ČAWAK ʔQIN
FORESTRY

Tree Farm Licence 44

Management Plan 6

Version 1.1

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Revision History

Version	Date	Description
1.1	Sept 12, 2022	Updated the revised timber supply analysis report in Appendix A
1.0	May 9, 2022	Initial version

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1 INTRODUCTION

This is the sixth Management Plan (MP) prepared for Tree Farm Licence (TFL) 44 and the second MP prepared to meet the requirements of the *Tree Farm Licence Management Plan Regulation* (B.C. Reg. 280/2009). This regulation, enacted by the provincial government in November 2009 (with associated amendments to the *Forest Act*), includes content requirements, submission timing and public review requirements for TFL Management Plans. TFL 44 is held by Tsawak-qin Forestry Limited Partnership (Tsawak-qin Forestry LP), a limited partnership between Huu-ay-aht First Nations-owned Huumiis Ventures Limited Partnership and Western Forest Products Inc. (Western or WFP). In October 2021, TFL 44 LP changed its name to Tsawak-qin Forestry Limited Partnership (Tsawak-qin Forestry LP, or Tsawak-qin), to be referred to as C̓awak ʔqin Forestry.

The regulation has replaced the content requirements specified in past TFL agreements. Management objectives and strategies that apply to operations within the TFL are specified in Forest Stewardship Plans (FSPs) consistent with the *Forest and Range Practices Act* (FRPA). These objectives and strategies are considered in the timber supply analysis that is included in this Management Plan. The timber supply analysis will provide information to the Chief Forester of BC for the determination of the next Allowable Annual Cut (AAC) for TFL 44.

2 DESCRIPTION OF TFL 44

TFL 44 is located in west-central Vancouver Island in the vicinity of the Alberni Inlet and Barkley Sound. It extends from Strathcona Park in the north to Walbran Creek in the south, including land from the Pacific Ocean to the Beaufort Range and Mount Arrowsmith. TFL 44 is comprised of both 'Schedule A' lands (Timber Licences) and 'Schedule B' (Crown) land (Figure 1).

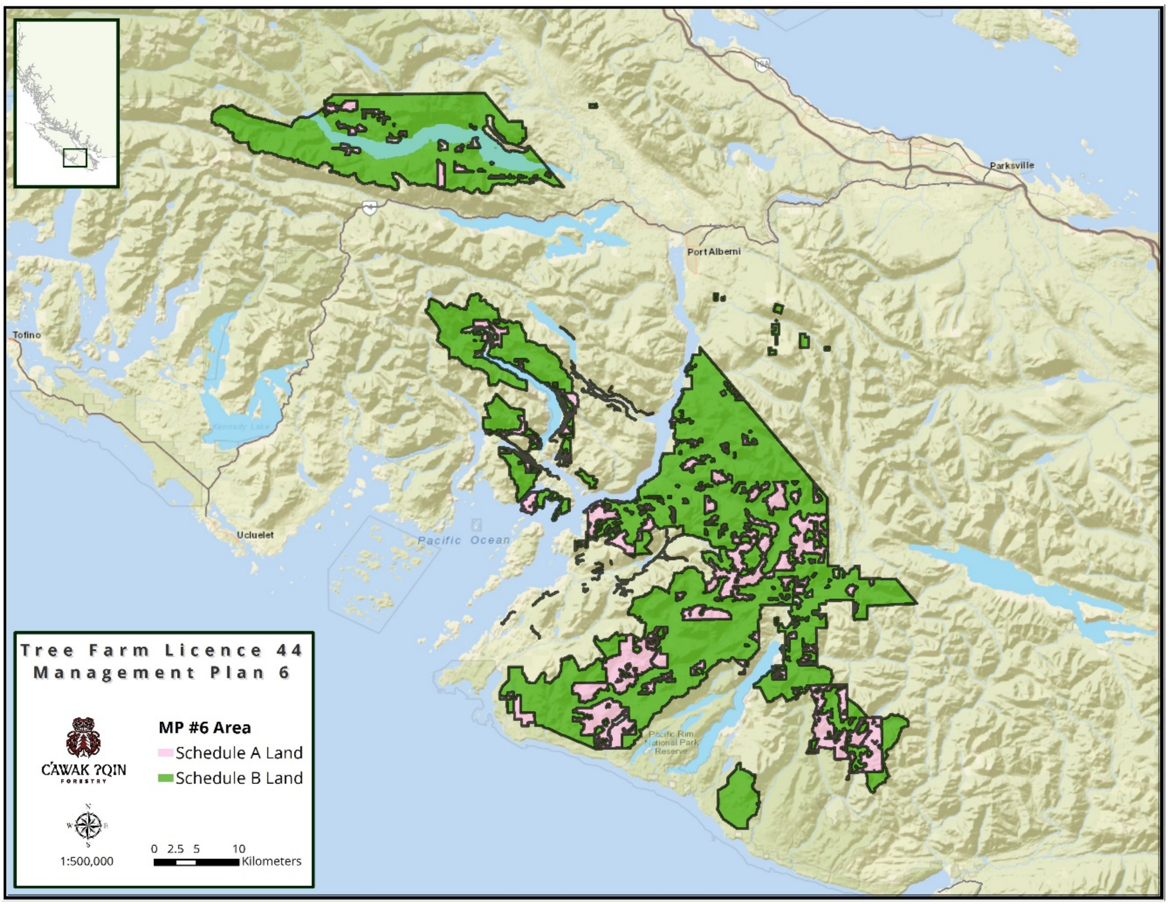

Figure 1 TFL 44 Overview

The forests of TFL 44 predominantly lie within the wetter and very dry maritime Coastal Western Hemlock biogeoclimatic zone. The major tree species include western hemlock, western red cedar, balsam (amabilis fir), Douglas-fir and yellow cedar. Annual precipitation levels reach 3,000 to 5,000 mm. At sea level, the climate is characterized by short winters with intermittent wet snowstorms; at the highest elevations a prolonged snowpack may persist. The summer period from July to September can be dry and warm.

The topography of TFL 44 is varied, with mountainous, steep formations dominating the landscape on the west side of the Alberni Inlet (Great Central Lake and Henderson Lake vicinities) and more rolling gentle terrain on the east side of the Alberni Inlet. The licence area is drained by numerous rivers and streams.

Many streams support significant anadromous (migratory, such as salmon) and non-anadromous (resident, such as rainbow trout) fish populations. Large animals, notably Roosevelt elk and Columbia black-tailed deer are abundant throughout the licence area. Numerous other large and small animals, reptiles, amphibians, and birds can also be found.

Communities within or near TFL 44 include:

- Port Alberni,
- Bamfield,
- Anacla
- Nitinaht

The land upon which the TFL 44 management plan operates is within the traditional territories of the Maa-nulth First Nations, which include Huu-ay-aht First Nation, Ka:'yu:'k't'h'/Che:k'tles7et'h' First Nations, Toquaht Nation, Uchucklesaht Tribe and Yuutu?il?ath First Nation. TFL 44 is also within the traditional territories of the following First Nations (some of them are to a minor degree only):

- Ahousaht First Nation
- Cowichan Tribes
- Ditidaht First Nation
- Halalt First Nation
- Hupačasath First Nation
- Lyackson First Nation
- Pacheedaht First Nation
- Penelakut Tribe
- Stz'uminus First Nation
- Tseshaht First Nation
- Ts'ubaa-asatx Nation (formerly Lake Cowichan)

Nearby parks include:

- Pacific Rim National Park Reserve of Canada
- Strathcona Park,
- Carmanah Walbran Park,
- Thunderbird's Nest (T'iitsk'in Paawats) Protected Area,

- Klanawa River Ecological Reserve,
- Nitinat River Park.

TFL 44 currently covers 136,900 hectares of land with approximately 120,900 hectares considered productive forest land. Among the productive forests, 74,261 hectares is anticipated to be available for timber harvesting, known as the Timber Harvesting Land Base (THLB), with roughly 46,700 hectares of productive forest assumed not available for harvesting, known as Non-Contributing Land Base (NCLB). The THLB is derived by deducting areas not available for harvesting due to the following reasons:

- Legal orders (e.g., ungulate winter range, wildlife habitat area),
- Areas identified to meet legal requirements but not yet legally designated (e.g., proposed old growth management areas),
- Forest Practice requirements (e.g., riparian management areas, wildlife tree retention areas),
- Estimates of areas required to be reserved to manage and conserve non-timber resources at the site-level (e.g., cultural heritage features, and unstable terrain), and
- Physical and economic constraints (e.g., low productivity, inoperable, uneconomic sites)

Figure 2 and Figure 3 present the age class distribution (by area) and the current volume distribution (by volume class) respectively for the THLB and NCLB.

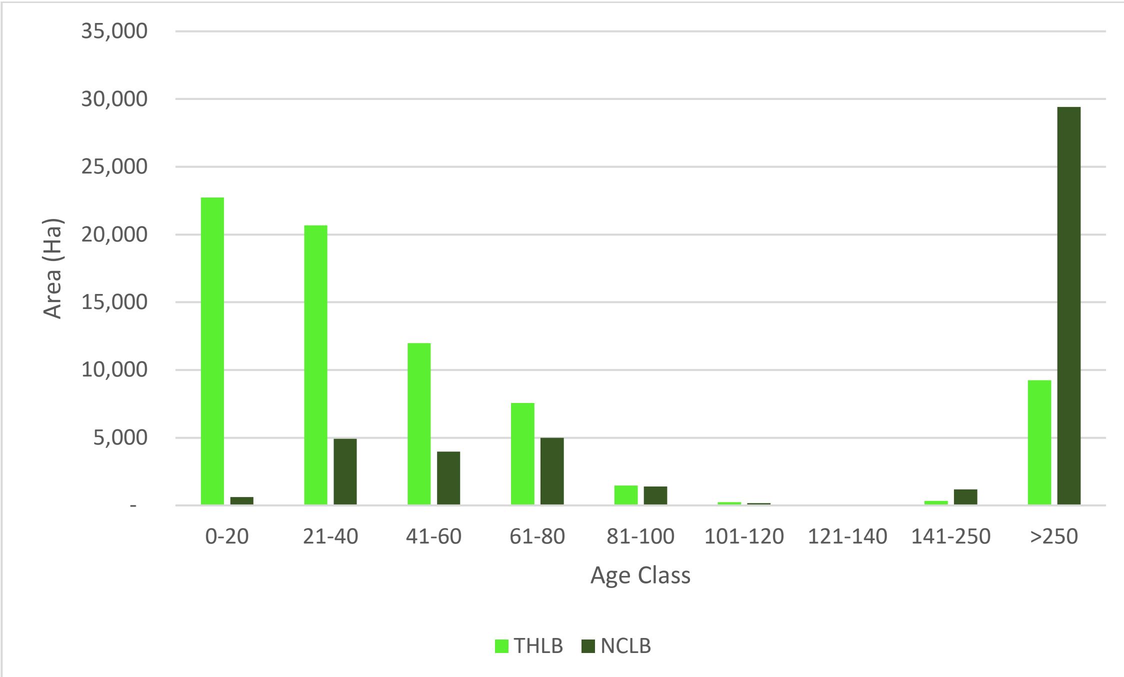

Figure 2 THLB and NCLB Age Class Distributions

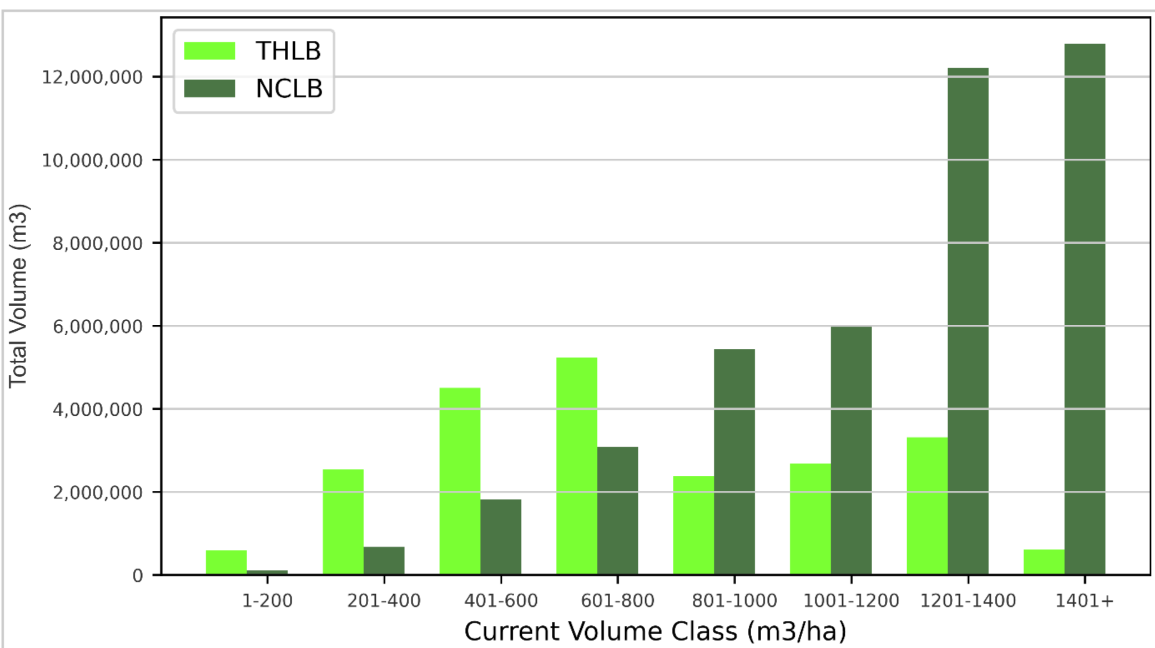

Figure 3 THLB and NCLB Volume Class Distributions

As indicated in Figure 2, the NCLB is dominated by old (251 years old and older) forest. This is a result of wildlife reserves, such as ungulate winter ranges and wildlife habitat areas, and old growth management areas preserving mostly old forest. Figure 3 indicates that the NCLB contains a greater proportion of the high-volume stands than are within the THLB. This is consistent with the greater amount of old forests in the NCLB.

3 TFL 44 LICENCE HOLDER HISTORY

Forest Management Licences (FMLs) No. 20 (Tofino) and No. 21 (Alberni) were originally awarded in 1955. FMLs were later renamed Tree Farm Licences (TFLs). TFL 44 was created in 1984 with the consolidation of TFL 20 and TFL 21. The licence holder has changed over time with successive corporate acquisitions and mergers. In March 2019, the management of the TFL 44 changed from Western Forest Products Inc. (WFP) to TFL 44 Limited Partnership (TFL 44 LP). TFL 44 LP is a limited partnership between Huumiis Ventures Limited Partnership (Huumiis) and WFP. Huumiis is a limited partnership beneficially owned by Huu-ay-aht First Nations (Huu-ay-aht). In October 2021, TFL 44 LP changed its name to Tsawak-qin Forestry Limited Partnership (Tsawak-qin Forestry LP, or Tsawak-qin), to be referred to as C̓awak ʔqin Forestry. Currently as of March 2022, Huumiis owns a 35% equity interest in C̓awak ʔqin Forestry, with WFP holding a 65% equity interest. Table 1 shows the TFL 44 Licence holders since its creation.

Table 1 TFL 44 Licence Holders

Licence	Date listed company became licence holder	Licence Holder	Description
FML 20 (Tofino)	January 24, 1955	MacMillan & Bloedel Limited	Original FML
FML 21 (Alberni)	March 19, 1955	MacMillan & Bloedel Limited	Original FML
TFL 44	August 1, 1984	MacMillan Bloedel Ltd.	TFLs replace FMLs plus consolidation
TFL 44	October 29, 1999	Weyerhaeuser Company Limited	Corporate Purchase
TFL 44	May 30, 2005	Cascadia Forest Products Ltd.	Corporate Purchase
TFL 44	May 1, 2006	Western Forest Products Inc.	Corporate Purchase
TFL 44	March 16, 2019	TFL 44 Limited Partnership	Ownership Transfer
TFL 44	October 29, 2021	Tsawak-qin Forestry Limited Partnership (C̓awak ʔqin Forestry)	Business Name Change

4 TFL 44 AAC HISTORY

Table 2 shows the history of the AAC for TFL 44 since the creation of TFL 44 in 1984. The reductions are mainly due to land base removals (see Section 6), and additional land use change to protect other forest values.

Table 2 TFL 44 AAC History

Date From	Date To	Management Plan No.	TFL 44 AAC (m^3/year)
01-Jan-85	31-Dec-90	1	2,838,000
01-Jan-91	31-Dec-93	2	2,680,000
01-Jan-94	31-May-94	2	2,450,000
01-Jun-94	31-Dec-97	2	2,228,000
01-Jan-98	26-Oct-99	3	1,890,000
27-Oct-99	31-Jul-03	3	1,766,200
01-Aug-03	08-Jul-04	4	1,700,000
09-Jul-04	16-May-10	4	1,327,000
17-May-10	15-Jun-10	4	1,308,318
16-Jun-10	25-Jul-10	4	1,029,143
26-Jul-10	31-Mar-11	4	942,268
01-Apr-11	04-May-11	4	846,798
05-May-11	16-Dec-15	5	800,000
17-Dec-15	07-Dec-20	5	793,600
08-Dec-20	Present	5	793,600[1]

[1] Economic Partition of 535,000 m^3/year, 110,000 m^3/year of the economic AAC in < 121-year-old stands

5 TFL 44 CONSOLIDATIONS AND SUBDIVISIONS

In 1984, TFL 44 was created through the consolidation of TFL 20 (Tofino) and TFL 21 (Alberni). In 1999, TFL 44 was subdivided into 2 TFLs – TFL 44 and TFL 57 (the former Clayoquot Sound portion of TFL 44) which was subsequently transferred to Iisaak Forest Resources Limited. Refer to Table 3 for exact dates of these events.

Table 3 TFL 44 Consolidations and Subdivisions

Date	Boundary Change
August 1, 1984	Consolidation of TFL 20 and TFL 21 to create TFL 44
October 27, 1999	Subdivision of TFL 44 to create TFL 57 (Clayoquot Sound)

6 SIGNIFICANT TFL 44 BOUNDARY CHANGES

Table 4 lists major changes to the TFL of record and the date of those changes. There have been multiple minor (< 200 ha) area revisions since the creation of TFL 44 in 1984 to accommodate other land use activities such as gravel pits, radio towers, and transmission line Right-of-Ways (RoW). There have also been multiple amendments transferring areas from ‘Schedule A’ to ‘Schedule B’ that had no effect on the TFL boundaries.

Table 4 TFL 44 Significant Boundary Changes

Date	Mechanism	Boundary Change
31-Mar-87	Instrument 4	Pacific Rim National Park additions land exchange
06-Jun-89	Instrument 6	Alberni Airport land exchange
03-Jan-90	Instrument 9	Addition of “Loop Farms” and lots immediately east of Sproat Lake Provincial Park
27-Oct-99	Instrument 28	Deletions to create or amend several provincial parks and to create one ecological reserve
27-Oct-99	Instrument 30	Subdivision of TFL 44 to create two TFLs (TFL 44 and TFL 57) and transfer TFL 57 (Clayoquot Sound) to Iisaak Forest Resources Limited
09-Oct-02	Instrument 35	Deletion of a portion of the Ucluelet Working Circle lands
01-Aug-03	Instrument 41	Deletion of remaining Ucluelet Working Circle lands
09-Jul-04	Instrument 42	Deletion of all private lands within TFL 44
17-Jan-09	Instrument 46	Deletion of lands for City of Port Alberni Community Forest
10-Jun-10	Instrument 50	Deletion of BCTS Operating Area (Sproat Lake and Nahmint)
26-Jul-10	Instrument 52	Deletion of area identified for Huu-ay-aht Community Forest
11-Apr-14	Instrument 53 & 54	Deletion of Maa-Nulth Treaty Settlement Lands
17-Dec-15	Forest Revitalization Act Order 3(4)27-4	Deletion of Hupačasath First Nations Woodland Licence
16-Dec-16	Forest Act Section 60.2 Order	Deletion of *T’iitsk’in Paawats* (Thunderbird’s Nest) near Henderson Lake (to become a Provincial Protected Area)

7 TFL 44 PLANNING DOCUMENTS

The following are the publicly available planning documents used by C̓awak ʔqin Forestry to guide forest management and operations within TFL 44.

7.1 Vancouver Island Land Use Plan Higher Level Plan Order

Started via the *Forest Practices Code of BC Act (*Pre-January 31, 2004*)* and continued under FRPA, the provincial government established a “higher level plan” (HLP) to declare forestry-related components of the Vancouver Island Land Use Plan (VILUP) as legal requirements. Effective December 1, 2000, the HLP established resource management objectives that vary from standard forest management standards. The HLP enables forest operations to be consistent with the intent of VILUP’s zones, including the special management and enhanced forestry zones which have unique requirements for forestry practices.

Special Management Zones (SMZs) are areas where forest management emphasis is on higher levels of protection for special resource values, including visual quality, biodiversity, and other wildlife values. Portions of four SMZ’s are found within TFL 44:

- Barkley Sound (SMZ 14)
- Strathcona-Taylor (SMZ 17)
- Alberni Canal (SMZ 18)
- Walbran Periphery (SMZ 21)

Enhanced Forestry Zones (EFZs) are areas where forest management emphasis is on increasing the availability of timber while maintaining environmental stewardship. Parts of TFL 44 are located within four different EFZs:

- Effingham (EFZ 38)
- Corrigan (EFZ 42)
- Sarita (EFZ 43)
- Klanawa (EFZ 44)

Parts of TFL 44 are also located in the five General Management Zones (GMZs):

- Ash-Central-Sproat (GMZ 35)
- Henderson (GMZ 37)
- Cameron-China (GMZ 41)
- Nitinat (GMZ 45)
- Gordon-Caycuse-San Juan (GMZ 46)

As of August 2022, the Vancouver Island HLP order can be found at:
https://www2.gov.bc.ca/gov/content/industry/crown-land-water/land-use-planning/regions/west-coast/vancouverisland-lup

7.2 Landscape Unit Plan

The Renfrew Landscape Unit Plan provides background information and processes used to select Old Growth Management Areas (OGMAs) and Wildlife Tree Retention Area (WTRA) requirements in the Caycuse, Nitinat and Walbran landscape units (plus two other units that are not within TFL 44). The OGMAs and WTRA requirements are incorporated into an order establishing land use objectives for these landscape units.

As of August 2022, the Renfrew Landscape Unit Plan can be found at:

https://www2.gov.bc.ca/gov/content/industry/crown-land-water/land-use-planning/regions/west-coast/vancouverisland-lup/southisland-lu

7.3 Forest Stewardship Plans

Forest Stewardship Plans (FSPs) indicate where a licensee may carry out forest development activities over a period of up to five or, if extended, up to ten years. The plan also states results, strategies or measures that the licensee will achieve or employ in order to be consistent with government objectives that apply to the area covered by the FSP. Once the FSP is approved the licensee may be issued a cutting permit or a road permit authorizing the harvest of timber or construction of roads.

As of August 2022, the FSP applicable to TFL 44 is *Western Forest Products Inc. Forest Stewardship Plan Stillwater & Port Alberni Forest Operations*. It can be found at https://www.westernforest.com/sustainability/environment/plans/forest-stewardship/replacement-plan-port-alberni-and-stillwater-forest-operations/.

7.4 Forestry Certification Plans

Operations within TFL 44 are certified to the Canadian Standards Association (CSA) Sustainable Forest Management standard (CAN/CSA-Z809). CSA is a forest certification standard with principles that protect water quality, biodiversity, wildlife habitat, species at risk and forests with exceptional conservation value. A Sustainable Forest Management Plan (SFMP) document is developed in support of the CSA certification. It lists values, objectives, indicators, and targets that are developed locally with the assistance of a community advisory group (West Island Woodlands Advisory Group for TFL 44) to address the criteria and critical elements for sustainable forest management listed in the CSA standard. The SFMP also describes strategies employed by C̓awak ʔqin Forestry to ensure operations are consistent with the SFMP. CSA is used widely across Canada and is accepted in the global marketplace under the Programme for the Endorsement of Forest Certification (PEFC).

As of August 2022, the most recent CSA SFMP can be found at: https://www.westernforest.com/wiwag/pdf/PAFO_LP_SFMP_2020_2021-05-15.pdf. The most recent CSA audit report can be found at: https://www.westernforest.com/wp-content/uploads/2017/10/WFP_CSA-Public-summary_RA_2021_FINAL.pdf. Details regarding the standard are available at https://www.csagroup.org/store/product/CAN%25100CSA-Z809-16/

8 C̓AWAK ʔQIN FORESTRY FOREST MANAGEMENT

The following are proprietary C̓awak ʔqin Forestry planning documents used to guide forest management and operations within TFL 44. C̓awak ʔqin Forestry closely follows WFP's forest management strategies, but uses different approaches on focused forest values specifically for TFL 44 (e.g., Section 8.2.5 below). These are internal WFP policies and practices that directly or indirectly influence forest management and therefore timber supply. Substantial detail is contained within each of these documents, with short summaries provided here for the reader to be made aware that these exist and are used by C̓awak ʔqin Forestry in managing the forests within its tenures.

8.1 Stewardship and Conservation Plan

The Western Stewardship and Conservation Plan (WSCP) sets direction on managing forest values across the landscape over time, while identifying key corporate indicators of Sustainable Forest Management. The WSCP connects and aligns practices through all planning levels from strategic to site-level. It also provides a standardized approach to achieving stewardship results. There are five programs within the WSCP:

- Wildlife and Biodiversity,
- Fish and Watershed,
- Carbon and Climate Change,
- Communities, and
- Timber and Reforestation.

The Wildlife and Biodiversity Program is complete and has been implemented. The remaining programs are under development.

8.1.1 Wildlife and Biodiversity Program

C̓awak ʔqin Forestry is committed to managing biodiversity on the tenure. The Wildlife and Biodiversity program that C̓awak ʔqin Forestry currently follows is founded on over 15 years of local research and adaptive management learnings which are summarized in *Forestry and Biodiversity- Learning to Sustain Biodiversity in Managed Forests* (2009) edited by Dr. Fred Bunnell and Glen Dunsworth. The program is designed to achieve the three indicators for the successful management of biodiversity in our coastal rainforests:

(i) Ecologically distinct ecosystem types are represented in the non-harvestable land base of the tenure to maintain lesser-known species and ecological function;

(ii) The amount, distribution, and heterogeneity of stand and forest structures important to sustain native species richness are maintained over time; and

(iii) The abundance, distribution and reproductive success of native species are not substantially reduced by forest practices.

The following outlines the nine components:

8.1.1.1 *Rare Ecosystems*

A rare ecosystem is an ecosystem within a biogeoclimatic unit that is either:

(i) a subset of an ecological community that is 'listed' by the BC Conservation Data Centre as being 'at risk' or

(ii) an unlisted community that is rare (<1% or <100ha) or uncommon (<2% or <500 ha) with the tenure.

Rare ecosystems are important to manage to ensure their long-term viability and minimize their risk of being lost. C̓awak ʔqin Forestry has collaborated with three independent ecologists to develop a robust approach for identifying and protecting rare forested ecosystems. C̓awak ʔqin Forestry has aligned management plans with established targets for maintaining high quality occurrences for each rare ecosystem and these targets have been met.

8.1.1.2 *Old Forest*

Retention of old forests and management for recruitment of old forest characteristics across a landscape are considered as foundational elements for sustaining biological diversity. These conserved old forests occur at low, mid and high elevations and are well distributed across the managed forest in a variety of patch sizes.

8.1.1.3 *Forest Interior Conditions*

Forest interior is generally defined as the portion of the forest that is not influenced by edge effects. An edge is the interface between two distinct habitats (e.g., a cutblock and the adjacent old forest) where a microclimate gradient exists between two habitat types. Forest interior conditions is a measure of quality of conserved forests for species that are not typically found near forest edges.

8.1.1.4 *Forest Structure*

There is strong scientific evidence that using a retention system across the landscape contributes to the management of biological diversity. The retention silvicultural system is designed to conserve biodiversity by sustaining species and ecological processes following disturbances. This is accomplished through maintaining habitat over time and reducing micro-climate effects of harvesting. In turn, retention enriches soil for regenerating trees by maintaining soil mycorrhizae and enhances connectivity by supporting the movement of mature and old forest species across the forested landscape.

Stand-level retention is a combination of retention used in Retention Silvicultural System cutblocks and Wildlife Tree Retention Areas. Both types of stand-level retention contribute to biodiversity management at the landscape-level. VILUP's three Forest Stewardship Zones, Special, General and Enhanced, have been refined to increase the use of retention silvicultural system. The General and Enhanced Zones have been refined to provide more retention in the drier ecosystems due to disturbance history and less in the windy zones of western Vancouver Island due to higher windthrow risk.

A rare feature of BC's coastal forests is exceptionally large, iconic trees. These trees have significant cultural, social, economic (tourism) and environmental values and are important to retain. In June 2016, WFP implemented a program to identify and retain very large Douglas-fir, Sitka spruce, western redcedar, and yellow-cedar by using them as anchors for stand-level retention or included in landscape-level reserves. Since then, the Big Tree Standard has expanded to include more species. In April 2019, a more robust big tree retention policy was developed and followed in the TFL. (Western Forest Products Inc., 2019) However, most recently in April 2022, C̓awak ʔqin Forestry developed and adopted an Indigenous-led big tree policy specific to TFL 44. More details are discussed in Section 8.2.5.

8.1.1.5 *Species at Risk*

Species evolve to survive in particular ecological niches over time. When changes occur in the environment through either natural or man-made processes, a species may become at risk of extinction if these changes negatively influence its persistence upon the landscape. The goal of species at risk management is to prevent a species from becoming extinct and facilitate species recovery. Species at Risk are species that are legally listed as Threatened or Endangered under the Federal Species at Risk Act (SARA), and fish species that has a final Federal Recovery Strategy, or non-fish species that has a final BC Implementation Plan.

8.1.1.6 *Species of Significant Concern*

When changes occur in the environment through either natural or man-made processes, a species may become less common. C̓awak ʔqin Forestry's process of determining species of significant concern is based on:

(i) global and provincial risk classification categories,
(ii) species distribution,
(iii) if the species is negatively influenced by forestry,
(iv) BC Conservation Framework priority 1 species, and
(v) if the species population is declining.

While being provincially yellow-listed (not at risk),

(i) Columbian black-tailed deer has been added to the list because C̓awak ʔqin Forestry considers significant concern due to a decreasing wild population, and

(ii) Coastal black bear has been added as a species of conservation concern due to their use of old hollow trees for winter denning.

8.1.1.7 *Common Species*

The overall goal of managing common species is to ensure they remain common. Maintaining common species is most effectively accomplished by selecting species that are sensitive to forest practices, can be effectively monitored and serve as indicators to the viability of other common species.

To support effective monitoring, the University of British Columbia (UBC) has developed the Species Accounting System as a tool to assign species to one of the following monitoring groups:

- Group 1 – Generalists, species that inhabit many habitat types or respond positively to forest practices;

- Group 2 – Species that has a validated association with a certain broad habitat types as defined
  - within forest cover (e.g., non-treed, recently disturbed, and old conifer);
- Group 3 – Species with strong dependencies on specific habitat elements (e.g., snags or
  - understory), so may be useful in effectiveness monitoring;
- Group 4 – Species restricted to specialized and highly localized habitats; and
- Group 5 – Species for which patch size and connectivity are considered important.
- Group 6 – Is included for completeness. It contains species known or expected to occur in the area, but that are not dependent upon forested environments and are not monitored.

Forest birds were selected because they inhabit a wide range of habitat types that can be classified using the Species Accounting System.

8.1.2 Fish and Watershed Program

The Fish and Watershed component is under development; however, the following two sections are completed:

8.1.2.1 *Watershed Management*

C̓awak ʔqin Forestry uses WFP watershed management strategies. WFP has watershed management strategies for all its tenures on Vancouver Island plus the portions of TFL 25 and TFL 39 in the Stafford and Phillips watersheds respectively. These strategies are based on measurable data on physical watershed processes. Inventories of the following are produced periodically to characterize each watershed, identify trends in condition and identify sensitive and key concerns:

- landslides,
- road stability hazard,
- sediment delivery potential from roads,
- stream channel type (alluvial, semi-alluvial, nonalluvial), and
- riparian forest condition.

From these inventories, a set of indicators are determined that allow the physical condition of any watershed to be evaluated from a consistent data set and allow comparison between watersheds with respect to watershed sensitivity and relative fisheries values. Periodic updates of the data allow trends in watershed condition to be identified and management strategies revised accordingly. These strategies are then connected to site-level decision-making through the Terrain Risk Management Strategy (TRMS).

8.1.2.2 *Terrain Risk Management*

Western's terrain risk management strategy that C̓awak ʔqin Forestry also employs is a framework for connecting landscape-level watershed management strategies to the site-level by managing landslide risk specific to detailed site-level information. The strategy considers the following components to determine a risk level:

- values at risk should a landslide occur (i.e. consequence), and
- the likelihood of a landslide occurring (i.e. hazard).

This risk level then guides C̓awak ʔqin Forestry's forest professionals in deciding whether to have a terrain stability assessment conducted by a qualified professional (e.g., Professional Engineer or Professional Geoscientist). Finally, areas selected for road building and harvesting have practices implemented that are appropriate for managing the identified risk.

8.2 Standards and Guidelines

8.2.1 Karst Management

C̓awak ʔqin Forestry's karst management guidelines are based on the *Karst Management Handbook for British Columbia* (Province of British Columbia, 2003) and BC inventory standards. The guidelines:

- provide information to manage karst terrain as a connected and functioning landscape system and individual features;
- provide a checklist to be used when conducting karst field assessments; and,
- protect worker safety from hazards that may occur in karst terrain.

Most of the known caves and karst potential polygons are either on the private lands that were removed from the TFL, or the area deleted from the TFL to form part of the Pacific TSA. If karst is found, this guideline will be followed for proper karst management. As a result, little area has been reserved for karst features.

8.2.2 Northern Goshawk Management

C̓awak ʔqin Forestry's management standard for Northern Goshawks provides direction regarding activities around Northern Goshawk nests. Strategies are intended to minimize risk of nest and territory abandonment while minimizing disruption to harvest activities. Reserves are designed around confirmed goshawk nests consistent with science-based guidelines (McClaren, Mahon, Doyle, & Harrower, 2015) and timing constraints for harvesting and road construction activities are applied in the vicinity of active nests.

8.2.3 Bald Eagle Nest Management

Similar to the goshawk standard, C̓awak ʔqin Forestry's eagle nest standard gives direction to maintain eagle nests in a functional state and to prevent disturbance of nesting eagles. Guidance is provided for ways of incorporating nest trees into forested reserves and timing constraints are listed for harvesting activities in the vicinity of active nests.

8.2.4 Bear Den Management

C̓awak ʔqin Forestry has a standard for bear den management in order to maintain viable bear dens in a functional state and prevent disturbance of hibernating bears. Where worker safety permits, all identified dens will be retained in a functional state by incorporating the den in a forested retention area. Where safety does not permit retention of the den, other habitat containing large diameter trees suitable for den recruitment will be retained. Proximity restrictions near active dens for harvesting activities apply during the denning season of October 21st – April 30th.

8.2.5 Big Trees

C̓awak ʔqin Forestry currently uses WFP's big tree retention policy to recognize and retain these unique and important features of coastal BC. WFP was one of the first B.C. forest companies to implement a big tree policy (Western Forest Products Inc., 2019).

In April 2022, C̓awak ʔqin Forestry took further steps to enhance protection of tall trees in TFL 44 (C̓awak ʔqin Forestry Limited Partnership, 2022). Trees within TFL 44 that are over 70 metres in height will be retained as part of C̓awak ʔqin Forestry's retention standards while the two-year Indigenous-led TFL 44-wide Integrated Resource Management Plan (IRMP) is completed and implemented in accordance with British Columbia's *Declaration on the Rights of Indigenous Peoples Act*. By using LiDAR data, more than 4,000 tall trees have been identified. Over the next 2 years, professional foresters and ecologists are working with the Indigenous Witwak Guardians to verify these LiDAR-identified tall trees and work with TFL 44-area Nations to determine long-term retention measures.

At the time of preparation for the MP, C̓awak ʔqin Forestry commits to retain:

- all trees in the BC Big Tree Registry (BC BigTree Registry, 2021)

and all live trees that:

- exceed 70 metres in height or
- meet the following diameter at breast height (DBH) by species requirements:
    - western redcedar: 300cm
    - yellow cedar: 210cm
    - coastal Douglas-fir: 210cm
    - Sitka spruce: 220cm
    - western white pine: 125cm
    - other tree species and DBH requirements in *Special Tree Protection Regulation* under FRPA

Identified trees are to be retained in contiguous forested areas; forested patches, preferably at least 2 hectares in size; or as a single tree or in a patch less than 0.25 hectares where worker safety or engineering constraints do not allow larger patch retention. Light Detection and Ranging (LiDAR) technology, a 3D mapping tool, is used to identify potential big trees that are then verified in the field.

9 Public Review Strategy Summary

Opportunity to review and provide comments on the TFL 44 Draft Management Plan #6 was intended to be based on a referral and public review strategy approved by the Regional Executive Director on December 2, 2019. However, due to unforeseen circumstances, including licence holder change, and provincial COVID-19 protocols, the timeline is behind the approved strategy. However, supplemental analyses, such as TFL 44 economic analysis that formed the foundation of the December 2020 TFL 44 AAC partition decision, provided timely updates to the TFL 44 land base to ensure the sustainability of the current AAC.

The first phase was public review and First Nations' information-sharing of a draft timber supply analysis information package (IP). The second phase was public review and First Nations' information-sharing of a draft MP that included the accepted IP and the timber supply analysis (TSA) results.

9.1 Review of Draft Information Package

The public review, including information-sharing with First Nations, of MP #6 began in June 2021. On or about June 23, 2021, copies of the draft IP were provided to the following provincial government agencies:

- Ministry of Forests (previously known as Ministry of Forests, Lands, Natural Resource Operations and Rural Development, FLNRORD at that time) - Forest Analysis and Inventory Branch (FAIB),
- Ministry of Forests – South Island Natural Resource District (SINRD), Port Alberni

Both Ministry of Forests offices were provided with digital files containing the documents and the maps. A hardcopy the IP was sent to the SINRD office.

On or about June 23, 2021, digital copies (via email or via Maa-nulth Connect Portal for Maa-nulth First Nations) and hard copies of the draft IP were provided to the following First Nations and First Nation organizations:

- Maa-nulth First Nations, which include Huu-ay-aht First Nation, Ka:'yu:'k't'h'/Che:k'tles7et'h' First Nations, Toquaht Nation, Uchucklesaht Tribe and Yuutu?il?ath First Nation
- Ahousaht
- Cowichan Tribes
- Ditidaht First Nation
- Halalt First Nation
- Hupačasath First Nation
- Lyackson First Nation
- Pacheedaht First Nation
- Penelakut Tribe
- Stz'uminus First Nation
- Tseshaht First Nation
- Ts'ubaa-asatx Nation (formerly Lake Cowichan)

The facilitator for C̓awak ʔqin Forestry's CSA advisory group for TFL 44 was notified prior to the beginning of the review period, and a digital copy of the IP was distributed to the members. In addition, a presentation in regard to the IP was delivered to the advisory group in June 2021. Ads ran in the *Alberni Valley News* newspaper on June 23rd and June 30th, 2021. The ads stated that the draft IP was available for review and comment from June 23, 2021 until August 22, 2021 at the following locations:

- C̓awak ʔqin Forestry Office (previously known as TFL44 Limited Partnership at that time), Port Alberni
- WFP Timberlands Corporate Office, Campbell River
- Ministry of Forests SINRD office, Port Alberni
- WFP internet site
- C̓awak ʔqin Forestry internet site

Phone numbers and an email address were provided for submitting comments. The on-site review locations were different from the approved referral and public review strategy. Two Huu-ay-aht First Nation Government Offices (Port Alberni and Anacla) were removed from the on-site review list due to provincial COVID-19 protocols. However, specific measures were arranged for potential on-site reviews in remaining locations. No known public visits were made to any of the viewing locations.

Bi-weekly calls were conducted among FAIB, SINRD and C̓awak ʔqin Forestry beginning July 5th, 2021 to address concerns, update the timber supply review progress and promote communications in all parties. Multiple FAIB comments were raised and addressed appropriately during the scheduled calls.

In an email dated July 23rd, 2021, SINRD staff provided comments regarding the draft IP. WFP responded to the comments on behalf of C̓awak ʔqin Forestry (previously known as TFL44 Limited Partnership at that time) on August 17th, 2021. On August 18th, 2021, SINRD staff replied that the responses appeared to address all concerns, and this was further confirmed in the August 30th, 2021 TFL 44 bi-weekly call.

In an email dated July 27th, 2021, Tseshaht First Nation provided comments regarding the draft IP. WFP responded to the comments on behalf of C̓awak ʔqin Forestry (previously known as TFL44 Limited Partnership at that time) on September 21st, 2021. No further comment was provided by Tseshaht First Nation.

In an email dated August 8th, 2021, one member of the general public, who is also a member of the CSA advisory group for TFL 44, provided comments regarding the draft IP. WFP responded to the comments on behalf of C̓awak ʔqin Forestry (previously known as TFL44 Limited Partnership at that time) on September 10th, 2021. No further comment was provided by the member.

9.2 Review of Draft Management Plan and Timber Supply Analysis

This section will be completed following the review period and be included in the final MP submission to the Ministry of Forests.

9.3 Summary of Revisions made to Documents

As a result of the comments received, additional information was provided in the Information Package (Version 2.1). The revisions are summarized at the beginning of the IP document (Appendix B to this document).

Other changes made include:

- Updated document dates.
- Updated new licensee name and logo
- Corrected typographical errors throughout the documents.

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10 Glossary (Province of British Columbia, 2008)

Allowable Annual Cut (AAC)	The rate of timber harvest permitted each year from a specified area of land, usually expressed as cubic metres per year.
Alluvial stream	Alluvial streams have at least one unconfined erodible bank in alluvial deposits. Alluvial deposits are material deposited by the stream under its current flow regime. These stream channels can widen or change direction due to disturbance or a large flood event.
Biogeoclimatic zones and variants (BEC)	A large geographic area with broadly homogeneous climate and similar dominant tree species.
Nonalluvial stream	Nonalluvial streams are confined to entrenched channels with stable position which is typically composed of bedrock.
Schedule “A” Land	Crown grant (private) and Crown land subject to timber licences contained within the boundaries of the TFL. Listed in Schedule “A” of the licence document.
Schedule “B” Land	Crown land contained within the boundaries of the TFL. Detailed in Schedule “B” of the licence document.
Semi-alluvial stream	Semi-alluvial streams have confining banks and stable position. They cannot widen their banks significantly or move laterally beyond the active channel.
Timber harvesting land base (THLB)	Forest land within the TFL where timber harvesting is considered both acceptable and economically feasible, given objectives for all relevant forest values, existing timber quality, market values and harvesting technology.
Timber Licence	A licence that describes an area of Crown land within which the licence holder is granted exclusive right during its term to harvest all merchantable timber. For the purposes of defining rights within a timber licence, merchantable timber means timber that on January 1, 1975 was older than 75 years old (*Forest Act* section 1).
Timber supply	The amount of timber that is forecast to be available for harvesting over a specified time period, under a particular management regime.
Tree Farm Licence (TFL)	Provides rights to harvest timber, and outlines responsibilities for forest management, in a particular area.

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11 References

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APPENDICES

Appendix A: TIMBER SUPPLY ANALYSIS REPORT

Appendix B: TIMBER SUPPLY ANALYSIS INFORMATION PACKAGE

Appendix A: TIMBER SUPPLY ANALYSIS REPORT

C̓AWAK ʔQIN
FORESTRY

Tree Farm Licence 44

Timber Supply Analysis

In Preparation of

MANAGEMENT PLAN 6

Submitted to the Ministry of Forests
Forest Analysis & Inventory Branch
Victoria, BC

Version 2
September 2022

REGISTERED PROFESSIONAL FORESTER
PROVINCE OF BRITISH COLUMBIA
YE HUANG
NO. 4887

Ye Huang, RPF
Timber Supply Forester
Western Forest Products Inc.

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Revision History

Version	Date	Description
2.0	Sept. 12, 2022	• Updated the AAC recommendation. • Updated Economic Partition definition and values to be consistent with the 2020 Economic Analysis (Western Forest Products Inc., 2020). • Updated Section 2.2 to include a comparison of inventory growing stock and area for MP# 5 Area, MP #5 fit to MP #6 Area and MP# 6 area. • Updated Section 2.3 to include a description for initial growing stock check between the model output and inventory growing stock. • Updated figure formatting and color schemes. • Updated Section 4.23 to include more details on non-declining even-flow • Removed Section 4.21 in the initial version. • Removed Section 2.7 and Section 4.23.1 in the initial version regarding carbon.
1.0	May 9, 2022	**Initial version**

Executive Summary

This Timber Supply Analysis report examines timber supply projections for Tree Farm Licence (TFL) 44 located on west-central Vancouver Island in the vicinity of the Alberni Inlet and Barkley Sound.

This Timber Supply Analysis uses computer models to perform analysis on the current stand description which is outlined in the Management Plan (MP) #6 Base Case, or Base (TFL 44 Information Package). The Base Case reflects current forest management practices and their impact on timber supply. The Timber Supply Analysis models the potential impact of management assumptions by incorporating a variety of sensitivity factors and considering how uncertainty in the land base impacts timber supply. After allowances for non-recoverable losses, the MP #6 Base Case, created from modelling current management practices, suggests an Allowable Annual Cut (AAC) of 715,200 m^3/year (a reduction of 9.9% from the current AAC) during the next five years, and 678,900 m^3/year for the 5 years to follow. This is equivalent to 697,000 m^3/year for the next 10 years (a reduction of 12.2% from the current AAC).

In both the Base Case and the sensitivity analyses, Patchworks™, a spatial harvest model, was used to model current management practices for protection and maintenance of ecological values and to estimate the residual timber potential through the 300-year planning horizon from Year 2020 to Year 2319.

In TFL 44, an economic partition is modelled via establishing a tenure-wide landscape-level net value objective (expressed in $/$m^3$) that is equivalent to the Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA) margin indicated the 2020 Economic Analysis submitted to the Chief Forester (Western Forest Products Inc., 2020) and accounting for an average long-term stumpage rate, for the first 20 years of the planning horizon. This ensures the economic operability of the projected timber supply harvest levels and smooth transition in harvest profile.

Several inputs and assumptions for this Timber Supply Analysis are based on recently acquired Light Detection and Ranging (LiDAR) data, including:

- site productivity,
- physical operability,
- Operational Adjustment Factor 1 (small non-productive areas within forest stands),
- growing site loss due to roads, and
- a sensitivity analysis using LiDAR individual tree inventory attributes, adjusted for known volume under-estimation in mature stand volume

LiDAR provides very accurate three-dimensional representation of the ground surface and vegetation height. The net effect of reviewing the applied assumptions with TFL-specific comprehensive data confirms that the Base Case volume yields are conservative. The LiDAR-based inventory sensitivity, adjusted for the known under-estimation of mature stand volume[1], infers that short-term and early portion of the mid-term timber supply may be greater than indicated by the Base Case.

