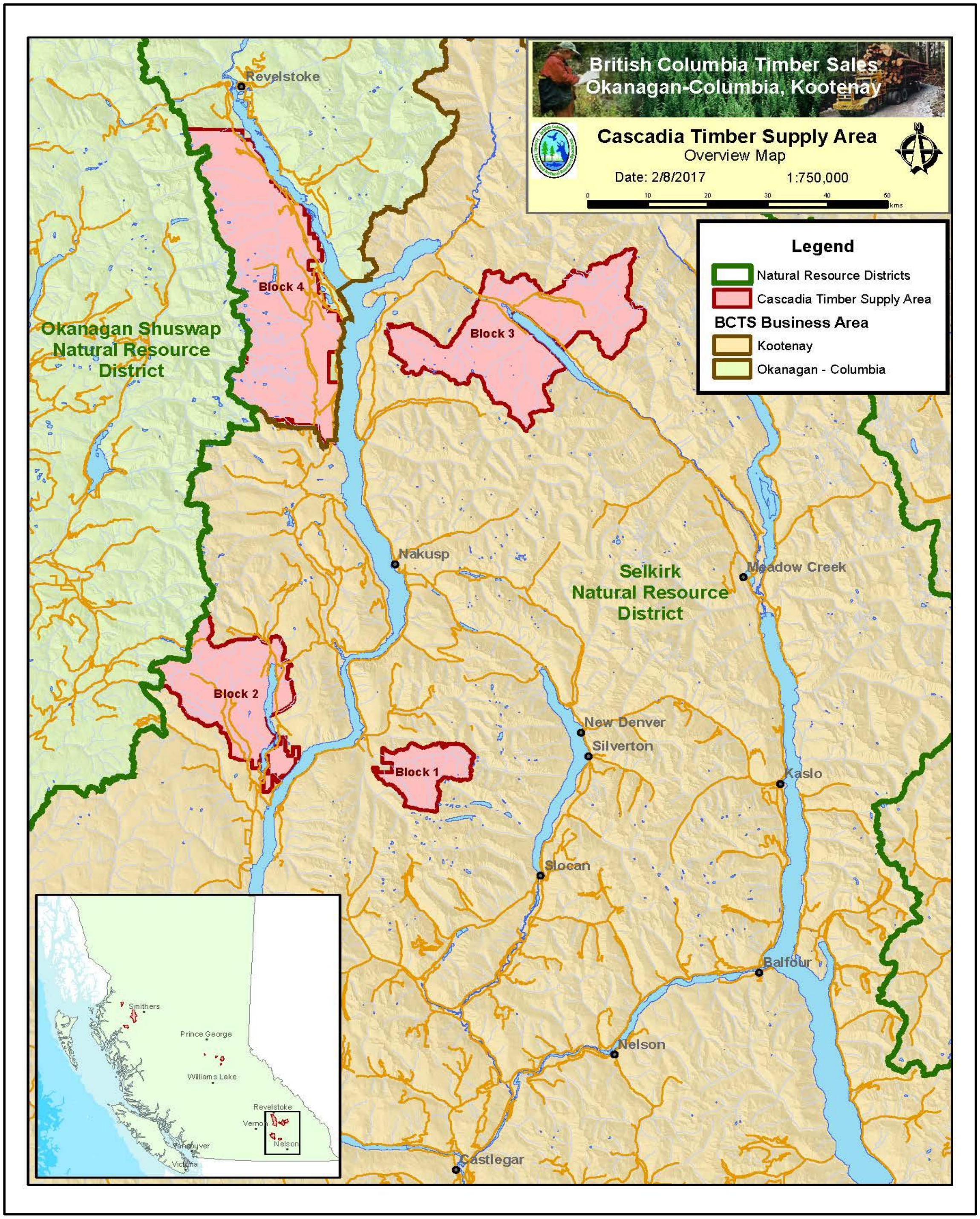

Figure 57: TOC BA: Block 4

6.2 Harvest Forecast

The Base Case forecast is shown in Figure 58. The initial harvest level of 59,345 m^3 per year is 10.8% less than the current AAC of 66,566 m^3 per year. Any attempt to increase the short-term harvest level resulted in a mid-term crash; however, it was possible to increase the long-term harvest level at year 151 to 61,130 m^3 per year. In the Base Case 1,325 ha of the THLB (6.9%) remained unharvested at the end of the planning horizon. The highest volume first harvest rule selects stands for harvest based on their volume per ha. This harvest rule leaves some of the lower volume stands out of the harvest queue by "recycling" the more productive stands at their expense. Table 19 summarizes the TOC Base Case.

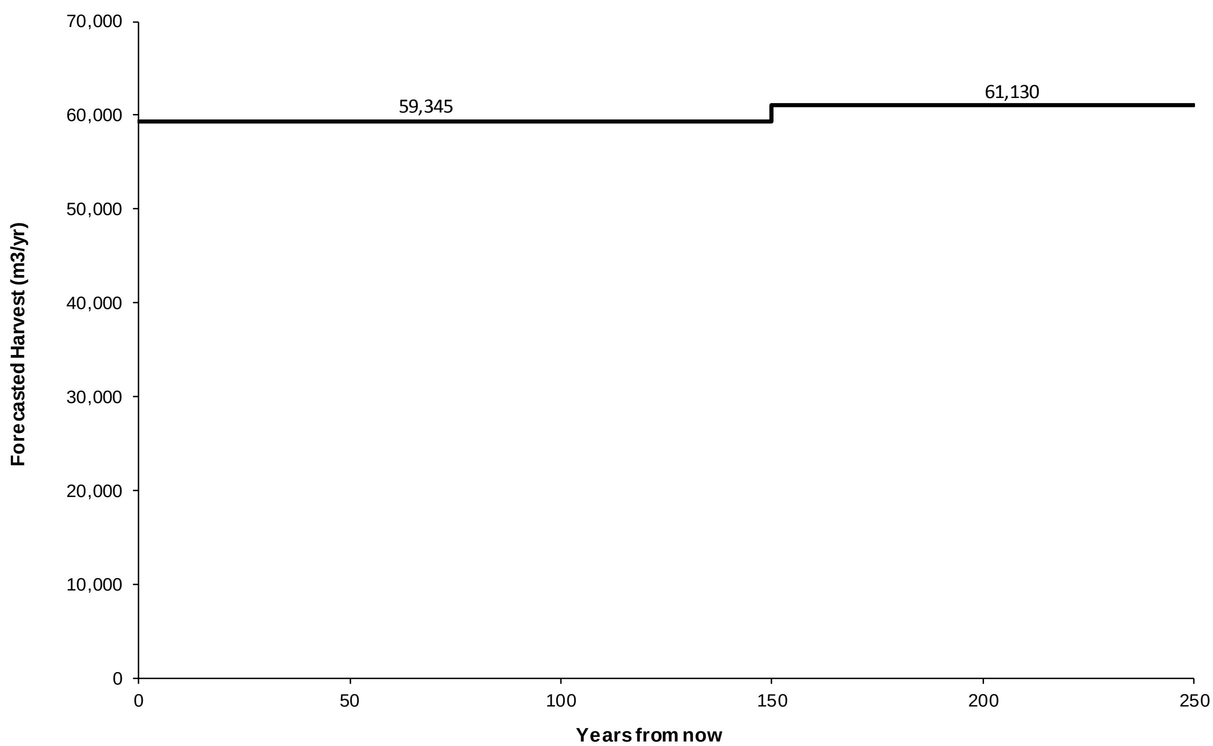

Figure 58: Base Case harvest forecast; TOC

Table 19: Harvest forecast summary, TOC

Period	Predicted Harvest (m^3 per year)	Unharvested THLB (ha)
Years 1 to 150:	59,345 m^3	1,325 ha (6.9%)
Years 151 to 250 (LTHL)	61,130 m^3	

6.3 Growing Stock

Figure 59 shows the predicted growing stock for the TOC Base Case. The merchantable or mature growing stock remains relatively high. In TOC VQOs and ungulates (deer) limit harvest opportunities.

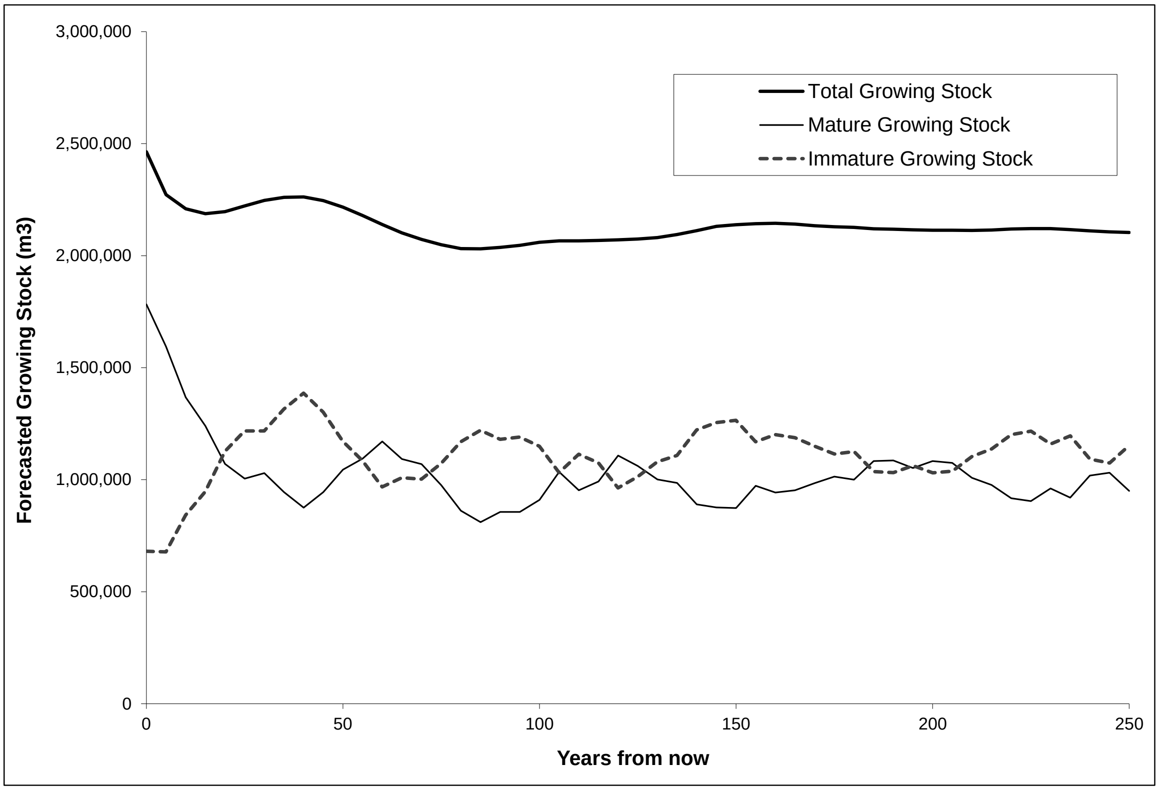

Figure 59: TOC Base Case; predicted growing stock

6.4 Harvest Age, Harvest Volume and Harvest Area

Figure 60 shows the TOC harvest forecast by age class. Almost the entire harvest is predicted to come from stands older than 100 years during the first 15 years of the planning horizon. After this, the harvest of older age classes declines and from year 36 on 70 to 80% of the harvest is predicted to come from age classes 4, 5 and 6 (age between 61 and 120). Figure 61 illustrates the average harvest age for the TOC Base Case, which reflects the harvest by age class and trends around 85 years in the long term.

Figure 62 shows the TOC harvest forecast by vol/ha class. Some higher volumes (300 to 500 m^3 per ha) are available for the next 20 years. In the medium and long terms approximately 60% of the harvest is predicted to come from stands with the volume between 200 and 300 m^3 per ha, with the balance consisting mostly of stands with the volume between 300 and 400 m^3 per ha. This corresponds with the predicted average harvest volume of around 300 m^3 per ha in the long term (Figure 63). The annual average harvest area in the long term is predicted to trend around 220 ha with some fluctuations (Figure 64).

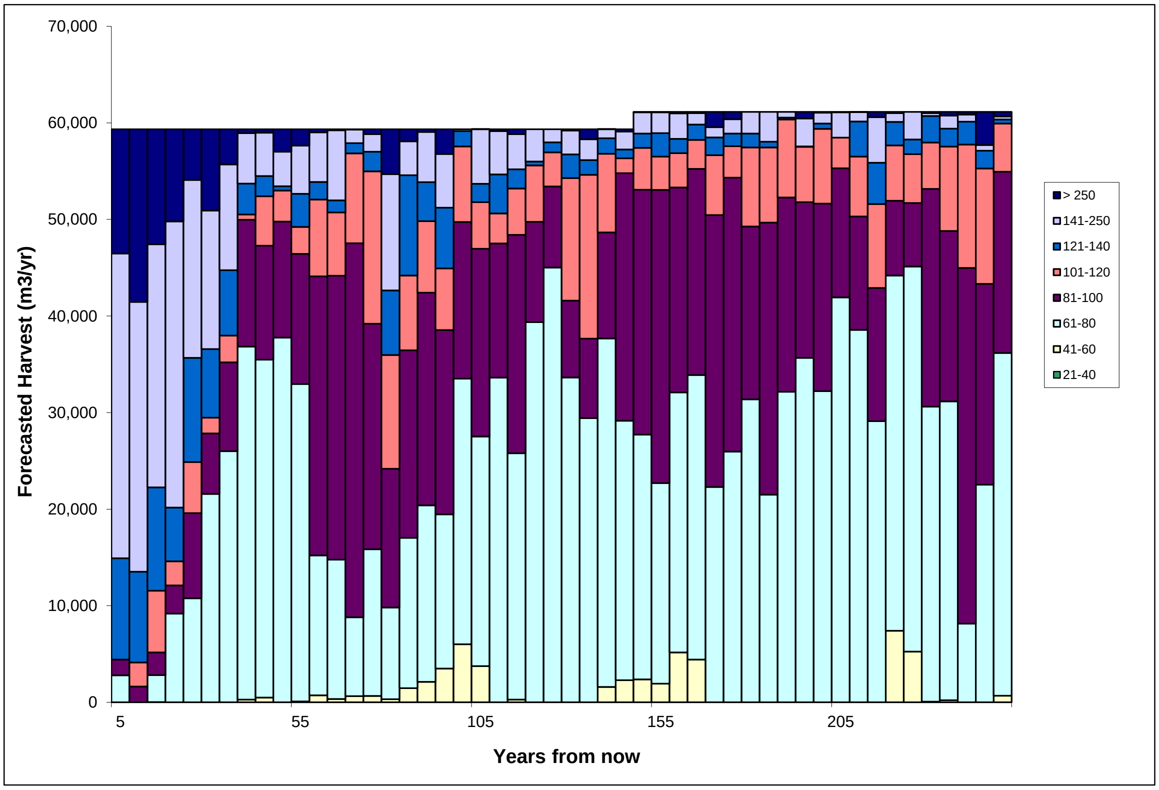

Figure 60: TOC Base Case; harvest forecast by age class

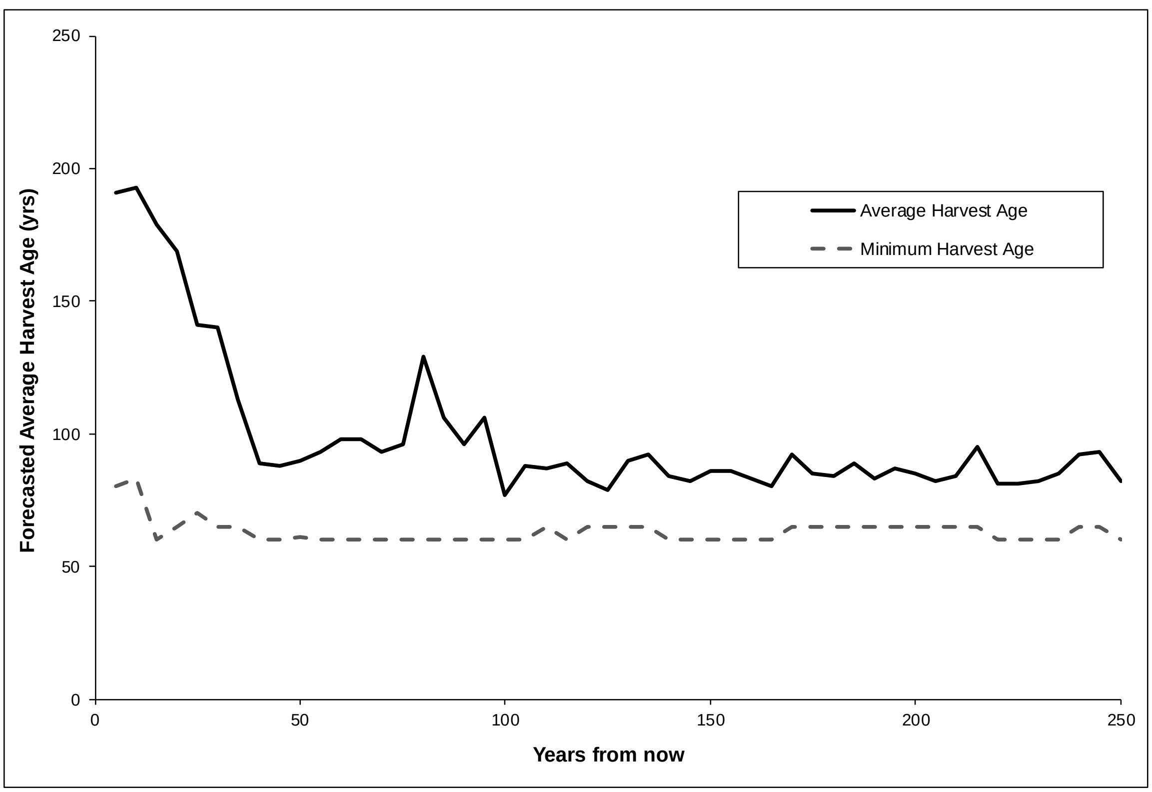

Figure 61: TOC Base Case; average and minimum harvest age

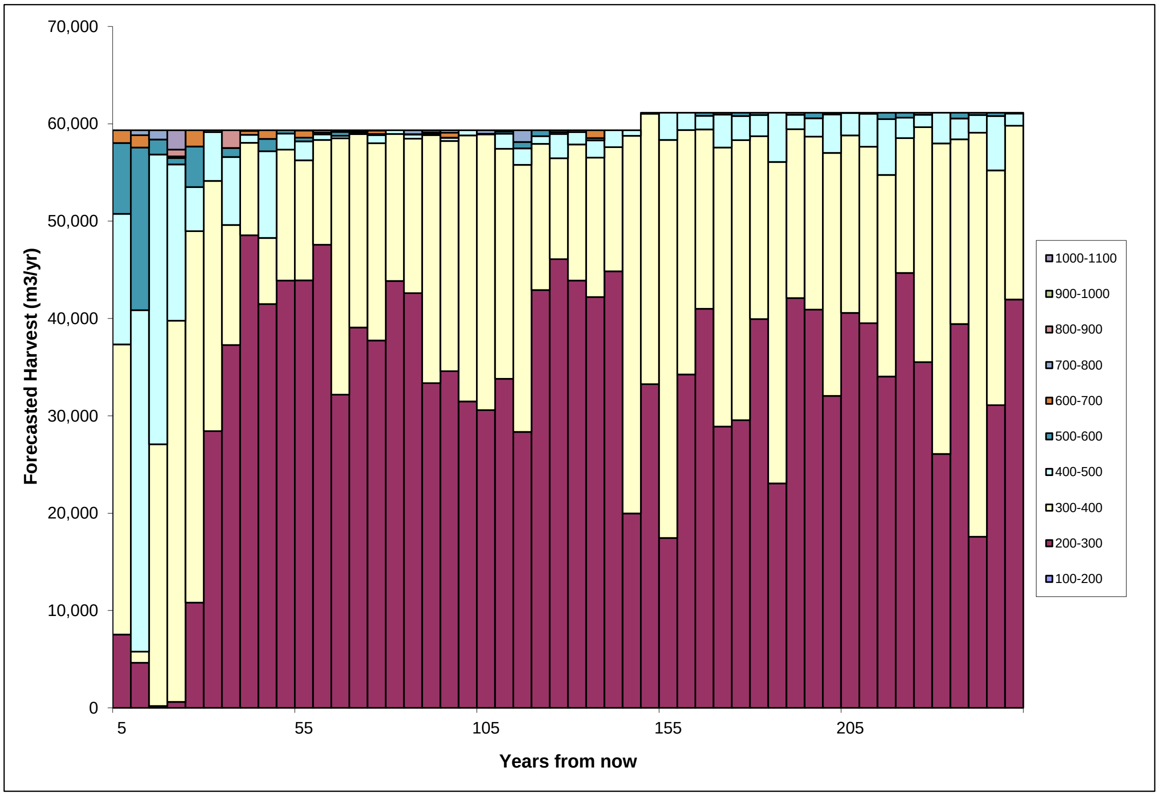

Figure 62: TOC Base Case; harvest forecast by vol/ha class

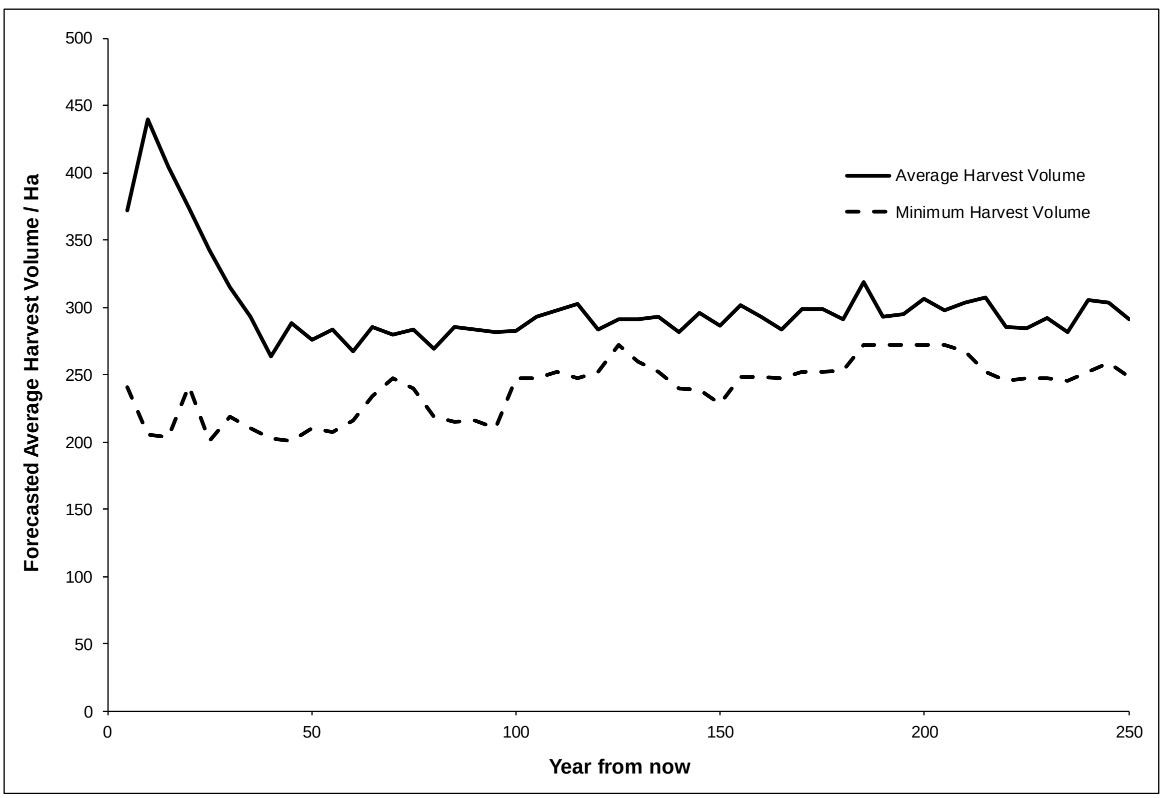

Figure 63: TOC Base Case; average harvest volume per ha

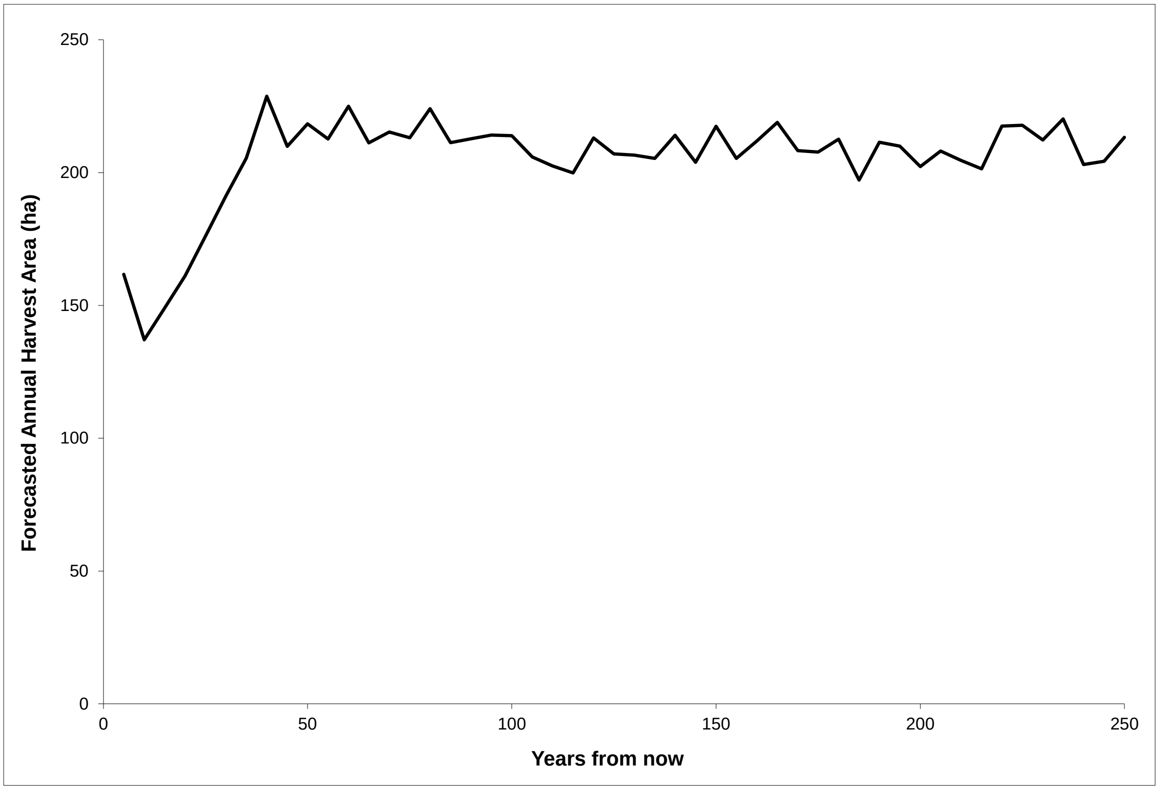

Figure 64: TOC Base Case; average annual area harvested

6.5 Composition of Harvest by Yield Type and Species

Figure 65 illustrates the TOC Base Case harvest forecast by yield type. The transition to managed stands is predicted to start after 30 years and by year 100 almost the entire harvest is predicted to come from managed stands.

Figure 66 provides the harvest forecast by species.

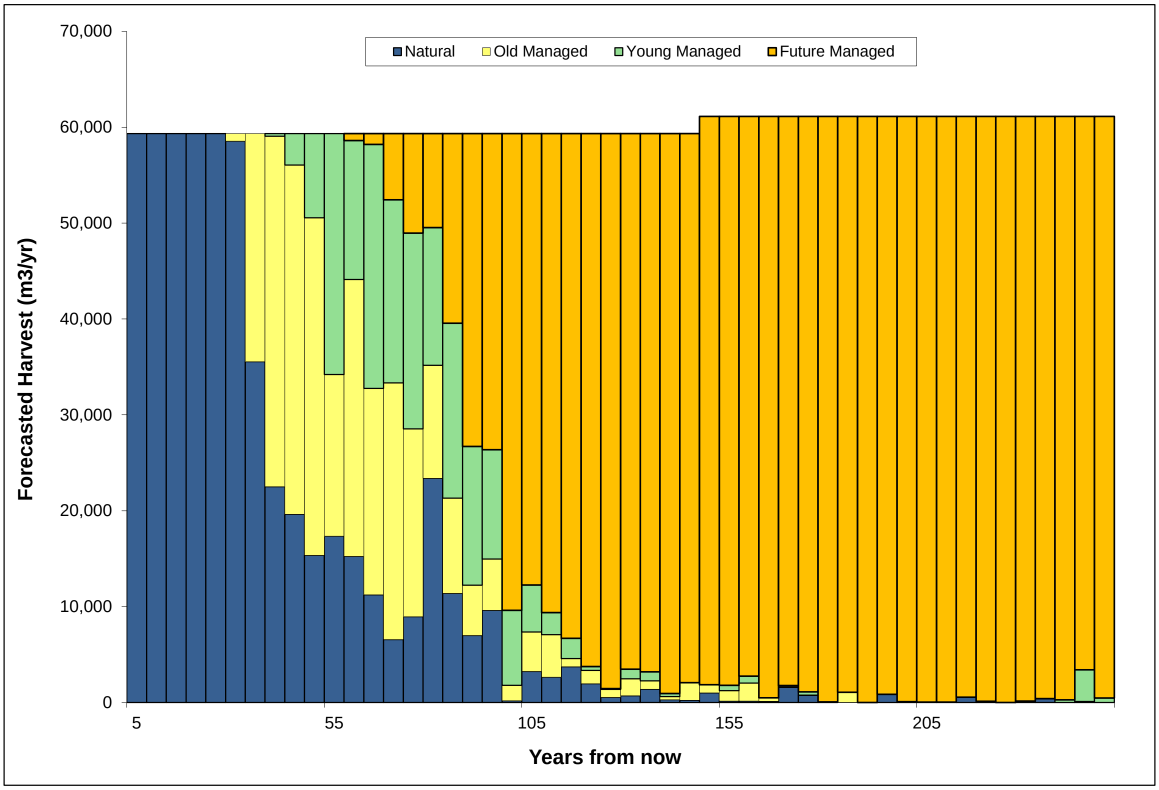

Figure 65: TOC Base Case; harvest forecast by yield type

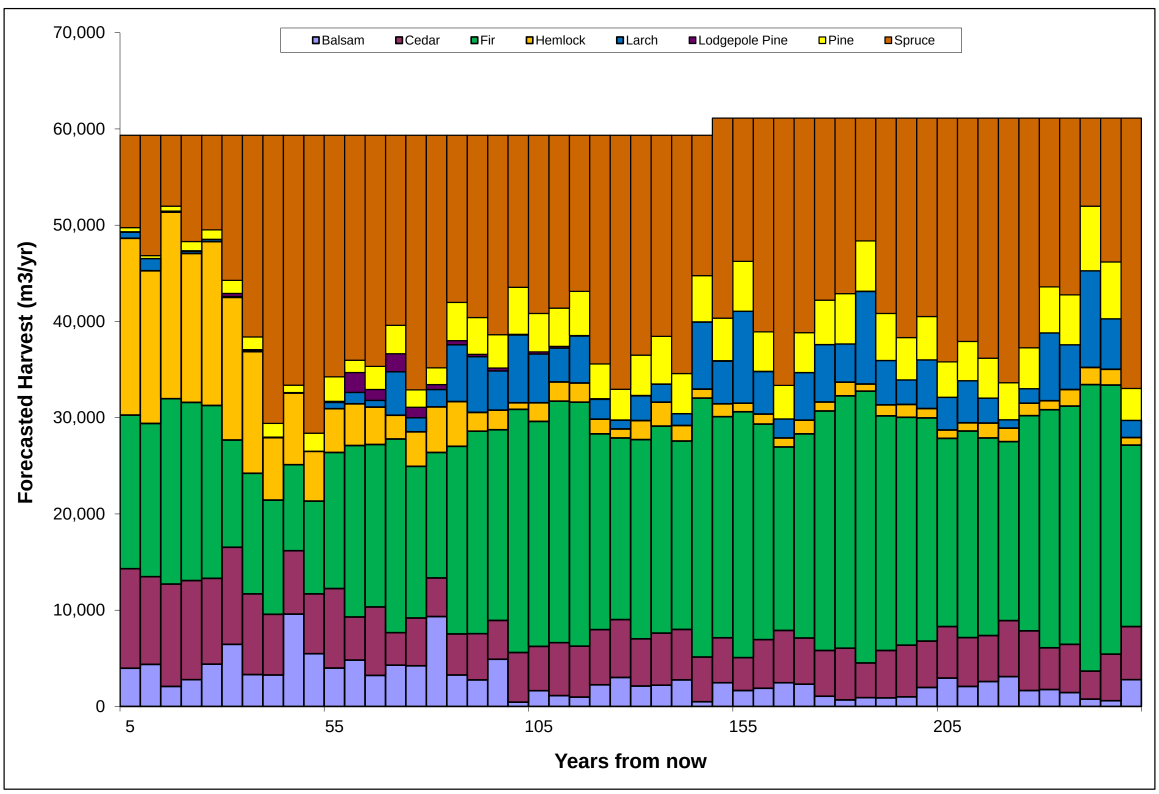

Figure 66: TOC Base Case; harvest forecast by species

6.6 Age Structure

Figure 67, Figure 68, Figure 69, Figure 70, Figure 71 and Figure 72 illustrate the projected age class structure of the forest, should the Base Case harvest schedule be followed. In the course of time, most of the NHLB will become late seral (over 250 years of age). The harvest would occur in the THLB, which would not generally age much beyond 100 years. Most of the harvest is expected to come from age class 4 and 5 stands in the long run.

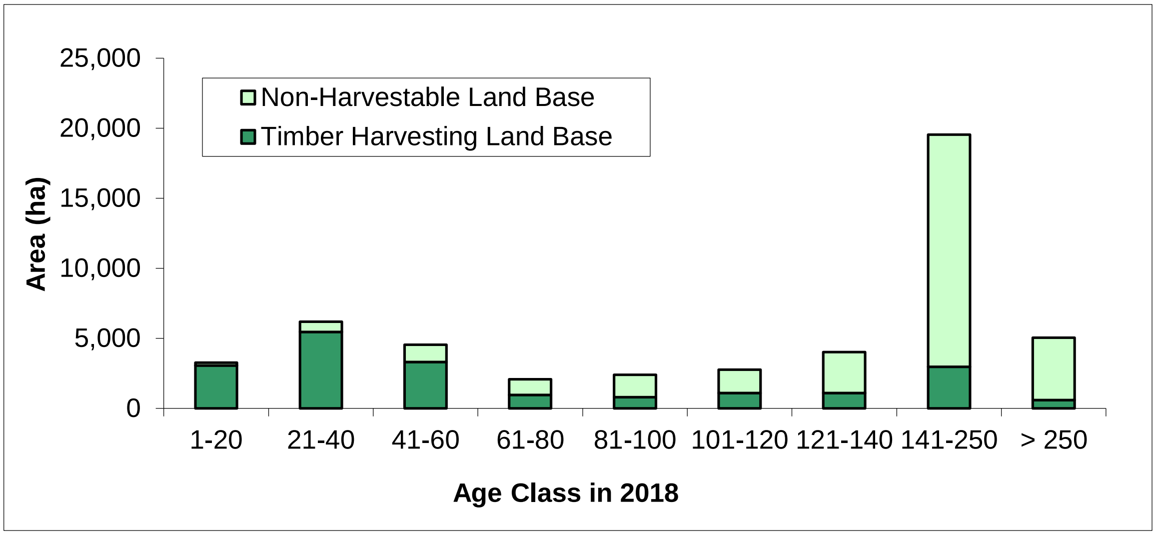

Figure 67: Current age class distribution, TOC

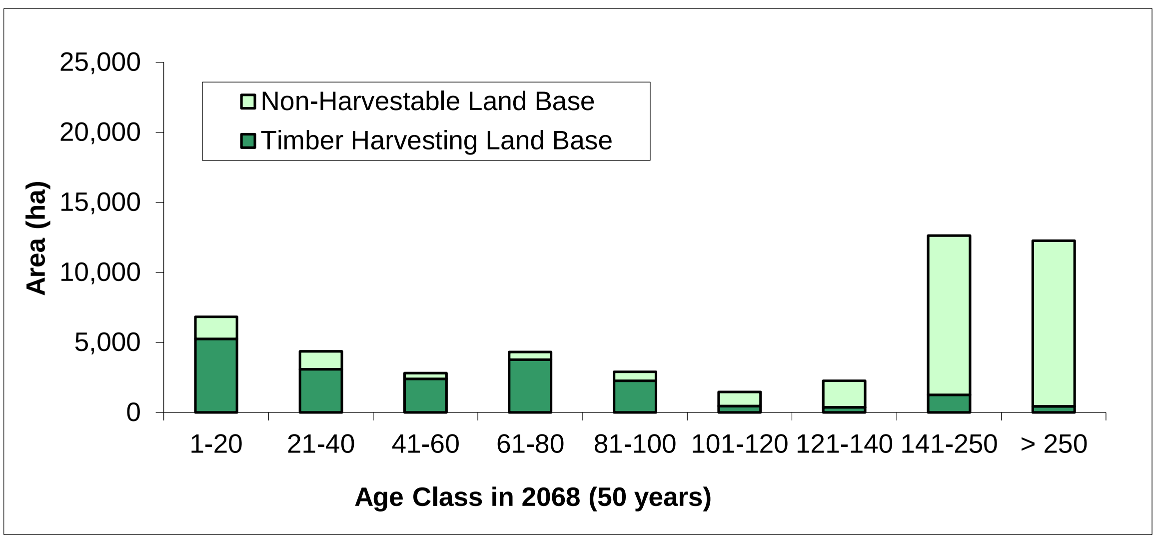

Figure 68: Projected age class distribution in 50 years, TOC

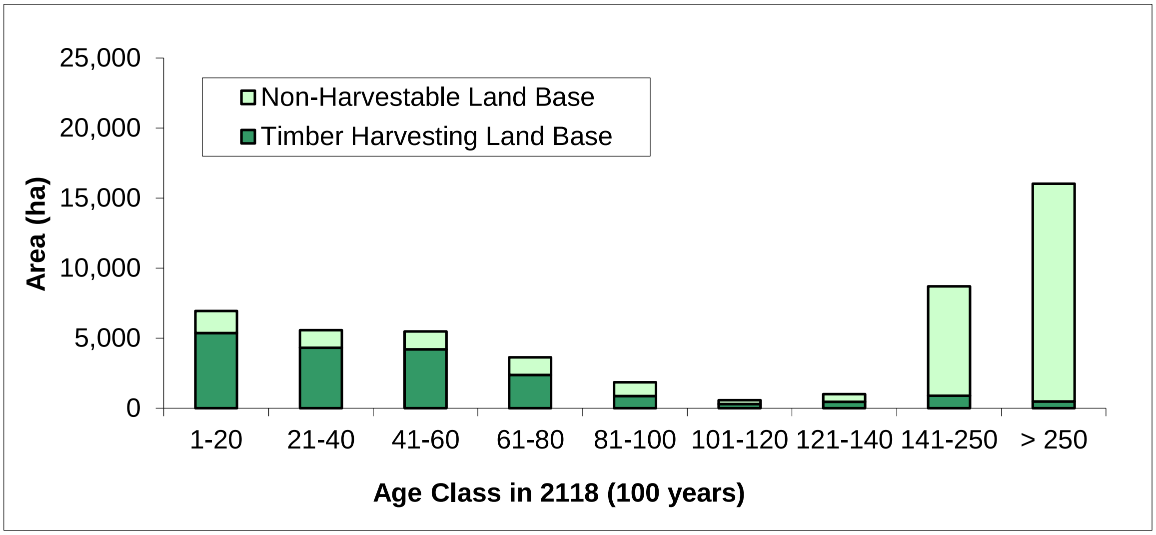

Figure 69: Projected age class distribution in 100 years, TOC

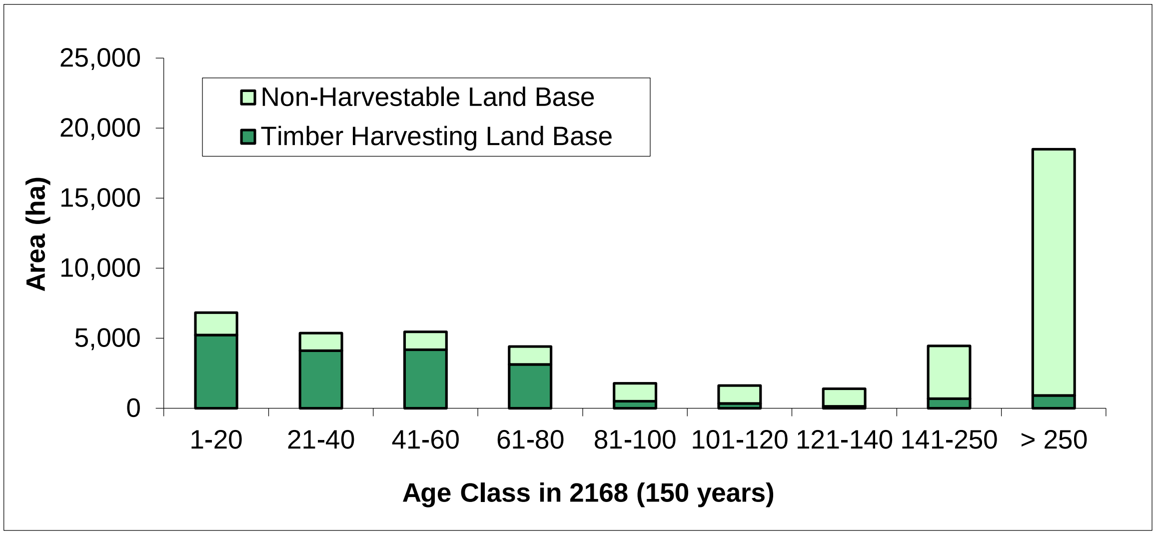

Figure 70: Projected age class distribution in 150 years, TOC

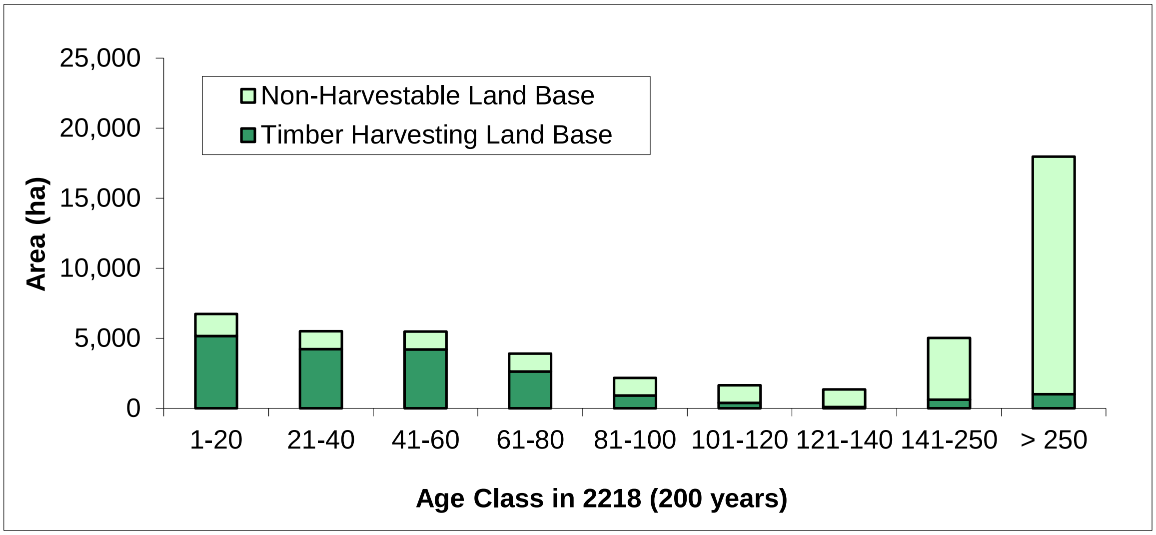

Figure 71: Projected age class distribution in 200 years, TOC

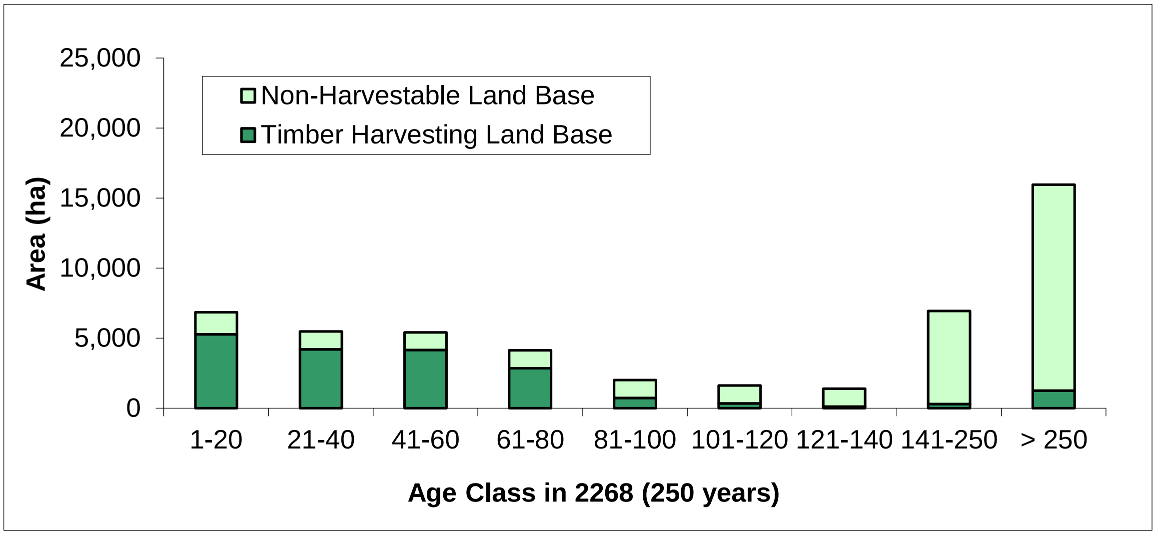

Figure 72: Projected age class distribution in 250 years, TOC

6.7 Sensitivity Analyses, TOC

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 harvest constraints correctly. Furthermore, sensitivity analyses also test the impact and risk of data uncertainties and modeling assumptions to the harvest level, particularly in the short-term. Table 20 presents a summary of the sensitivity analyses that were carried out to test the various uncertainties that exist in the Base Case data and assumptions.

Table 20: Summary of sensitivity analyses; TOC

Issue	Sensitivity analysis
Minimum harvest criteria	Consider only minimum harvest volume for **all** stands and remove the 95% MAI culmination rule.
	Increase minimum harvest volume (MHV) of **all** stands by 50 m^3 per ha, maintain 95% MAI culmination rule.
	Increase minimum harvest volume (MHV) of **all** stands by 100 m^3 per ha, maintain 95% MAI culmination rule.
	Decrease minimum harvest volume (MHV) of **all** stands by 50 m^3 per ha, remove 95% MAI culmination rule.
	Increase minimum harvest volume (MHV) of **managed** stands by 50 m^3 per ha, maintain 95% MAI culmination rule.
	Increase minimum harvest volume (MHV) of **managed** stands by 100 m^3 per ha, maintain 95% MAI culmination rule.
Volume of existing natural stands	Increase natural stand volumes by 10%
	Decrease natural stand volumes by 10%
Volume of managed stands	Increase managed stand volumes by 10%
	Decrease managed stand volumes by 10%
Marginal timber	Include helicopter operable area in the THLB
Harvest rule	Use a relative oldest first harvest rule
Armillaria root disease impact	Remove custom operational adjustment factors (OAF 2) to test impact of not considering Armillaria
Green-up	Maximum 33% of THLB in each LU less than green-up height

6.7.1 Minimum Harvest Criteria

In the Base Case, the stands can be harvested once they reach a volume of 200 m^3 per ha for ground-based operations and 250 m^3 per ha for cable operations. The stands must also reach the age at which the mean annual increment (MAI) of the stand achieves a value of 95 percent of the maximum (culmination).

Minimum harvestable volumes may be lower in good market conditions and at times higher volumes may be required for the harvest to be economic. In these sensitivity analyses the minimum harvest volumes were increased and decreased. The 95% MAI culmination rule was maintained, unless otherwise noted.

6.7.1.1 Consider Only Minimum Harvest Volume for All Stands

In this sensitivity analysis, only the minimum harvest volume criteria were considered, while the 95% MAI culmination rule was ignored. Only the long-term timber supply was impacted; it decreased by 3.0% (Figure 73).

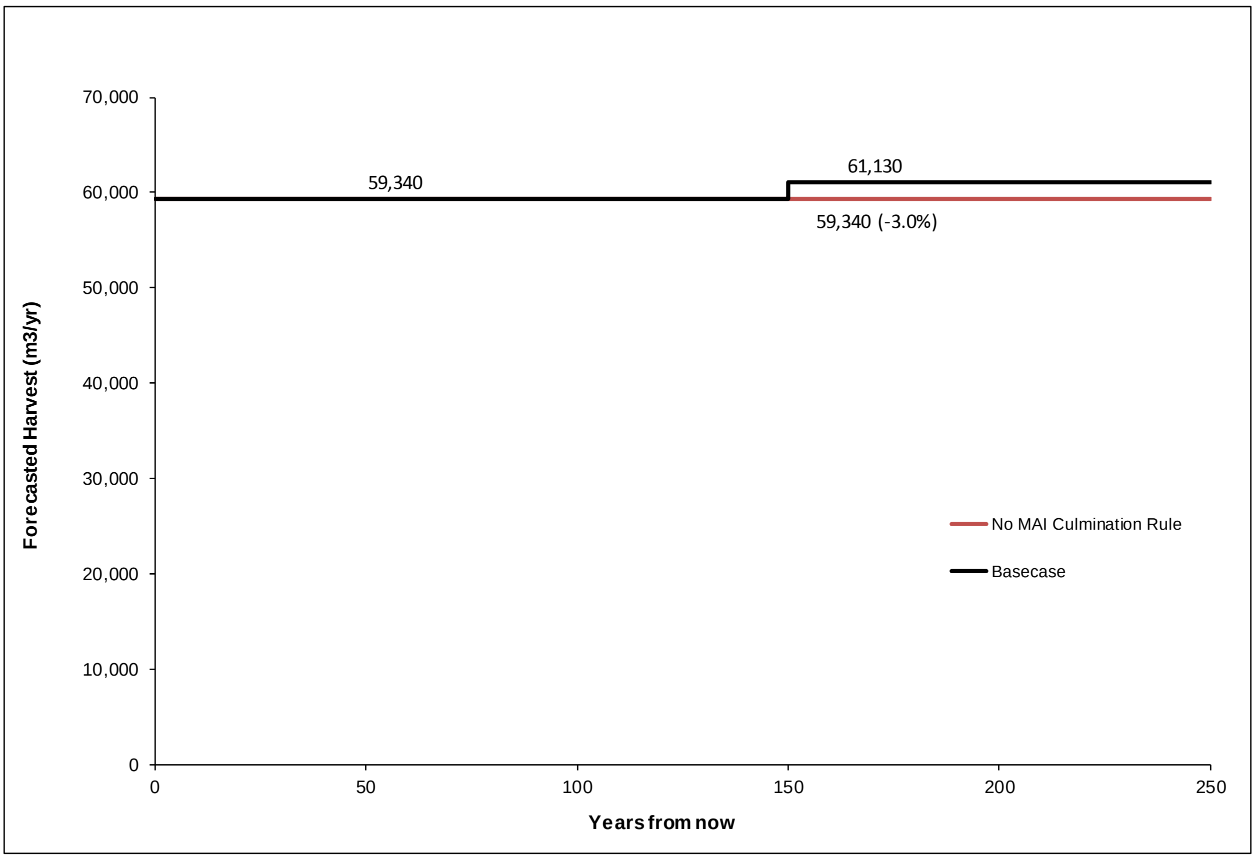

Figure 73: Sensitvity analysis; ignore MAI culmination rule, TOC

6.7.1.2 Increase Minimum Harvest Volume of All stands by 50 m^3 per ha

This sensitivity analysis increased the MHV of all stands by 50 m^3 per ha to 250 m^3 per ha for ground-based operations and 300 m^3 per ha for cable operations. The 95% MAI culmination rule was also enforced. As noted earlier, increasing the MHV for all stands effectively removes some natural stands from the THLB, because they never meet the increased MHV. In the Base Case, 1,325 ha (6.9%) of THLB is never harvested. In this sensitivity analysis the model did not harvest 1,955 ha (10.2%) of the THLB during the planning horizon. The impact was significant (Figure 74). The short-term harvest was reduced by 6.4 %, while the mid-term reduction ranged from 2.1% to 4.9%. The long-term forecast was reduced by 3.3%.