The minimum harvest age criteria in the Base Case are based on minimum average stand diameter-at-breast-height (DBH) that varies by harvest system and minimum volume per hectare (350 m^3 per hectare). Both minimum age and minimum volume requirements must be met before a stand can be harvested. However, a review in TFL 44 forecasted blocks shows a 5cm to 6cm DBH disparity in various

[1] LiDAR-based inventory under-estimates mature stand volume as verified by field samples (Appendix A)

harvest systems. The Base Case's DBH criteria lead to a 23- to 28-year delay in minimum harvest age compared to the DBH from forecasted blocks. In addition, an analysis shows a 20 to 40-year delay when comparing against the 95% culmination MAI age, which is used in multiple BC Coastal Timber Supply Areas. This infers that the minimum harvest age assumptions of the Base Case are conservative.

After applying the minimum harvest age assumptions that better reflect operational reality and using the adjusted LiDAR-based inventory, harvest flow was modelled in two ways: 1) a "flat line" even-flow for the entire planning horizon; and 2) "step-down" flow that maximizes the short-term AAC, steps down gradually in the mid-term, then bounces back in the long-term. It is determined that an even-flow harvest rate better demonstrates a commitment to long-term sustainability and supports economic stability for both the business and local communities. Since the economic partition volume is different in the two 5-year periods for the even-flow harvest rate, an AAC of 727,200 m^3/year is proposed for TFL 44 from Year 1 to Year 5. The AAC proposal includes:

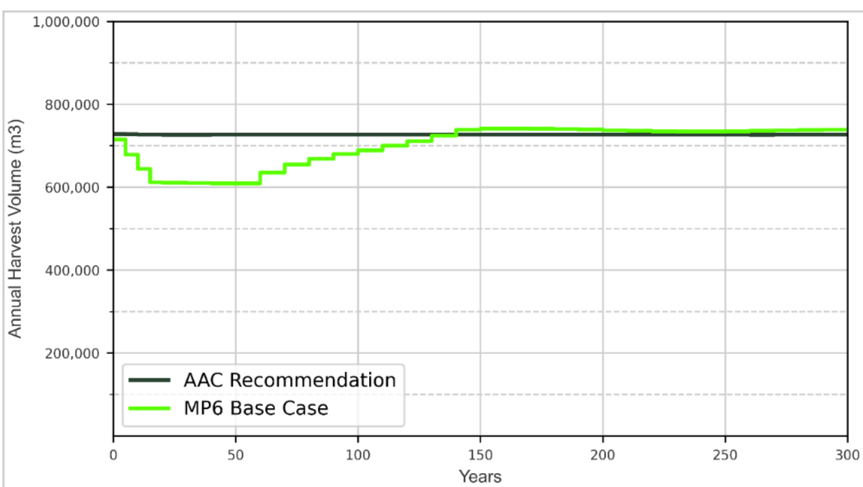
- 652,500 m^3/year of the AAC to be attributed to the economic land base, defined in the TFL 44 timber supply modelling spatial output;
- 309,400 m^3/year of the AAC to be attributed to the economic land base in stands with an age less than 121 years.

An AAC of 727,200 m^3/year is proposed from Year 6 to Year 10.

- 585,900 m^3/year of the AAC to be attributed to the economic land base, defined in the TFL 44 timber supply modelling spatial output;
- No limit on stands with an age less than 121 years as these stands are projected to comprise the majority of the timber supply in the economic partition.

The 727,200 m^3/year AAC includes 11,118 m^3/year allocated to First Nations.

This harvest level can accommodate ecological and social concerns in the short and longer terms. The conventionally operable land base contributes up to 93% of the harvest for the first 5 years and 88% of the harvest for the next 5 years.



Currently, 32% of the TFL productive forests are greater than 250 years old, and 76% of these 250+ years old forest is outside of the Timber Harvesting Land Base (THLB). The modelling indicates that a minimum of 26% of productive forest area will be maintained in old forests and a minimum of 27,000,000 m^3 of growing stock (GS) in old seral will be maintained on the productive forest land base throughout the 300-year planning horizon. In the absence of major natural disturbances, 39% of the productive forest is projected to be old at the end of Year 300.

In the long-term, the extent of land base managed for timber and other resource values is 74,058 ha (61% of the productive forest) while 46,912 ha (39%) is conserved for non-timber values. These forests are expected to contribute significantly to biodiversity conservation and complement protected areas within and adjacent to the Tree Farm Licence.

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Acknowledgements

The signatory greatly appreciates the following for their contributions to the preparation of this document:

- Mike Davis, RPF of WFP for his rich tenure history knowledge, tremendous timber supply analysis support, past management plan experience and overall direction;
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1 INTRODUCTION

1.1 Background

Tree Farm Licence (TFL) 44 is located in the South Island Natural Resource District, in the vicinity of the Alberni Inlet and Barkley Sound (Figure 1). Communities within or near TFL 44 include:

- Port Alberni,
- Bamfield,
- Anacla,
- Nitinaht.

The land upon which the TFL 44 management plan operates is within the traditional territories of the Maa-nulth First Nations, which include Huu-ay-aht First Nation, Ka:'yu:'k't'h'/Che:k'tles7et'h' First Nations, Toquaht Nation, Uchucklesaht Tribe and Yuutu?il?ath First Nation. TFL 44 is also within the traditional territories of the following First Nations (some of them are to a minor degree only):

- Ahousaht First Nation
- Cowichan Tribes
- Ditidaht First Nation
- Halalt First Nation
- Hupačasath First Nation
- Lyackson First Nation
- Pacheedaht First Nation
- Penelakut Tribe
- Stz'uminus First Nation
- Tseshaht First Nation
- Ts'ubaa-asatx Nation (formerly Lake Cowichan First Nation)

Nearby parks include:

- Pacific Rim National Park Reserve of Canada
- Strathcona Park,
- Carmanah Walbran Park,
- Thunderbird's Nest (T'iitsk'in Paawats) Protected Area,
- Klanawa River Ecological Reserve,
- Nitinat River Park.

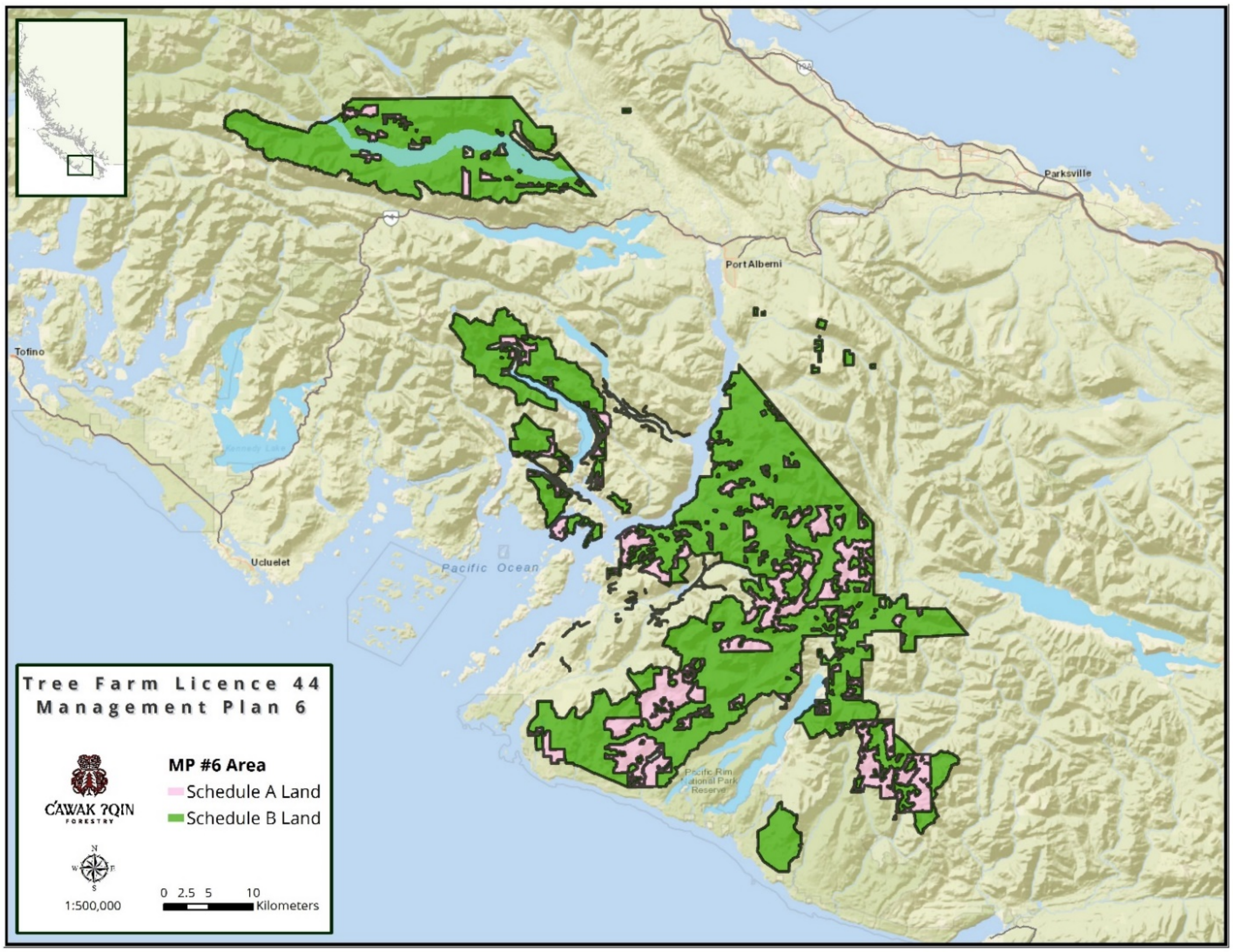

Figure 1 TFL 44 Overview

Since the last timber supply analysis was completed, some changes to the administration of the TFL have occurred:

- In June 2010, a portion of TFL 44 (Sproat Lake and Nahmint) was deleted via the Instrument 50 in accordance with the *Forest Revitalization Act* Order 3(4)27-1 for the creation of a British Columbia Timber Sales' Operating Area.
- In July 2010, a portion of TFL 44 was deleted via Instrument 52 for the creation of Huu-ay-aht Community Forest.
- In April 2014, a portion of TFL 44 was deleted via Instrument 53 for Maa-Nulth First Nations' Final Agreement (treaty).
- In December 2015, a portion of TFL 44 was deleted via the *Forest Revitalization Act* Order 3(4)27-4 for the creation of Hupacasath First Nations Woodland Licence.
- In October and December 2016, a portion of TFL 44 was deleted via the *Forest Act* Section 60.2 Order for the creation of the Thunderbird's Nest (T'iitsk'in Paawats) Protected Area.

- In March 2019, the management of TFL 44 changed from Western Forest Products Inc. (WFP) to TFL 44 Limited Partnership (LP). TFL 44 LP is a limited partnership between Huumiis Ventures Limited Partnership (Huumiis) and WFP. Huumiis is a limited partnership beneficially owned by Huu-ay-aht First Nations (Huu-ay-aht). Huumiis have gradually increased its share in the TFL 44 LP since. At the completion of this Timber Supply Analysis (TSA) report, Huumiis owns a 35% equity interest in TFL 44 LP, with WFP holding an equity interest of 65%. TFL 44 LP is currently applying the same forest management standards as WFP.
- In March 2020, a portion of TFL 44 was deleted via Instrument 55 in the Malachan Block B parcel.
- In October 2021, TFL 44 LP changed its name to Tsawak-qin Forestry Limited Partnership (Tsawak-qin Forestry LP), to be referred to as C̓awak ʔqin Forestry (Tsawak-qin is the anglicized spelling for legal and informational purposes). This is to reflect the culture and spirit of the limited partnership between Huumiis and WFP.

The TFL encompasses 136,900 hectares, of which 74,261 hectares are expected to be available for timber production. The allowable annual cut (AAC) for this land base is currently set at 793,600 m^3/year, with 535,000 m^3/year of AAC attributed to the economic land base, and 110,000 m^3/year of AAC attributed to stands less than 121-year-old in the economic land base. A history of the AAC is provided in the body of Management Plan (MP) #6.

1.2 Objective

The primary objective of this report is to estimate achievable timber flows for consideration by the Provincial Chief Forester in making the determination of the AAC for the term of MP #6. More specifically:

- The management of non-timber values such as fish and wildlife habitat, biodiversity, visual quality, and terrain stability is accounted for. Protection of non-timber values will be satisfied by land base reserves, rate-of-harvest constraints and/or by maintaining a percentage of the land base in older stands.
- Timber flow is estimated by considering harvestable inventory, growth potential of present and future stands, silvicultural treatments, potential timber losses, and operational and legislative constraints.
- Impacts of declining timber flow on community stability and employment are to be lessened by keeping rates of decline per decade as low as possible without inducing undue impacts on other values or long-term timber sustainability.

1.3 Timber Supply Model

Timber supply forecasts were completed with Patchworks™ software version October 2021 developed by Spatial Planning Systems Inc. based out of Deep River, Ontario (https://spatial.ca/). Patchworks is a spatial supply model and is described in more detail in the associated Information Package (IP) from September 2021.

The inventory database was current to December 31, 2019 for harvesting depletion and silviculture treatments and assessments. The model was constructed using four 5-year periods and 28 10-year periods for a total planning horizon of 300 years. This report presents results by 5-year intervals for the first 20 years, and by 10-year intervals for the rest of the 280 years. Since AAC's are effective for up to 10 years, the pairs of 5-year intervals can highlight the AAC in the immediate effective years with more granularity.

Analysis units (AU - grouping of forest stands) and associated timber volume yield curve parameters are described in more detail in Section 7.3 and Section 8 of the associated IP.

2 BASE CASE (Current Management Option)

2.1 Assumptions and Modelling Parameters Overview

The Base Case (or Current Management option) includes the following assumptions and modelling parameters that are described in more detail in the accompanying Information Package:

- The operable land base of forested area accessible using conventional (ground and cable) and non-conventional (helicopter) harvesting methods, based on the spatially delineated economic operability dataset via Land Base Blocking (LBB) process[1] (refer to Section 5.4.3 of the associated IP).
- A landscape-level economic metric that is consistent with the 2020 Economic Analysis for TFL 44 (Western Forest Products Inc., 2020), accounting for an average long-term stumpage rate, is established to define the economic land base. Projected harvest flow recommended for AAC determination will present volumes from the economic land base, profiled by mature (>120-year-old) and immature stands for the first 20 years.
- Harvesting of both mature and immature stands and performance in the non-conventional land base is addressed via the economic land base partition.
- Silviculture carried out on all regenerated stands to meet free growing requirements. Known tree improvement gains will be applied to existing stands established since 1999 and future regenerated stands.
- Exclusion of uneconomic forest stands from the Timber Harvesting Land Base (THLB).
- Visual quality objectives (VQOs) are modelled with upper range disturbance assumptions based on the VQOs Government Action Regulation (GAR) order established on December 15, 2005 and amended on December 30, 2011 for the South Island Natural Resource District.
- Green-up heights for cutblock adjacency are assigned based on Resource Management Zones established in the Vancouver Island Higher Level Plan (VIHLP). Special and General Zones have a 3m green-up requirement while Enhanced Zones have a 1.3m green-up height.
- Future Wildlife Tree and other stand-level retention within the THLB are accounted for by a percentage area reduction.
- Biodiversity and Landscape Units (LUs) – Established Old Growth Management Areas within the Caycuse, Gordon, Great Central, Nitinat, Sproat Lake and Walbran LUs are not included in the THLB. Also excluded are draft OGMAs in Ash, Corrigan, Effingham, Great Central, Henderson, Klanawa, Nitinat, and Sarita LUs. For the Effingham, Henderson and Sarita LUs, old seral stage targets are applied to each Biogeoclimatic (BEC) zone variant based on the *Order Establishing Provincial Non-Spatial Old Growth Objectives* effective June 30, 2004 (NSOG). Mature seral targets are incorporated for the four Special Management Zones within TFL 44.
- Established Ungulate Winter Ranges (UWRs) and Wildlife Habitat Areas (WHAs) are excluded from the THLB.

[1] The entire land base was reviewed using LiDAR data in terms of opportunity for timber harvesting and road development. Non forested area, low productive forest area, harvestable area, harvest system, and road locations are spatially delineated by qualified professionals.

- Suitable Marbled Murrelet Habitat in East Vancouver Island Conservation Region (Great Central/Ash/Corrigan/China/Caycuse LUs) are excluded from the THLB.
- Limited rate of harvest is employed in Community Watersheds. Equivalent Clearcut Area (ECA) restriction and hydrological recovery curves are used for Fisheries Sensitive Watersheds.
- Varying netdowns for terrain stability management depending on mapping type and relative climatic environment and applying ECA limit on various important fisheries watersheds to co-manage hydrologic/geomorphic response to prevent landslides.
- Riparian management based on the approved Forest Stewardship Plan (FSP) results/strategies, targets within the Sustainable Forest Management Plan (SFMP) developed for Canadian Standards Association (CSA) certification standard CAN/CSA-Z809-16 and a review of riparian management applied on more than one thousand cutblocks harvested or planned between 2000 and 2019.
- Minimum harvest age criteria based on minimum average stand diameter-at-breast-height (DBH) that varies by harvest system and minimum volume per hectare (350 m^3 per hectare). Both minimum age and minimum volume requirements must be met before a stand can be harvested.
- The Operational Adjustment Factor 1 (OAF 1) is 10.9%, derived from LiDAR-based inventory documented in Section 8.3 of the associated IP. The provincial default OAF 2 of 5% is used. This addresses the implementation instruction from the 2011 Chief Forester's AAC determination.
- The temporary and short-term nature of the June 2021 Old Growth Designated Area announcement in the central Walbran area and the November 2021 Old Growth Deferral announcement regarding Old Growth Strategic Review Panel recommendations deferrals does not align with the 300-year modelled planning horizon broken into 5- and 10-year periods. Therefore, it is omitted from the timber supply analysis and the Base Case. Additional Indigenous-led resources planning processes will guide future decisions.

2.2 Evolvement of Base Case Since MP #5

The Base Case in this timber supply analysis has evolved greatly since the MP #5 (Western Forest Products Inc., 2010). In addition to the iterative land use changes such as more biodiversity and wildlife related reserves since the previous AAC determination, there is a better available dataset in forest cover, advanced usage of LiDAR data, and several improved timber supply modelling assumptions and mechanics contributed to the differences between the two modelled harvest schedules.

Downward pressure on timber supply results is attributed to:

1. Different sources of TFL inventory:

The MacMillan Bloedel cruised-based legacy inventory was used in MP #5 and all the previous MPs. Stand yield and volume were projected in aggregation. Each stand was grouped by site productivity, age, species, and stocking condition (volume class in mature and in older second growth cruised during the last 30 years; basal area in cruised second-growth stands; and stems per hectare and distribution in younger stands). These measures of inventory were the best available data suited for the TFL management at that time. However, the boundary of TFL 44 has shrunk greatly since this legacy inventory was set up. Many source data points used to develop and calibrate stand volume projection are no longer inside TFL 44. This reality introduces greater uncertainty to inventory estimation and forest management, particularly if the method continues to be used in a geographical area that is a lot smaller than the original area used for inventory projections.

The uncertainty was mitigated by making an effort to convert the TFL44 legacy cruise-based modelled inventory to a more precise stand-based forest cover inventory. This stand-based forest cover dataset is used for the Base Case in MP #6. Each stand polygon now has its unique forest attributes, as opposed to an aggregated group projection approach used in MP #5. Iterative maintenance such as depletions and yearly growth of stands is conducted annually, similar to the updating procedures of the provincial Vegetation Resources Inventory (VRI). These two types of inventory methods result in differences in forest attributes from species composition, age, productivity, to volume and so on. They are highly supportive of the current estimation of the current forest inventory and future growth.

2. Different sources of Site Index (SI)

Biophysical site index model (BSIM) based SI was used in MP #5. This model assigns SI based on the leading tree species, BEC zone variant, and the geographic location (latitude, longitude as well as operating area in the old TFL 44 boundary from MacMillan Bloedel cruised-based legacy inventory). The TFL inventory source change and the substantive TFL area reduction discussed above made the BSIM model unsuitable for SI assignment.

In MP #6, SI comes from two sources based on stand age (described in Section 8.1 of the associated IP document). For natural stands established before 1962 (i.e. 57 years old and older), site index values are based on the forest inventory data, then aggregated to Land Base Blocking polygon, and weighted by area. For existing and future managed stands, site index values are based on Site Index Estimates by BEC Site Series (SIBEC). SIBEC is a long-term research project intended to provide site index estimates by tree species that reflect the average growth potential in forested site series in British Columbia.

There are alternative SI sources available for TFL 44. VRI in the South Island District was released within the last 5 years and TFL 44 is included in the VRI dataset. Therefore, VRI provides an independent assessment of SI. LiDAR heights can also be utilized to re-compute SI via Site Tools. These four SI data sources are presented in Table 1, with five leading species and the average for managed stands. It reveals that SIBEC used in the MP #6 is less than the BSIM approach used in MP #5. This change represents a 1.9m (7.2%) reduction in average SI for the managed stands between the two MPs. The LiDAR attributes have adjusted the overall site index upwards from SIBEC, but with some minor decreases in species such as Hw and Ba. VRI has the lowest overall site index amongst all the sources.

When it comes to timber supply impact, the ranking in overall site index has a positive correlation on the overall harvest level. The timber supply influence from LiDAR and VRI are presented as sensitivity analyses. MP #5 also examined the SIBEC-based SI implementation as a sensitivity analysis (Section 4.7 of the MP #5 timber supply analysis). The associated timber supply was 10.7% less than the MP #5 Base Case, when the average SI was 1.7m lower (6.3%) at that time.

Table 1 Managed Stand Site Index by Five Leading Species from Different Sources

Site Index Estimate Approach	Fd SI (m)	Cw SI (m)	Hw SI (m)	Ba SI (m)	Yc SI (m)	Overall SI (m)
MP #5 BSIM	27.1	20.4	20.0	33.9	29.0	28.4
SIBEC (MP #6 Base Case)	31.8	21.2	25.0	24.7	21.2	26.5
LiDAR	33.6	28.6	24.0	24.0	28.6	27.5
VRI	29.0	25.8	24.5	22.0	16.8	25.6

3. Different Operational Adjustment Factors (OAF) applications

OAFs are used to account for factors that reflect site conditions that in reality are not uniformly fully stocked and even-aged. Specifically, OAF 1 is used to account for voids or non-productive areas within a stand; and OAF 2 is used to account for forest health issues associated with the stand. The standard provincial default values for OAF 1 and OAF 2 are 15% and 5%, respectively.

In MP #5, a multiplicative OAF 1 and OAF 2 for uncruised stands (12% of total OAFs) and cruised stands (8% of total OAFs) were applied. This application was consistent with the previous MP. However, there was a request in the 2011 Chief Forester's AAC determination to assess this OAF application. As a response, LiDAR was used to evaluate voids and non-productive areas within stands (OAF 1) using LiDAR canopy crown data (Appendix C in the associated IP). Based on the findings from LiDAR, a LiDAR-based OAF 1 of 10.9% and the provincial default value of 5% for OAF 2 are applied in MP #6 (15.9% of total OAFs). The better data enables more accurate OAFs valuation for the TFL 44 land base. Note that higher OAF values represent an extra 3.9% to 7.9% reduction in managed stand yields compared to MP #5.

4. THLB Extra and/or Spatial Netdowns

Land use changes and THLB definition and netdown process have also contributed to the evolvement of the Base Case. The total area of TFL 44 reduced by over 2,500 hectares (1.9%) due to various Instruments and Ministerial Orders, but 5,330 hectares of THLB reduction (7.2%) is disproportionately more. This is attributed to several reasons:

- LiDAR implementation

Since the LiDAR acquisition of TFL 44 in 2016, LiDAR and its derived datasets have been used to assist in land use planning at both strategic and operational levels. LiDAR was leveraged to create more detailed mapping of low-productivity forests and forest operability that were not possible in the previous MP #5 THLB netdown process. This led to better identification of low productivity and inoperable sites and resulted in additional land base being excluded from the THLB.

- Iterative land use changes

Since the approval of MP #5 in 2011, there are many additional areas in TFL 44 that are set aside for forest values other than timber harvesting. These include more riparian management areas, ungulate winter ranges (UWRs), old growth management areas (OGMAs), wildlife habitat areas (WHAs), Marbled Murrelet habitat, wildlife tree retention areas, archaeological sites, and recreation sites. In addition, there are 12 active government research sites within TFL 44 associated with studying the growth of stands reforested with trial seedlings, fisheries, and silvicultural treatments. A 50m buffer was established around these research sites, which covers 383 hectares. A 60-year harvest deferral is applied in MP #6 on these areas to support ongoing research projects.

5. Different definitions of minimum harvest age

The minimum harvest volume of 350 m^3/ha remains unchanged, but the minimum harvest age between the two MPs has evolved to be more aligned with operational planning. In MP #5, minimum harvest age was defined by site productivity. There were four productivity classes in MP #5: high, good, medium, and poor. High productivity sites had lower minimum harvest ages and poor productivity sites had older minimum harvest ages. The MP #5 minimum harvest age ranged from 50 years in High to 90 years in Poor. In MP #6, a DBH and harvest system based minimum harvest age is employed. Harvest systems with a relatively lower cost have lower DBH requirements. Larger diameters in general reflect higher values and cable and helicopter yarding costs are particularly sensitive to log size. An economically sustainable harvesting program relies on average stand values being greater than average harvesting costs. Therefore, each analysis unit has three sets of unique minimum harvest age by harvest system. It is difficult to draw a direct comparison between the two approaches, but the oldest minimum harvest age for poor sites in MP #5 was 90 years old, whereas the equivalent weighted average minimum harvest ages for future managed stands in the Base Case in cable and helicopter system are 99 years old and 126 years old, respectively. When compared to MP #5, this indicates a postponement in the DBH and harvest system based minimum harvest age.

6. Different timber supply model mechanics

In MP #5, the timber supply modelling utilized Remsoft's Woodstock timber supply model. It is a pseudo-spatial model that simulates the forest estate sequentially. The spatial aspects of the land use objectives and requirements, such as cutblock adjacency and green-up, had to be achieved using proxies. Patchworks spatial timber supply model is used in MP #6. Both models can conduct timber supply analysis, but different modelling mechanisms and constructs can contribute to forming a different harvest schedule.

For instance, patch size targets are established so that Patchworks actively forms harvest patches of 5-40 ha in Vancouver Island Land Use Plan (VILUP) General & Special Management Zones, and 5-100 ha patches in Enhanced Forestry Zones. In other words, 0-5 ha and 50+ha patches in VILUP General & Special Management Zones and 100+ha in VILUP Enhanced Forestry Zones are not allowed. Patches of 40-50 ha are allowed to a minor degree in VILUP General & Special Management Zones, but not encouraged. This measure eliminates harvests in small stands or small stand aggregates that are economically inefficient, even though the minimum harvest criteria and other requirements are met. A five-hectare patch size was selected based on a review from blocks harvested since 2019 and blocks scheduled to be harvest until December 31st, 2023. It is indicated that 5ha will capture 90% of the blocks harvested recently or scheduled to be harvested in the short-term. However, it is also revealed that different harvest systems have different patch size distributions. Notably, the helicopter harvest system has a smaller patch size than the conventional harvest system. It is also noted that the planned harvest in existing natural stands will have smaller patch sizes than the harvests that occurred in the past, regardless of the harvest system. Therefore, a different Management Unit may have a separate set of patch size targets (e.g., 0-5 ha), or more refined patch criteria (e.g., patch size by harvest system by seral stage). Moreover, green-up heights for cutblock adjacency are assigned based on VILUP Resource Management Zones to ensure the achievement of green-up requirements.

In addition, the road network inside TFL 44 is incorporated within the Patchworks model so that Patchworks factors in the routes from potential harvest sites to various destinations. As a result, the

Patchworks model clusters the harvest (while meeting all non-timber objectives) to make the most efficient use of the road network. Based on the volume moved through each road section in a specific harvest schedule for different modelling periods, it enables road construction, maintenance and hauling cost tracking, which forms the foundation of operating economics and economic partition. None of these elements were capable in the MP #5 base case. The general hypothesis is that the spatial approach more accurately reflects what can be achieved, however the harvest projection may generally be less.

7. Economic Partition in short-term harvest

The current TFL 44 AAC was partitioned by economic operability and seral stage. MP #6 will continue to recommend an economic partition in the AAC to ensure the financial and ecological sustainability of the land base, and a smooth transition from old growth harvest to second growth harvest over the next two decades. Partitions are implemented in the model (Section 2.4) by directing the first 20 years of harvest to occur in truly economically viable stands first, defined by the net value objective expressed in $/m^3, then proceeding with harvest in other stands. For instance, if a stand meets the minimum harvest criteria and other requirements but is a significant drag from meeting the landscape-level net value objective (e.g. significant road construction cost compared to other stands), the model will prioritize harvesting other stands instead. This will create different harvest levels and schedules than if there is no such objective.

Upward pressure on timber supply results from:

1. Existing road Right-of-Way (RoW) site loss

Using LiDAR canopy height data, a review of vegetation gaps in road surface right-of-way areas in TFL 44 was conducted to determine the effective buffer for THLB determination (Section 6.5 and Appendix B in the associated IP). It was determined that the road buffers applied in MP #5 to represent site losses were likely too wide. This LiDAR-based process reduced the THLB reduction in this category from 4,068 hectares net THLB reduction in MP #5 to 1,592 hectares net THLB reduction in MP #6.

2. Spatial delineation of future roads

Thanks to the granularity of detailed information across the entire land base brought by LiDAR, future blocks and roads were assessed and spatially delineated by professionals at an operational scale. The improved future road network increased the THLB by reducing site loss to roads (see Appendix B of the associated IP) as well as reducing site occupancy within managed stands see Appendix C of the associated IP).

With all the changes indicated above, the inventory growing stock and area for both productive forest and THLB for MP #5 area, MP #6 area, and MP #5 data fit to the current MP #6 area are compared in Table 2. Based on the past harvest performance and land base changes over the 10 years, both THLB volume and area for MP# 6 are less than MP #5.

Table 2 Inventory Growing Stock and Area for Productive Forest and THLB among MP #5 Area and MP #6 Area

Land Base Category	Productive Forest		THLB		Source
	Volume ('000 m^3)	Area (Ha)	Volume ('000 m^3)	Area (Ha)	
Original MP #5	53,181	118,162	30,257	79,591	MP #5 Info Package
MP #5 Data Fit to MP #6 Area	52,410	116,745	29,537	78,486	MP #5 Information Package, clipped to current MP #6 tenure boundary
MP6	54,655	120,970	21,434	74,261	MP #6 Information Package

How the TFL 44 land base responds to these significant changes in timber supply is discussed in Section 2.6 below.

2.3 Base Case Harvest Statistics

The Base Case harvest flow is presented in Table 3 and Figure 2. All harvest volumes are rounded down to the nearest 100 and are net of the non-recoverable losses of 1% per year to account for windthrow, fire, insects, and diseases, as described in Section 9 of the associated IP. As noted, the first four periods are modelled in 5-year intervals and the rest of the 28 periods are modelled in 10-year intervals to provide a more granular view on the short-term timber supply forecasting.

Table 3 Base Case Harvest Levels

Period	Year	Start Year	End Year	Total	% Change from Previous Period
1	5	2020	2024	715,200	-9.9%
2	10	2025	2029	678,900	-5.1%
3	15	2030	2034	644,500	-5.1%
4	20	2035	2039	611,900	-5.1%
5	30	2040	2049	611,300	-0.1%
6	40	2050	2059	610,000	-0.2%
7	50	2060	2069	609,500	-0.1%
8	60	2070	2079	609,500	0.0%
9	70	2080	2089	635,700	4.3%
10	80	2090	2099	654,900	3.0%
11	90	2100	2109	668,900	2.1%
12	100	2110	2119	680,100	1.7%
13	110	2120	2129	689,300	1.4%
14	120	2130	2139	700,000	1.6%
15	130	2140	2149	711,000	1.6%
16	140	2150	2159	724,200	1.9%
17	150	2160	2169	738,700	2.0%
18	160	2170	2179	741,700	0.4%
19	170	2180	2189	741,500	0.0%
20	180	2190	2199	741,200	0.0%
21	190	2200	2209	740,400	-0.1%
22	200	2210	2219	739,200	-0.2%
23	210	2220	2229	737,400	-0.2%
24	220	2230	2239	736,000	-0.2%
25	230	2240	2249	734,800	-0.2%
26	240	2250	2259	734,300	-0.1%
27	250	2260	2269	734,300	0.0%
28	260	2270	2279	735,100	0.1%
29	270	2280	2289	736,200	0.1%
30	280	2290	2299	737,300	0.1%
31	290	2300	2309	738,300	0.1%
32	300	2310	2319	738,700	0.1%

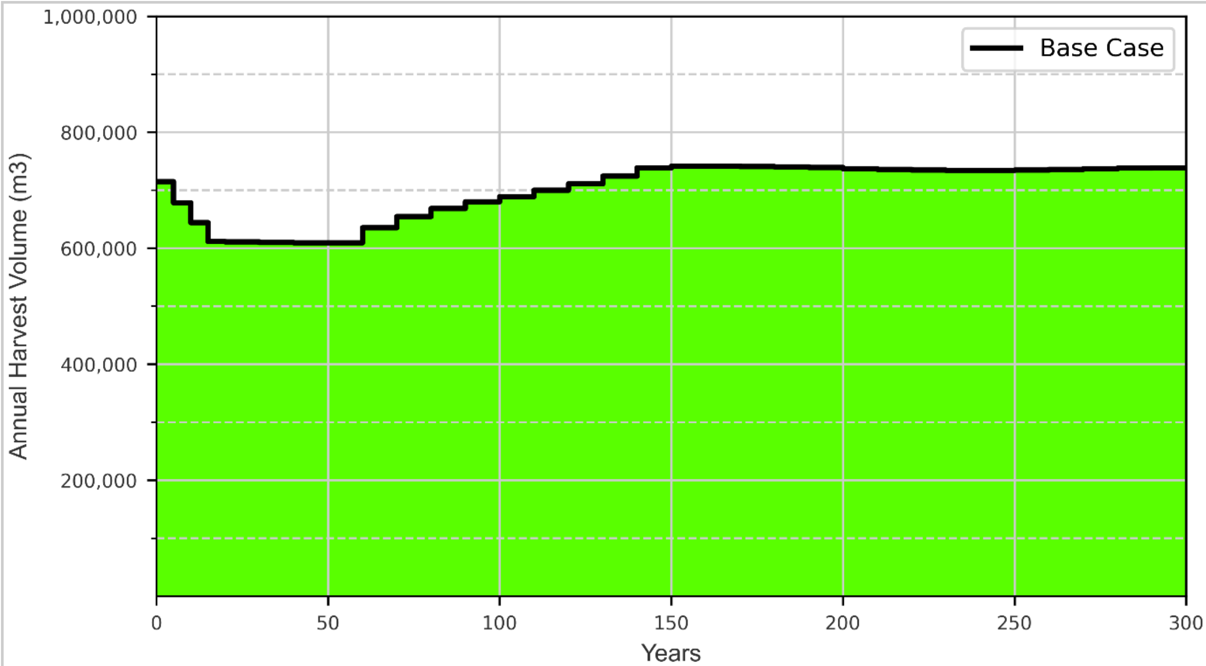

Figure 2 Base Case Harvest Schedule

The initial harvest level of 715,200 m^3/year for the first 5 years can be achieved when applying the assumptions and parameters discussed in Section 2.1. This is a reduction of 78,400 m^3/year (-9.9%) from the current AAC of 793,600 m^3/year. The harvest level is 678,900 m^3/year for the second 5 years of the 10-year horizon. When looking at the average harvest level of 697,000 m^3/year for the first 10 years, it represents a reduction of 96,600 m^3/year (-12.2%) from the current AAC.

The projected harvest level declines on average 5.1% per 5-year period over the following 15 years, reaching 611,968 m^3/year through to 2039. The harvest level stays at this rate for 40 years, before increasing to a long-term harvest level (LTHL) estimate of approximately 738,700 m^3/year.

The short-term timber supply “dip” occurs during the transition from natural to managed second growth stands (see Figure 4), coinciding with a period of low harvestable (i.e., meets minimum harvest criteria) inventory (see Figure 7 – GS total). The total volume harvested over the 300 years is roughly 210.36 million m^3.

Figure 3 indicates the contribution to the total harvest volume by period from each of the three broad stand eras used to define the analysis units. As expected, existing natural stands (greater than 57 years old in 2020, i.e., stands established prior to 1962) are the greatest proportion of the harvested volume in the first 10 years. But their contribution is less than half of the harvested volume at Year 20, then comes back slightly at Year 30, before further dropping below 10% the harvested volume at Year 50. The existing managed stands starts at below 10% of the harvested volume in the first decade, but their contribution quickly rises to nearly half of the harvested volume in the subsequent 10 years. They provide the largest proportion of the volume briefly at Year 20, but consistently starting at Year 40, as natural stands’ harvest continues to decline. Future managed stands contribute some volume for harvest in the sixth decade (2070 – 2079) and provide most of the harvest volume as of the tenth decade (2110 – 2119).

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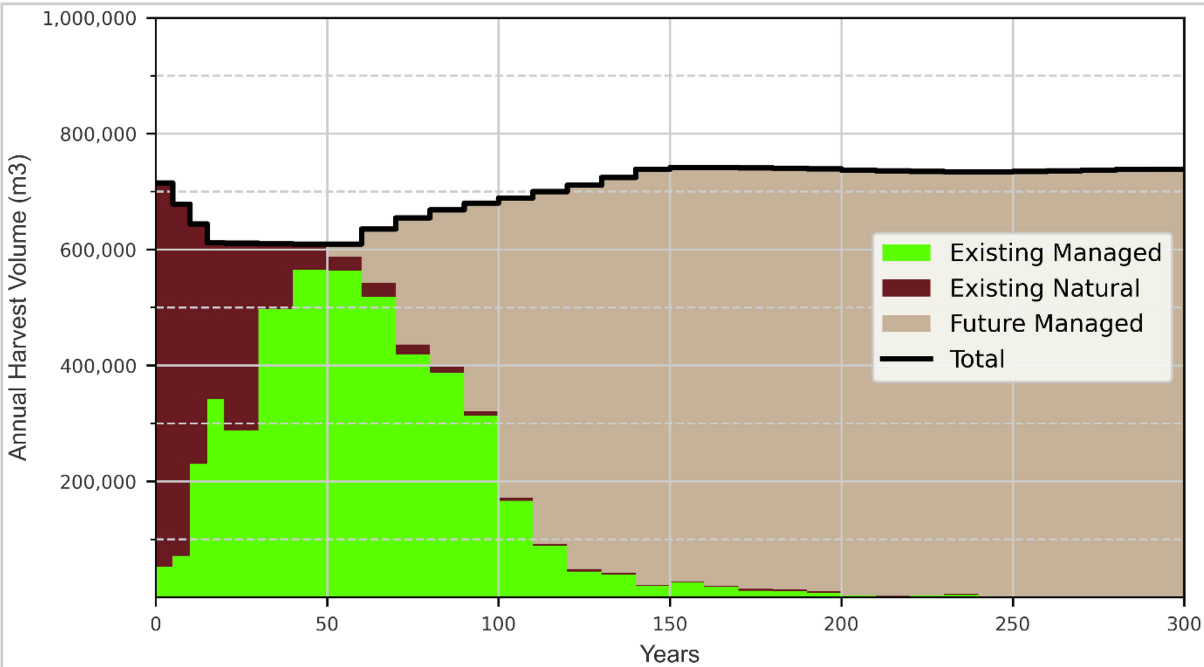


Figure 3 Stand Eras' Contribution to Base Case Harvest

Figure 4 illustrates the harvest level by seral stage. As expected, existing old stands (greater than 250 years old in 2020) contribute more than half of the harvested volume in the first 10 years. But in the subsequent 20 years, their contribution decreases to below 1/3 of the harvested volume, and quickly becomes negligible after Year 40, counting less than 3% of the projected annual harvest level. The mid seral stands provide the largest proportion of the volume in Year 15 and Year 20 as old stands' harvest continues to decline. But mature seral stand harvest takes over at Year 30 and become the largest contributor to the harvest in the next 160 years until Year 210, after which mid seral and mature seral stand harvesting alternates as the largest contributor in the last 90 years of the planning horizon.

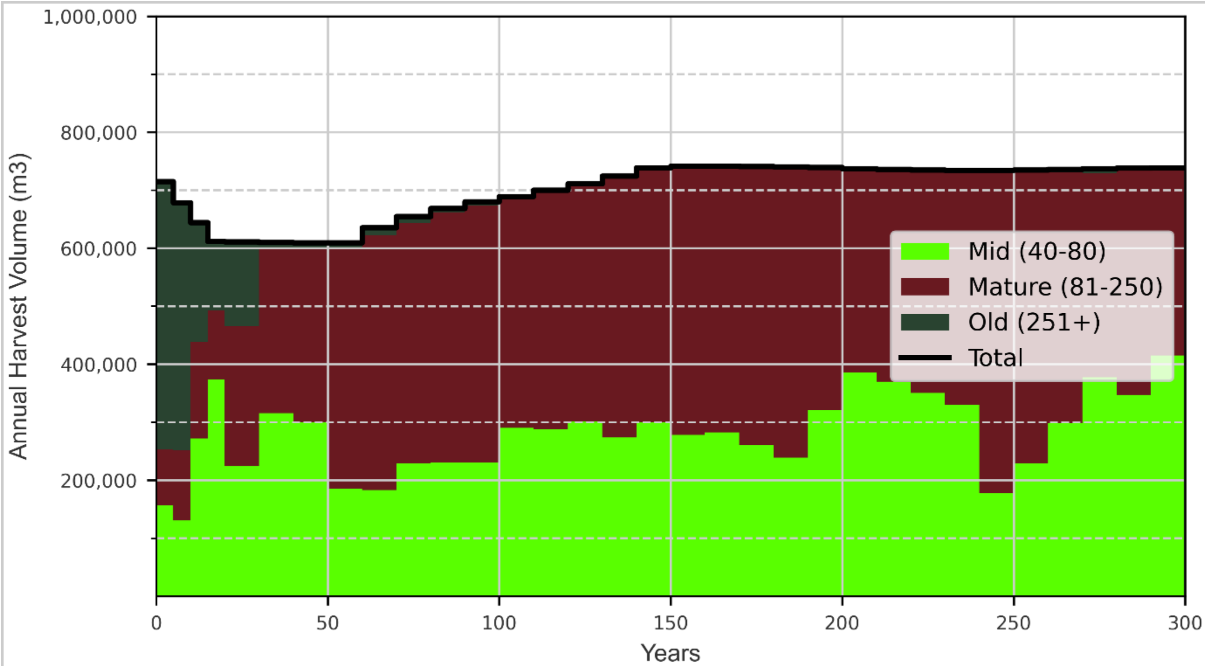


Figure 4 Stand Seral Contribution to Base Case Harvest

The detailed age class distributions over time are examined in Figure 5 for productive forests (THLB and NCLB). A snapshot of the age class distributions is taken every 50 years. The oldest age class currently covers more than 39,600 hectares, accounting for 32% in the entire productive forests. Over three quarters (76%) of them are outside of the THLB. As harvesting of current old stands occurs in the THLB, the total productive area in the oldest age class gradually declines, but then increases to more than 48,400 hectares by Year 300. This represents 22% more than the current amount, as younger reserved timber ages into the oldest age class. The total THLB area less than 80 years old increases initially as harvesting in natural older aged stands occur, up to 10% more than the current amount at Year 40, until a relatively balanced age class distribution is achieved (refer to Figure 9) in a fully regulated forest. The THLB age class distribution at the end of the harvest schedule (2270) is relatively balanced, whereas the oldest age class is mostly conserved. This age class distribution ensures a sustainable harvest beyond the analysis period is achievable.

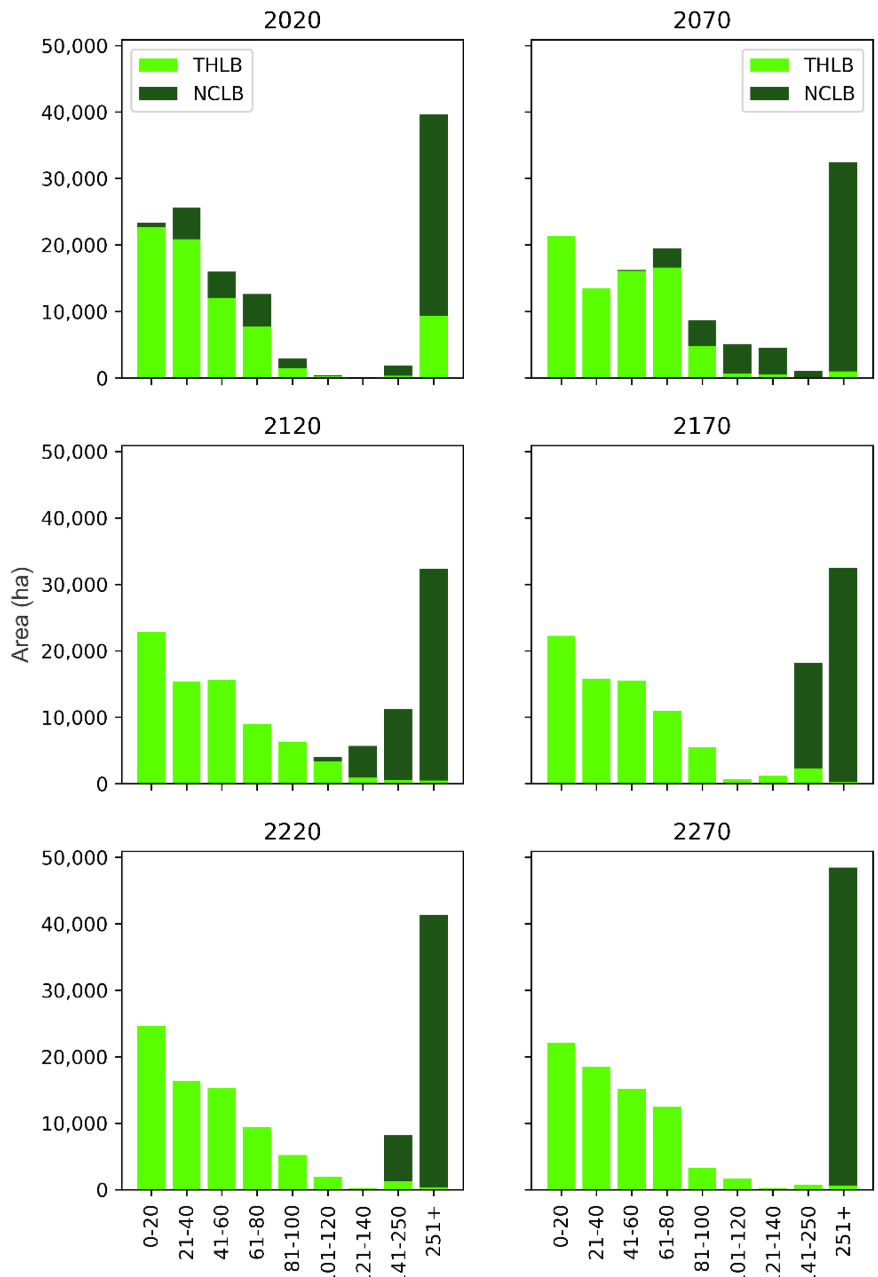


Figure 5 Base Case Age Class Distribution of Productive Forest Area (120,970 ha)

In terms of harvest systems, the timber harvesting land base is dominated by the conventional harvest system (see Figure 6). Helicopter harvest only accounts for an average of 6% in the entire 300-year planning horizon, in which the range varies from 1% (Year 40 – Year 90) to 13% (Year 0 – Year 5) of the volume harvested in any given period. Conventional harvesting is generally an even split between ground-based and cable-based harvesting. After the land base reaches LTHL after Year 150, the cable-based harvest system contributes on average 5% more towards the total volume harvested than the ground-based harvest system, notably around Year 250 and Year 260.