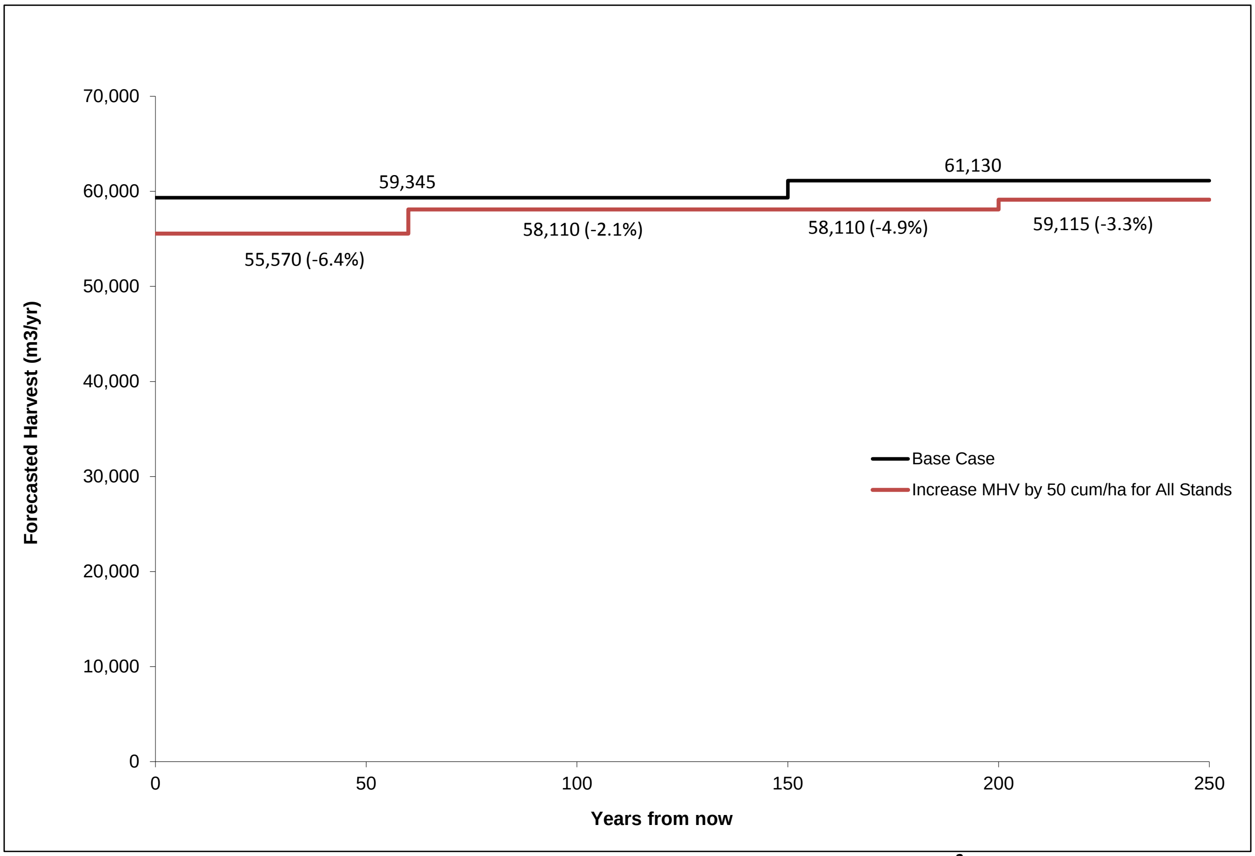

Figure 74: Sensitivity analysis; increase minimum harvest volume of all stands by 50 m^3/ha, TOC

6.7.1.3 Increase Minimum Harvest Volume of All stands by 100 m^3 per ha

This sensitivity analysis increased the MHV of all stands by 100 m^3 per ha to 300 m^3 per ha for ground-based operations and 350 m^3 per ha for cable operations. The 95% MAI culmination rule was also enforced. In this sensitivity analysis, 3,710 ha (19.3%) of the THLB was left unharvested due to the high volumes required for harvesting. The short-term harvest was reduced by 29.9 %, while the mid-term reduction ranged from 10.5% to 24.0% (Figure 75). The long-term forecast was reduced by 13.1 %.

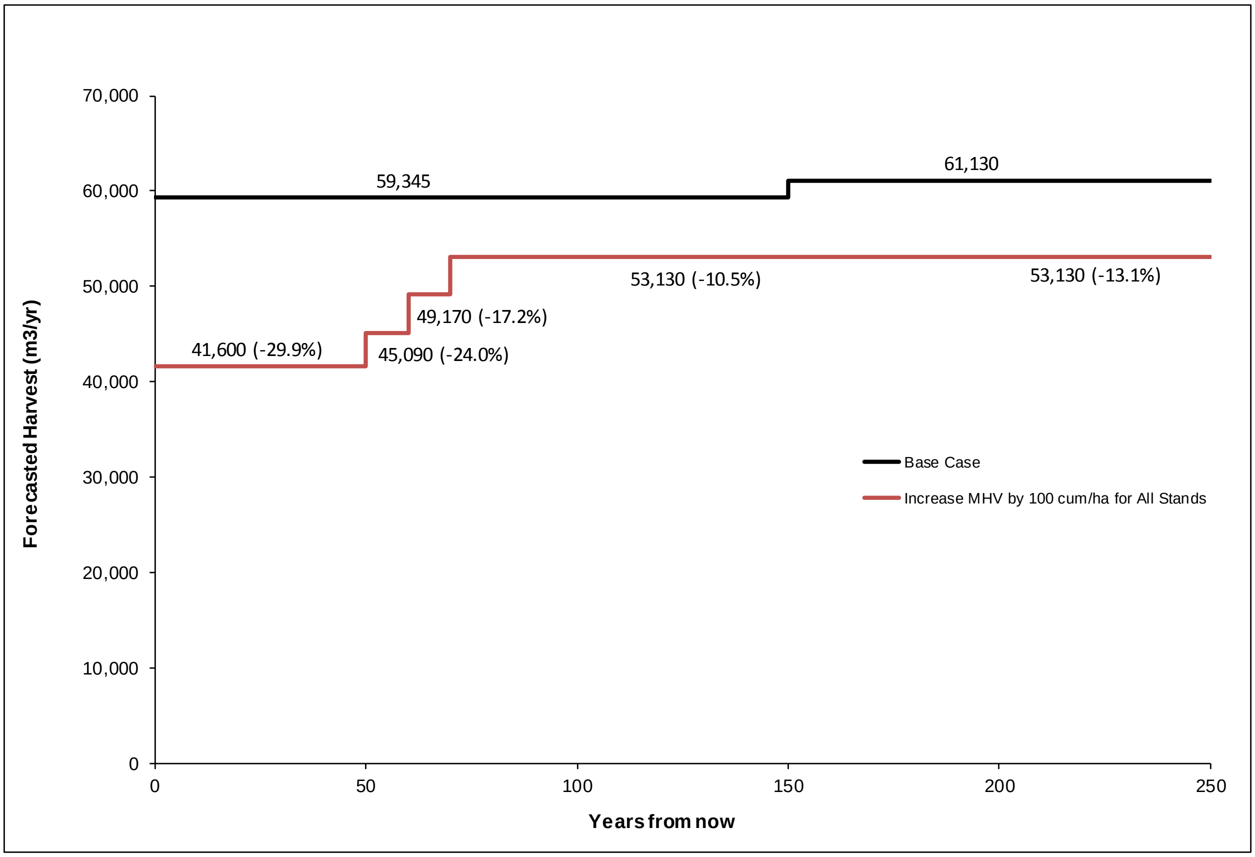

Figure 75: Sensitivity analysis; increase minimum harvest volume of all stands by 100 m^3/ha, TOC

6.7.1.4 Decrease Minimum Harvest Volume of All stands by 50 m³ per ha

This sensitivity analysis decreased the MHV of all stands by 50 m^3 per ha to 150 m^3 per ha for ground-based operations and 200 m^3 per ha for cable operations. The 95% MAI culmination rule was ignored.

Reducing the MHV for all stands allowed the timber supply model to harvest young managed stands earlier than in the Base Case. In many cases, the harvest of these young stands occurs several years before their MAI culmination. This erodes the growing stock and forces a lower harvest level in the long term. The long-term harvest forecast was reduced by 3.0% (Figure 76). Note that this result was similar to the one where the 95% MAI culmination rule was simply ignored (Section 6.7.1.1).

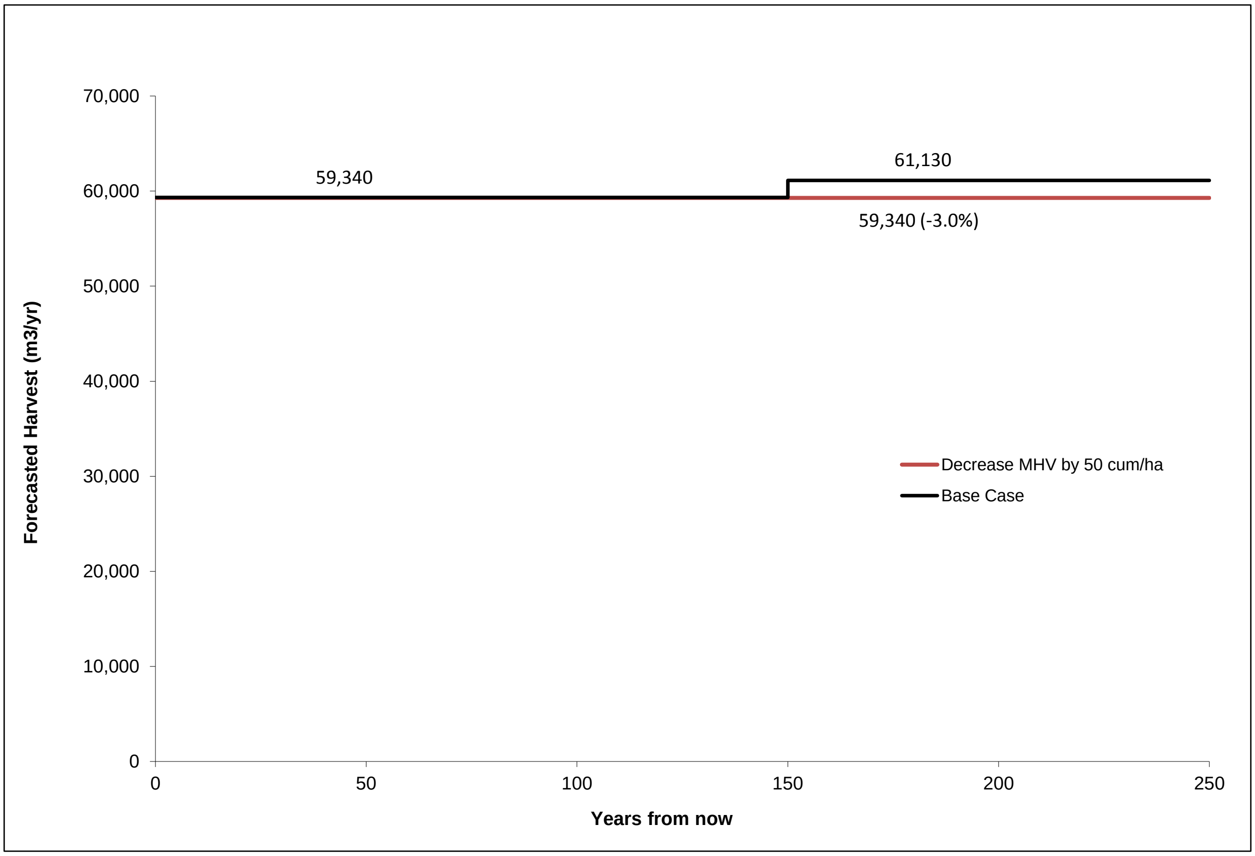

Figure 76: Sensitivity analysis; decrease minimum harvest volume of all stands by 50 m³/ha, TOC

6.7.1.5 Increase Minimum Harvest Volume of Managed Stands by 50 m^3 per ha

This sensitivity analysis increased the minimum harvest volumes of managed stands by 50 m^3 per ha to 250 m^3 per ha for ground-based operations and 300 m^3 per ha for cable operations. The short-term harvest forecast was reduced by 2.1% in the first 40 years, while the long-term forecast was 1.6% higher than in the Base Case (Figure 77). The transition to the long-term harvest level happened 25years earlier than in the Base Case.

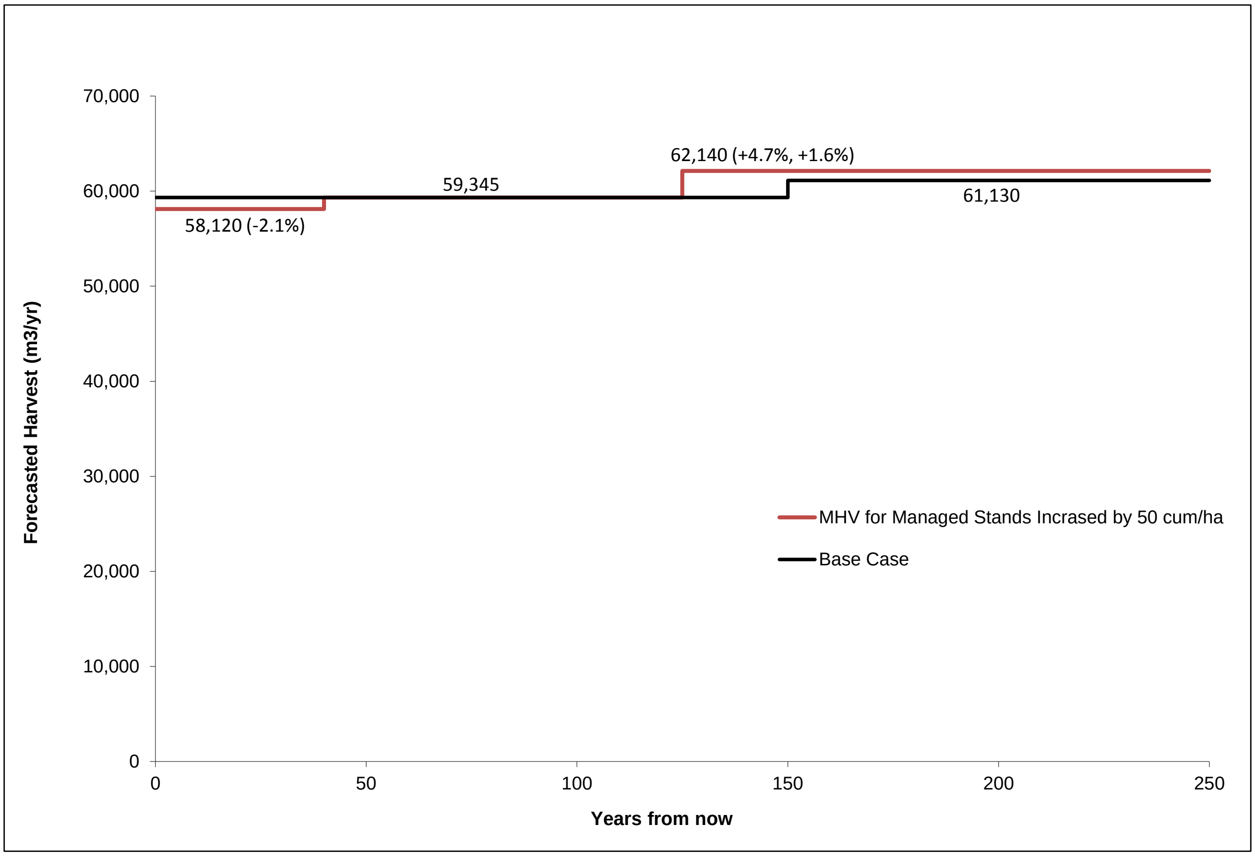

Figure 77: Sensitvity analysis; increase MHV for managed stands by 50 m^3 per ha, TOC

6.7.1.6 Increase Minimum Harvest Volume of Managed Stands by 100 m^3 per ha

This sensitivity analysis increased the minimum harvest volumes of managed stands by 100 m^3 per ha to 300 m^3 per ha for ground-based operations and 350 m^3 per ha for cable operations.

The harvest must be reduced in the first 45 years by 13.9%, because the current growing stock is not high enough to support the transition to managed stands, if their MHV is increased as much as 100 m^3 per ha (Figure 78). The long-term harvest forecast is slightly (0.9%) lower than that of the Base Case. The stands are held so long that the long-term harvest forecast is somewhat reduced, while a large volume of growing stock is maintained in the THLB. The long-term growing stock is over 30% higher compared to the Base Case (Figure 79).

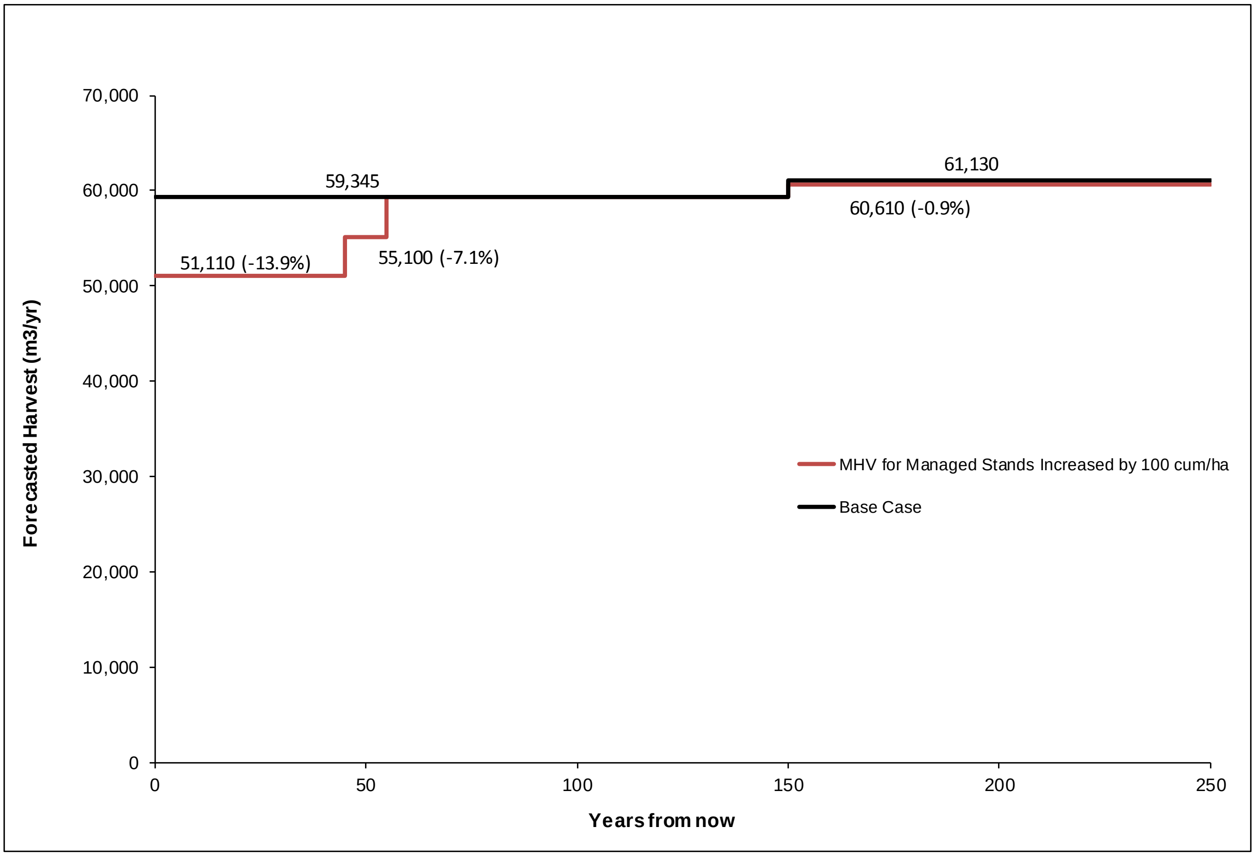

Figure 78: Sensitvity analysis; increase MHV for managed stands by 100 m^3 per ha, TOC

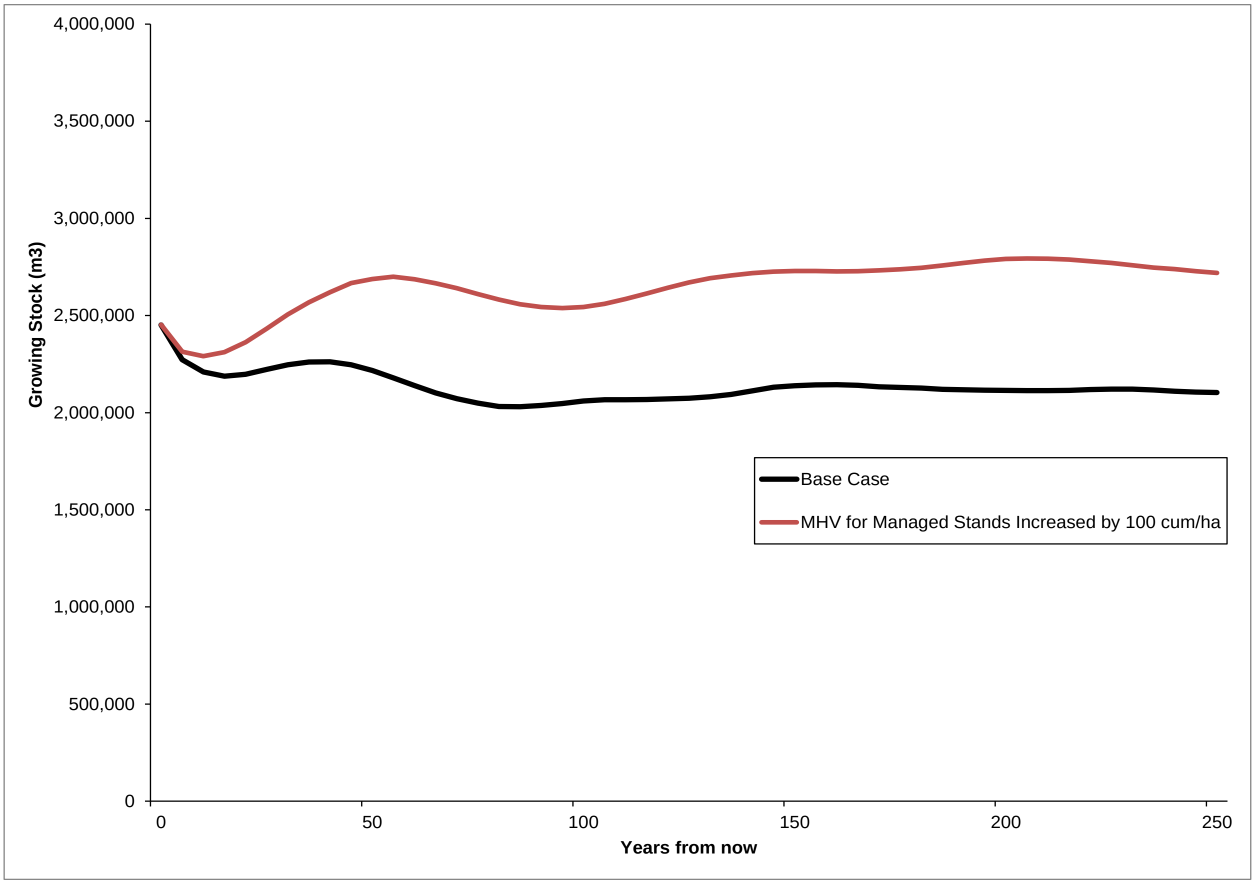

Figure 79: Sensitvity analysis, growing stock; increase MHV for managed stands by 100 m^3 per ha, TOC

6.7.2 Uncertainty of Predicted Inventory Volumes

The purpose of this sensitivity analysis is to test the risk associated with an overestimation in volumes predicted by the VRI. While underestimation of the inventory volumes poses no risk to timber supply, its impact was tested as well.

6.7.2.1 Increase Natural Stand Volumes by 10%

Increasing the natural stand volumes by 10% elevated the timber supply forecast by 8.0% in the first 50 years (Figure 80) of the planning horizon. The harvest forecast was also increased between years 51 and 150 by 2.9%, while the long-term forecast was not impacted.

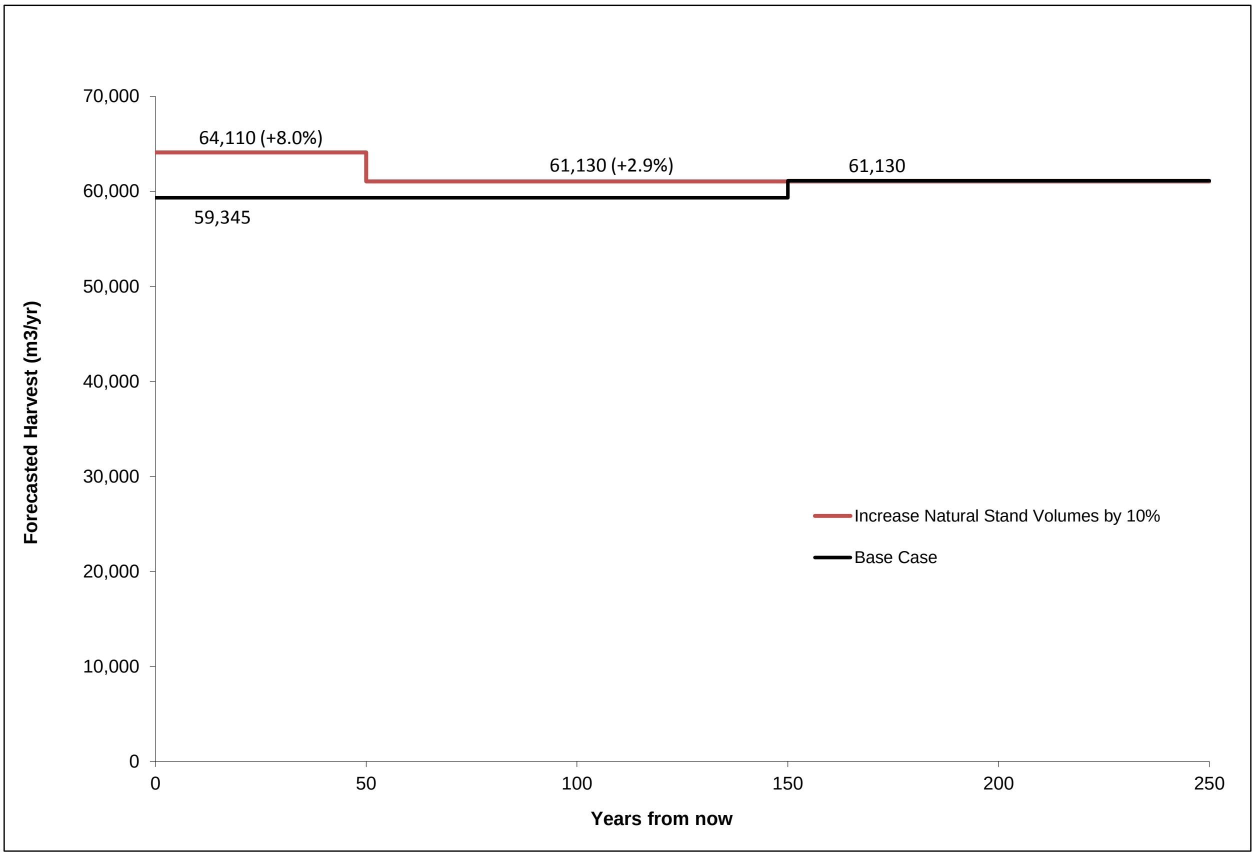

Figure 80: Sensitvity analysis; increase natural stand volumes by 10%, TOC

6.7.2.2 Decrease Natural Stand Volumes by 10%

Reducing the natural stand volumes by 10% decreased the timber supply forecast by 7.1% in the first 100 years of the planning horizon (Figure 81). The harvest forecast remained at the Base Case level until year 150; however, the long-term forecast was reduced by 3.3% compared to the Base Case. Decreasing the natural stand volumes caused more THLB to remain unharvested than in the Base Case; in this sensitivity analysis 9.6% of the THLB was never harvested (6.9% in the Base Case). As less THLB was harvested, the long-term harvest level was impacted.

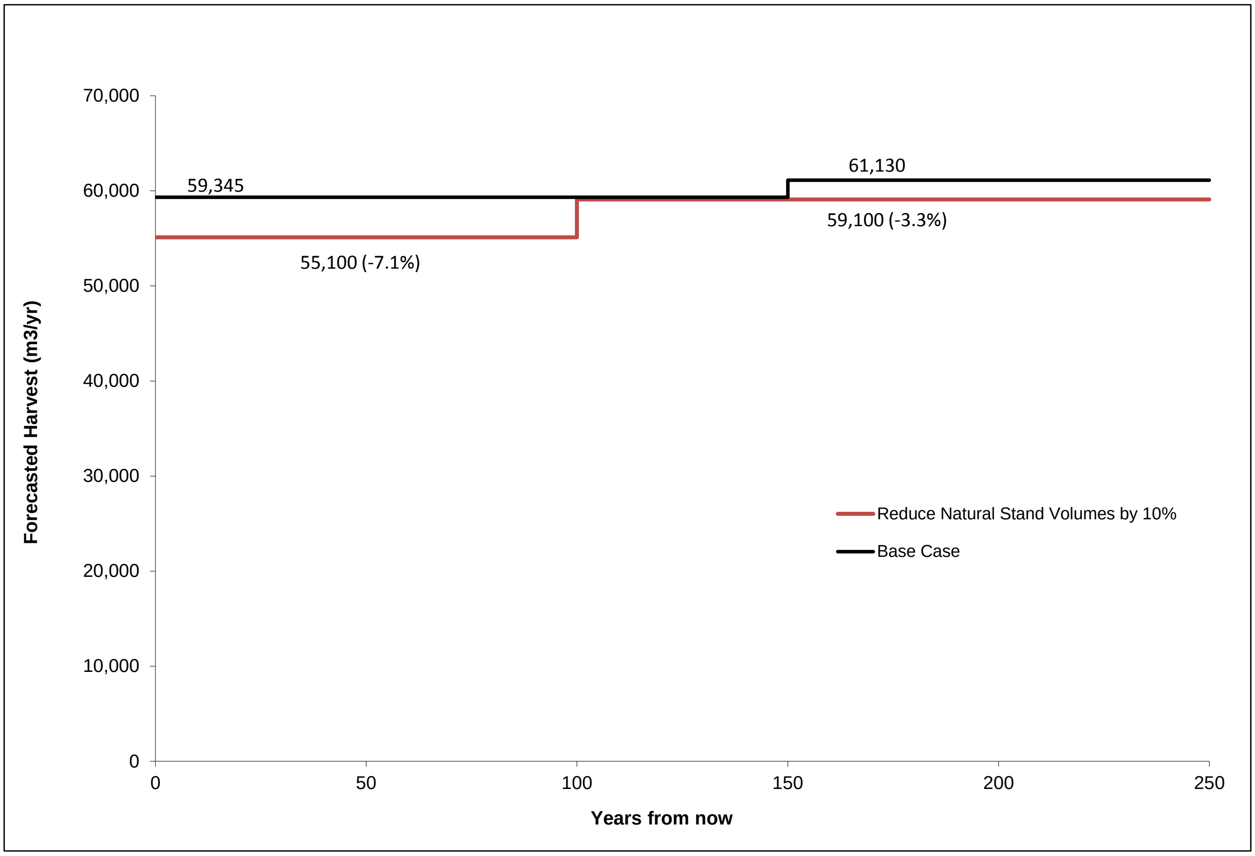

Figure 81: Sensitvity analysis; reduce natural stand volumes by 10%, TOC

6.7.3 Uncertainty of Predicted Growth and Yield of Managed Stands

Existing and future managed stands are the dominant source of volume in the medium and long terms. The purpose of this sensitivity analysis is to assess the impact associated with an over- or under-estimation in the growth of existing and future managed stands.

6.7.3.1 Increase the Volume of Managed Stands by 10%

Increasing the volume (yield) of managed stands by 10% increased the harvest forecast between years 76 150 by 9.7% (Figure 82). The predicted long-term timber supply was increased by 6.5%.

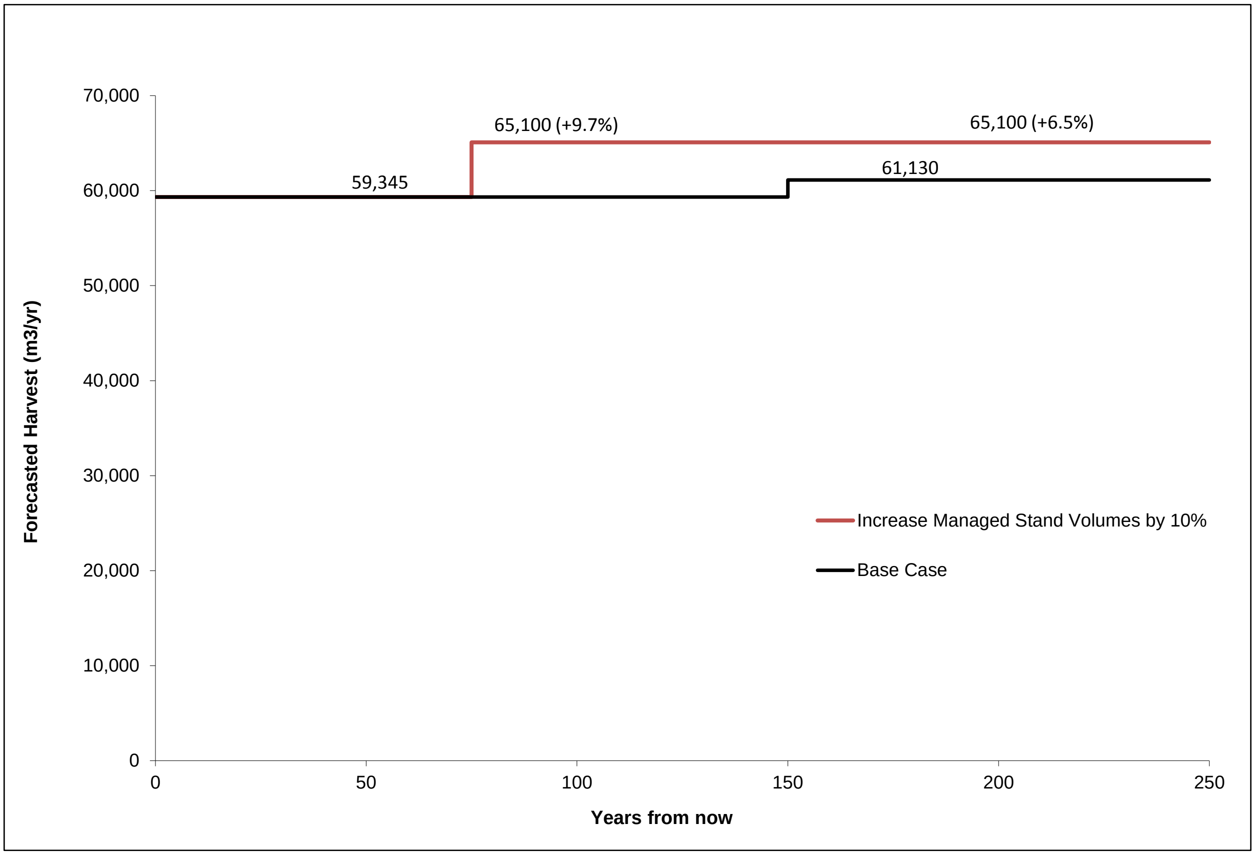

Figure 82: Sensitvity analysis; increase managed stand volumes by 10%, TOC

6.7.3.2 Decrease the Volume of Managed Stands by 10%

Decreasing the volume of managed stands by 10% impacted the timber supply starting at year 26; the harvest forecast was reduced by 7.2% between years 26 and 150, and 9.9% in the long term (Figure 83).

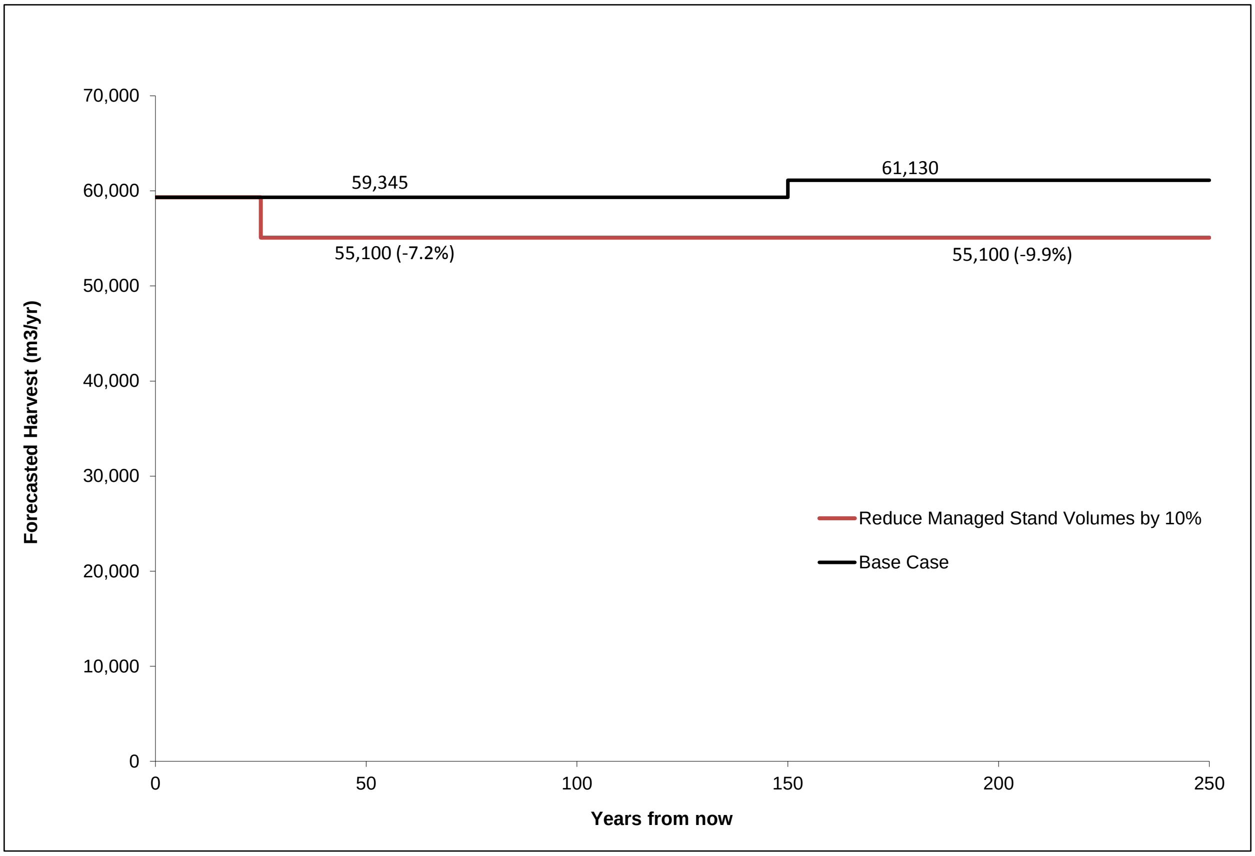

Figure 83: Sensitvity analysis; reduce managed stand volumes by 10%, TOC

6.7.4 Marginal Timber

6.7.4.1 Include Helicopter Operable Area in the THLB

This sensitivity analysis tested the impact of including the helicopter operable land base in the THLB. The net increase in the THLB was 0 ha with no timber supply impact.

Including the helicopter operable land base in the THLB did not increase the size of it, because other netdown factors and the minimum harvest criteria for helicopter operations maintained the added area as NHLB. According to the TOC Business Area, the minimum harvest criteria for helicopter operations is 400 m^3 per ha with the stand required to have at least 80% Cw.

6.7.5 Harvest Scheduling

This sensitivity analyses tested the impact of using the relative oldest first harvest rule as opposed to the highest volume first harvest rule that was employed in the Base Case.

Figure 84 illustrates the timber supply impact of using relative oldest first harvest rule. The short-term and the early mid-term harvest forecast were increased by 2.1%. The late mid-term and the long-term harvest forecast were elevated as well; the mid-term by 1.6% to 4.7% and the long-term by 3.2%. The impact comes mostly from a more efficient utilization of the THLB, i.e. less THLB is left unharvested than in the Base Case. In the Base Case 1,325 ha (6.9%) of the THLB was never harvested. In this sensitivity analysis only 521 ha of the THLB (2.7%) was never harvested throughout the planning horizon.

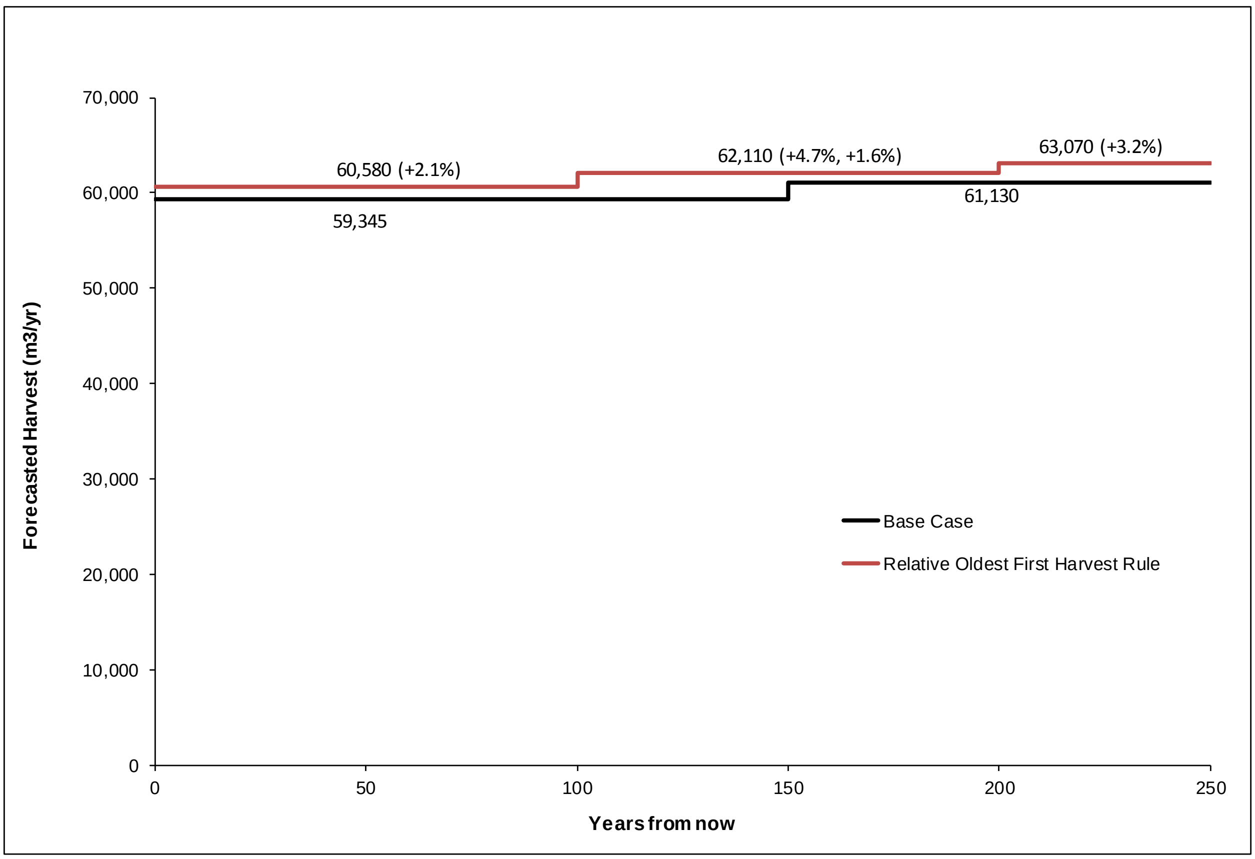

Figure 84: Sensitvity analysis; employ relative oldest first harvest rule, TOC

6.7.6 Armillaria Impact

The Base Case incorporated customized operational adjustment factors (OAF) in modelling the growth and yield of managed stands in TKO and TOC to account for losses due to Armillaria root disease. Armillaria is a common forest health agent in the interior wet belt that affects tree growth and mortality. This sensitivity analysis tested the impact of using the default value of 5% OAF2 for managed stands.

Figure 85 illustrates the harvest forecast of this sensitivity analysis compared to the Base Case. The harvest forecast is 6.5% higher during the first 85 years of the planning horizon. The harvest is then increased in two consecutive steps to the long-term harvest level which is reached at year at year 96. The long-term harvest forecast is 17.1% higher than that of the Base Case.

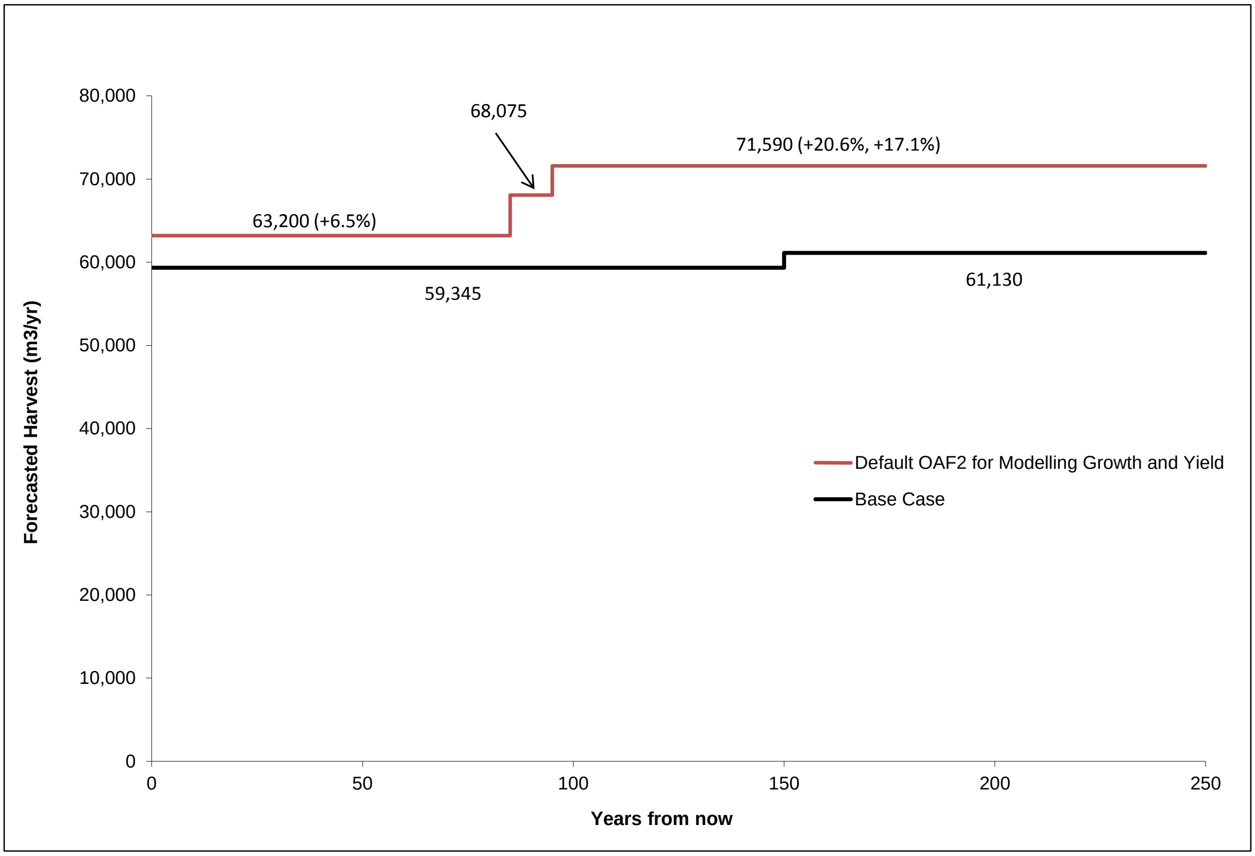

Figure 85: Sensitvity analysis; employ default OAF 2 for modelling growth and yield of managed stands, TOC

6.7.7 Green-Up

As a surrogate for spatial cutblock adjacency constraint, a landscape green-up constraint was applied in the Base Case, specifying that no more than 25% of the THLB area in each landscape unit outside of VQOs may be below the green-up height of 2.0 m at any given time.

One sensitivity analysis was completed. The maximum percentage of the THLB that could be below the green-up height was increased to 33%. There was no impact on timber supply.

6.8 Alternative Harvest Forecasts, TOC

Figure 86 illustrates the analysis results for two alternate harvest forecasts compared to the Base Case. The first alternate forecast set the initial harvest level at the current AAC of 66,566 m^3 per year. Initially, the current AAC was maintained for 10 years; however, this forecast produced a lower long-term harvest forecast than the Base Case; the model left more THLB unharvested than the more aggressive approach of maintaining the current AAC for 15 years. The mid-term harvest forecast remained the same, whether the current AAC was maintained 10 years or 15 years, while the long-term harvest level equaled that of the Base Case.

When the current AAC was maintained for 15 years the forecast had to be reduced by 12.7% at year 16 to the mid-term harvest level. The mid-term harvest level was 2.1% less than in the Base Case between years 16 and 100. The long-term forecasts remained at the Base Case level.

Figure 86 also presents the maximum non-declining even flow alternative; the highest possible even flow harvest level equals the short- and mid-term harvest level of the Base Case at 59,345 m^3 per ha.

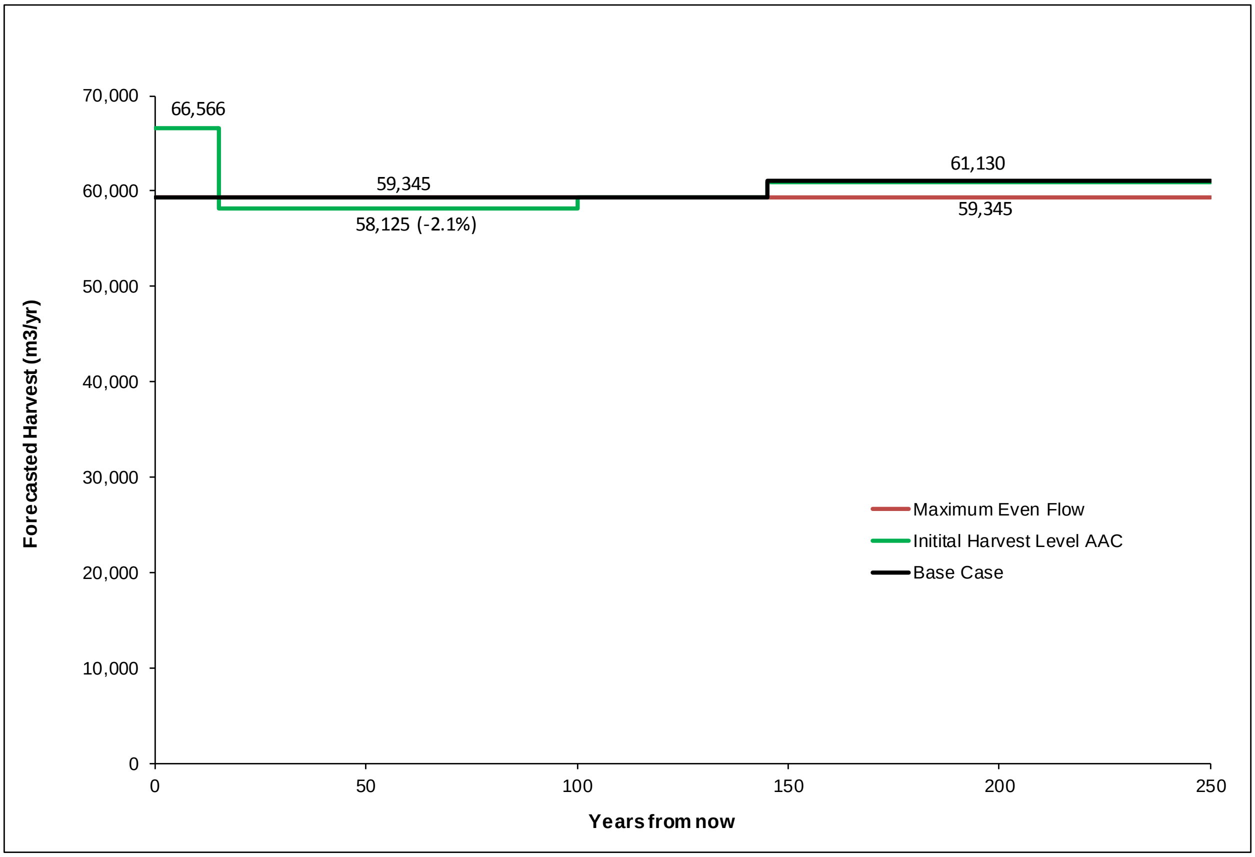

Figure 86: Alternative harvest forecasts; TOC

6.9 Discussion

In this analysis, the growth and yield of managed stands was reduced significantly due to the predicted impacts of Armillaria on tree growth. On the other hand, these factors were compensated at least partly by high site indices of managed stands and their assumed high genetic gain.

The initial harvest level for the Base Case harvest forecast in TOC is 59,345 m^3 per year, 12.7% lower than the current AAC of 66,566 m^3 per year. The timber supply is not particularly constrained aside from VQOs and ungulates (deer); a further analysis indicates that the predicted long-term harvest level is at approximately 90% of the long-range sustained yield (LRSY) estimate for TOC.

The TOC staff is concerned over the predicted harvest ages and per hectare volumes of managed stands in the Base Case. Their preference would be to introduce a management strategy in TOC that would aim to increase the predicted harvest ages and per ha volumes of managed stands significantly. The completed sensitivity analyses showed that while increasing the minimum harvest criteria for managed stands produced higher volumes per hectare, they also impacted the timber supply.

Increasing the minimum harvest volumes of managed stands by 50 m^3 per ha reduced the short-term harvest forecast 2.1% in the first 40 years, while the long-term forecast was 1.6% higher than in the Base Case. If the minimum harvest volumes of managed stands were increased by 100 m^3 per ha, the harvest had to be reduced by 13.9% in the first 45 years. The stands are held so long that the long-term harvest forecast was also somewhat reduced (0.9%), while a large volume of growing stock was maintained in the THLB.

The timber supply is sensitive to changes in the growth and yield assumptions of natural stands and managed stands. Reducing the natural stand volumes by 10% decreased the timber supply forecast by 7.1% in the first 100 years of the planning horizon. The long-term forecast was also reduced by 3.3%; however, this reduction was also influenced by the unharvested THLB as described earlier in this document.

Decreasing the volume of managed stands by 10% impacted the timber supply throughout the planning horizon.

Including the helicopter operable land base in the THLB did not increase the size of it, because other netdown factors and the minimum harvest criteria for helicopter operations maintained the added area as NHLB.

7 Base Case, TCC

7.1 TCC Business Area

The analysis was completed separately for each BA. Blocks 5, 6, 7 and 8 in Figure 87 depict the TCC BA.