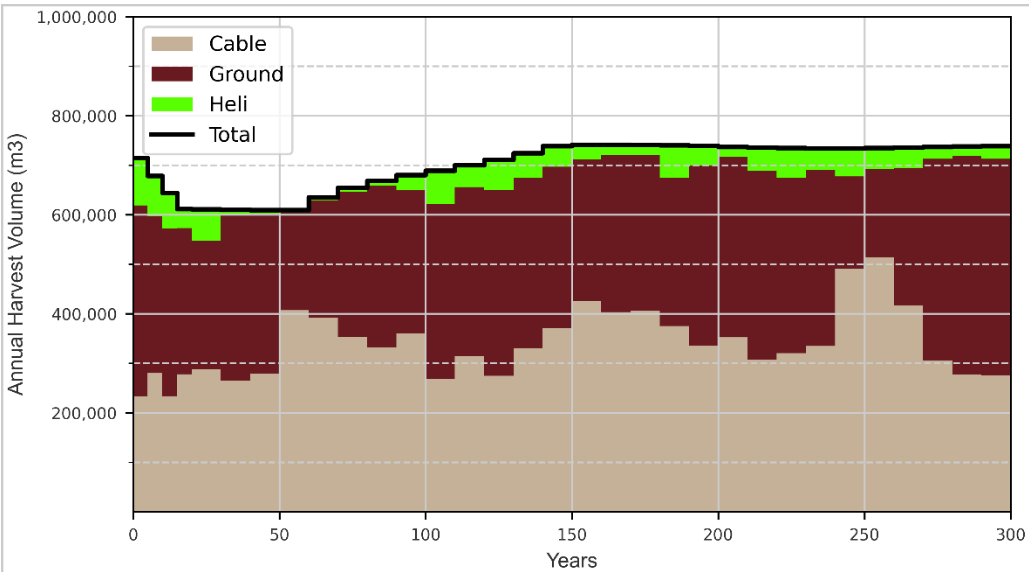


Figure 6 Base Case Harvest System

Figure 7 illustrates merchantable (i.e., meets minimum harvest criteria) and growing stock (GS) levels for the timber harvesting land base by the conventional / helicopter harvest system split. The initial GS level for the THLB is approximately 21.9 million m³. This is in line with the current THLB inventory volume indicated in Table 6 of the associated IP.

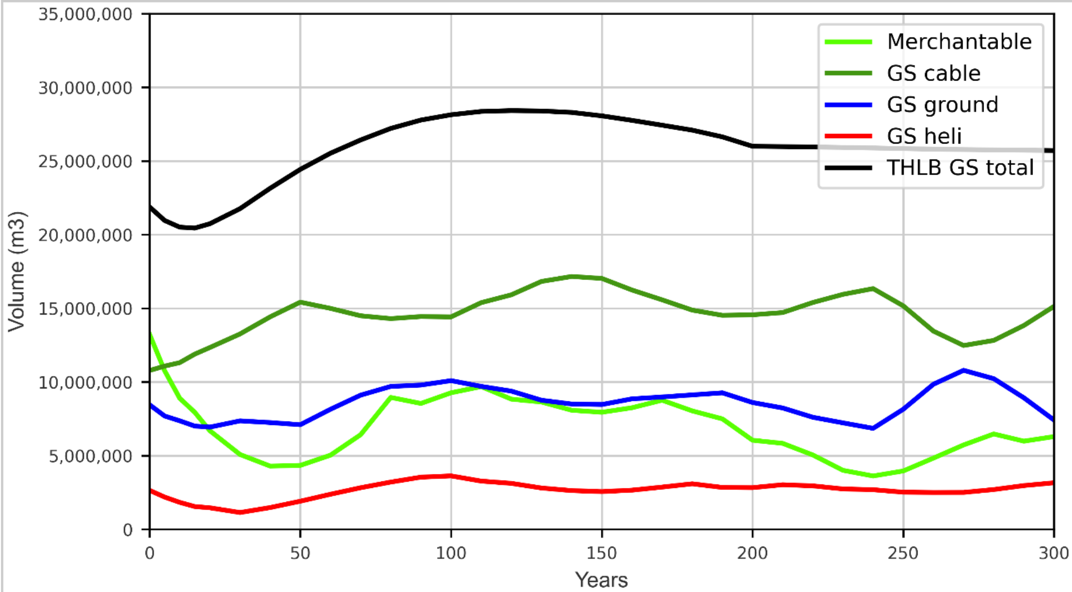


Figure 7 THLB Growing Stock by Harvest System

The total THLB GS declines below the starting level by up to 6.6% over the first 15 years while older stands contribute a considerable proportion of the total harvest. Then the GS level increases after Year 15 once the contribution from existing managed stands makes up a meaningful amount of the harvested volume. The total GS level continues to grow as future stands begin to acquire merchantable volume. The total GS reaches up to 30% more of the starting GS between Year 110 to Year 130 before stabilizing at Year 200 at approximately 18% more than the initial GS. This pattern corresponds well with the contribution of each stand era or stand seral stage to the total harvest level over time shown in Figure 3 and Figure 4. Once the transition to future managed stands is completed, THLB GS is steady at approximately 25.8 million m^3.

Conventional (ground and cable) THLB GS declines initially as current mature stands are harvested. As second growth stands begin acquiring merchantable volume, the conventional THLB inventory increases above current levels at Year 20 and then averages approximately 23.5 million m^3 (8.7 million m^3 for ground and 14.8 million m^3 for cable), which is about 22% more than the starting conventional THLB GS.

Helicopter THLB growing stock initially declines as current stands are harvested. Year 30 to Year 40 are projected to have the lowest helicopter THLB GS available, which resulted the smallest proportion of the harvest from the helicopter harvest system shown in Figure 6. But then it recovers to a long-term average of 2.8 million m^3, about 5% more than the initial GS level.

A detailed view on merchantable THLB growing stock by harvest system is provided in Figure 8. The total merchantable THLB volume begins at 13.2 million m^3 and declines over the first 40 years as mature and existing second growth stands are harvested and replaced with managed stands. Once the transition to future stands is complete and THLB GS is stabilized after Year 200, harvestable volume fluctuates between 3.6 and 6.5 million m^3, averaging about 5.3 million m^3. Each merchantable volume by harvest system follows the same trend.

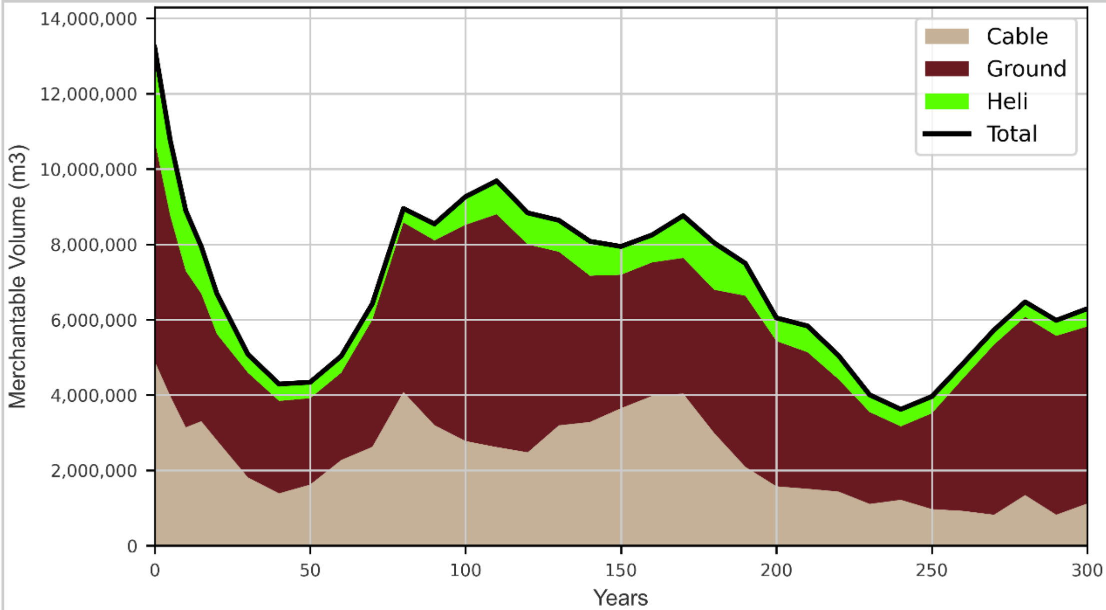


Figure 8 Merchantable Growing Stock by Harvest System of Base Case

Figure 9 provides average statistics for timber harvested through the harvest projection. As expected, the mean age of stands harvested (yellow line) declines rapidly as the transition to managed stands occurs. The average age of harvested stands (shown as the secondary y axis in Figure 9) starts at 223 years and continues to decline to 82 years old in the mid-term at Year 40. Then it stabilizes between 80 to 90 years old for the rest of the 250 years. Annual area harvested (dark green line) generally fluctuates between 763 and 987 hectares, with a long-term average of 875 hectares. The merchantable volume per hectare harvested (light green line) varies within a range of 722 to 916 m^3/ha, with a long-term average of 850 m^3/ha.

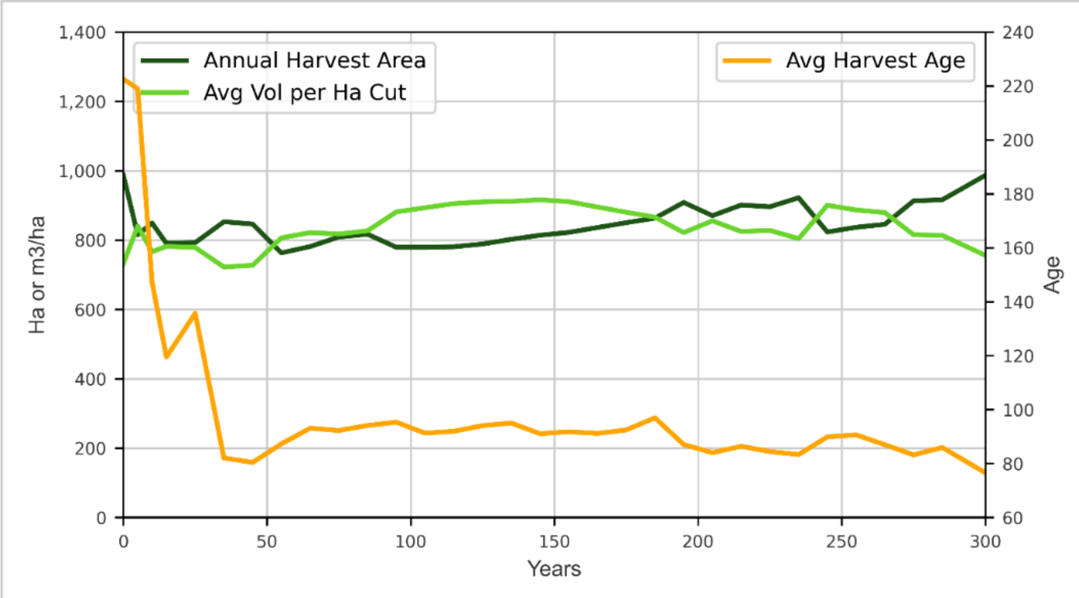


Figure 9 Base Case Harvest Statistics

Figure 10 shows the species composition of the volume harvested. Hemlock and balsam ("HemBal") are the dominant species in the harvested volume for both existing and future stand eras. Hemlock consistently accounts for at least 1/3 of the harvested volume in any given period. Douglas-fir has the second largest presence in both natural and existing managed stands, delivering more than 1/4 of the harvested volume on average. Western red cedar contributes just over 10% of the harvest volume in the short-term. However, as the land base transitions into harvesting future managed stands, its contribution increases to approximately 30% of the long-term harvested volume due to reforestation strategies.

In the short-term until Year 20, roughly 52% of the harvest is HemBal, with Douglas-fir, red cedar, and yellow cedar contributing roughly 29%, 11%, and 4%, respectively. Between Year 30 to Year 150, as the projected harvest volume experiences an even flow low point, followed by a steady climb, HemBal contributes 42% and Douglas-fir contributes 26% of the harvest, with red cedar providing most of the remainder.

From Year 150 to the end of the planning horizon, Hembal, red cedar and Douglas-fir consistently account for 42%, 29%, and 25% of the harvest volume, respectively.

Few (average 3%) yellow cedar are harvested over the 300-year planning horizon due to lack of its presence in both natural and managed stands. Approximately 2% is sourced from other minor coniferous species such as spruce and pine and deciduous species such as red alder.

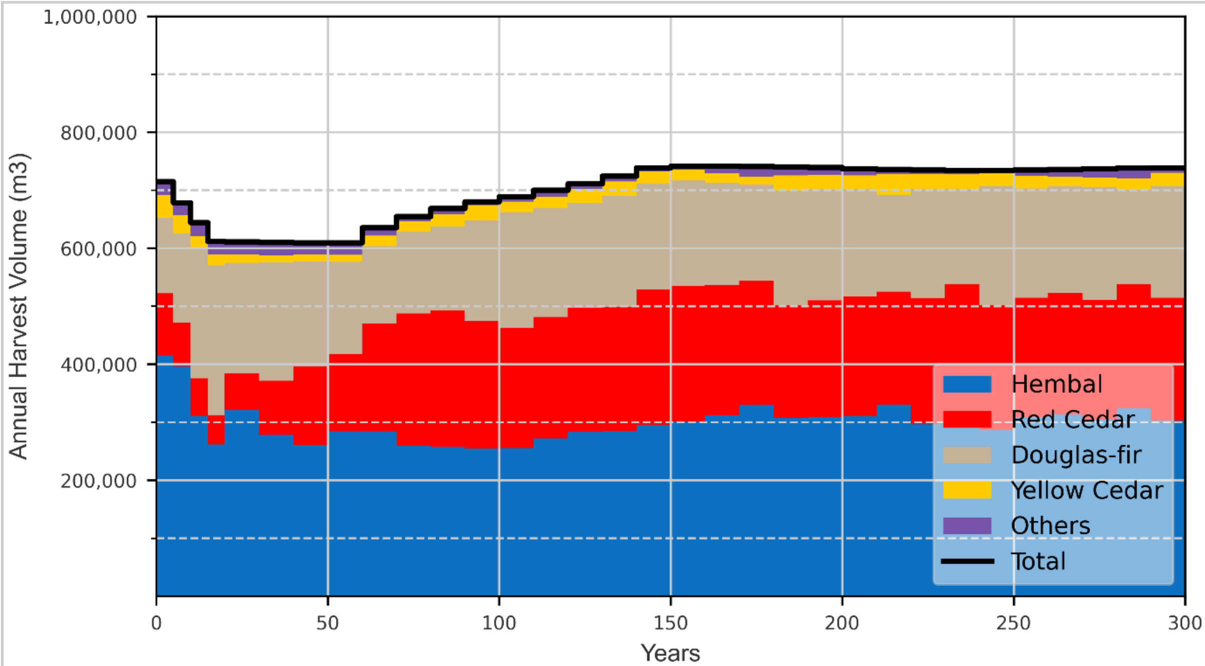


Figure 10 Species Composition of Base Case Harvest

Elevation ranges of less than 300m (generally operable year-round), 300m – 800m (generally operable from spring to early winter) and greater than 800m (generally only operable summer to early winter) for the Base Case are illustrated in Figure 11. Overall, the harvest contributions from the three elevation bands hold steady across the 300-year planning horizon, except for harvest in higher elevations for the first decade due to targeting natural old stands. The average harvest contributions for the three elevation bands are 40%, 56% and 4%, respectively, with a standard deviation of 4% for the less than 300m and 300m-800m bands, and 3% for the 800+m elevation band.

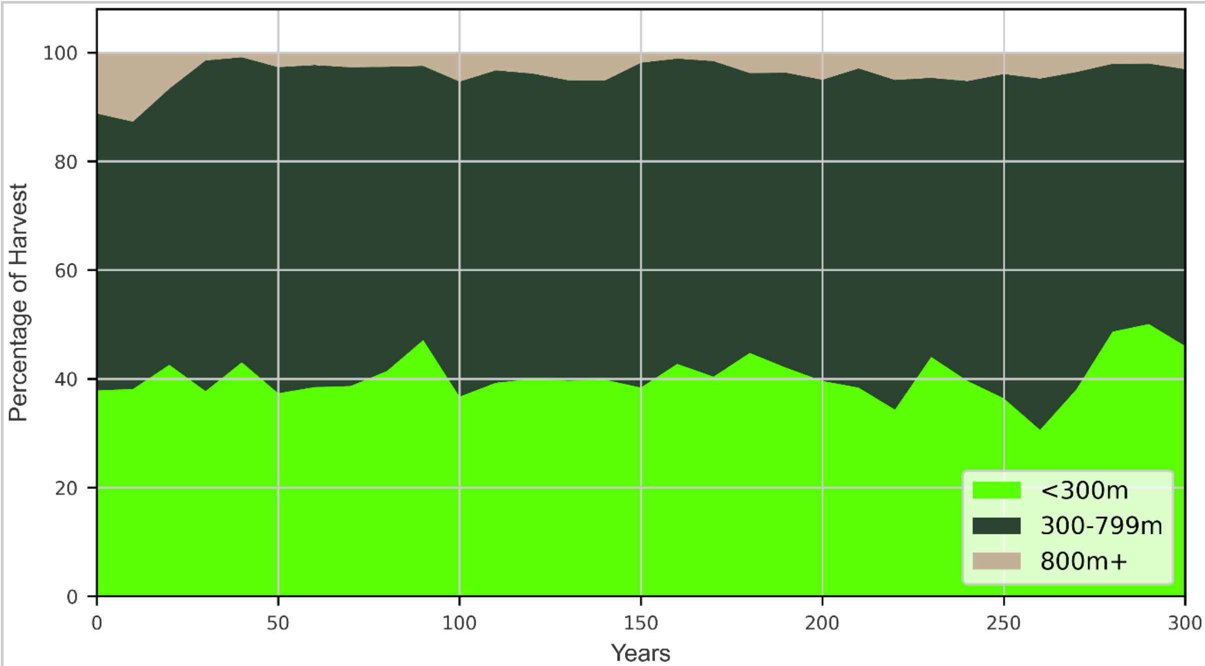


Figure 11 Harvest percentage by elevation range

2.4 Economic Partition

In the December 2020 Chief Forester's Partition decision, the TFL 44 AAC was partitioned into two categories: 1) economic operability and 2) seral stage (e.g., stands less than 121 years old). Because the intent for the economic partition is to manage the transition from old growth to second growth over the next two decades, and to ensure the sustainable management of timber supply, the economic profile in the timber supply modelling is shown for the first 20 years of the harvest schedule.

To implement and model the economic partition in the timber supply analysis, an economic metric for the land base is established. The economic metric is based on three factors:

1) past average stumpage rate for TFL 44;
2) the margin indicated in the 2020 Economic Analysis for TFL 44 (Western Forest Products Inc., 2020), which includes earnings before interest, taxes, depreciation, and amortization (EBITDA), excluding stumpage, and was expressed in dollars per cubic metre ($\$/m^3$);
3) second growth stands (SG; stands less or equal to 120-year-old) chosen by the modelled scenario are considered economic due to previous harvest history. This assumption is consistent with the 2020 Economic Analysis (Western Forest Products Inc., 2020).

Because the 2020 Economic Analysis was to investigate and impose partitions on AAC that were based on the previous MP #5, a portion of the harvest is inevitably from part of the land base deemed to be not economically viable. And the Chief Forester recognized this challenge in the December 2020 decision. This timber supply analysis is carried out with the economic partition as part of the model assumption. The time frame of the financial data ranges from 2018 to 2020 and it is still relevant to this timber supply analysis. Therefore, the same economic data points are used in the timber supply modelling.

Because of the economic operability foresight in the timber supply analysis, and the ability to model harvesting spatially while tracking road-related costs via Patchworks, a different approach is used in the modelling process. Firstly, much of the uneconomic land base for TFL 44 has been excluded from the THLB, either due to physical operability (described in the Section 6.8 of the associated IP), or economic operability (described in the Section 6.13 of the associated IP). To establish an economic partition to the projected harvest level, instead of assigning an economic land base indicator to each stand, a tenure-wide landscape-level net value objective (expressed in $/m^3) is established. The value is equivalent to summation of the quarterly average stumpage rate from Q1 2010 to Q3 2021 in TFL 44, and the EBITDA margin indicated in the 2020 Economic Analysis. This net value objective is applied to the first 20 years of the modelling period. The modelled harvest schedule strives to generate a landscape-level net value equal to or above this net value objective for each 5-year interval of the 20 years. With Patchworks' optimization function, the modelled harvest schedule will form the new economic partition to best reflect the operational reality and economics for TFL 44. Once the economic harvest schedule is established, the model further develops the harvest schedule with no net value objective to achieve a full harvest capacity with all the other land base objectives met.

As for the seral stage, the same age criteria of 120-years-old (age at Year 2020) is used to profile the modelled harvest schedule. Stands less or equal to 120-year-old chosen by the modelled scenario are considered economic due to previous harvest history.

The economic profile of the Base Case harvest is shown in Table 4. Figure 12 provides a graphical snapshot. Data in 5-year intervals is presented to provide better granularity for decision-making. Overall, more than 3/4 of the harvest comes from the economic land base. This outcome is sensible given economic partition is one of the objectives to consider in the timber supply modelling.

Within the economic partition, in the first 5 years, 55% of the harvest consists of stands greater than 120 years old. Their contribution decreases by 3% to 52% in the following 5 years. The average harvest contribution for 120+ years old stands in the first decade is 53%. From 2030 to 2034, however, the harvest contribution reduces to 19% of the total economic partition volume, and dips to only 9% from 2035 to 2040. This corresponds to the average harvest age drop shown in Figure 9. It demonstrates that with economic margin considered in the harvest level modelling, the transition from harvesting primarily mature to old forests to harvesting mid to mature forest will occur in the imminent future. And it makes sense to profile the economic partition for the next 10 years (2020 to 2029).

Table 4 Economic Partition of Base Case Harvest

Year	Base Case (m^3)						
	Harvest Level	Economic > 120 years	Economic <= 120 years	Total Economic	Economic %	> 120 years within Economic %	Definition of Economic
Current AAC	793,600	425,000	110,000	535,000	67%	79%	• 2020 TFL 44 Economic Analysis • All SG is economic
2020-2024	715,200	294,100	244,800	538,900	75%	55%	• Timber supply model selection • All SG is economic
2025-2029	678,900	268,100	244,100	512,200	75%	52%	
2030-2034	644,500	104,100	429,900	534,000	83%	19%	
2035-2039	611,900	47,800	491,000	538,800	88%	9%	

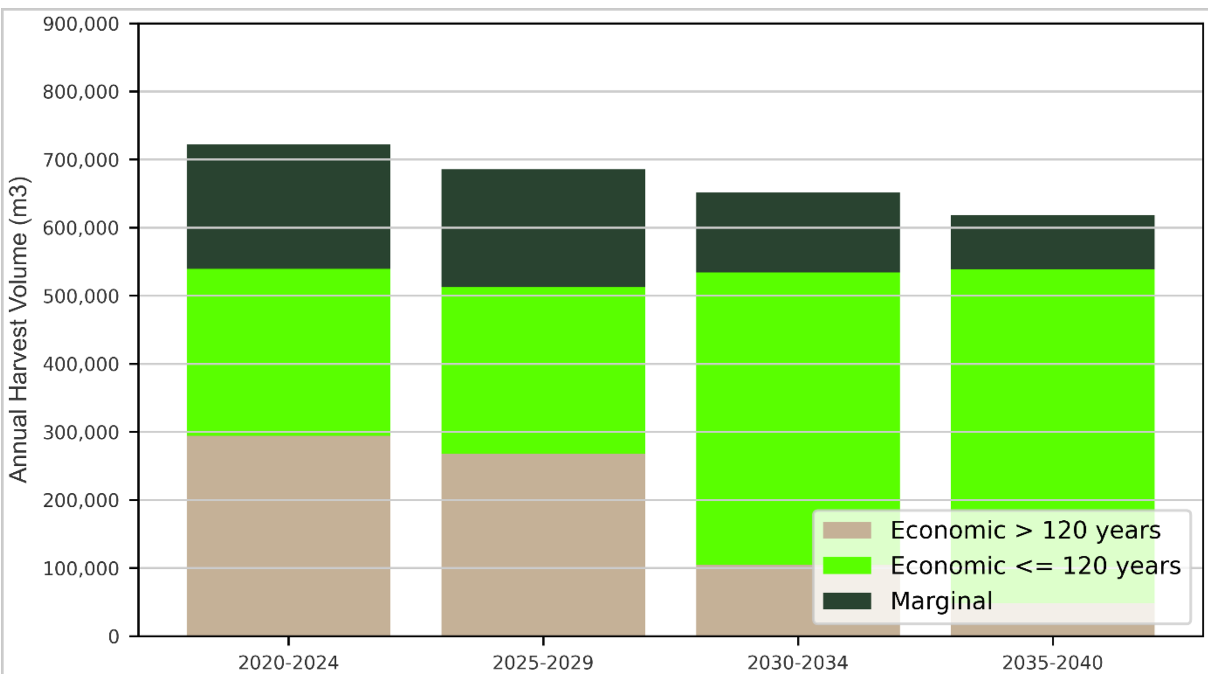


Figure 12 Economic Partition of Base Case Harvest

2.5 Western Red Cedar and Yellow Cedar Projections

Traditional and cultural uses of cedar (Western red cedar and yellow cedar) are important to First Nations. Opportunities for accessing and managing cedar have increased through the allocation of AAC to First Nations. Monumental cedar was also identified as an implementation item of note in the 2011 TFL 44 AAC Determination Rationale. A monumental cedar conservation strategy has been discussed via a robust big tree retention policy (Western Forest Products Inc., 2019) and this has been addressed in the existing and future stand-level retention netdown. Details can be found in Section 3.6 of the associated IP document. The other factor for supplying monumental cedar is to analyze the cedar volume on the land base given the projected harvest schedule in the Base Case.

Currently, 16% of the productive GS contains cedar (more than 10 million m^3). This proportion increases to 22% (more than 17 million m^3) for the long-term productive GS once the harvest level stabilizes.

On the other hand, harvested monumental cedar are also highly valued for cultural uses. The harvest profile of cedar has been illustrated in Figure 10 of Section 2.3. The estimated volume of western red cedar (Cw) and yellow cedar (Yc) on the THLB and Non-Contributing Land Base (NCLB) associated with the Base Case harvest schedule are demonstrated in Figure 13. The summation of the two land base categories represents the Cw and Yc volume within the total productive forest. These estimates are based on the current cedar component in the TFL 44 forest cover and each analysis unit.

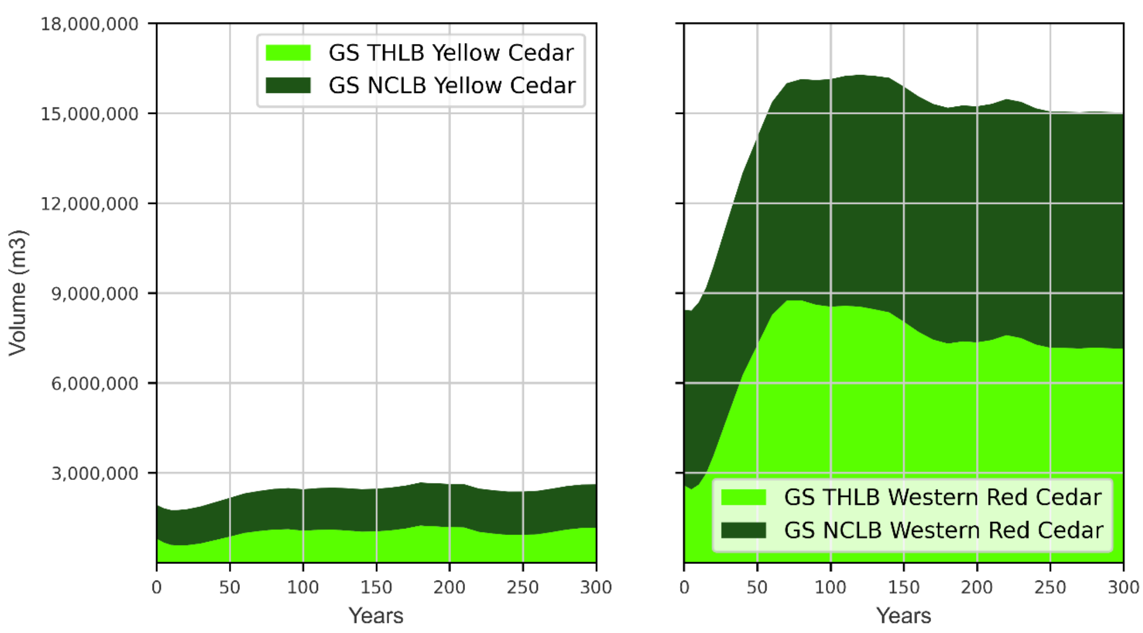


Figure 13 Base Case Cedar Inventory

The amount of cedar (Cw and Yc) declines over the first 5 years as harvesting occurs in the oldest stands. The reason for this temporary decline in cedar inventory is that the older managed stands and younger unmanaged stands have less cedar within them. Older managed stands are dominated by Douglas fir (Fd) as it was the main species planted due to early seedling production focussing on fir. Younger unmanaged stands are dominated by Fd and hemlock (Hw) as these species naturally regenerate very successfully after harvesting while cedar tends to form a minor component. The dominance of fir in these age ranges can be seen by the significant increase in Fd harvest in Year 20 to Year 40 in Figure 10 when cedar harvest is low. However, the declines are very minor (maximum 5.2% for Cw and maximum 16.5% for Yc). By the time old stand contribution to harvest is less than 10% at Year 50 (Figure 4), Cw and Yc inventory volumes climb to higher levels than the initial GS. This is particularly true for Cw as its THLB volume and its composition in the total THLB GS are more than doubled at Year 50 compared to the starting GS. This indicates there is a large inventory of Cw within the existing managed stands. Their presence in the THLB, the relatively lower component in the harvest schedule during these periods, and the ability to acquire volume with a faster greater mean annual increment (MAI) contribute to the fast cedar volume recovery and acceleration from the initial drop due to harvesting old stands. In addition, recent reforestation strategies have ensured cedar forms a more substantial component of regenerating stands (future managed) than early planting efforts.

Yc volume accounts for between 3% to 5% of the THLB GS and 3% of the NCLB GS. Its proportion holds steady for the entire 300-year planning horizon.

After the harvest level enters the LTHL at Year 150, the total productive cedar volume is 77% more than the current volume and averages in excess of 17 million m^3 from then until the end of the planning horizon.

Figure 14 illustrates the total volume of Cw and Yc greater than 250 years old within the productive forest. Total old cedar currently is 7.7 million m^3. It then declines in the short-term as harvesting of old stands occurs. Once the harvest transitions out of existing natural stands at Year 30, its volume becomes relatively stable for a lengthy period (150 years) at above 6 million m^3. At Year 160, the amount of old cedar begins to increase steadily as today’s reserved young stands age beyond 250 years. At the end of the planning horizon, the land base has approximately 9.5 million m^3 of cedar greater than 250 years old, about 23% more than today’s 250 years and older cedar volume.

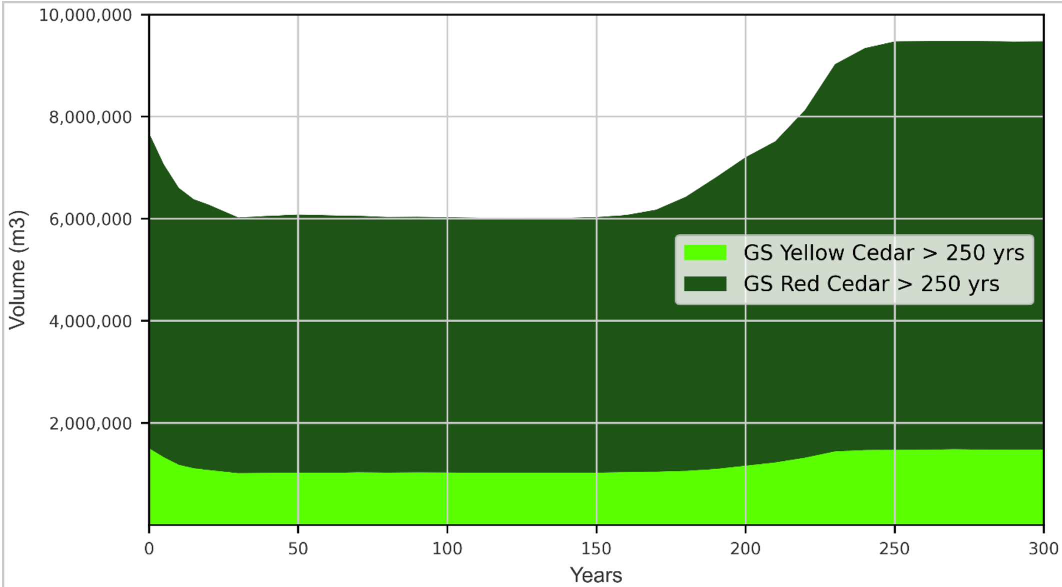


Figure 14 Volume of Old Cedar in Productive Forests

2.6 Timber Supply Changes Since MP #5

As can be seen in Section 2.2, changes in input data and model assumptions relative to those applied in MP #5 are significant. Isolating each factor clearly and quantifying its proportional timber supply impact is a challenging task due to the intertwined and complex nature of forest dynamics. However, a series of model runs were conducted to benchmark against the MP #5 timber supply result to explain the influence of each factor. The first four changes that bring downward pressure to the timber supply are: inventory source, site index source, OAF, and THLB netdown, and the two changes that bring upward pressure: Road Right-of-Way and future roads in the LiDAR–based THLB netdown, to the MP #6 Base Case are either impossible to provide (e.g. updating outdated MP #5 inventory to Year 2020), or are fully engrained into the MP #6 timber supply processes (e.g. THLB netdowns). Therefore, it is prudent to form a MP #5 benchmark using the MP #6 dataset and Patchworks model with these changes acknowledged. However, the 60-year harvest delay for research sites was reverted as this was not part of the MP #5 Base Case forest practice.

The MP #5 benchmark scenario is then created by disabling the Patchworks spatial functions to mimic behavior from a pseudo-spatial timber supply model. Specifically, cutblock patch accounts are disabled, and spatial road network is removed from Patchworks model. The same aspatial proxy to control adjacent cutblock green-up in MP #5 is applied: a maximum of 25% of the THLB within a zone but outside of VQO polygons is permitted to be less than 10 years old. Green-up requirements are not modelled in the Enhanced Forestry Zones (outside of VQO polygons). It is acknowledged that the Patchworks timber supply model will still use a heuristic search algorithm to find the best solution, instead of linear programming used in the Woodstock timber supply model used in MP #5.

As for minimum harvest criteria, what the MP #5 did differently is that it utilized site productivity classes to specify minimum harvest age. There were four site productivity classes in MP #5: high, good, medium, and poor, and their corresponding minimum harvest age were 50, 60, 70 and 90 years old, respectively. But the poor site class accounts for less than 1% of the MP #5 THLB, so the MHA of 90 years in poor site is largely irrelevant to the timber supply impact. The site productivity class is embedded in the AU definition. In MP #5, site productivity classes were based on the BSIM site index value for the future stand leading species by BEC variant, whereas the site productivity class for the same stand type in MP #6 is based on the SIBEC site index value range by variant. The differences in site index sources are illustrated in Section 2.2 already. Therefore, this MP #5 benchmark scenario employs the following minimum harvest age: 50 years old for MP #6 good sites; 60 years old for MP #6 medium sites, and 70 years old for MP #6 poor sites. The minimum harvest volume of 350 m^3/ha is still applicable.

Table 5 and Figure 15 demonstrate the results of comparing MP #5 base case (brown line) against MP #5 Benchmark Scenario (dark green line). Year -10 to Year 0 represents the period since the completion of MP #5 until this timber supply analysis. It must be acknowledged that the associated AAC determined by the Chief Forester in 2011 was 800,000 m^3/year which is 4.5% lower than the modelled harvest level of 837,200 m^3/year in MP #5. Also, the current AAC is 793,600 m^3/year, which is 1.6% lower than the modelled harvest level of 806,600 m^3/year at the time of completion.

The MP #5 benchmark scenario demonstrates that the current collective timber supply impact brought by inventory source difference, SI source difference, OAF application difference, and additional THLB netdown is 64,100 m^3/year (-7.9%) and 75,500 m^3/year (-9.4%) for each of the 5-year period in the first decade. The impact against the current AAC of 793,600 m^3/year for the first 10 years is 56,800 m^3/year (-7.2%).

The MP #5 benchmark scenario is unable to maintain the even flow harvest pattern like the MP #5 Base Case to meet all the non-timber objectives. As a result, the projected harvest flow must step down gradually, increasing the gap up to 10.7% at Year 20. As increasingly vigorous growing second growth stands become merchantable in the mid-term, the gap starts to shrink at Year 30, and finally stabilizes to 6.8% less than the MP #5 LTHL.

Table 5 MP #5 Base Case and MP #5 Benchmark Scenario Harvest Levels

Period	Start Year	End Year	Annual Harvest Volume (m³)			% Difference
			MP #5 Base Case	MP #5 Benchmark	Difference	
0	2008	2012	837,200	N/A	N/A	N/A
0	2013	2019	806,600	N/A	N/A	N/A
1	2020	2024	806,600	742,500	-64,100	-7.9%
2	2025	2029	806,600	731,100	-75,500	-9.4%
3	2030	2034	806,600	722,600	-84,000	-10.4%
4	2035	2039	806,500	720,000	-86,500	-10.7%
5	2040	2049	806,600	721,300	-85,300	-10.6%
6	2050	2059	806,600	726,700	-79,900	-9.9%
7	2060	2069	806,600	734,900	-71,700	-8.9%
8	2070	2079	806,600	741,000	-65,600	-8.1%
9	2080	2089	806,600	745,300	-61,300	-7.6%
10	2090	2099	806,600	750,500	-56,100	-7.0%
11	2100	2109	806,600	753,900	-52,700	-6.5%
12	2110	2119	806,600	758,700	-47,900	-5.9%
13	2120	2129	806,600	759,800	-46,800	-5.8%
14	2130	2139	806,600	759,700	-46,900	-5.8%
15	2140	2149	806,500	759,700	-46,800	-5.8%
16	2150	2159	806,600	759,400	-47,200	-5.9%
17	2160	2169	806,600	759,100	-47,500	-5.9%
18-26	2170	2259	806,600	751,800	-54,800	-6.8%

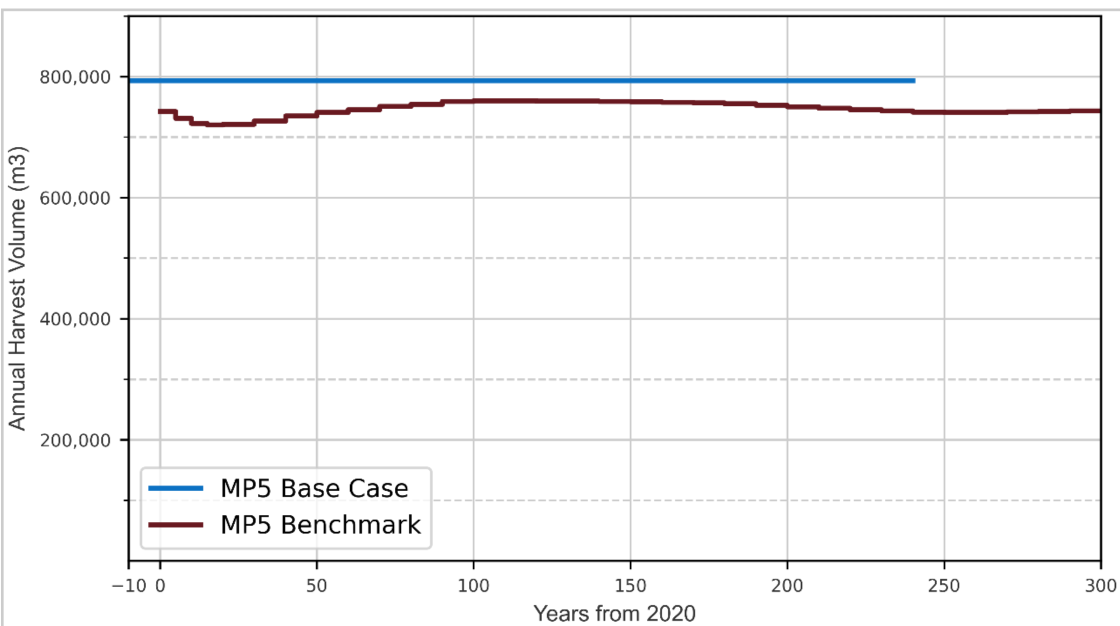


Figure 15 MP #5 Base Case and MP #5 Benchmark Scenario Harvest Levels

The second MP #5 benchmark scenario is to test the timber supply impact brought by the different minimum harvest age criteria. As described in the downward pressure factor No. 5 in Section 2.2 above, minimum harvest age was based on site productivity in MP #5, whereas it is based on average DBH and harvest system in MP #6. This “MP #5 New MHA” scenario substitutes the minimum harvest age in the

MP #5 benchmark scenario with the MP #6 Base Case minimum harvest age. The difference from the first MP #5 benchmark scenario is the timber supply impact of the different minimum harvest age criteria.

Table 6 illustrates the two different sets of minimum harvest age, as well as the 95% Culmination MAI age from the current MP #6 inventory. The comparison shows a significant difference when the two different structures of minimum harvest age are applied. The MP #5 minimum harvest age applied onto MP #6 inventory will lead to average minimum harvest age being earlier than the 95% Culmination MAI age, which is a close approximation of the "optimal biological rotation age to maximize long-term volume" for the current inventory (Province of British Columbia, 2008). Having said this, it must be recognized that the inventory attributes, site productivity source, and THLB areas are vastly different than the original MP #5 dataset. It does not indicate that the MP #5 minimum harvest age was not sustainable at the time of the previous timber supply analysis.

Table 6 Minimum Harvest Age Comparison MP #5 vs. MP #6. (*Wtd: weighted)

Site Classes	MP #5 MHA		MP #6 MHA			
	MHA	Wtd Avg Future Stand Age	Harvest System	Minimum Average DBH	Wtd Avg Future Stand Age	95% Culmination MAI Wtd Avg Future Stand Age
Good	50 years		Ground	30 cm	64 years	
Medium	60 years	63 years	Cable	37 cm	99 years	78 years
Poor	70 years		Heli	42 cm	126 years	

By applying MP #6 minimum harvest age to the previous MP #5 benchmark scenario, Table 7 and Figure 16 show the harvest level (light brown line) when comparing against the original MP #5 Base Case (blue line) and the previous MP #5 benchmark scenario (dark brown line).

It is shown that the changes in minimum harvest age criteria results in a decrease in harvest level of 66,800 m^3/year (-9.0%) and 67,800 m^3/year (-9.3%) for each of the 5-year periods in the first decade, or 67,300 m^3/year (-9.1%) for the first 10 years against the "MP #5 benchmark" scenario. The timber supply impact from the minimum harvest age criteria holds relatively steady around -9% for the next 40 years. Starting at Year 50, the timber supply impact begins to reduce, as the land base transition to the fully regulated forest state. The long-term timber supply impact is estimated to be -1.4%.

Table 7 MP #5 Benchmark Scenario and MP #5 new MHA Scenario Harvest Levels

Period	Start Year	End Year	Annual Harvest Volume (m^3)		Difference vs. MP #5 Benchmark	% Difference vs. MP #5 Benchmark
			MP #5 Benchmark	MP #5 New MHA		
1	2020	2024	742,500	675,700	66,800	9.0%
2	2025	2029	731,100	663,300	67,800	9.3%
3	2030	2034	722,600	656,400	66,200	9.2%
4	2035	2039	720,000	653,500	66,500	9.2%
5	2040	2049	721,300	654,500	66,800	9.3%
6	2050	2059	726,700	661,000	65,700	9.0%
7	2060	2069	734,900	673,200	61,700	8.4%
8	2070	2079	741,000	685,800	55,200	7.4%
9	2080	2089	745,300	695,100	50,200	6.7%
10	2090	2099	750,500	703,400	47,100	6.3%
11	2100	2109	753,900	710,300	43,600	5.8%
12	2110	2119	758,700	715,800	42,900	5.7%
13	2120	2129	759,800	722,400	37,400	4.9%
14	2130	2139	759,700	729,400	30,300	4.0%
15	2140	2149	759,700	736,200	23,500	3.1%
16	2150	2159	759,400	744,100	15,300	2.0%
17	2160	2169	759,100	744,400	14,700	1.9%
18-26	2170	2259	751,800	741,100	10,700	1.4%

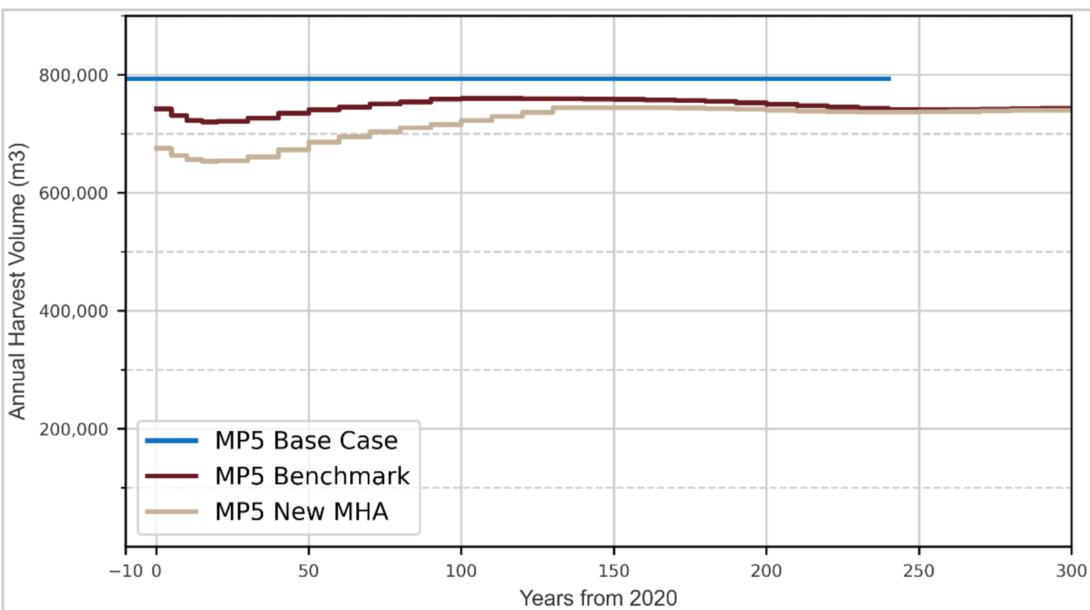


Figure 16 MP #5 Base Case, MP #5 Benchmark Scenario and MP #5 new MHA Scenario Harvest Levels

The third benchmark scenario is to test the timber supply impact brought by different timber supply model mechanisms. As described in the downward pressure factor No. 6 above, the pseudo-spatial model Woodstock was used in MP #5, whereas the spatial Patchworks model with spatial patch and road network enabled is used in MP #6. This “MP #5 New MHA Spatial” scenario with the MP #6 spatial model setup and objectives replaces the aspatial model setup in the “MP #5 New MHA” scenario. As a result, the Patchworks model will optimize the harvest accordingly based on operable grouping of stands, road construction and maintenance needs, and hauling distance and cost to different destinations (i.e., mills or log sorts) to generate the harvest flow. The aspatial proxy to manage cutblock adjacency and green-up is no longer needed, replaced with the spatial control laid out in the MP #6 Base Case. In addition, because this “MP #5 New MHA Spatial” scenario is close to the MP #6 Base Case (except for the economic partition, which will be illustrated below), the 60-year harvest delay for the research sites is enabled. The difference from the “MP #5 New MHA” scenario is the timber supply impact due to timber supply model mechanics.

Table 8 and Figure 17 illustrate the results from the “MP #5 New MHA Spatial” scenario (purple line) that compares against the previous “MP #5 benchmark” scenario (dark brown line), “MP 5 New MHA” aspatial scenario (light brown line) and the MP #5 Base Case (blue line).

For the first 5 years, Patchworks was able to leverage its spatial optimization function to deliver 21,800 m^3/year (3.2%) more than the aspatial set up. But this boost is short-lived for just these 5 years. Starting from Year 6, the “MP #5 New MHA Spatial” scenario harvest level experiences a sharper step-down drop than the “MP #5 new MHA” aspatial scenario, resulting in a negative timber supply impact going forward. The average timber supply impact for the first 10 years is an increase of 10,100 m^3/year (1.5%) against the “MP #5 new MHA” aspatial scenario.

The spatial model mechanism really shows a different harvest pattern after Year 10. The timber supply impact becomes more pronounced, down by 11.4% at Year 50. The “MP 5 New MHA” aspatial scenario starts to increase its harvest level at Year 30, but the “MP #5 New MHA Spatial” scenario remains relatively unchanged until year 50, after which it recovers more quickly. As a result, the timber supply impact reduces after age 50. The long-term timber supply impact of using the spatial model is 0.6%.

Table 8 MP #5 new MHA Scenario and MP #5 new MHA Spatial Scenario Harvest Levels

Period	Start Year	End Year	Annual Harvest Volume (m^3)		Difference vs. MP #5 New MHA	% Difference vs. MP #5 New MHA
			MP #5 New MHA	MP 5 New MHA Spatial		
1	2020	2024	675,700	697,500	-21,800	-3.2%
2	2025	2029	663,300	661,800	1,500	0.2%
3	2030	2034	656,400	628,100	28,300	4.3%
4	2035	2039	653,500	596,500	57,000	8.7%
5	2040	2049	654,500	596,400	58,100	8.9%
6	2050	2059	661,000	596,200	64,800	9.8%
7	2060	2069	673,200	596,700	76,500	11.4%
8	2070	2079	685,800	631,400	54,400	7.9%
9	2080	2089	695,100	651,900	43,200	6.2%
10	2090	2099	703,400	666,400	37,000	5.3%
11	2100	2109	710,300	678,100	32,200	4.5%
12	2110	2119	715,800	687,000	28,800	4.0%
13	2120	2129	722,400	694,400	28,000	3.9%
14	2130	2139	729,400	703,700	25,700	3.5%
15	2140	2149	736,200	714,200	22,000	3.0%
16	2150	2159	744,100	726,100	18,000	2.4%
17	2160	2169	744,400	739,700	4,700	0.6%
18-26	2170	2259	741,100	736,900	4,200	0.6%

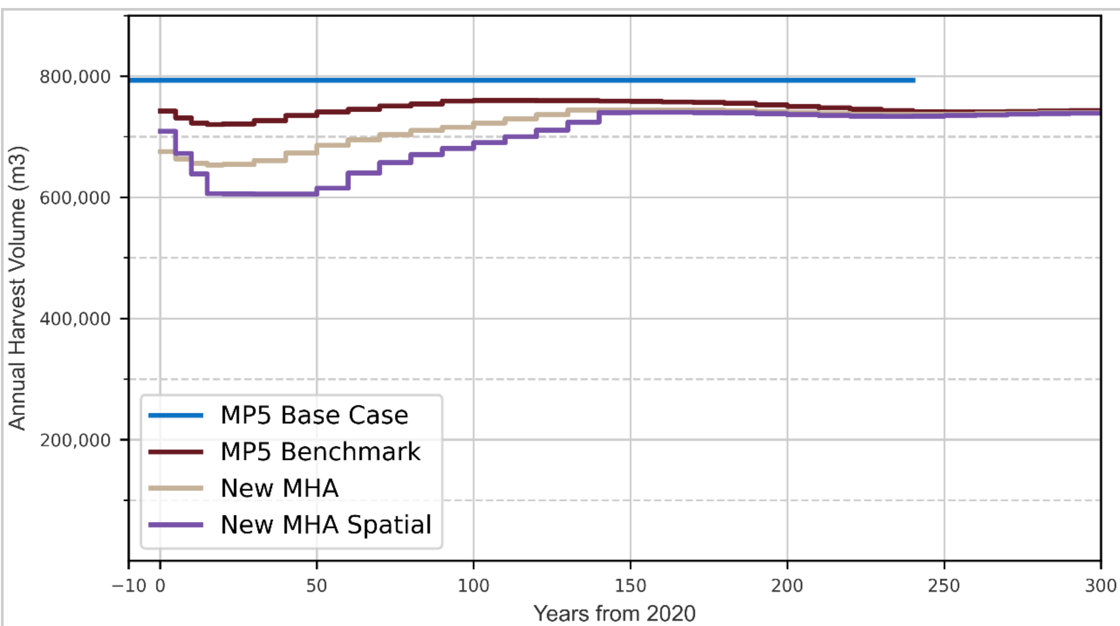


Figure 17 MP #5 Base Case, MP #5 Benchmark Scenario, MP #5 new MHA Scenario and MP #5 new MHA Spatial Scenario Harvest Levels

As elaborated in Section 2.2, there are three factors involved in the spatial model mechanism: spatial harvest patch size, green-up adjacency, and road network. Given the level of change in the 300-year timber harvest flow pattern compared to the aspatial modelling setup (higher short-term level and mid-term reduction), a subset of modelling was conducted to understand and quantify the timber supply impact of each spatial factor: spatial with patch size only, spatial with patch size and green-up, and fully spatial (with road network).

The results are shown in Figure 18. It can be concluded that harvest patch size explains most of the difference on the mid-term timber supply dip (green line versus blue line in Figure 18). Further analysis shows that the 0-5ha patch size target has the greatest short-term timber supply impact. By turning this sub-target off, the short-term harvest level can be increased by a meaningful amount. Having said that, spatial control is modeled to ensure fragmented stands do not inflate the harvest level. In future analyses, there is an opportunity to potentially refine the area definition of small stands, specifically the patch size. For accessing existing natural stands, the patch size is projected to be smaller as harvesting occurs further away from existing roads. As discussed in Section 2.2, this definition could be segmented by harvest system on inclusion of small but economically viable helicopter-yarding stands or be profiled by seral stage or timeframe to provide flexibility and to align with operational reality.

When including green-up adjacency in the spatial model setting on top of patch sizes, to access the totality of spatial harvest pattern and optimize the 300-year harvest flow, the timber supply model decides to increase the short-term harvest level (blue line versus red line in Figure 18). As a trade-off of the higher short-term harvest level, the mid-term harvest dip must be prolonged.

Finally, when the road network is included in the spatial timber supply modelling, it explains a minor portion of the spatial vs. aspatial difference (red line versus yellow line in Figure 18). By including the LiDAR-based detailed future projected roads, the harvest level recognizes the spatial road locations and optimizes the road construction and usage accordingly.

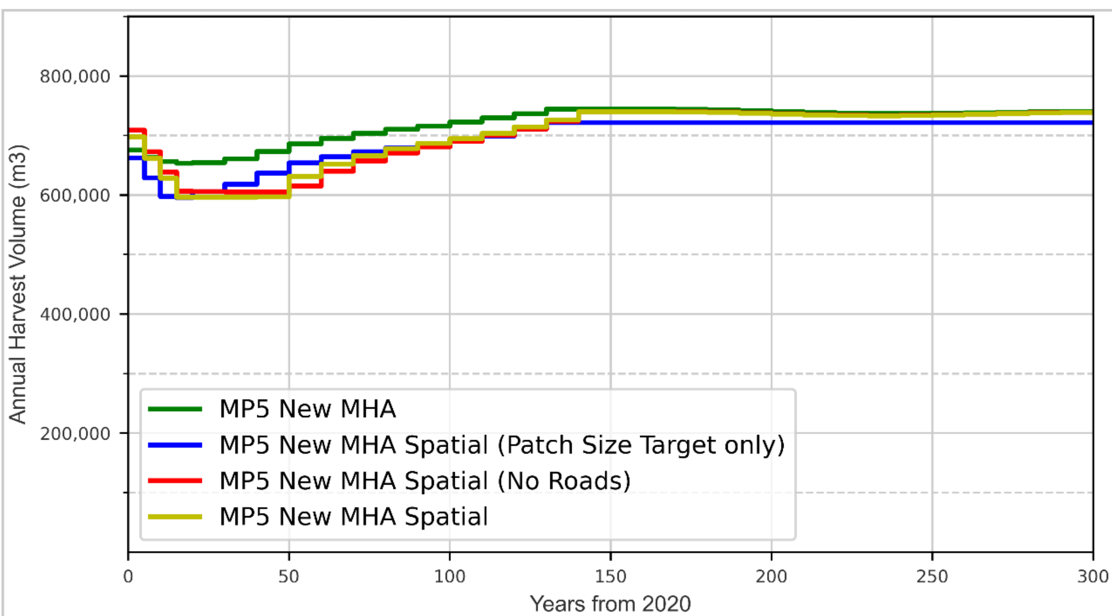


Figure 18 Harvest Levels for Aspatial and Spatial Scenarios: Aspatial, Spatial with Patch only; Spatial with Patch and Green-up; And Spatial

The final benchmark scenario is to quantify the timber supply impact of the economic partition. As described in Section 2.4, the economic partition is developed by asking the model to deliver a 20-year harvest schedule striving to meet a landscape-level net value objective ($/m^3) that is equivalent to the EBITDA margin in the 2020 Economic Analysis (Western Forest Products Inc., 2020). Once that is achieved, the remainder of the harvest schedule is then developed by Patchworks with no net value objective to form a full harvest level. As expected, the projected harvest level developed this way will include differences if the harvest schedule is to be developed without any landscape-level net value objective. The quantification of timber supply impact brought by economic partition can be achieved by comparing the previous “MP #5 new MHA Spatial” scenario against the MP #6 base case.

Table 9 and Figure 19 showcase the results from the MP #6 Base Case scenario (yellow line) that compares against the previous MP #5 benchmark scenario (dark brown line), “MP 5 New MHA” aspatial scenario (light brown line), “MP #5 New MHA Spatial” scenario (purple line) and the MP #5 Base Case (blue line). Having the economic objective on causes the Patchworks model to shift harvest level more towards the short-term and the first half of the mid-term. Specifically, including the economic objective in the analysis results in approximately 17,400 m^3/year (2.5%) higher short-term harvest level than the scenario without the economic objective for the first 10 years. This difference is maintained throughout the periods until the harvest level hits the mid-term. But the higher short-term harvest level in the MP #6 Base Case is a trade-off from a lower mid-term harvest level. Starting from Year 60, the MP #6 Base Case harvest level experiences a shortage of 21,900 m^3/year (-3.5%) relative to the “MP 5 New MHA Spatial” scenario. However, as more second growth stands become merchantable, the gap is gradually bridged. The long-term harvest level difference is 0.2%.

When examining the total volume harvested for the entire 300-year planning horizon, the harvest level for the MP #6 Base Case (with the economic objective) is 110,000 m^3 (0.05%) higher than the “MP #5 new MHA Spatial” scenario (without the economic objective). This translates to 367 m^3/year difference between the two scenarios over 300 years. Therefore, it can be concluded that having an economic partition established brings a smoother transition to the second growth harvest and achieves a reasonable economic return to the licence holder, at no extra cost to the overall long-term timber supply.

Table 9 MP #5 new MHA Spatial Scenario and MP #6 Base Case Harvest Levels

Period	Start Year	End Year	Annual Harvest Volume (m^3)		Difference vs. MP 5 New MHA Spatial	% Difference vs. MP 5 New MHA Spatial
			MP 5 New MHA Spatial	MP #6 Base Case		
1	2020	2024	697,500	715,200	-17,700	-2.5%
2	2025	2029	661,800	678,900	-17,100	-2.6%
3	2030	2034	628,100	644,500	-16,400	-2.6%
4	2035	2039	596,500	611,900	-15,400	-2.6%
5	2040	2049	596,400	611,300	-14,900	-2.5%
6	2050	2059	596,200	610,000	-13,800	-2.3%
7	2060	2069	596,700	609,500	-12,800	-2.1%
8	2070	2079	631,400	609,500	21,900	3.5%
9	2080	2089	651,900	635,700	16,200	2.5%
10	2090	2099	666,400	654,900	11,500	1.7%
11	2100	2109	678,100	668,900	9,200	1.4%
12	2110	2119	687,000	680,100	6,900	1.0%
13	2120	2129	694,400	689,300	5,100	0.7%
14	2130	2139	703,700	700,000	3,700	0.5%
15	2140	2149	714,200	711,000	3,200	0.4%
16	2150	2159	726,100	724,300	1,800	0.2%
17	2160	2169	739,700	738,700	1,000	0.1%
18-26	2170	2259	736,900	738,500	-1,600	-0.2%

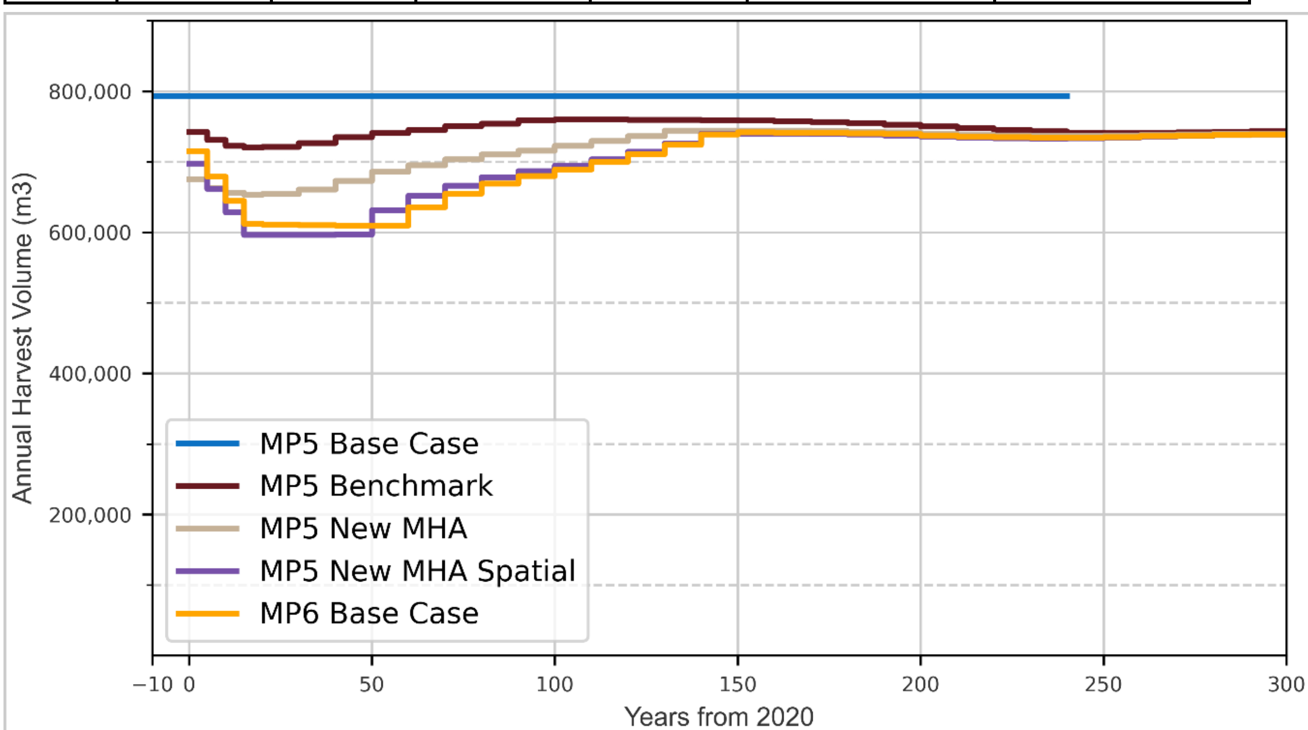


Figure 19 MP #5 Base Case, MP #5 Benchmark Scenario, MP #5 new MHA Scenario, MP #5 new MHA Spatial Scenario and MP #6 Base Case Harvest Levels

In summary, Figure 20 presents the influence of each of the above items on the AAC in moving from the MP #5 AAC determination of 793,600 m^3/year to the MP #6 Base Case initial harvest of 697,000 m^3/year for the next 10-year timber supply period (an average of 715,200 m^3/year for the first 5 years and 678,900 m^3/year for the second 5 years).

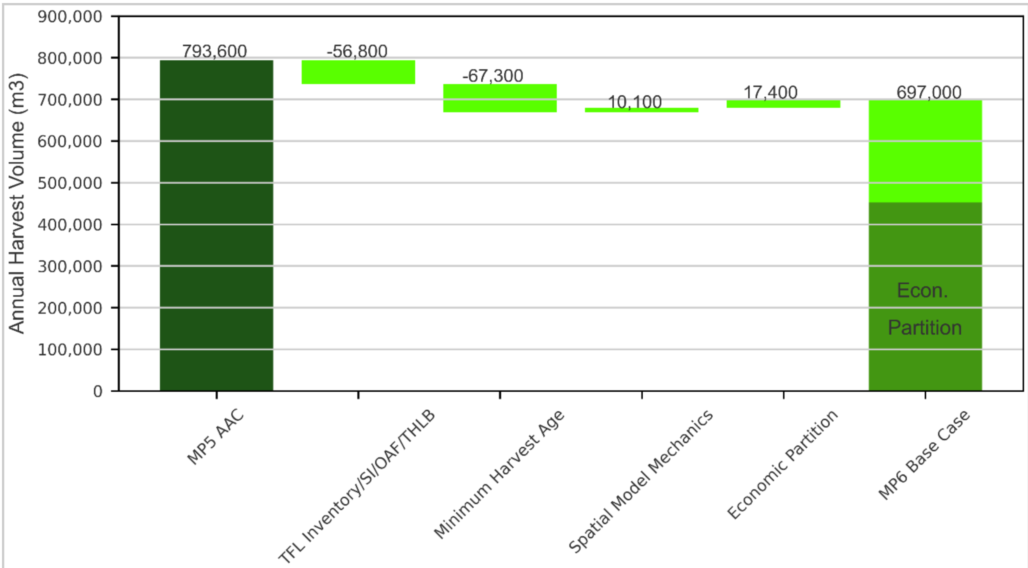


Figure 20 Timber Supply Impacts of Revised Data and Assumptions Since MP #5

Table 10 provides the short-term (first 10 years), mid-term (11 to 150 years) and long-term (151-300 years) proportional timber supply impact for each of the above items. The first 10 years impact is already shown in Figure 20 graphically, but this table provides a full picture of the entire 300-year planning horizon. In particular, the table demonstrates how the spatial model mechanics impact the short-term timber supply which is opposite of the mid-term and long-term impact.

Table 10 Short/Mid/Long-term Timber Supply Impacts Since MP #5

		Percentage Impact from the Previous Scenario		
	Current AAC (m^3/yr)	793,600		
Scenario	**Issue Tested**	**Harvest Interval (years)**		
		0-10	**11-150**	**151-300**
MP5 Benchmark	Downward: TFL inventory/SI/OAF/THLB reduction Upward: LiDAR Road Width, LiDAR Future Roads	-7.2%	-6.1%	-5.8%
MP #5 New MHA	Minimum Harvest Age	-9.1%	-6.2%	-1.0%
MP 5 New MHA Spatial	Spatial Model Mechanics	1.5%	-5.5%	-0.5%
MP#6 Base Case	Economic Partition	2.6%	-0.1%	0.2%

3 ALTERNATE HARVEST FLOWS

This section examines two alternate flow scenarios:

- maintaining the current AAC;
- non-declining even-flow.

Similar to the Base Case harvest level reported in Section 2.3, harvest volumes for these two alternate harvest flows are rounded down to the nearest 100 and are net of the non-recoverable losses of 1% per year. The first four periods are modelled in 5-year intervals and the rest of the 28 periods are modelled in 10-year intervals.

3.1 Maintain current AAC

Table 11 and Figure 21 represent an attempt to maintain the current AAC of 793,600 m^3/year for the first 10 years.

Table 11 Harvest Levels with Maintaining Current AAC

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Maintain Current AAC	Difference	
1	2020	2024	715,200	793,600	-78,300	-10.9
2	2025	2029	678,900	589,600	89,200	13.1
3	2030	2034	644,500	550,500	93,900	14.6
4	2035	2039	611,900	558,100	53,700	8.8
5	2040	2049	611,300	583,100	28,200	4.6
6	2050	2059	610,000	601,000	8,900	1.5
7	2060	2069	609,500	622,700	-13,300	-2.2
8	2070	2079	609,500	646,300	-36,800	-6.0
9	2080	2089	635,700	661,200	-25,500	-4.0
10	2090	2099	654,900	673,000	-18,200	-2.8
11	2100	2109	668,900	683,700	-14,800	-2.2
12	2110	2119	680,100	690,800	-10,800	-1.6
13	2120	2129	689,300	697,700	-8,500	-1.2
14	2130	2139	700,000	706,200	-6,300	-0.9
15	2140	2149	711,000	715,600	-4,600	-0.6
16	2150	2159	724,300	727,200	-3,000	-0.4
17	2160	2169	738,700	739,500	-800	-0.1
18-32	2170	2319	737,800	736,200	1,500	0.2

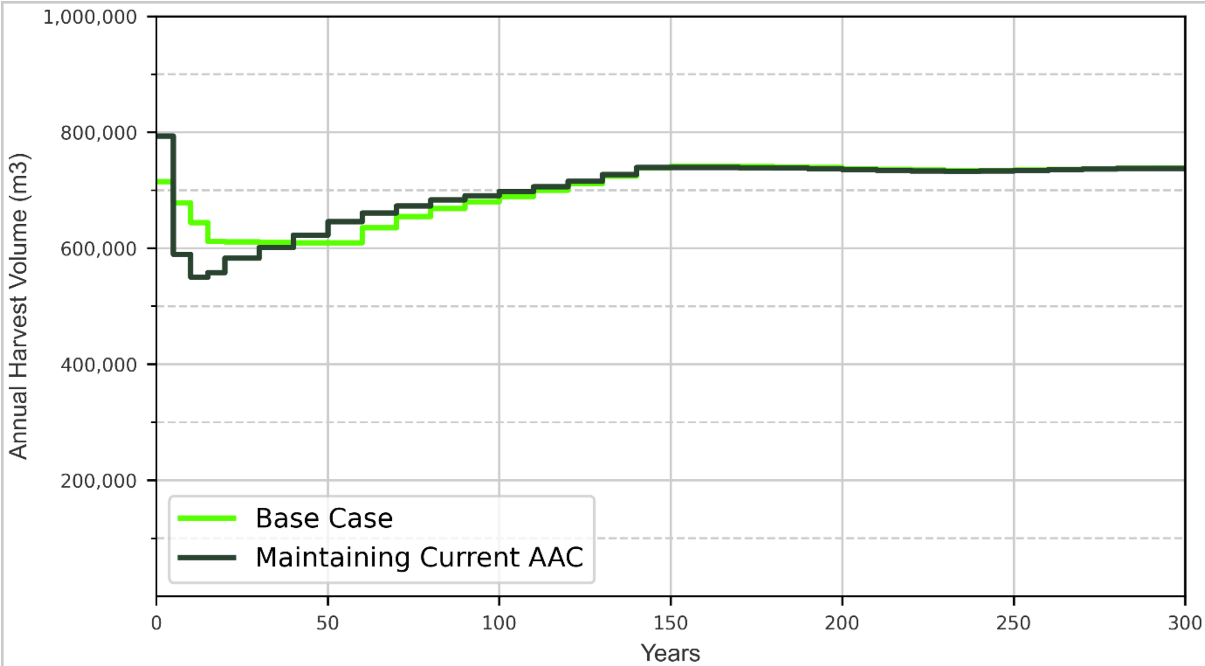


Figure 21 Harvest Levels with Maintaining Current AAC

The model scenario indicates that maintaining the current AAC for an additional 5 years is at the cost of 25.7% harvest reductions in the next 5 years and another 6.6% decline for the 5 years to follow, resulting a 10-year harvest reduction of 16.2%, rather than -5.1% in the Base Case. The short-term harvest is heavily reliant on the contribution from the existing older stands. The opportunity cost of accessing more volume upfront to maintain the current AAC is to incur more decline in the harvest level once the THLB GS for existing older stands decreases, while waiting for THLB GS for existing managed stands to become merchantable. After experiencing this level of decrease, the harvest level in the latter half of the second decade starts to recover, and the harvest level is 2.2% more than the Base Case by Year 2060. Harvest after that point is higher than the Base Case till the harvest enters LTHL. After Year 120, the difference between the two scenarios is within 1%. Over the 300 years, a total of 27,500 m^3 (0.01%) more volume is harvested in this sensitivity.

3.2 Non-Declining Even Flow

Table 12 and Figure 22 show the impact of establishing a non-declining even flow (NDEF) harvest level. Despite an even flow objective being set up, the modelled harvest schedule has some minor (up to 0.34%) fluctuations in the short-term.

Table 12 Harvest Levels with Non-Declining Even Flow

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Even Flow	Difference	
1	2020	2024	715,200	643,800	71,300	10.0
2	2025	2029	678,900	642,800	36,000	5.3
3	2030	2034	644,500	640,600	3,800	0.6
4	2035	2039	611,900	640,800	-28,900	-4.7
5	2040	2049	611,300	641,300	-30,100	-4.9
6	2050	2059	610,000	641,800	-31,800	-5.2
7	2060	2069	609,500	642,400	-33,000	-5.4
8	2070	2079	609,500	643,600	-34,100	-5.6
9	2080	2089	635,700	643,600	-8,000	-1.3
10	2090	2099	654,900	643,600	11,200	1.7
11	2100	2109	668,900	643,600	25,200	3.8
12	2110	2119	680,100	643,600	36,400	5.4
13	2120	2129	689,300	643,600	45,600	6.6
14	2130	2139	700,000	643,600	56,300	8.1
15	2140	2149	711,000	643,600	67,300	9.5
16	2150	2159	724,300	643,600	80,600	11.1
17	2160	2169	738,700	643,600	95,000	12.9
18-32	2170	2319	737,800	643,600	94,100	12.8

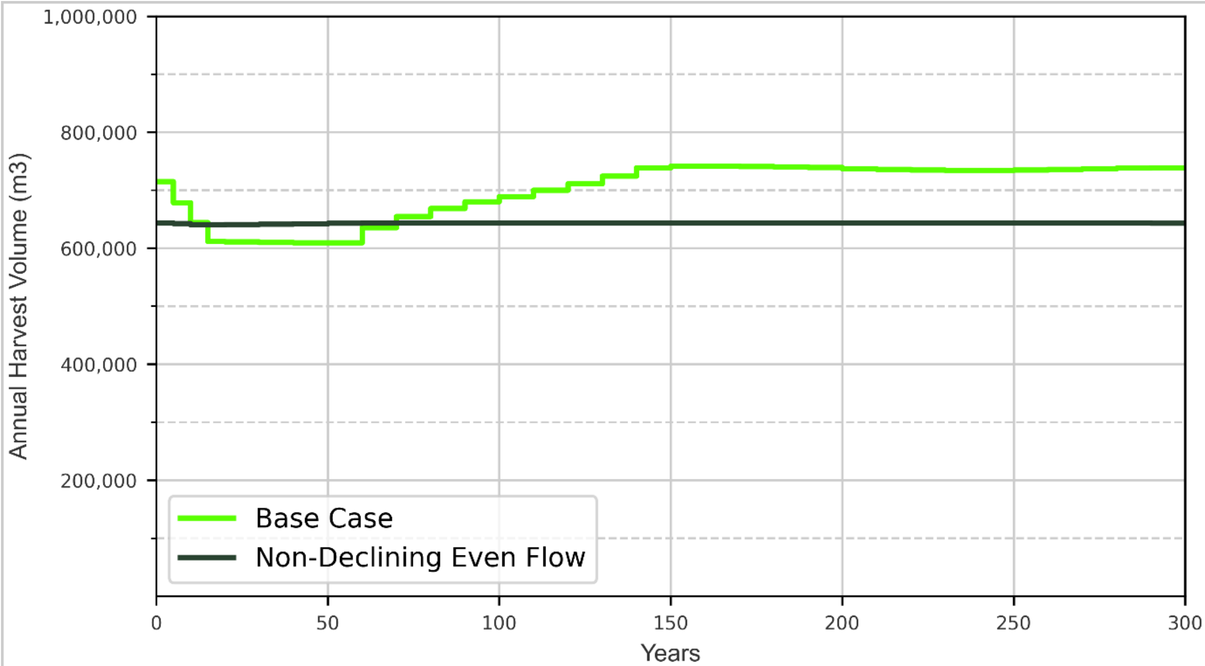


Figure 22 Harvest Levels with Non-Declining Even Flow

The harvest schedule for the NDEF starts about 71,300 m^3/year lower (-10.0%) than the Base Case, averaging 53,650 m^3/year less for the first 10-years (-7.6%). After 15 years, harvest levels in the NDEF scenario become higher than the Base Case and remain that way for the next 60 years. The NDEF's short-term and mid-term harvest during these periods is about 27,650 m^3/year (4.5%) more than the Base Case, with the widest gap of 34,100 m^3/year (5.6%) in the sixth decade. Once the THLB GS for existing managed stands to become merchantable in the Base Case, the gap in harvest levels between the NDEF scenario and the Base Case starts shrinking in Year 70. By Year 80, the NDEF harvest levels drop below the Base Case, and is 12.8% less over the long term. Over the 300 years, 17.3 million m^3 (-8.25%) less volume is harvested in the NDEF scenario compared to the Base Case.

4 SENSITIVITY ANALYSES

Sensitivity analyses are conducted for the current Base Case to examine the potential impact of uncertainty of the assumptions made in the Base Case. By developing and testing a number of sensitivity issues, it is possible to determine which variables most affect results. This, in turn, facilitates management decisions that must be made in the face of uncertainty. As Patchworks was used as a simulation and optimization tool to generate the Base Case, it is expected that the results will be sensitive to any changes to the inputs.

To allow meaningful comparison of sensitivity analyses, they are performed by varying (from the Base Case) only the assumption being evaluated.

In general, sensitivities with negative impacts were run with the goal of keeping the short-term harvest as close as possible to the harvest in the Base Case. Where impacts were positive, adjustments were made to (1) raise the short-term and mid-term flow, and optionally (2) increase the long-term harvest level.

Sensitivity issues are summarized in Table 13. This list has been updated since the publication of the associated IP to reflect additional factors that emerged during the modelling process as well as feedback from the IP review and consultation. The timber supply impacts are illustrated in Sections 4.1 through 4.25. Similar to the Base Case harvest level reported in Section 2.3, harvest volumes for these two alternate harvest flows are rounded down to the nearest 100 and are net of the non-recoverable losses of 1% per year. The first four periods are modelled in 5-year intervals and the rest of the 28 periods are modelled in 10-year intervals.

Table 13 Current Management Sensitivity Analyses

Issue Tested	Sensitivity Analysis Summary	Section
Climate Change	Apply predicted 2050 BEC zones	4.1
Growth and Yield	Increase natural stand yields by 10%	4.2
	Decrease natural stand yields by 10%	4.3
	Increase managed stand yields by 10%	4.4
	Decrease managed stand yields by 10%	4.5
Forest Management / Silviculture	Exclude genetic gain adjustments	4.6
OAF	Use default provincial OAF 1	4.7
	Use increased OAF 2 to reflect root-rot in Douglas fir leading managed stands	4.8
Minimum Harvest Criteria	Add 2cm to the minimum harvest criteria	4.9
	Subtract 2cm from the minimum harvest criteria	4.10
	Harvest at 95% of culmination MAI	4.11
Area of Traditional Use	Remove Thunder Mountain Government Actions Regulation (GAR) order area	4.12
	Remove potential Ditidaht First Nation Agreement-In-Principle offer lands	4.13
Operability	Remove Partition to include economically marginal stands	4.14
	Remove area within 30m of nearby parks	4.15
Watershed Management	Use Equivalent Clear-cut Area (ECA) constraints of 20%	4.16
	Apply ECA constraints on 400+m elevation	4.17
Visual Management	Use more restrictive visual management constraints	4.18
Biodiversity	Apply Marbled Murrelet provincial targets by LU / LU aggregate	4.19
	Remove WFP Stewardship and Conservation Plan impacts	4.20
Inventory	Use adjusted LiDAR-based inventory attributes	4.21
	Use adjusted LiDAR-based inventory attributes with alternative minimum harvest criteria	4.22
	Use adjusted LiDAR-based inventory attributes with alternative minimum harvest criteria – Non-Declining Even Flow	4.23
	Use Provincial VRI as base inventory	4.24

4.1 Apply Predicted 2050 BEC Zones

Climate Change potentially represents significant uncertainties to the timber supply forecast. To test the sensitivity of timber supply to potential climate change implications, a raster data layer with the predicted boundaries of biogeoclimatic (BEC) variants in 2050 was obtained from Climate BC (Wang, 2020; http://climatebc.ca/) (Table 14). Figure 23 shows the current BEC zone boundaries and Figure 24 presents the predictions for 2050 for the vicinity of TFL 44. The Mountain Hemlock (MH) zone is predicted to nearly disappear, replaced by the Coastal Western Hemlock (CWH) zone. Within the CWH zone, the CWHxm1, CWHmm1, CWHvh1, and CWHvm1 subzone variants are all expected to increase, whereas CWHxm2, CWHmm2, and CWHvm2 are predicted to decrease in area.

Table 14 BEC Variant Current vs. 2050 Prediction

BEC Variant	Total Area (Ha)	
	Current BEC	2050 Predicted BEC
CWHxm1	17	10,557
CWHxm2	19,175	14,751
CWHmm1	4,698	8,259
CWHmm2	7,831	764
CWHvh1	9,172	21,854
CWHvm1	71,812	78,723
CWHvm2	18,234	1,181
MHmm1	5,962	127
No Prediction	N/A	683
Total	136,900	136,900

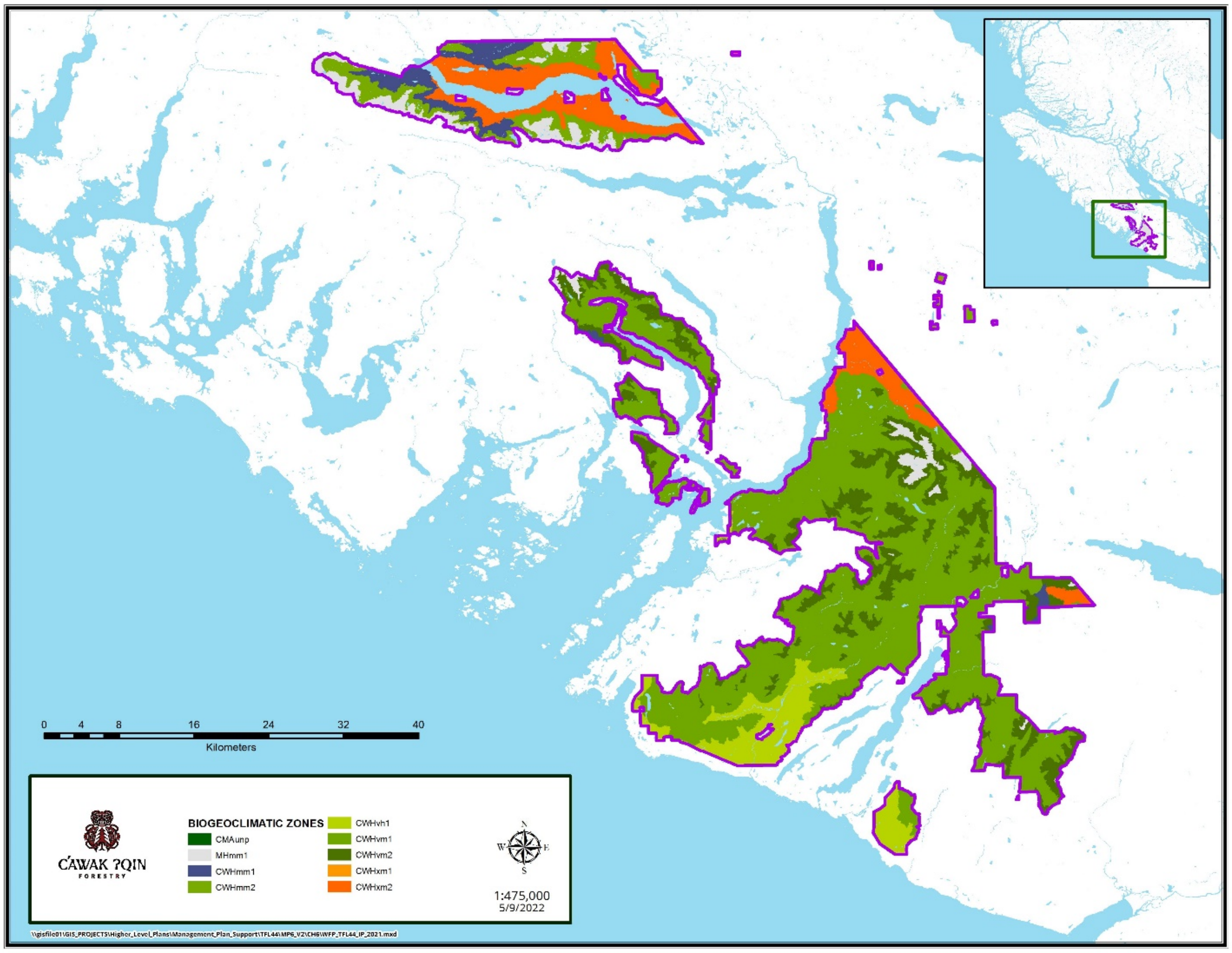


Figure 23 Current BEC Variant in TFL 44

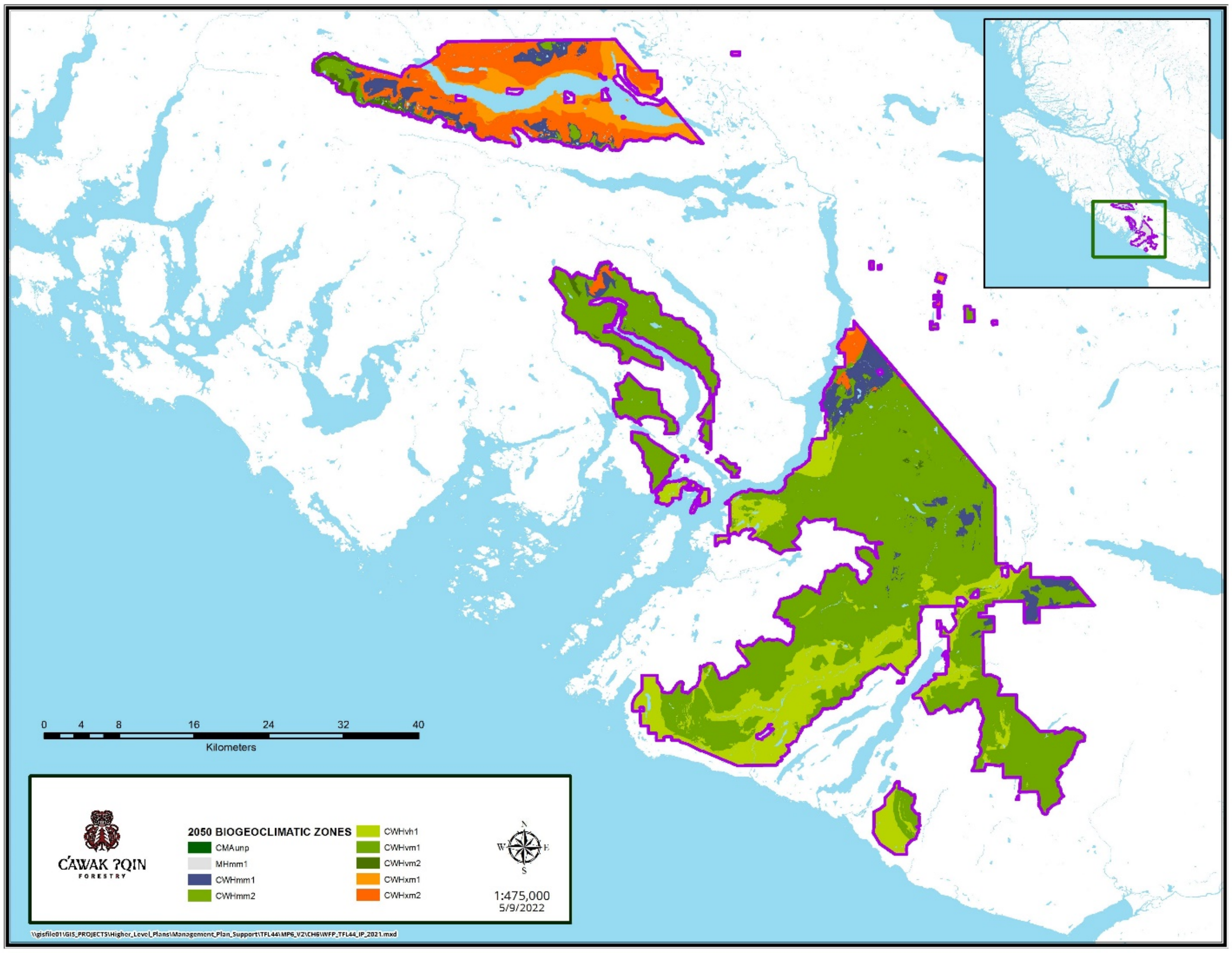


Figure 24 Predicted 2050 BEC Variant in TFL 44

The 2050 BEC variants were incorporated into the model and harvested stands transitioned to the corresponding future stand based on the revised BEC variant. For example, if a current stand is within the MHmm1 variant but is predicted to become CWHmm2 in the 2050 BEC dataset, this current stand will transition to the CWHmm2 variant stand once harvested, with a new yield and AU assignment. The current conditions of the stands and AU assignment are not altered until the stand is harvested and transitioned to the future AU. This represents the condition that any future growth of the stand is in the new BEC trajectory.

The predicted shift decreases the average productivity of the TFL, particularly for the future managed stands, constraining the harvest level for the sensitivity. This is because the managed stand yields rely on area weighted SIBEC SI as input. As shown in Table 14, current BEC variants and future BEC variants have quite different areas. Thus, for the same AU, the area weighted SI inputs are different under this sensitivity. To quantify the change, an area weighted average of cumulation MAI for the future AUs are calculated for the Base Case and this sensitivity, and this sensitivity has 0.90 m^3/ha/year less (9.8%) maximum MAI than the Base Case. The long run sustained yield (LRSY), the maximum even-flow harvest level if stands were harvested at the maximum MAI age, was calculated to have the 9.8% LRSY gap as well. This means that as the land base gradually transitions to future managed stands, the available inventory of the predicted BEC variants will be less than the existing BEC variants due to the slower growth.

The results of applying predicted future BEC variants and comparison against the Base Case are presented in Table 15 and Figure 25. The yield constraint explains the 5% reduced short-term harvest level and approximately 9% reduced mid-term and long-term harvest levels. Over the 300-year planning horizon, 17.5 million m^3 (-8.3%) less volume is harvested.

The approach taken in the sensitivity is to substitute the BEC inputs in AU assignment once the stands are harvested. Despite the availability of a BC-based climate change prediction tool such as ClimateBC, there are still a lot of uncertainties in the growth and yield impacts of climate change. For instance, more robust climate-influenced yield projections are needed on existing natural and managed forests, and future forests that are still predicted to be within the same BEC variant, but with different climatic variables. More elaborated measures and tools are required to properly account for the full-scale timber supply influence.