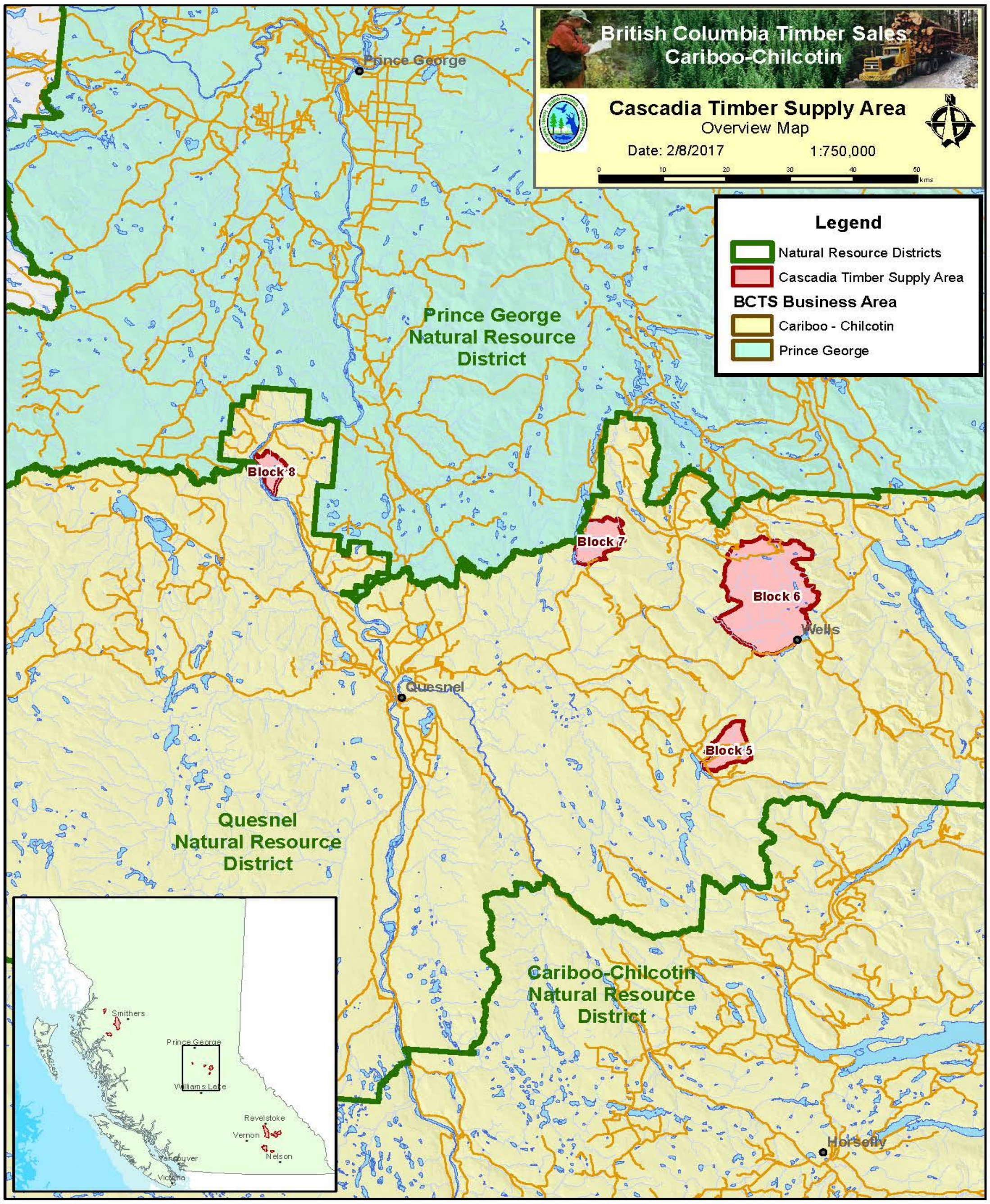

Figure 87: TCC BA: Blocks 5, 6, 7 and 8

7.2 Harvest Forecast

Figure 88 illustrates the Base Case harvest forecast for TCC. The initial harvest level of 55,190 m^3 per year is 28.3% less than the current AAC of 76,986 m^3 per year. The initial harvest level can be maintained for 170 years, after which the long-term harvest level of 58,790 m^3 per year is achieved. In the Base Case, 282 ha of the THLB (1.6%) remained unharvested at the end of the planning horizon. Note that contrary to all other Business Areas, a relative oldest first harvest rule was employed in TCC. This harvest rule tends to be more efficient in harvesting almost the entire THLB, because the lower volume stands are not left out of the harvest queue by "recycling" the more productive stands, which often happens when the highest volume first harvest rule is employed. Table 21 summarizes the TCC Base Case.

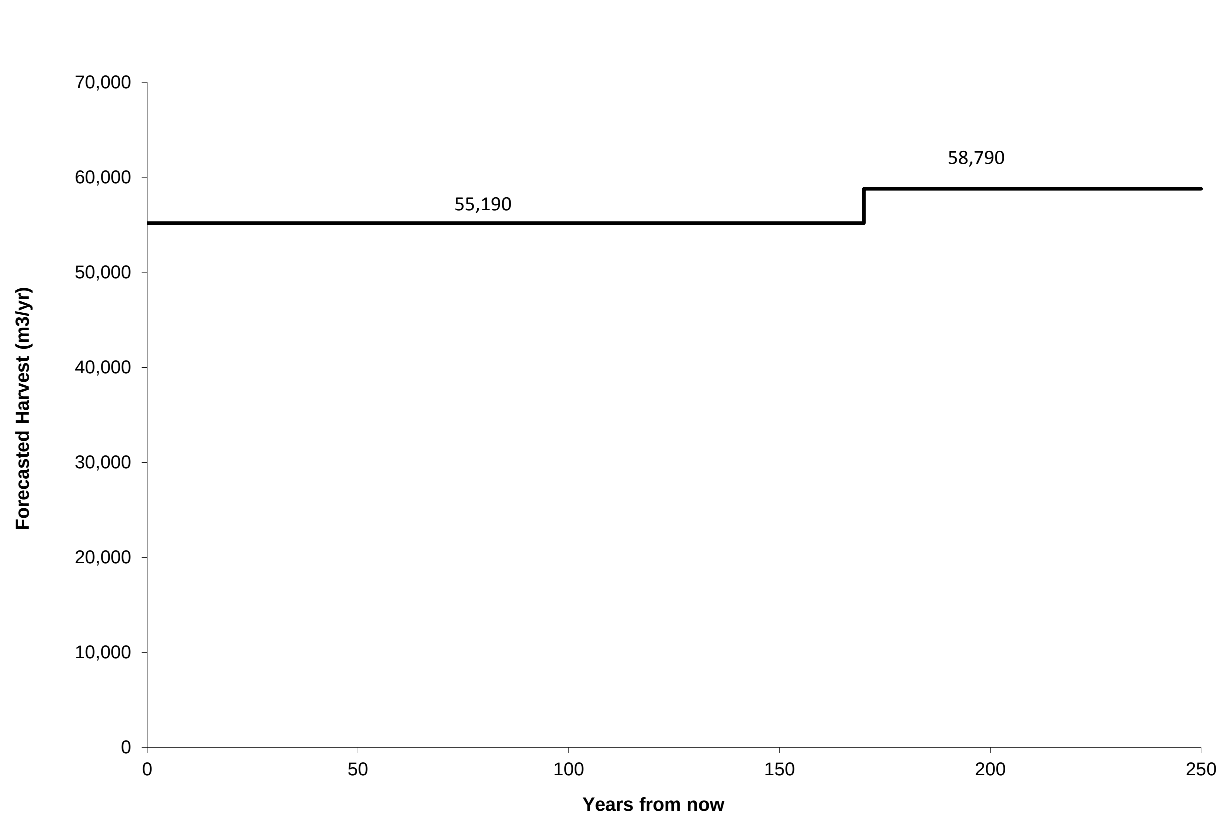

Figure 88: Base Case harvest forecast; TCC

Table 21: Harvest forecast summary, TCC

Period	Predicted Harvest (m^3 per year)	Unharvested THLB (ha)
Years 1 to 170:	55,190 m^3	282 ha (1.6%)
Years 171 to 250 (LTHL)	58,790 m^3	

7.3 Growing Stock

Figure 89 shows the predicted growing stock for the TCC Base Case. The merchantable or mature growing stock remains relatively high; the harvest is not constrained by lack of merchantable timber. In TCC the main constraints are VQOs, mature and old targets (Swift ESSFwk) and Caribou (WHA 5-089).

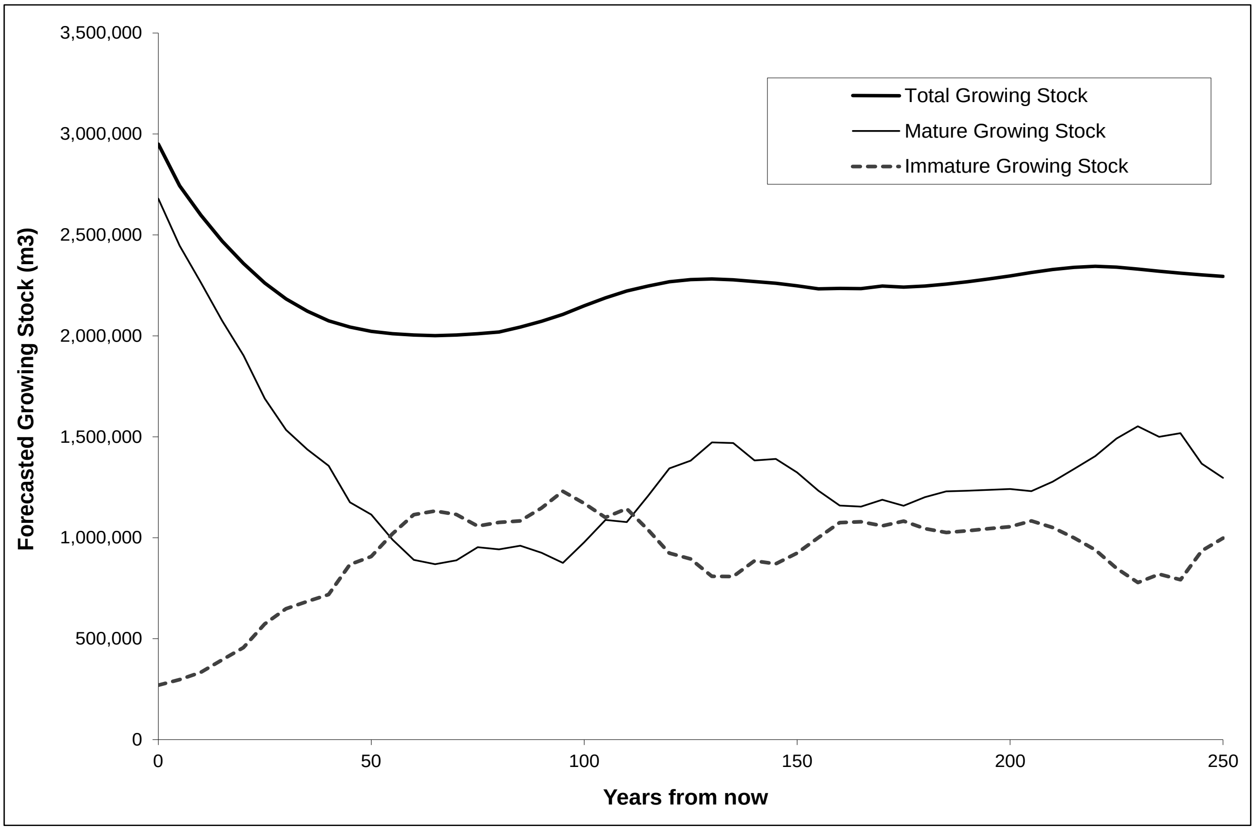

Figure 89: TCC Base Case; predicted growing stock

7.4 Harvest Age, Harvest Volume and Harvest Area

Figure 90 shows the TCC harvest forecast by age class. Stands older than 100 form most of the harvest in the first 45 years. In the long term, much of the harvest is predicted to come from age class 4 (61-80 years old) and 5 (81-100 years old) stands. Figure 91 illustrates the average harvest age for the TCC Base Case. During the first 25 years the average harvest age is around 200 years. It then declines quickly and trends around 80 years in the long term.

Figure 92 shows the TCC harvest forecast by vol/ha class. Throughout the planning horizon the harvest volumes are predicted to be mostly between 200 and 400 m^3 per ha, with the 300 to 400 m^3 per ha class predominant in the long term.

Figure 93 illustrates the predicted average harvest volume per ha; it fluctuates between 260 and 385 m^3 per ha until the long term and settles around 320 m^3 per ha.

The annual average harvest area ranges from 150 to 225 ha with the average trending just below 200 ha per year in the long term (Figure 94).

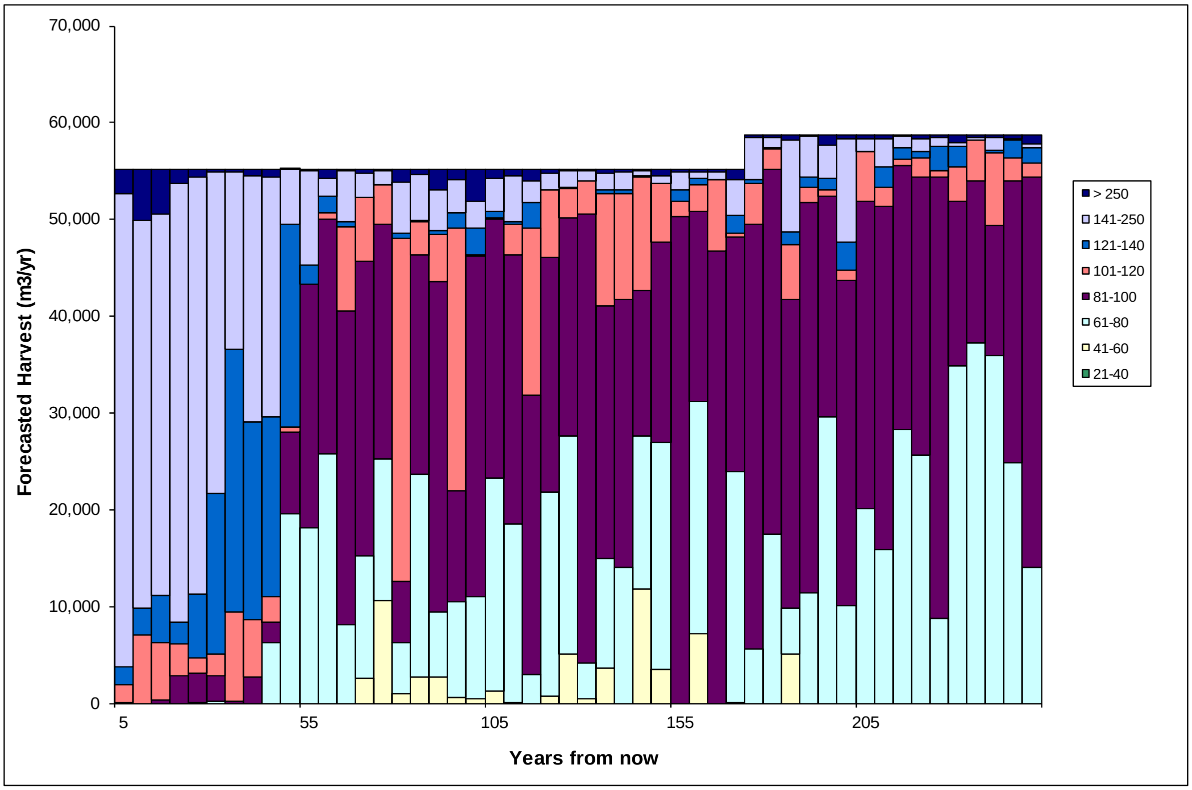

Figure 90: TCC Base Case; harvest forecast by age class

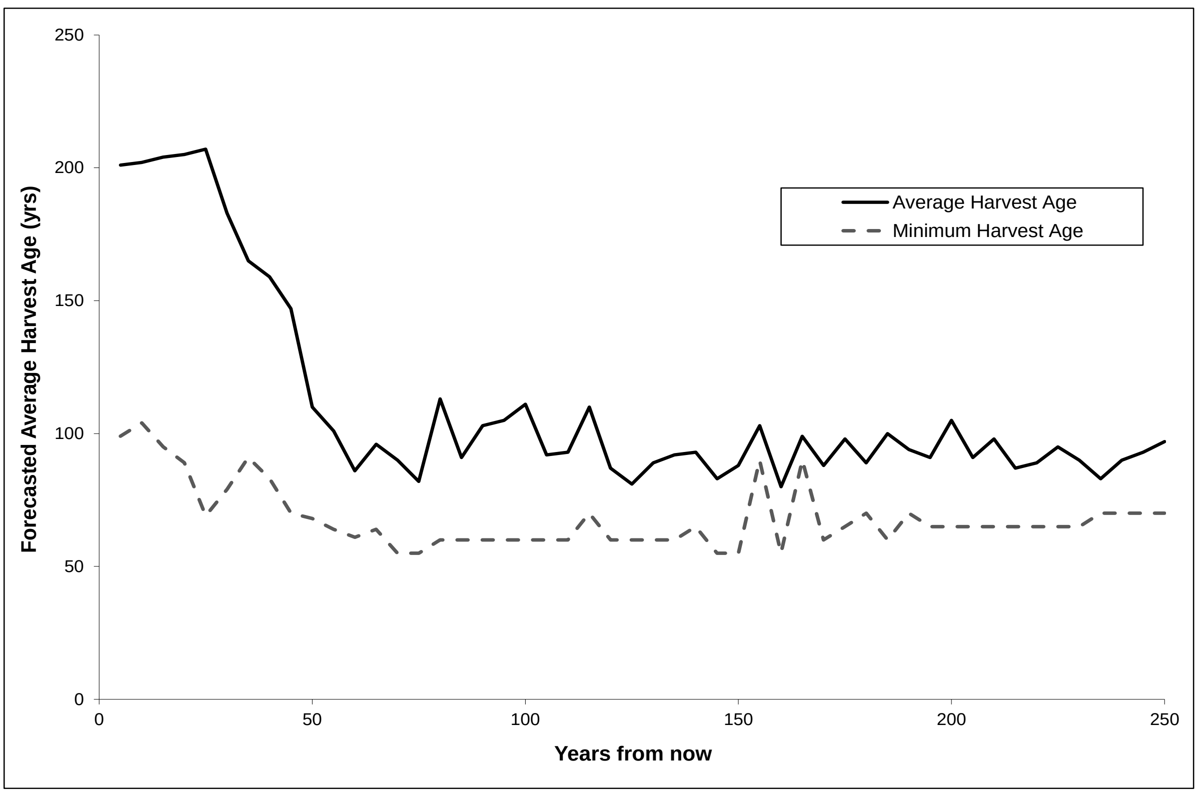

Figure 91: TCC Base Case; average and minimum harvest age

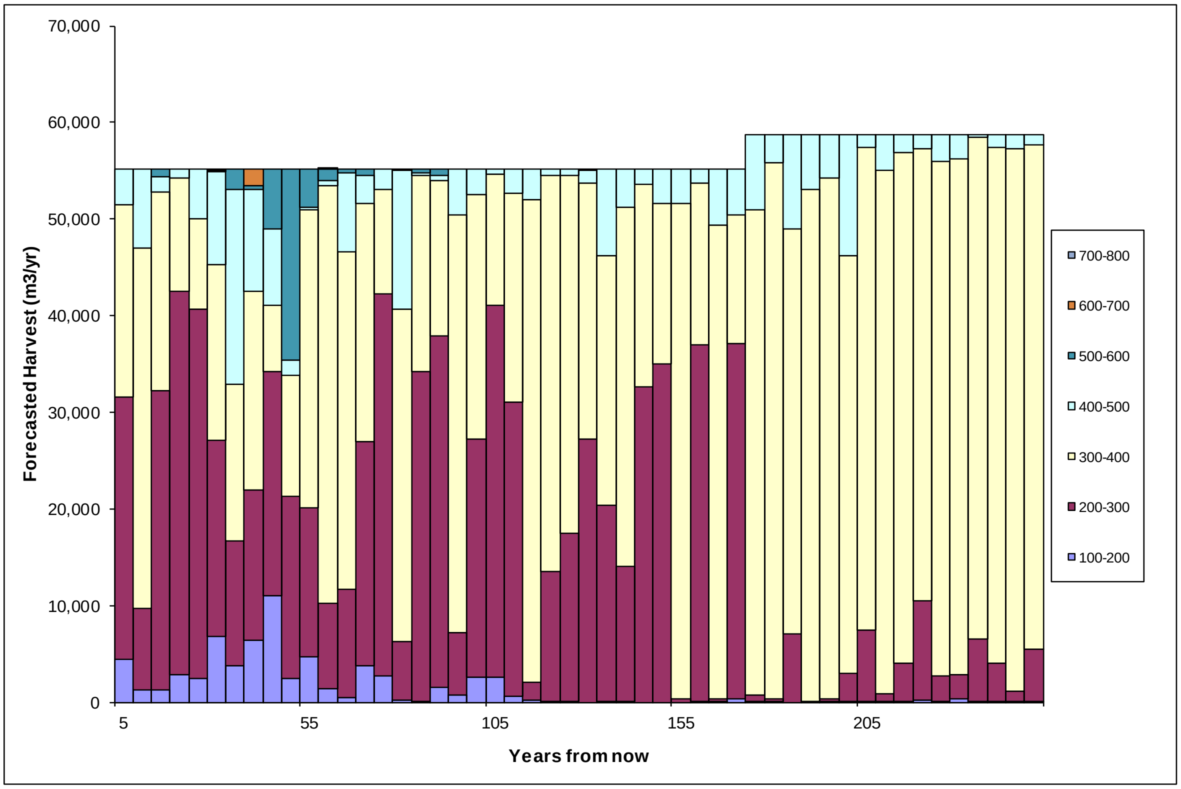

Figure 92: TCC Base Case; harvest forecast by vol/ha class

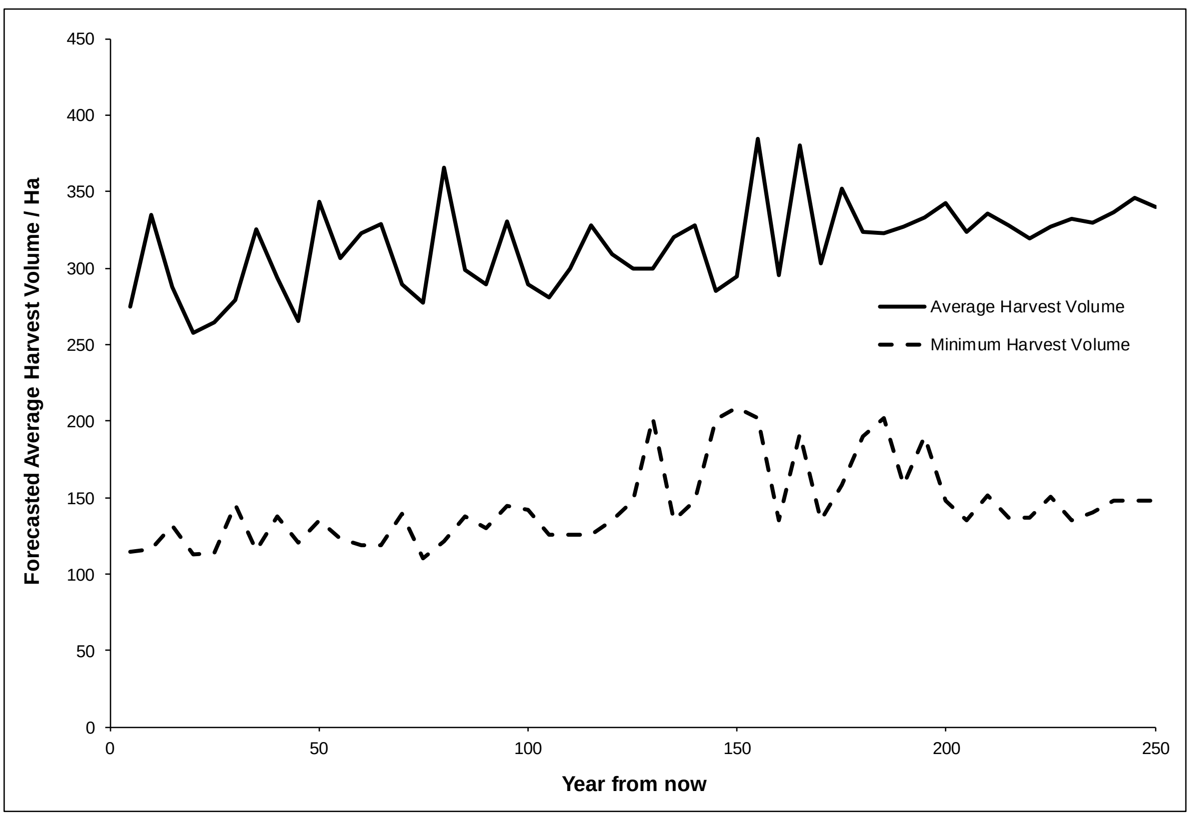

Figure 93: TCC Base Case; average harvest volume per ha

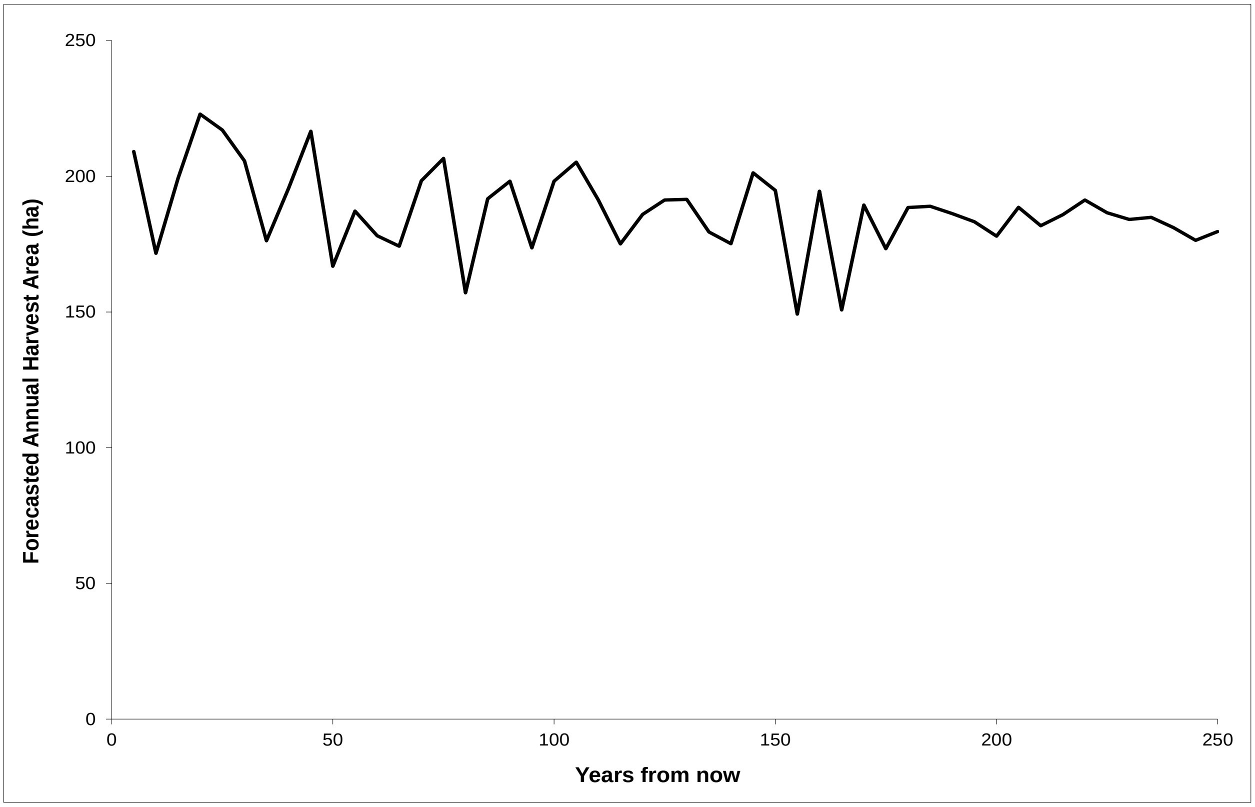

Figure 94: TCC Base Case; average annual area harvested

7.5 Composition of Harvest by Yield Type, Species and Block

Figure 95 illustrates the TCC Base Case harvest forecast by yield type. The transition to managed stands is predicted to start after 40 years and by year 115 almost the entire harvest is predicted to come from managed stands.

Figure 96 provides the harvest forecast by species. Until the harvest transitions to managed stands, the timber supply is predicted to consist mostly of balsam and spruce stands. In the late medium term and in the long term lodgepole pine is predicted to form the majority of harvest.

Figure 97 provides the Base Case harvest forecast by BA Block.

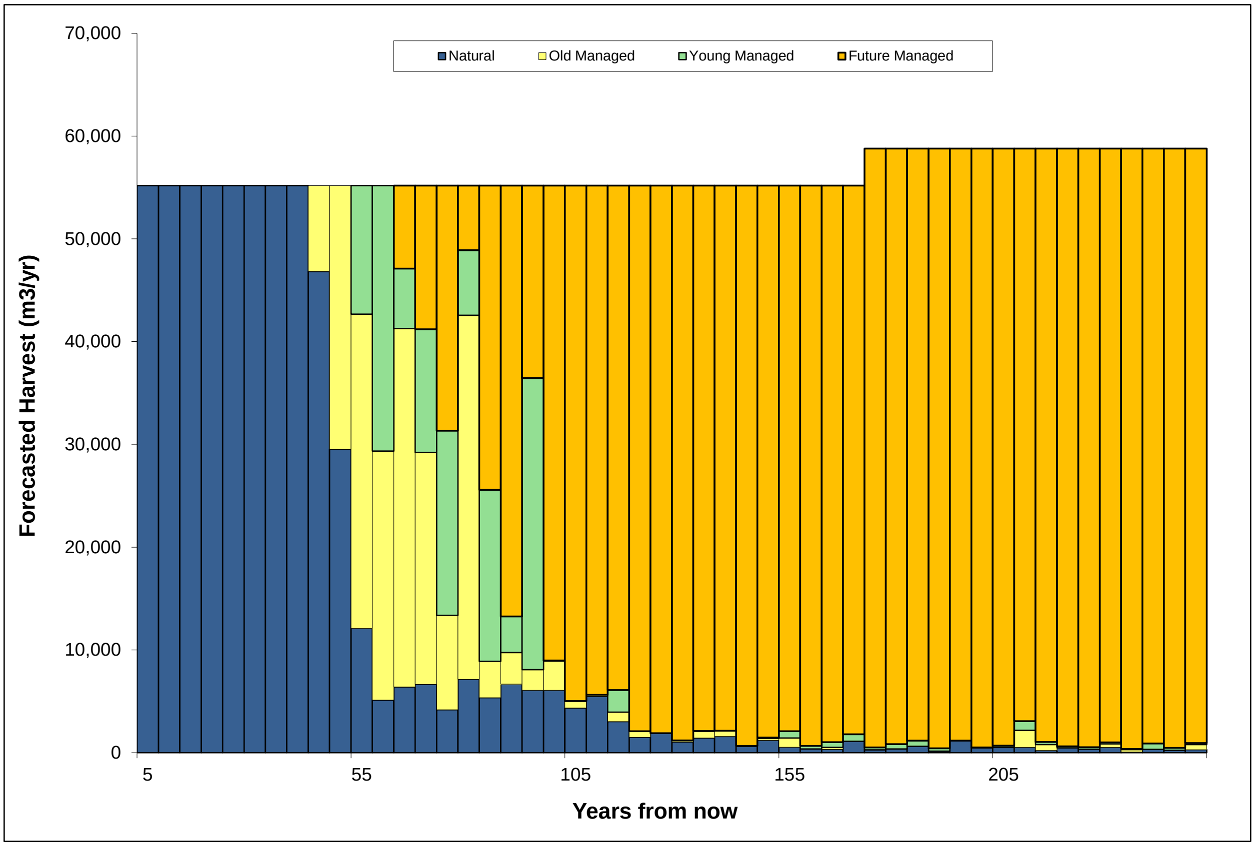

Figure 95: TCC Base Case; harvest forecast by yield type

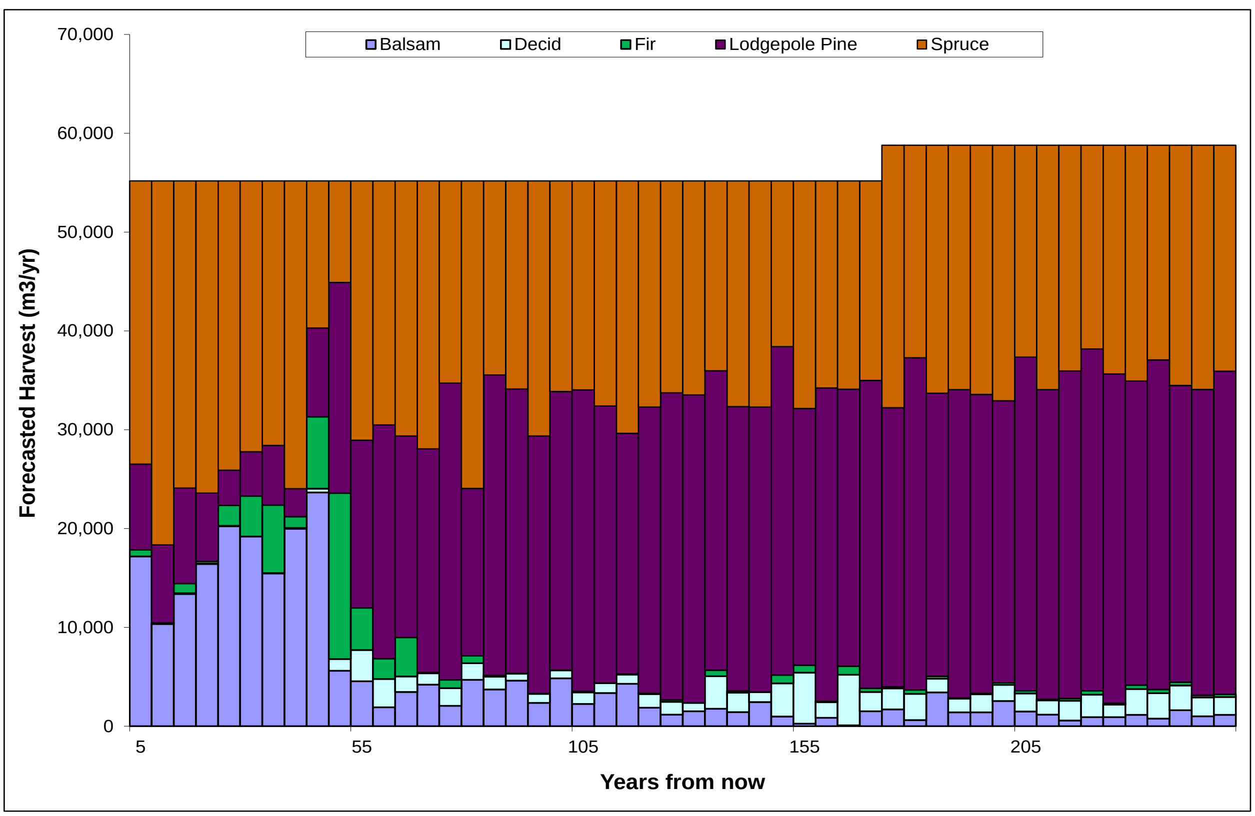

Figure 96: TCC Base Case; harvest forecast by species

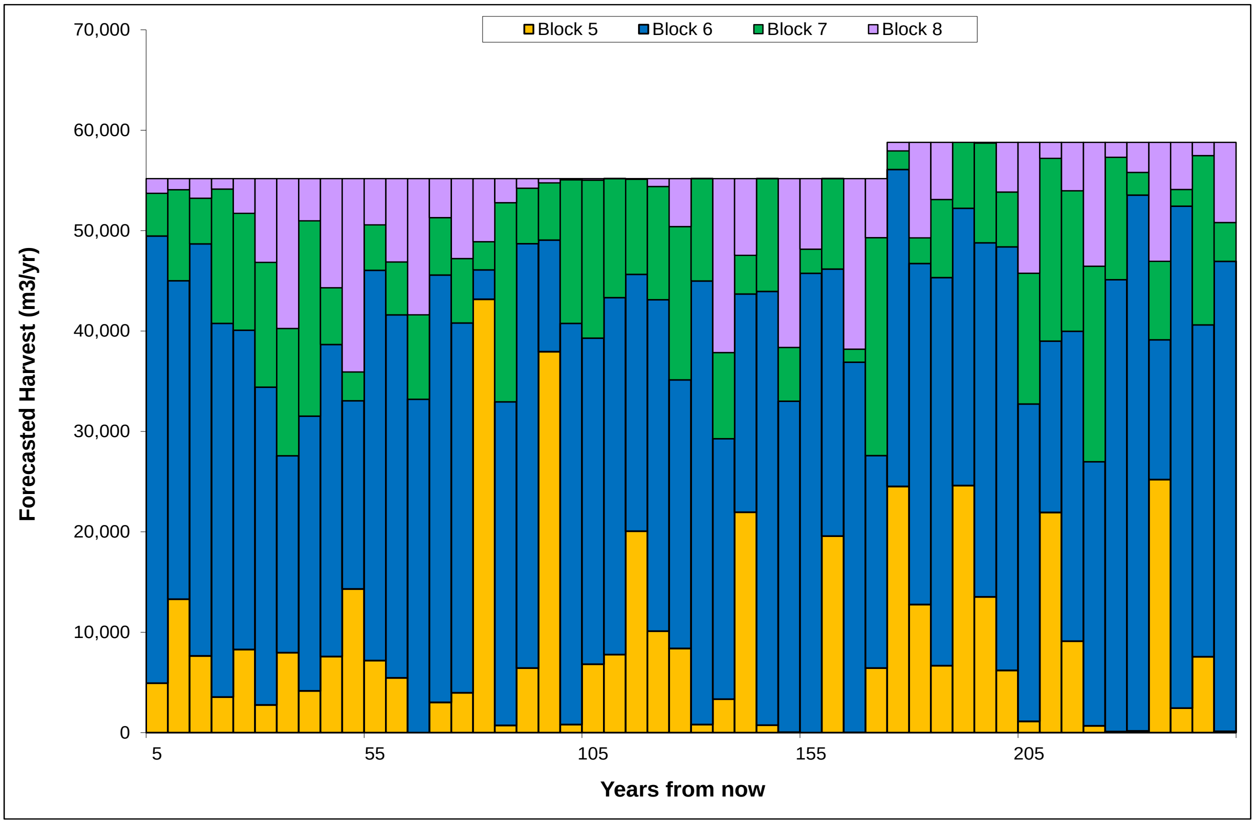

Figure 97: TCC Base Case; harvest forecast by Block

7.6 Age Structure

Figure 98, Figure 99, Figure 100, Figure 101, Figure 102 and Figure 103 illustrate the projected age class structure of the forest, should the Base Case harvest schedule be followed. In the course of time, much of the NHLB will become late seral (over 250 years of age). The harvest would occur in the THLB, which does not generally age much beyond 100 years. Most of the harvest is expected to come from age class 4 and 5 stands in the long run.

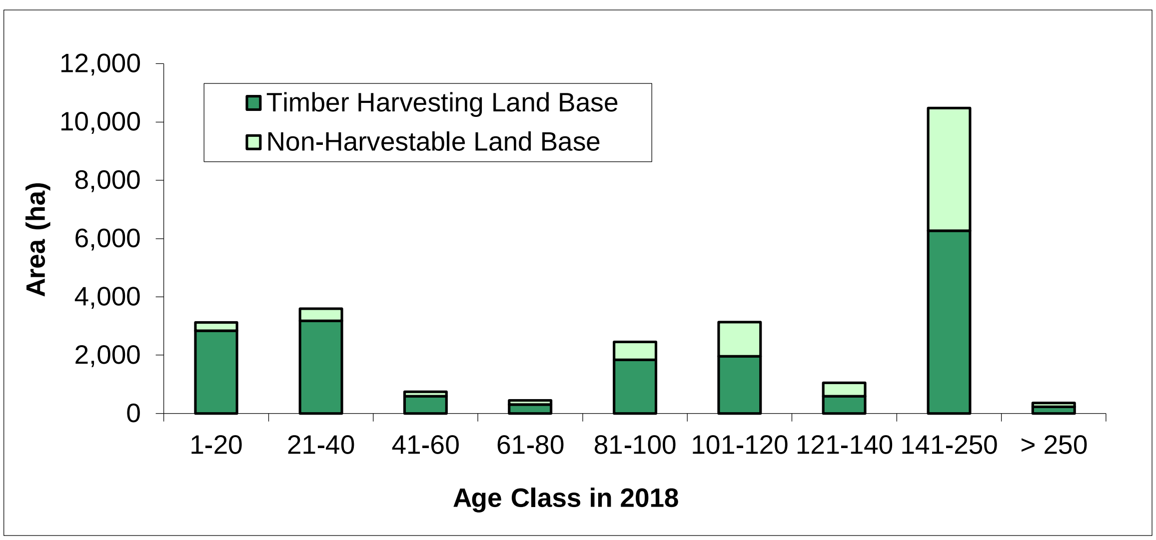

Figure 98: Current age class distribution, TCC

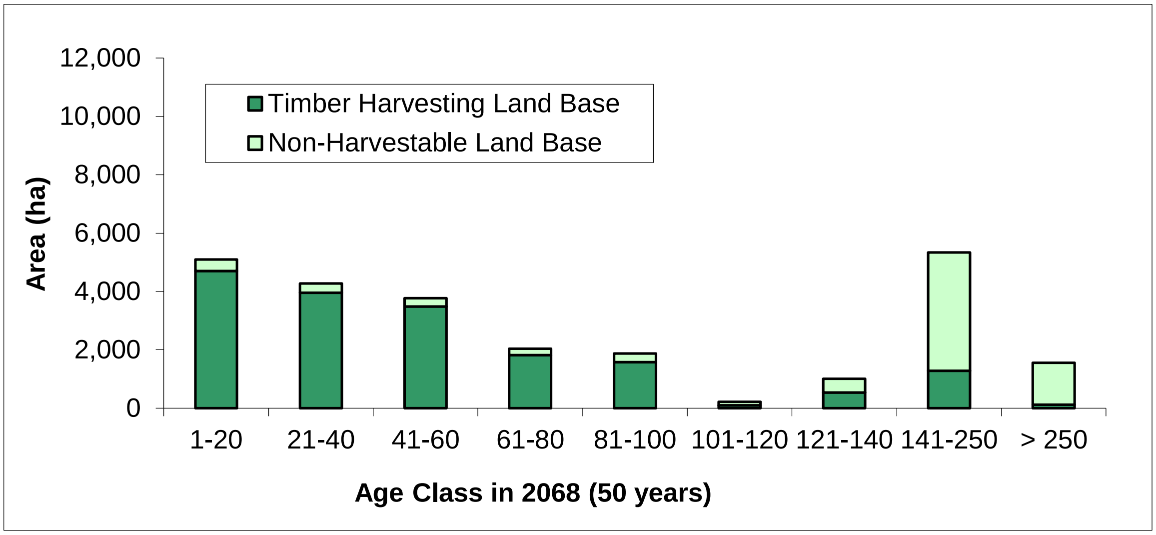

Figure 99: Projected age class distribution in 50 years, TCC

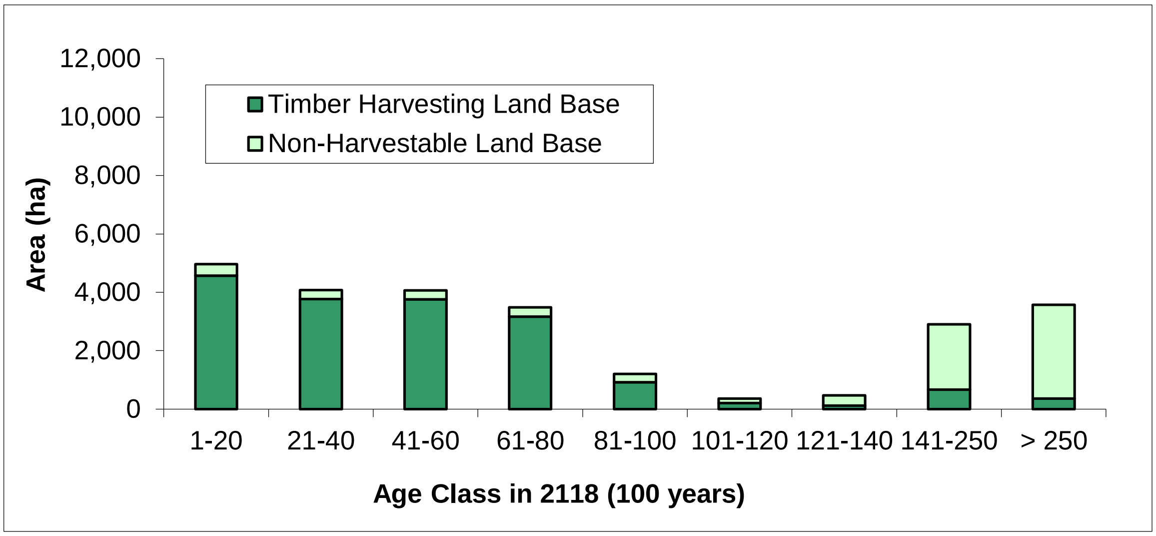

Figure 100: Projected age class distribution in 100 years, TCC

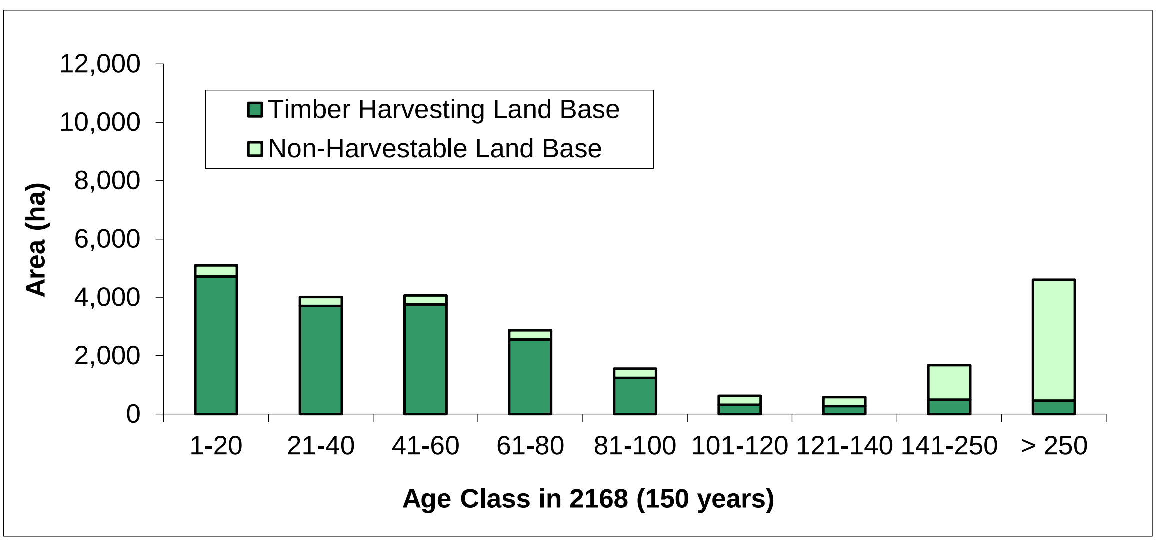

Figure 101: Projected age class distribution in 150 years, TCC

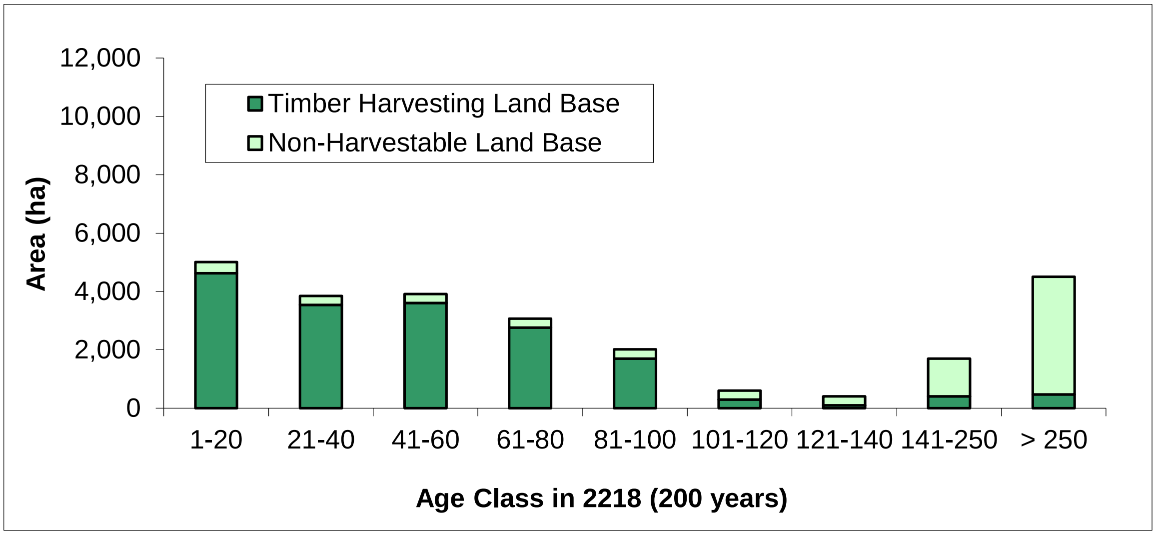

Figure 102: Projected age class distribution in 200 years, TCC

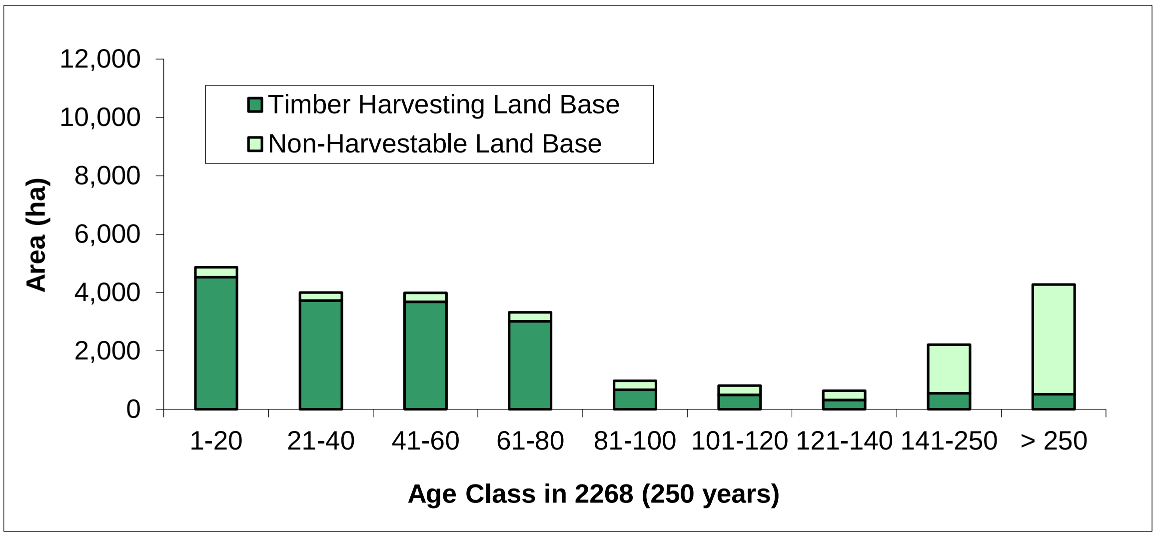

Figure 103: Projected age class distribution in 250 years, TCC

7.7 Sensitivity Analyses, TCC

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 harvest constraints correctly. Furthermore, sensitivity analyses also test the impact and risk of data uncertainties and modeling assumptions to the harvest level, particularly in the short-term. Table 22 presents a summary of the sensitivity analyses that were carried out to test the various uncertainties that exist in the Base Case data and assumptions.

Table 22: Summary of sensitivity analyses; TCC

Issue	Sensitivity analysis
Minimum harvest criteria	Consider only minimum harvest volume for **all** stands and remove the 95% MAI culmination rule.
	Decrease minimum harvest volume (MHV) of **all** stands by 30 m^3 per ha, remove 95% MAI culmination rule.
Volume of existing natural stands	Increase natural stand volumes by 10%
	Decrease natural stand volumes by 10%
Volume of managed stands	Increase managed stand volumes by 10%
	Decrease managed stand volumes by 10%
Harvest rule	Use a relative highest volume first harvest rule
Forest Health	Test the impact of incorporating custom OAF2 factors to account for rust and MPB impacts in young stands
Green-up	Maximum 33% of THLB in each LU less than green-up height

7.7.1 Minimum Harvest Criteria

In the Base Case, the stands can be harvested once they reach a volume of 110 m^3 per ha for ground-based operations and 200 m^3 per ha for cable operations. The stands must also reach the age at which the stand's mean annual increment (MAI) achieves a value of 95 percent of the maximum (culmination).

Minimum harvestable volumes may be lower in good market conditions and at times higher volumes may be required for the harvest to be economic. In these sensitivity analyses the minimum harvest volumes were decreased. The 95% MAI culmination rule was ignored.

7.7.1.1 Consider Only Minimum Harvest Volume for All Stands

In this sensitivity analysis, only the minimum harvest volume criteria were considered, while the 95% MAI culmination rule was ignored. The long-term timber supply was impacted as illustrated in Figure 104; it was reduced by 6.1%. Ignoring the MAI culmination rule allowed the timber supply model to harvest young managed stands earlier than in the Base Case. In many cases, the harvest occurs several years before their MAI culmination. This erodes the growing stock forcing a lower harvest level in the long term.