Table 15 Harvest Levels with Predicted 2050 BEC Zones

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Predicted 2050 BEC Zones	Difference	
1	2020	2024	715,200	680,000	35,200	4.9
2	2025	2029	678,900	645,000	33,900	5.0
3	2030	2034	644,500	611,900	32,500	5.1
4	2035	2039	611,900	580,900	31,000	5.1
5	2040	2049	611,300	580,400	30,900	5.1
6	2050	2059	610,000	579,200	30,700	5.0
7	2060	2069	609,500	578,700	30,700	5.1
8	2070	2079	609,500	578,500	30,900	5.1
9	2080	2089	635,700	578,500	57,100	9.0
10	2090	2099	654,900	591,600	63,200	9.7
11	2100	2109	668,900	606,100	62,800	9.4
12	2110	2119	680,100	617,700	62,400	9.2
13	2120	2129	689,300	627,600	61,700	9.0
14	2130	2139	700,000	640,100	59,900	8.6
15	2140	2149	711,000	655,100	55,900	7.9
16	2150	2159	724,300	670,500	53,700	7.4
17	2160	2169	738,700	674,800	63,900	8.7
18-32	2170	2319	737,800	670,000	67,700	9.2

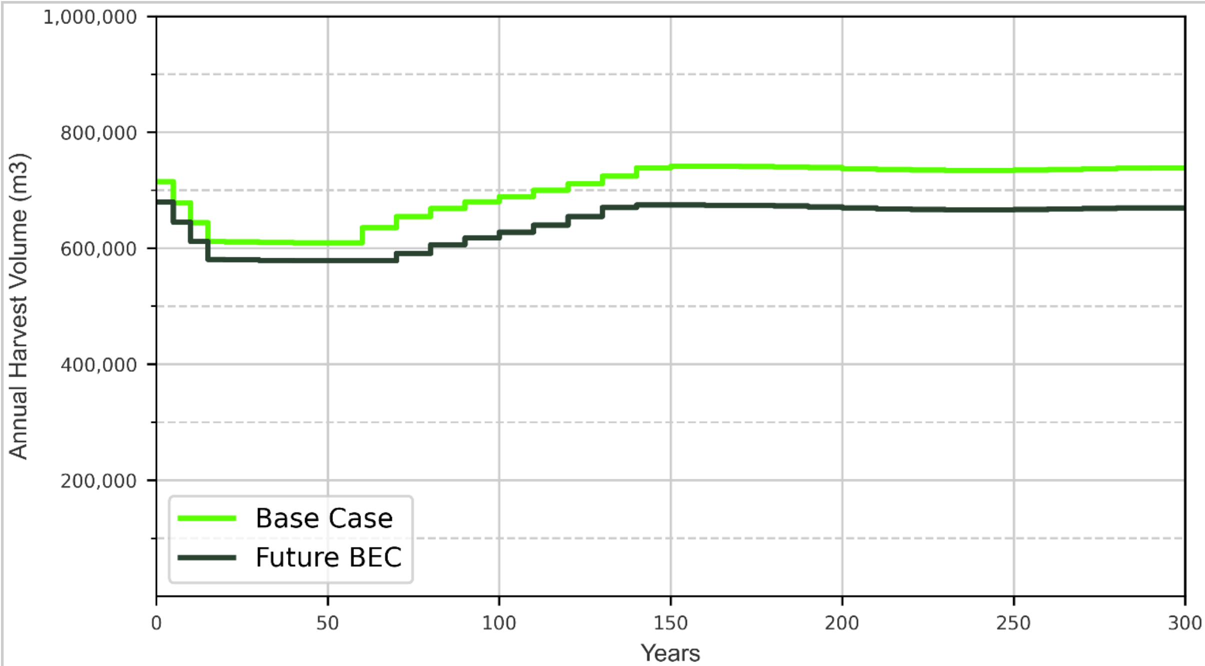


Figure 25 Harvest Levels with Predicted 2050 BEC Zones

4.2 Increase Natural Stand Yields by 10%

The sensitivity of timber supply to existing natural stands (older than 57 years) volume estimates is tested by increasing (this Section) and decreasing (Section 4.3) these volumes by 10%. The volumes in these stands are estimated from the forest attributes and assumptions detailed in Section 8 of the associated IP document and the MoF's Variable Density Yield Projection (VDYP) version 7.33b.

The increased yields result in approximately 1.4 million m^3 (6.5%) more inventory on the THLB today when compared to the Base Case, of which more than 1.2 million m^3 is merchantable immediately (i.e., meets minimum harvest criteria).

Table 16 and Figure 26 indicate the results when compared against increased natural stand yields of the Base Case. The harvest level pattern remains the same as the Base Case, but the level improves between 3.2% to 3.3% using the additional natural stands' inventory. The long-term harvest levels between the two scenarios are the same as the increased natural stand volume reduces in the short-term/mid-term. The total harvest over the entire 300 years is 1.4 million m^3 (0.7%) more than the base case.

Table 16 Harvest Levels with Increased Natural Stand Yields

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Increased Natural Yields	Difference	
1	2020	2024	715,200	739,000	-23,900	-3.3
2	2025	2029	678,900	701,200	-22,400	-3.3
3	2030	2034	644,500	665,500	-21,100	-3.3
4	2035	2039	611,900	631,800	-20,000	-3.3
5	2040	2049	611,300	631,200	-19,900	-3.2
6	2050	2059	610,000	629,700	-19,800	-3.2
7	2060	2069	609,500	629,200	-19,800	-3.2
8	2070	2079	609,500	629,100	-19,700	-3.2
9	2080	2089	635,700	640,600	-5,000	-0.8
10	2090	2099	654,900	657,600	-2,800	-0.4
11	2100	2109	668,900	671,100	-2,200	-0.3
12	2110	2119	680,100	681,900	-1,800	-0.3
13	2120	2129	689,300	691,300	-2,000	-0.3
14	2130	2139	700,000	702,500	-2,500	-0.4
15	2140	2149	711,000	713,600	-2,600	-0.4
16	2150	2159	724,300	726,200	-2,000	-0.3
17	2160	2169	738,700	741,200	-2,600	-0.3
18-32	2170	2319	737,800	737,400	300	0.0

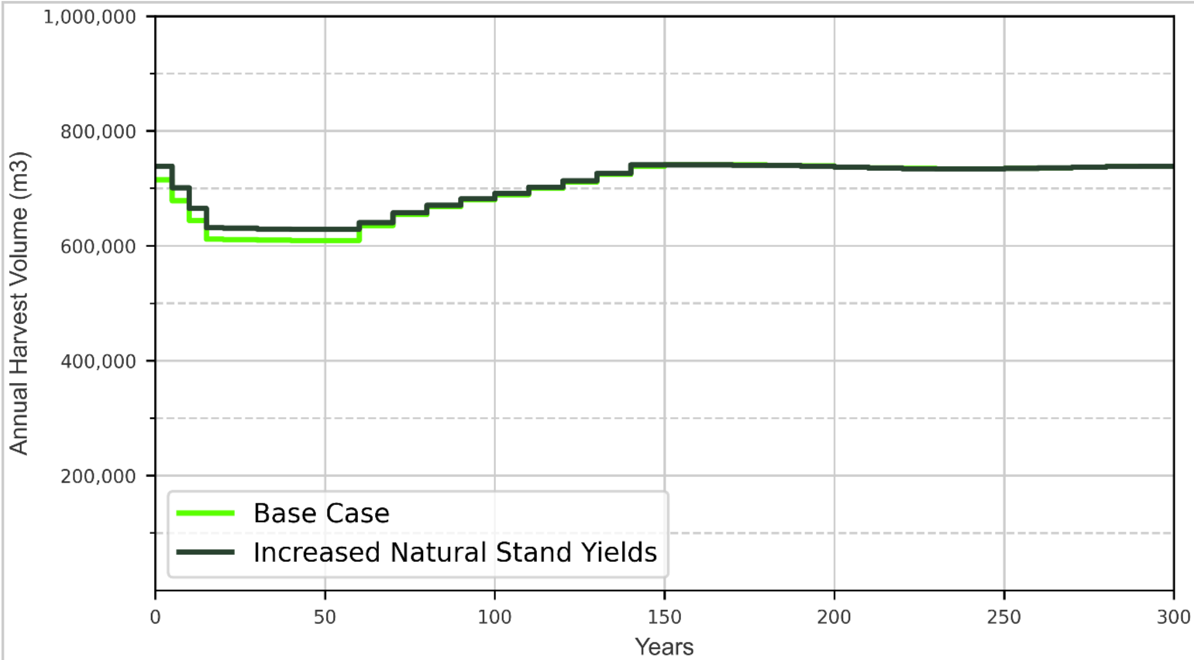


Figure 26 Harvest Levels with Increased Natural Stand Yields

4.3 Decrease Natural Stand Yields by 10%

A decrease of 10% in natural yields results in approximately 1.4 million m^3 (6.5%) less inventory on the THLB today when compared to the Base Case. Table 17 and Figure 27 indicate that with decreased natural stand yields, short and mid-term harvest levels are affected.

Natural stands provide more than 91% of the volume in the first decade of the Base Case harvest schedule and still accounts for more than 50% of the harvested volume in the second and third decade (refer to Figure 3). With reduced natural yields, short-term harvest is roughly 6.8% lower than the Base Case. As the natural stand volume reduces, the mid-term harvest level starts to recover by harvesting managed stands at Year 40. Thus, the gap between these two scenarios begins to shrink, reaching within 1% of the Base Case at Year 80. The long-term harvest impact is negligible (<0.2%). This scenario results in approximately 2.0 million m^3 (1.0%) less harvest than the Base Case over the 300-year planning horizon.

Table 17 Harvest Levels with Decreased Natural Stand Yields

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Decreased Natural Yields	Difference	
1	2020	2024	715,200	667,000	48,200	6.7
2	2025	2029	678,900	632,800	46,000	6.8
3	2030	2034	644,500	600,700	43,800	6.8
4	2035	2039	611,900	570,400	41,500	6.8
5	2040	2049	611,300	570,100	41,100	6.7
6	2050	2059	610,000	569,900	40,000	6.6
7	2060	2069	609,500	572,600	36,900	6.1
8	2070	2079	609,500	618,500	-9,000	-1.5
9	2080	2089	635,700	643,300	-7,600	-1.2
10	2090	2099	654,900	658,900	-4,100	-0.6
11	2100	2109	668,900	671,600	-2,800	-0.4
12	2110	2119	680,100	681,800	-1,700	-0.2
13	2120	2129	689,300	690,900	-1,600	-0.2
14	2130	2139	700,000	700,700	-800	-0.1
15	2140	2149	711,000	710,600	300	0.1
16	2150	2159	724,300	723,000	1,200	0.2
17	2160	2169	738,700	739,700	-1,100	-0.1
18-32	2170	2319	737,800	736,500	1,200	0.2

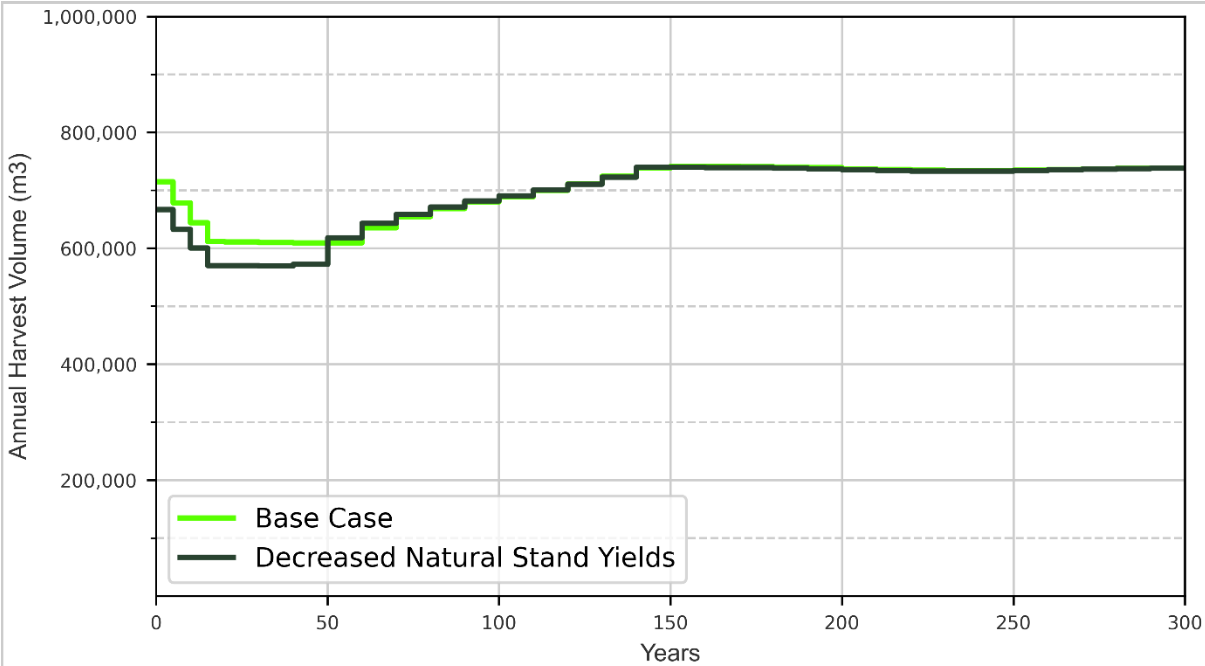


Figure 27 Harvest Levels with Decreased Natural Stand Yields

4.4 Increase Managed Stand Yields by 10%

The sensitivity of timber supply to managed stands (younger than 58 years) volume estimates is tested by increasing (this Section) and decreasing (Section 4.5) these volumes by 10%. Volumes in these younger stands are estimated from attributes and assumptions detailed in Section 8 of the associated IP document and MoF's Table Interpolation Program for Stand Yields (TIPSY) version 4.5.

With managed stand yields increased by 10%, initial THLB inventory is increased by 0.76 million m^3 (3.5%). The harvest schedule in Table 18 and Figure 28 indicates that harvest levels are about 3.3% greater for the first four decades. Short-term harvest cannot be increased more due to minimum harvest criteria. However, mid-term harvest levels do not need to decline as significantly, or to stay at lower level for as long to allow the transition to the higher long-term harvest levels (relative to the Base Case schedule). Over the entire 300-year planning horizon, 19.2 million m^3 (9.1%) more is harvested in this sensitivity scenario.

Table 18 Harvest Levels with Increased Managed Stand Yields

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Increased Managed Yields	Difference	
1	2020	2024	715,200	738,600	-23,400	-3.3
2	2025	2029	678,900	700,800	-21,900	-3.2
3	2030	2034	644,500	665,200	-20,700	-3.2
4	2035	2039	611,900	631,600	-19,700	-3.2
5	2040	2049	611,300	631,500	-20,300	-3.3
6	2050	2059	610,000	631,400	-21,500	-3.5
7	2060	2069	609,500	660,800	-51,300	-8.4
8	2070	2079	609,500	698,500	-89,100	-14.6
9	2080	2089	635,700	718,700	-83,100	-13.1
10	2090	2099	654,900	732,800	-77,900	-11.9
11	2100	2109	668,900	743,600	-74,800	-11.2
12	2110	2119	680,100	752,500	-72,500	-10.6
13	2120	2129	689,300	760,400	-71,100	-10.3
14	2130	2139	700,000	769,000	-69,100	-9.9
15	2140	2149	711,000	778,300	-67,300	-9.5
16	2150	2159	724,300	788,600	-64,400	-8.9
17	2160	2169	738,700	801,900	-63,300	-8.6
18-32	2170	2319	737,800	807,900	-70,200	-9.5

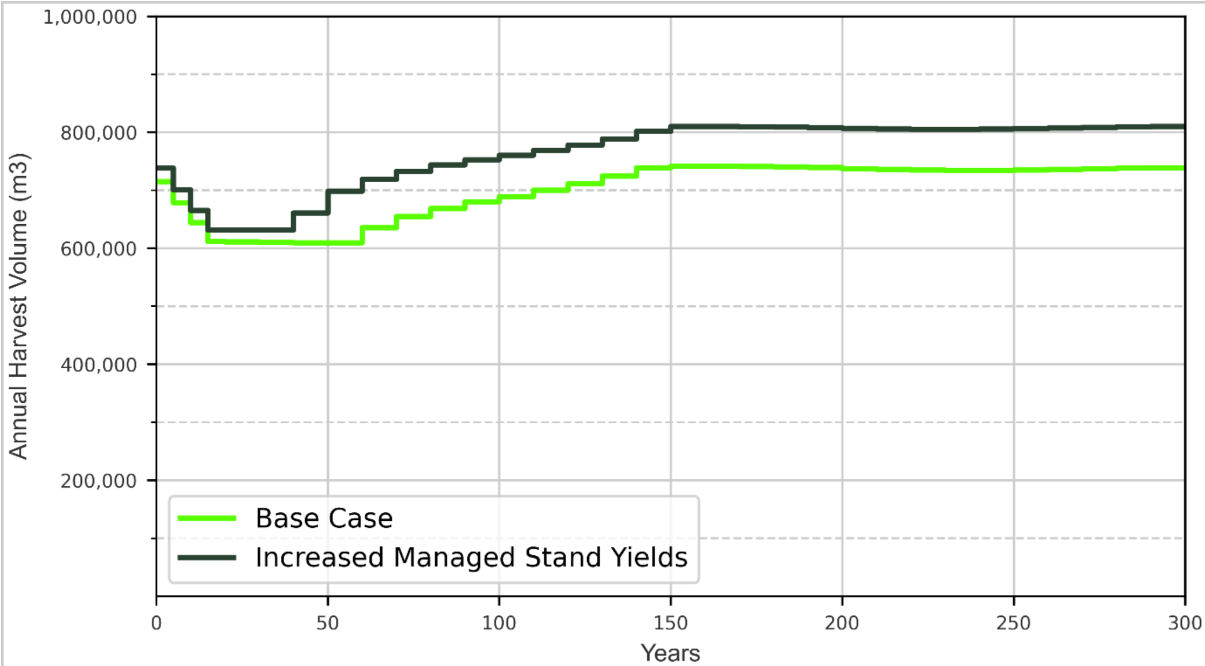


Figure 28 Harvest Levels with Increased Managed Stand Yields

4.5 Decrease Managed Stand Yields by 10%

With managed stands yields decreased by 10%, initial THLB inventory is reduced by 0.76 million m^3 (3.5%). The harvest schedule in Table 19 and Figure 29 indicates that harvest levels would need to be reduced by 7.3% for the short-term. Mid-term harvest, especially the latter part starting at Year 70, must be reduced even more (up to 11.2% at Year 70) to adjust to the lower managed stand yields. Long-term harvest is 9.9% less than the Base Case. Total harvest over the entire 300 years is 19.9 million m^3 (9.5%) less than the Base Case.

Table 19 Harvest Levels with Decreased Managed Stand Yields

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Decreased Managed Yields	Difference	
1	2020	2024	715,200	663,900	51,200	7.2
2	2025	2029	678,900	629,800	49,000	7.2
3	2030	2034	644,500	597,700	46,800	7.3
4	2035	2039	611,900	567,400	44,500	7.3
5	2040	2049	611,300	566,800	44,500	7.3
6	2050	2059	610,000	565,500	44,500	7.3
7	2060	2069	609,500	564,800	44,600	7.3
8	2070	2079	609,500	564,700	44,800	7.4
9	2080	2089	635,700	564,700	71,000	11.2
10	2090	2099	654,900	584,200	70,600	10.8
11	2100	2109	668,900	599,600	69,300	10.4
12	2110	2119	680,100	611,700	68,400	10.1
13	2120	2129	689,300	620,500	68,700	10.0
14	2130	2139	700,000	631,200	68,800	9.8
15	2140	2149	711,000	643,900	67,100	9.4
16	2150	2159	724,300	658,300	65,900	9.1
17	2160	2169	738,700	668,900	69,800	9.5
18-32	2170	2319	737,800	664,600	73,100	9.9

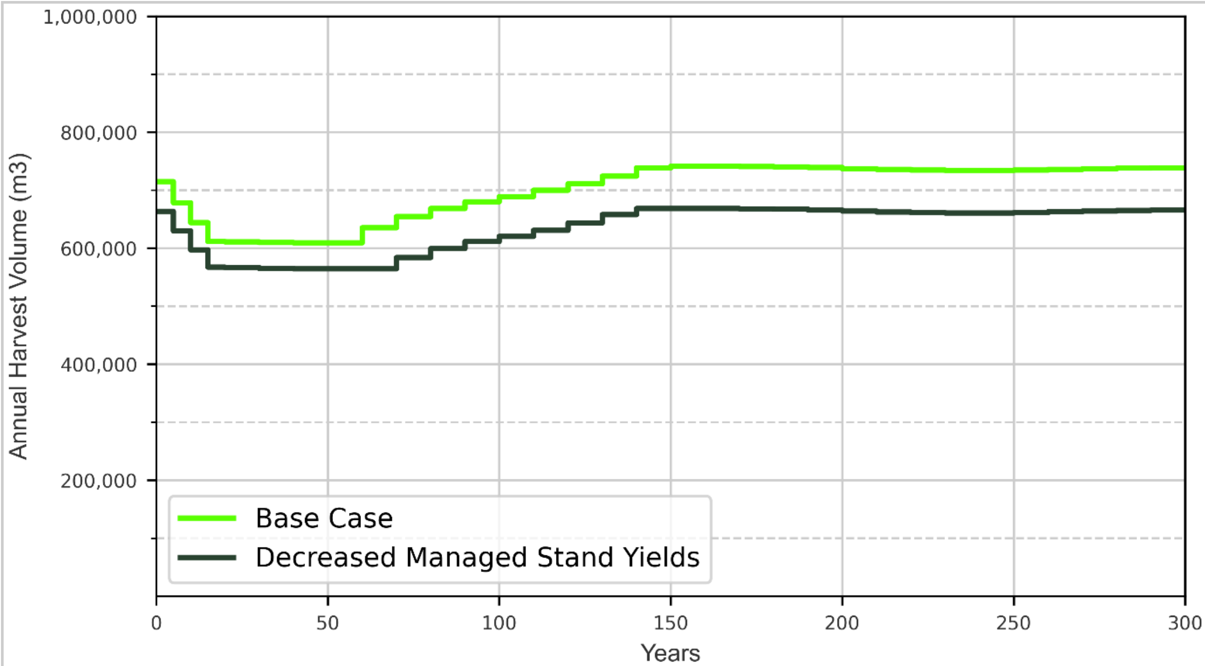


Figure 29 Harvest Levels with Decreased Managed Stand Yields

4.6 Exclude Genetic Gain Adjustments

The Base Case includes yield improvements from genetic gain associated with select seed produced at WFP's Saanich Forestry Centre. Long-term tree breeding programs produce well-adapted selectively bred seeds that will grow into trees with stable and improved volume, growth and quality while maintaining the genetic diversity found in natural populations[1]. This sensitivity tests the impact on timber supply if this silviculture investment to improve yields did not occur.

Genetic gain is applied to future stands and current stands less than 20 years old. The initial THLB growing stock for this sensitivity maintains at the same level as the Base Case (<1% difference) as the impacted stands generally do not contribute to timber supply until after Year 40 or so (when future managed stands start to contribute to the harvest – see Figure 3). However, removing genetic gain assumptions has an immediate impact on timber supply due to harvest level change restrictions between each modelling period. Therefore, a decrease in harvest needs to occur at present to compensate for the reduced yields from managed stands. Table 20 and Figure 30 demonstrate that the short-term and mid-term harvest levels need to decrease for approximately 5.5% compared to the Base Case. The genetic gain assumptions have the greatest influence on timber supply after 60 years. Mid-term harvest levels, particularly after Year 70, need to be reduced further to adjust to the reduced yields from these stands. In the long term, the lack of genetic gain generates harvest levels about 7.8% lower than the base case. Overall, approximately 15.0 million m^3 (7.1%) less is harvested over the 300 years.

Table 20 Harvest Levels with No Future Genetic Gain

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	No Genetic Gain	Difference	
1	2020	2024	715,200	675,200	39,900	5.6
2	2025	2029	678,900	640,800	38,000	5.6
3	2030	2034	644,500	608,300	36,200	5.6
4	2035	2039	611,900	577,600	34,300	5.6
5	2040	2049	611,300	577,400	33,900	5.6
6	2050	2059	610,000	576,900	33,000	5.4
7	2060	2069	609,500	576,700	32,700	5.4
8	2070	2079	609,500	576,700	32,700	5.4
9	2080	2089	635,700	593,400	42,300	6.7
10	2090	2099	654,900	610,000	44,800	6.8
11	2100	2109	668,900	623,400	45,400	6.8
12	2110	2119	680,100	632,200	47,900	7.0
13	2120	2129	689,300	640,500	48,800	7.1
14	2130	2139	700,000	650,800	49,100	7.0
15	2140	2149	711,000	662,700	48,200	6.8
16	2150	2159	724,300	676,300	47,900	6.6
17	2160	2169	738,700	684,400	54,200	7.3
18-32	2170	2319	737,800	680,100	57,600	7.8

[1] See https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/tree-seed/forest-genetics/tree-breeding-improvement

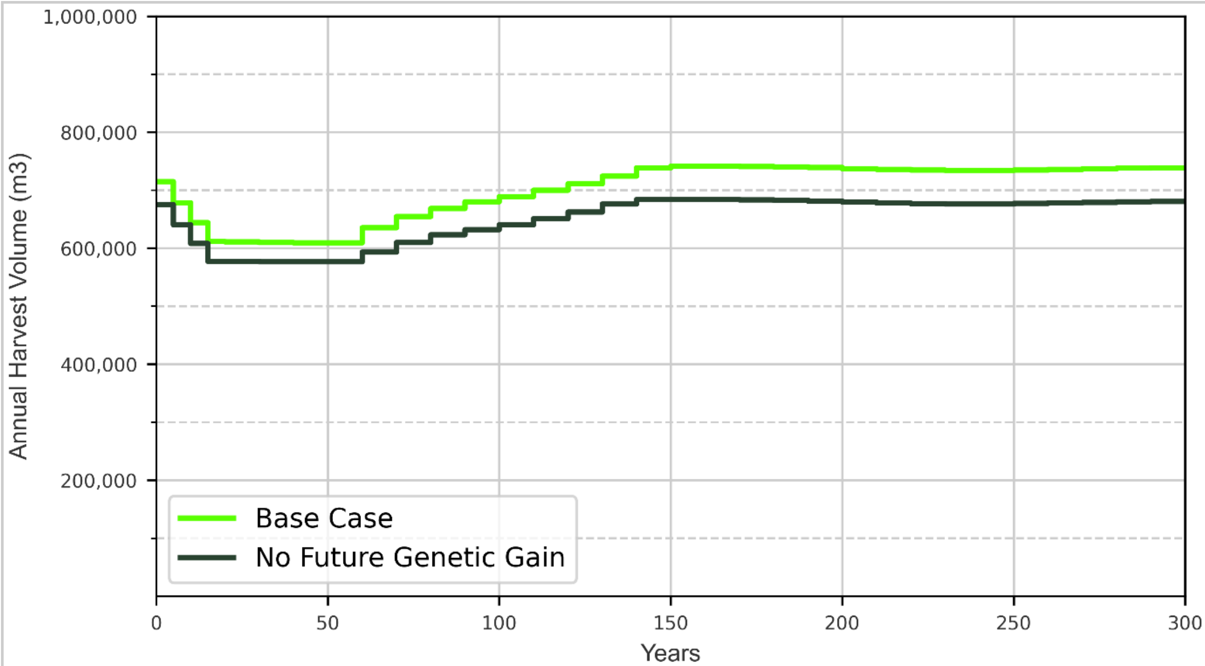


Figure 30 Harvest Levels with No Future Genetic Gain

4.7 Use Provincial Default OAF 1

With the availability of LiDAR data acquired for TFL 44, an in-depth analysis was conducted to quantify gaps in crown cover as a proxy for the extent of non-productive area within managed stands, as described in Appendix C of the associated IP document. The Base Case deploys a tenure-specific OAF 1 of 10.9%. This sensitivity tests the impact on timber supply if the provincial default OAF 1 of 15% is used in the managed stand yields.

Table 21 and Figure 31 quantify that the 4.1% difference in OAF 1 translates to a 3.9% decrease in short-term timber supply. As the managed stands dominate the harvest in the mid-term, the provincial default OAF results in a 4.3% lower harvest level than the Base Case. The long-term timber supply impact for OAF 1 is estimated to be 4.5%. Overall, approximately 9.1 million m^3 (4.3%) less volume is harvested over the 300 years compared to the Base Case.

Table 21 Harvest Levels with Provincial Default OAF 1

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Provincial Default OAF 1	Difference	
1	2020	2024	715,200	687,600	27,500	3.9
2	2025	2029	678,900	652,500	26,300	3.9
3	2030	2034	644,500	619,300	25,100	3.9
4	2035	2039	611,900	588,000	23,900	3.9
5	2040	2049	611,300	587,500	23,700	3.9
6	2050	2059	610,000	586,500	23,400	3.8
7	2060	2069	609,500	586,200	23,300	3.8
8	2070	2079	609,500	586,100	23,300	3.8
9	2080	2089	635,700	609,000	26,700	4.2
10	2090	2099	654,900	626,500	28,400	4.3
11	2100	2109	668,900	640,400	28,500	4.3
12	2110	2119	680,100	651,500	28,600	4.2
13	2120	2129	689,300	660,000	29,300	4.3
14	2130	2139	700,000	670,200	29,700	4.3
15	2140	2149	711,000	681,500	29,500	4.1
16	2150	2159	724,300	695,000	29,200	4.0
17	2160	2169	738,700	708,100	30,600	4.1
18-32	2170	2319	737,800	704,300	33,400	4.5

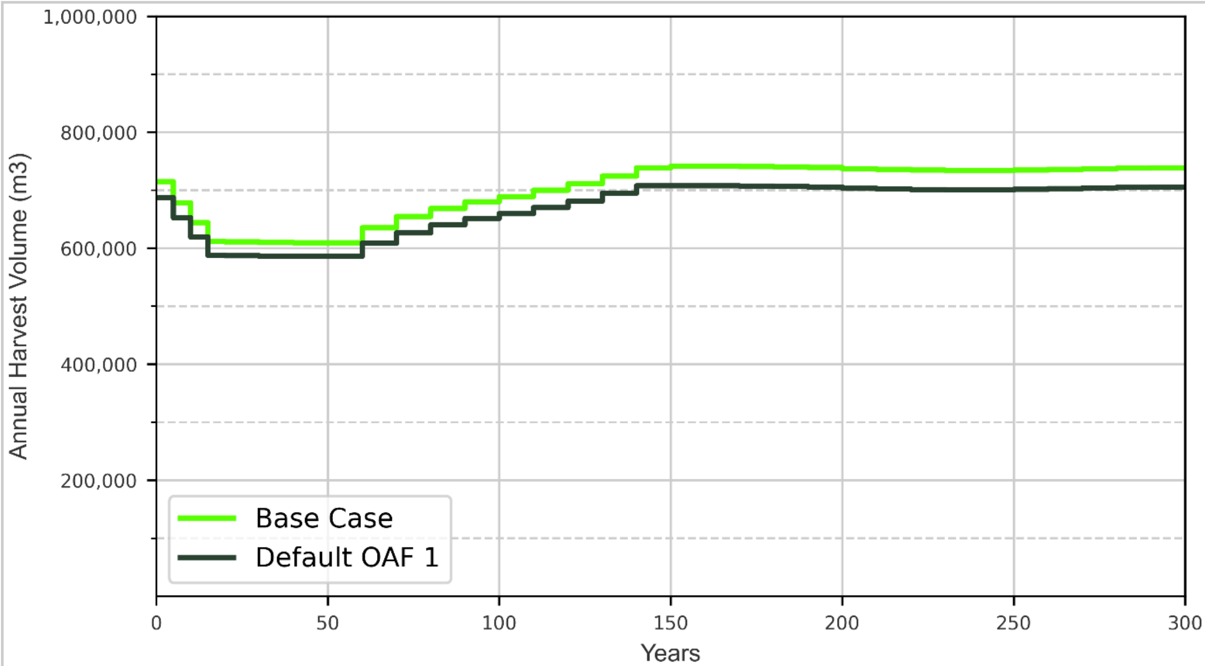


Figure 31 Harvest Levels with Provincial Default OAF 1

4.8 Use Increased OAF 2 to Reflect Root-Rot in Selected Fd-Leading Managed Stands

OAF 2 is used to account for forest health issues associated with the stand. The provincial default of 5% is used in the Base Case. An increased 12.5% OAF 2 is applied to Douglas-fir leading managed and future stands in CWHmm1, xm1 and xm2 zones to address the risks associated with laminated root rot issues, as described in Section 9.2 of the associated IP.

As Figure 10 in Section 2.3 shows, Douglas-fir (Fd) constitutes between 18% and 42% of the Base Case harvests, averaging around 26% for the entire planning horizon. Increased yield reduction in managed Douglas-fir leading stands in these BEC variants causes slight reduction (-0.2%) in the initial Douglas-fir growing stock. Despite the small immediate impact, the longer-term impact is greater due to the reduced future growth potential.

Table 22 and Figure 32 demonstrate that the increased OAF 2 in selected Fd-Leading managed stands decrease timber supply by an average of 2.1% for the first 50 years. The early timber supply impact corresponds to the early harvest contribution from existing managed stands where the increased OAF 2 is applicable. The lower Fd yields caused the Patchworks model to have a slightly modified harvest schedule to be able to optimize the total harvested volume. For the first 50 years, 7,700 m^3/year less Douglas-fir volume is harvested on average. The harvest level for this sensitivity briefly exceeds the Base Case at Year 60. This is when the harvested Fd volume has the smallest difference. Then the difference starts to grow again, but the magnitude is within 1%. The timber supply impact stabilizes around 1.1% less than the Base Case for the long term. Overall, approximately 2.2 million m^3 (-1.0%) less volume is harvested over the 300 years.

Table 22 Harvest Levels with Increased OAF 2 in Selected Fd-Leading Managed Stands

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Increased OAF 2 in Selected Fd Stands	Difference	
1	2020	2024	715,200	699,900	15,300	2.1
2	2025	2029	678,900	664,000	14,800	2.2
3	2030	2034	644,500	630,100	14,300	2.2
4	2035	2039	611,900	598,200	13,700	2.2
5	2040	2049	611,300	597,900	13,400	2.2
6	2050	2059	610,000	597,300	12,700	2.1
7	2060	2069	609,500	597,100	12,300	2.0
8	2070	2079	609,500	610,400	-900	-0.1
9	2080	2089	635,700	637,800	-2,200	-0.3
10	2090	2099	654,900	653,200	1,600	0.2
11	2100	2109	668,900	665,600	3,300	0.5
12	2110	2119	680,100	675,500	4,500	0.7
13	2120	2129	689,300	684,400	4,900	0.7
14	2130	2139	700,000	694,500	5,400	0.8
15	2140	2149	711,000	704,700	6,200	0.9
16	2150	2159	724,300	717,800	6,400	0.9
17	2160	2169	738,700	732,600	6,000	0.8
18-32	2170	2319	737,800	730,000	7,700	1.1

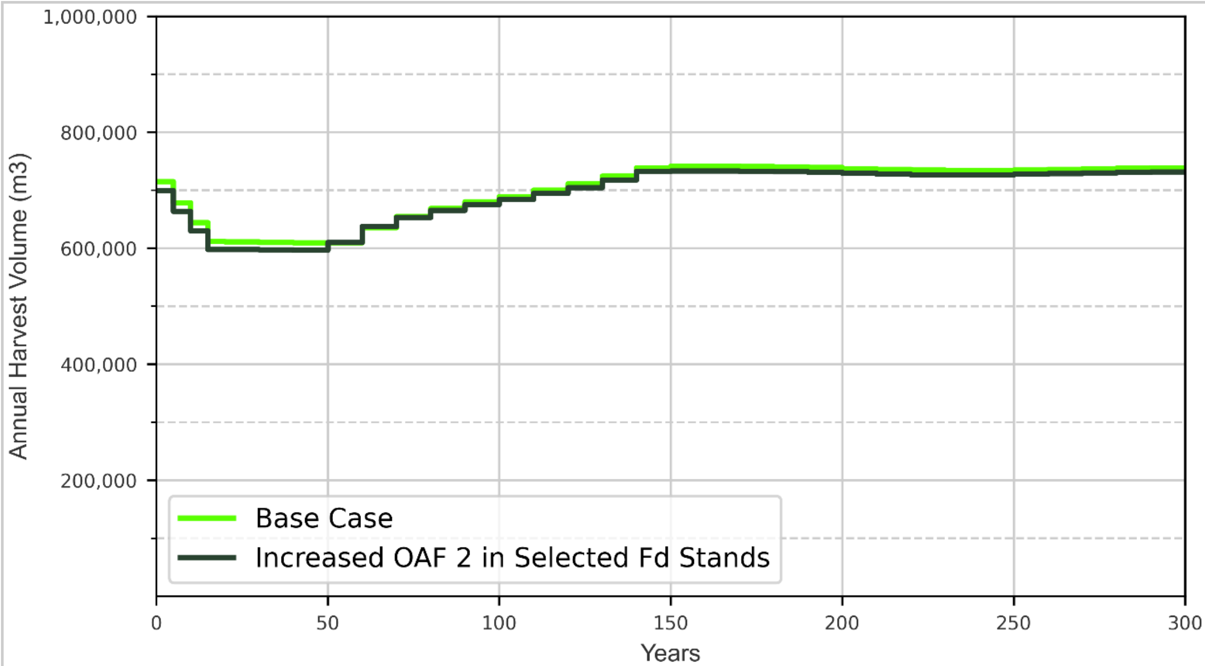


Figure 32 Harvest Levels with Increased OAF 2 in Selected Fd-Leading Managed Stands

4.9 Add 2cm to the Minimum Harvest Criteria

Minimum harvest criteria are used in the timber supply model to determine whether a stand can be harvested - stands are not available for harvest by the model until the minimum criteria are met. Actual harvesting occurs in some stands below the minimum modelled criteria while other stands are not harvested until well past the minimum criteria due to managing for other resource values and timing/rate of harvest constraints. Minimum criteria are often specified by an age and a minimum volume per hectare. Minimum Harvest Criteria prescribed in this timber supply analysis contains minimum harvest diameters and minimum harvest volume (refer to Section 10.3.1 of the associated IP). The concept is that larger diameters in general reflect higher net values.

Table 23 shows the minimum average stand DBH threshold used in the Base Case and in this sensitivity analysis. The minimum DBHs were increased by 2cm for the sensitivity analysis. In terms of years, this 2cm increase translates to delays in harvest eligibility from 5 to 60 years depending on the analysis unit. In timber supply modelling, the minimum harvest diameters translate to minimum harvest ages (MHA). The detailed break-down on minimum average stand age for each analysis unit for this sensitivity is shown in Table 24.

Table 23 Minimum Harvest Criteria Comparison Base Case vs. Increase DBH

Harvest System	Base Case		Increase DBH Sensitivity	
	Minimum Average DBH	Wtd Avg Future Stand Age	Minimum Average DBH	Wtd Avg Future Stand Age
Ground	30 cm	64 years	32 cm	73 years
Cable	37 cm	99 years	39 cm	109 years
Heli	42 cm	126 years	44 cm	139 years

Table 24 Minimum Harvest Age for Current and Future Stands for Increase DBH Scenario

Analysis Unit	Current THLB Area (ha)	Ground-based Harvest		Cable Harvest		Helicopter Harvest	
		MHA	Volume at MHA	MHA	Volume at MHA	MHA	Volume at MHA
Managed Stands 21-57 years old (established 1962 - 1999)							
1131	346	82	638	127	985	167	1,180
1133	1,060	59	552	87	845	108	999
1134	256	67	622	100	976	127	1,175
1136	32	72	598	110	966	145	1,180
1233	218	56	557	81	857	100	1,022
1234	19	57	597	82	919	100	1,086
1333	24	54	543	78	816	96	957
2131	168	81	650	125	1,006	163	1,205
2133	153	68	575	103	880	132	1,043
2134	471	67	622	99	964	126	1,164
2231	141	71	637	108	996	139	1,196
2233	204	70	564	109	881	142	1,046
2234	126	67	631	99	967	124	1,153
2333	118	65	572	98	867	124	1,018
3131	314	76	636	116	993	153	1,211
3133	59	85	561	141	849	194	991

Analysis Unit	Current THLB Area (ha)	Ground-based Harvest		Cable Harvest		Helicopter Harvest	
		MHA	Volume at MHA	MHA	Volume at MHA	MHA	Volume at MHA
3134	232	78	625	122	978	159	1,173
3231	194	84	631	132	976	174	1,168
3233	221	74	563	118	871	155	1,023
3234	137	74	620	113	969	147	1,170
3333	4	79	558	128	864	176	1,023
4132	25	139	528	250	684	250	684
4232	37	124	543	250	790	250	790
4234	117	133	589	250	874	250	874
4332	1,154	112	546	230	855	250	875
4334	340	90	602	146	944	202	1,129
5131	53	70	634	105	973	134	1,168
5132	506	68	574	103	923	136	1,156
5133	1,995	53	565	75	852	91	1,002
5134	5,881	64	611	95	960	119	1,155
5137	40	49	552	69	840	83	986
5138	39	111	523	187	845	250	988
5231	24	61	660	91	1,029	114	1,246
5232	1,925	66	587	98	927	128	1,161
5233	2,531	52	557	74	852	90	1,008
5234	8,141	62	620	90	960	113	1,162
5238	25	50	522	71	845	88	1,060
5332	97	68	596	102	936	133	1,165
5333	1,205	52	575	73	865	89	1,025
5334	346	61	603	89	940	112	1,135
5338	15	50	554	71	899	87	1,112
6134	8	124	595	228	899	250	932
6231	58	72	652	110	1,012	143	1,231
6232	15	82	586	131	941	190	1,164
6233	44	65	560	97	845	123	994
6234	597	76	639	116	987	150	1,187
6331	152	85	622	135	965	180	1,156
6332	67	84	576	135	895	192	1,083
6333	613	67	570	100	856	128	1,011
6334	2,459	73	633	110	975	144	1,185
6336	48	82	609	130	958	185	1,183
7331	31	215	586	250	645	250	645
Managed Stands 1-20 years old (established 1999 - 2019)							
1122	76	53	552	76	833	93	986
1123	320	53	554	76	837	93	990
1124	63	52	549	74	829	91	987
1223	153	53	540	78	832	95	972
1224	53	49	557	68	823	82	968
1322	44	49	545	69	814	84	957
1323	2,310	49	538	70	819	85	959
1324	15	47	542	66	816	80	964
2121	16	57	579	84	944	106	1,162
2123	12	65	573	99	942	131	1,165

Analysis Unit	Current THLB Area (ha)	Ground-based Harvest		Cable Harvest		Helicopter Harvest	
		MHA	Volume at MHA	MHA	Volume at MHA	MHA	Volume at MHA
2124	48	62	578	93	945	120	1,164
2221	63	68	575	105	934	138	1,137
2224	19	68	577	105	936	137	1,134
2323	39	64	550	98	847	126	1,001
3121	136	72	577	113	919	150	1,108
3123	30	70	582	108	922	143	1,117
3124	73	70	584	108	925	142	1,117
3126	46	73	577	115	920	154	1,110
3221	196	75	584	118	922	158	1,109
3223	22	70	577	109	924	144	1,118
3224	24	71	579	110	922	146	1,115
3323	78	73	559	116	870	157	1,039
3324	11	69	560	108	876	142	1,043
3326	12	67	558	104	877	137	1,052
4122	283	109	542	250	849	250	849
4124	55	62	553	95	950	126	1,202
4222	204	118	529	250	771	250	771
4321	24	65	570	99	958	130	1,193
4322	1,731	104	552	210	887	250	936
4323	20	80	565	131	927	198	1,146
4324	353	79	562	129	937	190	1,148
4328	23	64	568	97	956	128	1,200
5121	23	67	574	102	916	134	1,135
5122	954	65	583	97	922	126	1,143
5123	227	63	573	95	922	125	1,139
5124	1,274	63	574	94	917	122	1,143
5126	13	66	582	99	930	129	1,147
5127	12	61	579	90	924	116	1,150
5221	173	68	583	104	930	138	1,160
5222	1,374	65	589	97	933	127	1,165
5223	11	70	576	109	944	146	1,161
5224	3,454	65	591	97	935	127	1,168
5228	36	62	591	92	937	119	1,175
5322	2,421	62	578	91	900	116	1,110
5323	1,009	61	571	90	899	115	1,112
5324	651	61	575	90	903	115	1,117
5328	10	60	581	88	914	111	1,121
6121	85	95	582	166	915	250	1,072
6122	93	75	593	118	944	164	1,165
6124	59	79	585	127	933	182	1,147
6126	49	83	581	137	929	205	1,129
6224	145	75	602	116	940	160	1,160
6321	406	76	589	120	930	165	1,136
6322	193	77	591	121	926	168	1,134
6323	77	80	593	127	922	180	1,127
6324	1,475	76	591	119	927	164	1,138
6326	77	84	586	138	922	200	1,101

Analysis Unit	Current THLB Area (ha)	Ground-based Harvest		Cable Harvest		Helicopter Harvest	
		MHA	Volume at MHA	MHA	Volume at MHA	MHA	Volume at MHA
7321	73	167	568	250	691	250	691
Future Managed Stands							
Analysis Unit	**Future THLB Area (ha)**	**Ground-based Harvest**		**Cable Harvest**		**Helicopter Harvest**	
		MHA	**Volume at MHA**	**MHA**	**Volume at MHA**	**MHA**	**Volume at MHA**
1110	4,590	54	634	75	880	90	1,007
1210	970	53	635	73	879	87	1,002
1310	2,959	51	629	70	875	84	1,005
2110	1,466	68	695	98	983	123	1,143
2210	567	68	696	98	985	123	1,146
2310	157	68	683	100	980	125	1,134
3110	2,072	78	662	120	945	157	1,089
3210	964	83	706	125	1,014	165	1,192
3310	114	84	711	127	1,019	166	1,192
4110	620	119	647	250	707	250	707
4210	767	120	643	250	841	250	841
4310	4,079	113	722	185	1,019	250	1,145
5110	17,113	68	678	100	988	130	1,194
5210	20,704	66	707	96	1,021	123	1,227
5310	7,123	64	707	92	1,030	115	1,226
6110	828	89	728	137	1,031	186	1,210
6210	1,996	83	728	125	1,034	168	1,226
6310	6,496	87	732	134	1,050	183	1,242
7110	120	250	619	250	619	250	619
7210	83	250	669	250	669	250	669
7310	474	250	636	250	636	250	636

The larger DBH criteria decreases the initial merchantable inventory by 0.92 million m^3 (6.9%). Table 25 and Figure 33 show the comparison of this sensitivity with the Base Case. Due to the less merchantable initial inventory and more rigid minimum harvest criteria, the harvest level is below the Base Case. Particularly for the short-term timber supply where the bottleneck is clearly the available starting inventory and the late merchantability for managed stands brought by this DBH threshold adjustment, the sensitivity has 11.7% lower projected harvest level than the Base Case for the first 30 years. As the existing natural stand volume decreases, the transition to harvest existing managed stands occurs, and existing managed stands become merchantable, the gap in harvest level starts to shrink after Year 50 and recover back to the same level as the Base Case. After Year 150, the harvest levels of this sensitivity are driven by the objective to have a flat THLB growing stock level. Thus, the harvest level maintains a long-term gap of 1.3%. Overall, 5.2 million m^3 (-2.5%) less is harvested in this sensitivity analysis compared to the Base Case.