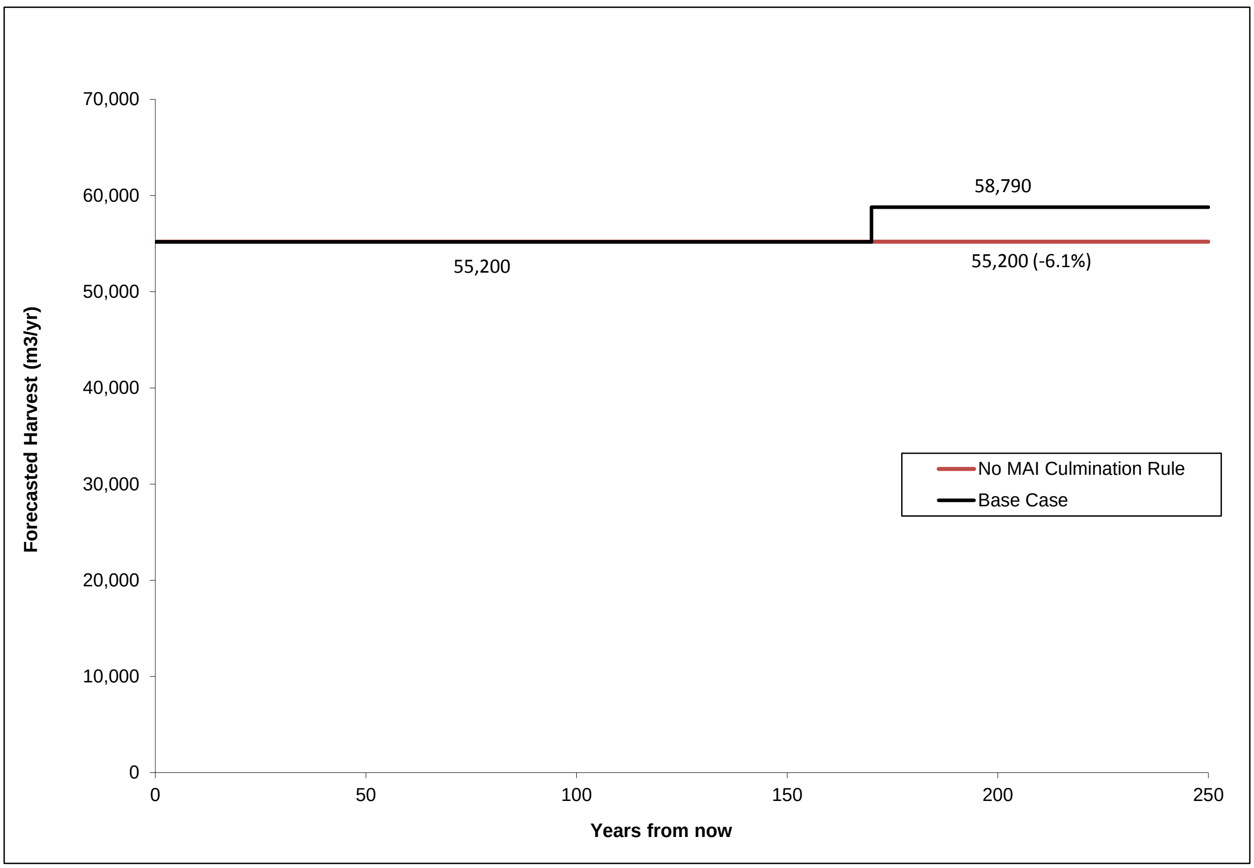

Figure 104: Sensitvity analysis; ignore MAI culmination rule, TCC

7.7.1.2 Decrease Minimum Harvest Volume of All stands by 30 m^3 per ha

This sensitivity analysis decreased the MHV of all stands by 30 m^3 per ha to 80 m^3 per ha for ground-based operations and 170 m^3 per ha for cable operations. The 95% MAI culmination rule was ignored.

In this sensitivity analysis the effective MHV reduction is greater than in the previous analysis, where only the MAI culmination rule was ignored; the impact is similar, while marginally smaller. The long-term harvest forecast was reduced by 5.1% (Figure 105).

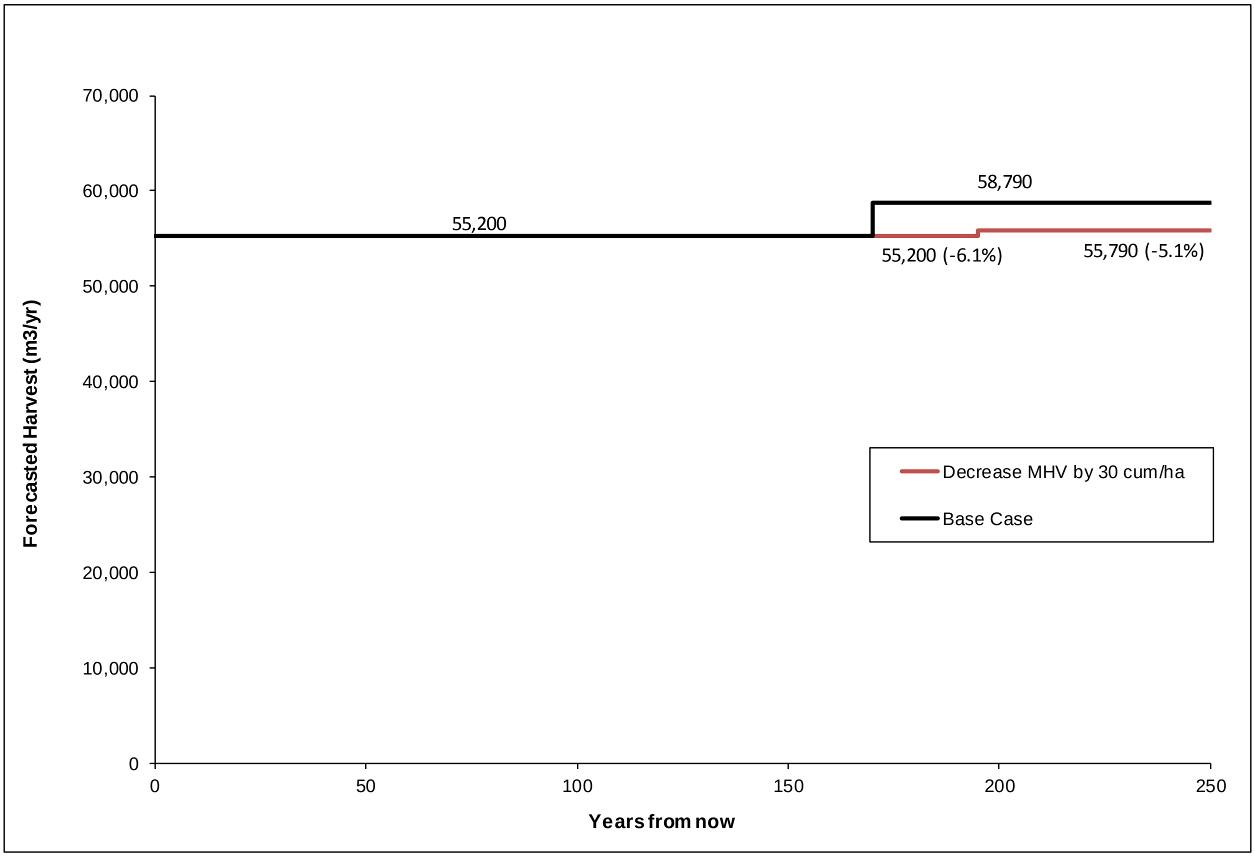

Figure 105: Sensitivity analysis; decrease MHV of all stands by 30 m^3/ha, TCC

7.7.2 Uncertainty of Predicted Inventory Volumes

The purpose of this sensitivity analysis is to test the risk associated with an overestimation in volumes predicted by the VRI. While underestimation of the inventory volumes poses no risk to timber supply, its impact was tested as well.

7.7.2.1 Increase Natural Stand Volumes by 10%

Increasing the natural stand volumes by 10% elevated the timber supply forecast by 19.2% in the first 10 years and 9.2% between years 11 and 50 (Figure 106). The late mid-term forecast, and the long-term forecast were not impacted.

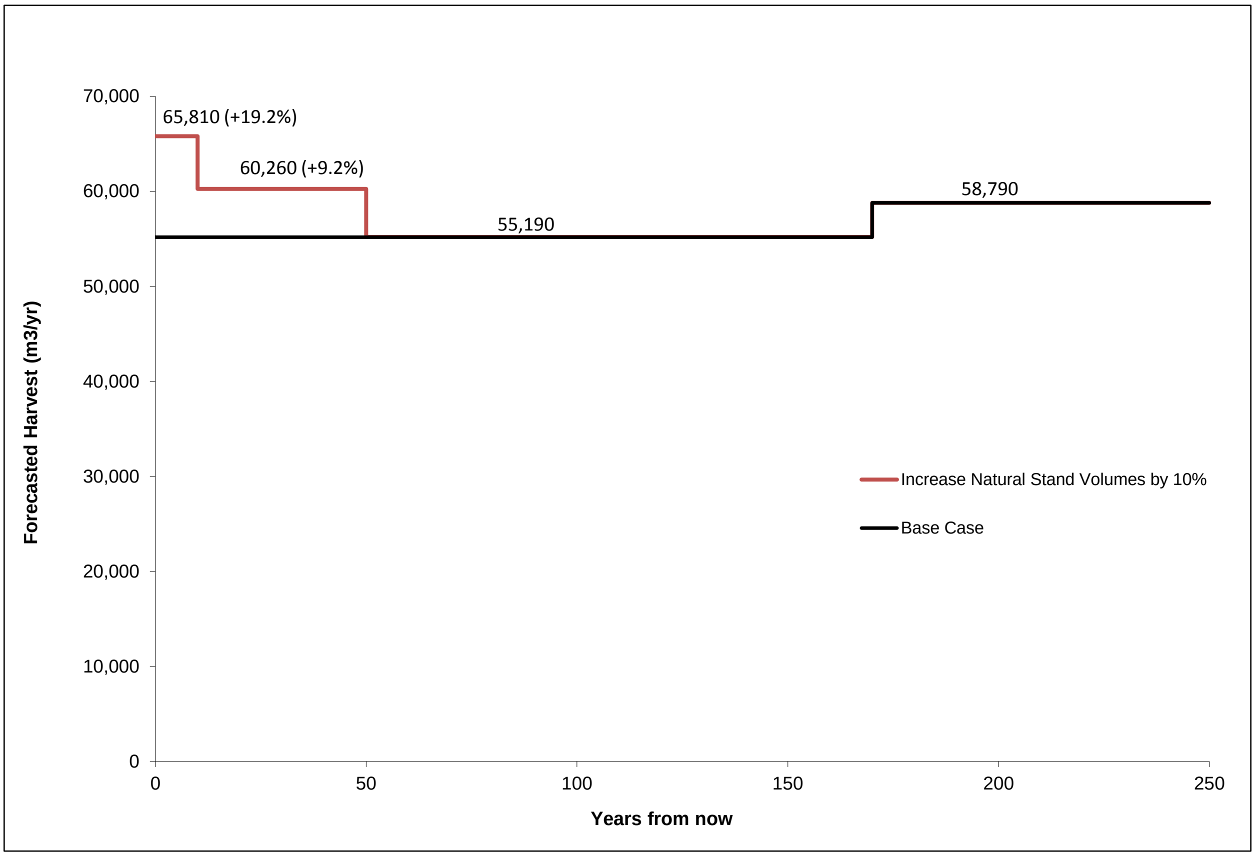

Figure 106: Sensitvity analysis; increase natural stand volumes by 10%, TCC

7.7.2.2 Decrease Natural Stand Volumes by 10%

Reducing the natural stand volumes by 10% decreased the timber supply forecast by 6.1% in the first 100 years of the planning horizon (Figure 107). The long-term harvest forecast was unaffected.

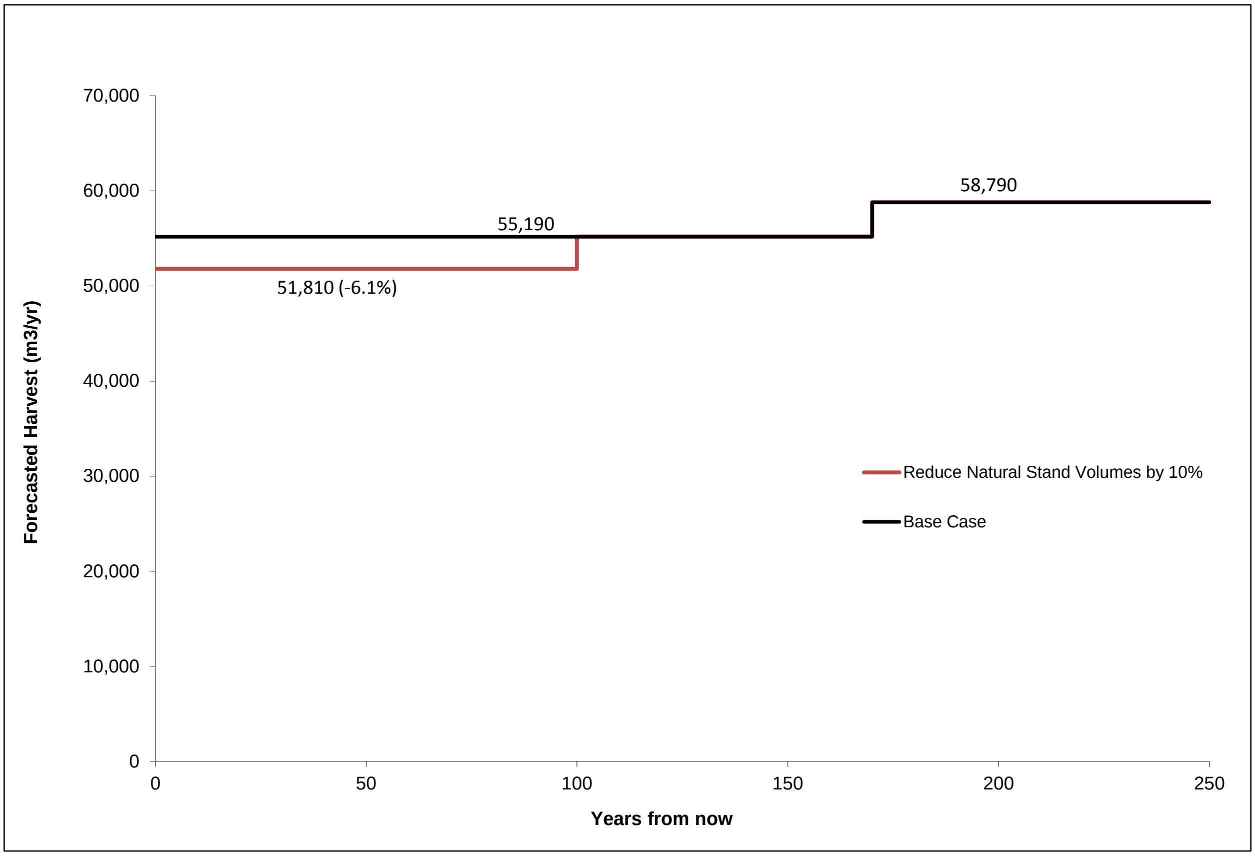

Figure 107: Sensitvity analysis; reduce natural stand volumes by 10%, TCC

7.7.3 Uncertainty of Predicted Growth and Yield of Managed Stands

Existing and future managed stands are the dominant source of volume in the medium and long terms. The purpose of this sensitivity analysis is to assess the impact associated with an over- or under-estimation in the growth of existing and future managed stands.

7.7.3.1 Increase the Volume of Managed Stands by 10%

Increasing the volume (yield) of managed stands by 10% increased the harvest forecast between years 51 150 by 6.5% (Figure 108). The long-term harvest level was achieved 20 years earlier than in the Base Case. It was also increased by 10.4%.

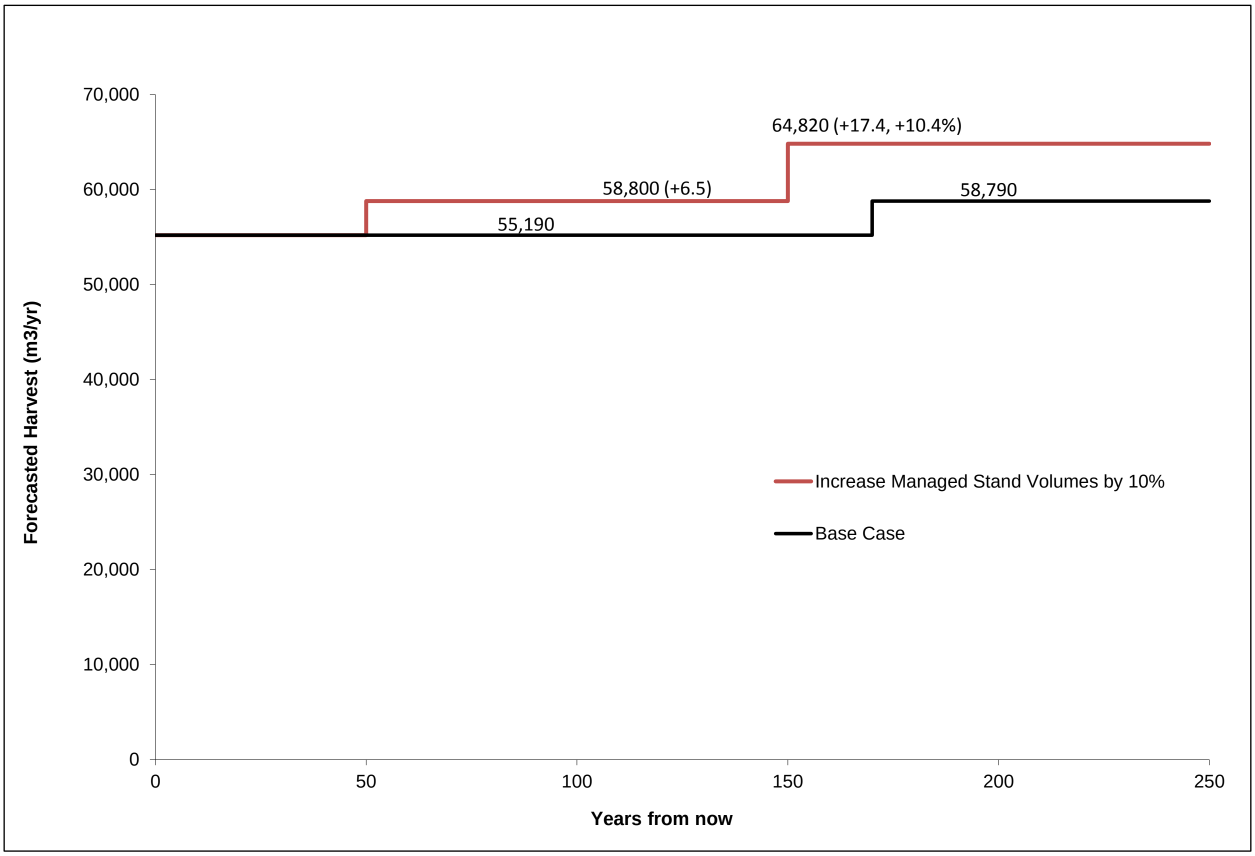

Figure 108: Sensitvity analysis; increase managed stand volumes by 10%, TCC

7.7.3.2 Decrease the Volume of Managed Stands by 10%

Decreasing the volume of managed stands by 10% impacted the timber supply immediately at the beginning of the planning horizon. The timber supply was reduced by 4.4% in the first decade; it remained 7.5% below the Base Case level until year 175, when the long-term harvest level was reached, 5 years later than in the Base Case. The long-term harvest forecast was reduced by 10.2% compared to the Base Case (Figure 109).

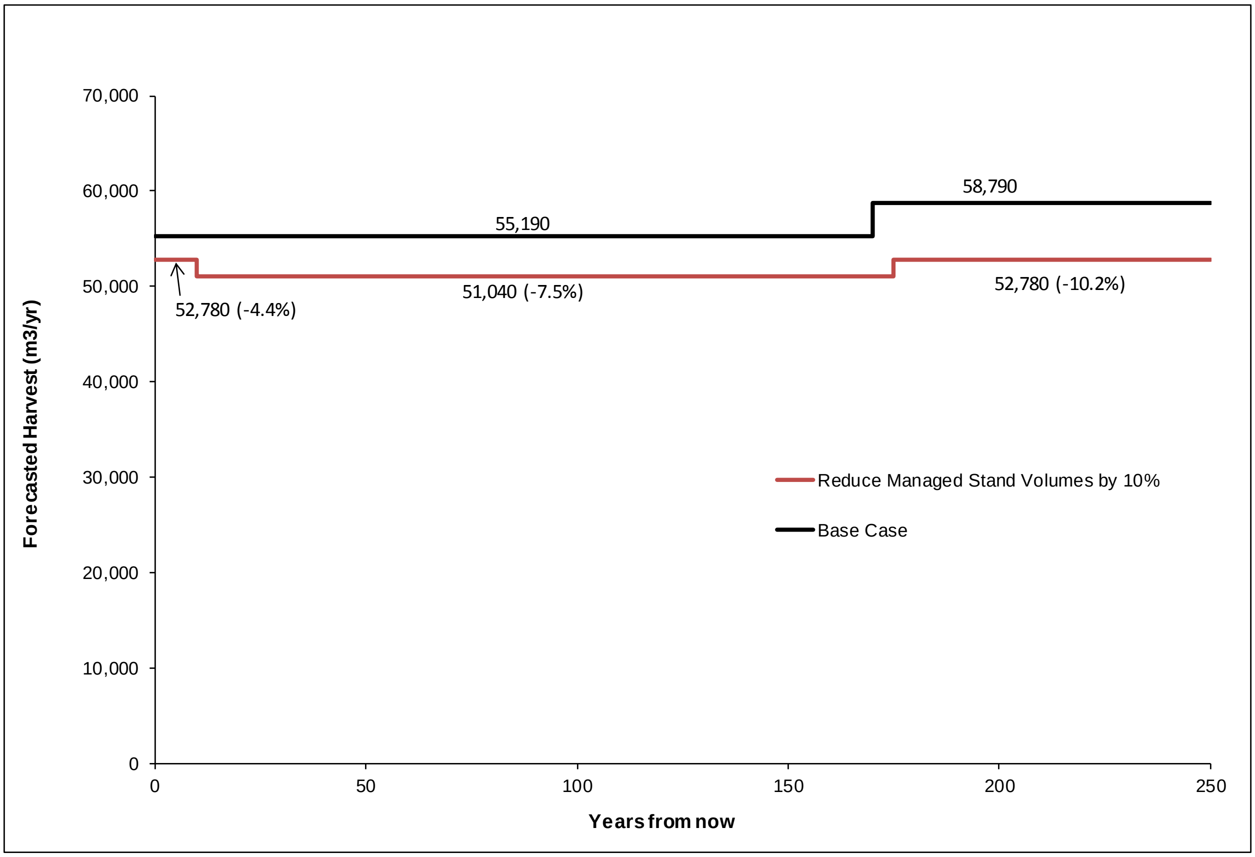

Figure 109: Sensitvity analysis; reduce managed stand volumes by 10%, TCC

7.7.4 Harvest Scheduling

The TCC Business Area staff felt that the relative oldest harvest rule best reflected their operations. This harvest rule was used in the Base Case. This sensitivity analysis tests the impact of using the highest volume first harvest rule in the analysis.

The short- and medium-term harvest forecast was reduced by 2.5%, while the long-term harvest forecast was reduced by 6.0% (Figure 110). The reduction in the harvest forecast is caused by the less efficient utilization of the THLB, when the highest volume first harvest rule is employed. In the TCC Base Case 282 ha (1.6%) of the THLB remains unharvested. In this sensitivity analysis 1,519 ha (8.7%) of the THLB is never harvested by the timber supply model.

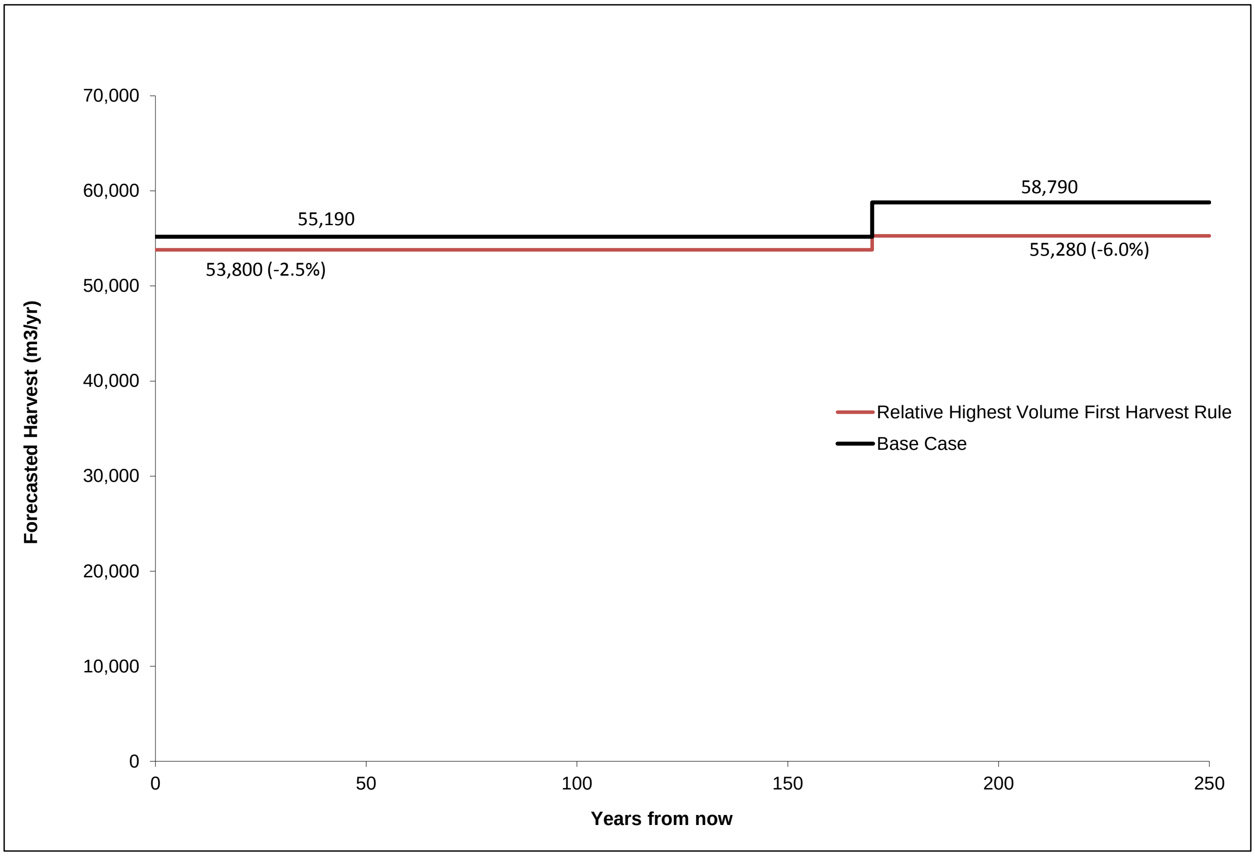

Figure 110: Sensitvity analysis; employ relative highest volume first harvest rule, TCC

7.7.5 Forest Health

This sensitivity analysis tested the effect of incorporating predicted impacts of rust and mountain pine beetle (MPB) on timber supply. These health agents are known to exist in managed stands in TCC. The suggested rust impact was first tested at stand level with TASS. There was no impact and therefore, the rust impact was ignored in further analysis.

At the request of the TCC BCTS staff the pine volume in pine leading stands was reduced by 25% for stands between 21 and 40 years old. In pine-leading stands between 41 and 60 years old, the pine volume was reduced by 50%.

The short and mid-term harvest forecast was reduced by 1.1% (Figure 111). The long-term harvest level was reached 20 years earlier than in the Base Case; however, its level was not impacted.

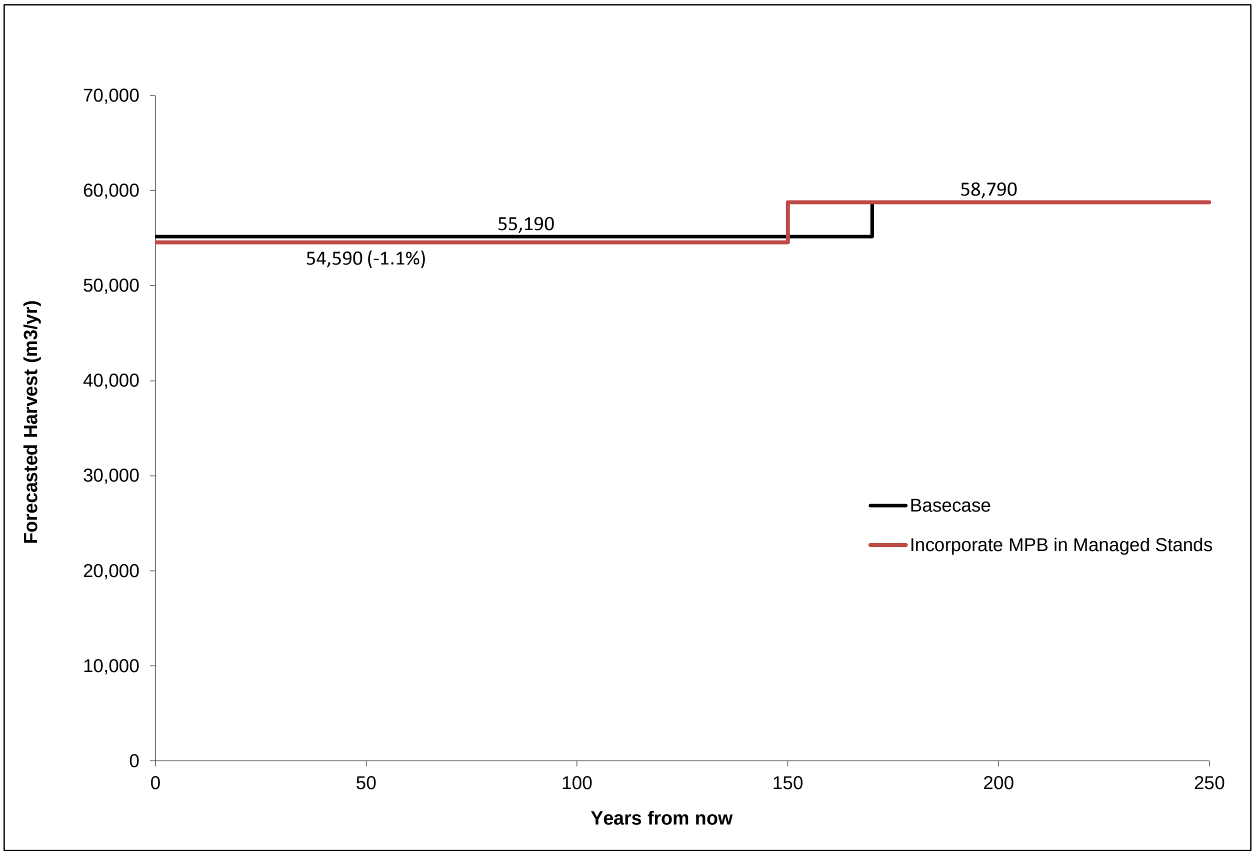

Figure 111: Sensitivity analysis; incorporate MPB impact in managed stands, TCC

7.7.6 Green-Up

As a surrogate for spatial cutblock adjacency constraint, a landscape green-up constraint was applied in the Base Case, specifying that no more than 25% of the THLB area in each landscape unit outside of VQOs may be below the green-up height of 3.0 m at any given time.

One sensitivity analysis was completed. The maximum percentage of the THLB that could be below the green-up height was increased to 33%. There was no impact on timber supply.

7.8 Alternative Harvest Forecasts, TCC

Figure 112 illustrates the analysis results for two alternate harvest forecasts compared to the Base Case. The first alternate forecast set the initial harvest level at the current AAC of 76,986 m^3 per year. This harvest level is 39.4% higher than that of the Base Case. It is maintained for 10 years until the forecast is reduced to 52,790 m^3 per year. This mid-term harvest forecast is 4.3% lower than the Base Case mid-term harvest forecast. The long-term harvest forecasts remain at the Base Case level; however, it is reached at year 125, 45 years earlier than in the Base Case.

Figure 112 also presents the maximum non-declining even flow alternative; the highest possible even flow harvest level equals the short- and mid-term harvest level of the Base Case at 55,190 m^3 per ha.

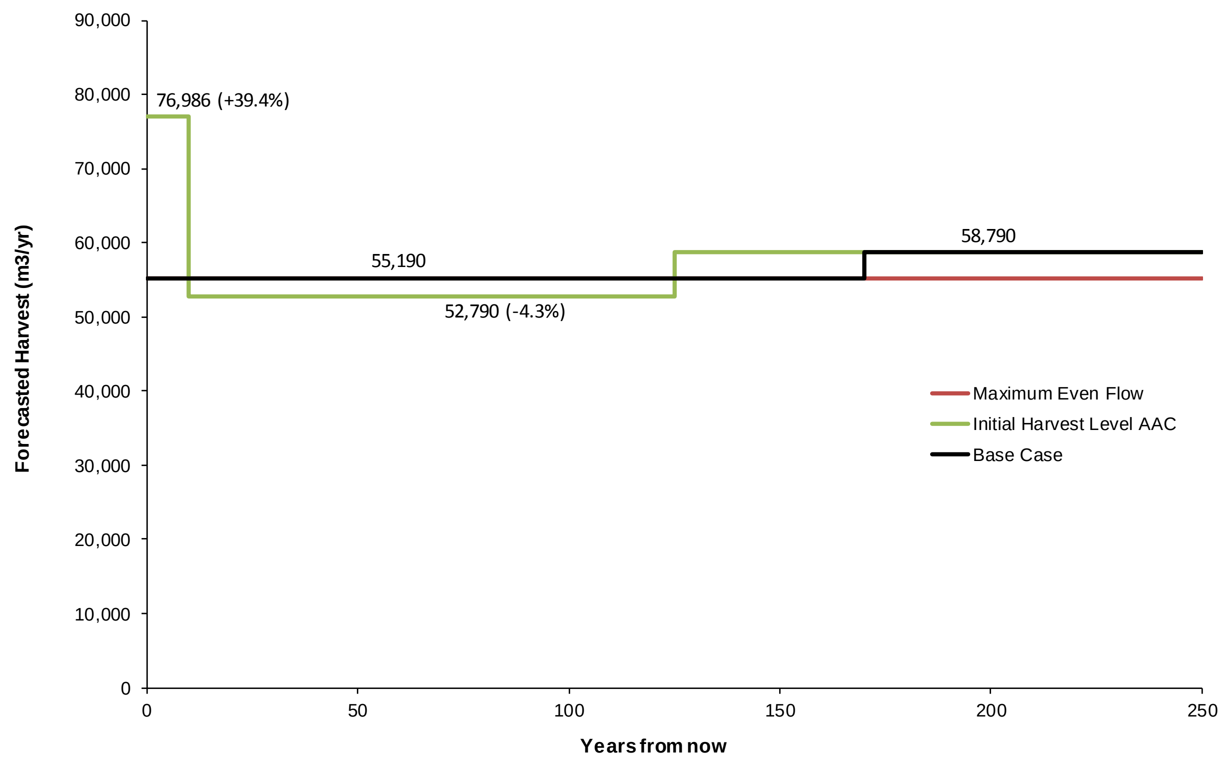

Figure 112: Alternative harvest forecasts; TCC

7.9 Discussion

The current AAC of 76,986 m^3 is not feasible as the initial harvest level. It is 39.4% higher than the initial harvest level in the Base Case. The current AAC can be maintained for 10 years; however, at year 11 the harvest must be reduced below the Base Case level, where it stays for 115 years.

In TCC, the timber supply model employed the relative oldest harvest rule, rather than the relative highest volume harvest rule, as was done in all other Business Areas. This harvest rule was chosen because, according to the BCTS staff, it best reflects operational and tactical planning in the TCC Business Area, where candidate stands for harvesting are selected based on their age with a higher priority given to older stands. When the relative oldest first harvest rule is applied, only 1.6% of the THLB is never harvested, significantly less than in other Business Areas.

A sensitivity analysis showed that using the relative highest volume harvest rule reduced the short- and medium-term harvest forecast by 2.5%, while the long-term harvest forecast was reduced by 6.0%. A total of 1,519 ha of THLB was never harvested by the timber supply model.

The timber supply is sensitive to changes in the growth and yield assumptions of natural stands and managed stands. Reducing the natural stand volumes by 10% decreased the timber supply forecast by 6.1% in the first 100 years of the planning horizon, while the long-term harvest forecast was unaffected.

Decreasing the volume of managed stands by 10% impacted the timber supply immediately at the beginning of the planning horizon and throughout the planning horizon.

This sensitivity analysis tested the effect of incorporating predicted impacts of rust and mountain pine beetle (MPB) on timber supply. The short and mid-term harvest forecast was reduced by 1.1%. The long-term harvest level was not impacted; however, it was reached 20 years earlier than in the Base Case.

8 Base Case, TSK

8.1 TSK Business Area

The analysis was completed separately for each BA. Blocks 9, 10, and 11 in Figure 113 depict the TSK BA.

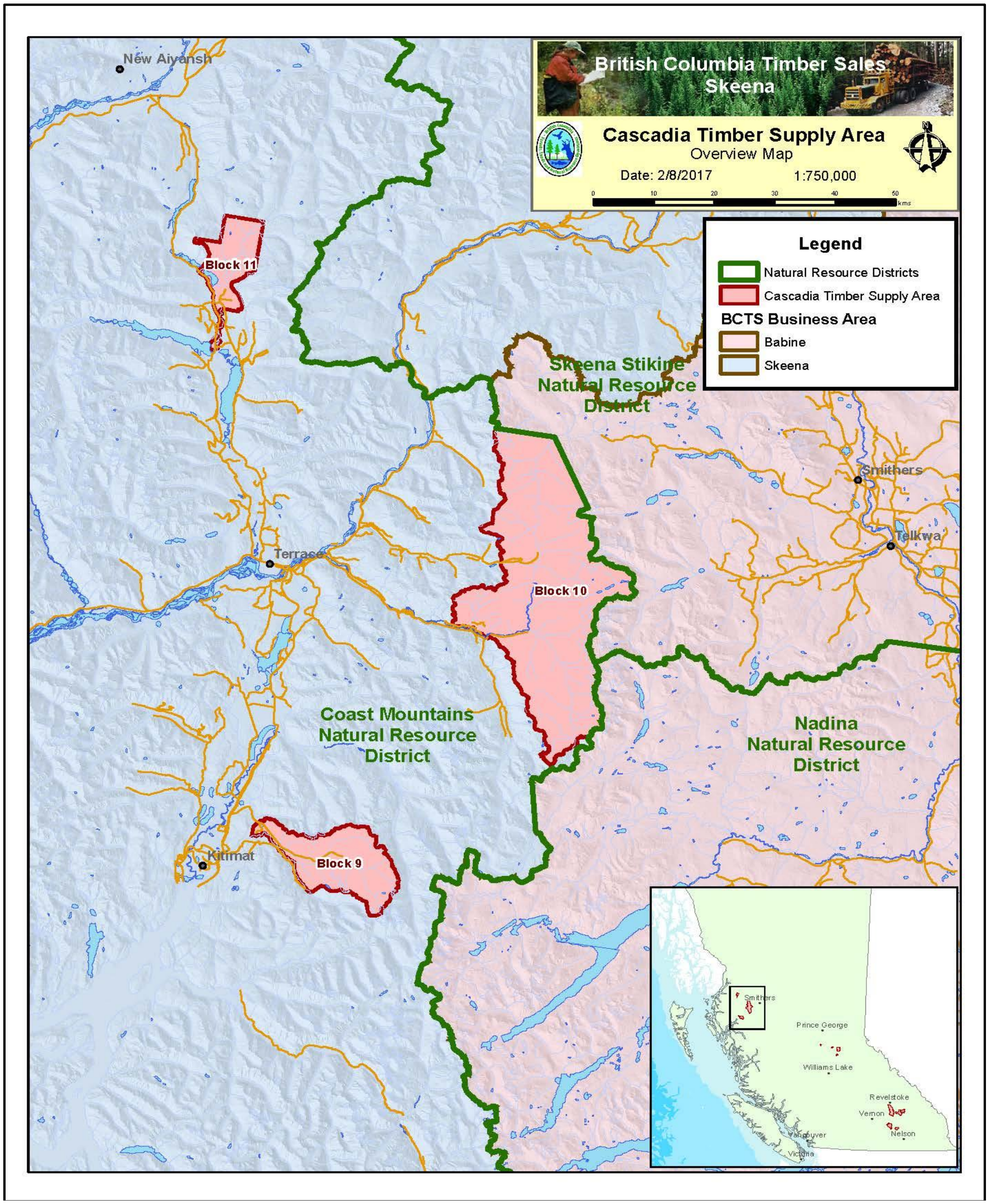

Figure 113: TSK BA: Blocks 9, 10 and 11

8.2 Harvest Forecast

Figure 114 illustrates the TSK Base Case harvest forecast. The initial harvest level of 126,070 m^3 per year is 11.0% less than the current AAC of 141,616 m^3 per year. The initial harvest level can be maintained for 15 years. At year 16 the forecast decreases to 113,770 m^3 per year for another 15 years. The long-term harvest level of 102,830 m^3 per year is reached at year 31. In the Base Case 3,222 ha of the THLB (13.6%) remained unharvested at the end of the planning horizon. The highest volume first harvest rule selects stands for harvest based on their volume per ha. This harvest rule leaves some of the lower volume stands out of the harvest queue by "recycling" the more productive stands at their expense. Table 23 summarizes the TSK Base Case.

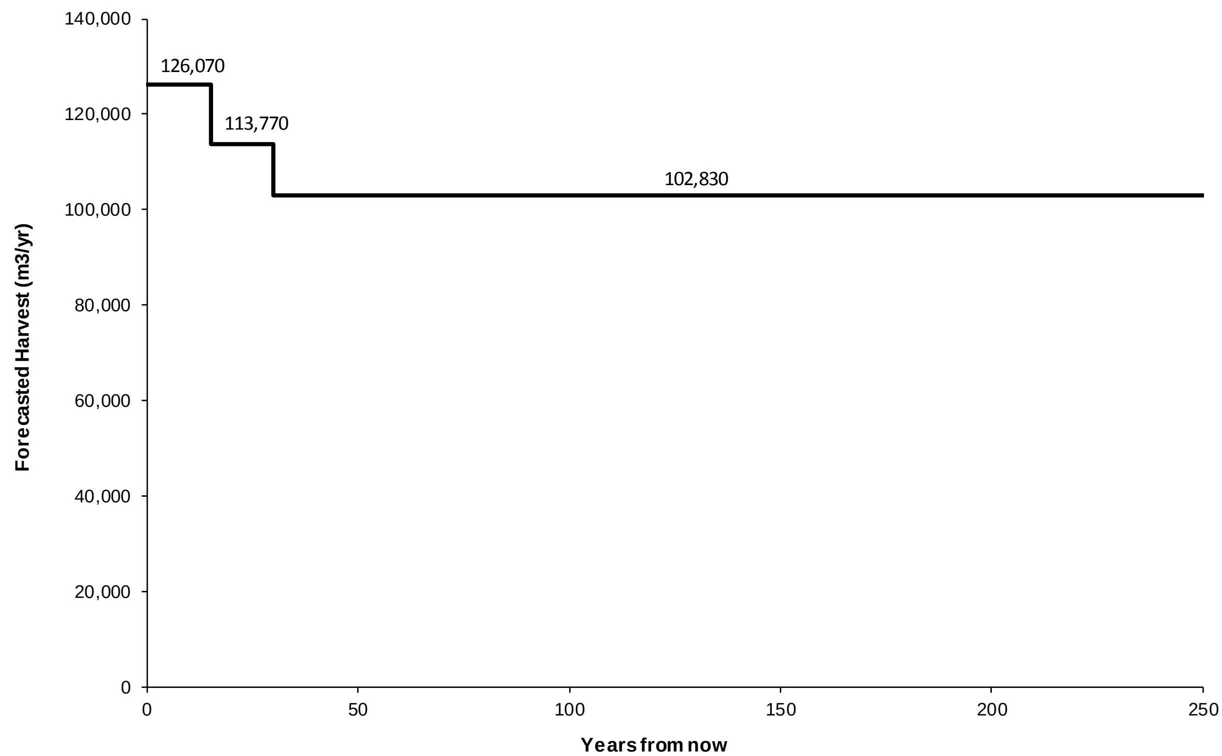

Figure 114: Base Case harvest forecast; TSK

Table 23: Harvest forecast summary, TSK

Period	Predicted Harvest (m^3 per year)	Unharvested THLB (ha)
Years 1 to 15:	126,070 m^3	3,222 ha (13.6%)
Years 16 to 30	113,770 m^3	
Years 31 to 250 (LTHL)	102,830 m^3	

8.3 Growing Stock

Figure 115 shows the predicted growing stock for the TSK Base Case. The merchantable growing stock remains relatively high; the harvest is not constrained by lack of merchantable timber. In TSK the main constraints are early seral requirements and grizzly bear management in the Copper watershed. The watershed is in Block 10 and contains 20,764 ha of forest and 9,213 ha of THLB. The management constraint for grizzly bear requires that no more than 30% of the watershed can be between ages 25 and 100 at any time. This constraint is the equivalent of allowing only 10% of the watershed to be harvested in 25 years.

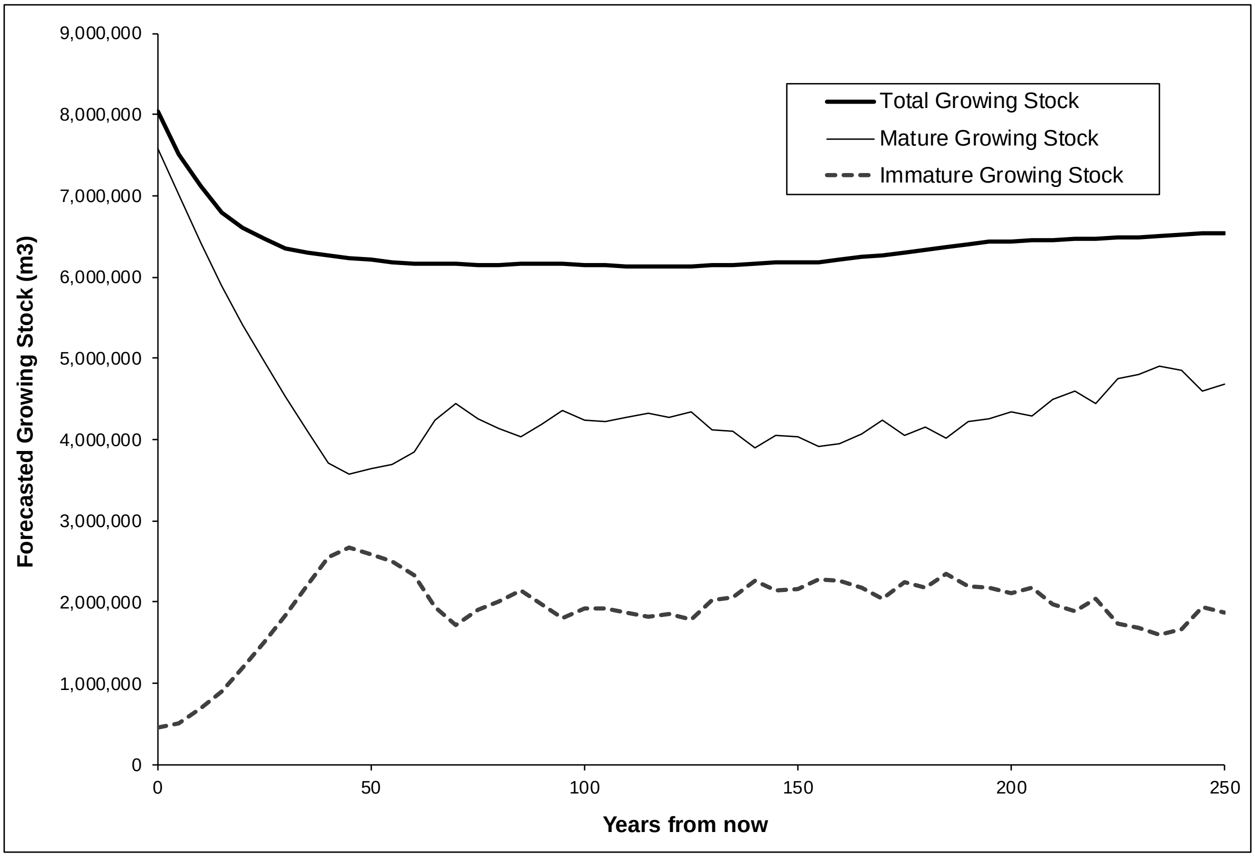

Figure 115: TSK Base Case; predicted growing stock

8.4 Harvest Age, Harvest Volume and Harvest Area

Figure 116 shows the TSK harvest forecast by age class. Stands older than 250 are harvested almost exclusively in the first 30 years. Their harvest is predicted to continue for 80 years with small amounts harvested in the long term as well. In the long term, the harvest is predicted to come from age class 5, 6 and 7 stands in approximately equal amounts. Figure 117 illustrates the average harvest age for the TSK Base Case, which fluctuates significantly but settles at around 100 years after the first 80 years.

Figure 118 shows the TSK harvest forecast by vol/ha class. Throughout the planning horizon the predicted harvest volumes are high, generally higher than 500 m^3 per ha. This is reflected in Figure 119 illustrating the predicted average harvest volume per ha, which trends around 600 m^3 per ha with some lower volumes and significantly higher ones in some periods. The annual average harvest area ranges from 100 to 200 ha and trends around 170 ha per year (Figure 120).

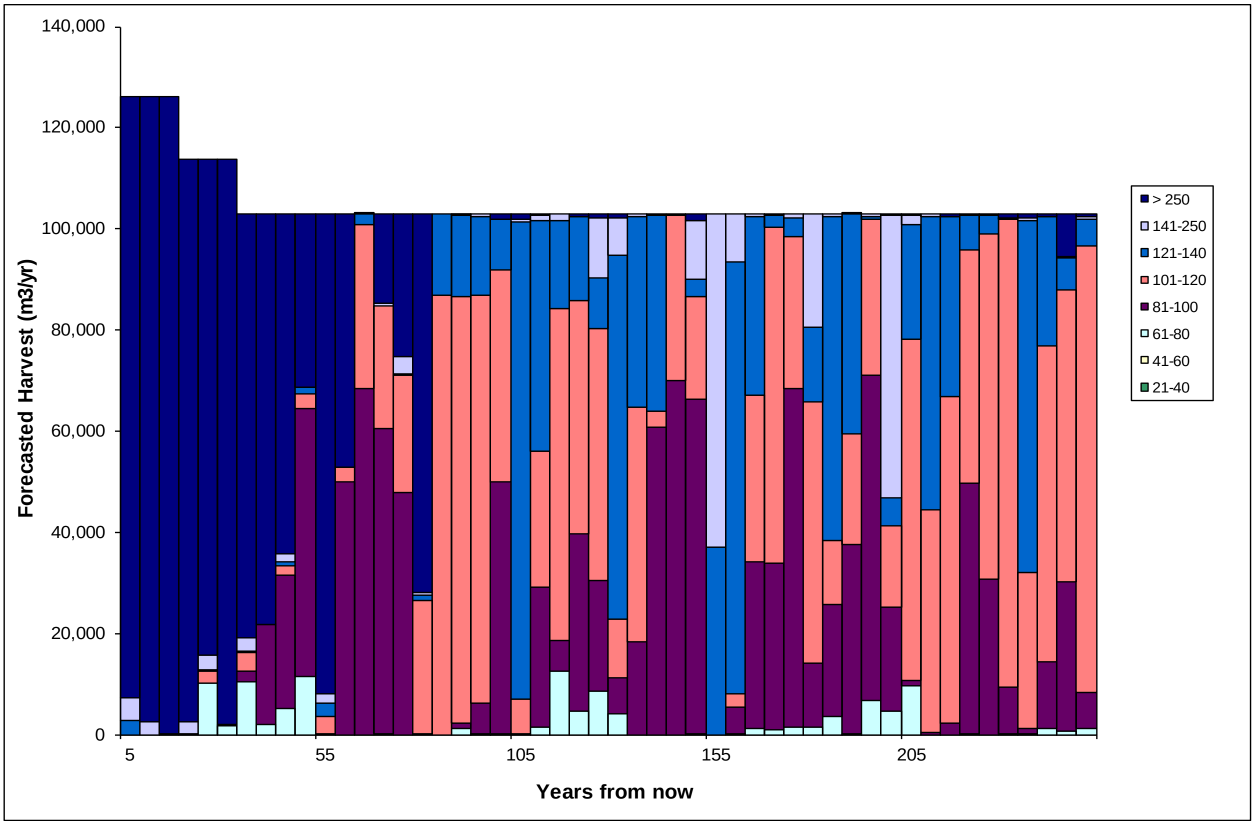

Figure 116: TSK Base Case; harvest forecast by age class

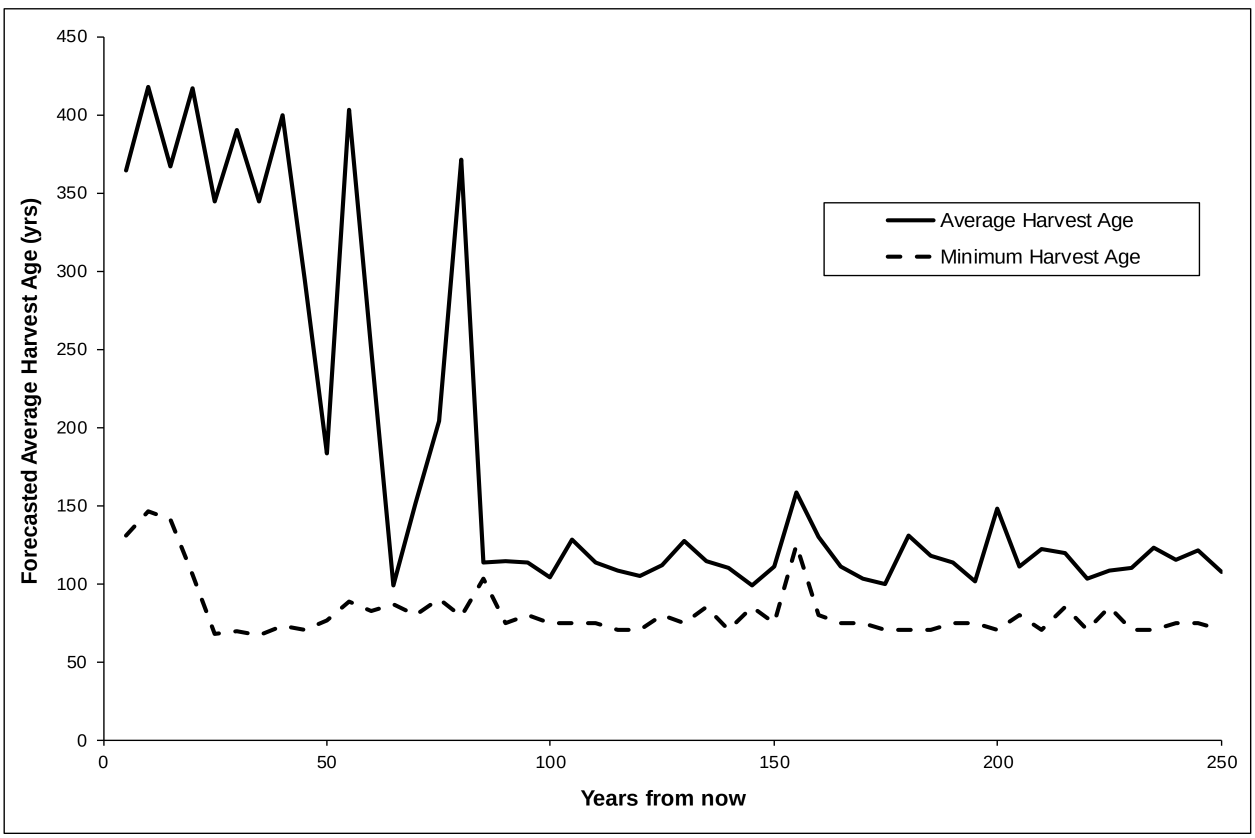

Figure 117: TSK Base Case; average and minimum harvest age

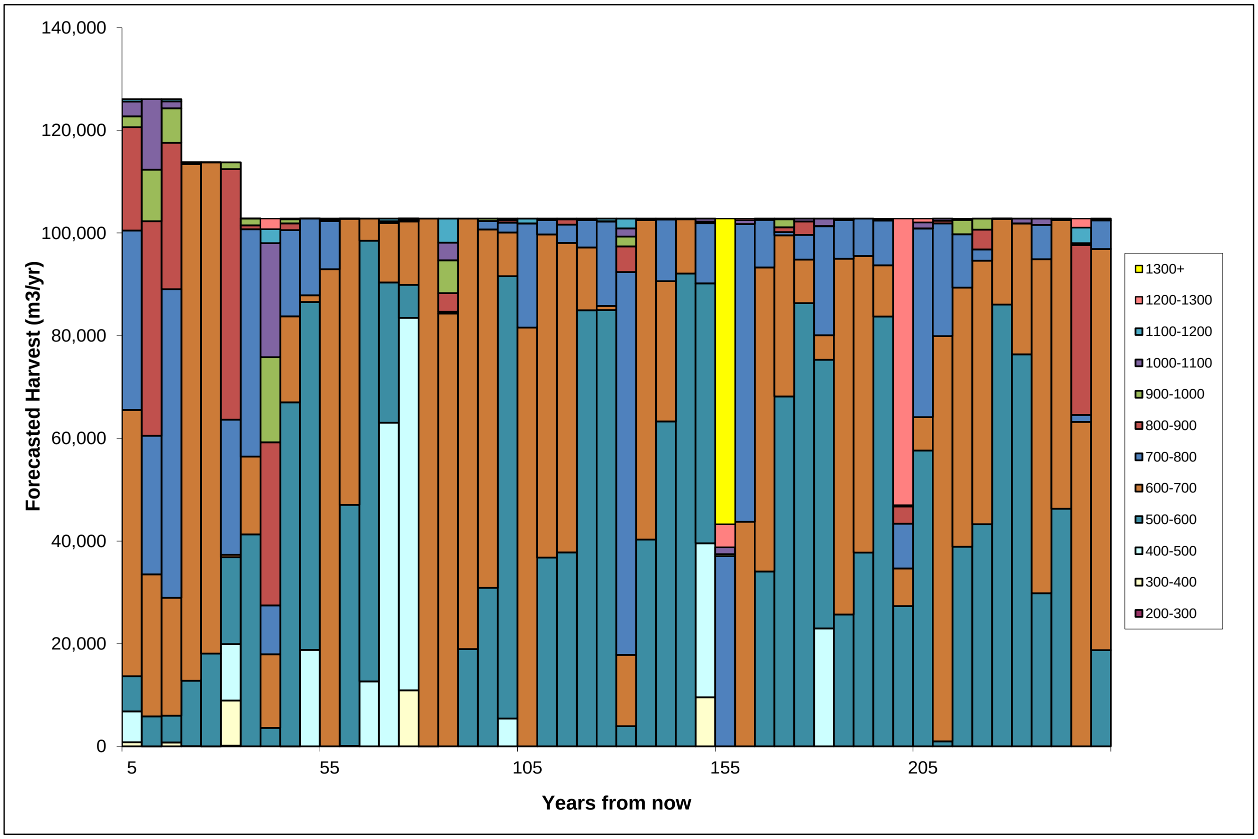

Figure 118: TSK Base Case; harvest forecast by vol/ha class

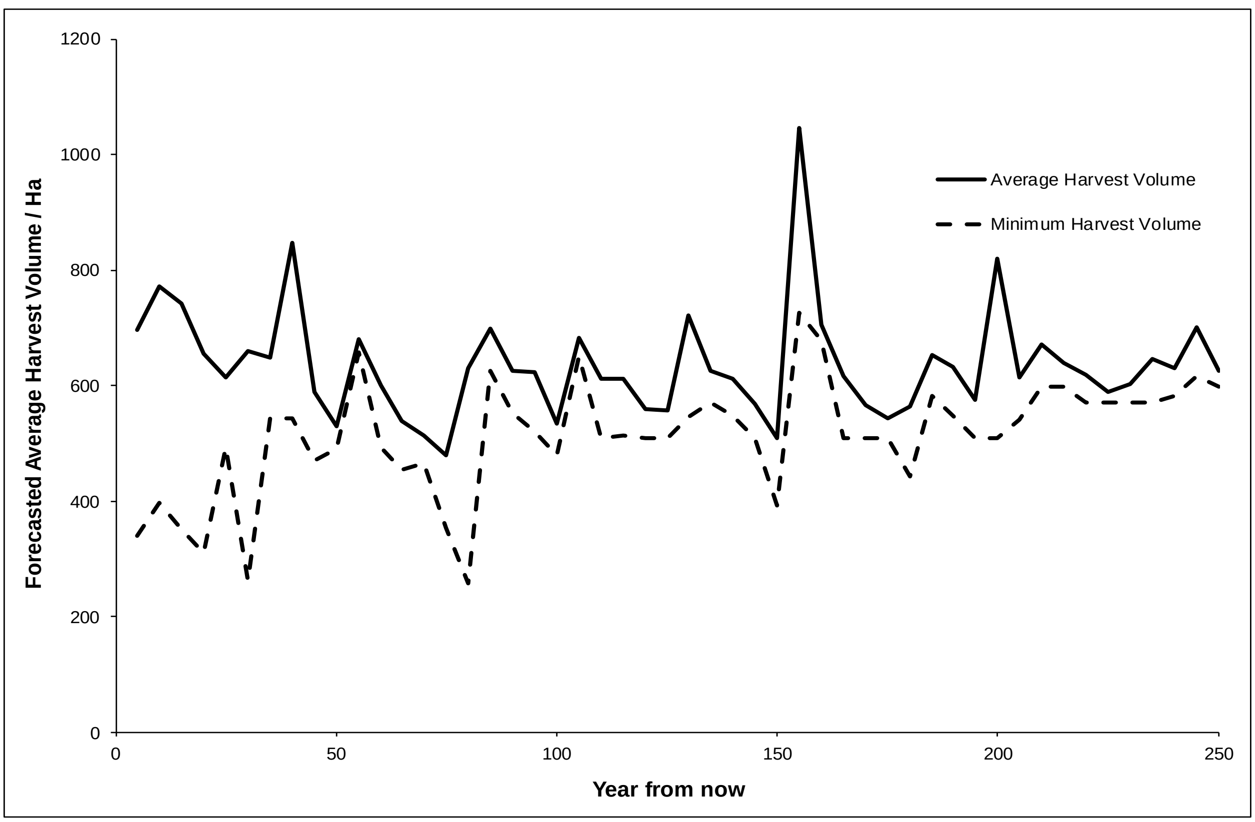

Figure 119: TSK Base Case; average harvest volume per ha

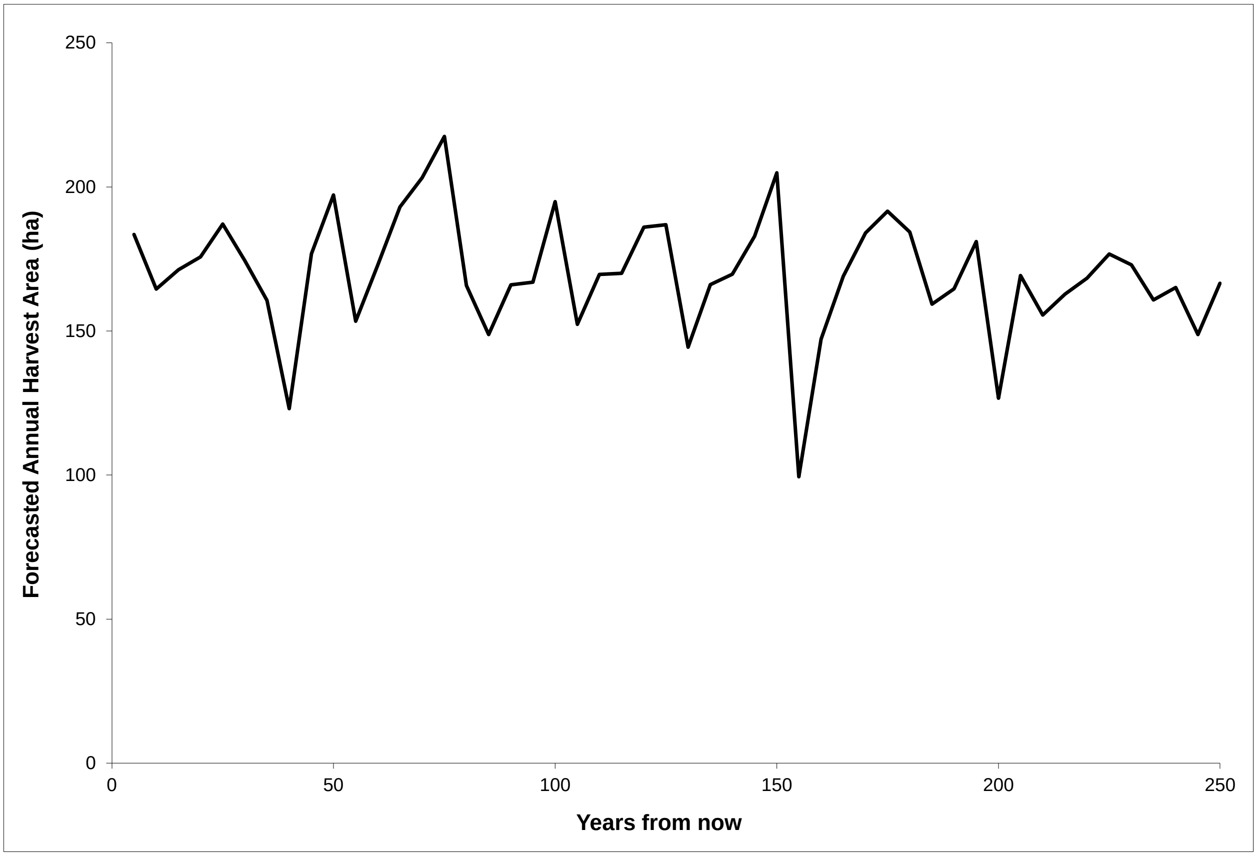

Figure 120: TSK Base Case; average annual area harvested

8.5 Composition of Harvest by Yield Type, Species and Block

Figure 121 illustrates the TSK Base Case harvest forecast by yield type. The transition to managed stands is predicted to start after 50 years and by year 100 almost the entire harvest is predicted to come from managed stands.

Figure 122 provides the harvest forecast by species. The timber supply is almost entirely dependent on hemlock and balsam stands during the first 30 years of the planning horizon. In the medium and long terms, more Sitka spruce and some cedar are expected enter the harvest profile.

Figure 123 provides the Base Case harvest forecast by BA Block.

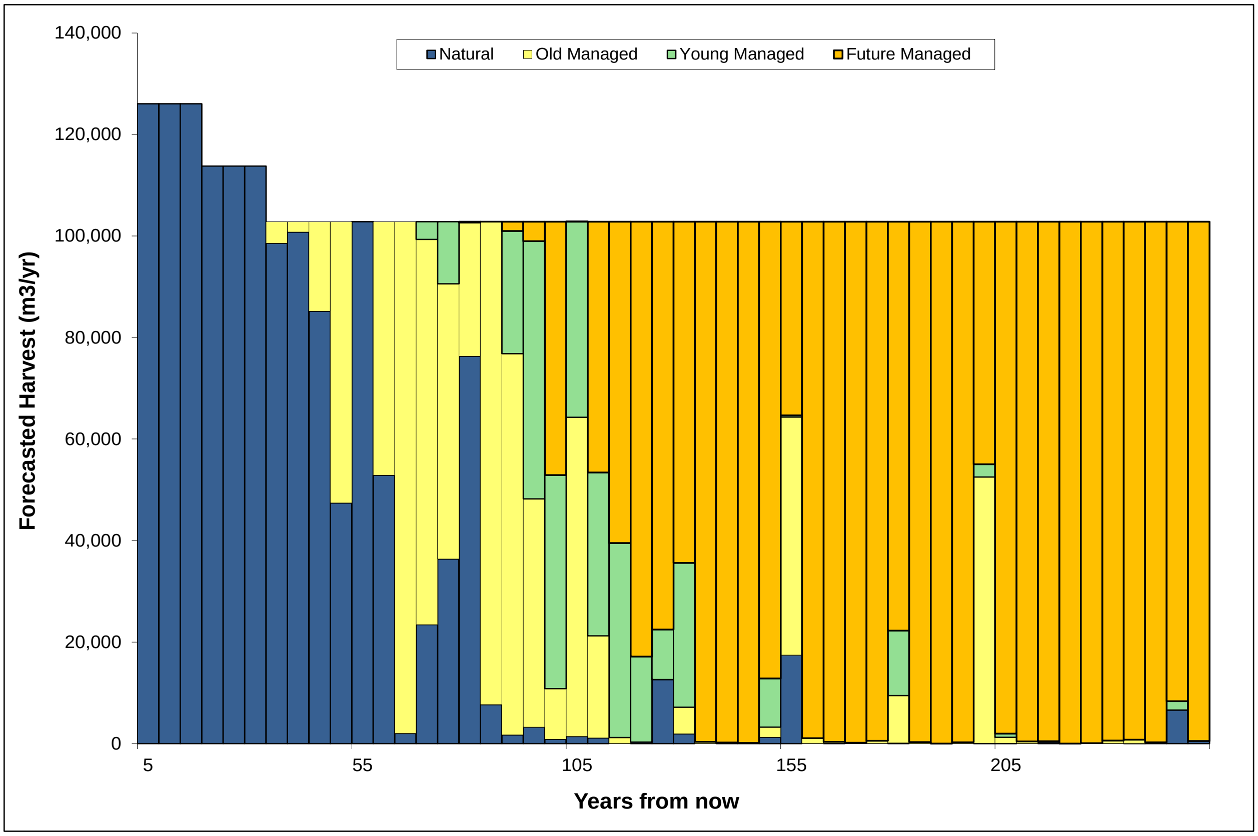

Figure 121: TSK Base Case; harvest forecast by yield type

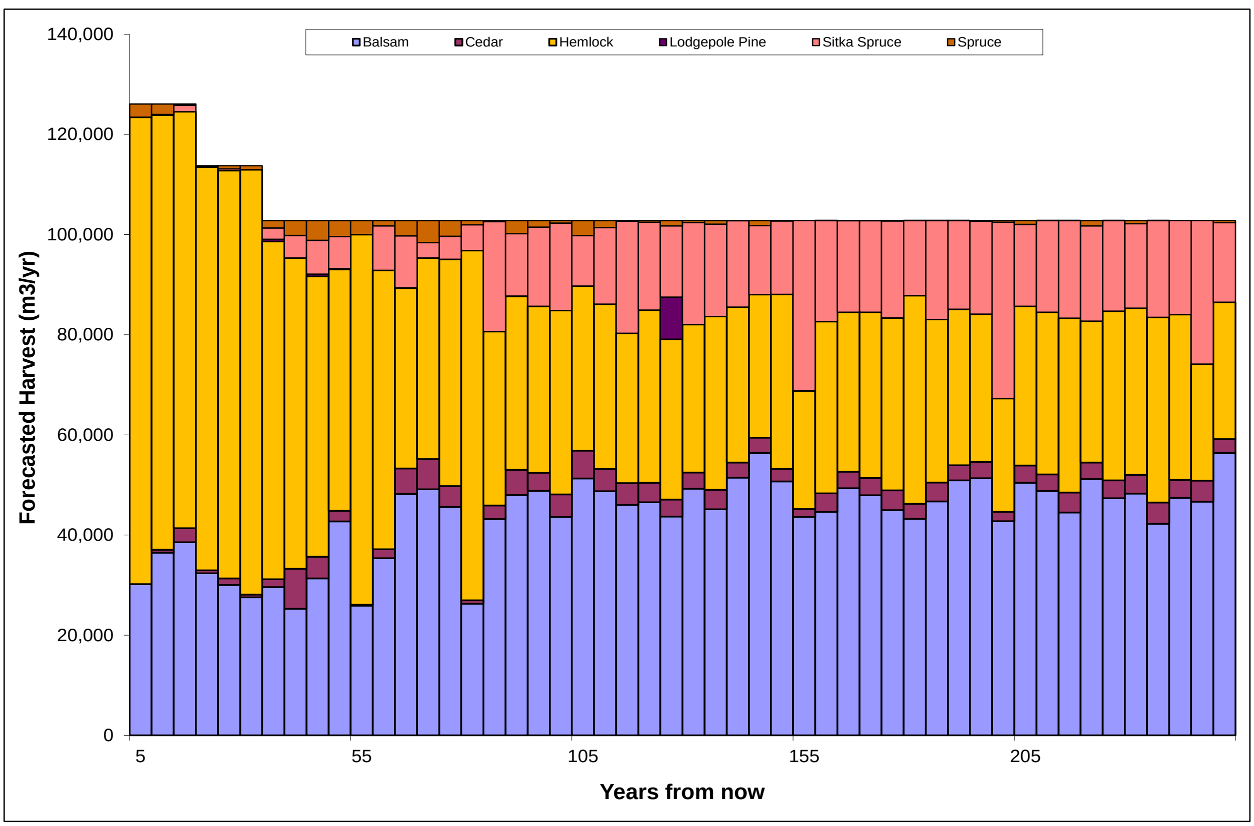

Figure 122: TSK Base Case; harvest forecast by species

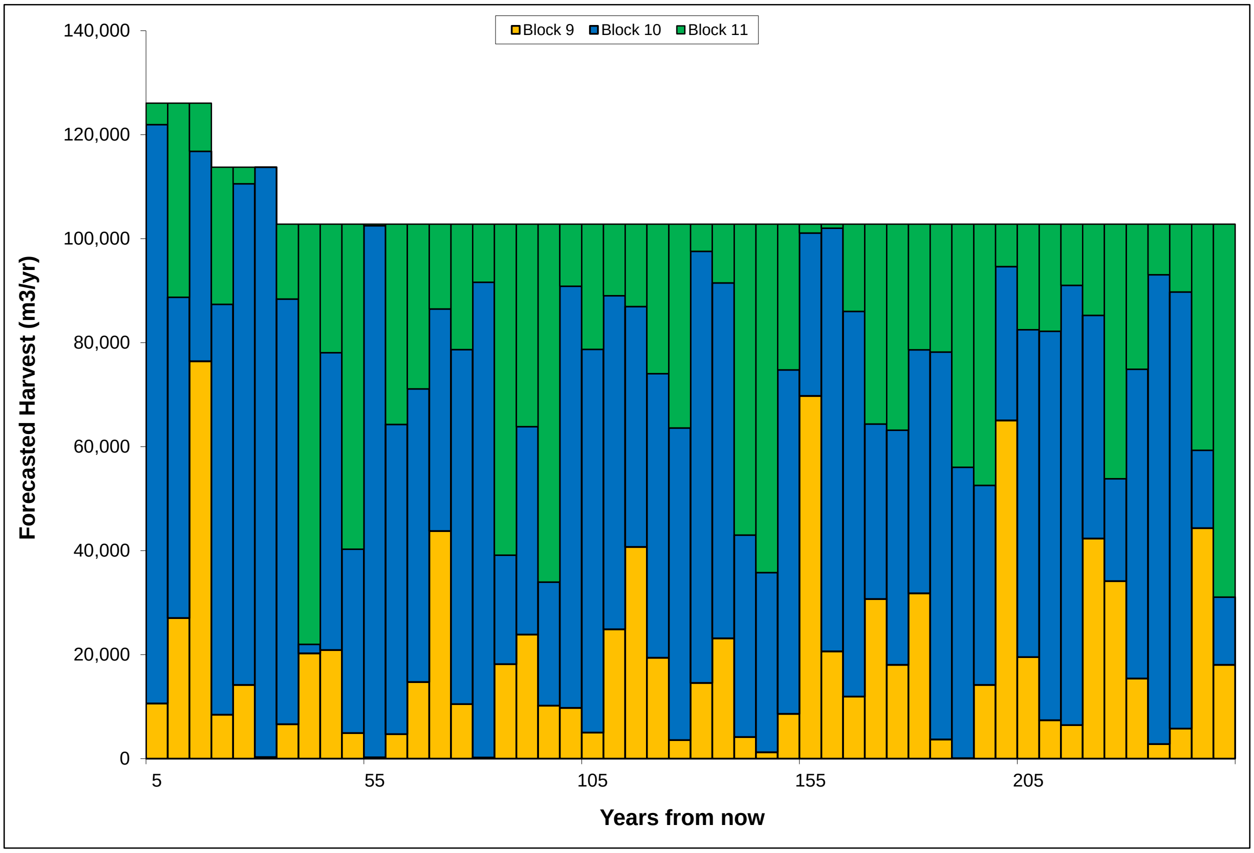

Figure 123: TSK Base Case; harvest forecast by Block

8.6 Age Structure

Figure 124, Figure 125, Figure 126, Figure 127, Figure 128 and Figure 129 illustrate the projected age class structure of the forest, should the Base Case harvest schedule be followed. Most age classes are well represented in the THLB throughout the planning horizon, except for age class 7. Age class 8 and 9 are predicted to become dominant in the NHLB over time.

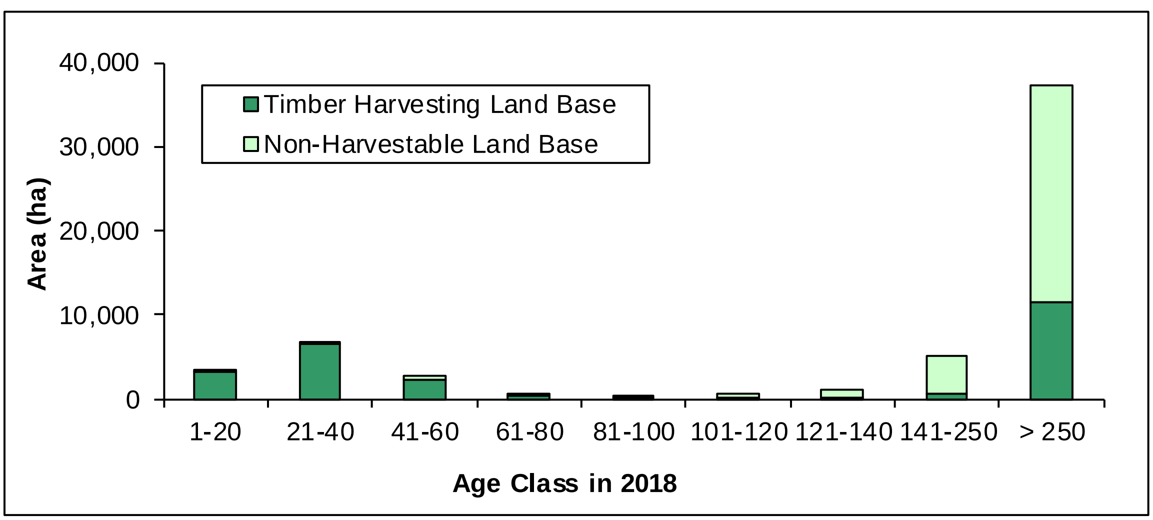

Figure 124: Current age class distribution, TSK

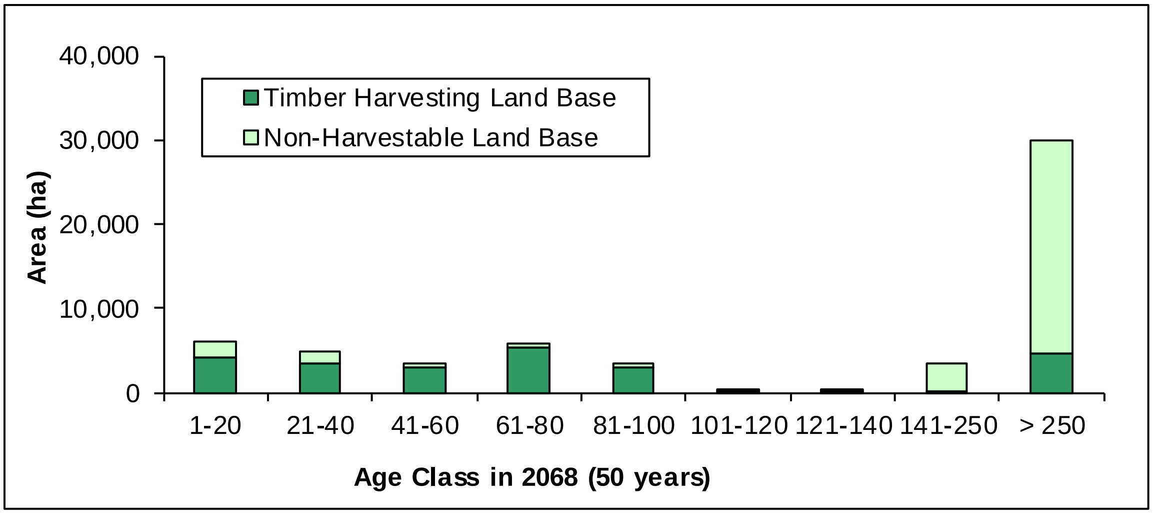

Figure 125: Projected age class distribution in 50 years, TSK

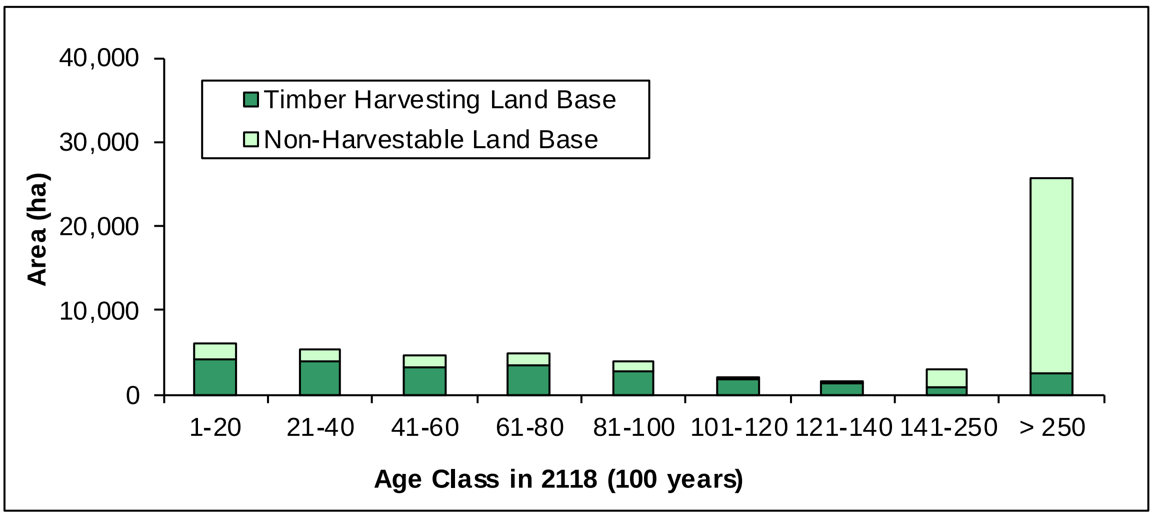

Figure 126: Projected age class distribution in 100 years, TSK

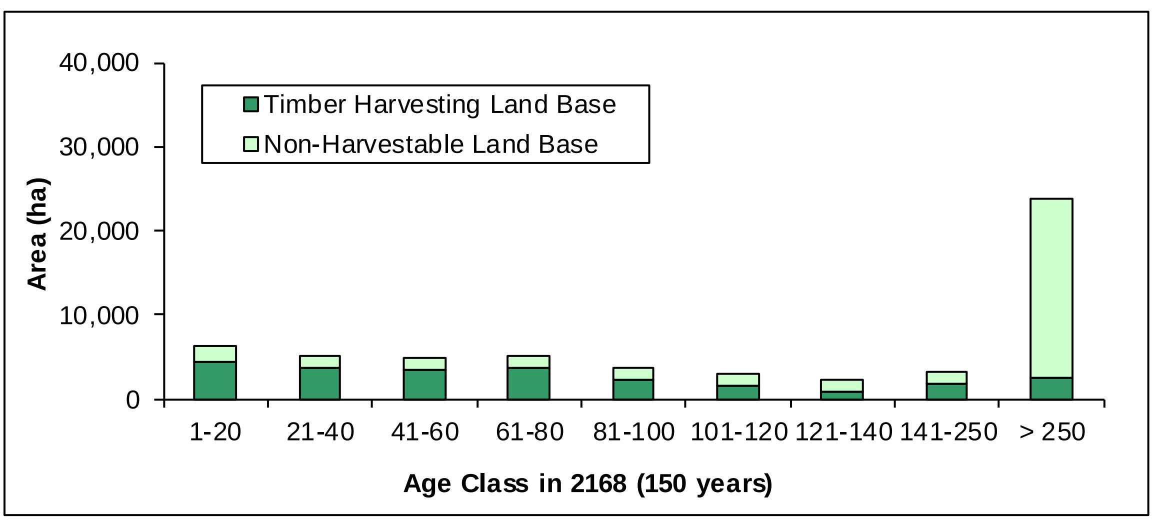

Figure 127: Projected age class distribution in 150 years, TSK

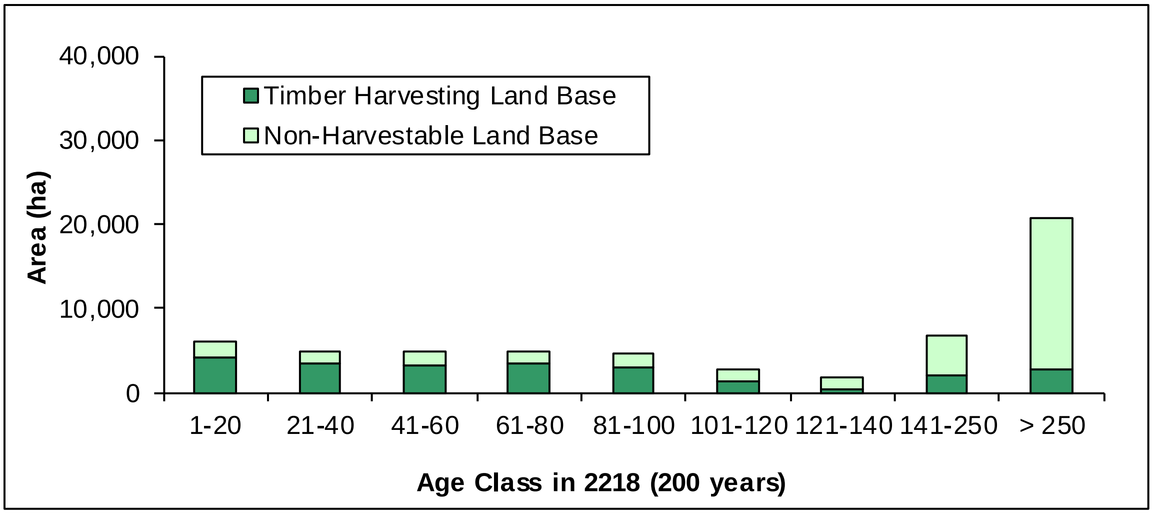

Figure 128: Projected age class distribution in 200 years, TSK

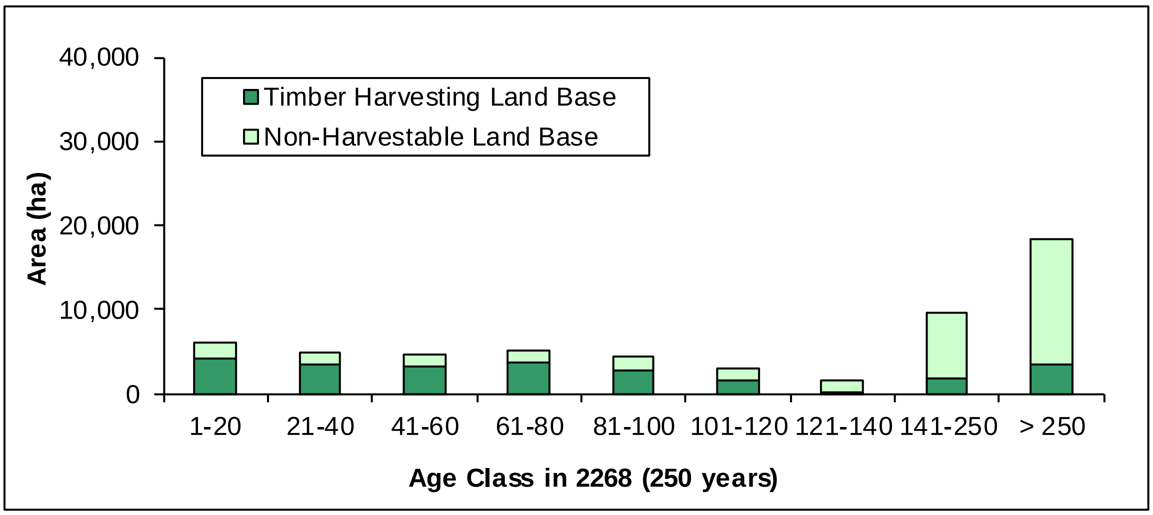

Figure 129: Projected age class distribution in 250 years, TSK

8.7 Sensitivity Analyses, TSK

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 harvest constraints correctly. Furthermore, sensitivity analyses also test the impact and risk of data uncertainties and modeling assumptions to the harvest level, particularly in the short-term. Table 24 presents a summary of the sensitivity analyses that were carried out to test the various uncertainties that exist in the Base Case data and assumptions.

Table 24: Summary of sensitivity analyses; TSK

Issue	Sensitivity analysis
Minimum harvest criteria	Consider only minimum harvest volume for **all** stands and remove the 95% MAI culmination rule.
	Decrease minimum harvest volume (MHV) of **all** stands by 50 m^3 per ha, remove 95% MAI culmination rule.
Volume of existing natural stands	Increase natural stand volumes by 10%
	Decrease natural stand volumes by 10%
Volume of managed stands	Increase managed stand volumes by 10%
	Decrease managed stand volumes by 10%
Marginal timber	Include helicopter operable area in Block 9 in the THLB.
	Include conventionally operable areas classified as low volume or uneconomic in the THLB in Blocks 10 and 11
Harvest rule	Use a relative oldest first harvest rule
Deferral	Defer harvest in Block 9 for 5 years.
Land withdrawal	Remove the Kitsumkalum Agreement-in-Principle Area from THLB
Green-up	Maximum 33% of THLB in each LU less than green-up height

8.7.1 Minimum Harvest Criteria

In the Base Case, the stands can be harvested once they reach a volume of 250 m^3 per ha for both ground-based and cable operations. The stands must also reach the age at which the stand's mean annual increment (MAI) achieves a value of 95 percent of the maximum (culmination).

Minimum harvestable volumes may be lower in good market conditions and at times higher volumes may be required for the harvest to be economic. In these sensitivity analyses the minimum harvest volumes were decreased. The 95% MAI culmination rule was ignored.

8.7.1.1 Consider Only Minimum Harvest Volume for All Stands

In this sensitivity analysis, only the minimum harvest volume criteria were considered, while the 95% MAI culmination rule was ignored. The timber supply was not impacted.

8.7.1.2 Decrease Minimum Harvest Volume of All stands by 50 m^3 per ha

This sensitivity analysis decreased the MHV of all stands by 50 m^3 per ha to 200 m^3 per ha. The 95% MAI culmination rule was ignored.

Figure 130 illustrates the harvest forecast for this sensitivity analysis compared to the Base Case. Lowering the MHV of managed stands by 50 m^3 per ha required a 4.9% reduction in the mid and long-term harvest level. However, it also allowed for an increased harvest levels during the first 40 years of the planning horizon; 5.9% of more timber is harvested during this time period (Figure 130). In the first 10 years, the forecast is 12.3% higher than the Base Case.

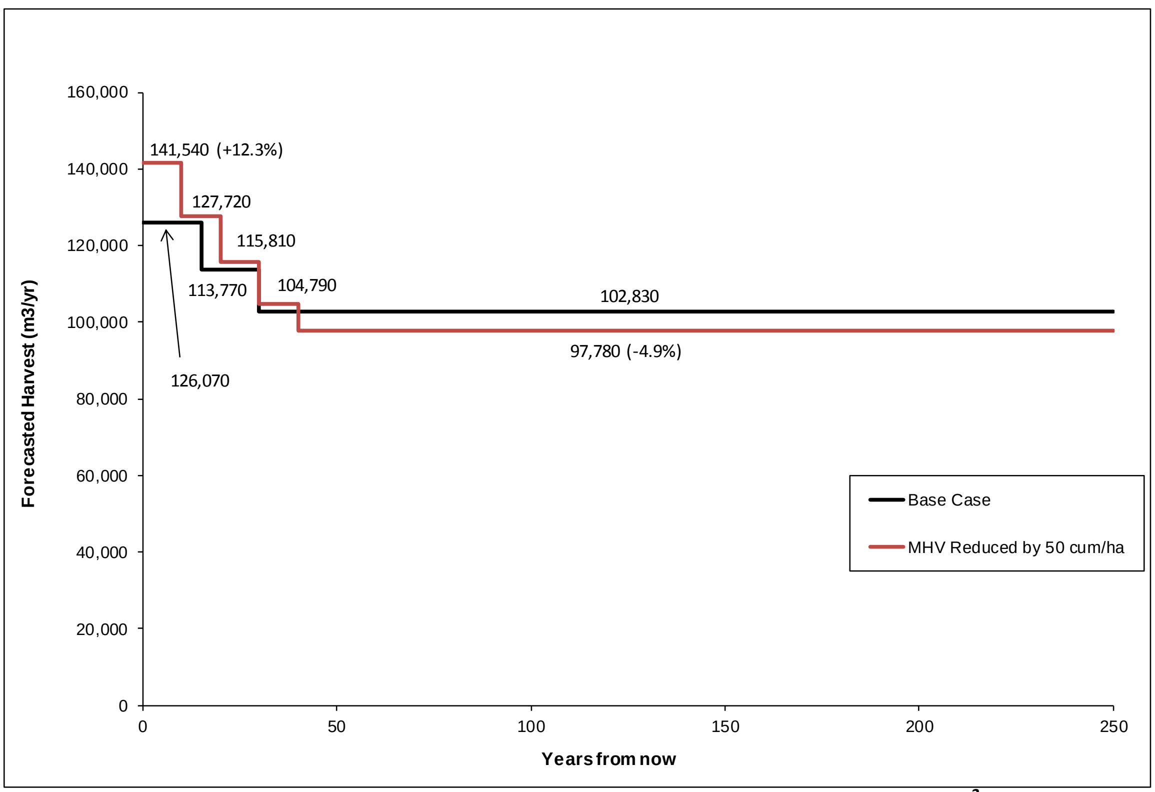

Figure 130: Sensitivity analysis; decrease minimum harvest volume of all stands by 50 m^3/ha, TSK

8.7.2 Uncertainty of Predicted Inventory Volumes

The purpose of this sensitivity analysis is to test the risk associated with an overestimation in volumes predicted by the VRI. While underestimation of the inventory volumes poses no risk to timber supply, its impact was tested as well.

8.7.2.1 Increase Natural Stand Volumes by 10%

Increasing the natural stand volumes by 10% elevated the timber supply forecast by approximately 12% in the first 50 years of the planning horizon (Figure 131). The mid-term forecast and the long-term forecast were also increased by 2.0%; this increase is attributable to the more efficient utilization of the THLB. In this sensitivity analysis 2,719 ha (11.5%) of the THLB remained unharvested; 503 ha less than in the Base Case (3,222 ha, 13.6%).

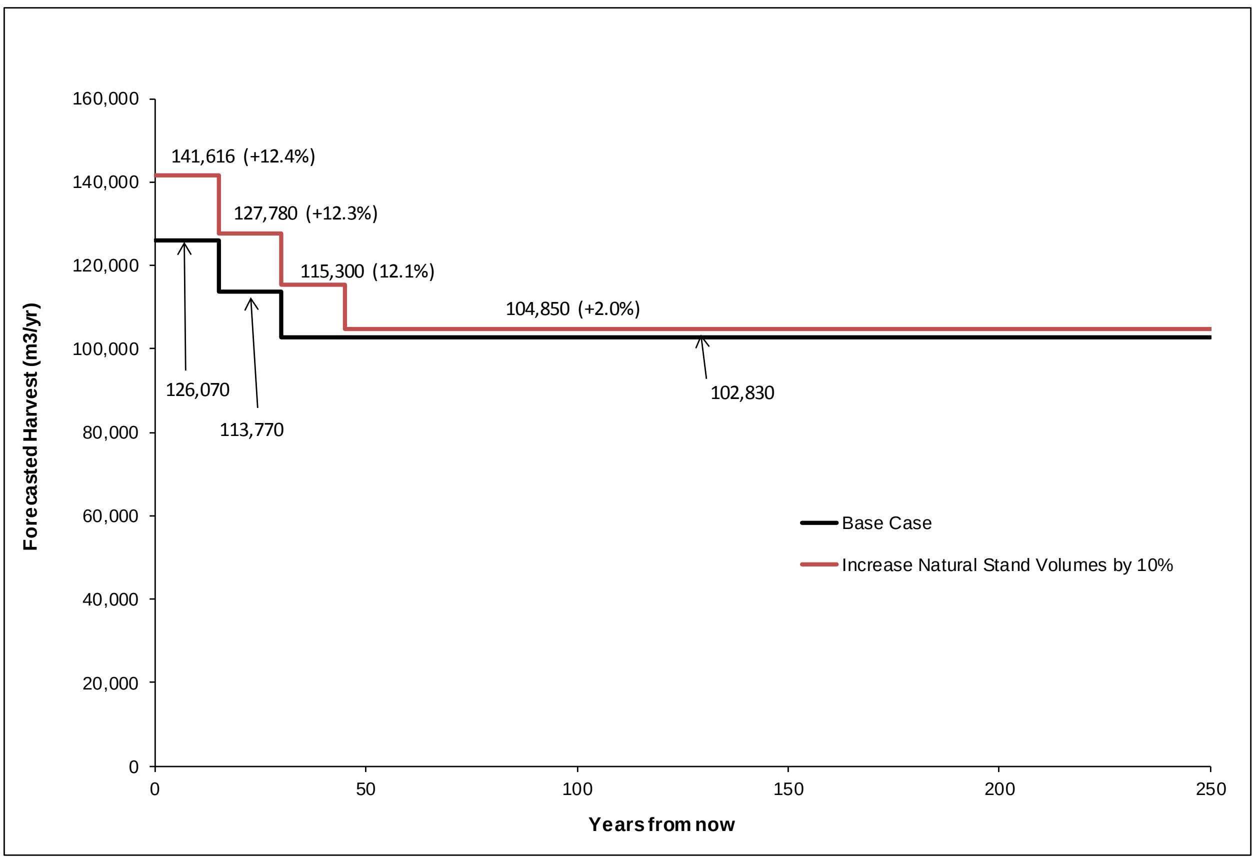

Figure 131: Sensitvity analysis; increase natural stand volumes by 10%, TSK

8.7.2.2 Decrease Natural Stand Volumes by 10%

Reducing the natural stand volumes by 10% decreased the timber supply forecast by 15.9% in the first 30 years of the planning horizon (Figure 132). The mid- and long-term harvest forecasts were also reduced by 2.0%. This decrease is partly attributable to the less efficient utilization of the THLB. In this sensitivity analysis 3,450 ha (14.6%) of the THLB remained unharvested; 228 ha more than in the Base Case (3,222 ha, 13.6%).

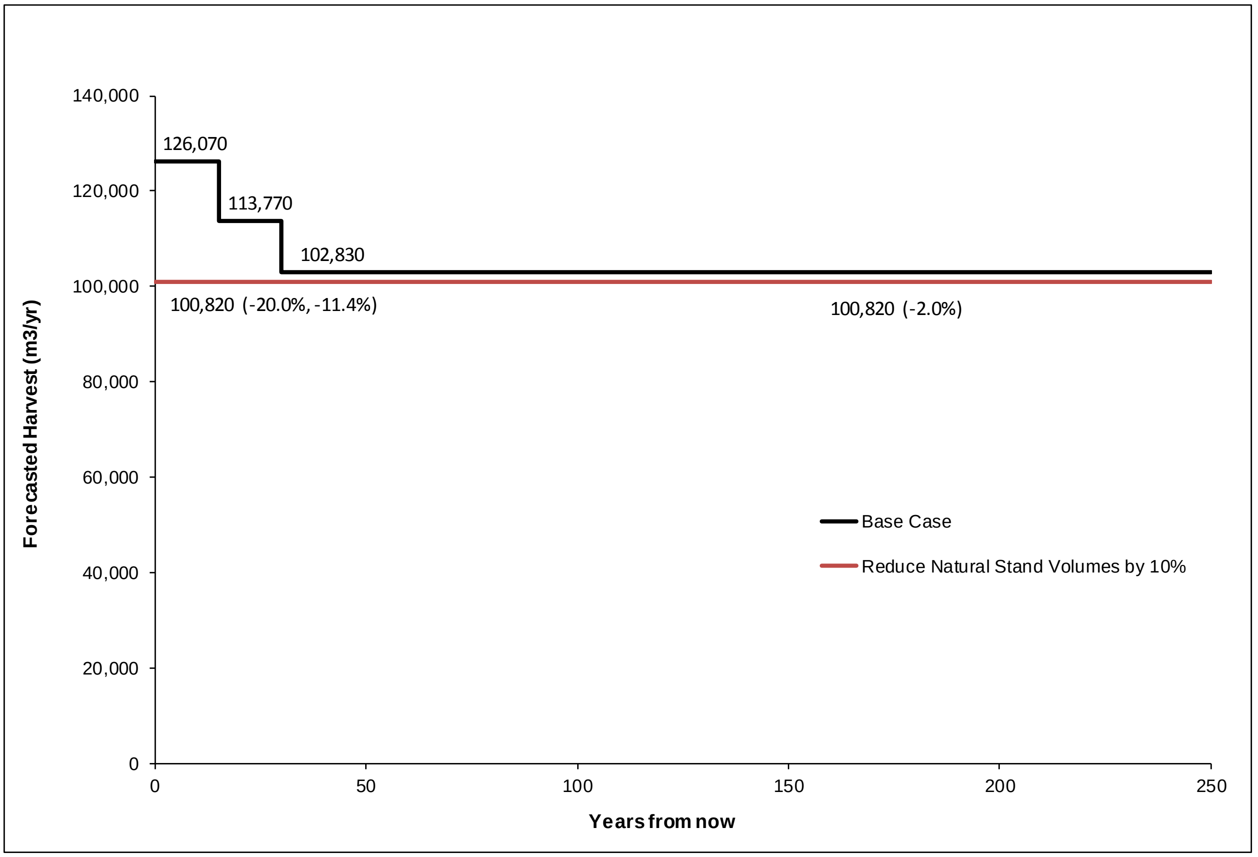

Figure 132: Sensitvity analysis; reduce natural stand volumes by 10%, TSK

8.7.3 Uncertainty of Predicted Growth and Yield of Managed Stands

Existing and future managed stands are the dominant source of volume in the medium and long terms. The purpose of this sensitivity analysis is to assess the impact associated with an over or underestimation in the growth of existing and future managed stands.

8.7.3.1 Increase the Volume of Managed Stands by 10%

Increasing the volume (yield) of managed stands by 10% increased the harvest forecast between years 51 250 by 5.8% (Figure 133).

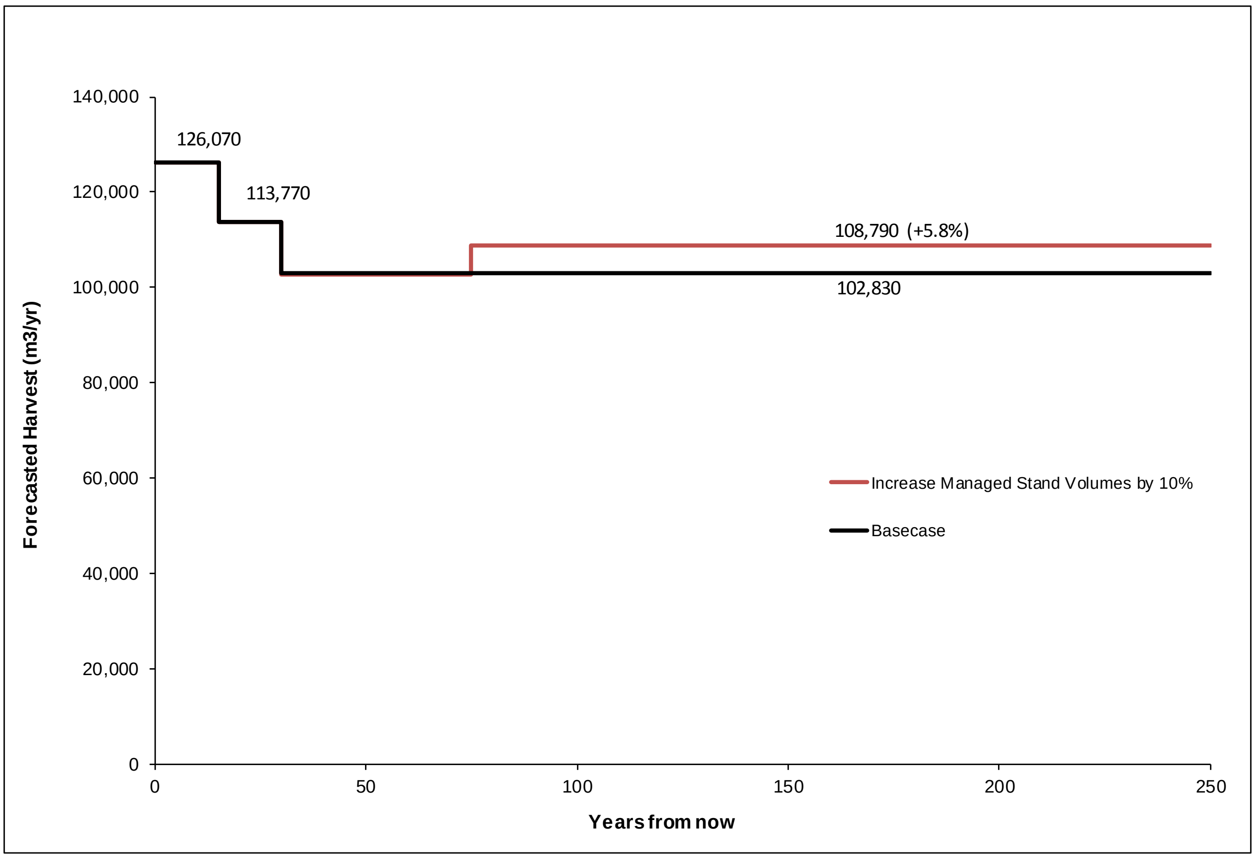

Figure 133: Sensitivity analysis; increase managed stand volumes by 10%, TSK

8.7.3.2 Decrease the Volume of Managed Stands by 10%

Decreasing the volume of managed stands by 10% impacted the timber supply immediately at the beginning of the planning horizon. The timber supply was reduced by 5.8% in the first 15 years and it remained 2.5% below the Base Case level between years 16 and 30. The midterm harvest forecast was reduced by 9.5%, while the long-term harvest forecast was decreased by 7.8% compared to the Base Case (Figure 134).

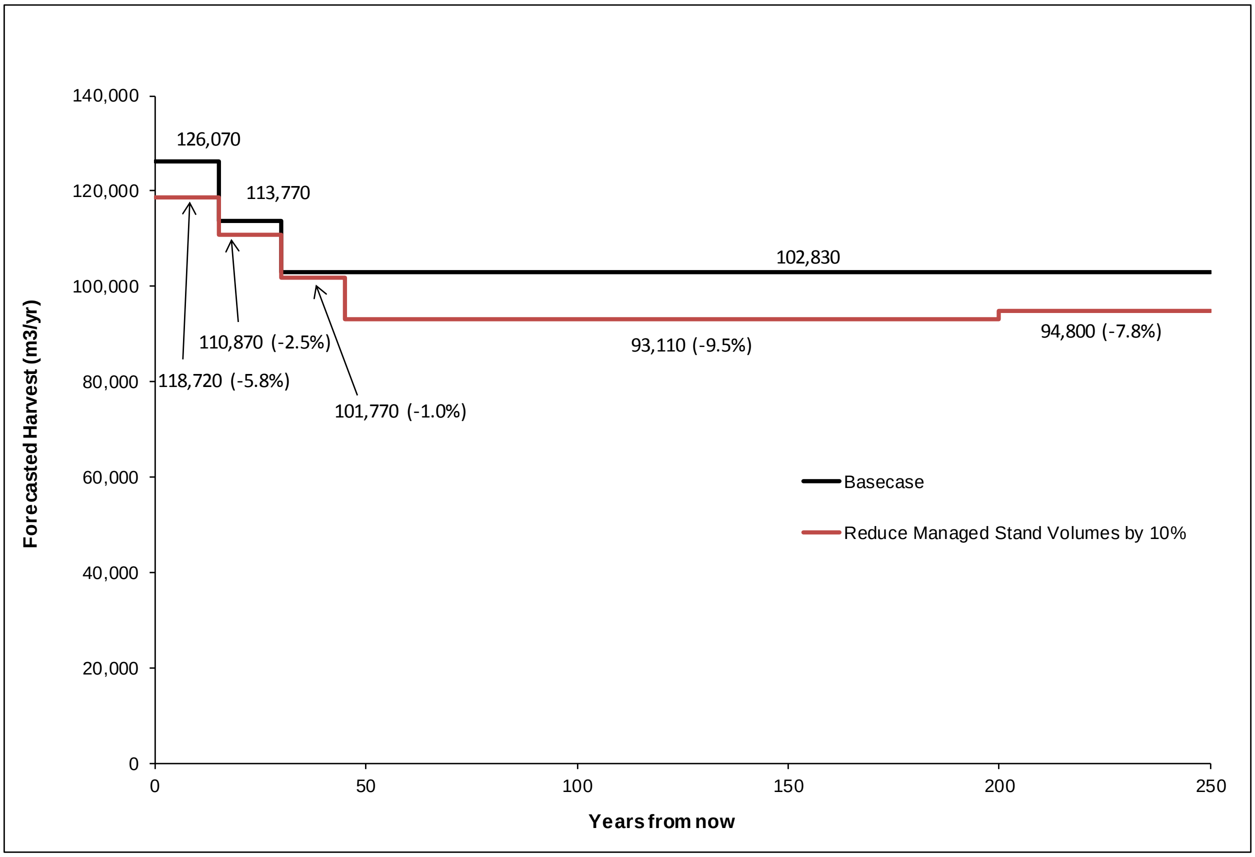

Figure 134: Sensitivity Analysis; reduce managed stand volumes by 10%, TSK

8.7.4 Marginal Timber

8.7.4.1 Include Helicopter Operable Area in Block 9 in the THLB.

This sensitivity analysis included the helicopter operable area in Block 9 in the THLB. However, due to other netdown categories and the minimum harvest criteria that required a minimum of 500 m^3 per ha and at least 30% Cw in the stand for the harvest to occur, only 2 ha were actually added to the THLB. There was no timber supply impact.