Table 25 Harvest Levels with Increased Minimum Harvest DBH

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Increased Min. DBH	Difference	
1	2020	2024	715,200	631,700	83,500	11.7
2	2025	2029	678,900	599,300	79,500	11.7
3	2030	2034	644,500	568,700	75,700	11.8
4	2035	2039	611,900	540,100	71,800	11.7
5	2040	2049	611,300	540,100	71,200	11.6
6	2050	2059	610,000	543,400	66,600	10.9
7	2060	2069	609,500	580,000	29,500	4.8
8	2070	2079	609,500	613,900	-4,500	-0.7
9	2080	2089	635,700	638,700	-3,000	-0.5
10	2090	2099	654,900	654,100	700	0.1
11	2100	2109	668,900	665,900	3,000	0.5
12	2110	2119	680,100	674,700	5,300	0.8
13	2120	2129	689,300	681,700	7,500	1.1
14	2130	2139	700,000	690,300	9,600	1.4
15	2140	2149	711,000	699,000	12,000	1.7
16	2150	2159	724,300	711,600	12,600	1.7
17	2160	2169	738,700	725,600	13,000	1.8
18-32	2170	2319	737,800	728,200	9,500	1.3

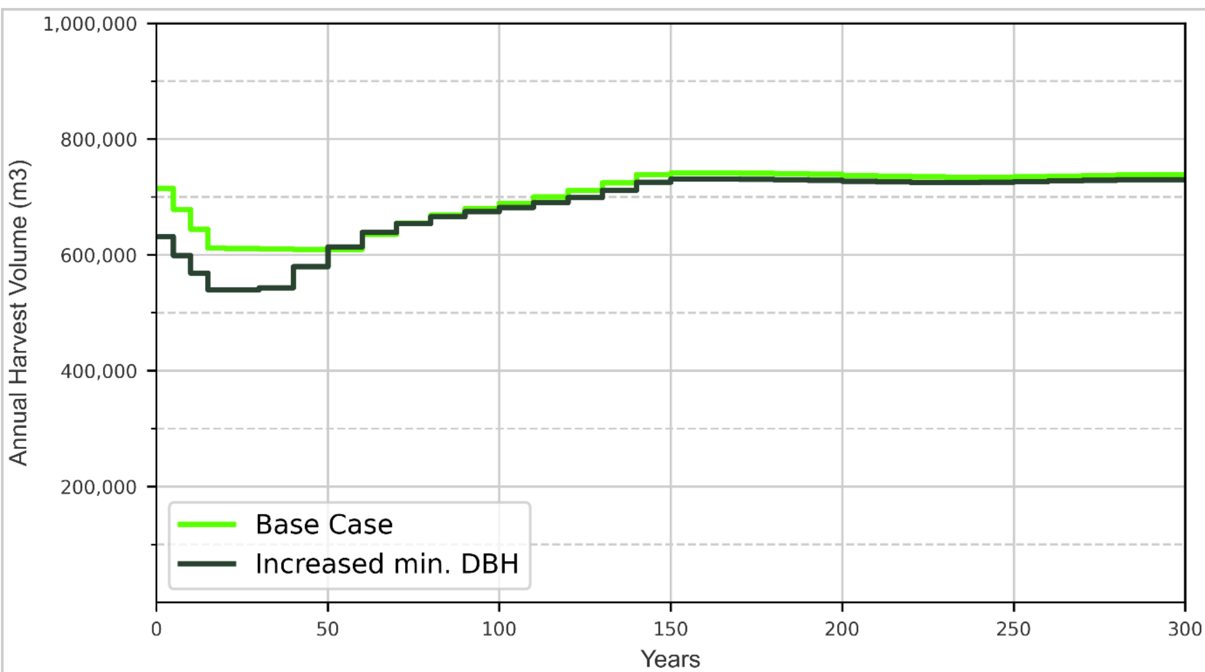


Figure 33 Harvest Levels with Increased Minimum Harvest DBH

4.10 Subtract 2cm from the Minimum Harvest Criteria

This sensitivity tests the scenario where the minimum harvest DBHs are decreased by 2cm. The minimum harvest DBH is shown in Table 26. In terms of stand ages, this advances harvest eligibility from 5 to 75 years depending on the analysis unit. The detailed break-down on minimum average stand age for each analysis unit for this sensitivity is shown in Table 27.

Table 26 Minimum Harvest Criteria Comparison Base Case vs. Decreased DBH

Harvest System	Base Case		Decreased DBH Sensitivity	
	Minimum Average DBH	Wtd Avg Future Stand Age	Minimum Average DBH	Wtd Avg Future Stand Age
Ground	30 cm	64 years	28 cm	56 years
Cable	37 cm	99 years	35 cm	88 years
Heli	42 cm	126 years	40 cm	114 years

Table 27 Minimum Harvest Age for Current and Future Stands for Decrease DBH Scenario

Analysis Unit	Current THLB Area (ha)	Ground-based Harvest		Cable Harvest		Helicopter Harvest	
		MHA	Volume at MHA	MHA	Volume at MHA	MHA	Volume at MHA
Managed Stands 21-57 years old (established 1962 - 1999)							
1131	346	62	425	100	801	134	1,024
1133	1,060	46	379	71	694	91	879
1134	256	52	417	80	779	105	1,016
1136	32	56	401	88	765	116	1,007
1233	218	45	395	67	702	85	894
1234	19	45	412	68	753	86	958
1333	24	42	368	64	669	82	851
2131	168	61	427	99	821	132	1,047
2133	153	52	391	82	714	109	919
2134	471	52	418	80	777	105	1,013
2231	141	55	432	86	803	114	1,038
2233	204	53	376	86	710	115	916
2234	126	51	414	80	785	104	1,008
2333	118	49	381	78	705	103	900
3131	314	58	422	92	800	123	1,039
3133	59	62	376	107	699	150	879
3134	232	59	415	96	794	129	1,020
3231	194	63	416	103	793	140	1,017
3233	221	56	384	92	709	125	904
3234	137	56	408	90	784	119	1,008
3333	4	59	374	98	696	137	900
4132	25	97	362	215	657	250	684
4232	37	90	366	173	691	250	790
4234	117	95	398	177	738	250	874
4332	1,154	83	372	149	698	250	875
4334	340	68	406	112	763	156	986
5131	53	54	430	83	783	110	1,008
5132	506	54	398	81	728	109	977

Analysis Unit	Current THLB Area (ha)	Ground-based Harvest		Cable Harvest		Helicopter Harvest	
		MHA	Volume at MHA	MHA	Volume at MHA	MHA	Volume at MHA
5133	1,995	42	392	62	695	78	884
5134	5,881	50	415	77	777	100	1,002
5137	40	39	381	58	692	72	874
5138	39	85	357	139	663	200	883
5231	24	48	453	73	831	95	1,071
5232	1,925	52	404	78	738	104	981
5233	2,531	41	379	61	688	77	885
5234	8,141	48	415	73	772	95	1,006
5238	25	41	365	58	653	75	899
5332	97	53	404	80	741	107	980
5333	1,205	41	393	61	710	77	910
5334	346	48	414	73	764	94	984
5338	15	40	367	58	692	74	942
6134	8	89	402	160	740	248	929
6231	58	55	434	87	819	116	1,056
6232	15	63	394	99	739	140	993
6233	44	50	386	78	692	102	878
6234	597	58	430	92	803	122	1,026
6331	152	65	425	105	787	144	1,010
6332	67	64	396	102	719	145	939
6333	613	51	386	80	700	105	888
6334	2,459	56	425	88	793	117	1,023
6336	48	63	415	99	761	138	1,004
7331	31	140	400	250	645	250	645
Managed Stands 1-20 years old (established 1999 - 2019)							
1122	76	41	372	62	676	79	863
1123	320	41	373	62	679	79	867
1124	63	41	381	61	677	78	870
1223	153	42	376	63	670	81	860
1224	53	39	389	57	678	71	858
1322	44	39	383	57	663	72	846
1323	2,310	39	377	58	670	73	848
1324	15	38	387	55	668	69	853
2121	16	45	389	68	736	88	991
2123	12	51	386	79	735	105	990
2124	48	49	391	75	743	98	991
2221	63	53	390	83	735	110	970
2224	19	53	391	83	737	110	972
2323	39	49	376	78	690	104	885
3121	136	55	387	89	738	120	962
3123	30	54	394	85	731	115	967
3124	73	54	396	85	734	114	964
3126	46	56	389	90	734	122	960
3221	196	57	390	92	737	125	961
3223	22	54	389	86	735	115	962
3224	24	55	396	87	735	117	964
3323	78	55	376	90	700	124	910

Analysis Unit	Current THLB Area (ha)	Ground-based Harvest		Cable Harvest		Helicopter Harvest	
		MHA	Volume at MHA	MHA	Volume at MHA	MHA	Volume at MHA
3324	11	53	384	84	699	114	911
3326	12	52	385	82	703	110	915
4122	283	81	368	146	693	250	849
4124	55	50	378	75	720	100	1,002
4222	204	87	364	165	678	250	771
4321	24	51	378	78	731	104	1,002
4322	1,731	78	373	136	709	240	926
4323	20	62	384	98	724	140	976
4324	353	61	375	98	730	138	984
4328	23	51	384	77	729	102	1,004
5121	23	52	387	80	726	108	964
5122	954	50	388	77	732	102	966
5123	227	49	387	75	727	100	965
5124	1,274	49	387	75	728	99	963
5126	13	51	387	79	738	105	981
5127	12	48	393	72	728	95	975
5221	173	53	397	81	734	110	980
5222	1,374	50	393	77	741	103	986
5223	11	55	394	86	746	116	993
5224	3,454	50	395	77	743	102	980
5228	36	49	409	73	738	97	989
5322	2,421	48	388	73	721	96	947
5323	1,009	48	393	72	716	95	947
5324	651	48	395	71	708	94	941
5328	10	47	391	70	719	92	954
6121	85	70	385	119	735	180	955
6122	93	58	404	90	742	125	989
6124	59	60	391	96	736	136	983
6126	49	64	401	102	737	147	976
6224	145	58	413	89	742	124	990
6321	406	58	399	92	742	127	971
6322	193	59	404	93	740	129	971
6323	77	60	395	97	740	136	969
6324	1,475	58	400	92	745	127	975
6326	77	64	401	103	738	147	962
7321	73	110	386	247	688	250	691
Future Managed Stands							
Analysis Unit	**Future THLB Area (ha)**	**Ground-based Harvest**		**Cable Harvest**		**Helicopter Harvest**	
		MHA	**Volume at MHA**	**MHA**	**Volume at MHA**	**MHA**	**Volume at MHA**
1110	4,590	42	452	63	753	78	908
1210	970	41	449	61	747	76	908
1310	2,959	40	450	59	745	73	904
2110	1,466	52	486	80	828	103	1,019
2210	567	52	488	80	830	103	1,021
2310	157	52	479	81	822	104	1,008

Analysis Unit	Current THLB Area (ha)	Ground-based Harvest		Cable Harvest		Helicopter Harvest	
		MHA	Volume at MHA	MHA	Volume at MHA	MHA	Volume at MHA
3110	2,072	58	461	95	798	126	972
3210	964	62	484	100	855	132	1,051
3310	114	63	494	102	866	134	1,055
4110	620	84	440	180	750	250	707
4210	767	85	441	184	789	250	841
4310	4,079	82	502	140	869	198	1,049
5110	17,113	53	482	81	824	106	1,036
5210	20,704	51	497	78	852	101	1,066
5310	7,123	50	498	75	852	96	1,069
6110	828	67	511	108	868	145	1,070
6210	1,996	63	514	99	864	133	1,079
6310	6,496	66	516	105	874	142	1,091
7110	120	180	492	250	619	250	619
7210	83	164	493	250	669	250	669
7310	474	174	493	250	636	250	636

The smaller DBH criteria increases the initial merchantable inventory by 0.84 million m^3 (6.3%). Table 28 and Figure 34 illustrate the projected harvest levels against the base case. Not surprisingly, this sensitivity scenario is the opposite of the increased minimum harvest DBH scenario discussed in Section 4.9. More merchantable starting inventory pushes the harvest level to be approximately 6.0% higher than the Base Case for the first 60 years. The scale of the change is more aligned with the merchantable inventory change. Compared to the -11.7% change in harvest level on the similar change of -6% in initial merchantable inventory from the increased minimum harvest DBH scenario, the harvest impact for TFL 44 land base appears to be more severe with the increased minimum harvest criteria. As the harvest moves towards managed stands, this difference decreases gradually to below 2%. The long-term timber supply impact is about 0.4% more than the Base Case. Overall, 3.6 million m^3 (1.7%) more volume is harvested in this sensitivity analysis.

Table 28 Harvest Levels with Decreased Minimum Harvest DBH

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Decreased Min. DBH	Difference	
1	2020	2024	715,200	758,000	-42,800	-6.0
2	2025	2029	678,900	719,300	-40,500	-6.0
3	2030	2034	644,500	682,800	-38,300	-5.9
4	2035	2039	611,900	648,200	-36,400	-5.9
5	2040	2049	611,300	647,600	-36,400	-5.9
6	2050	2059	610,000	646,300	-36,400	-6.0
7	2060	2069	609,500	645,700	-36,200	-5.9
8	2070	2079	609,500	645,500	-36,100	-5.9
9	2080	2089	635,700	646,400	-10,800	-1.7
10	2090	2099	654,900	662,100	-7,300	-1.1
11	2100	2109	668,900	676,300	-7,400	-1.1
12	2110	2119	680,100	689,400	-9,400	-1.4
13	2120	2129	689,300	701,700	-12,400	-1.8
14	2130	2139	700,000	712,700	-12,800	-1.8
15	2140	2149	711,000	723,600	-12,700	-1.8
16	2150	2159	724,300	735,200	-11,000	-1.5
17	2160	2169	738,700	745,100	-6,500	-0.9
18-32	2170	2319	737,800	740,800	-3,100	-0.4

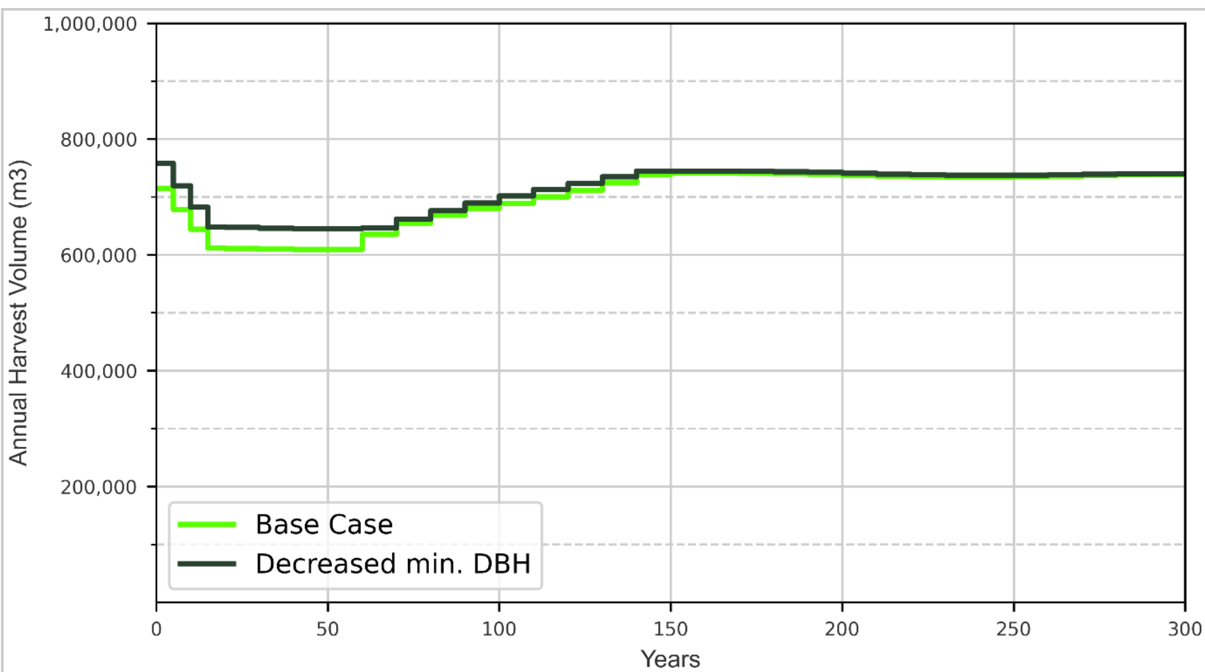


Figure 34 Harvest Levels with Decreased Minimum Harvest DBH

4.11 Harvest at 95% of Culmination MAI Age

As discussed in the preceding two sections, the minimum DBH criteria in the Base Case is to manage stands for financial rotation reasons. A traditional concept to maximize yield from a forest over time is to harvest stands when they reach their highest average growth rate or mean annual increment (MAI). This age is often referred to as the culmination age and is the optimal biological rotation age to maximize long-term volume (Province of British Columbia, 2008). Given conflicting forest-level objectives, it is not feasible to consistently harvest all stands at their culmination age. Therefore, achieving 95% of culmination is often seen as a reasonable objective.

The practice of using 90% or 95% culmination MAI age as minimum harvest age can be found in recently completed or ongoing timber supply analysis for other timber supply areas (TSA) on the BC coast. For instance, the Arrowsmith TSA which is outside of TFL 44 used 90% culmination MAI age as a sensitivity (Province of British Columbia, 2016). 95% culmination MAI was also used in the North Island TSA timber supply review data package (Province of British Columbia, 2020) and the Sunshine Coast TSA timber supply review data package (Province of British Columbia, 2021).

For this sensitivity, minimum harvest age was set at the age when the MAI first reaches 95% of the culmination MAI (see Table 29). If the 95% of the culmination MAI is less than 40 years old, the minimum harvest age is set to age 40. Because 95% culmination MAI age is not related to which harvest system the stand is subject to, the minimum harvest age is the same across the three harvest systems. The results indicate that the DBH criteria applied in the Base Case produces have longer rotations than culmination MAI criteria for cable and helicopter harvest systems, whereas it is shorter for ground-based harvest systems. The detailed break-down on minimum average stand for each analysis unit for this sensitivity is shown in Table 30.

Table 29 Minimum Harvest Criteria Comparison Base Case vs. 95% Culmination MAI

Harvest System	Base Case		Culmination Sensitivity
	Minimum Average DBH	Wtd Avg Future Stand Age	Wtd Avg Future Stand Age
Ground	30 cm	64 years	78 years
Cable	37 cm	99 years	
Helicopter	42 cm	126 years	

Table 30 Minimum Harvest Age for Current and Future Stands for 95% Culmination MAI Scenario

Analysis Unit	Current THLB Area (ha)	95% Culmination MAI	
		MHA	Volume at MHA
Managed Stands 21-57 years old (established 1962 - 1999)			
1131	346	95	761
1133	1,060	76	746
1134	256	86	840
1136	32	95	842
1233	218	76	806
1234	19	76	855
1333	24	67	702
2131	168	95	789
2133	153	86	746
2134	471	86	841
2231	141	86	803

Analysis Unit	Current THLB Area (ha)	95% Culmination MAI	
		MHA	Volume at MHA
2233	204	86	707
2234	126	86	845
2333	118	76	689
3131	314	95	832
3133	59	86	565
3134	232	95	788
3231	194	100	768
3233	221	86	660
3234	137	95	832
3333	4	86	610
4132	25	114	440
4232	37	114	500
4234	117	124	547
4332	1,154	114	557
4334	340	105	713
5131	53	86	811
5132	506	86	773
5133	1,995	67	757
5134	5,881	86	871
5137	40	67	810
5138	39	124	591
5231	24	76	871
5232	1,925	76	724
5233	2,531	67	767
5234	8,141	76	817
5238	25	76	918
5332	97	86	796
5333	1,205	67	789
5334	346	76	807
5338	15	76	976
6134	8	114	547
6231	58	86	808
6232	15	95	710
6233	44	76	676
6234	597	86	747
6331	152	95	713
6332	67	95	671
6333	613	76	665
6334	2,459	86	772
6336	48	95	731
7331	31	162	466
Managed Stands 1-20 years old (established 1999 - 2019)			
1122	76	67	735
1123	320	67	738
1124	63	67	750
1223	153	67	716
1224	53	67	806
1322	44	67	785
1323	2,310	67	778

Analysis Unit	Current THLB Area (ha)	95% Culmination MAI	
		MHA	Volume at MHA
1324	15	57	706
2121	16	86	963
2123	12	86	813
2124	48	86	871
2221	63	95	852
2224	19	95	854
2323	39	76	674
3121	136	86	710
3123	30	95	823
3124	73	95	826
3126	46	95	776
3221	196	86	685
3223	22	95	818
3224	24	95	808
3323	78	86	665
3324	11	76	633
3326	12	86	735
4122	283	114	568
4124	55	95	952
4222	204	114	512
4321	24	95	921
4322	1,731	114	611
4323	20	95	703
4324	353	95	708
4328	23	95	938
5121	23	86	782
5122	954	76	729
5123	227	76	747
5124	1,274	76	749
5126	13	95	892
5127	12	76	781
5221	173	86	779
5222	1,374	76	738
5223	11	91	785
5224	3,454	76	740
5228	36	76	780
5322	2,421	76	761
5323	1,009	76	768
5324	651	76	771
5328	10	76	790
6121	85	105	651
6122	93	86	705
6124	59	95	730
6126	49	95	688
6224	145	86	713
6321	406	86	690
6322	193	86	681
6323	77	95	726
6324	1,475	86	693

Analysis Unit	Current THLB Area (ha)	95% Culmination MAI	
		MHA	Volume at MHA
6326	77	95	682
7321	73	114	402
Future Managed Stands			
Analysis Unit	**Future THLB Area (ha)**	**Ground-based Harvest**	
		MHA	**Volume at MHA**
1,110	4,590	57	683
1,210	970	57	699
1,310	2,959	57	722
2,110	1,466	76	787
2,210	567	76	789
2,310	157	76	772
3,110	2,072	76	647
3,210	964	95	812
3,310	114	95	809
4,110	620	105	575
4,210	767	105	566
4,310	4,079	105	669
5,110	17,113	76	774
5,210	20,704	76	831
5,310	7,123	76	865
6,110	828	86	700
6,210	1,996	86	754
6,310	6,496	86	722
7,110	120	143	395
7,210	83	133	401
7,310	474	133	381

Figure 35 compares the merchantable inventory (i.e., meets minimum harvest criteria) over time by harvest system for the Base Case and this sensitivity. Despite less merchantable volume for the ground harvest system, the shorter rotation age in cable and helicopter harvest systems increases the starting merchantable inventory by 11%. The sensitivity has on average 7.2% more merchantable volume for the first 30 years than the Base Case (The projected harvest levels are expected to decrease and level out at Year 30). The extra merchantable volume supports a higher harvest level, particularly in the short-term. When managed stands contribute to more than 50% of harvest in the mid-term, the younger MHA expands harvest eligibility to more stands, increasing merchantable volumes. The trend is maintained for the long-term harvest as well.

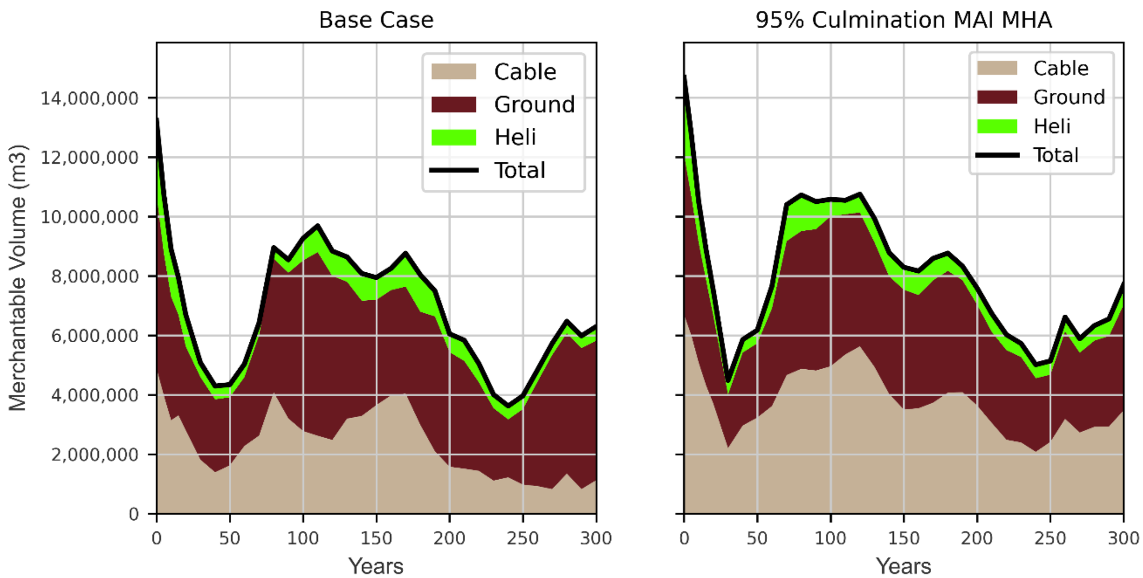


Figure 35 Merchantable Volume Base Case versus 95% Culmination MAI as Minimum Harvest Age

Table 31 and Figure 36 demonstrate the projected harvest levels versus the Base Case. Using 95% culmination MAI ages increases harvest by 9.3% for the first 40 years, as there is more merchantable volume available in the short term as illustrated above. The shorter rotations associated with using 95% culmination MAI ages allows the mid-term harvest level to increase by as much as 16.1% in Year 60. Long-term harvest levels are 1.3% more than the Base Case. Over the 300-year planning horizon, 10.5 million m^3 (5.0%) more volume is harvested for the sensitivity.

Given the wide implementation of 95% culmination MAI as the minimum harvest age in BC coast timber supply reviews, this suggests that the minimum harvest criteria in the Base Case may be conservative.

Table 31 Harvest Levels Using 95% Culmination as Minimum Harvest Age

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	95% Culmination MAI MHA	Difference	
1	2020	2024	715,200	781,400	-66,300	-9.3
2	2025	2029	678,900	741,700	-62,900	-9.3
3	2030	2034	644,500	704,100	-59,700	-9.2
4	2035	2039	611,900	668,600	-56,700	-9.3
5	2040	2049	611,300	668,200	-56,900	-9.3
6	2050	2059	610,000	668,100	-58,200	-9.5
7	2060	2069	609,500	683,400	-74,000	-12.1
8	2070	2079	609,500	707,600	-98,100	-16.1
9	2080	2089	635,700	718,800	-83,100	-13.1
10	2090	2099	654,900	727,600	-72,800	-11.1
11	2100	2109	668,900	734,800	-65,900	-9.8
12	2110	2119	680,100	741,400	-61,300	-9.0
13	2120	2129	689,300	747,900	-58,600	-8.5
14	2130	2139	700,000	755,000	-55,000	-7.9
15	2140	2149	711,000	757,700	-46,800	-6.6
16	2150	2159	724,300	757,700	-33,500	-4.6
17	2160	2169	738,700	757,600	-18,900	-2.6
18-32	2170	2319	737,800	747,600	-9,900	-1.3

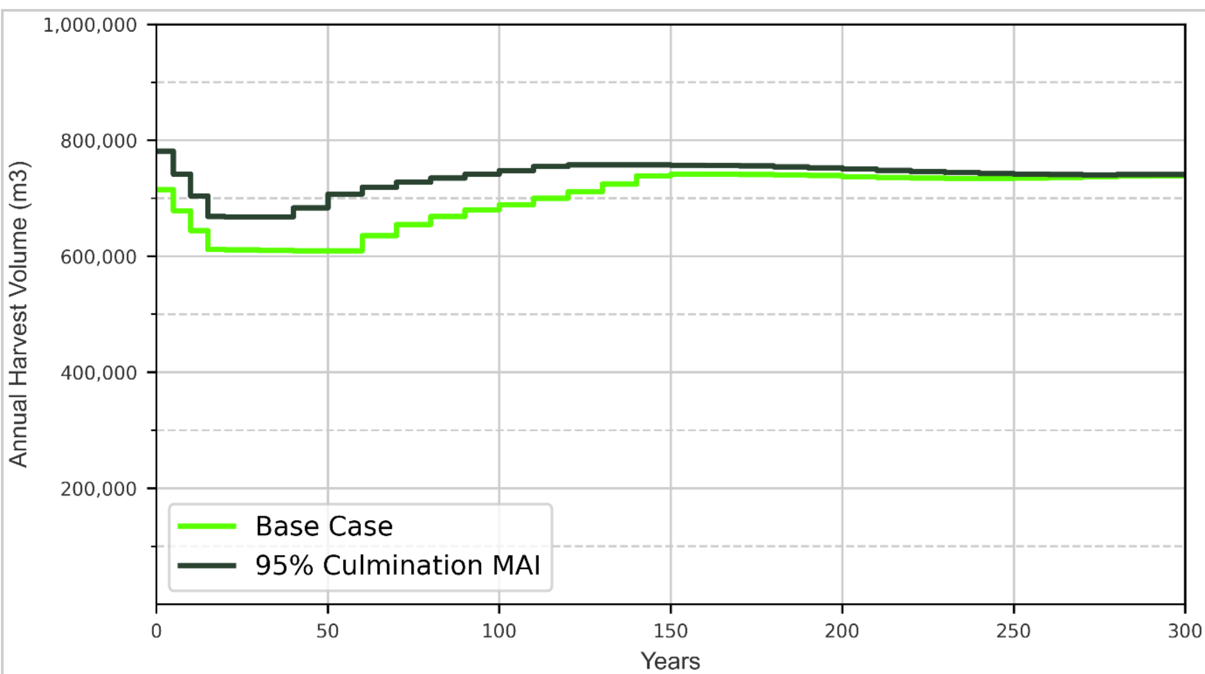


Figure 36 Harvest Levels Using 95% Culmination as Minimum Harvest Age

4.12 Remove Thunder Mountain GAR Order Area

In 2013, a GAR Order was established to protect the cultural heritage resource known as Thunder Mountain. 846.7 ha out of the total 863.5 ha GAR Order area is inside TFL 44 in the Great Central Lake block. The current GAR Order does not specify details on what activities are not allowed. The licensee may adopt unique results and strategies on how to manage the cultural heritage resources within FSP(s) or other plans, in collaboration with the applicable First Nations. Therefore, the Thunder Mountain area remains in the THLB in the Base Case. With the regular THLB netdown categories/methodology applied, 666.6 ha of the Thunder Mountain GAR Order area is classified as THLB. This sensitivity explores the timber supply impact when 100% of the Thunder Mountain GAR Order area is excluded from the THLB. This THLB exclusion translates to 0.9% reduction in the overall THLB and 1.1% reduction in the initial THLB growing stock.

Table 32 and Figure 37 show the projected harvest level against the Base Case. The reduced THLB leads to a lower harvest level for this sensitivity. Due to more natural stand presence in that area, the harvest level reduction is proportionally more obvious in the short-term, with -3.7% lower harvest level than the Base Case for the first 50 years. As the managed stands contribute more to the harvest levels, the mid-term and long-term harvest impact can be mitigated by the land base and different dynamics in harvest schedule selection. This is evident by 0.2% harvest level difference from Year 60 to Year 150. The 1.2% long-term harvest reduction level is more in line with the 0.9% THLB reduction level for the land base. Overall, 0.8 million m^3 (-0.4%) less volume is harvested over 300 years in this sensitivity analysis.

Table 32 Harvest Levels with Thunder Mountain GAR Order Area Removed

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	GAR Order Area Removed	Difference	
1	2020	2024	715,200	688,300	26,800	3.8
2	2025	2029	678,900	653,100	25,700	3.8
3	2030	2034	644,500	619,900	24,500	3.8
4	2035	2039	611,900	588,600	23,200	3.8
5	2040	2049	611,300	588,500	22,700	3.7
6	2050	2059	610,000	588,400	21,500	3.5
7	2060	2069	609,500	589,300	20,200	3.3
8	2070	2079	609,500	624,200	-14,800	-2.4
9	2080	2089	635,700	643,800	-8,100	-1.3
10	2090	2099	654,900	659,000	-4,200	-0.6
11	2100	2109	668,900	670,500	-1,600	-0.2
12	2110	2119	680,100	680,200	-100	0.0
13	2120	2129	689,300	688,000	1,200	0.2
14	2130	2139	700,000	697,400	2,500	0.4
15	2140	2149	711,000	706,700	4,200	0.6
16	2150	2159	724,300	718,700	5,500	0.8
17	2160	2169	738,700	732,700	5,900	0.8
18-32	2170	2319	737,800	729,200	8,500	1.2

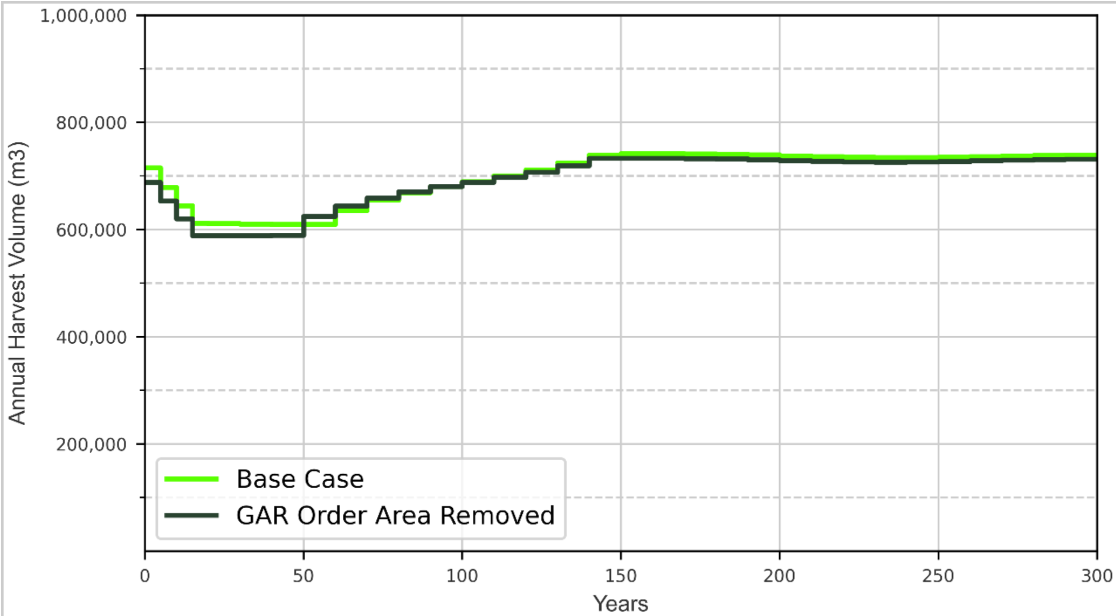


Figure 37 Harvest Levels with Thunder Mountain GAR Order Area Removed

4.13 Remove Potential Ditidaht First Nation Agreement-In-Principle Offer Lands

Ditidaht First Nation (DFN) is engaging with the Government of British Columbia in the British Columbia treaty process. The current stage for the negotiation is at Stage 5 - negotiating to finalize a treaty. An Agreement-In-Principle (AIP) Offer Lands area has been identified within their territory. The overlapping area in TFL 44 is estimated to be 1,621 hectares, of which 1,017 hectares are classified as THLB. This sensitivity removes this overlapping area from the THLB. This THLB exclusion translates to 1.4% reduction in the overall THLB and 2.6% in the initial THLB growing stock.

Table 33 and Figure 38 show the projected harvest level against the Base Case. The reduced THLB leads to a lower harvest level compared to the Base Case. Similar to the Thunder Mountain GAR order area discussed in Section 4.12, there are more natural stands in that area, which results in disproportionally more harvest level reduction in the short-term, averaging -3.4% lower than the Base Case. As managed stands contribute more to the harvest levels, the long-term harvest reduction level matches the corresponding THLB reduction level, stabilizing at 1.6%. Overall, 3.8 million m^3 (-1.8%) less volume is harvested over 300 years in this sensitivity analysis.

Table 33 Harvest Levels with Potential DFN AIP Offered Lands Removed

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	DFN Lands Removed	Difference	
1	2020	2024	715,200	691,100	24,000	3.4
2	2025	2029	678,900	655,700	23,100	3.4
3	2030	2034	644,500	622,300	22,100	3.4
4	2035	2039	611,900	590,900	21,000	3.4
5	2040	2049	611,300	590,400	20,900	3.4
6	2050	2059	610,000	589,400	20,500	3.4
7	2060	2069	609,500	589,200	20,200	3.3
8	2070	2079	609,500	598,100	11,300	1.9
9	2080	2089	635,700	628,600	7,100	1.1
10	2090	2099	654,900	646,200	8,600	1.3
11	2100	2109	668,900	659,800	9,100	1.4
12	2110	2119	680,100	670,700	9,400	1.4
13	2120	2129	689,300	680,400	8,900	1.3
14	2130	2139	700,000	690,700	9,200	1.3
15	2140	2149	711,000	701,600	9,300	1.3
16	2150	2159	724,300	713,300	10,900	1.5
17	2160	2169	738,700	729,700	8,900	1.2
18-32	2170	2319	737,800	725,900	11,800	1.6

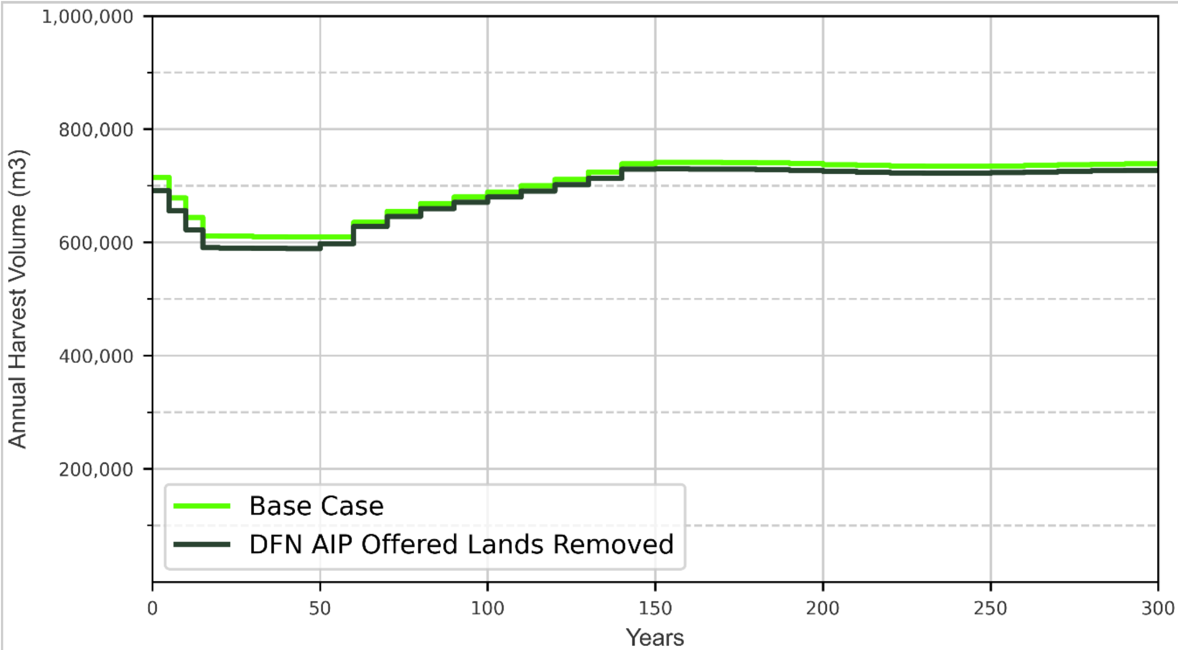


Figure 38 Harvest Levels with Potential DFN AIP Offered Lands Removed

4.14 Remove Partition to Include Economically Marginal Stands

As described in Section 2.4, a landscape-level net value objective ($/m³) is used in the timber supply modelling to capture the economic operability of the corresponding harvest levels, matching the EBITDA margin used in the 2020 Economic Analysis that informed the current TFL 44 AAC Partition decision. This sensitivity is to explore the timber supply impact of removing this net value objective. Note that the economic operability measures in the THLB netdown process still apply. This means that the merchantable growing stock for this sensitivity is the same as the Base Case.

The projected harvest levels are shown in Table 34 and Figure 39. The lack of a net value objective leads to approximately 2.5% less volume harvested in the first 50 years than the Base Case. At Year 60, the harvest level for the sensitivity exceeds the Base Case by 3.6%. Over the long-term, harvest levels are approximately the same level (less than 1% difference after Year 110) as the Base Case. The total harvest over the entire 300 years is 108,900 m³ (0.05%) more than the Base Case. This scenario indicates that the timber supply impact brought by the economic objective is neutral on a 300-year planning horizon. By including the economic objective, the timber supply model will tend to access more timber in the short-term, leveraging the higher economic values brought by existing natural stands to justify road building costs. This behavior is also confirmed in Figure 19 in Section 2.6. Therefore, it can be concluded that having an economic partition established brings a smoother transition to the second growth harvest and achieves economic reality to the licence holder, at no extra cost to the overall timber supply.

Table 34 Harvest Levels with Economic Partition Requirement Removed

Period	Start Year	End Year	Annual Harvest Volume (m³)			% Difference
			Base Case	Economic Partition Removed	Difference	
1	2020	2024	715,200	697,500	17,700	2.5
2	2025	2029	678,900	661,800	17,000	2.5
3	2030	2034	644,500	628,100	16,300	2.5
4	2035	2039	611,900	596,500	15,400	2.5
5	2040	2049	611,300	596,400	14,900	2.4
6	2050	2059	610,000	596,200	13,700	2.3
7	2060	2069	609,500	596,700	12,700	2.1
8	2070	2079	609,500	631,400	-22,000	-3.6
9	2080	2089	635,700	651,900	-16,300	-2.6
10	2090	2099	654,900	666,400	-11,600	-1.8
11	2100	2109	668,900	678,100	-9,300	-1.4
12	2110	2119	680,100	687,000	-6,900	-1.0
13	2120	2129	689,300	694,400	-5,200	-0.7
14	2130	2139	700,000	703,700	-3,800	-0.5
15	2140	2149	711,000	714,200	-3,200	-0.4
16	2150	2159	724,300	726,100	-1,900	-0.3
17	2160	2169	738,700	739,700	-1,100	-0.1
18-32	2170	2319	737,800	736,600	1,100	0.2

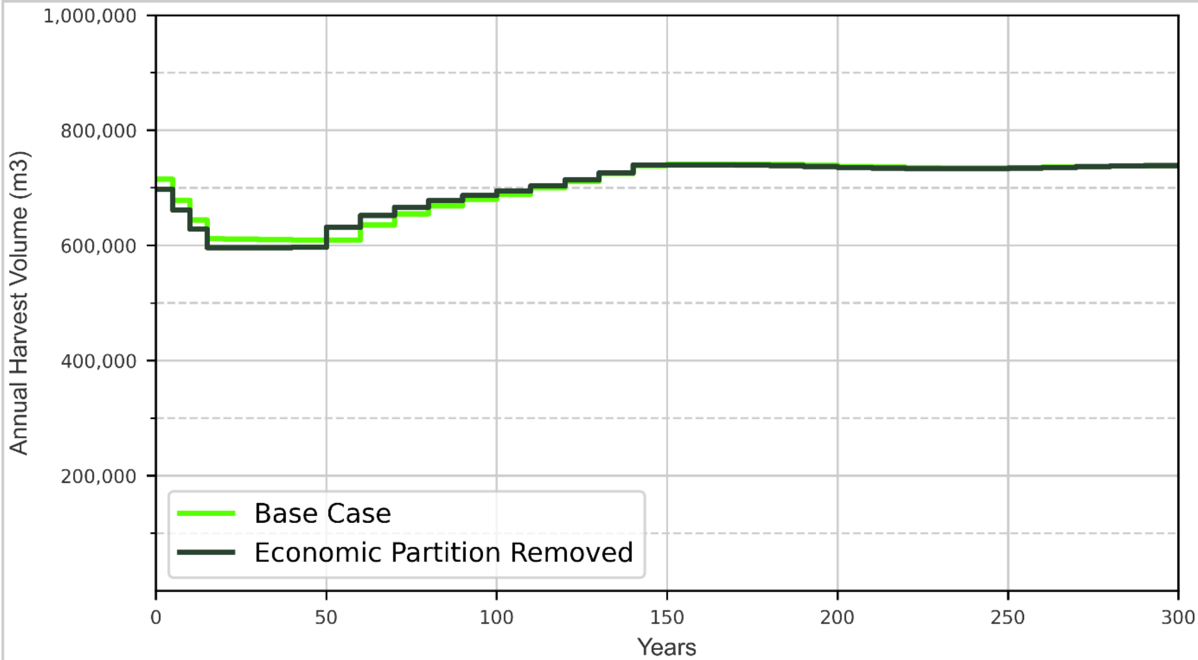


Figure 39 Harvest Levels with Economic Partition Requirement Removed

The economic viability regarding western hemlock (Hw) or amabilis fir (Ba) leading operable stands marked with non-conventional harvest system is further reviewed. The economic analysis that set up the foundation for the December 2020 Chief Forester's partition decision concluded that 79% of the uneconomic profile in TFL 44 is deemed to be non-conventional harvest grounds; of which, 68% is HwBa leading (Western Forest Products Inc., 2020).

The average helicopter HwBa harvest contributions for the Base Case and this sensitivity for the entire 300-year planning horizon are 2.8% and 2.9%, respectively. Within the Base Case economic partition proposed for the first 20 years, the average helicopter HwBa harvest contribution is 0.8%. Therefore, the proportion of this type of stand contributed to harvest flow is minor. However, in the first 15 years where existing natural stands contribute to the majority of harvesting, helicopter HwBa contribution is heavier than other periods in both Base Case and this sensitivity, with 8.4% and 9.7% of the annual harvest levels, respectively. Without the landscape-level net value objective implemented in this sensitivity, the helicopter HwBa contribution increased by 1.3% compared to the Base Case during these periods.

To explore the worst-case operating economic environment, a subset of this sensitivity is run so that harvest contributions from HwBa non-conventional stands are completely removed from the harvest. Table 35 illustrates the outcome with comparison to the Base Case. Because of the relatively heavier helicopter HwBa harvest contribution indicated in this sensitivity for the short-term, by removing these volumes, it results in a 9.9% lower harvest level than the Base Case for the first 30 years, whereas the impact is 2.5% in the original sensitivity. Between Year 40 and Year 150, the harvest level after all the HwBa non-conventional stands removed is estimated to incur 1.5% more reduction than the original sensitivity. Once the harvest level enters LTHL after Year 150, the harvest level is 2.2% lower than the original sensitivity, resulted an overall 2.4% lower LTHL than the Base Case.

However, the Base Case does have economically viable helicopter HwBa harvest contribution as discussed above. The harvest levels in Table 35 is to only showcase the most conservative scenario without the landscape-level net value objective implemented in an undesirable market condition. Whereas the economic partition embedded in the Base Case ensures the landscape-level economic profitability associated with the harvest level.