8.7.4.2 Include Conventionally Operable Areas Classified as Low Volume or Uneconomic in the THLB in Blocks 10 and 11

This sensitivity analysis included in the THLB the conventionally operable areas that are classified as low volume or uneconomic in Blocks 10 and 11. The THLB was increased by 2,527 ha or 10.7%.

The larger THLB increased the harvest forecast by 13.0% in the first 45 years of the planning horizon (Figure 135). The mid- and long-term impacts were more modest at 2.9% and 4.9%.

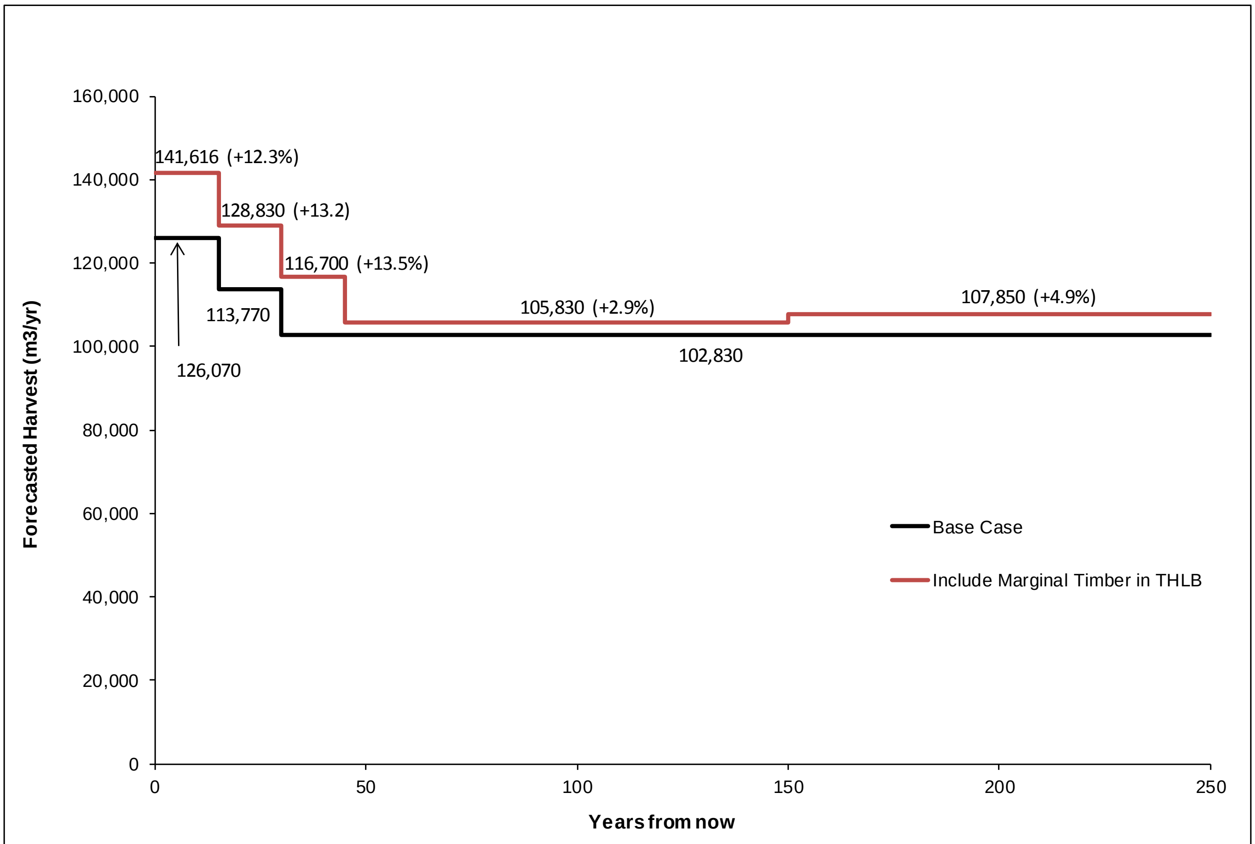

Figure 135: Sensitivity analysis; include low volume/uneconomic in the THLB in Blocks 10 and 11, TSK

8.7.5 Harvest Scheduling

This sensitivity analyses tested the impact of using the relative oldest first harvest rule as opposed to the highest volume first harvest rule that was employed in the Base Case.

Figure 136 illustrates the timber supply impact of using relative oldest first harvest rule. The long-term harvest forecast was increased by 11.6%. The impact comes mostly from a more efficient utilization of the THLB, i.e. less THLB is left unharvested than in the Base Case. In the Base Case 3,222 ha (13.6%) of the THLB was never harvested. In this sensitivity analysis only 86 ha of the THLB (0.4%) was never harvested throughout the planning horizon.

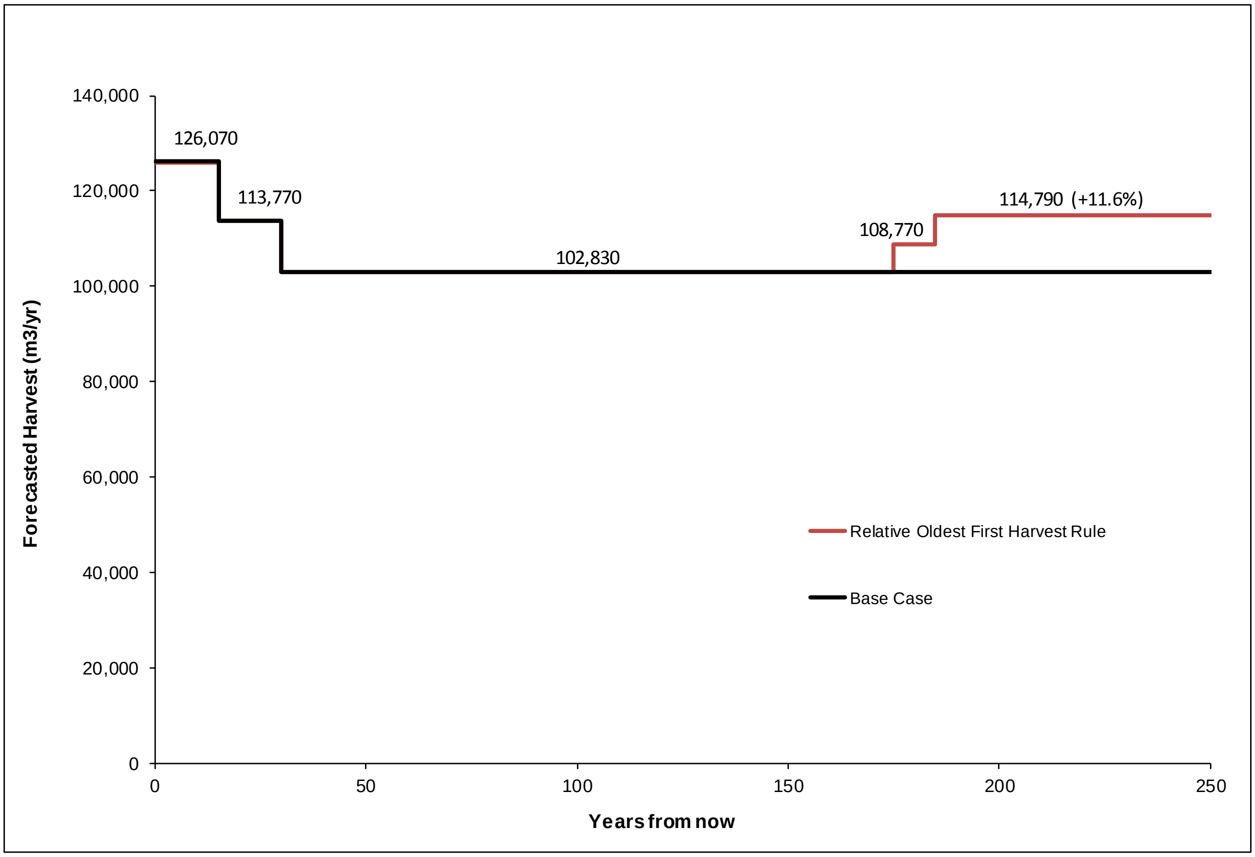

Figure 136: Sensitvity analysis; employ relative oldest first harvest rule, TSK

8.7.6 Defer block 9

This sensitivity analysis deferred the harvest in Block 9 for 5 years. The timber supply was not impacted.

8.7.7 Remove the Kitsumkalum Agreement-in-Principle Area from THLB

In 2015 the Kitsumkalum First Nation and the governments of B.C. and Canada reached a milestone in the B.C. treaty process with the signing of an Agreement-in-Principle (AIP). The AIP area represents the area that will likely be included in the actual treaty once it is finalized and implemented. The AIP lands remain in the CFLB and THLB until the implementation of the treaty.

This sensitivity analysis tested the impact on the timber supply of removing the AIP area from the THLB. In total 1,318 ha or 5.6% of THLB was removed. The timber supply forecast was reduced by 7.4% for the first 15 years of the planning horizon and 6.1% between years 16 and 30 (Figure 137). Both the mid and long-term harvest forecasts were reduced by 4.9%.

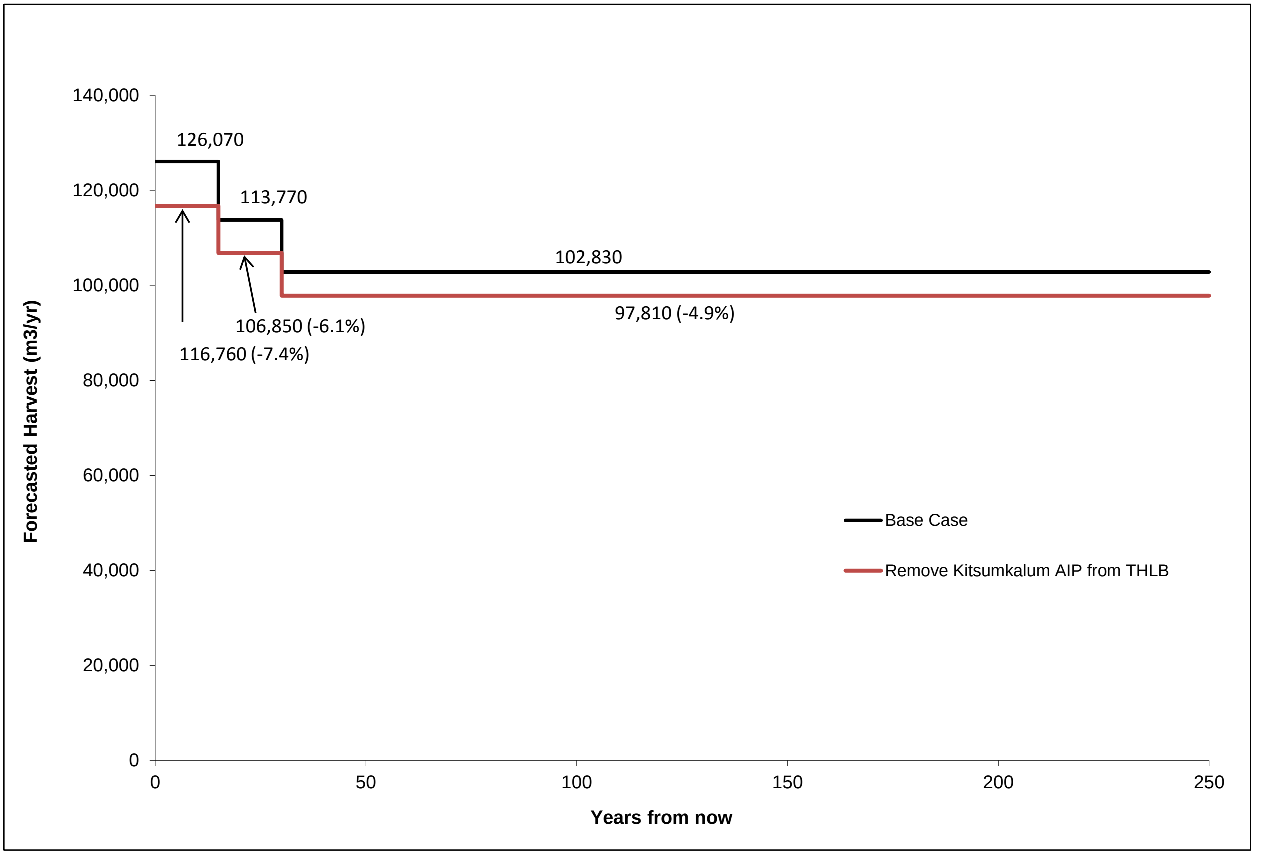

Figure 137: Sensitivity analysis; remove Kitsumkalum AIP area from the THLB, TSK

8.7.8 Green-Up

As a surrogate for spatial cutblock adjacency constraint, a landscape green-up constraint was applied in the Base Case, specifying that no more than 25% of the THLB area in each landscape unit outside of VQOs may be below the green-up height of 2.0 m at any given time.

One sensitivity analysis was completed. The maximum percentage of the THLB that could be below the green-up height was increased to 33%. There was no impact on timber supply.

8.8 Alternative Harvest Forecasts, TSK

Figure 138 illustrates the analysis results for two alternate harvest forecasts compared to the Base Case. The first alternate forecast set the initial harvest level at the current AAC of 141,616 m^3 per year. This harvest level is maintained for 10 years until the forecast is reduced by 26.7%, significantly more than the desired maximum of 10%. The mid- and long-term forecasts remain at the Base Case level.

Figure 138 also presents the maximum non-declining even flow alternative; the highest possible even flow harvest level equals the long-term harvest level of the Base Case at 102,830 m^3 per year.

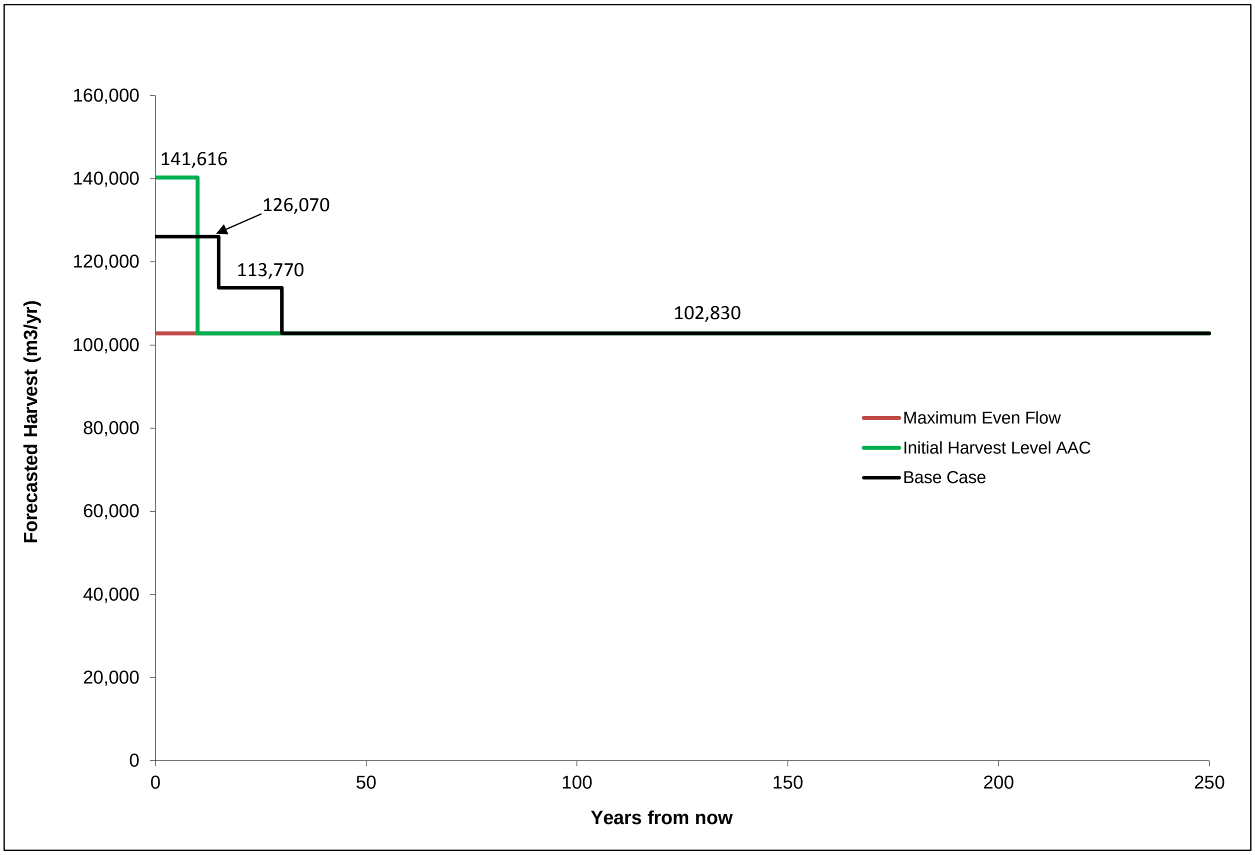

Figure 138: Alternative harvest forecasts, TSK

8.9 Discussion

In TSK, early seral requirements and grizzly bear management in the Copper watershed constrain timber supply. The watershed is in Block 10 and contains 20,764 ha of forest and 9,213 ha of THLB. The management constraint for grizzly bear requires that no more than 30% of the watershed can be between ages 25 and 100 at any time. This constraint is the equivalent of allowing only 10% of the watershed to be harvested in 25 years.

The large reserve of natural stands together with the constrained land base delay the transition of the harvest from natural stands to managed stands; the harvest of natural stands is predicted to continue for the next 50 years and the timber supply is not expected to fully convert to managed stands until around year 100. For this reason, the harvest ages and volumes of managed stands are predicted to remain high throughout the planning horizon.

Due to the prominence of natural stands in TSK, the timber supply is sensitive to uncertainty over the inventory volumes in the VRI. Reducing the natural stand volumes by 10% decreased the timber supply forecast by 15.9% in the first 30 years of the planning horizon.

Decreasing the volume of managed stands by 10% impacted the timber supply immediately at the beginning of the planning horizon. The timber supply was reduced by 5.8% in the first 15 years and it remained 2.5% below the Base Case level between years 16 and 30. The midterm harvest forecast was reduced by 9.5%, while the long-term harvest forecast was decreased by 5.5%.

Sensitivity analyses that tested the impact of uncertainty in the size of the THLB produced predictable results. Including the marginal timber in the THLB increased the size of it by 10.7%. The larger THLB increased the harvest forecast by 13.0% in the first 45 years of the planning horizon while the mid and long-term impacts were more modest at 2.9% and 4.9%. The long-term impacts were limited, because the marginal timber areas added to the THLB were of lower productivity.

Removing the Kitsumkalum First Nation AIP area from the THLB reduced it by 5.6%. The timber supply forecast was reduced by 7.4% for the first 15 years of the planning horizon and 6.1% between years 16 and 30. Both the mid and long-term harvest forecasts were reduced by 4.9% indicating that the AIP area is of average productivity compared to the rest of the TSK BA.

9 Cascadia TSA Harvest Forecast

This section provides a harvest forecast for the Cascadia TSA as one unit; the Business Area harvest forecasts are discussed as well; however, there was no attempt to control the harvest in any way from individual Business Areas. As most of the Business Areas chose to utilize the relative highest volume first harvest rule, it is also used here for the entire land base. The model limitations prevented the use of a different harvest rule for TCC, as was done in the individual Business Area timber supply analysis.

Figure 139 illustrates the harvest forecast for the entire TSA. The initial harvest level 347,930 m^3 per year is 12.5% lower than the current AAC of 397,818 m^3 per year. The contribution to the total harvest forecast by individual Business Areas is shown in Figure 140. The TSK Business Area is the largest contributor to the harvest with approximately 110,450 m^3 per year average over the planning horizon. TKO contributes approximately 79,834 m^3 per year average with TCC and TOC at 57,165 m^3 per year average and 55,060 m^3 per year average respectively.

Figure 141 compares the summed-up individual Business Area harvest forecasts to the TSA harvest forecast. The differences are small: in the first 60 years of the planning horizon, the TSA harvest forecast was 0.6% higher than the summed-up individual Business Area harvest forecasts. The mid-term forecast in the TSA run was 1.1% higher, while the long-term harvest forecast was 0.6% higher.

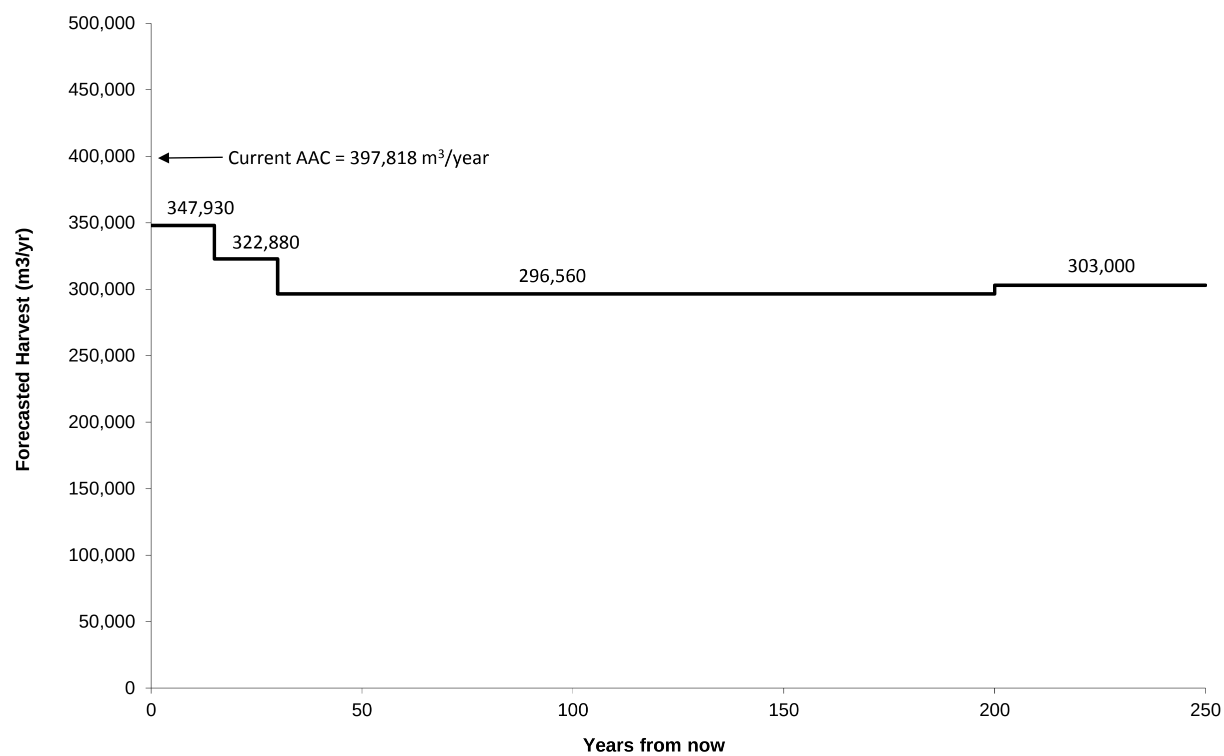

Figure 139: Harvest forecast for the entire Cascadia TSA; individual Business Areas are ignored

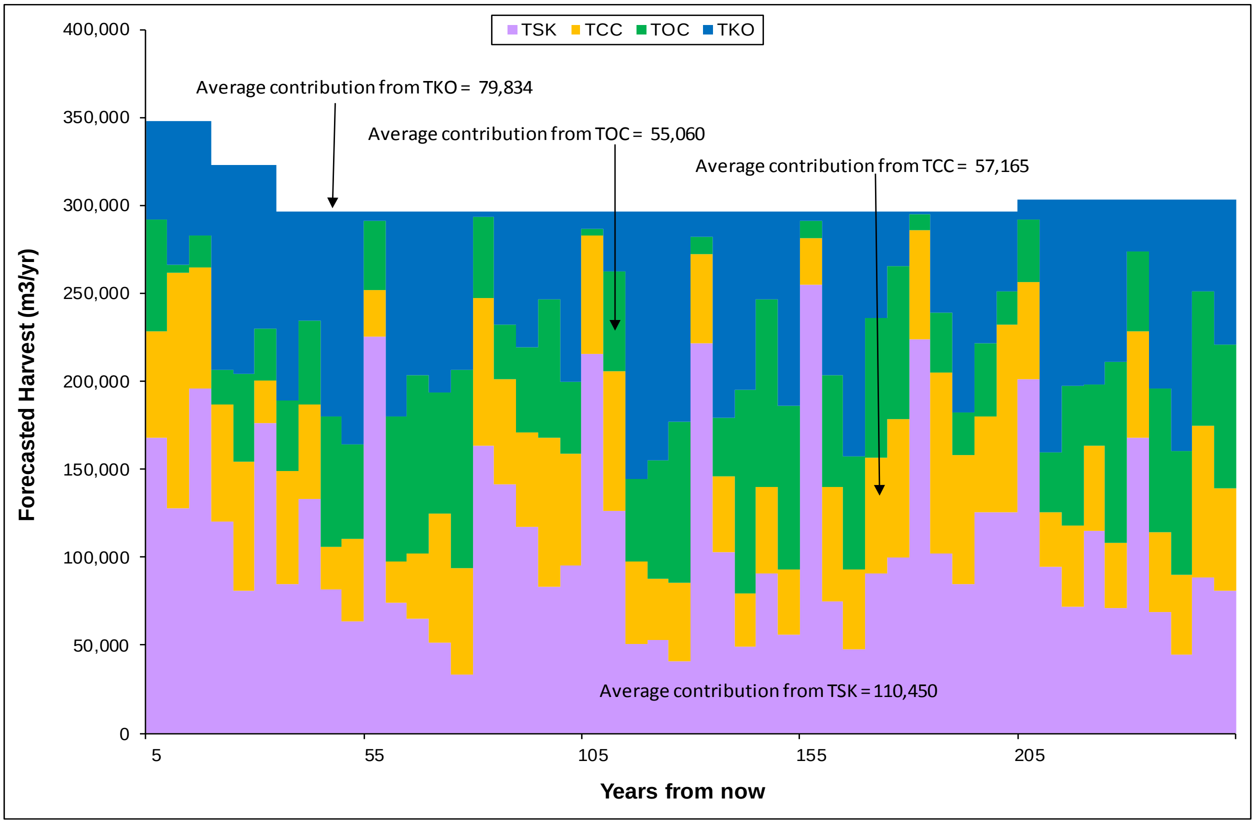

Figure 140: Contribution of different Business Areas to the TSA level harvest forecast

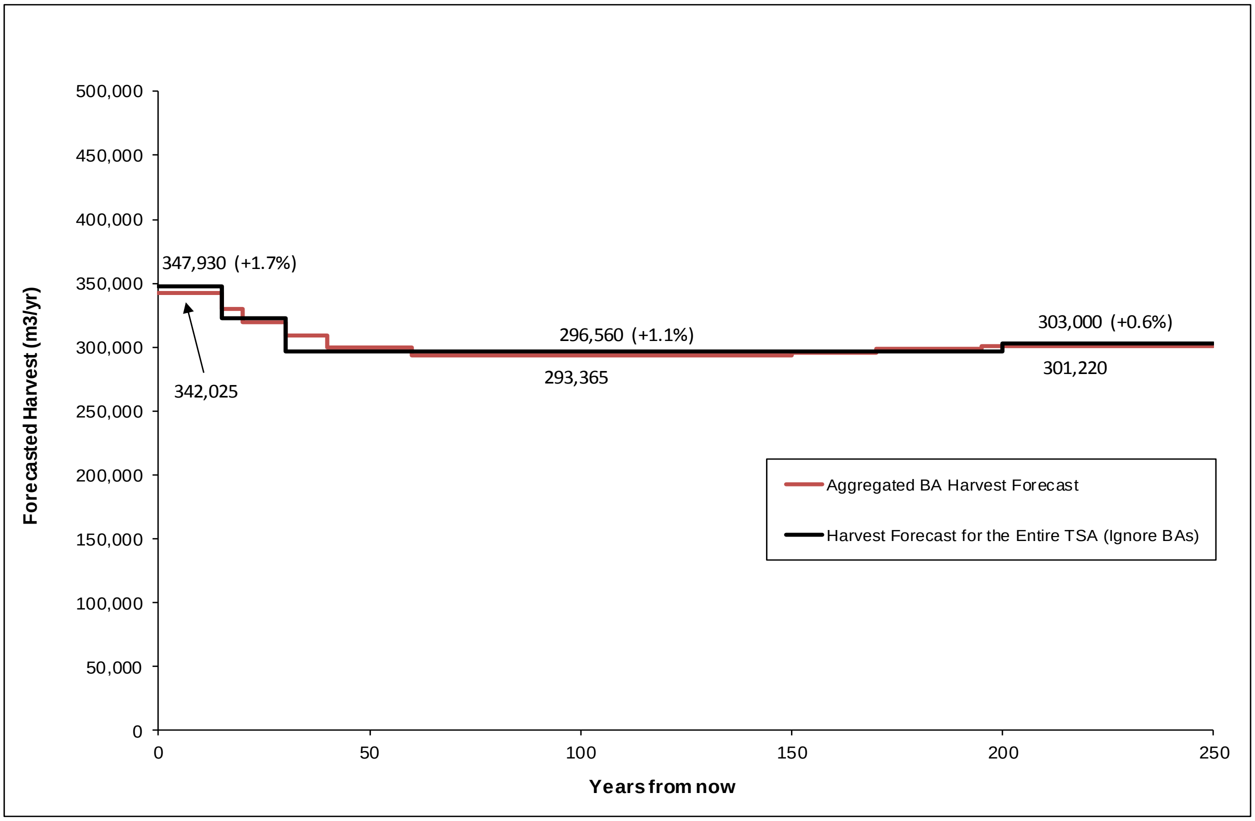

Figure 141: Summed up harvest contribution of BA Base Cases compared to the TSA level harvest forecast.

10 Conclusions

The current AAC for the Cascadia TSA is 397,818 m^3 per year. This analysis completed separate analysis runs for each Business Area. It also completed an analysis run for the entire TSA, without controlling the Business Area harvests in any way. Both approaches yielded similar results as shown in Table 25. Depending on the approach taken, the short-term timber supply is predicted to be 12.5% to 13.8% lower than the current AAC.

Table 25: Current AAC compared to the TSA initial harvest level

Run	Initial Harvest Level	Current AAC	Difference
BA runs summed up to TSA level	342,925 m^3 per year	397,818 m^3 per year	-13.8%
Entire TSA run	347,930 m^3 per year		-12.5%

It is difficult to compare the initial harvest level of this analysis to the current AAC. The current AAC is not a result of one timber supply analysis and a subsequent AAC determination. Rather, it is a result of a calculation attempting to determine the short-term harvest level for each Business Area using the THLB – as it was defined in past TFL analyses – and its relationship to the AAC of each TFL for the parcels that make up the Cascadia TSA.

It is important to note that this analysis used a more current version of the inventory, which in some cases was adjusted based on LiDAR data. Furthermore, the modelling of managed stands was completed using TASS rather than TIPSY with the regeneration assumptions accounting for ingress, genetic gain and the impact of pests and diseases.

Table 26 shows the THLB in this analysis compared to the takeback THLB – the current assumed THLB in each Business Area and the Cascadia TSA. The THLB for the TSA is significantly smaller in this analysis (-19%). In fact, a larger than experienced reduction in the short-term harvest forecast could be expected.

However, the timber supply reductions are not consistent across Business Areas. As noted before, in TKO the THLB was reduced by over 30%, while the short-term harvest forecast is reduced only by a little more than 10%, much of that due to woodsheds. A similar but opposite discrepancy applies to TSK, where the short-term harvest forecast is 11% lower than the current AAC on a THLB only 3% smaller than the takeback THLB.

The results for TOC and TCC were more consistent. The THLB in TOC was reduced by 8% corresponding well to the approximately 10% reduction in the short-term harvest forecast compared to the current AAC. In TCC the short-term harvest forecast was 28% below the current AAC; the TCC THLB is 21% less in this analysis than the takeback AAC.

Table 26: THLB in this analysis compared to the takeback THLB

Business Area	Takeback THLB (ha)	THLB in this analysis (ha)	Difference (ha)	Difference (%)
TKO	38,552	26,085	-12,467	-32%
TOC	21,081	19,328	-1,753	-8%
TCC	22,612	17,813	-4,799	-21%
TSK	24,871	24,059	-813	-3%
Total	**107,117**	**87,285**	**-19,832**	**-19%**

The base cases in all the four Business Areas are sensitive to changes in growth and yield inputs. The chosen harvest rule accentuates this sensitivity in TKO, TOC and TSK. In TKO and TSK, a reduction in inventory volumes reduced the short-term harvest forecast significantly, while in TOC the harvest forecast reduction was moderate. In all these units, a reduction in inventory volumes also reduced the long-term harvest forecast. In TCC, with a different harvest rule, the short-term impact was moderate, while the long-term was not impacted.

The transition from natural stands to managed stands is predicted to happen in 35 to 45 years depending on the Business Area. Sensitivity analyses showed that different Business Areas responded differently to reductions in managed stand volumes. In TKO and TOC the harvest forecast reductions were limited to the mid and long terms; the predicted decrease in harvest also corresponded with the tested decrease in growth and yield, In TSK and TCC, the short-term harvest forecast was also impacted as a result of lower assumed managed stand harvest volumes.

There is some concern among the BCTS staff, whether the managed stands as modeled will be of adequate size and quality at harvest. Sensitivity analyses in TKO and TOC Business Areas showed that larger average harvest volumes per ha could be achieved by increasing the minimum harvest criteria. However, the increased harvest volumes come at a cost; increasing the minimum harvest volume per ha reduced the short-term harvest forecast by 10% in TKO and 14% in TOC.

11 List of Acronyms

Acronym	Description
AAC	Annual Allowable Cut
AIP	Agreement in Principal
BA	Business Area
BCTS	BC Timber Sales
BEC	Biogeoclimatic Ecosystem Classification
CFLB	Crown Forested Land Base
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
FESL	Forest Ecosystem Solutions Ltd.
FLNRORD	Ministry of Forests, Lands, Natural Resource Operations, and Rural Development
FPPR	Forest Planning and Practices Regulation
FRPA	Forests and Range Practices Act
FSOS	Forest Simulation and Optimization System (model used for analysis)
IRM	Integrated Resource Management
KBHLPO	Kootenay-Boundary Higher Level Plan Order
KSRMP	Kalum Sustainable Resource Management Plan
LiDAR	Light Detection and Ranging
LTHL	Long-term Harvest Level
LU	Landscape Unit
MAI	Mean Annual Increment
MHV	Minimum Harvest Volume
MPB	Mountain Pine Beetle
NHLB	Non-Harvesting Land Base
NRL	Non-recoverable Losses
OAF	Operational Adjustment Factor
OGMA	Old Growth Management Area
PEM	Predictive Ecosystem Mapping
SIBEC	Site Index by BEC Site Series
SOP	Standard Operating Procedure
TASS	Tree and Stand Simulator
TCC	BCTS Cariboo-Chilcotin Business Area
TEM	Terrestrial Ecosystem Mapping
THLB	Timber Harvesting Land Base
TIPSY	Table Interpolation for Stand Yields
TKO	BCTS Kootenay Business Area

Acronym	Description
TSA	Timber Supply Area or Timber Supply Analysis
TOC	BCTS Okanagan-Columbia Business Area
TSK	BCTS Skeena Business Area
TSR	Timber Supply Review
UWR	Ungulate Winter Range
VDYP	Variable Density Yield Projection
VRI	Vegetation Resource Inventory
VQO	Visual Quality Objective

Appendix 1 – Information Package

Timber Supply Review

Information Package – Cascadia TSA

Version 1.8

DRAFT

Prepared by:
Forest Ecosystem Solutions Ltd
227 – 998 Harbourside Drive
North Vancouver, BC
V7P 3T2
604-998-2222
amakitalo@forestecosystem.ca

forest ecosystem solutions ltd.

Prepared for:
Cariboo-Chilcotin, Kootenay, Okanagan-Columbia and Skeena Business Areas
BC Timber Sales
Cascadia TSA

BCTS
BC Timber Sales

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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 7 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 5.

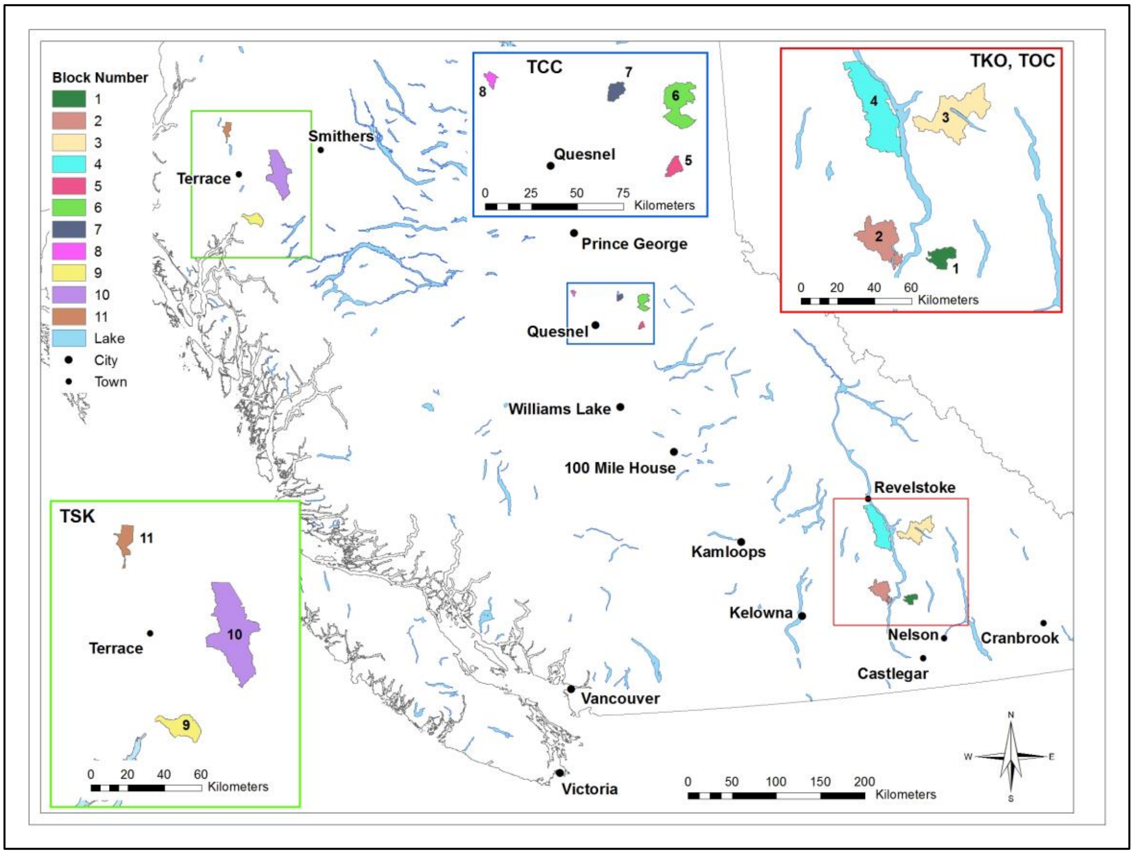

Figure 142: Cascadia TSA Blocks

Table 27: 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 6.

Table 28: 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 29 shows land use plans in force for each Business Area and Block.

Table 29: 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 18 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 18, the TSA will be analyzed as an aggregate unit in a sensitivity analysis.

Table 30: Proposed sensitivity analyses

Issue	Sensitivity analysis	Notes
Minimum harvest criteria (age and/or volume per ha)	Increase and decrease minimum harvest criteria.	BAs separately. As per different BA requirements.
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
Green-up	Maximum 33% of THLB in each LU less than green-up height compared to 25%	All Business Areas
	Maximum 20% of THLB in each LU less than green-up height compared to 25%	TKO
Harvest rule	Use a different harvest rule; relative highest volume first in TCC, relative oldest first in all other BAs.	BAs separately
BEC version	Use a different BEC version	TKO
BCTS Business Area harvest	Run the analysis for the TSA as an aggregated unit.	Total aggregated harvest forecast and forecast by BA.
Armillaria impact	Remove custom operational adjustment factors (OAF 2) to test impact of not considering Armillaria root disease.	TKO, TOC
Woodsheds	Remove minimum periodic harvest requirements for woodsheds.	TKO
Forest Health	Test the impact of incorporating custom OAF2 factors to account for rust and MPB impacts in young stands	TCC
Deferral	Defer harvest in Block 9 for 5 years.	TSK
Land withdrawal	Remove the Kitsumkalum Agreement-in-Principle Area from 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 397,818 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 31 lists all the spatial data layers used in the analysis, with their source and vintage.

Table 31: 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
Block2_woodsheds	Woodsheds in TKO (Block 2) with minimum harvest targets	BCTS	2018

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 32 shows the areas of missing VRI data in the Cascadia TSA by Block.

Table 32: 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

Block	Null Area (ha)
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 33.

Table 33: 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

Block	Yes (ha)	No (ha)
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

[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.

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 ;
- 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 34 summarizes the total areas and lengths of the riparian classes within the Cascadia TSA.

Table 34: 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	

Riparian Class	Definition	Length (km)	Area (ha)
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
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 7, and the netdowns for each Business Area are shown in Table 36, Table 9, Table 10, and Table 11 with each reduction described below.

Table 35: Cascadia TSA netdown summary

Netdown Category	NetArea (hectares)	GrossArea (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	4,327	11,421
Archeological Sites	55	103
WTP	1,676	1,795
NHLB Area	**128,153**	
THLB Area	**87,285**	
Future Roads	1,026	
Future THLB	**86,258**	

Table 36: TKO netdown summary

Netdown Category	NetArea (ha)	GrossArea (ha)
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	1,185	4,198
Archeological Sites	1	29
WTP	470	506
NHLB Area	**56,610**	
THLB Area	**26,085**	
Future Roads	182	
Future THLB	**25,903**	

Table 37: TOC netdown summary

Netdown Category	NetArea (ha)	GrossArea (ha)
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	2,398	3,491
Archeological Sites		
WTP	599	652
NHLB Area	**30,544**	
THLB Area	**19,328**	
Future Roads	115	
Future THLB	**19,213**	

Table 38: TCC netdown summary

Netdown Category	NetArea (ha)	GrossArea (ha)
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	452	2,297
Archeological Sites	10	16
WTP	212	224
NHLB Area	**7,595**	
THLB Area	**17,813**	
Future Roads	330	
Future THLB	**17,483**	

Table 39: TSK netdown summary

Netdown Category	NetArea (ha)	GrossArea (ha)
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	293	1,435
Archeological Sites	44	58
WTP	395	413
NHLB Area	**33,405**	
THLB Area	**24,059**	
Future Roads	399	
Future THLB	**23,660**	

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 40.

Table 40: 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 41.

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 41 shows the road classes and their widths in different Business Areas. Road areas after buffering are shown in Table 42. The total existing road area is 4,347 ha.

Table 41: 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 42: 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 43.

Table 43: 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 44. The units that allow harvest are also included in Table 44. 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 44: 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. 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 45.

Table 45: 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 46.

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 46: 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 47.

Table 47: 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 48 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 48: 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 49. 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.

After the analysis file was completed, the TOC staff discovered that the Mt. Begbie trail was inadvertently omitted from the netdown. Because of this omission, the THLB in the Cascadia TSA and in TOC is overestimated by 7.4 ha.

Table 49: 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 50. The total area removed from the THLB is 195 ha.

Table 50: 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 51).

Table 51: 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 52.

Table 52: 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 53. Note that deciduous volumes are also removed from all conifer leading stand yield curves, because they are generally not utilized.

Table 53: 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 54 were first removed from the THLB. Younger natural stands were projected to age 150 using VDYP. Those stands that did not meet the Table 54 criteria were also removed from the THLB.

Table 54: Minimum volume per ha criteria

Business Area	Minimum Volume by Harvest Method (m^3/ha)		Area (ha)
	Cable	Ground	
TKO	200	150	4,198
TOC	250	200	3,491
TCC	200	110	2,297
TSK	250	250	1,435
Total			**11,421**

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 55.

Table 55: 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 56) 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 56 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 56: 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 57 shows the percent road used for each BA.

Table 57: 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 58. 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 58: 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 8). However, there are distinct differences between the Business Areas, as shown in Figure 9, Figure 10, Figure 11, and Figure 12.

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.

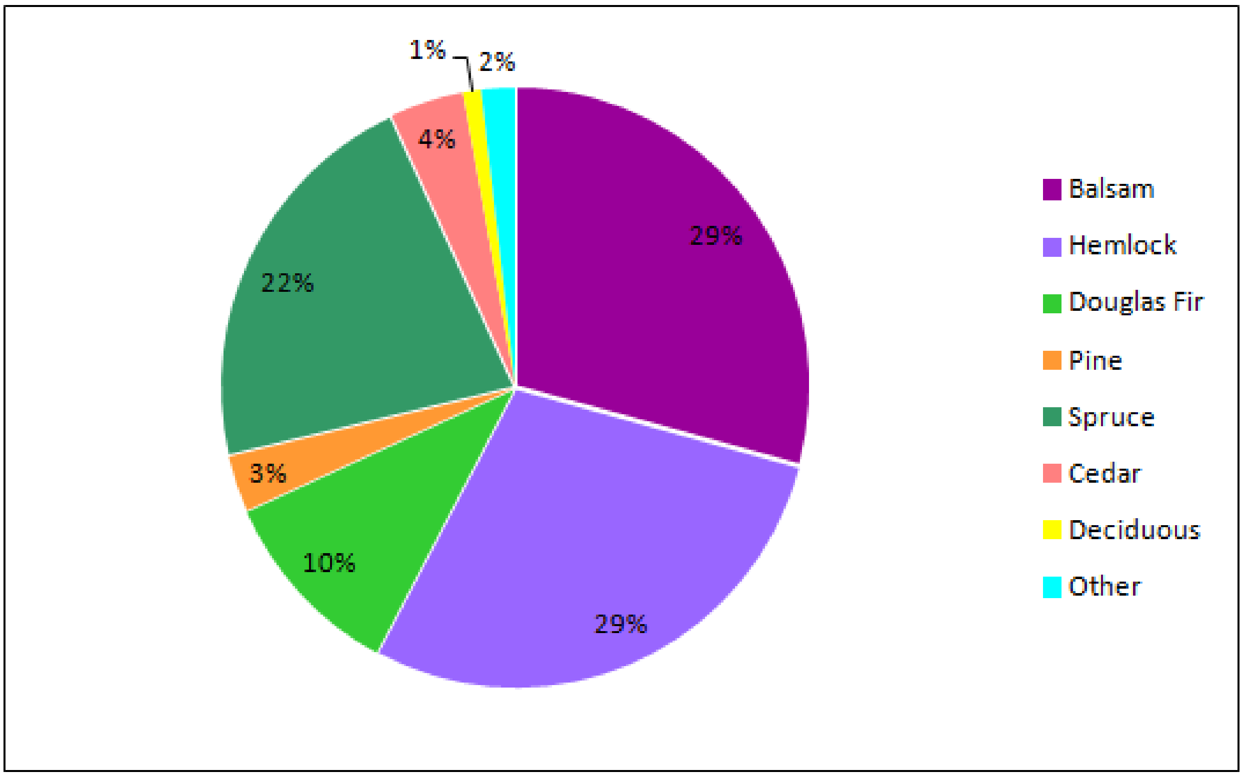

Figure 143: Leading species in the CFLB, Cascadia TSA

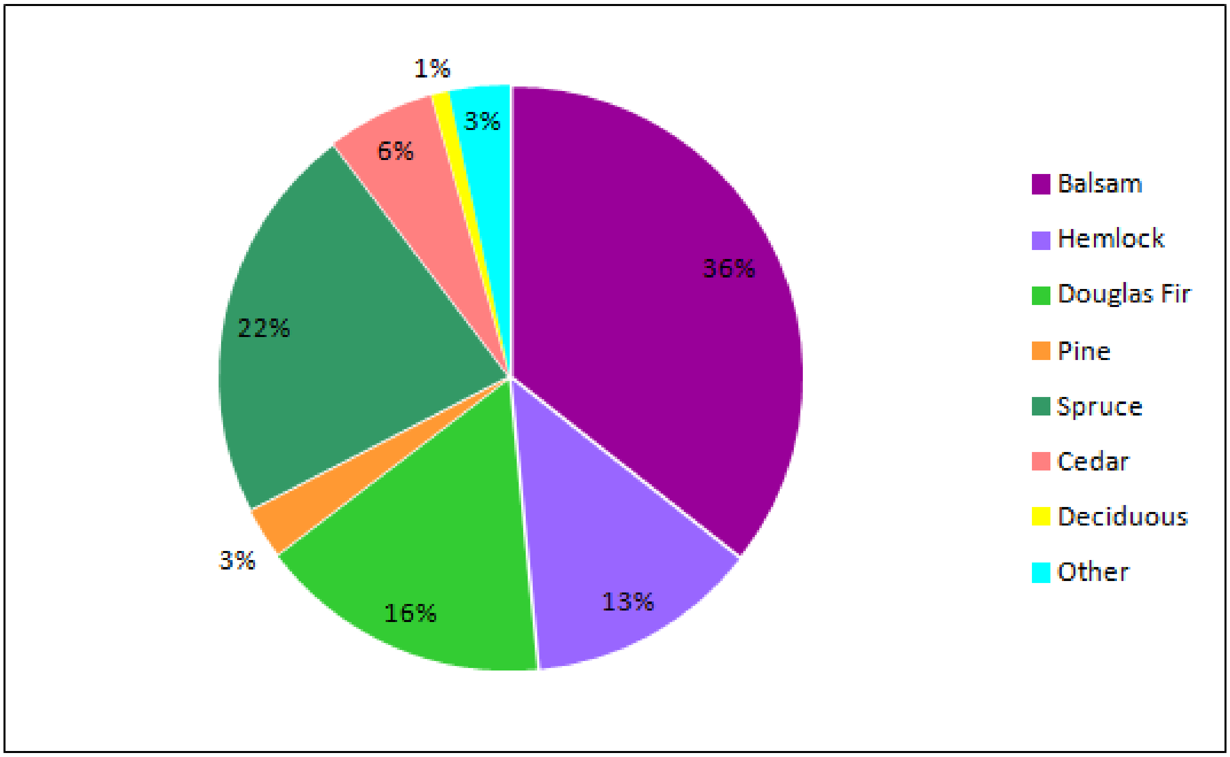

Figure 144: Leading species in the CFLB, TKO

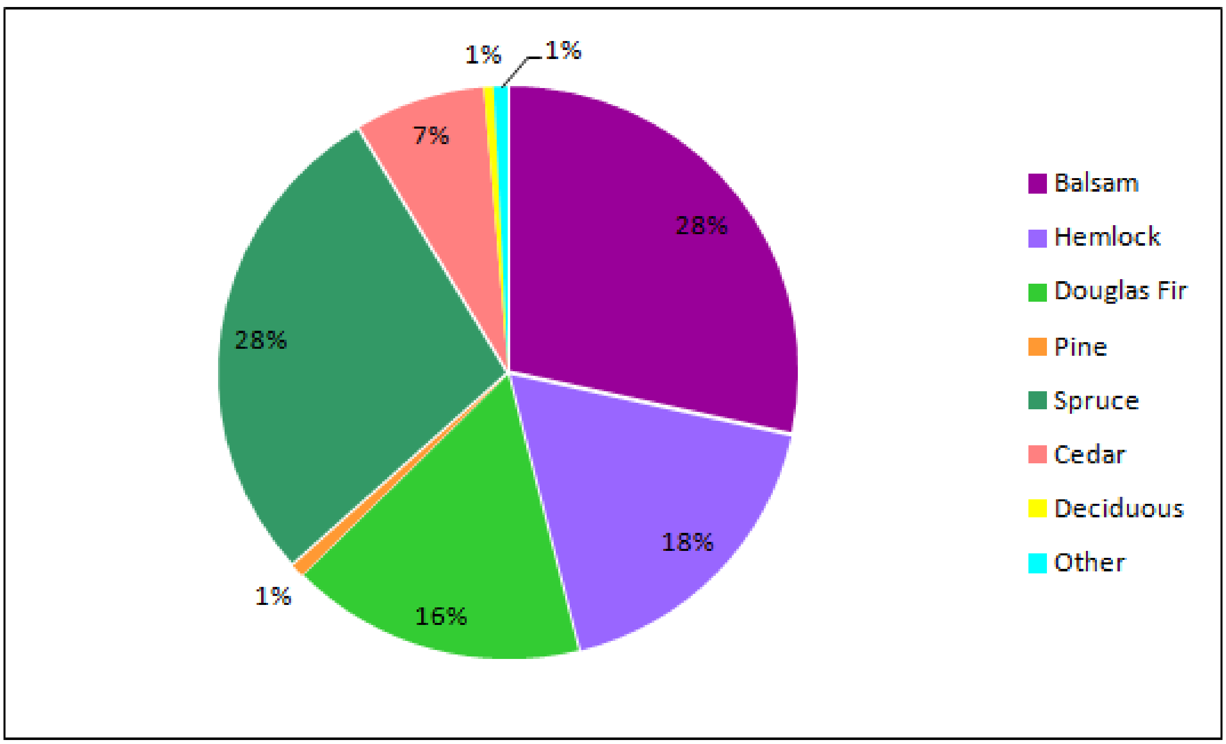

Figure 145: Leading species in the CFLB, TOC

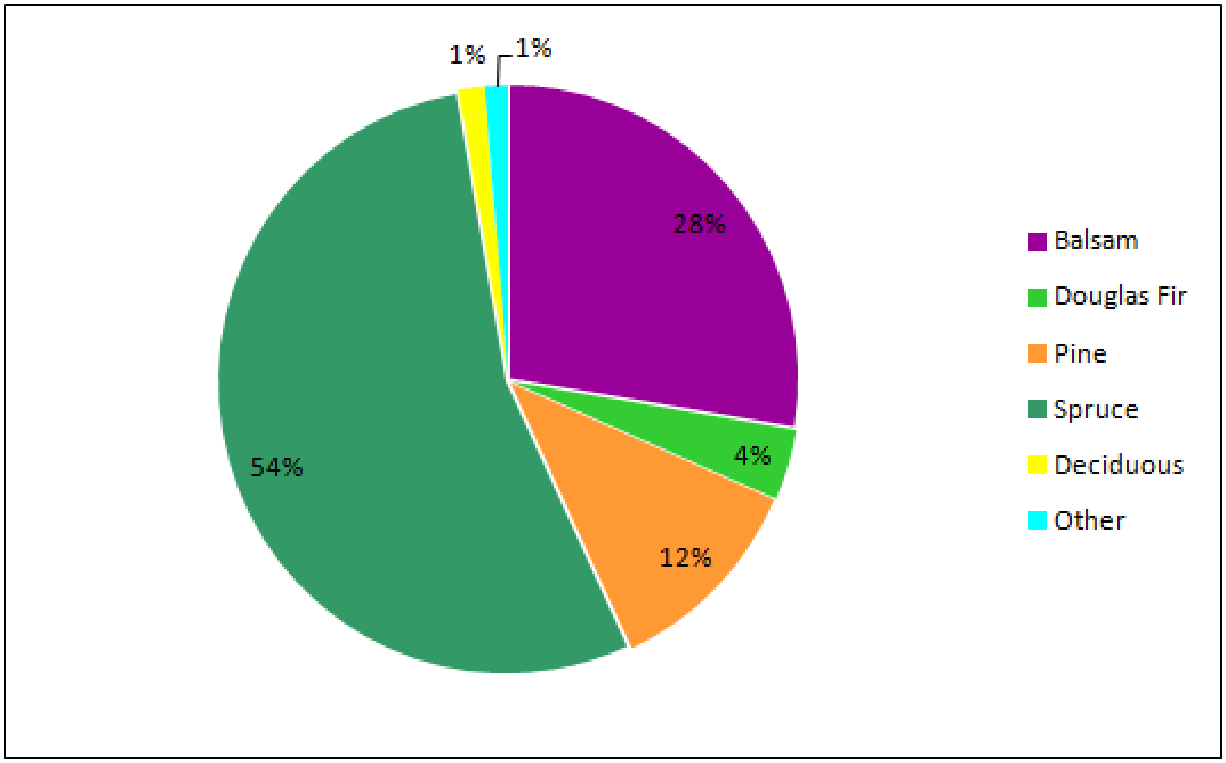

Figure 146: Leading species in the CFLB, TCC

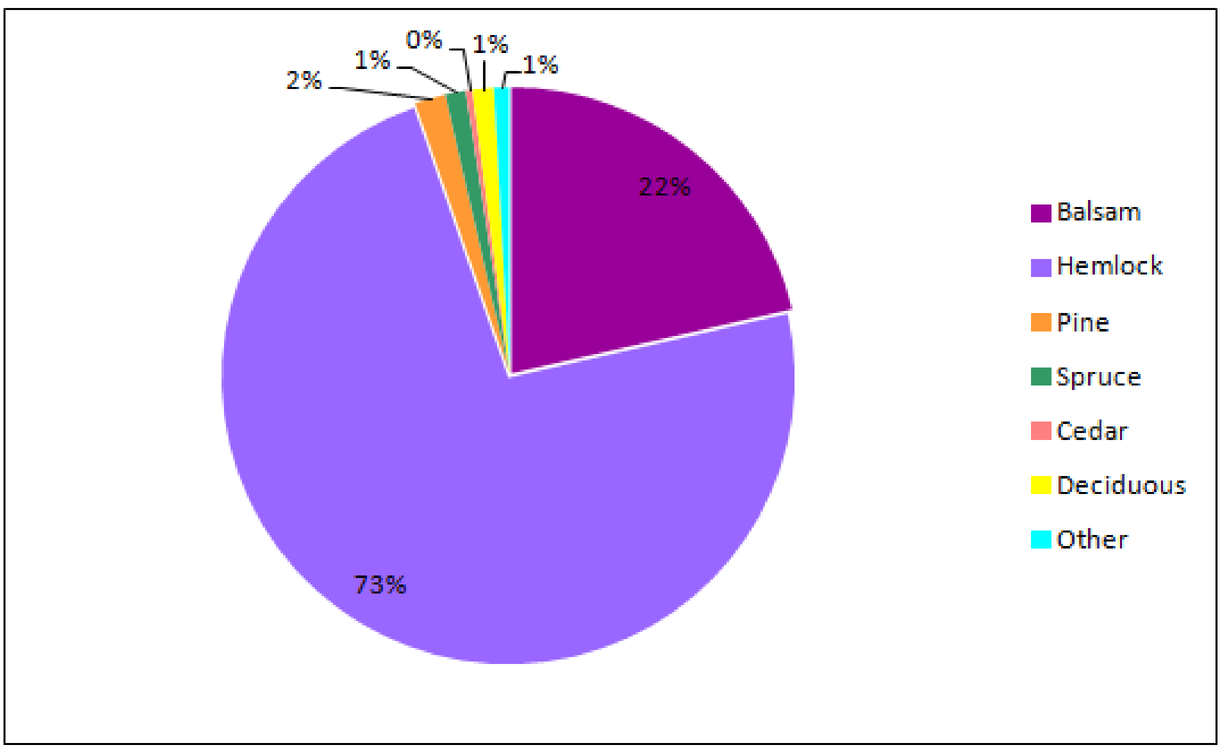

Figure 147: Leading species in the CFLB, TSK

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 13). The leading species in the THLB for each Business Area are shown in Figure 14, Figure 15, Figure 16, and Figure 17.

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.

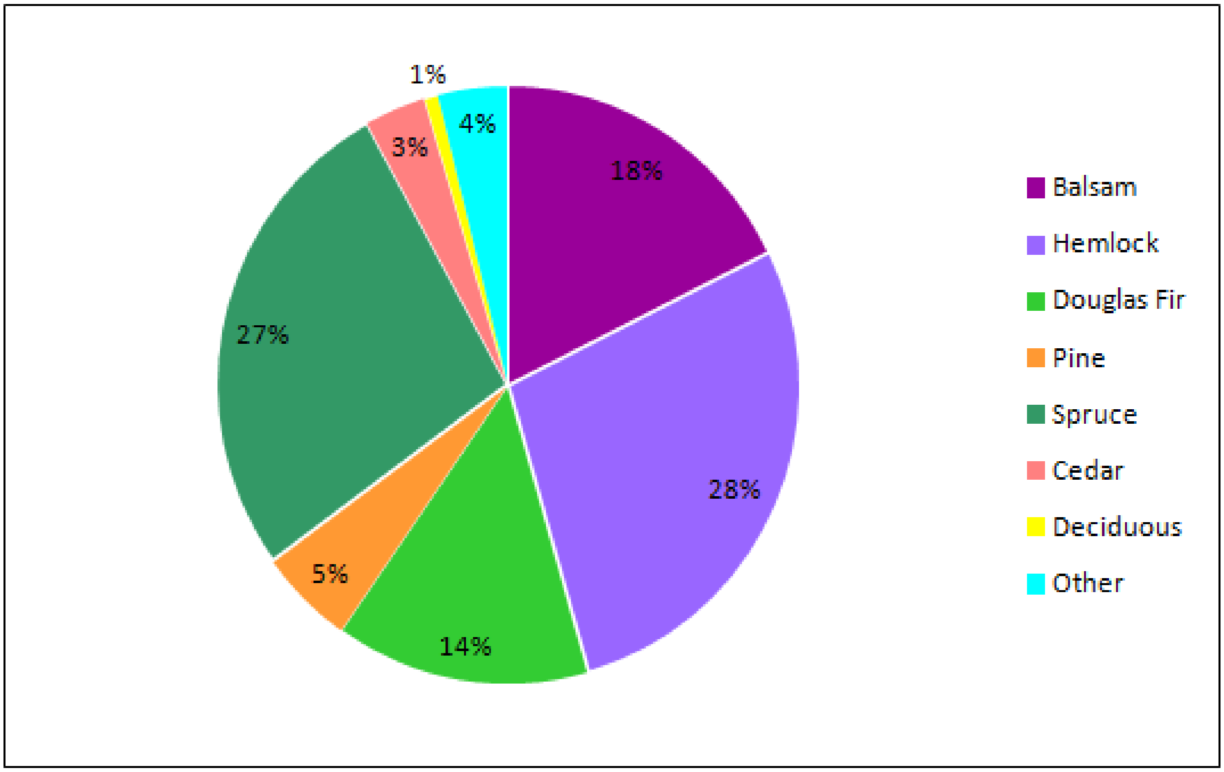

Figure 148: Leading species in the THLB, Cascadia TSA

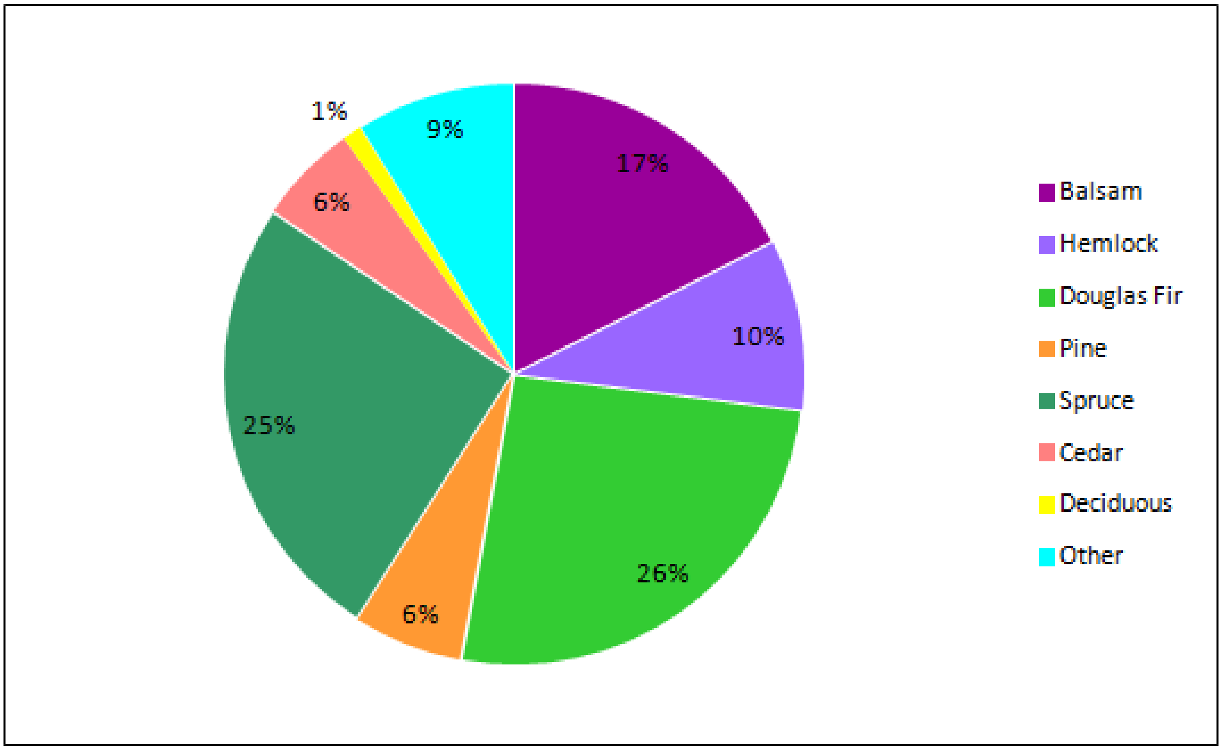

Figure 149: Leading species in the THLB, TKO

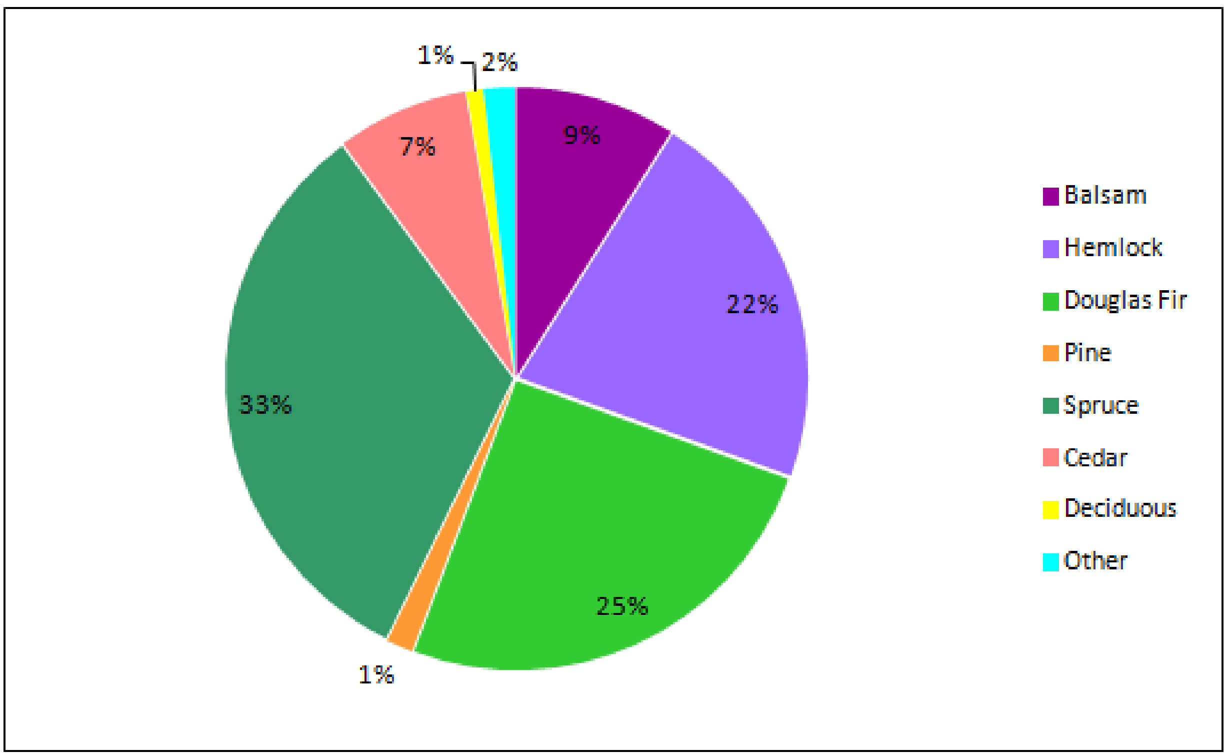

Figure 150: Leading species in the THLB, TOC

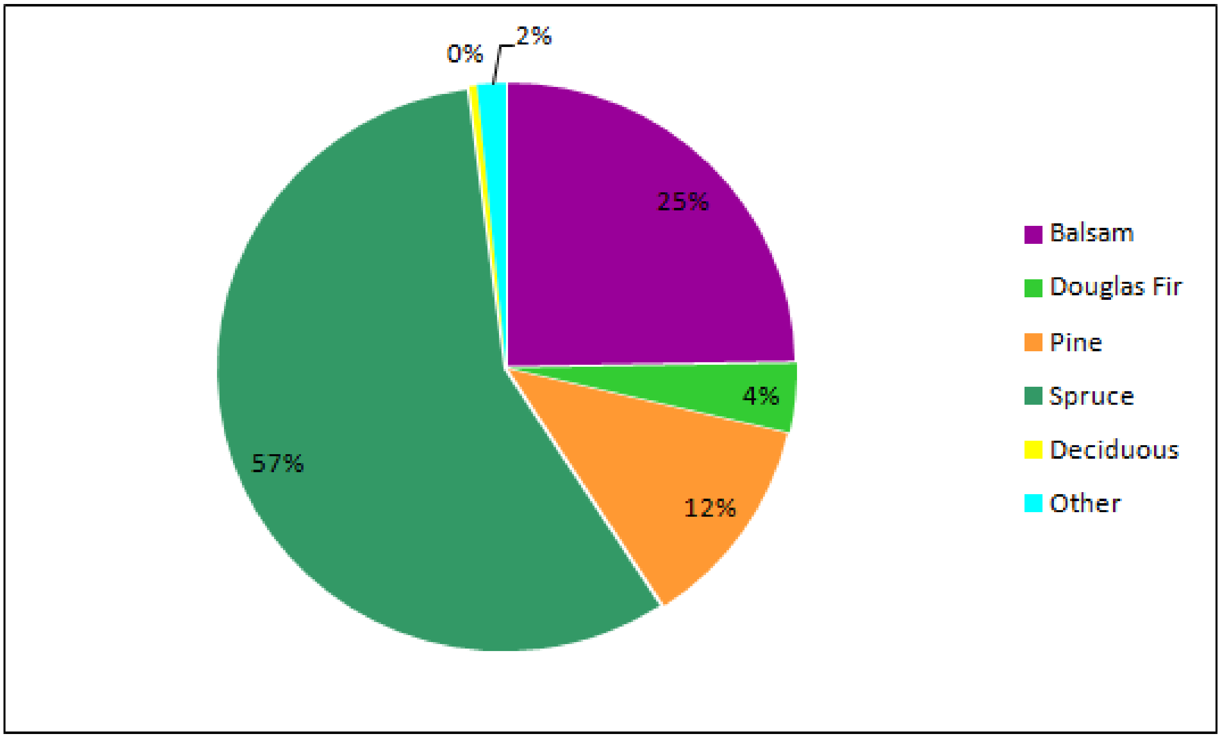

Figure 151: Leading species in the THLB, TCC

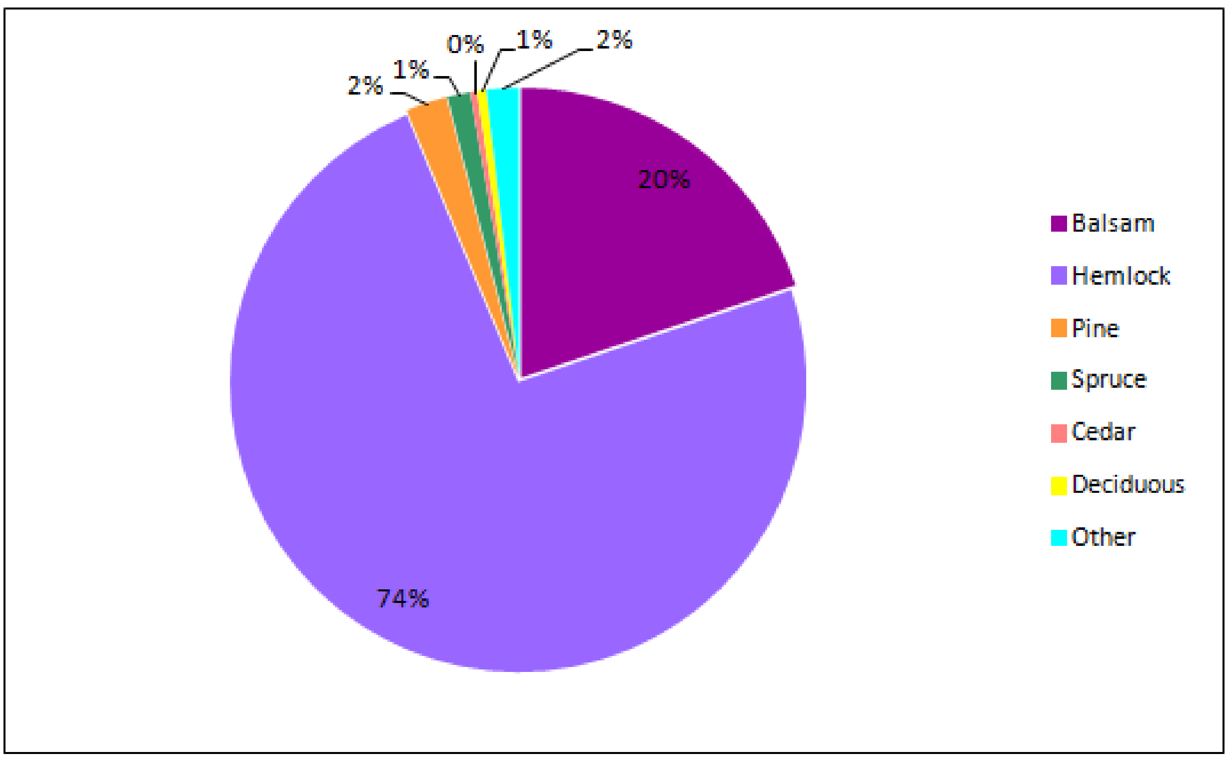

Figure 152: Leading species in the THLB, TSK

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 18).

The age class distributions for each Business Area are shown in Figure 19, Figure 20, Figure 21 and Figure 22. 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 153: Age class distribution in the Cascadia TSA

Figure 154: Age class distribution, TKO

Figure 155: Age class distribution, TOC

Figure 156: Age class distribution, TCC

Figure 157: Age class distribution, TSK

5.2.4 Growing Stock

The total merchantable growing stock in the Cascadia TSA is estimated at 18 million m^3. Hemlock (6.8 million m^3, 38%) and balsam (4 million m^3, 22%) volume forms the majority of the merchantable growing stock at around 10.8 million m^3 (60%). The shares of spruce and Douglas-fir volume are significant at 3 million m^3 (16%) and 2 million m^3 (11%) correspondingly (Table 12).

A large portion of the merchantable growing stock is older than 250 years (age class 9, 43%) most of it hemlock or balsam located in TSK (Figure 23 and Table 12).

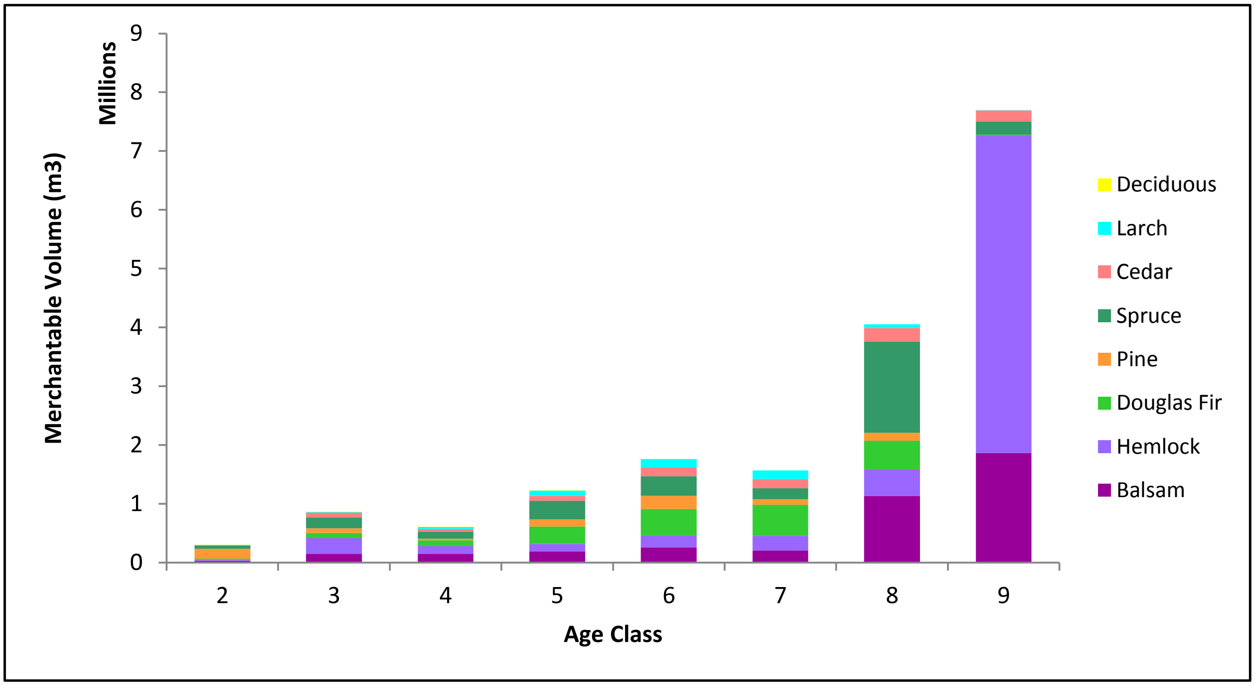

Figure 158: Merchantable growing stock by species and age class in the Cascadia TSA

Table 59: 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	736,071	427,330	1,132,106	591,525	472,518	426,473	821,283	0	**4,607,306**
TOC	218,761	396,068	666,011	635,521	16,209	42,913	488,081	0	**2,463,564**
TCC	918,957	0	185,928	0	0	360,070	1,482,923	2,112	**2,949,990**
TSK	2,097,856	117,003	0	5,623,179	0	17,893	172,800	0	**8,028,731**
Total	**3,971,644**	**940,402**	**1,984,045**	**6,850,225**	**488,727**	**847,349**	**2,965,087**	**2,112**	**18,049,591**

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 60 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 60: 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 63.	Varies, see Table 64	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 6.3.3.
	Landscape Level Biodiversity	Old	Met through spatial OGMAs	Non-legal OGMAs	
		Mature and Old	Min targets, see Table 66	CFLB by LU/BEC	See Section 6.3.4.1. Targets are specified by LU/BEC.
		Mature and old	Min targets, see Table 67	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 73	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 73	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 68	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 72	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 71	CFLB by LU/BEC	See Section 6.3.4.4. Targets are specified by LU/BEC.
		Early	Max targets, see Table 69	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 73	CFLB in UWR tag/management unit	See Section 6.3.5.2
	Grizzly bear	Forest cover	Max target, see Table 75	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 outside of VQOs may be below the specified green-up height at any given time. The green-up heights vary by BA within the TSA (Table 61).

Table 61: 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 38,696 ha (18%) of the CFLB.

Table 62: VQO classes in the Cascadia TSA

Business Area	VQO Class Area (ha)			
	R	PR	M	Total
TKO	0	5,657	6,664	**12,321**
TOC	0	5,396	14,683	**20,079**
TCC	610	1,828	1,404	**3,842**
TSK	0	348	2,106	**2,454**
Total	**610**	**13,229**	**24,857**	**38,696**

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 63 shows the overall area-weighted average VEG tree height for the different slope classes.

Table 63: 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 64. 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 64: 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%	30	9,057
	H	15.0%	4	1,441
Modification (M)	L	15.1%	27	5,098
	M	20.0%	62	16,369
	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 159 illustrates the resulting HR curve and its relationship to ECA. As can be observed from Figure 159, in the example stand, a 30% ECA is reached when trees are 11 meters tall. Figure 159 also shows that a 30% ECA is reached at 70% HR.

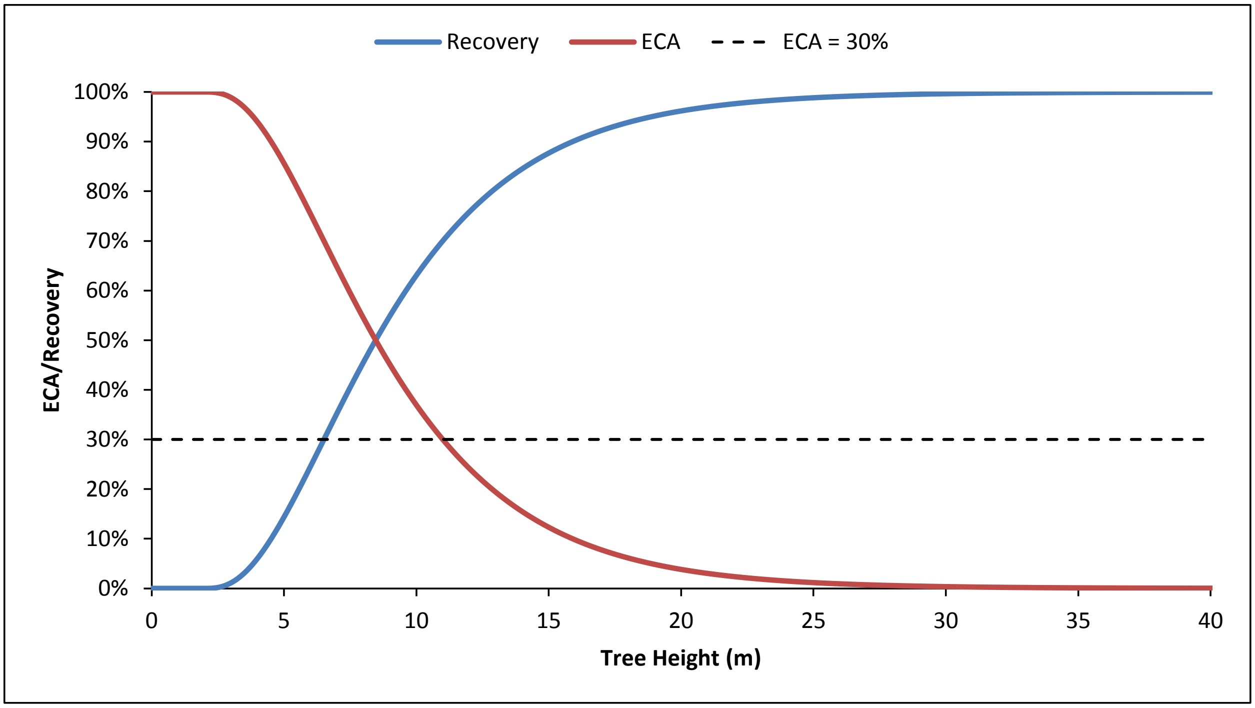

Figure 159: Recovery curve and ECA curve for a single stand in a TKO watershed

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 587 ha.

6.3.3.3 Domestic Watersheds

There are 16 domestic watersheds in TKO (Table 65), all with the maximum ECA of 30% as per current management by BCTS.

Table 65: 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 66). Note that by applying the percent targets, the area targets are pro-rated 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 67. 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 67 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 66: 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 67: 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 68. All landscape units are currently meeting their targets for mature and old except for Antler and Umiti.

Table 68: 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 69, Table 70, and Table 71. 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 69: 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 70: 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 71: 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 72: 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 73. The targets and constraints are applied by UWR management unit, which are shown in Table 74.

Table 73: 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 74: 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 watershed as per the Kalum SRMP.

Table 75: 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	20,764

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, and 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 397,818 m^3 per year as the initial harvest level. The AAC will be allocated to different BAs as per Table 76. 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 76: Cascadia TSA AAC by BA

Business Area	AAC m^3/Year
TKO	112,650
TOC	66,566
TCC	76,986
TSK	141,616
Total	**397,818**

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 for TKO, TOC and TSK. Contrary to all other Business Areas, a relative oldest first harvest rule will be employed in TCC. According to the TCC staff, this harvest rule better reflects harvest planning in TCC.

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 77. These levels are consistent with TSL specifications

Table 77: 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 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:

1. The age at which the stand's mean annual increment (MAI) achieves a value of 95 percent of the maximum (culmination); and
2. The age at which the stand is predicted to reach a volume as described in Table 15. 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 the forest for other, non-timber forest values.

A stand must meet both of these criteria to be eligible for harvesting in the timber supply model.

Table 78: Minimum harvest volume 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 Minimum Periodic Volume

Minimum volume requirements can be set for an area, when it is known that the financial viability of the harvest from that area requires a minimum harvestable volume. The following table shows all the TSA woodsheds that are subject to minimum volume requirements in the Base Case. The requirements are applied to a period of 5 years. All the woodsheds that require a minimum periodic harvest volume are in the TKO BA.

Table 79: Minimum 5-year harvest volume requirements, TKO only

Woodshed	Minimum Periodic Target (m^3 in 5 Years)
Block 1	35,000
Block 3	35,000

7.8 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. TASS will be used instead of TIPSY for this analysis for the following reasons:

1. Stands with both planted and ingress trees can be modeled in TASS. This is not possible in TIPSY.
2. Mixed species stands can be simulated in TASS, while the TIPSY database does not include simulations for mixed-species stands.

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 80). In addition, managed stands were split by era.

Table 80: 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
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

Group #	Business Area	BEC Variant	Site Series	THLB Area (ha)
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 81.

Table 81: 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 82 shows the THLB area of Era 2 stands by BA.

Table 82: 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 % (or 85%) 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 by multiplying the yields by 0.85.

OAF 2 allows for increasing volume losses towards maturity, attributable to decay, waste and breakage, disease and pest factors. The standard OAF2 of 5 % (or 95%) 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 in TCC and TSK. In TKO and TOC the OAF 2 was adjusted to account for Armillaria root disease, as described below.

8.2.3.1 Armillaria Impact

The set of Armillaria OAFs were provided by Dr. Mike Cruickshank (Canadian Forest Service) for the Arrow TSA timber supply analysis (Table 83). These were used for the Cascadia TSA timber supply analysis as well.

Table 83: Armillaria OAFs by species, infection level and age.

Species	Infection Severity	Age				
		20	50	80	100	300
Fdi	L	0.89	0.94	0.91	0.94	0.34
Fdi	M	0.85	0.85	0.79	0.80	0.73
Fdi	H	0.78	0.80	0.76	0.78	0.90
Ba	L	1.00	0.80	0.86	0.88	0.48
Ba	M	1.00	0.80	0.86	0.88	0.48
Ba	H	1.00	0.80	0.86	0.88	0.48
Cw	L	0.99	0.98	0.96	0.95	0.14
Cw	M	0.99	0.98	0.96	0.95	0.14

Species	Infection Severity	Age				
		20	50	80	100	300
Cw	H	0.99	0.98	0.96	0.95	0.14
Hw	L	0.99	0.98	0.96	0.95	0.14
Hw	M	0.99	0.98	0.96	0.95	0.14
Hw	H	0.99	0.98	0.96	0.95	0.14
Pl	L	1.00	1.00	1.00	0.99	0.32
Pl	M	0.98	0.89	0.84	0.86	0.45
Pl	H	0.98	0.89	0.84	0.86	0.45
Sw	L	0.98	0.90	0.81	0.78	0.55
Sw	M	0.98	0.90	0.81	0.78	0.55
Sw	H	0.98	0.90	0.81	0.78	0.55
Lw	L	0.88	0.92	1.00	0.99	0.23
Lw	M	0.88	0.92	1.00	0.99	0.23
Lw	H	0.88	0.92	1.00	0.99	0.23

The values in Table 83 were linearly interpolated between the provided ages to generate an Armillaria OAF for each age. The combined OAF applied by species, infection level and age was calculated as:

$OAF_{combined} = OAF1 * OAF2 * OAF_{armillaria}$

Armillaria OAFs were applied to the following yield curves and species.

- All yield curves in the TKO and TOC Business Areas;
- Fdi and Ba had high “H” Armillaria OAFs applied;
- All other conifers had medium “M” Armillaria OAFs applied;
- Armillaria OAFs were not applied to any deciduous species.

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

Table 84: 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 14 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 85: Annual non-recoverable losses

Forest Health Factor	Average Annual losses (m3/year)			
	TKO	TOC	TCC	TSK
Douglas-fir bark beetle	600	562	210	
Fire	1469	358	500	103
Mountain Pine beetle	500			
Spruce bark beetle			331	
Western Balsam bark beetle			1000	617
Drought				437
Flooding				88
Total	**2569**	**920**	**2041**	**1245**

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 3.4.2.
2. Silviculture free growing survey inventory and planting data were analyzed and summarized 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 86, Table 87 and **Error! Reference source not found.** 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 89 and Table 90. Natural ingress delay is described in section 8.4.4.

Table 86: 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
201	TKO	ESSFwh1/mh	101,102,103, 104,105	Sx	18.4	900	Sx65Pli25Bl10	4	1900	Bl65Pli35	0	15	5
202	TKO	ESSFwh1/mh	110,111,111, 112,113	Sx	19.5	800	Sx70Pli20Bl10	4	1700	Bl70Pli30	0	15	5
203	TKO	ESSFwc4/wc w/dc1/dcw	all	Sx	15.2	900	Sx60Pli25Bl10Cw5	4	1750	Bl70Pli30	0	15	5
204	TKO	ICHwk1/vk1	101,102,103, 104	Sx	22.6	1200	Sx40Fd40Cw15Pw5	4	1300	Sx50Hw45At5	0	15	5
205	TKO	ICHwk1/vk1	110,111,112, 113,Fm02, Fm04	Sx	24.8	1100	Sx50Fdi30Cw20	4	1000	Hw70Fdi15Sx10At5	0	15	5
206	TKO	ICHmw2/mw5/ dw1	101,102,103, 104,105	Fdi	22	1200	Fdi50Pli20Sx20Lw10	4	2630	Pli35Fdi25Hw20Cw15 At5	0	15	5
207	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
208	TOC	ESSFwh1	all	Sx	19.1	900	Sx100	4	1900	Bl50Sx30Hw20	0	15	5
209	TOC	ESSFwc4	all	Sx	16.6	900	Sx100	4	1750	Bl50Sx50	0	15	5
210	TOC	ICHwk1/vk1	101,102,103, 104	Sx	23.1	1000	Sx60Fd30Cw5Pw5	4	1500	Hw45Sx25Cw25At5	0	15	5
211	TOC	ICHwk1/vk1	110,111,112, 113,Fm02, Fm04	Sx	24.3	900	Sx65Fdi25Cw5Pw5	4	1200	Hw45Cw35Sx15At5	0	15	5
212	TOC	ICHmw2	101,102,103, 104	Fdi	22.8	1200	Fdi75Pli10Sx10Lw5	4	2630	Hw40Cw30Fdi25At5	0	15	5
213	TOC	ICHmw2	110,111,112, 113,114	Sx	23.2	1000	Sx50Fdi45Pw5	4	2500	Hw40Cw30Fdi25At5	0	15	5
214	TOC	ICHmw3	01,02,03,04, 05	Fdi	20.8	1200	Fdi75Sx20Pl5	4	1600	Hw50Cw30Fdi15At5	0	15	5
215	TOC	ICHmw3	06,07,08,09	Fdi	22.4	1000	Fdi50Sx50	4	1600	Hw50Cw30Fdi15At5	0	15	5
216	TCC	ESSFwk1	01,02,03	Pli	19.5	1600	Pli70Sx30	2	300	Bl20Sx35Pli40At5	1	15	5
217	TCC	ESSFwk1	01,02,03	Sx	16.8	1600	Sx90Pli10	2	300	Bl45Sx35Pli15At5	1	15	5
218	TCC	ESSFwk1	04,05,06,07	Sx	18.7	800	Sx60Pli40	2	100	Bl35Sx35Pli25At5	1	15	5
219	TCC	ESSFwc3	all	Sx	15.7	1600	Sx85Pli15	2	500	Bl55Sx25Pli15At5	1	15	5
220	TCC	SBSwk1	01,02,03,04, 05	Pli	20.7	1600	Pli70Sx20Fdi10	2	1500	Pli60Bl10Sx20At10	1	15	5
221	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
222	TCC	SBSwk1	06,07,08,09, 10, 11	Sx	21.4	950	Sx60Pli40	2	600	Sx40Pli30Bl20At10	1	15	5
223	TCC	SBSmh	all	Pli	22.4	1600	Pli60Sx25Fdi15	2	2600	Pli60Bl5Sx25At10	1	15	5
224	TCC	SBSmw	01,02,03,04	Pli	22.3	1600	Pli60Sx30Fdi10	2	2600	Pli60Bl5Sx25At10	1	15	5
225	TCC	SBSmw	05,06,07,08, 09,10	Sx	21.8	950	Sx60Pli40	2	800	Sx50Pli35Bl5At10	1	15	5
226	TSK	CWHvm1/vm2	01,03,04,05		23.9	0			6000	Hw55Ba25Cw10Ss10	1	15	5
227	TSK	CWHvm1	06,07,08,09, 10,11,12,13,1 4	Ba	27	1200	Ba40Cw10Ss30Hw20	2	5000	Hw70Ba30	1	15	5
228	TSK	CWHws1	01,04		21.4	0			5000	Hw55Ba35Cw5Ss5	1	15	5
229	TSK	CWHws1	02,03		21.9	0			5000	Hw55Ba35Cw5Ss5	1	15	5
230	TSK	CWHws1	05,06,07,08, 09,10,11	Ba	25.3	1230	Ba50Hw30Cw10Sx10	2	4000	Hw50Ba50	1	15	5
231	TSK	CWHws2	01,02, 03, 04		22.8	0			5400	Ba45Hw45Sx5Cw5	1	15	5
232	TSK	CWHws2	05,06,07,08, 09,10,11	Ba	23.2	1240	Ba45Hw40Cw10Sx5	2	4400	Ba55Hw45	1	15	5
233	TSK	MHmm1/2	all		12	0			4000	Ba50Hm25Hw25	1	15	5

Genetic gain = 0

Table 87: 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
101	TKO	ESSFwh1/mh	101,102,103, 104,105	Sx	18.3	1200	Sx65Pli20Fdi10Lw5	2	2210	Bl65Pli35	0	15	5
102	TKO	ESSFwh1/mh	110,111,111, 112,113	Sx	19.5	1200	Sx65Pli25Bl10	2	2000	Bl70Pli30	0	15	5
103	TKO	ESSFwc4/wc w/dc1/dcw	101,102,103, 104,105	Sx	16.1	1400	Sx60Pli25Bl10Cw5	2	2155	Bl70Pli30	0	15	5
104	TKO	ESSFwc4/wc w/dc1/dcw	110,111,111, 112,113	Sx	16.6	1200	Sx60Pli25Bl10Cw5	2	1950	Bl75Pli25	0	15	5
105	TKO	ICHwk1/vk1	101,104	Sx	22.5	1500	Sx40Cw25Fdi25Pw5Lw5	2	1120	Hw75Fdi20At5	0	15	5
106	TKO	ICHwk1/vk1	102,103	Fdi	22.8	1500	Fdi40Cw30Sx25Pw5	2	1500	Hw70Fdi15Lw10At5	0	15	5
107	TKO	ICHwk1/vk1	110,111,112, 113,Fm02, Fm04	Cw	19.8	1400	Cw40Sx30Fdi25Pw5	2	800	Hw70Fdi15Lw10At5	0	15	5
108	TKO	ICHmw2/mw5 /dw1	101,102,103, 104,105	Fdi	22.1	1330	Fdi30Pli20Lw20Pw20Sx1 0	2	2630	Pli35Fdi25Hw20Cw15At5	0	15	5
109	TKO	ICHmw2/mw5 /dw1	110,111,111, 112,113,114, Fm01,Fm02, Fm04	Sx	24	1330	Sx30Fdi20Pli20Lw20Pw1 0	2	2630	Pli25Fdi25Hw25Cw20At5	0	15	5
110	TOC	ESSFwh1	all	Sx	18.6	1400	Sx90Cw7Bl3	2	2000	Bl50Sx30Hw20	0	15	5
111	TOC	ESSFwc4	all	Sx	16	1400	Sx90Bl10	2	2155	Bl50Sx50	0	15	5
112	TOC	ICHwk1/vk1	101,102,103, 104	Fdi	24	1500	Fdi35Cw30Sx25Pw10	2	1120	Hw45Sx25Cw25At5	0	15	5
113	TOC	ICHwk1/vk1	110,111,112, 113,Fm02, Fm04	Cw	20.4	1400	Cw35Sx30Fdi25Pw10	2	800	Hw45Cw35Sx15At5	0	15	5
114	TOC	ICHmw2	101,102,103, 104	Fdi	22.8	1500	Fdi60Lw20Pw15Cw5	2	2450	Hw40Fdi30Cw25At5	0	15	5
115	TOC	ICHmw2	110,111,112, 113,114	Cw	19.5	1500	Cw30Fdi30Lw20Sx10Pw1 0	2	2450	Hw40Cw30Fdi25At5	0	15	5
116	TOC	ICHmw3	01,02,03,04, 05	Fdi	21	1500	Fdi60Cw20Pw10Sx5Lw5	2	1400	Hw50Cw30Fdi15At5	0	15	5
117	TOC	ICHmw3	06,07,08,09	Fdi	22.1	1500	Fdi40Cw45Sx10Pw5	2	1400	Hw50Cw30Fdi15At5	0	15	5
118	TCC	ESSFwk1	01,02,03	Sx	17	1800	Sx80Pli20	2	825	Bl55Pli40At5	1	15	5
119	TCC	ESSFwk1	04,05,06,07	Sx	16.9	1200	Sx60Pli40	2	600	Bl55Sx20Pli20At5	1	15	5
120	TCC	ESSFwc3	01,02	Sx	16	1800	Sx95Bl5	2	1025	Bl75Pli20At5	1	15	5
121	TCC	SBSwk1	01,02,03,04, 05	Sx	21.1	1750	Sx55Pli45	2	3850	Pli60Bl25At5Fdi10	1	15	5
122	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
123	TCC	SBSmh	all	Pli	22.4	1700	Pli60Sx35Fdi5	2	6700	Pl55At10Sx20Fd10Bl5	1	15	5
124	TCC	SBSmw	01,02,03,04	Pli	22.4	1700	Pli60Sx35Fdi5	2	6700	Pl55At10Sx20Fd10Bl5	1	15	5
125	TCC	SBSmw	05,06,07,08, 09,10	Pli	22.5	1400	Pli60Sx40	2	1500	Sx50Pli35Bl5At10	1	15	5
126	TSK	CWHvm1/ vm2	all		24	0		2	6000	Hw60Ba30Cw5Ss5	1	15	5
127	TSK	CWHws1	01,04,05,06, 07,08, 09,10,11		21.2	0		2	5200	Hw45Ba45Cw5Ss5	1	15	5
128	TSK	CWHws1	02,03		21.4	0		2	5200	Hw45Ba45Cw5Ss5	1	15	5
129	TSK	CWHws2	all		22.1	0		2	5800	Ba45Hw45Cw5Ss5	1	15	5
130	TSK	MHmm1/2	all		12	0		2	4000	Ba50Hm25Hw25	1	15	5

Genetic Gain, see Section 8.4.3, Table 89

Table 88: 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	Sx40Cw25Fdi25Pw5L w5	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	Sx30Fdi20Pli20Lw20P w10	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	Fdi60Cw20Pw10Sx5L w5	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	12	800	Ba100	2	3000	Ba40Hm30Hw30	1	15	5

Genetic Gain; see Section 8.4.3, Table 90.

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) or to 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 89.

Table 89: 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 90.

Table 90: 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

10 References

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Appendix 1 – Yield Tables

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

Table 91: Managed stands established between 1976 and 1995, part 1

Age	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.08	0.08	0.00	0.00	0.00	0.74	0.91	0.00	0.00	0.00	0.00	0.25	0.00	0.08	0.00	0.00	0.00
25	4.21	4.13	1.38	0.13	0.28	13.20	14.50	0.00	0.00	0.07	0.13	4.03	0.07	1.30	0.07	0.44	0.20
30	19.17	16.78	9.94	2.92	7.90	33.81	34.96	0.00	0.00	3.01	4.20	10.20	2.74	3.84	1.45	3.21	2.27
35	36.93	32.24	22.96	15.81	34.22	56.39	59.76	1.01	0.00	20.63	25.37	22.08	14.70	9.49	6.22	10.42	8.03
40	55.80	50.56	37.14	41.68	74.54	78.75	89.40	9.94	0.77	50.52	61.90	36.67	35.83	20.25	17.52	21.92	17.95
45	76.90	76.02	51.88	71.87	116.90	102.25	121.52	30.14	7.06	86.35	102.19	56.24	62.64	32.88	35.52	36.97	35.16
50	99.63	100.92	66.84	107.30	159.03	124.58	151.08	59.05	20.20	123.73	141.89	78.08	90.24	49.87	56.08	55.79	56.34
55	124.49	129.21	82.86	141.17	196.41	145.05	176.81	92.47	39.62	158.81	177.73	99.65	118.75	68.99	79.47	75.14	80.17
60	149.66	157.57	100.16	170.94	229.10	164.38	199.63	128.75	62.28	191.04	209.76	121.54	144.28	88.38	103.84	96.20	103.97
65	174.05	184.71	118.14	198.68	258.62	182.20	219.56	163.86	86.71	218.54	239.13	142.74	167.68	105.91	124.38	116.95	126.21
70	196.78	210.61	135.72	222.94	283.90	198.24	236.04	195.73	113.41	242.23	263.04	162.27	189.95	122.55	144.57	137.37	148.36
75	218.58	233.15	152.58	245.96	305.86	212.68	248.84	226.56	140.03	262.16	283.49	181.13	209.99	138.73	163.20	156.07	168.42
80	237.20	253.24	169.41	266.09	324.34	225.79	261.19	252.79	163.27	279.60	301.60	198.40	226.18	154.27	180.29	174.60	186.44
85	256.22	273.27	188.56	285.44	344.24	240.61	272.19	277.96	188.04	298.03	320.52	215.90	244.14	170.84	197.61	194.13	205.28
90	273.16	291.64	205.84	304.20	359.46	250.45	278.91	300.04	212.36	313.90	336.14	232.76	260.53	187.27	214.27	212.01	224.57
95	289.72	307.46	223.63	321.48	371.38	260.29	284.22	319.47	233.49	327.85	349.18	250.15	275.10	202.92	229.61	228.99	241.79
100	304.17	322.26	238.96	336.89	382.49	270.18	288.07	336.05	253.43	338.93	358.75	266.41	287.84	217.81	245.08	245.71	258.62
105	314.16	332.42	250.03	347.84	391.66	277.20	288.06	349.20	270.98	347.80	365.15	280.25	300.18	230.56	258.44	259.38	272.50
110	322.00	339.87	260.72	355.42	400.87	280.04	287.77	359.10	286.98	354.99	372.13	291.72	310.20	243.68	271.17	272.75	285.06
115	328.26	344.88	269.15	362.47	408.94	281.86	288.14	365.06	300.94	362.05	378.41	304.92	318.08	255.08	283.06	285.50	297.35
120	330.78	346.16	278.22	372.35	417.99	285.89	286.56	370.32	313.69	366.47	383.88	313.72	328.11	266.61	293.96	297.39	308.86

Age	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217
125	331.11	346.89	285.22	381.51	425.37	287.27	287.89	372.87	324.94	371.62	386.70	325.14	335.59	278.40	305.12	308.58	319.55
130	331.07	348.48	291.84	389.34	433.25	290.91	287.96	371.26	334.43	374.82	389.87	337.49	341.42	289.37	314.96	319.11	329.60
135	332.42	346.45	297.15	394.38	440.48	293.06	286.94	368.51	339.09	379.11	394.26	347.55	348.95	299.10	323.68	328.94	339.01
140	331.06	346.72	301.87	402.36	444.45	292.25	285.32	364.65	345.09	381.60	396.02	357.84	356.81	306.91	332.91	337.97	347.95
145	331.49	346.82	305.80	405.67	446.76	293.39	287.34	361.63	349.53	381.90	397.97	367.41	365.88	315.63	340.13	346.75	355.89
150	327.41	341.76	308.08	410.96	447.47	295.36	286.08	360.06	348.64	384.52	395.40	378.95	369.06	323.13	348.21	355.11	364.38
155	323.72	336.83	309.31	415.50	449.40	299.69	286.60	357.11	345.11	388.24	396.74	388.23	374.09	331.92	356.46	363.29	371.80
160	319.67	334.54	309.44	420.21	454.82	301.49	287.30	351.89	341.04	391.66	393.76	397.53	381.15	340.17	362.97	371.09	378.68
165	316.53	330.63	308.52	423.01	458.63	304.17	290.31	345.85	338.96	394.42	396.34	405.30	388.31	348.36	369.67	377.94	386.06
170	313.75	324.53	307.18	424.34	464.96	305.79	292.60	340.93	334.68	394.32	393.57	412.32	391.86	355.83	376.67	384.95	392.62
175	310.18	317.66	307.03	425.99	468.23	308.36	291.45	335.62	328.40	394.55	395.90	418.54	397.65	360.84	382.58	388.96	397.94
180	305.53	314.46	305.88	429.53	474.19	310.34	293.27	329.96	321.55	396.42	395.28	427.06	402.39	367.00	387.66	395.38	403.24
185	303.07	309.24	303.03	434.25	477.74	313.33	293.92	323.38	314.74	398.74	397.09	433.69	407.31	373.63	394.30	401.15	407.00
190	299.03	301.48	301.95	437.06	481.88	314.97	294.65	317.89	310.99	402.28	398.23	440.34	411.03	378.23	400.91	407.63	411.94
195	293.89	296.61	299.93	439.17	483.16	315.11	294.24	310.76	306.08	401.76	398.49	445.79	417.72	384.31	408.10	412.80	415.35
200	288.87	292.53	297.72	442.36	487.17	316.12	292.08	307.69	300.40	402.23	398.34	453.27	421.06	389.62	412.29	415.02	419.80