Table 35 Harvest Levels with Both Economic Partition Requirement and Helicopter HwBa Harvest Removed

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Economic Partition and Helicopter HwBa Harvest Removed	Difference	
1	2020	2024	715,200	636,300	78,900	11.0
2	2025	2029	678,900	586,200	92,700	13.7
3	2030	2034	644,500	572,800	71,700	11.1
4	2035	2039	611,900	562,000	49,900	8.2
5	2040	2049	611,300	564,000	47,300	7.7
6	2050	2059	610,000	592,800	17,200	2.8
7	2060	2069	609,500	593,700	15,800	2.6
8	2070	2079	609,500	627,800	-18,300	-3.0
9	2080	2089	635,700	649,100	-13,400	-2.1
10	2090	2099	654,900	663,900	-9,000	-1.4
11	2100	2109	668,900	676,200	-7,300	-1.1
12	2110	2119	680,100	680,700	-600	-0.1
13	2120	2129	689,300	672,500	16,800	2.4
14	2130	2139	700,000	683,500	16,500	2.4
15	2140	2149	711,000	686,600	24,400	3.4
16	2150	2159	724,300	705,900	18,400	2.5
17	2160	2169	738,700	726,600	12,100	1.6
18-32	2170	2319	737,800	720,200	17,600	2.4

4.15 Remove Area within 30m from Nearby Parks

As discussed in Section 10.3.8 in the associated IP, when operational planning is conducted in areas near neighbouring federal and provincial parks, blocks are planned with a 30m buffer (approximate one tree length) from the TFL boundary. This is to provide flexibility for instances such as removal of danger trees for safety purposes outside of the proposed net harvest area or windthrow mitigation treatments to occur within the TFL to protect park boundaries. This sensitivity explores the situation that excludes a 30m buffer of surrounding parks from the THLB. The removal reduces the THLB area by 170 ha, or 0.2%. This translates to a reduction of 94,400 m^3 (-0.7%) in the initial merchantable standing inventory.

Table 36 and Figure 40 indicate the results of this sensitivity. The modelled harvest level for this sensitivity is 1.8% lower than the Base Case in the short-term. This is disproportionally higher than the THLB reduction, due to higher volume included in the buffer. But the slightly higher harvest level in the Base Case creates a mid-term shortfall for up to 0.8% in Year 70. As the harvest fully transitions to managed stands, the gap is gradually bridged, eventually stabilizing at 0.3%. This is in line with the proportion of the THLB reduction for the sensitivity. Overall, 0.8 million m^3 (-0.4%) less is harvested in this sensitivity analysis.

Table 36 Harvest Levels with Areas within 30m from Nearby Parks Removed

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Area within 30m from Nearby Parks Removed	Difference	
1	2020	2024	715,200	702,500	12,600	1.8
2	2025	2029	678,900	666,600	12,200	1.8
3	2030	2034	644,500	632,700	11,700	1.8
4	2035	2039	611,900	600,800	11,100	1.8
5	2040	2049	611,300	600,400	10,800	1.8
6	2050	2059	610,000	599,800	10,100	1.7
7	2060	2069	609,500	599,700	9,800	1.6
8	2070	2079	609,500	611,600	-2,200	-0.3
9	2080	2089	635,700	640,600	-4,900	-0.8
10	2090	2099	654,900	657,400	-2,600	-0.4
11	2100	2109	668,900	670,200	-1,400	-0.2
12	2110	2119	680,100	681,000	-900	-0.1
13	2120	2129	689,300	689,300	-100	0.0
14	2130	2139	700,000	699,400	500	0.1
15	2140	2149	711,000	709,700	1,200	0.2
16	2150	2159	724,300	721,900	2,300	0.3
17	2160	2169	738,700	737,800	800	0.1
18-32	2170	2319	737,800	735,300	2,400	0.3

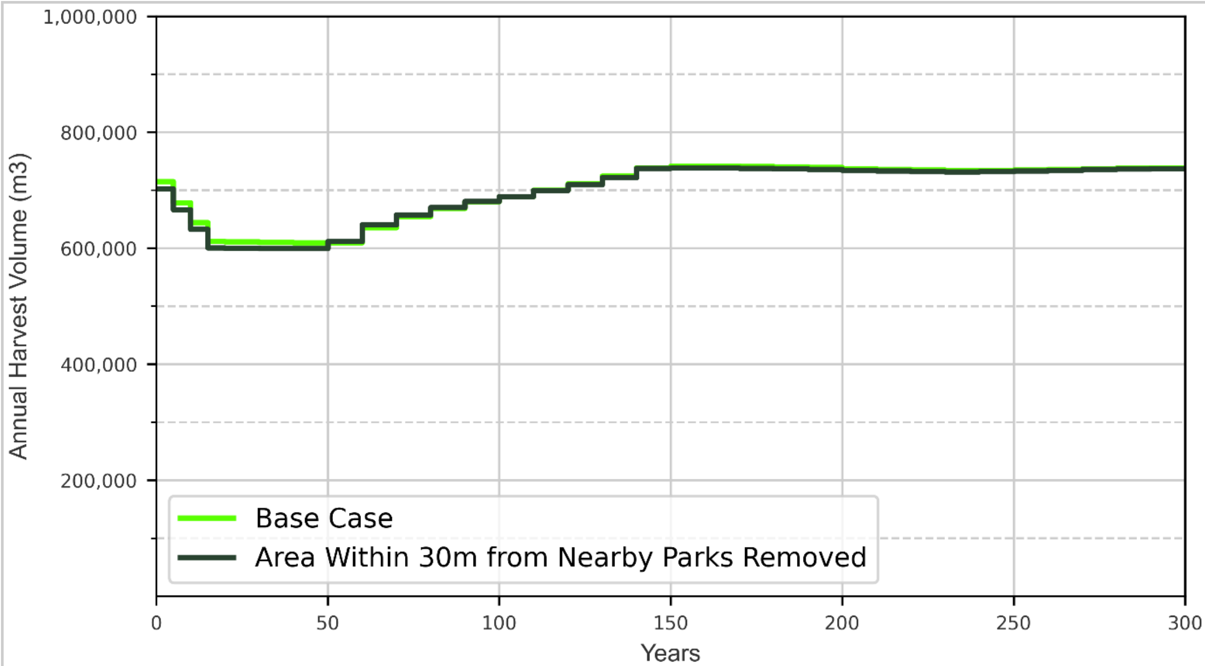


Figure 40 Harvest Levels with Areas within 30m from Nearby Parks Removed

4.16 Use ECA constraints of 20%

As discussed in Section 10.2.6 of the associated IP document, the equivalent clearcut area (ECA) calculation with improved methodology (See Appendix E of the associated IP document) on hydrological recovery factors is used in the model to manage and protect Fisheries Sensitive Watersheds (FSWs). Harvested and re-forested areas will contribute to the ECA until the regeneration reaches 34m in height, at which time it is assumed the stands will be fully recovered hydrologically.

In the Base Case, an ECA limit of 35% in the rain-on-snow zone (defined as above 500 m elevation) of the basin is applied to the Klanawa River and Hatton Creek watersheds which are both FSWs. In addition, this 35% ECA limit is also applied to the Nitinat River (excluding Little Nitinat) to manage terrain stability (discussed in Section 10.2.7 of the associated IP document). For this sensitivity analysis, an ECA limit of 20% is used on these FSWs. This limit is referenced by the *Great Bear Rainforest Order* (GBRO) Division 3 for Important Fisheries Watersheds (3-10. (1), GBRO 2016, p.16) (Province of British Columbia, 2016).

The harvest levels for this sensitivity are shown in Table 37 and Figure 41. Hatton Creek and a few sub-basins in the Klanawa River have a starting ECA between 20% to 30%. Therefore, short-term harvest schedules are altered by the timber supply model to meet the 20% ECA threshold in this sensitivity. With the optimization functions of the timber supply model weighting all the objectives, the modelled harvest level for this sensitivity is 1.3% lower than the Base Case in the first 50 Years. But with the lower short-term harvest, a mid-term increase in harvest levels is observed from Year 60 to Year 120. The long-term timber supply impact is negligible. Over the 300 years, 360,800 m^3 (-0.2%) less is harvested in this sensitivity analysis.

Table 37 Harvest Levels with 20% ECA Limit

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	20% ECA Threshold	Difference	
1	2020	2024	715,200	705,700	9,400	1.3
2	2025	2029	678,900	669,500	9,300	1.4
3	2030	2034	644,500	635,400	9,100	1.4
4	2035	2039	611,900	603,200	8,700	1.4
5	2040	2049	611,300	602,800	8,400	1.4
6	2050	2059	610,000	602,100	7,800	1.3
7	2060	2069	609,500	602,000	7,400	1.2
8	2070	2079	609,500	612,000	-2,500	-0.4
9	2080	2089	635,700	643,400	-7,800	-1.2
10	2090	2099	654,900	659,300	-4,500	-0.7
11	2100	2109	668,900	671,900	-3,000	-0.4
12	2110	2119	680,100	681,500	-1,500	-0.2
13	2120	2129	689,300	691,100	-1,900	-0.3
14	2130	2139	700,000	700,900	-900	-0.1
15	2140	2149	711,000	711,100	-200	0.0
16	2150	2159	724,300	723,000	1,300	0.2
17	2160	2169	738,700	738,900	-300	0.0
18-32	2170	2319	737,800	736,800	900	0.1

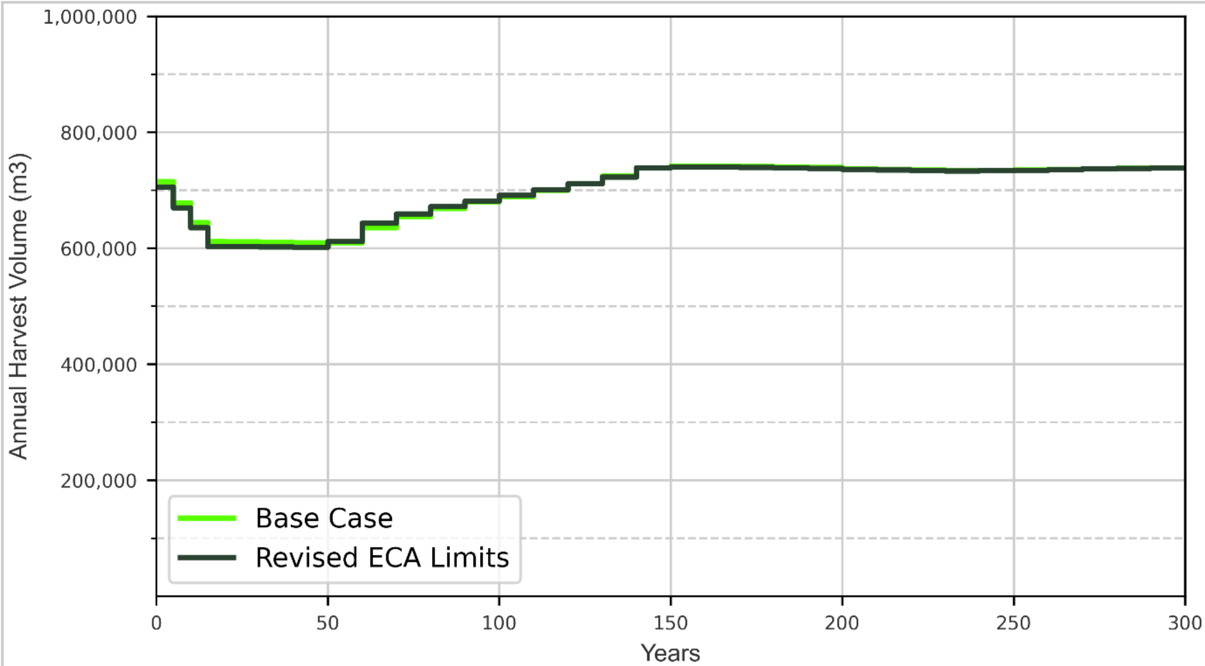


Figure 41 Harvest Levels with 20% ECA Threshold

4.17 Apply ECA constraints on 400+m elevation

ECA constraints with the improved hydrological recovery methodology is also implemented to manage terrain stability risk. In addition to ECA limits, the hydrological recovery of the stand also depends on its elevation. In this sensitivity, the ECA analysis utilize 400m elevation as the definition for the rain-on-snow zone, as opposed to the 500m elevation used in the Base Case. The lower elevation expands this harvest restriction to more areas within all watersheds where the ECA limit is applied.

The harvest levels are illustrated in Table 38 and Figure 42. The results between two scenarios have no more than 1.4% difference over 300 years. The more restricted requirement in this sensitivity lowers the short-term harvest level by 1.4%, while mid-term levels are slightly higher. The long-term impact on harvest levels is not significant (0.1%). Overall, 311,900 m^3 (-0.15%) less volume is harvested compared to the Base Case.

Table 38 Harvest Levels with 400m Elevation ECA Threshold

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	400m ECA Threshold	Difference	
1	2020	2024	715,200	705,500	9,600	1.4
2	2025	2029	678,900	669,400	9,500	1.4
3	2030	2034	644,500	635,300	9,100	1.4
4	2035	2039	611,900	603,200	8,700	1.4
5	2040	2049	611,300	602,800	8,400	1.4
6	2050	2059	610,000	602,200	7,700	1.3
7	2060	2069	609,500	602,100	7,400	1.2
8	2070	2079	609,500	613,600	-4,200	-0.7
9	2080	2089	635,700	641,100	-5,500	-0.9
10	2090	2099	654,900	658,200	-3,400	-0.5
11	2100	2109	668,900	671,300	-2,400	-0.4
12	2110	2119	680,100	682,000	-2,000	-0.3
13	2120	2129	689,300	691,200	-1,900	-0.3
14	2130	2139	700,000	700,900	-900	-0.1
15	2140	2149	711,000	710,600	400	0.1
16	2150	2159	724,300	723,400	800	0.1
17	2160	2169	738,700	739,900	-1,300	-0.2
18-32	2170	2319	737,800	737,200	500	0.1

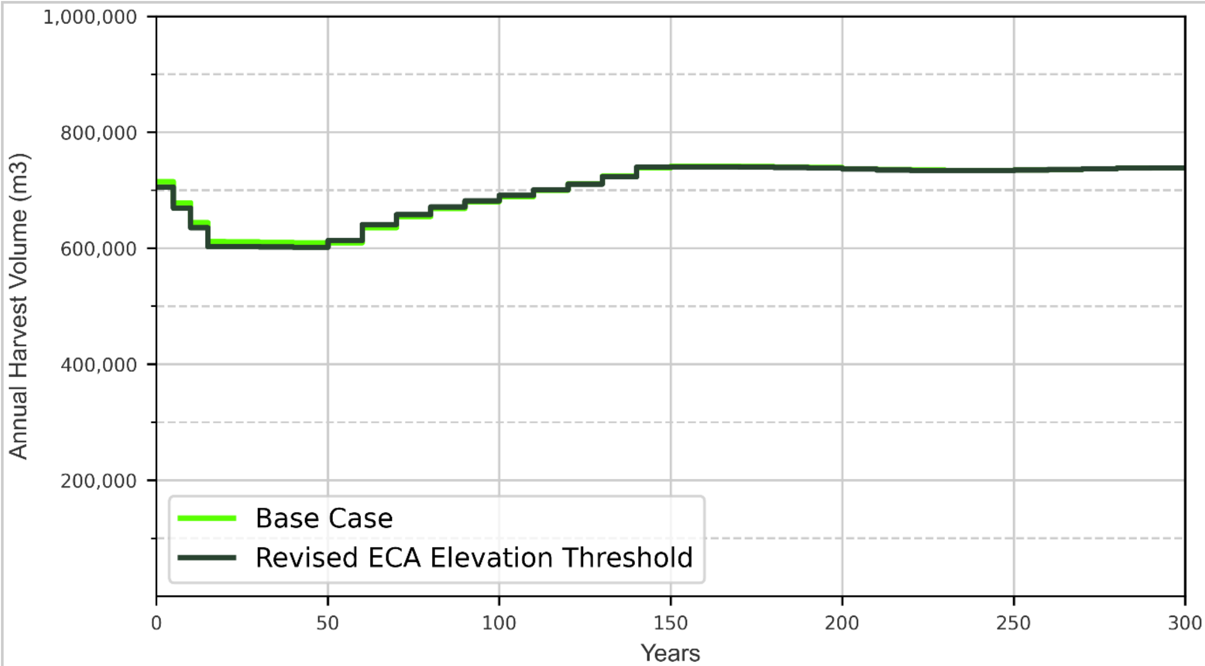


Figure 42 Harvest Levels with 400m Elevation ECA Threshold

4.18 Use More Restrictive Visual Management Constraints

To test the sensitivity of timber supply to the assumptions used for managing VQO, this sensitivity uses the mid-point of the disturbance range for each VQO class rather than the upper limit as in the Base Case. The VQO restriction comparison is summarized in Table 39.

Table 39 Maximum disturbance by VQO class

Visual Quality Objective	Maximum Disturbance (% of productive area)	
	Base Case	More Restricted VQO Sensitivity
Retention (R)	5%	3%
Partial Retention (PR)	15%	10%
Modification (M)	25%	20%
Maximum Modification (MM)	40%	32.5%

Table 40 and Figure 43 indicate the results of this sensitivity. Short term harvest levels are reduced by 3.8% for the first 50 years as inventory inside the visually sensitive areas is more restricted in the sensitivity. Commencing in Year 60 though, less short-term harvests in this more restrictive visual quality management assumptions are compensated by up to 3.4% higher harvest flow. By Year 130, the differences in harvest projections from the Base Case are negligible. The long-term timber supply impact is estimated to be 0.4%. Over the 300 years, 1.0 million m^3 (-0.5%) less is harvested in this sensitivity analysis.

In the operational planning, visual impact assessments are used to guide cutblock design in order to mitigate the visual impact of cutblocks and roads. The screening effect of strategically located stand level retention can be used to effectively reduce the visual impact of cutblocks.

Table 40 Harvest Levels with More Restrictive VQO Maximum Allowable Disturbance Target

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	More Restrictive VQO	Difference	
1	2020	2024	715,200	686,400	28,700	4.0
2	2025	2029	678,900	651,300	27,500	4.1
3	2030	2034	644,500	618,200	26,200	4.1
4	2035	2039	611,900	587,100	24,800	4.1
5	2040	2049	611,300	586,900	24,300	4.0
6	2050	2059	610,000	586,700	23,200	3.8
7	2060	2069	609,500	593,000	16,500	2.7
8	2070	2079	609,500	630,000	-20,500	-3.4
9	2080	2089	635,700	650,300	-14,600	-2.3
10	2090	2099	654,900	665,000	-10,200	-1.5
11	2100	2109	668,900	676,800	-7,900	-1.2
12	2110	2119	680,100	686,200	-6,100	-0.9
13	2120	2129	689,300	693,400	-4,100	-0.6
14	2130	2139	700,000	701,600	-1,700	-0.2
15	2140	2149	711,000	710,900	100	0.0
16	2150	2159	724,300	722,500	1,700	0.2
17	2160	2169	738,700	737,700	900	0.1
18-32	2170	2319	737,800	734,500	3,200	0.4

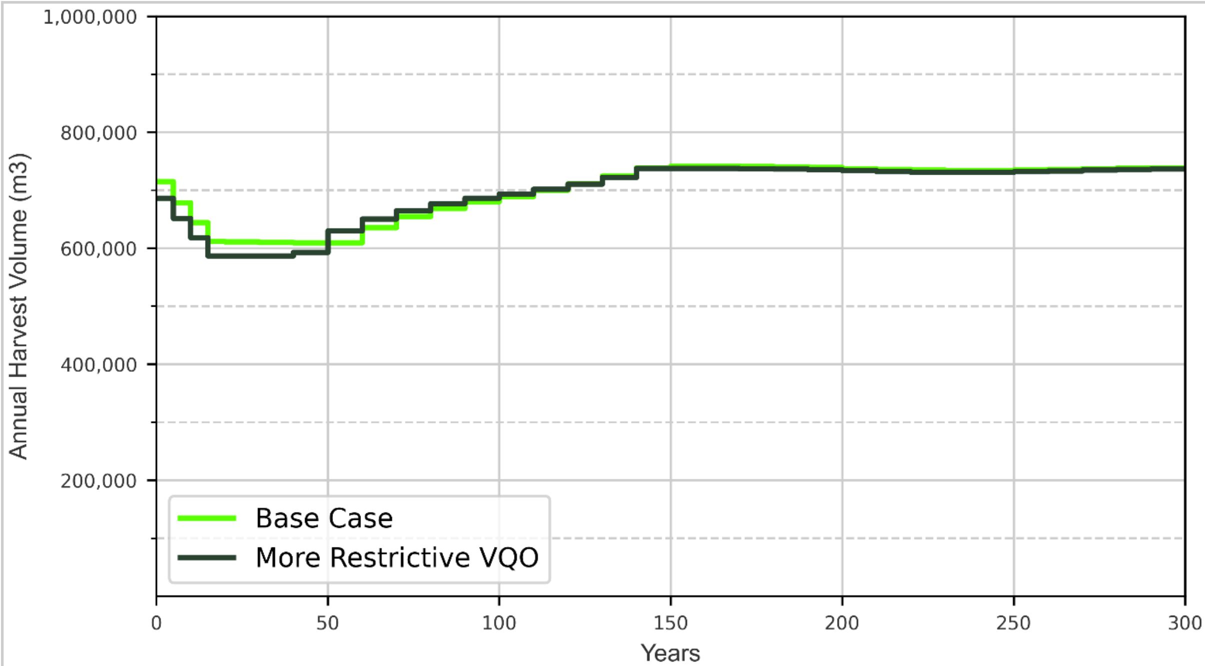


Figure 43 Harvest Levels with More Restrictive VQO Maximum Allowable Disturbance Target

4.19 Apply Marbled Murrelet Provincial Targets by LU/LU aggregate

The Order for the Recovery of Marbled Murrelet (*Brachyramphus marmoratus*) came into effect on December 2nd, 2021 (Province of British Columbia, 2021). Table 2 in Schedule 7 of the Marbled Murrelet order specifies the suitable marbled murrelet habitat target by LU and LU aggregate. At the time of preparation for this timber supply analysis, this order was not in effect. Therefore, the Base Case implemented the approach to exclude the suitable Marbled Murrelet habitat ranking greater than 3 on East Vancouver Island (Great Central/Ash/Corrigan/China/Caycuse LUs) from the THLB as the management strategy. Details can be found in Section 6.12.3 of the associated IP document. This sensitivity looks at the timber supply impact on full implementation of the Marbled Murrelet Order. For LUs that are not fully within TFL 44 boundaries, the LU and LU aggregate are prorated based on the available marbled murrelet habitat inventory inside TFL 44 versus the entire LU.

Table 41 and Figure 44 indicate the results of implementing the Marbled Murrelet Order. Despite the December 2021 release of the Order, the lengthy process and release of the draft targets are positive factors for timber supply impact mitigation. Much of the Marbled Murrelet habitat in TFL 44 has already been accounted for in various landscape-level planning exercises, such as establishing Old Growth Management Areas (OGMAs) and Wildlife Habitat Areas (WHAs). The pre-emptive measures on suitable marbled murrelet habitat THLB exclusion are also helpful alleviating the timber supply impact.

Marbled Murrelet prefers habitats within mature and old seral classes. This results in the greater impact in the short-term when the existing natural stands are driving the harvest pattern. On average, 15,100 m^3/year less (-2.4%) is harvested for the first 50 years in this sensitivity. Though the changed harvest schedule resulted in slight increase of 1.6% in the next 50 years, thanks to the optimization functions of the timber supply model. The long-term impact on harvest levels is not significant (-0.2%). Overall, 397,500 m^3 (-0.2%) less volume is harvested compared to the Base Case over the 300 years.

Table 41 Harvest Levels with Marbled Murrelet Order Targets Applied

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Marbled Murrelet Order Targets	Difference	
1	2020	2024	715,200	697,300	17,800	2.5
2	2025	2029	678,900	661,700	17,100	2.5
3	2030	2034	644,500	628,100	16,300	2.5
4	2035	2039	611,900	596,400	15,400	2.5
5	2040	2049	611,300	596,300	15,000	2.5
6	2050	2059	610,000	596,000	13,900	2.3
7	2060	2069	609,500	596,000	13,500	2.2
8	2070	2079	609,500	627,000	-17,600	-2.9
9	2080	2089	635,700	649,100	-13,400	-2.1
10	2090	2099	654,900	663,700	-8,900	-1.4
11	2100	2109	668,900	675,700	-6,800	-1.0
12	2110	2119	680,100	685,100	-5,000	-0.7
13	2120	2129	689,300	693,200	-3,900	-0.6
14	2130	2139	700,000	702,200	-2,300	-0.3
15	2140	2149	711,000	711,700	-800	-0.1
16	2150	2159	724,300	723,600	600	0.1
17	2160	2169	738,700	738,600	0	0.0
18-32	2170	2319	737,800	736,300	1,400	0.2

Figure 44 Harvest Levels with Marbled Murrelet Order Targets Applied

4.20 Remove WFP Stewardship and Conservation Plan Impacts

Nearly all of the harvest within TFL 44 since the last MP was done using the retention silviculture system (mainly group retention). The internal policies (forest management strategies) are major contributors to this result. WFP's Stewardship and Conservation Plan (WSCP), that C̓awak ʔqin Forestry also follows, requires additional stand-level retention to be present in the land base. The amount of stand level retention varies based on Resource Management Zones in the Vancouver Island Land Use Plan and by eco-section that stratifies British Columbia's terrestrial and marine ecosystem complexity. Details can be found in Section 6.19.2 and Section 10.3.4 of the associated IP document. This additional retention on the land base exceeds the current legal requirements of forest management in BC.

The Base Case includes a THLB reduction for WSCP ranging from 2.6% to 6.0% in different management zones. This sensitivity is to have this target removed and evaluate the associated timber supply impact. The initial THLB without WSCP targets is increased by 0.8%, with the initial merchantable volume increased by 0.9%. Table 42 and Figure 45 indicate the result. Despite the higher merchantable volume, the model chooses to have slightly less short-term harvest (-1.1% for the first 50 years) in order to have higher mid-term harvest flow (1.6% more from Year 60 to Year 100). The long-term harvest level achieved is 0.3% higher than the Base Case. Overall, 0.73 million m^3 (0.34%) more volume is harvested compared to the Base Case.

Table 42 Harvest Levels with WSCP Retention Target Removed

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	WSCP Retention Target Removed	Difference	
1	2020	2024	715,200	706,900	8,200	1.2
2	2025	2029	678,900	670,700	8,100	1.2
3	2030	2034	644,500	636,700	7,800	1.2
4	2035	2039	611,900	604,500	7,300	1.2
5	2040	2049	611,300	604,200	7,000	1.2
6	2050	2059	610,000	603,800	6,100	1.0
7	2060	2069	609,500	603,700	5,800	1.0
8	2070	2079	609,500	625,300	-15,900	-2.6
9	2080	2089	635,700	649,000	-13,300	-2.1
10	2090	2099	654,900	664,200	-9,300	-1.4
11	2100	2109	668,900	676,600	-7,700	-1.1
12	2110	2119	680,100	686,200	-6,100	-0.9
13	2120	2129	689,300	694,300	-5,000	-0.7
14	2130	2139	700,000	704,200	-4,300	-0.6
15	2140	2149	711,000	715,000	-4,100	-0.6
16	2150	2159	724,300	727,600	-3,400	-0.5
17	2160	2169	738,700	743,000	-4,400	-0.6
18-32	2170	2319	737,800	740,000	-2,300	-0.3

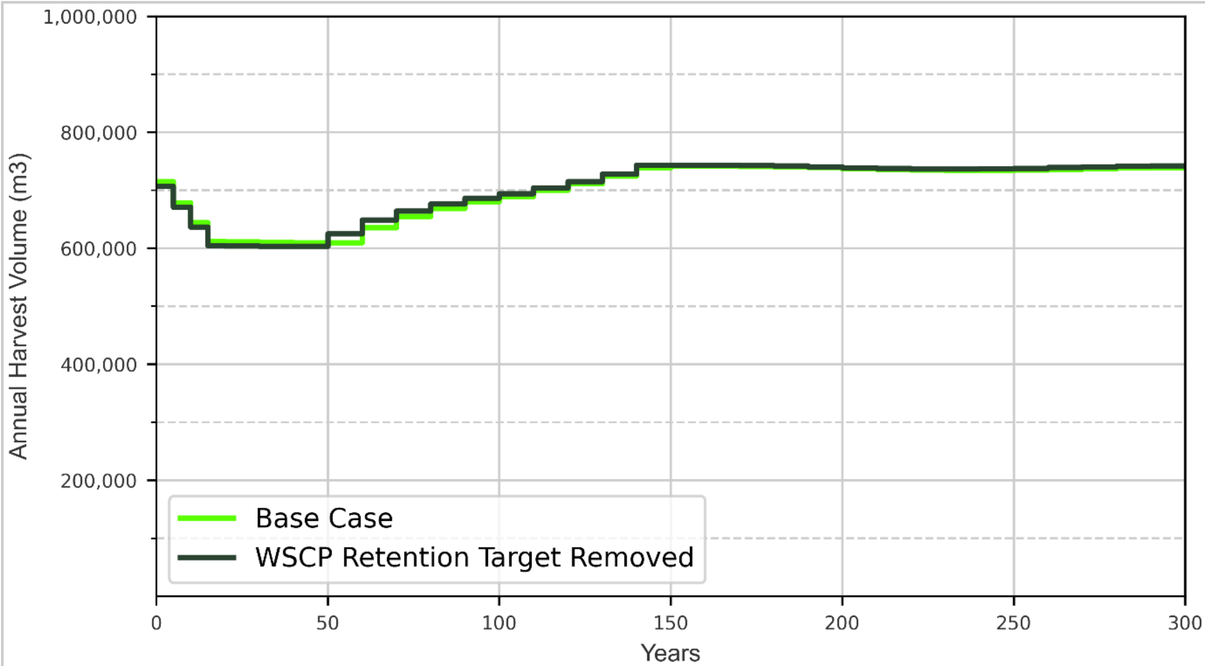


Figure 45 Harvest Levels with WSCP Target Removed

4.21 Use Adjusted LiDAR-based Inventory Attributes

Light Detection and Ranging (LiDAR) data was acquired to help improve strategic inventories for TFL 44. LiDAR is widely used in this timber supply analysis, as discussed in Section 5.4 of the associated IP. WFP conducted a study to test the difference and relative accuracy of three different forest inventories in TFL 44: TFL 44 Forest Cover, provincial VRI, and Individual Tree Inventory (ITI) based on LiDAR data acquired in 2016 (Western Forest Products Inc., 2021). This is detailed in Section 5.3 of the associated IP and the full updated study is included in the Appendix A. Forest Cover is already used in the Base Case. This sensitivity uses the LiDAR inventory to substitute several attributes in the forest cover:

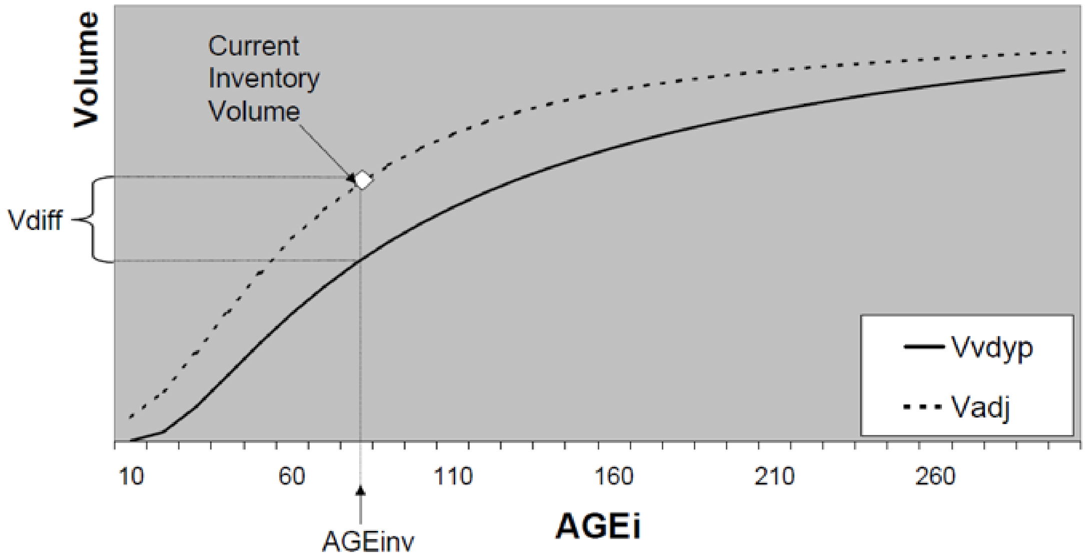
- Height: the ITI heights for all individual trees within the polygon are summarized to stand-level;
- Volume: the ITI volume for all individual trees within the polygon are summarized to stand-level;
- Site Index (SI): SI is re-computed using Site Tools version 4.1 using LiDAR height.

Analysis Units for managed stands are re-classified accordingly based on the LiDAR-derived SI. VDYP and TIPSY (only for 21 - 57 years old stands) growth and yield curves are then re-generated with these updated LiDAR-based inputs.

There are known weaknesses for utilizing ITI attributes directly, particularly in existing natural stands in old seral stages. This is because LiDAR is acquired from the air and the laser signals have more difficulty penetrating dominant tree crowns into co-dominant and understory layers. This leads to an under-estimation of understory basal area, total stems per hectare, and total stand volume per hectare in this sensitivity for stands containing understory trees (Sparks & Smith, 2022). Despite these limitations, there is strong evidence that the ITI data derived from LiDAR is reliable and correlates well with stand-level data.

To address the known LiDAR under-estimation issue in mature and older seral stands, a correction factor was developed for the ITI-derived volume. This is described in Appendix A in the associated IP. Since then, feedback received from the Forest Analysis and Inventory Branch (FAIB) further improved the methodology and the sample set used. In summary, 101 blocks harvested from 2016 (since LiDAR was acquired) to mid-2020 were analysed. 73 blocks were used to develop a volume correction factor of 0.624 m^3/ha/year by fitting linear regressions to the ITI volume estimates. Then the adjusted ITI volumes were tested using an independent set of 28 blocks and found to have the highest accuracy and precision at predicting volume compared to forest cover, provincial VRI and the unadjusted ITI using both cruise plot data and scaled harvest data.

For this sensitivity, the correction factor is applied to the ITI volume. VDYP LiDAR-based growth and yield curves (stands greater than 57 years old) are forced to go through the known adjusted ITI volume and age points using the adjustment formula (Pienaar & Rheney, 1995). This adjustment method is used and documented in TFL 37 MP #9 (Canadian Forest Products Ltd., 2004) located in Northern Vancouver Island. Figure 46 shows an illustration for a generic yield curve adjustment using Pienaar & Rheney's (1995) methodology. This approach is more desirable than applying a uniform multiplier because the adjusted yield curve will use the unadjusted LiDAR curve as a guide for converging on either side of the inventory adjustment. This approach reduces the risk of overestimating future volumes in younger stands (more sensitive to mid-term and long-term timber supply) or older stands (more sensitive to short-term timber supply). As for TIPSY yields, only existing managed AUs (between 21 and 57 years old) TIPSY yields have been adjusted based on new SI resulting from LiDAR heights. TIPSY yields for 1 to 20 year old AUs and future AUs remain the same as used in the Base Case.



$$V_{ADJi} = V_{VDYPi} + V_{DIFF} * A_1 * A_2$$

$$A_1 = Age_i / Age_{inv}$$

$$A_2 = e / e \hat{} (Age_i / Age_{inv})$$

Where:

V_{ADJi} is the adjusted volume at any age i on the yield curve;

V_{VDYPi} is the unadjusted volume from the VDYP yield curve at any age i;

V_{DIFF} is the difference between the inventory volume and the VDYP yield curve at inventory age, Age_{inv};

Age_{inv} is the inventory age of the polygon, and the age at which V_{DIFF} is measured;

Age_i is the x-axis of the yield curve; and

e is the base of the natural logarithm, with a numerical value of 2.71828.

Figure 46 A Generic Yield Curve Adjustment (Pienaar & Rheney, 1995)

The THLB growing stock for the sensitivity and the Base Case are compared in Figure 47. The adjusted LiDAR-based inventory sensitivity has 23.1 million m^3 THLB growing stock, which is 1.2 million m^3 more (5.4%) than the Base Case. In terms of age class distribution, however, the old seral stands in the adjusted LiDAR-based inventory sensitivity have 2.0 million m^3 less (-23.6%) than the Base Case in starting THLB growing stock. For both old and mature stands (121+ years old), the relative proportion in the starting THLB growing stock for this sensitivity is 23.3% less than the Base Case. But the adjusted LiDAR-based inventory sensitivity indicates 3.2 million m^3 more (24.9%) young and mid seral (less or equal to 120 years old) THLB growing stock. This difference in mature-stand starting inventory estimate leads to different timber supply modelling dynamics.

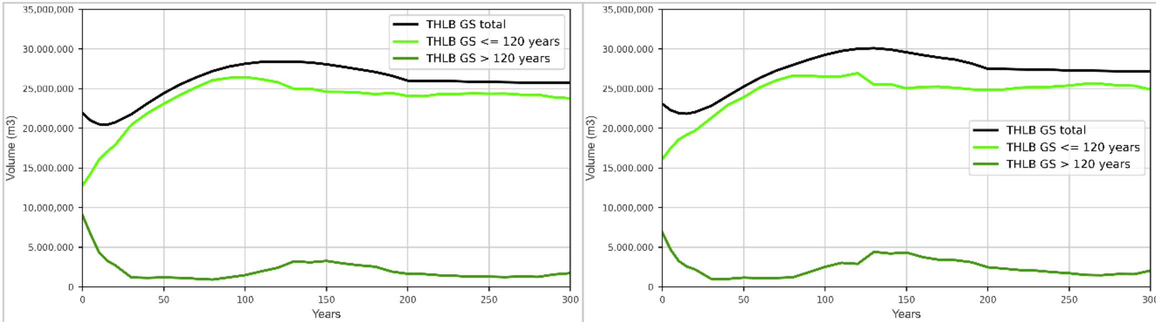


Figure 47 THLB Growing Stock by Mature/Immature Comparison Base Case (left) vs. Adjusted LiDAR Inventory (right)

The THLB merchantable growing stock for the sensitivity and the Base Case by harvest system are compared in Figure 48. Despite 5.4% more volume in total THLB growing stock (black line) for the adjusted LiDAR volumes, this sensitivity gives a slightly lower (1.6% less) merchantable volume (light green line) than the Base Case. In terms of harvest systems, the sensitivity and the Base Case have similar THLB growing stock break-down. Cable system, ground system and helicopter systems maintain approximately 50%, 40% and 10% of total harvest respectively (+/- 2%) for both scenarios (Figure 49).

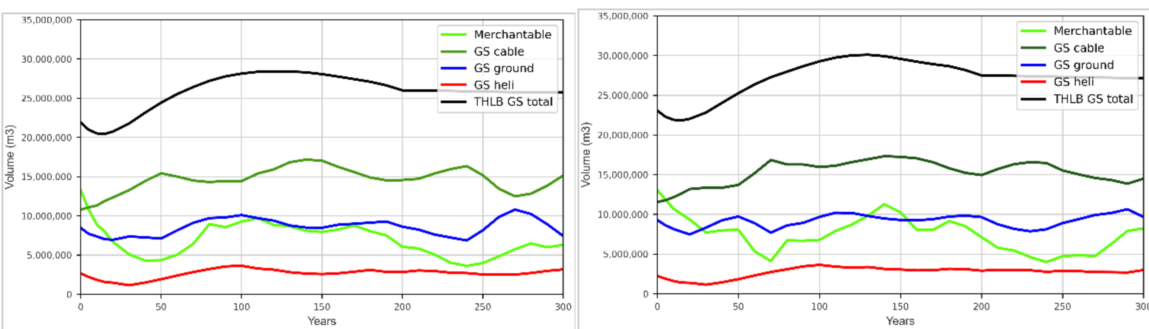


Figure 48 THLB Growing Stock by Harvest System Comparison Base Case (left) vs. Adjusted LiDAR Inventory (right)

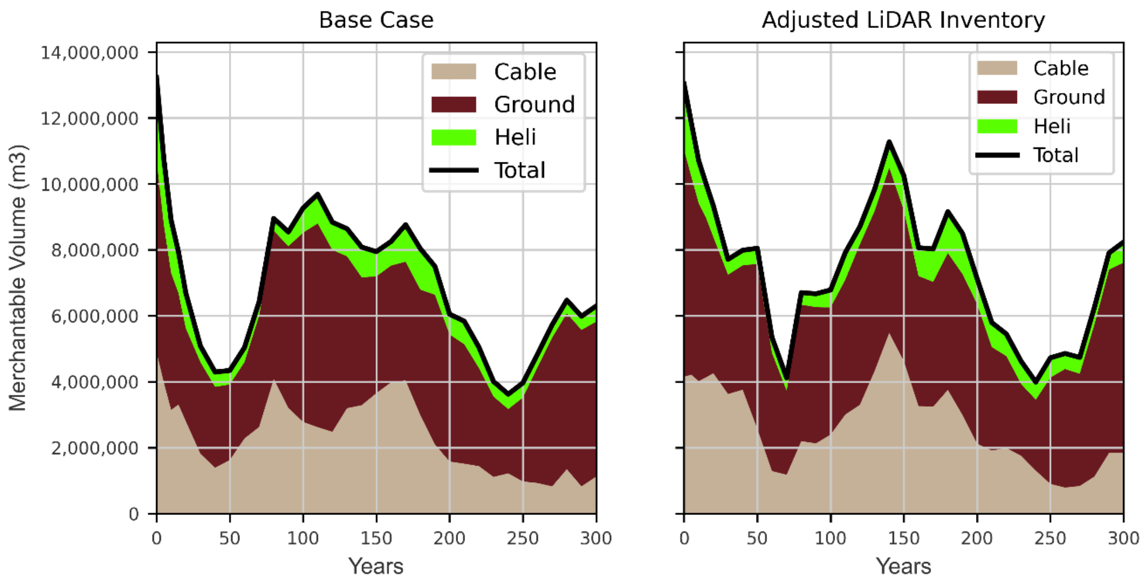


Figure 49 Merchantable Growing Stock by Harvest System Comparison Base Case (left) vs. Adjusted LiDAR Inventory (right)

These increase THLB growing stocks but lower the existing natural stand proportion in this sensitivity which impacts harvest levels (Table 43 and Figure 50). The initial harvest level of this sensitivity is 755,139 m^3/year for the first 5 years. Comparing to the Base Case, this harvest level is 5.6% higher, but still is a reduction of 38,461 m^3/year (-4.9%) from the current AAC of 793,600 m^3/year. The harvest level is 716,200 m^3/year for the second 5 years of the 10-year horizon. When looking at the average harvest level of 735,700 m^3/year for the first 10 years, it represents an improvement of 38,630 m^3/year (5.5%) from the Base Case, but it is still a reduction of 57,885 m^3/year (-7.3%) from the current AAC.

In subsequent periods, the projected harvest schedule shows a similar trend to the Base Case, declining on average 5.5% per 5-year period until the end of Year 20, reaching a harvest level of 644,716 m^3/year. Starting from this point, the harvest level enters a more stable period until Year 90, with an average reduction of 0.3% every 10 years. Overall, the sensitivity delivers 5.4% higher net harvested volume for the first 30 years and 4.8% more net harvested volume for the first 60 years than the Base Case.

However, higher short-term harvest level in this sensitivity is at the cost of lower harvest level in the latter part of the mid-term period and LTHL. This sensitivity has a prolonged period of harvest level that stays at the “bottom” of the harvest flow. It takes 70 years for the harvest level to increase meaningfully in this sensitivity, compared to 40 years in the Base Case. The turning point is at Year 70 when the harvest level for this sensitivity is 0.6% lower than the Base Case. After that period, the harvest level is always lower than the Base Case, with a maximum gap of 6.1% at Year 100. The earlier harvest in existing managed stand in this sensitivity makes them not available to support timber supply in the latter half of the mid-term period, which results in the harvest level staying at the lower level for a prolonged period. The net harvested volume in this sensitivity is 3.2% less than the Base Case from Year 70 to Year 150 before the harvest level enters LTHL. The LTHL of this sensitivity is approximately 725,300 m^3/year, 1.7% less than the Base Case. The total volume harvested over the 300 years is 2.0 million m³ (-0.95%) less than the Base Case.

Table 43 Harvest Levels with Adjusted LiDAR Inventory Attributes

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	Adjusted LiDAR Attributes	Difference	
1	2020	2024	715,200	755,100	-39,900	-5.6
2	2025	2029	678,900	716,200	-37,400	-5.5
3	2030	2034	644,500	679,500	-35,000	-5.4
4	2035	2039	611,900	644,700	-32,800	-5.4
5	2040	2049	611,300	643,100	-31,800	-5.2
6	2050	2059	610,000	638,300	-28,400	-4.6
7	2060	2069	609,500	635,100	-25,700	-4.2
8	2070	2079	609,500	633,200	-23,700	-3.9
9	2080	2089	635,700	632,100	3,500	0.6
10	2090	2099	654,900	631,800	23,000	3.5
11	2100	2109	668,900	631,700	37,100	5.6
12	2110	2119	680,100	638,800	41,300	6.1
13	2120	2129	689,300	658,000	31,300	4.5
14	2130	2139	700,000	675,200	24,700	3.5
15	2140	2149	711,000	694,500	16,400	2.3
16	2150	2159	724,300	715,200	9,000	1.2
17	2160	2169	738,700	730,500	8,100	1.1
18-32	2170	2319	737,800	725,300	12,400	1.7

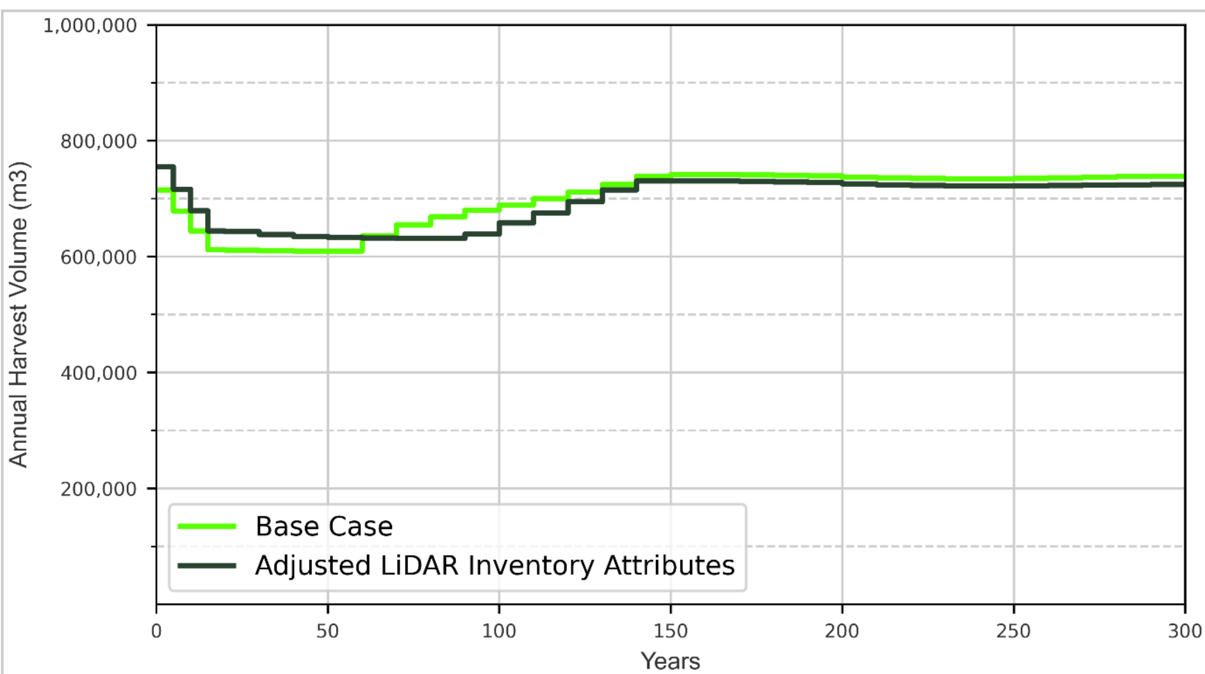


Figure 50 Harvest Levels with Adjusted LiDAR Inventory Attributes

4.22 Use Adjusted LiDAR-based inventory attributes with alternative minimum harvest criteria

As illustrated in Section 2.6 and Section 4.11, the DBH-based minimum harvest criteria (30cm/37cm/42cm for ground/cable/helicopter harvest system) in the Base Case is more conservative than using a 95% of culmination MAI approach. Therefore, exploration of alternative minimum harvest criteria was conducted for the adjusted LiDAR-based inventory sensitivity in two directions: 1) using a separate set of DBH threshold; 2) harvest at 95% of culmination MAI age.