Table 92: Managed stands established between 1976 and 1995, part 2

Age	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.17	0.00	3.37	0.67	3.62	6.48	6.73	5.22	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00
25	6.72	2.60	26.27	6.04	18.72	34.08	35.00	23.42	0.34	27.28	0.00	0.00	2.27	0.00	0.76	0.00
30	17.25	9.21	58.77	15.32	38.35	69.07	70.66	47.14	9.54	87.58	0.50	0.50	28.55	0.00	12.22	0.00
35	29.81	17.45	89.69	32.57	66.64	103.81	105.31	76.50	45.51	150.57	8.60	10.86	70.40	3.51	39.84	0.00
40	48.56	25.82	120.62	63.47	101.88	138.44	138.86	115.29	102.21	221.49	37.40	41.82	120.95	18.24	76.47	0.00
45	72.45	36.64	150.72	102.28	142.00	173.57	171.49	155.21	170.58	293.63	80.68	85.66	178.14	50.18	120.64	0.00
50	101.11	51.88	180.34	142.71	181.58	207.02	202.88	193.84	240.83	364.24	135.92	136.16	236.11	96.14	168.98	0.00
55	132.34	70.10	210.29	184.25	219.55	238.40	231.95	230.63	305.85	432.82	192.93	197.23	294.61	148.05	220.38	0.99
60	161.60	94.49	237.29	223.36	254.44	267.88	259.22	265.16	367.07	497.83	246.94	251.88	347.61	200.93	270.35	4.29
65	191.37	120.15	262.75	257.98	286.76	294.33	281.58	297.12	425.41	559.54	297.21	301.98	396.47	248.93	317.52	11.35
70	221.55	148.14	284.95	290.20	315.47	317.11	301.28	325.72	480.99	619.21	344.09	349.67	442.44	294.47	362.96	20.42
75	249.61	176.06	304.26	317.84	340.83	341.24	321.60	351.55	533.83	675.36	388.94	394.99	485.39	336.58	404.24	31.91
80	276.87	202.78	320.77	343.86	364.02	360.75	339.21	373.73	584.01	727.30	430.60	437.46	525.67	375.03	442.92	47.00
85	302.92	229.51	336.78	363.48	384.88	373.41	349.88	393.75	630.92	777.09	470.34	477.50	563.93	412.06	479.37	63.81
90	327.87	254.48	353.11	382.82	401.25	381.93	357.66	407.74	676.19	825.31	508.72	514.65	600.29	446.30	514.32	83.04
95	351.54	278.83	365.95	399.06	415.66	393.07	364.74	419.71	717.41	870.27	545.04	551.60	633.29	479.06	547.06	102.58
100	373.71	301.28	373.79	413.68	429.43	400.84	370.80	430.72	757.03	911.18	579.22	586.08	665.78	509.86	579.06	123.79
105	394.55	323.44	377.64	423.31	439.73	409.29	378.93	438.45	796.92	947.36	612.65	620.38	696.89	538.88	610.55	145.21
110	413.35	341.94	380.90	429.10	446.85	419.70	384.84	444.44	830.88	984.86	644.69	652.40	726.62	567.01	639.79	166.43
115	431.17	359.71	385.66	434.77	452.15	426.04	391.03	449.51	864.73	1019.75	675.03	683.12	755.14	593.79	667.10	186.18
120	446.88	375.13	391.43	440.25	457.91	434.02	396.46	450.32	898.64	1054.84	702.64	711.35	782.86	620.50	694.49	206.46
125	458.60	389.43	396.84	441.23	459.32	438.76	402.50	453.26	930.67	1087.89	729.70	739.82	812.41	644.35	721.01	226.79
130	467.87	403.57	402.30	442.20	457.46	444.11	404.69	450.62	957.04	1117.42	756.68	767.97	839.89	670.21	748.26	246.77
135	473.59	415.65	402.26	437.45	461.62	448.15	407.65	452.83	985.47	1146.37	784.70	795.56	864.67	691.64	774.08	265.13

Age	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233
140	478.57	422.21	405.92	438.41	461.97	452.64	411.93	455.49	1012.55	1173.02	810.89	821.01	889.63	715.40	801.09	283.47
145	482.41	429.51	408.77	438.10	461.91	454.81	412.56	454.58	1037.50	1199.67	835.36	846.16	910.89	738.94	826.77	300.84
150	486.45	431.65	407.51	440.30	461.21	455.63	417.42	448.79	1060.34	1217.74	862.12	869.36	933.67	761.48	850.49	318.67
155	481.53	435.11	409.78	444.83	455.66	461.77	417.94	445.54	1080.29	1238.92	884.41	894.45	959.53	782.95	874.61	335.45
160	473.81	434.64	410.08	439.17	453.87	462.55	422.05	445.74	1099.73	1260.51	904.54	918.62	981.96	801.94	896.95	351.51
165	468.63	437.20	411.07	435.72	453.97	465.35	421.83	443.83	1119.59	1283.67	927.82	942.95	1006.43	821.99	920.02	367.24
170	468.52	440.36	408.01	435.54	451.17	468.13	422.55	441.53	1140.03	1294.88	948.31	966.67	1029.04	840.90	942.79	381.72
175	463.44	444.67	408.21	431.33	449.86	467.08	423.10	439.00	1158.24	1311.12	968.83	987.76	1049.73	859.63	965.34	396.73
180	463.87	446.31	407.87	430.61	449.94	470.98	423.80	438.96	1175.72	1326.09	992.01	1008.49	1067.59	877.85	989.85	411.81
185	457.43	442.92	408.06	433.05	443.85	468.46	424.87	437.52	1185.06	1337.56	1013.12	1030.56	1087.72	895.49	1010.81	426.57
190	453.40	444.63	408.93	433.40	441.78	469.78	425.40	438.01	1202.88	1351.50	1031.10	1050.26	1107.26	914.02	1031.80	440.47
195	452.14	445.62	410.41	434.65	438.11	473.70	422.23	434.73	1219.50	1363.49	1048.74	1068.99	1124.61	933.28	1050.89	454.06
200	447.75	442.94	410.19	433.60	432.91	474.61	423.12	434.37	1236.55	1380.14	1068.93	1088.29	1143.75	952.27	1072.38	466.50

Table 93: Managed stands established between 1996 and 2016, part 1

Age	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.33	0.58	0.00	0.00	0.15	0.00	0.00	3.79	3.85	0.00	0.00	0.00	0.00	0.07	0.74
25	6.07	8.02	3.00	3.73	1.84	0.46	1.56	17.82	17.75	0.00	0.00	0.78	1.57	1.98	4.68
30	19.83	22.43	14.00	14.24	9.81	5.76	12.86	38.41	41.10	0.00	0.00	9.10	18.32	7.33	15.77
35	37.21	41.37	28.97	28.59	30.41	20.20	42.36	64.25	72.55	5.80	0.08	34.73	53.42	20.72	33.55
40	57.24	65.00	45.37	45.42	61.59	43.11	81.01	89.81	107.32	22.90	2.39	67.15	95.40	37.12	60.45
45	79.84	92.14	63.42	64.62	97.72	71.51	122.75	116.61	142.51	50.39	11.51	106.57	140.53	57.77	92.88
50	104.11	121.60	81.45	84.78	135.51	103.70	162.52	143.18	174.74	82.93	28.23	143.01	182.67	82.22	126.07
55	131.55	150.99	99.68	106.06	171.02	134.27	198.79	170.70	205.16	118.47	50.55	176.59	220.22	107.46	157.21
60	158.99	179.80	120.30	127.39	203.35	161.10	231.79	196.56	233.01	154.41	74.71	207.06	252.20	132.81	188.85
65	183.32	207.26	140.18	149.01	231.84	186.50	261.37	221.65	257.05	187.47	100.94	234.65	281.44	157.85	218.73
70	206.89	231.40	159.70	169.45	256.78	209.63	288.23	243.14	279.10	219.15	126.71	258.86	306.80	183.40	247.06
75	227.96	252.43	178.74	188.59	281.12	232.03	312.17	264.73	301.00	247.94	151.54	280.63	328.94	206.83	274.73
80	246.66	271.52	195.96	206.88	302.84	251.49	333.41	283.43	318.18	272.49	175.22	300.49	345.99	229.55	300.23
85	265.25	290.39	215.11	226.60	323.60	272.69	356.43	301.53	331.02	295.66	199.25	319.86	362.75	253.19	323.74
90	282.96	307.45	232.23	245.46	343.18	291.54	373.49	317.80	342.24	317.44	221.25	336.48	379.55	275.42	346.26
95	300.31	322.98	248.23	262.02	359.08	308.15	390.70	332.83	352.46	334.44	242.15	352.55	392.34	297.78	367.38
100	314.46	335.95	263.58	276.84	372.16	324.38	403.82	344.00	361.58	349.26	260.95	366.33	404.99	318.31	385.58
105	323.95	343.00	274.49	288.47	382.45	337.43	417.38	350.96	365.09	361.25	278.14	376.26	414.37	335.03	400.97
110	332.45	346.31	283.90	298.38	391.71	350.05	429.65	355.26	371.11	364.32	292.46	384.90	422.82	351.76	415.94
115	336.31	346.77	292.71	307.49	401.21	361.16	439.38	361.15	374.97	368.06	304.75	394.70	430.35	365.73	426.85
120	337.05	345.51	298.86	313.70	408.30	373.33	447.47	366.08	379.80	367.63	314.39	404.22	435.50	377.17	437.66
125	337.90	341.61	304.30	318.84	415.95	384.71	457.02	370.23	381.04	368.26	324.45	411.83	440.51	389.66	446.89
130	337.01	341.38	309.75	324.71	423.19	395.66	463.19	373.34	379.90	371.05	331.09	417.60	444.86	402.13	454.07
135	337.74	338.26	313.18	328.74	429.46	404.66	470.97	374.87	380.95	369.09	337.26	423.70	450.20	412.72	462.35
140	337.20	333.48	315.36	330.87	435.45	411.73	472.91	379.14	379.72	369.54	339.56	429.03	454.90	422.80	466.82

Age	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
145	334.68	324.87	316.51	331.11	440.88	420.19	479.63	381.17	381.44	363.23	338.34	433.87	459.41	432.46	472.27
150	333.70	321.22	317.15	331.32	443.94	428.87	482.55	384.78	383.39	359.16	336.85	440.13	464.53	438.77	475.97
155	330.05	317.56	315.77	331.03	447.62	433.45	488.14	387.37	382.45	357.53	336.79	445.35	467.62	446.09	480.41
160	327.39	313.02	313.06	327.71	451.86	442.89	490.61	387.66	379.26	354.57	333.66	451.24	471.73	452.00	483.60
165	323.41	308.59	311.59	325.38	452.81	448.18	494.47	386.84	377.76	352.58	334.02	455.62	476.15	458.81	484.19
170	321.21	302.80	308.76	321.70	455.98	453.36	499.56	386.19	375.41	348.37	329.71	458.97	478.95	464.29	484.37
175	315.33	301.29	306.42	318.82	459.30	460.30	502.22	386.17	374.87	342.31	324.23	463.89	479.38	467.70	485.68
180	307.95	297.32	303.81	315.76	461.97	465.67	504.89	386.58	372.86	337.55	320.44	467.13	477.08	472.12	486.61
185	302.74	292.75	299.75	311.48	464.32	469.99	507.89	387.13	369.96	335.23	316.70	469.67	477.55	474.61	486.88
190	298.43	288.92	296.92	306.99	466.85	475.91	509.06	387.50	367.16	329.30	316.07	470.34	478.61	479.63	486.59
195	295.93	282.74	291.79	305.84	468.01	480.28	512.32	385.27	364.66	323.28	312.09	472.93	479.98	482.70	486.50
200	294.01	278.68	288.47	301.40	470.82	483.26	514.24	383.97	363.09	319.21	309.97	476.29	479.76	483.94	484.93

Table 94: Managed stands established between 1996 and 2016, part 2

Age	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.42	0.84	0.00	4.63	5.64	5.13	8.58	12.12	0.00	0.00	0.00	0.00	0.00
25	0.44	0.20	8.06	12.25	0.67	25.94	25.10	31.39	37.86	43.48	0.17	0.00	0.00	0.00	0.00
30	3.21	2.27	22.44	29.47	4.52	54.42	50.49	65.89	73.59	78.87	6.78	0.25	0.42	0.08	0.00
35	10.42	8.03	39.08	47.77	11.52	85.10	85.68	98.80	108.15	116.58	36.41	7.43	9.77	3.42	0.00
40	21.92	17.95	57.31	67.64	20.41	119.95	128.28	131.70	141.28	158.02	85.13	32.99	37.24	20.74	0.00
45	36.97	35.16	78.85	91.56	34.48	156.62	173.15	164.68	173.15	197.42	150.89	73.86	83.84	50.52	0.00
50	55.79	56.34	104.09	117.52	54.45	194.26	215.72	196.58	204.62	234.45	219.45	126.22	137.57	93.65	0.08
55	75.14	80.17	131.52	144.91	77.04	230.38	255.92	226.99	233.52	268.57	284.44	183.35	194.67	141.35	1.24
60	96.20	103.97	158.80	175.12	105.45	262.03	292.29	255.18	260.54	298.39	343.57	236.14	248.34	191.94	5.11
65	116.95	126.21	188.16	202.55	136.19	290.38	323.52	277.55	282.90	326.98	400.17	285.28	299.10	239.56	12.42

Age	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130
70	137.37	148.36	215.81	229.59	167.91	313.34	350.08	298.49	302.18	350.00	454.09	331.71	347.13	284.87	24.03
75	156.07	168.42	241.67	256.15	199.38	332.73	373.23	320.05	320.30	370.37	504.62	374.78	391.88	326.76	35.59
80	174.60	186.44	267.16	280.54	227.91	350.06	393.80	337.74	334.80	385.32	552.27	416.24	434.19	367.04	50.59
85	194.13	205.28	289.50	302.68	254.91	368.93	411.25	344.19	345.33	395.05	596.90	455.36	474.81	404.90	68.37
90	212.01	224.57	311.22	323.08	280.70	378.92	419.59	353.27	356.28	401.41	639.90	493.14	512.38	440.70	88.16
95	228.99	241.79	330.97	343.36	304.26	384.09	418.50	359.55	361.01	403.19	680.25	528.52	548.20	475.25	109.95
100	245.71	258.62	349.00	362.89	325.91	387.60	422.97	366.36	369.27	406.25	719.64	561.86	583.18	507.59	132.11
105	259.38	272.50	365.16	380.22	343.98	394.15	425.96	372.81	373.29	408.16	756.17	593.88	617.00	539.20	152.14
110	272.75	285.06	379.70	392.95	362.67	398.09	426.37	379.54	374.23	410.06	789.03	623.64	648.54	569.66	174.87
115	285.50	297.35	394.15	405.61	379.09	400.32	424.68	384.30	376.61	408.49	824.04	653.56	677.75	598.84	197.08
120	297.39	308.86	402.62	411.96	392.47	403.34	420.67	390.15	379.05	408.77	852.37	681.95	708.15	626.98	216.45
125	308.58	319.55	409.12	415.89	405.37	407.52	422.98	396.13	382.58	411.27	883.18	707.94	735.91	655.11	236.91
130	319.11	329.60	414.54	421.77	417.64	406.59	425.83	395.31	385.53	410.97	910.78	733.55	763.04	680.39	256.47
135	328.94	339.01	418.11	425.96	426.75	406.85	425.01	395.36	388.07	411.69	940.85	761.40	789.06	704.49	274.64
140	337.97	347.95	423.15	430.27	432.09	407.11	423.71	398.02	388.45	407.90	967.73	785.68	814.45	727.02	293.28
145	346.75	355.89	423.12	429.98	437.86	408.30	423.28	403.18	390.96	404.52	994.93	809.19	838.12	747.54	311.96
150	355.11	364.38	424.02	429.69	440.38	407.43	425.05	407.12	393.05	405.00	1023.54	832.64	864.17	770.68	329.83
155	363.29	371.80	422.02	427.11	446.25	406.18	421.47	409.63	392.69	404.77	1048.06	855.72	887.16	791.89	346.90
160	371.09	378.68	421.03	424.31	448.24	404.61	420.72	412.90	393.89	397.49	1068.45	878.42	911.34	814.61	363.40
165	377.94	386.06	424.41	424.49	447.34	399.53	418.01	412.87	390.95	397.97	1089.49	901.77	934.21	835.01	379.80
170	384.95	392.62	422.94	419.29	448.76	399.53	416.56	415.94	391.91	396.57	1110.39	923.58	956.63	852.18	395.25
175	388.96	397.94	423.03	422.41	452.03	398.36	416.36	417.13	390.76	395.88	1128.69	945.02	978.53	873.59	410.31
180	395.38	403.24	421.09	417.77	449.64	396.03	417.07	418.93	389.38	393.32	1146.95	966.49	999.05	893.16	424.96
185	401.15	407.00	421.33	416.70	453.80	396.49	418.16	420.25	386.15	392.63	1168.56	988.05	1018.99	913.77	438.91
190	407.63	411.94	417.24	412.86	448.55	396.16	415.32	420.09	386.39	392.78	1189.11	1005.64	1037.49	933.10	452.86
195	412.80	415.35	421.54	410.80	448.00	396.83	415.32	419.39	389.09	392.77	1209.45	1025.80	1055.79	951.77	466.03
200	415.02	419.80	420.06	408.13	448.60	394.82	411.11	418.53	386.55	392.14	1229.05	1045.22	1074.44	967.88	478.74

Table 95: Managed stands established after 2016, part 1

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.25	0.41	0.00	0.00	0.21	0.07	0.47	4.33	3.94	0.00	0.00	0.00	0.00	0.07	0.00
25	6.86	7.53	2.75	3.89	3.26	2.24	5.09	18.24	18.01	0.00	0.00	0.00	0.00	3.74	3.68
30	22.10	22.59	12.81	14.79	13.81	10.90	23.73	39.43	41.24	0.32	0.48	0.00	0.00	16.62	14.39
35	41.19	42.80	27.25	28.58	39.77	27.72	60.65	64.55	73.59	7.28	9.76	0.31	0.00	43.32	33.24
40	62.31	67.63	42.66	44.75	75.00	50.16	105.33	92.58	109.56	26.85	33.37	4.01	3.32	76.77	57.92
45	85.77	94.99	59.49	63.82	116.22	75.90	152.02	120.41	145.58	55.03	65.39	17.75	15.39	114.45	87.76
50	110.08	125.60	77.99	85.70	155.74	105.50	194.89	150.48	178.44	89.13	101.12	37.92	34.40	153.44	121.13
55	135.26	155.80	97.02	108.73	191.00	133.65	233.60	178.46	209.50	124.43	140.19	62.22	59.40	188.20	151.60
60	159.81	184.69	117.26	131.80	223.50	163.04	268.87	204.43	238.26	160.67	176.90	88.89	85.41	218.34	181.88
65	184.56	211.90	137.30	154.03	252.14	189.11	300.26	229.04	262.85	193.46	209.56	117.03	113.37	247.13	210.67
70	207.47	236.39	157.79	175.06	278.16	213.64	327.88	252.23	284.63	224.02	240.34	143.04	139.18	272.30	236.13
75	227.96	258.59	176.01	194.10	301.40	235.85	353.34	275.56	305.65	252.24	267.49	169.12	165.36	295.15	260.02
80	245.30	278.47	193.52	213.24	322.84	256.72	375.64	295.43	320.65	277.78	290.32	193.08	188.67	315.12	281.27
85	264.77	298.46	211.90	232.69	342.94	279.10	396.79	314.14	334.40	299.67	311.65	216.31	211.96	336.33	305.54
90	282.37	315.05	229.92	250.99	360.47	299.45	415.69	330.67	344.79	319.04	328.70	238.28	233.64	354.78	328.73
95	298.49	328.49	246.57	267.10	377.32	318.82	433.86	346.64	351.32	333.60	344.62	258.69	253.28	373.23	351.04
100	313.18	340.72	260.86	282.28	389.60	336.78	449.88	362.06	359.36	346.75	356.89	276.90	271.72	389.17	371.61
105	319.90	344.37	271.90	292.77	401.48	352.16	465.23	367.17	366.82	355.72	361.27	293.47	287.80	403.25	388.79
110	325.39	349.12	281.55	301.68	410.09	366.89	472.42	372.58	369.00	359.92	365.11	304.82	301.44	413.07	405.30
115	326.94	348.72	289.28	308.92	418.44	379.68	483.02	379.28	373.92	364.42	367.71	315.96	313.24	423.71	422.14
120	327.70	347.63	297.04	316.11	426.57	391.76	490.62	386.44	378.08	364.94	369.78	324.47	323.36	432.07	434.49
125	328.23	346.91	303.57	322.53	432.52	401.18	499.78	391.43	381.61	364.64	368.20	331.46	330.13	441.50	446.89
130	327.79	346.35	307.97	327.23	439.44	411.57	508.59	396.67	382.67	362.24	366.76	333.95	336.35	450.99	459.89
135	327.15	342.70	311.26	328.07	442.44	420.52	518.29	400.86	385.30	360.85	363.33	334.14	335.62	459.51	473.88

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
140	324.96	335.88	312.93	328.68	448.39	429.23	523.91	401.50	383.86	359.40	358.75	331.77	334.42	468.11	482.42
145	323.02	336.25	315.47	328.00	453.49	436.69	530.14	403.84	385.73	353.08	354.70	331.21	333.05	474.25	493.92
150	321.18	331.71	316.20	327.79	459.06	446.80	536.93	406.00	384.86	351.37	347.69	328.67	332.04	481.97	504.77
155	319.31	327.07	315.29	323.83	464.03	452.00	541.54	408.65	384.77	344.81	341.25	329.34	326.70	488.62	513.91
160	314.23	324.62	312.60	322.45	467.25	458.76	544.57	408.00	386.14	341.06	337.99	327.26	324.61	495.03	521.71
165	310.74	321.40	311.73	318.05	469.95	465.78	550.25	409.27	387.27	334.91	330.33	324.89	321.65	501.75	527.50
170	310.20	318.14	307.84	313.73	471.84	472.26	555.06	410.80	384.53	327.08	324.22	321.43	316.37	508.64	535.92
175	308.36	314.30	304.18	311.49	476.25	478.42	557.84	411.55	384.30	321.34	322.71	317.71	311.42	512.66	543.99
180	305.54	310.89	298.84	309.31	477.73	483.35	557.51	412.42	384.48	316.92	316.40	318.18	307.83	517.10	549.21
185	303.16	304.93	294.42	305.97	478.20	490.01	559.57	414.21	384.44	308.78	310.29	309.74	304.99	519.90	554.49
190	298.01	300.30	292.83	303.36	479.58	492.85	557.88	414.04	382.65	305.37	307.91	305.52	302.85	524.32	562.04
195	296.35	296.79	288.85	297.44	480.82	497.71	558.91	414.90	380.43	304.39	303.54	300.93	301.87	526.82	567.91
200	293.76	292.73	286.07	293.02	480.08	498.57	559.53	414.73	378.32	304.76	300.85	296.83	297.95	529.17	573.31

Table 96: Managed stands established after 2016, part 2

Age	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.26	0.44	0.37	0.00	0.00	0.25	0.25	0.00	0.00	1.77	2.86	1.60	3.79	1.68	3.45
25	4.00	4.91	5.15	0.13	0.20	7.55	9.90	0.17	3.02	19.22	21.66	21.66	30.81	21.15	27.62
30	22.14	17.04	17.24	2.04	2.70	22.44	26.71	2.51	13.48	47.22	46.38	56.26	64.80	54.59	58.69
35	55.26	34.94	38.82	8.69	8.80	40.00	45.18	6.85	26.39	78.17	77.67	91.11	99.88	87.60	93.53
40	96.38	58.01	65.73	20.02	19.67	58.98	65.81	11.91	39.57	112.54	118.20	123.20	137.11	119.29	131.36
45	139.63	85.47	97.52	33.96	37.25	79.43	89.82	19.11	53.84	151.72	160.11	154.88	175.15	150.64	169.08
50	179.44	115.08	130.56	52.90	58.86	102.93	116.61	30.42	71.52	190.45	203.71	183.73	210.25	180.83	208.18
55	215.33	144.30	162.15	72.52	85.04	129.86	144.99	47.86	90.93	226.83	243.61	211.70	244.76	209.14	242.95
60	248.04	173.80	193.22	93.99	108.56	157.48	173.06	69.51	113.29	259.96	279.59	236.88	276.45	236.14	275.96

Age	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
65	275.27	203.14	221.27	114.87	130.86	185.36	202.80	96.30	138.16	288.98	311.27	260.12	303.95	258.97	304.69
70	299.80	231.19	248.07	135.50	152.87	212.69	230.82	126.65	162.98	312.60	339.42	280.69	325.80	279.13	329.90
75	321.28	258.62	273.14	154.26	172.96	237.83	257.05	157.65	187.11	333.88	363.25	299.76	346.15	296.65	353.10
80	339.10	283.84	298.30	172.12	191.36	261.69	282.25	187.11	212.08	351.45	384.17	316.44	364.26	314.16	372.10
85	356.60	310.06	320.13	191.09	210.96	285.10	306.26	213.24	236.43	366.41	400.83	328.15	374.63	328.24	387.73
90	372.32	334.33	340.58	209.64	230.04	307.49	327.78	240.93	258.70	378.92	411.72	334.28	385.34	334.85	393.29
95	388.68	357.02	361.32	227.71	247.81	328.06	347.73	266.61	279.40	385.71	415.74	344.50	393.07	344.98	394.94
100	398.44	378.85	381.14	244.94	264.95	346.90	365.72	290.30	299.02	390.75	419.98	353.60	396.64	352.23	400.84
105	410.55	397.15	394.81	259.25	279.84	363.14	381.83	310.96	317.64	392.78	419.44	360.49	401.72	361.05	403.90
110	419.49	412.98	407.37	272.37	293.29	377.29	395.60	331.90	334.71	396.48	420.02	365.16	401.30	366.68	399.46
115	428.47	429.33	419.04	284.93	306.64	389.51	406.73	349.21	350.81	398.64	420.19	368.04	400.16	371.96	401.92
120	434.12	442.36	430.23	296.39	318.79	398.38	415.24	364.58	366.18	402.30	420.91	366.26	399.82	374.57	402.14
125	438.00	454.87	439.31	307.66	330.75	404.97	424.50	378.44	378.20	405.69	421.95	371.10	399.55	381.15	400.43
130	442.68	466.38	447.17	318.44	341.96	410.25	432.19	390.30	389.67	408.42	418.75	378.30	404.29	385.85	398.33
135	447.85	476.78	453.92	327.65	352.04	410.34	432.61	399.40	400.43	407.17	418.51	381.33	404.16	389.02	397.11
140	450.39	484.77	460.64	337.33	362.87	414.78	433.98	406.00	409.48	402.29	418.10	379.84	404.18	389.48	396.83
145	455.95	491.21	466.24	345.76	372.66	416.42	438.26	412.32	418.31	401.05	419.18	380.15	403.81	392.61	393.48
150	461.28	498.78	472.86	355.10	381.25	419.23	442.19	418.99	424.81	403.35	415.30	382.12	407.36	393.28	389.12
155	464.40	505.64	477.59	362.91	390.14	424.45	443.11	424.53	431.43	401.63	415.59	384.30	408.61	394.10	390.89
160	468.42	511.83	480.26	370.60	398.44	425.10	442.38	430.49	434.71	401.09	413.37	384.43	408.13	391.78	391.70
165	470.89	516.06	483.35	376.44	405.62	425.58	442.50	435.17	438.21	400.15	413.72	386.97	405.69	389.70	390.09
170	471.49	518.07	485.96	383.78	412.24	428.85	442.70	435.31	437.02	399.61	411.97	384.60	404.82	388.33	387.94
175	474.51	520.77	487.70	389.61	419.07	425.59	439.78	437.53	438.23	398.44	412.09	386.11	403.64	388.51	388.90
180	476.93	524.53	488.90	395.58	423.92	426.66	433.93	439.89	436.72	394.95	408.49	384.89	402.92	388.68	386.60
185	474.94	530.46	489.31	401.23	430.85	425.88	430.81	440.15	436.21	395.25	407.44	386.38	400.96	389.39	384.92
190	478.62	533.31	491.76	406.44	437.04	426.78	430.55	441.32	433.70	393.24	404.93	388.01	400.16	389.32	382.47
195	477.33	534.78	490.82	411.76	442.48	424.83	431.20	437.26	434.42	389.93	405.73	388.01	397.60	389.93	380.72
200	475.07	536.50	492.16	416.47	448.27	422.43	430.62	437.66	432.45	388.47	402.39	387.17	398.34	387.63	381.89

Table 97: Managed stands established after 2016, part 3

Age	31	32	33	34	35	36	37	38	39	40	41	42	43
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.08	0.08	26.10	0.00	0.00	4.70	0.00	0.00	0.00	0.34	0.00	0.00	0.00
30	6.20	7.28	76.61	0.33	0.42	33.41	2.68	0.08	0.42	11.72	0.00	0.00	0.00
35	35.49	34.99	135.96	9.77	12.94	75.50	17.79	3.09	9.85	41.59	0.00	0.00	0.00
40	86.80	87.96	202.17	38.57	43.15	124.53	46.65	20.66	37.73	76.22	0.00	0.00	0.00
45	149.23	150.39	273.36	84.42	90.65	181.55	83.00	50.52	79.60	116.74	0.00	0.00	0.42
50	219.04	218.62	343.10	137.32	150.00	243.07	124.73	93.57	133.26	162.27	0.00	0.00	2.24
55	285.76	283.04	410.92	196.65	209.80	301.39	167.31	141.68	189.63	212.03	0.41	0.00	8.18
60	347.20	344.97	475.82	250.73	266.15	358.08	209.92	192.44	241.58	260.54	2.72	0.00	19.13
65	403.70	402.72	538.57	301.89	318.18	409.05	251.48	243.01	291.37	308.31	9.70	0.00	33.14
70	456.88	456.55	598.70	348.52	367.31	456.47	290.86	288.48	337.29	352.30	20.42	0.00	48.07
75	507.65	507.65	655.73	392.54	413.89	502.00	328.72	331.50	380.43	394.17	32.07	0.00	63.08
80	555.29	555.70	710.41	435.01	456.80	544.84	365.89	370.55	421.79	433.21	45.94	0.73	80.62
85	601.29	601.78	762.36	474.73	497.52	585.50	402.05	407.91	460.57	469.69	63.48	2.28	99.86
90	645.58	646.07	811.75	512.94	536.16	623.26	436.64	443.13	497.60	504.67	82.15	5.36	120.95
95	686.48	685.91	857.23	548.20	572.57	660.74	470.31	477.84	533.54	537.91	102.50	9.80	142.49
100	725.46	725.94	900.36	582.61	608.05	695.90	502.83	509.05	567.59	569.21	122.09	14.86	164.16
105	761.72	764.95	940.36	615.55	641.64	728.38	534.29	540.17	600.73	599.52	142.39	21.66	185.88
110	796.90	801.56	978.36	646.86	673.20	760.36	564.12	569.34	632.96	629.67	164.10	29.56	207.32
115	828.92	835.33	1015.43	677.91	701.79	790.47	593.63	597.72	662.85	658.85	184.90	37.57	228.88
120	856.77	868.35	1051.16	706.64	733.16	817.54	620.98	625.94	691.06	685.70	205.18	46.10	248.65
125	886.60	900.15	1082.00	733.52	761.57	847.32	648.10	652.40	718.62	711.85	226.15	56.58	267.91
130	913.33	930.02	1108.76	760.26	789.27	875.42	674.19	676.89	745.63	738.56	244.70	66.36	287.14
135	942.91	956.94	1136.39	785.17	816.17	905.49	697.91	702.74	771.22	763.85	263.15	76.57	306.03

Age	31	32	33	34	35	36	37	38	39	40	41	42	43
140	969.94	985.12	1163.62	808.68	841.88	934.37	721.49	726.00	796.59	787.10	281.66	86.24	323.87
145	994.77	1013.77	1183.59	835.05	868.16	961.11	744.23	746.99	820.78	811.00	299.11	98.15	341.29
150	1019.45	1042.02	1206.58	860.24	893.18	988.39	765.96	766.91	846.08	836.18	316.23	109.29	358.22
155	1046.02	1068.68	1225.43	884.65	914.68	1014.11	786.09	785.61	870.46	858.22	332.94	120.36	374.97
160	1071.18	1091.44	1242.44	909.70	940.67	1040.14	808.28	806.71	895.70	881.55	349.55	131.38	391.16
165	1098.45	1114.21	1261.99	933.04	964.63	1064.45	829.79	828.07	918.77	905.04	365.76	143.26	406.94
170	1120.43	1135.44	1282.51	955.54	987.28	1088.46	848.60	848.37	942.24	929.18	380.94	154.85	422.32
175	1141.33	1157.54	1300.72	978.84	1010.41	1114.73	867.69	869.09	964.57	951.30	395.88	165.98	437.22
180	1160.17	1177.81	1310.08	1001.68	1031.93	1139.68	886.66	889.14	987.76	973.91	409.65	177.67	451.03
185	1178.74	1196.25	1323.60	1020.22	1052.62	1160.61	902.28	908.22	1008.73	994.30	423.95	188.60	465.60
190	1195.49	1210.95	1340.03	1041.03	1074.72	1182.95	916.56	928.18	1029.95	1014.41	437.47	199.39	479.24
195	1214.59	1231.93	1354.13	1062.16	1094.92	1204.31	932.98	946.56	1051.96	1036.08	450.69	210.19	492.65
200	1232.80	1251.08	1371.65	1081.10	1115.52	1227.83	948.68	964.74	1071.61	1057.31	463.67	220.47	505.51

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 80th 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.

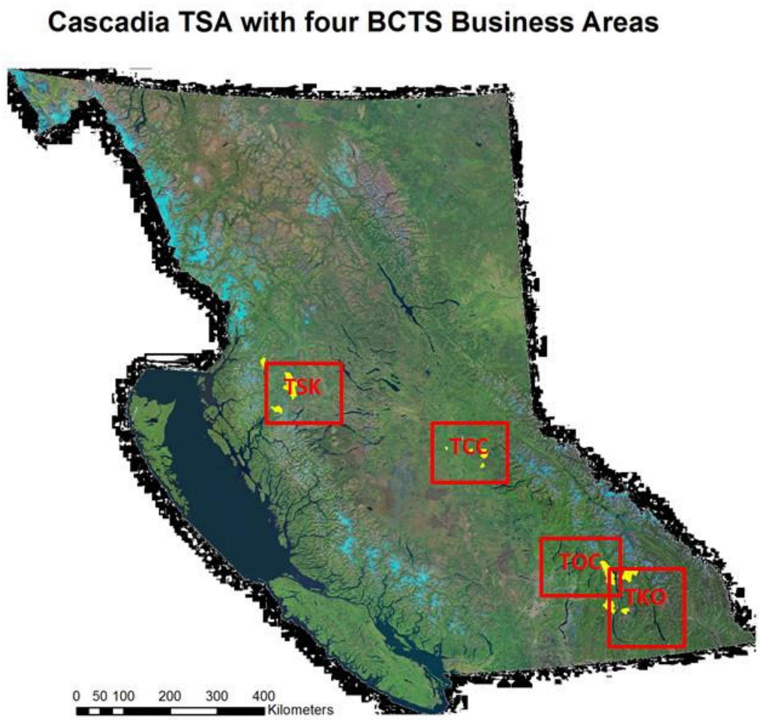


Figure 1 - Cascadia TSA overview with four business areas identified. TSK – Skeen, TCC- Cariboo-Chilcotin, TKO – Kootenay and, TOC- Okanagan-Columbia.

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.

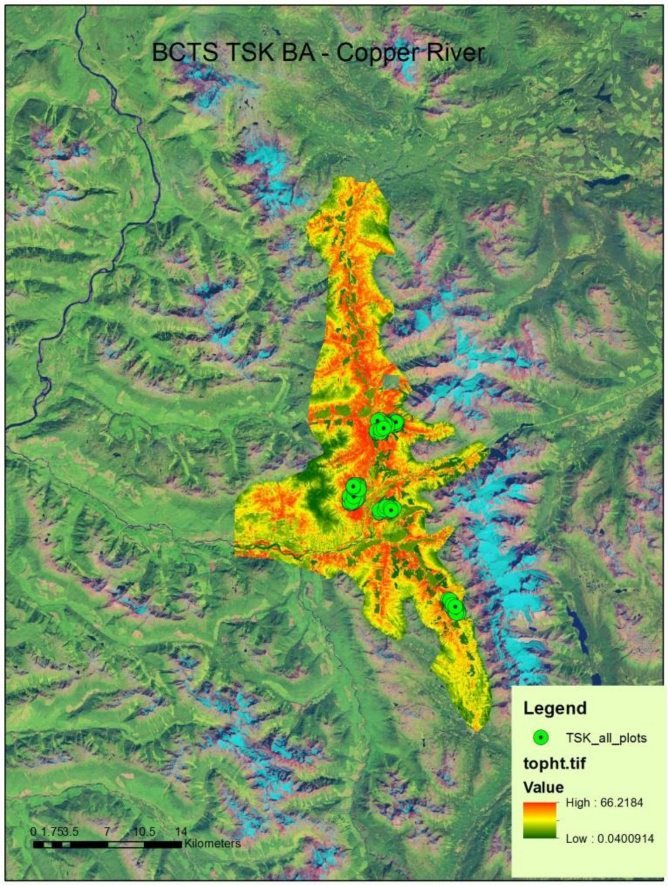


Figure 2 - Skeena area Copper River Basin showing LiDAR coverage and validation cruise plot locations (138 plots).

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.

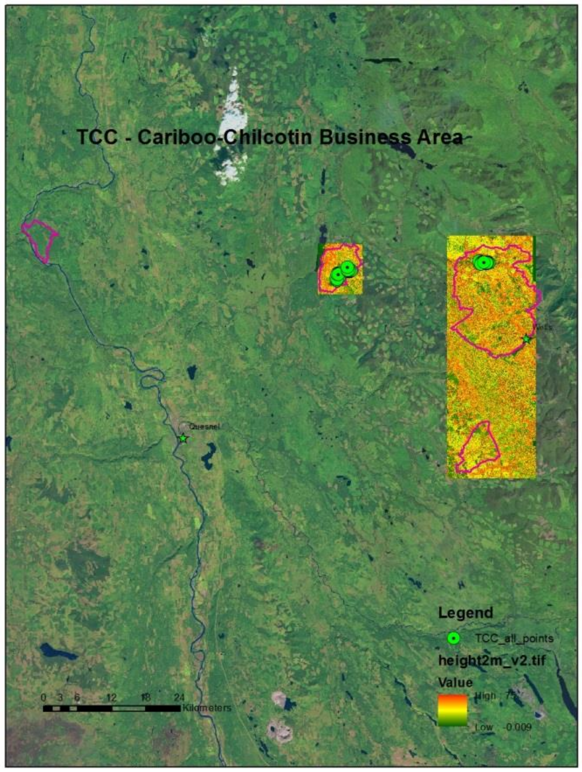


Figure 3 – TCC LiDAR forest inventory update was located in east Quesnel TSA.

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.

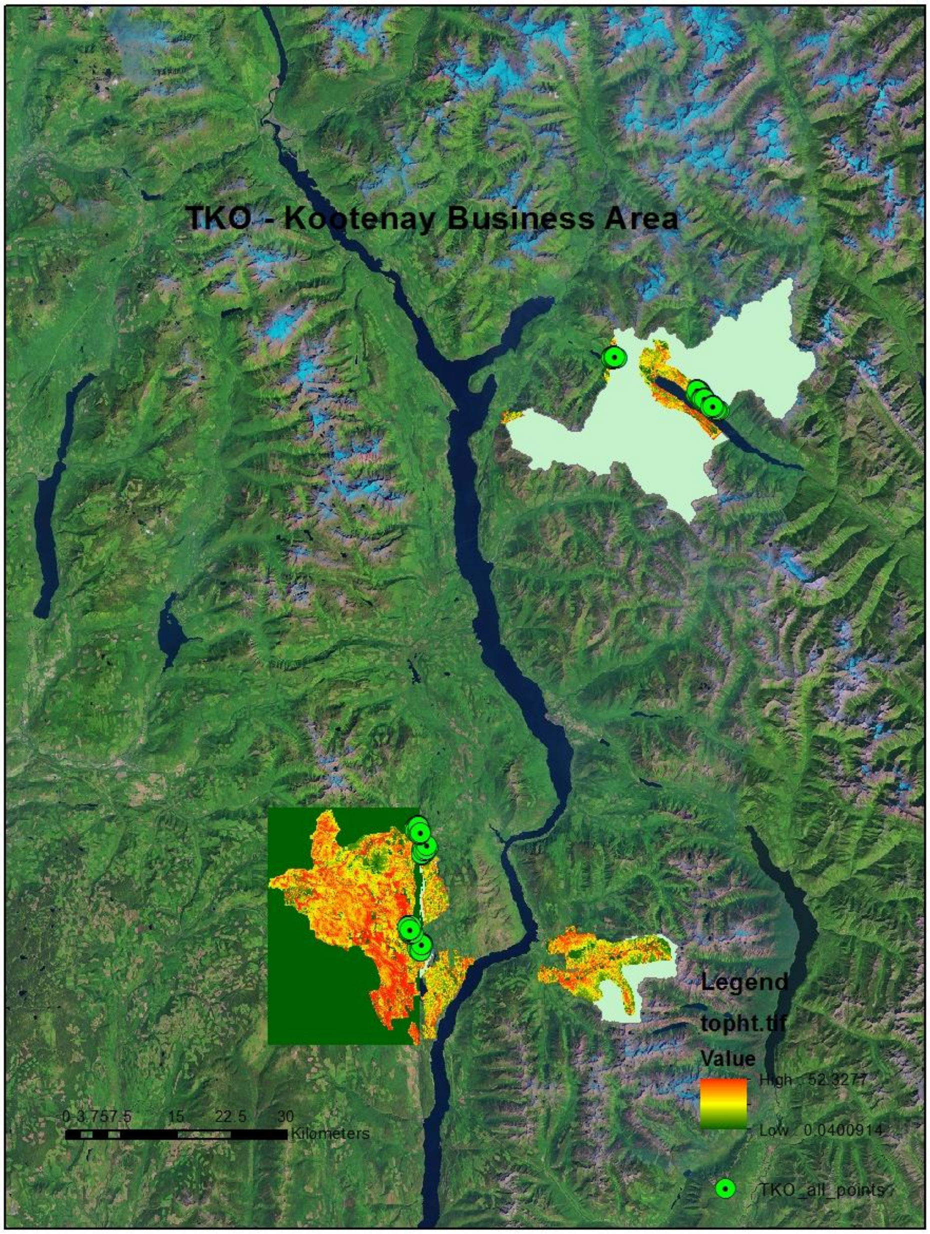


Figure 4 – BCTS Kootenay locations for LiDAR inventory update with 191 cruise plots. Note some of the mountain areas are not included as they are under a no-harvest order for Mountain Caribou.

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.

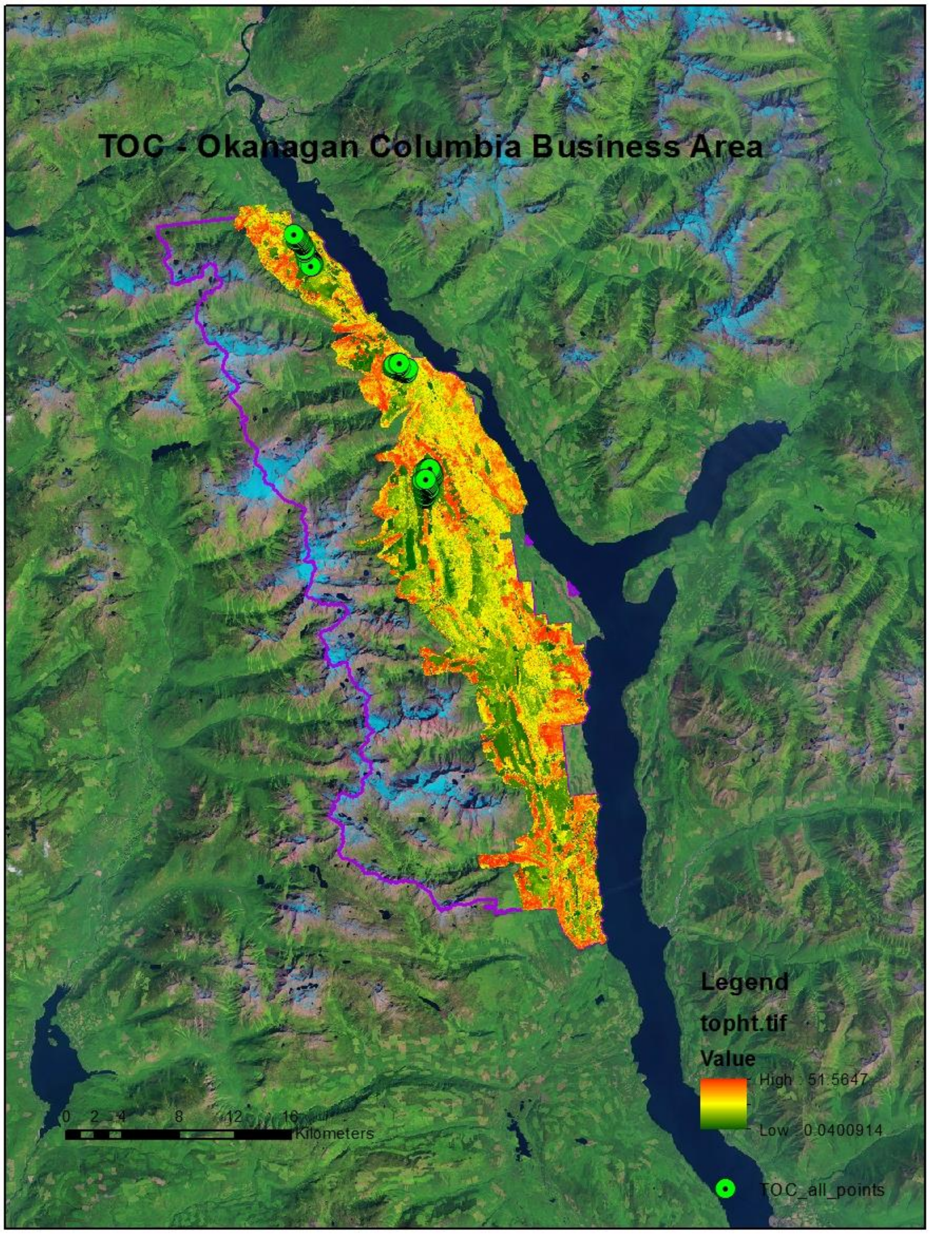


Figure 5 – BCTS Okanagan Columbia locations for LiDAR inventory update with 163 cruise plots.

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 – 80^{th} 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				

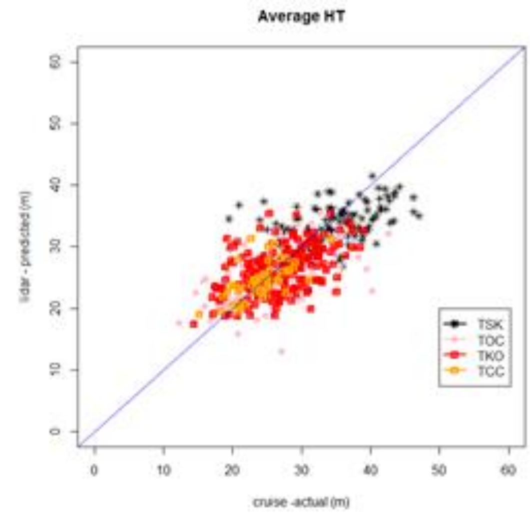
Table 2 – Tabular results for the comparison between cruise plots located in the TKO business area with the LiDAR-derived EFI layers. Average and top height LiDAR predictions (in Yellow) performed best across this business area.

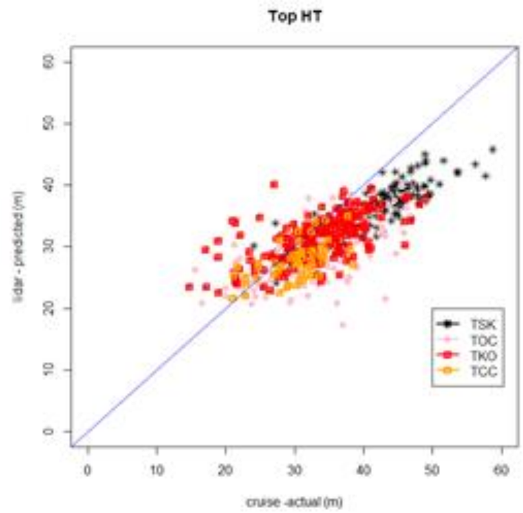
TOC BCTS 2018				
Attribute	r2	rmse	intercept	slope
Basal Area	0.7	20.88	29.73	0.37
Avg. Height	0.76	4.62	13.48	0.43
Top Height	0.76	6.6	15.09	0.42
Avg. DBH	0.58	16.81	20.03	0.18
Gross Vol	0.81	187.5	203.68	0.55
Net Vol	0.74	167.87	199.97	0.5
*Cruise data for 163 locations				

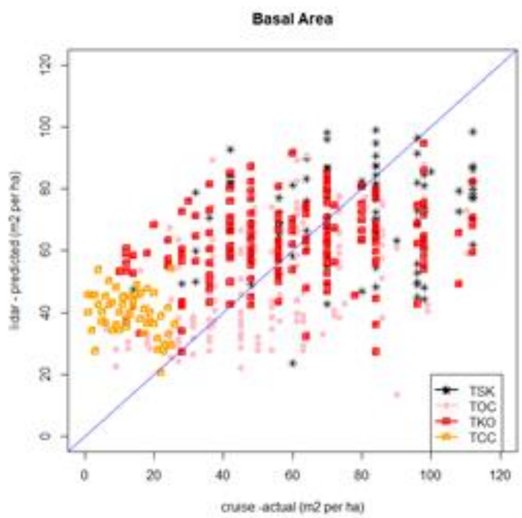
Table 3– Tabular results for the comparison between cruise plots located in the TOC business area with the LiDAR-derived EFI layers. In this case, gross volume, average and top height LiDAR predictions (in yellow) performed best across this business area.

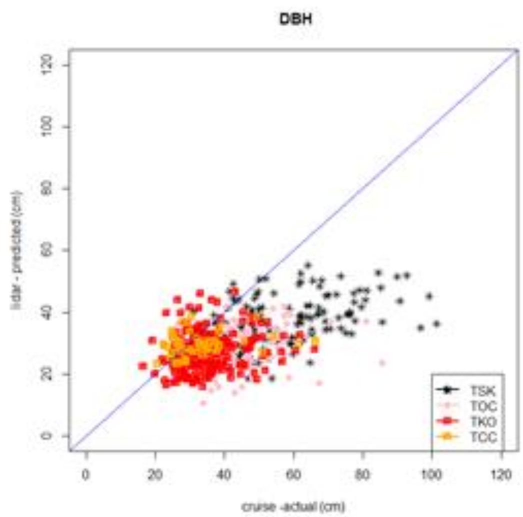
TCC BCTS 2018				
Attribute	r2	rmse	intercept	slope
Basal Area	0.22	14.87	38.66	0.24
Avg. Height	0.79	2.78	11.588	0.5325
Top Height	0.755	4.37	15.17	0.409
Avg. DBH	0.46	9.97	26.98	0.0809
Gross Vol	0.47	145.02	315.57	0.1512
Net Vol	0.51	112.13	250.51	0.193
*Cruise data for 51 locations				

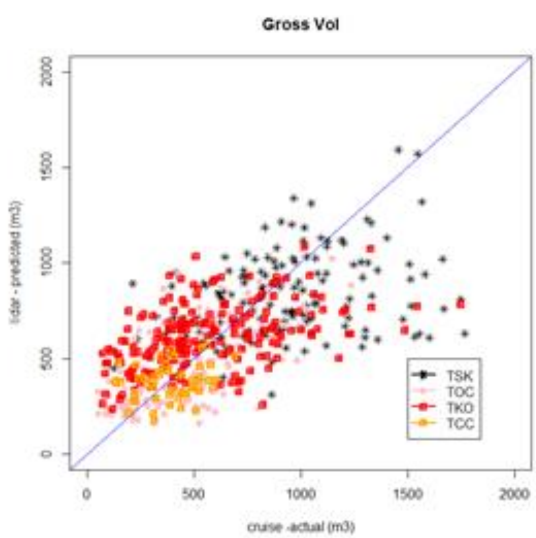
Table 4– Tabular results for the comparison between cruise plots located in the TCC business area with the LiDAR-derived EFI layers. In this case, average and top height LiDAR predictions (in yellow) performed best across this business area. Note this area had a reduced sample size when compared to the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


Average HT
lidar - predicted (m)
cruise -actual (m)
TSK
TOC
TKO
TCC


Top HT
lidar - predicted (m)
cruise -actual (m)
TSK
TOC
TKO
TCC


Basal Area
lidar - predicted (m2 per ha)
cruise -actual (m2 per ha)
TSK
TOC
TKO
TCC


DBH
lidar - predicted (cm)
cruise -actual (cm)
TSK
TOC
TKO
TCC


Gross Vol
lidar - predicted (m3)
cruise -actual (m3)
TSK
TOC
TKO
TCC

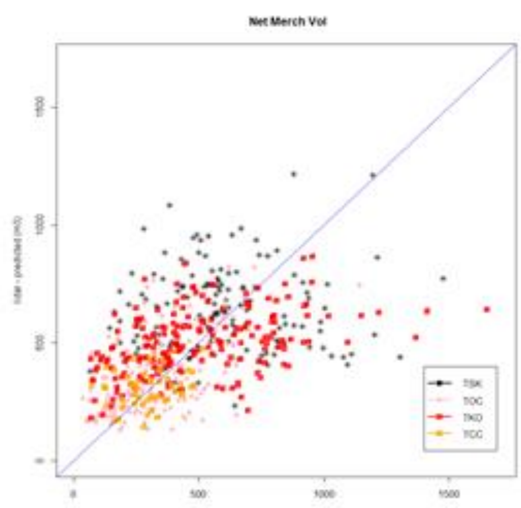

Net Merch Vol

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.

<u>6.0 Vegetation Resource Inventory (VRI) Update</u>

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.

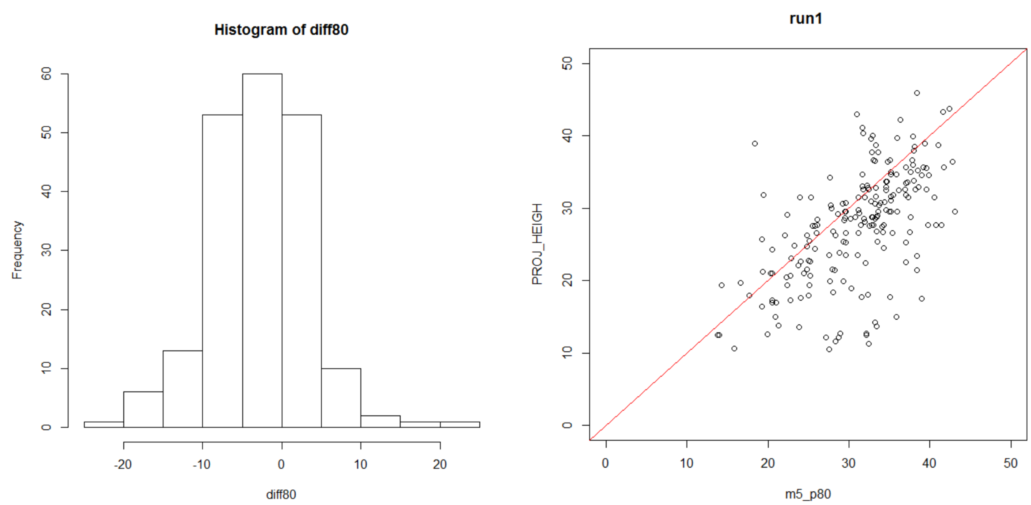


Figure 8 – Difference histogram of VRI PROJ_HT1-LiDAR-derived P80 (left). Scatterplot comparisons of VRI projected stand height (y-axis) versus LiDAR predictions of stand height based on P80 (right). X-axis percentiles in this case (i.e. p80) are the LiDAR raster percentiles summarized over the polygons, 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.