The average DBH of harvested stands can be quite variable and influenced by outside factors, such as harvest equipment capacity, seasonality, and markets at the time. Therefore, the DBH thresholds from forecasted blocks were analyzed. The average inventory diameters of planned blocks for each harvest system were evaluated, with the average diameter at the 20th percentile used to represent the minimum harvest diameter. In other words, 80% of the planned harvest area had larger average diameters than those used. It was concluded that 31cm/31cm/37cm DBH thresholds for ground/cable/helicopter harvest system represented the 20th percentile of planned block diameters in TFL 44. These results were anecdotally supported from operation staff, who suggested that ground and cable harvest systems are typically used at the same time within one block or one entry in the same operating area. It is therefore more realistic to use the same DBH threshold for the conventional systems. Compared to the DBH criteria used in the Base Case, this represents a 1cm increase in the ground harvest system, and 6cm decreases in the cable and helicopter harvest systems.

Using the 95% culmination MAI as minimum harvest age, as explained in Section 4.11, is a common practice in other BC coastal management units. Therefore, these two alternative minimum harvest criteria were tested in the adjusted LiDAR-based inventory attributes scenario. Table 44 shows the comparison of the average minimum harvest age for the future managed stands among the Base Case, and using the alternative DBH threshold, and the 95% culmination MAI age in the adjusted LiDAR-based inventory attributes scenario. The alternative minimum harvest criteria result in a 7-year delay in minimum harvest age for the ground harvest system, which accounts for 40% of the initial THLB growing stock. The decreased DBH in cable and helicopter harvest system advance the minimum harvest age by 28 years and 23 years, respectively. As for the 95% culmination MAI age, LiDAR-based growth and yield advances the minimum harvest age by 9 years than the Base Case.

Table 44 Minimum Harvest Criteria Comparison Base Case vs. Alternative DBH on Adjusted LiDAR -based inventory Scenario

Harvest System	Base Case MHA			Alternative DBH on Adj. LiDAR MHA		
	Minimum Average DBH	Wtd Avg Future Stand Age	95% Culmination MAI Wtd Avg Future Stand Age	Minimum Average DBH	Wtd Avg Future Stand Age	95% Culmination MAI Wtd Avg Future Stand Age
Ground	30 cm	64 years	78 years	31 cm	71 years	69 years
Cable	37 cm	99 years		31 cm	71 years	
Heli	42 cm	126 years		37 cm	103 years	

The harvest levels for applying the alternative DBH threshold and 95% culmination MAI age on the adjusted LiDAR-based inventory scenario are illustrated and compared in Table 45 and Figure 51. Other modelling assumptions are the same for all three scenarios, including implementing the landscape-level economic objective for the first 20 years, with the exception of the minimum harvest age. The two alternative minimum harvest age scenarios generate a slightly higher modelled harvest level for the first 5-year period than the current AAC of 793,600 m³/year. It can also be observed that the alternative minimum harvest criteria provided noticeably higher harvest levels than the Base Case's minimum harvest criteria. Moreover, there are slight differences between the two alternative minimum harvest criteria scenarios for the first 50 year's harvest level (<1% difference). The meaningful differences occur after Year 100 when the 95% culmination MAI age scenario projects 5%-6% higher harvest flow than the alternative DBH scenario. Having said that, after Year 150 when the LTHL is reached, the differences become very minor again (0.3%). This means that the alternative DBH threshold derived from planned harvest blocks in TFL 44 aligns well with the 95% culmination MAI age minimum harvest criteria.

Table 45 Harvest Levels with alternative DBH threshold versus 95% Culmination MAI as Minimum Harvest Age using Adjusted LiDAR Inventory Attributes

Period	Start Year	End Year	Annual Harvest Volume (m³)			% Difference	Annual Harvest Volume (m³)		% Difference
			Adjusted LiDAR Attributes	Alt. DBH Criteria on Adj. LiDAR Inventory	Difference		95% CMAI Age MHA on Adj. LiDAR Inventory	Difference	
1	2020	2024	755,100	827,700	-72,600	-9.6%	828,800	-73,700	-9.8%
2	2025	2029	716,200	785,100	-68,900	-9.6%	786,300	-70,100	-9.8%
3	2030	2034	679,500	744,700	-65,200	-9.6%	745,900	-66,400	-9.8%
4	2035	2039	644,700	706,400	-61,700	-9.6%	707,600	-62,900	-9.8%
5	2040	2049	643,100	704,300	-61,200	-9.5%	705,800	-62,700	-9.7%
6	2050	2059	638,300	697,900	-59,600	-9.3%	701,300	-63,000	-9.9%
7	2060	2069	635,100	693,300	-58,200	-9.2%	698,900	-63,800	-10.0%
8	2070	2079	633,200	690,000	-56,800	-9.0%	698,200	-65,000	-10.3%
9	2080	2089	632,100	687,800	-55,700	-8.8%	697,900	-65,800	-10.4%
10	2090	2099	631,800	686,400	-54,600	-8.6%	697,800	-66,000	-10.4%
11	2100	2109	631,700	685,600	-53,900	-8.5%	697,800	-66,100	-10.5%
12	2110	2119	638,800	685,200	-46,400	-7.3%	710,000	-71,200	-11.1%
13	2120	2129	658,000	685,100	-27,100	-4.1%	720,600	-62,600	-9.5%
14	2130	2139	675,200	685,100	-9,900	-1.5%	731,100	-55,900	-8.3%
15	2140	2149	694,500	705,500	-11,000	-1.6%	742,200	-47,700	-6.9%
16	2150	2159	715,200	725,900	-10,700	-1.5%	745,200	-30,000	-4.2%
17	2160	2169	730,500	739,400	-8,900	-1.2%	745,100	-14,600	-2.0%
18-32	2170	2319	725,300	731,400	-6,100	-0.8%	733,500	-8,200	-1.1%

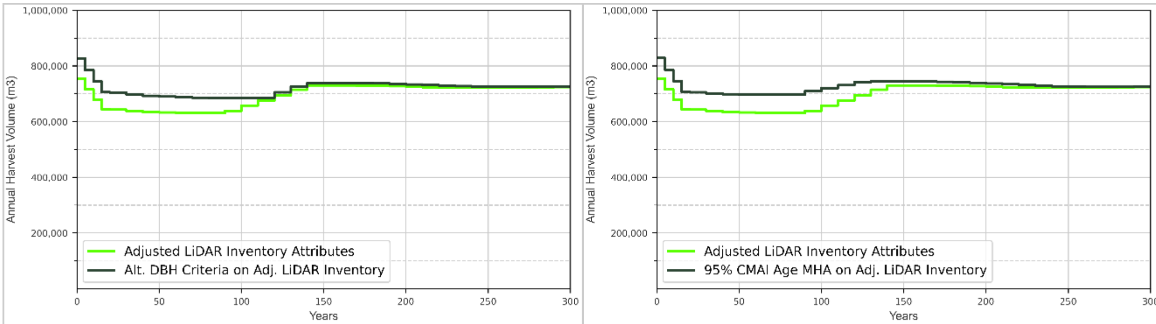


Figure 51 Harvest Levels with alternative DBH threshold (left) versus 95% Culmination MAI as Minimum Harvest Age (right) using Adjusted LiDAR Inventory Attributes

Given the wide implementation of 95% culmination MAI age in timber supply analyses for BC coastal management units, this sensitivity scenario is selected to be further analyzed in all aspects of harvest statistics compared against the Base Case. Two different harvest flows were modelled for this scenario: step-down to maximize short-term AAC and NDEF. The detailed scenario description and comparison against the Base Case for the step-down harvest flow is presented below. And the harvest statistics for the NDEF is described in Section 4.23.

Table 46 and Figure 52 indicate the results of comparing the Base Case with the adjusted LiDAR inventory attributes with 95% culmination MAI age (step-down) scenario. The dynamics of different inventory sources, and minimum harvest criteria considerably change harvest level projections for the first 150 years. The harvest level begins to decrease at the same rate as the Base Case of -5.1%, reaching the bottom at Year 20 at 707,600 m^3/year. Overall, for the first 60 years, this sensitivity proposes harvest levels that are 97,800 m^3/year (15.4%) higher than the Base Case. In the next 70 years, the harvest level for this sensitivity is relatively flat (0.2% reduction per decade). Although the Base Case harvest level experiences a 30-year faster rebound than this sensitivity, its harvest level during this “bottom” period averages 90,200 m^3/year (-14.8%) lower. Starting at Year 100, the harvest level for this sensitivity gradually increases, and enters LTHL of 733,500 m^3/year after Year 150, which is 4,200 m^3/year (-0.6%) less than the Base Case. Over the 300 years, 7.9 million m^3 (3.8%) more is harvested in this sensitivity analysis.

Table 46 Harvest Levels Comparison between the Base Case and the Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	95% Culmination MAI MHA on Adj. LiDAR Inventory	Difference	
1	2020	2024	715,200	828,800	-113,600	-15.9
2	2025	2029	678,900	786,300	-107,500	-15.8
3	2030	2034	644,500	745,900	-101,400	-15.7
4	2035	2039	611,900	707,600	-95,800	-15.6
5	2040	2049	611,300	705,800	-94,600	-15.5
6	2050	2059	610,000	701,300	-91,300	-15.0
7	2060	2069	609,500	698,900	-89,500	-14.7
8	2070	2079	609,500	698,200	-88,800	-14.6
9	2080	2089	635,700	697,900	-62,200	-9.8
10	2090	2099	654,900	697,800	-42,900	-6.6
11	2100	2109	668,900	697,800	-28,900	-4.3
12	2110	2119	680,100	710,000	-30,000	-4.4
13	2120	2129	689,300	720,600	-31,400	-4.5
14	2130	2139	700,000	731,100	-31,200	-4.5
15	2140	2149	711,000	742,200	-31,300	-4.4
16	2150	2159	724,300	745,200	-21,000	-2.9
17	2160	2169	738,700	745,100	-6,500	-0.9
18-32	2170	2319	737,800	733,500	4,200	0.6

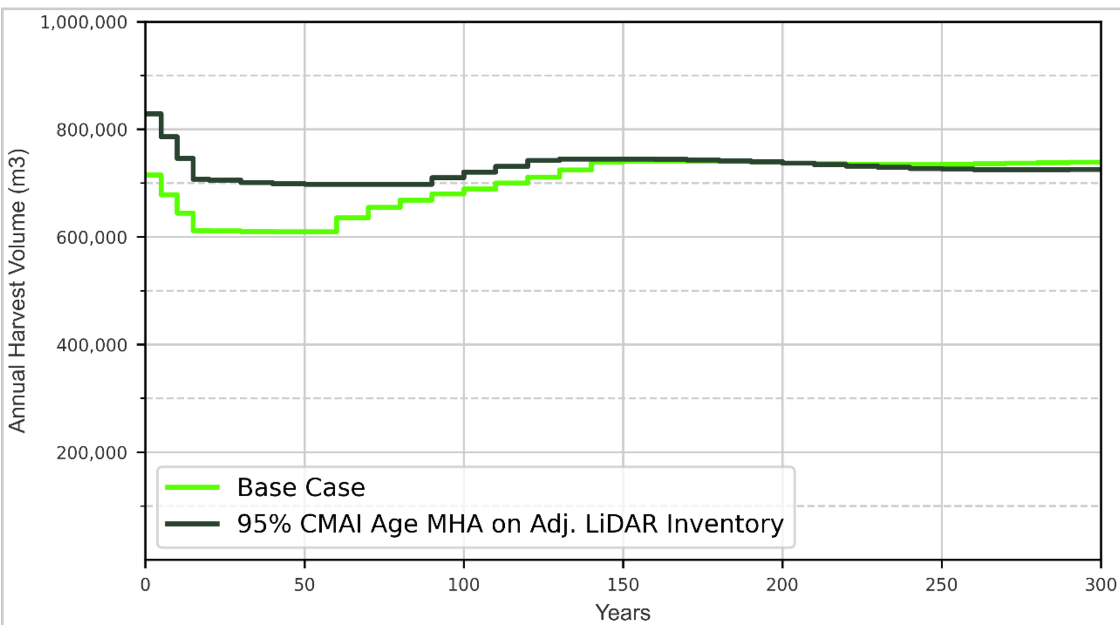


Figure 52 Harvest Levels Comparison between the Base Case and the Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA

The THLB growing stock for the sensitivity and the Base Case are compared in Figure 53. The initial state brought by adjusted LiDAR inventory is the same as what Figure 47 demonstrated: there is 5.4% more total THLB growing stock, 23.3% less old and mature stands (121+ years old) THLB growing stock, and

24.9% more young and mid seral (less or equal to 120 years old) THLB growing stock. Due to different minimum harvest criteria, higher harvest levels in this sensitivity lead to lower carrying growing stock on the land base. However, the core idea for utilizing the 95% cumulation MAI age as the minimum harvest age is to harvest as close as possible to when the stand growth rate is at its highest point. This means that the overall growing stock level is relatively stable across the entire planning horizon. This is exactly the case for this sensitivity. After commencement of harvest activities in the first period, the THLB growing stock for the sensitivity remains steady, ranging from 19.6 million to 22.9 million m^3 for the rest of 295 years. For the Base Case through, the delayed minimum harvest age created high THLB growing stock that cannot contribute to harvest levels, especially in the mid-term when the harvest level dip is created and the THLB growing stock peaked to more than 28 million m^3. The long-term THLB growing stock for this sensitivity is 6.1 million m^3 (-23.6%) less than the Base Case.

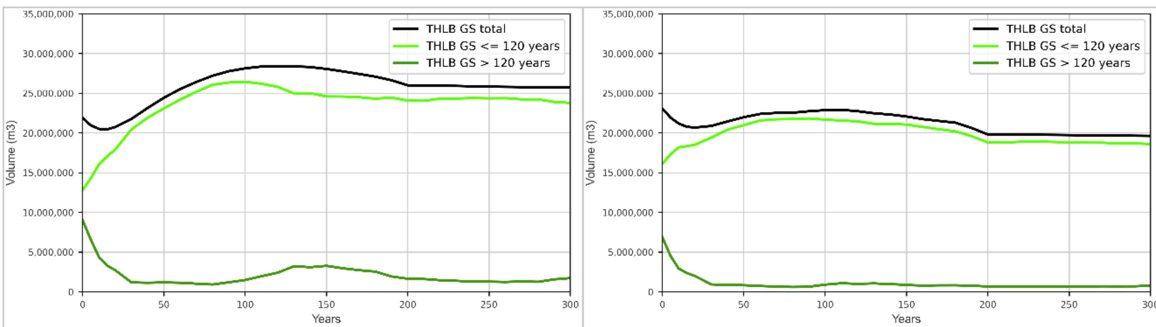


Figure 53 THLB Growing Stock by 120-Years-Old Cut-Off Comparison: Base Case (left) vs. Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA (right)

A detailed view on merchantable THLB growing stock by harvest system is provided in Figure 54. Previously in Figure 49, with the Base Case's minimum harvest criteria, the initial merchantable THLB growing stock in the original adjusted LiDAR inventory attributes scenario is 1.6% less than the Base Case. By using the 95% Culmination MAI age as the minimum harvest age, 1.8 million m^3 extra merchantable volume (13.8% more) becomes immediately available. Most of the merchantable volume change comes from the cable harvest system, with approximately 2.1 million m^3 more (42.4%) merchantable volume immediately available. Ground merchantable volume remains the same (0.8% more) and helicopter merchantable volume is 11.8% less. Since cable accounts for close to 50% of the THLB, the increased merchantable volume in this sensitivity supports the 15.8% higher short-term harvest levels than the Base Case.

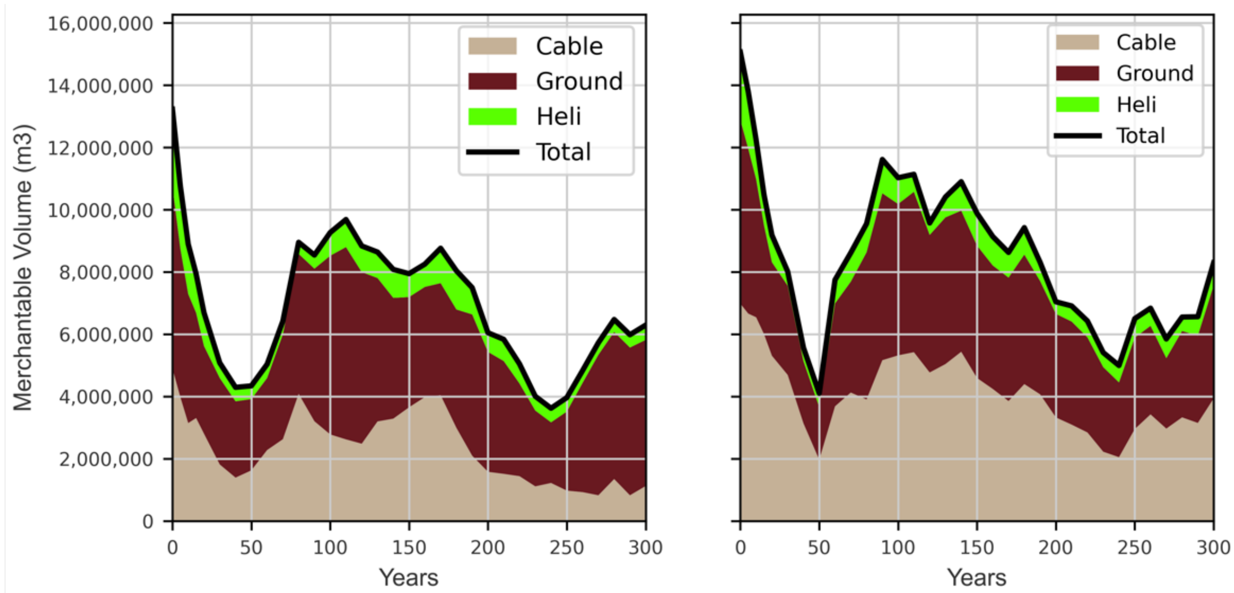


Figure 54 Merchantable THLB Growing Stock of Base Case (left) and Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA (right)

Figure 55 indicates the contribution to the total harvest volume by period from the three broad stand eras used to define the analysis units for the Base Case and this sensitivity. With the similar harvest flow pattern, but higher starting merchantable inventory, the timber supply model manages to overcome the lower existing natural stand inventory (shown in Figure 53) and delivers a contribution profile that is similar to the Base Case for the 300-year planning horizon. The existing natural stands account for more than half of the projected harvest for the first 15 years for both scenarios, but the proportional contribution is about 15%-25% lower in this sensitivity. Accessing more existing managed stands that are now considered merchantable provides higher short-term harvest level for the adjusted LiDAR inventory with 95% culmination MAI age (step-down) scenario. The existing natural stands further drop to below 10% of the harvested volume at Year 40, 10 years earlier than the Base Case. Then the land base fully transitions to second growth harvesting. In the original adjusted LiDAR inventory scenario, the earlier reliance on managed stands limits timber supply due to the minimum harvest ages, especially for some future AUs with relatively old minimum harvest age. But the using 95% culmination MAI as the minimum harvest ages mitigate this pinch point.

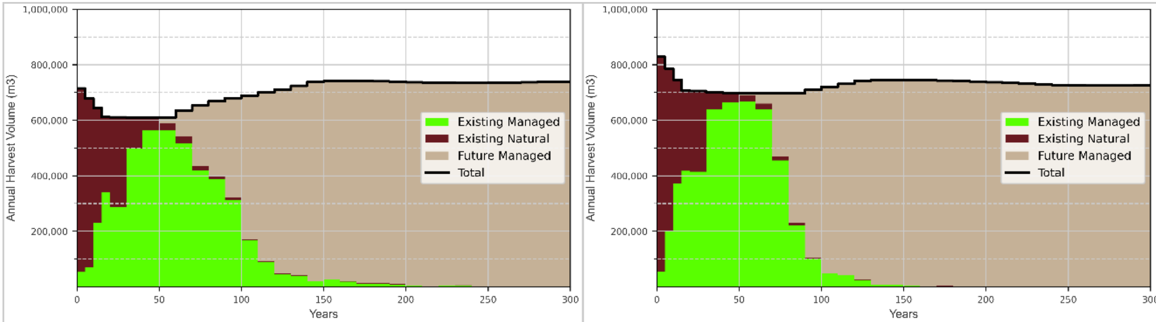


Figure 55 Stand Eras' Contribution to Base Case (left) and Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA (right)

The detailed age class distributions over time are examined in Figure 56 for productive forests. A snapshot of the age class distributions is taken every 50 years. The age class distribution follows the same pattern and has only very subtle differences from the Base Case. 32% of the productive forest is currently in the oldest age class in productive forest. And 76% of the productive old area is outside of the THLB. The total productive old area is expected to grow to 39% of the productive forest at the end of the 300-year planning horizon. The total THLB area less than 80 years old also increases initially as harvesting in natural older aged stands occur. The 300-year pattern is the same as the Base Case. However, since the adjusted LiDAR inventory indicated more mid seral initial THLB growing stock (Figure 53), the amount is slightly higher than the Base Case in the mid-term, until a relatively balanced age class distribution is achieved (refer to Figure 59) in a fully regulated forest. Given the stable THLB age class distribution after Year 2120, and the large productive oldest age class presence outside of the THLB, it ensures a sustainable harvest beyond the analysis period is achievable.

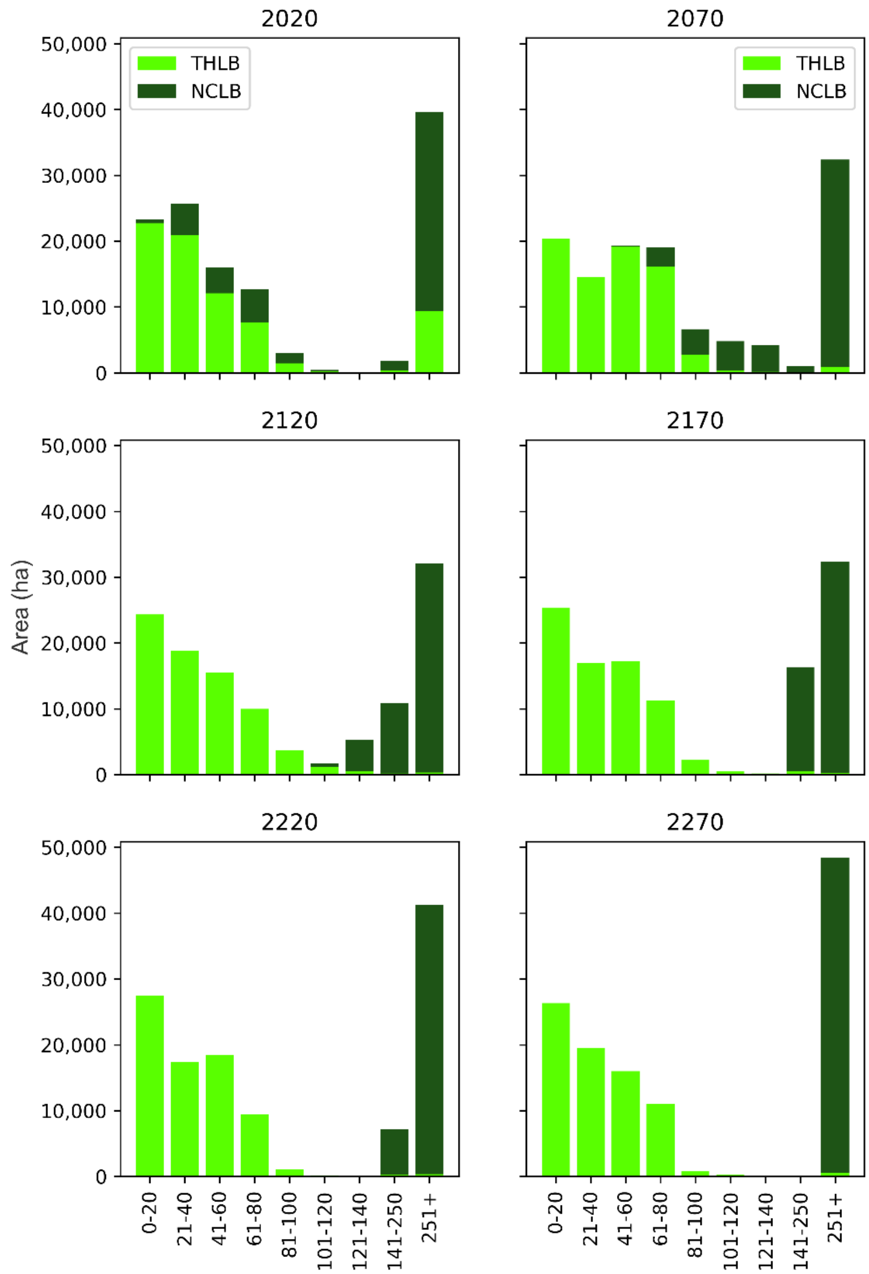


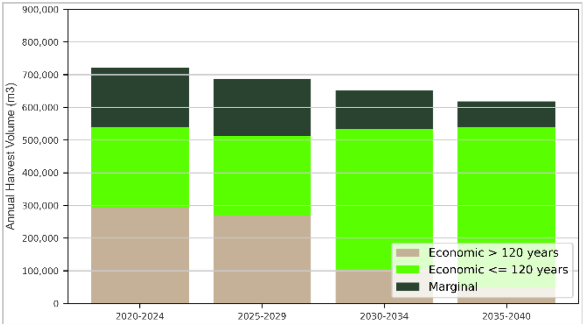
Figure 56 Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario Age Class Distribution of Productive Forest Area (120,970 ha)

The economic profile for the first 20 years against the Base Case is shown in Table 47 and Figure 57. As with the Base Case, the economic partition is increased to 86% of the overall harvest level due to economic partition being one of the modelling objectives. The higher overall harvest level in the adjusted LiDAR inventory sensitivity leads to higher economic partition. On average for the first 10 years, the economic partition of this sensitivity is 137,950 m^3/year higher than the Base Case. However, the lower starting inventory in existing natural stands and higher overall harvest level leads to a lower contribution from the economic natural stands in the sensitivity. This sensitivity starts the economic partition with 48% from mature stands for the first 5 years, as opposed to 55% in the Base Case. The existing mature proportion for the sensitivity then drops to 24% in the subsequent 5 years, whereas the proportion for the Base Case remains at 52%. From Year 10 to Year 20, existing natural stands are only supplemental in the economic partition in both cases. The economic mature stands account for 19% and 9% of the harvest in the Base Case for each of the 5-year interval during this period; the corresponding proportion is only 5% and 4% for this sensitivity (though the overall harvest level in the sensitivity is higher).

This echoes the conclusion in Section 2.4 that an economic partition profiled by stand seral stage is prudent to ensure a smooth transition from harvesting primarily mature and old forests to primarily mid-seral and mature forests over the next 10 years.

Table 47 Economic Partition of the Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario and Difference Against the Base Case

Year	Adjusted LiDAR Inventory Attributes - 95% CMAI MHA (m3)						Difference vs. Base Case	
	Harvest Level	Economic > 120 years	Economic <= 120 years	Total Economic	Economic %	> 120 years within Economic %	Economic (m^3)	> 120 years within Economic (m^3)
AAC	793,600	425,000	110,000	535,000	67%	79%	N/A	
2020-2024	828,800	343,100	369,100	712,200	86%	48%	173,300	49,000
2025-2029	786,300	148,100	466,700	614,800	78%	24%	102,600	-120,000
2030-2034	745,900	34,800	628,300	663,100	89%	5%	129,100	-69,300
2035-2039	707,600	24,700	624,600	649,300	92%	4%	110,500	-23,100



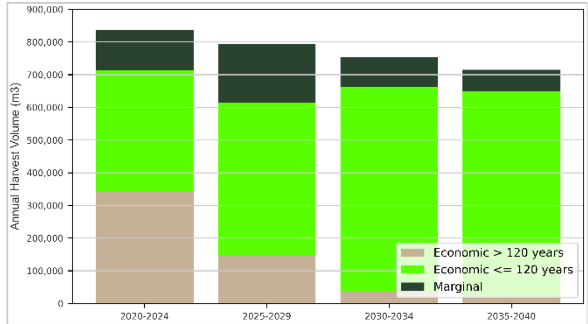
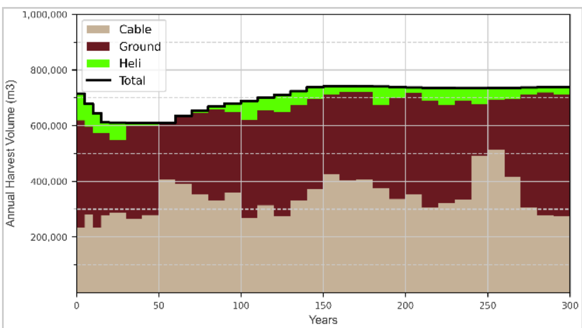


Figure 57 Economic Partition of Base Case (left) and Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right) From Year 0 to Year 20

In terms of harvest systems, this sensitivity also uses predominantly conventional harvest systems (Figure 58). The adjusted LiDAR inventory starting THLB growing stock has the same breakdown in each harvest system: 50% for cable, 40% for ground and 10% for helicopter. For conventional harvests, this sensitivity generally follows the trend in the Base Case, with a few deviations in Year 30 to 40, Year 60 to 70, and Year 250 to 260. Helicopter harvest is on average about 6% of the total harvest for both cases.



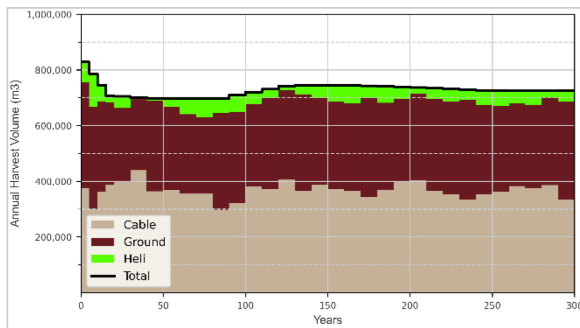


Figure 58 Harvest System for Base Case (left) and Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right)

As for average harvest age, harvest area and harvest volume per hectare, Figure 59 provides these statistics for timber harvested through the harvest projection. With 5.4% more starting THLB growing stock due to a different inventory source and 13.8% more immediate merchantable inventory due to different minimum harvest ages in this sensitivity, the different harvest schedules between the two scenarios create some differences in harvest statistics. In the short-term, despite slightly lower harvested volume/hectare for the first decade in this sensitivity, the higher annual harvest area results in higher harvest volumes than the Base Case. Once the harvest enters the mid-term, the harvest level in the Base Case recovers gradually and eventually back at the same level as this sensitivity. This explains why the harvest statistics go back to the same pattern. In general, compared to the Base Case, this sensitivity has 79 hectares more area harvested annually, and 34 m^3/ha lower average volume per hectare. The lower average harvested stand volume in this sensitivity is primarily due to more flexible minimum harvest criteria. As for the average age of harvested stands, LiDAR does not impact the stand age, so the differences are due to harvest scheduling differences. For this sensitivity, it follows the same pattern as the Base Case. One notable exception for this sensitivity is in the short-term due to less mature and old volume, which results in a faster transition to second growth harvesting. After Year 50, the mid-term and long-term average harvested age for the sensitivity are around 94 years old, about 6 years younger than the Base Case.

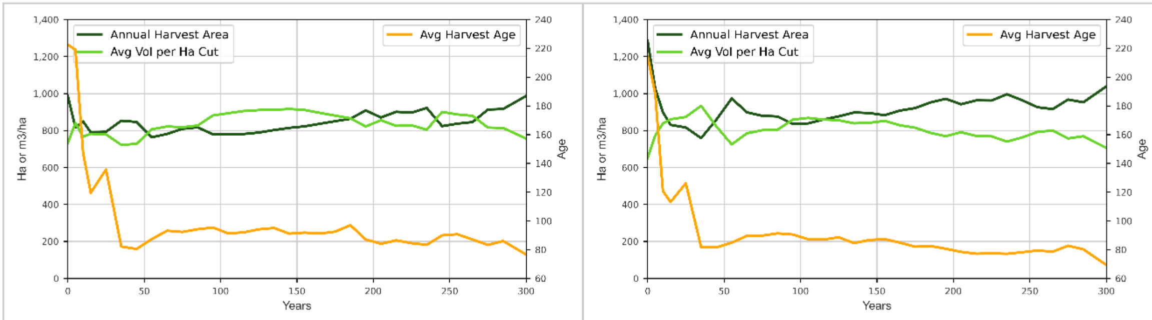


Figure 59 Harvest Statistics for Base Case (left) and Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right)

Figure 60 shows the species composition of the volume harvested for the two scenarios. The overall species profile for the harvest level is similar, especially for the mid-term and long-term after Year 100. HemBal are still the dominant species in this sensitivity, followed by Douglas-fir and western red cedar. This is expected given the subtle difference for the mid-term and long-term harvest level. The species composition difference is concentrated in the short-term period when the harvest levels diverge between the Base Case and this sensitivity. This sensitivity harvests more in HemBal and less in Douglas-fir for the first 20 years than the Base Case, but the species choice is reversed immediately at Year 30. For the long-term harvest for both scenarios, HemBal, western red cedar and Douglas-fir contributes approximately 40%, 30% and 25% of the harvest, respectively (but with +/- 2% variance per species). The rest of the 5% is made up from yellow cedar (3%) and other species (e.g., Sitka spruce).

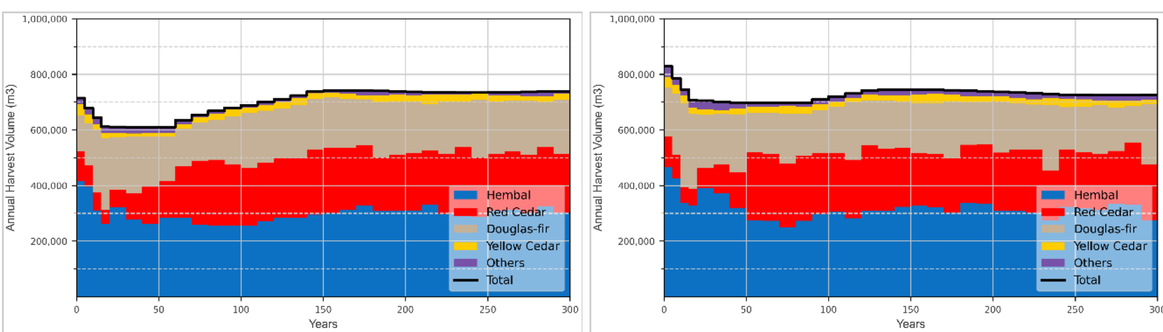


Figure 60 Species Composition for Base Case (left) and Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right)

As for cedar volumes, the Cw and Yc inventory on both THLB and NCLB over 300 years are illustrated in Figure 61. Although the 300-year patterns between the two scenarios are similar due to the similar harvested cedar components illustrated in Figure 60, the lowered growing stock in this sensitivity have also lowered the total cedar inventory. The initial cedar inventory in this sensitivity is 1.7 million m^3 less (-16.1%) than the Base Case. This is largely attributed to 23.7% less NCLB cedar volume. Because there is no harvest in the NCLB, it gives time for younger cedar stands to grow into older cedar stands that increase its volume. At the end of the 300-year planning horizon though, there is still a 2.0 million m^3 NCLB cedar volume difference (-13.5%) from the Base Case.

For the THLB, the adjusted LiDAR inventory attributes have a very minor impact on initial Cw and Yc volumes. The overall initial THLB cedar volume for the sensitivity is 0.5% less than the Base Case. As the short-term harvest occurs targeting older stands first for both scenarios, the amount of cedar on the THLB declines over the first 5 years. But the volume quickly recovers as existing second growth cedar stands continue to grow with rapid growth rates. For the first 50 years, this sensitivity actually has more proportional cedar growing stock than the Base Case, but the 10% reduction in total THLB growing stock negates this difference, making the amount of THLB cedar volume between the two scenarios at the same level of 8.1 million m^3 by Year 50. As shown in Figure 53, the total THLB growing stock for this sensitivity remains relatively stable, whereas the THLB growing stock climbs, thanks to different harvest levels caused by different minimum harvest age. This deviation in total THLB growing stock has a cascading impact to cedar volume as well. After Year 50, the cedar THLB growing stock for the Base Case keeps increasing to a peak of 9.9 million m^3 by Year 80 before it experiences a gradual decrease (no more than +/- 3.5% change decade by decade). But the cedar THLB growing stock for this sensitivity starts the gradual decrease after Year 50 at the same rate as the Base Case. The cedar THLB growing stock for the Base Case eventually stabilizes around 8.5 million m^3, whereas the cedar THLB growing stock for this sensitivity stabilizes around 6.4 million m^3.

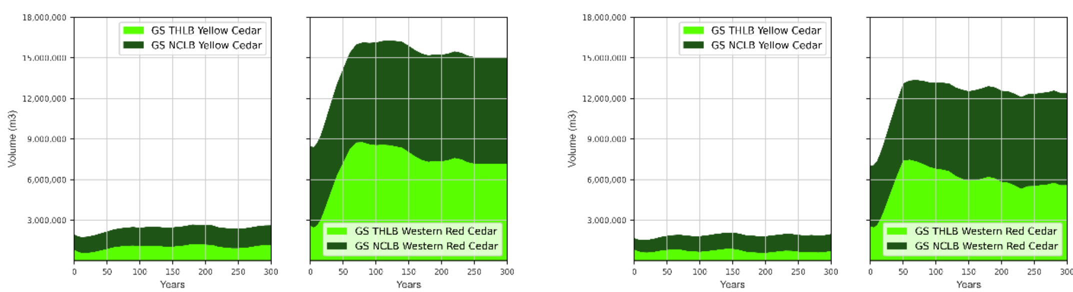


Figure 61 Cedar Inventory for Base Case (left) and Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right)

When it comes to old cedar stands, Figure 62 provides an overview of the old cedar volume over time within the productive forest. The same story in the total cedar volume repeats in the old cedar volume. The lower existing natural stand inventory and lower NCLB Cw and Yc volume in this sensitivity have lowered the current old cedar inventory by 24% compared to the Base Case. They both share the same pattern as harvesting occurs in the THLB and stands mature in the NCLB. The old cedar volume first declines in the short-term as harvesting of old stands occurs. Once the land base enters second growth harvesting, the old cedar volume is relatively stable. As a result, the volume difference for this sensitivity is maintained at 24% for this period. At Year 150, the amount of old cedar begins to increase steadily as today's existing managed stands start to enter old seral stage. The old cedar volume differences start to shrink as well. At the end of the planning horizon, the Base Case has approximately 9.5 million m^3 of old cedar, which is 23% more than today's old cedar volume. The sensitivity has 8.2 million m^3 old cedar volume at Year 300, which is 13% less than the Base Case. But due to the lower starting old cedar volume estimate, this represents a 41% increase when comparing against today's old cedar volume.

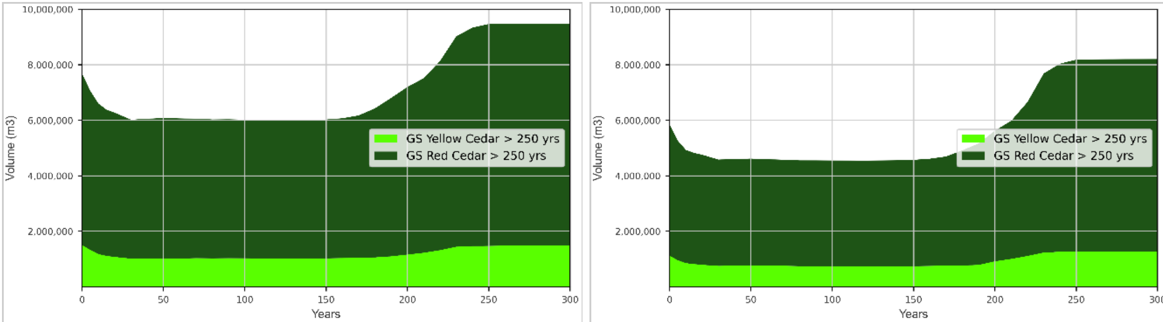


Figure 62 Old Cedar Volume for Base Case (left) and Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right)

In terms of harvest schedules on different elevation bands, the two scenarios are quite similar. Detailed harvest schedule distribution on the three elevation bands (less than 300m, 300m – 800m, and greater than 800m) is shown in Figure 63. Both scenarios have harvest distributed in these three elevation bands at an approximate proportion of 40%, 56% and 4%, respectively.

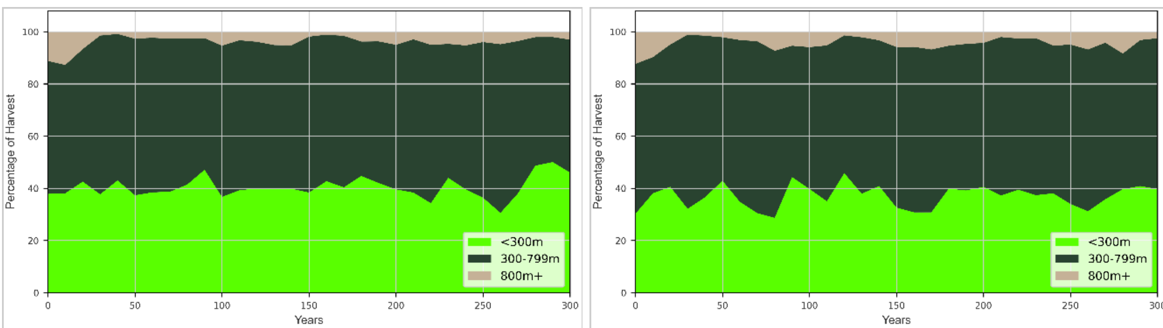


Figure 63 Harvest percentage by elevation range for Base Case (left) and Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right)

When quantifying the timber supply impact since MP #5, Figure 64 shows an updated illustration to include the adjusted LiDAR inventory attributes and modified MHA for the step-down harvest flow variant. This is an update to Figure 20 in Section 2.6. The adjusted LiDAR inventory attributes provides an extra 38,600 m^3/year to the Base Case. And the modified minimum harvest age incurs another 54,200 m^3/year increase, making the average harvest level at 789,900 m^3/year for the next 10 years.

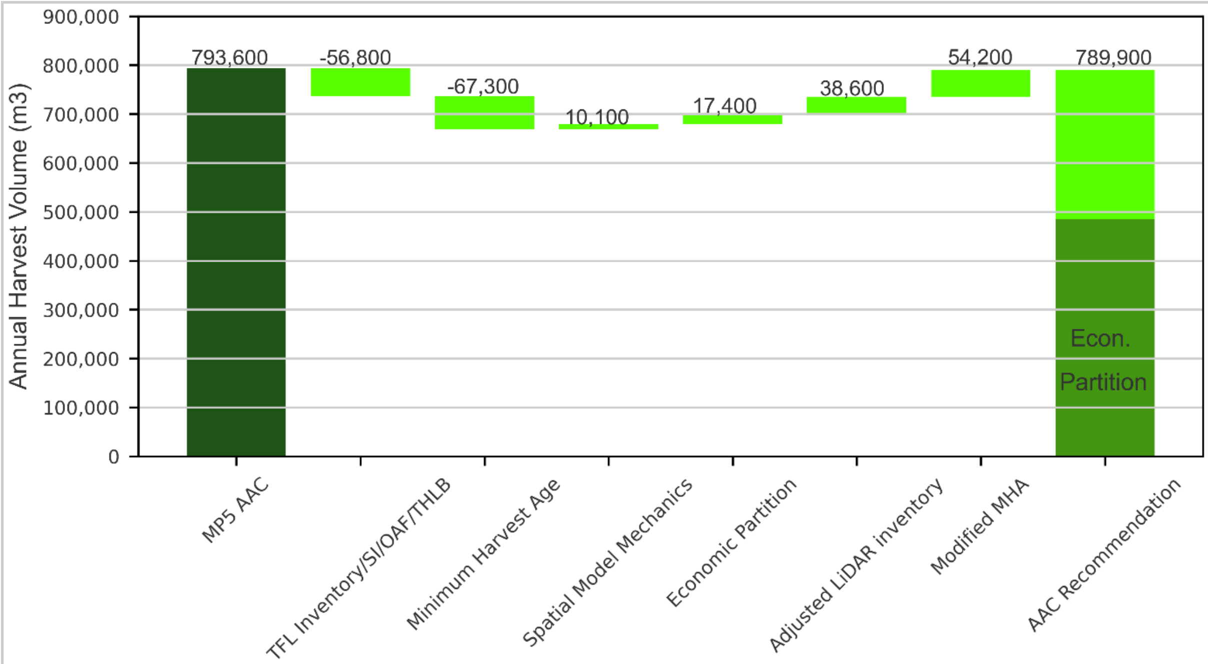


Figure 64 Updated Timber Supply Impacts of Revised Data and Assumptions Since MP #5

Table 48 provides the updated short-term (first 10 years), mid-term (11 to 150 years) and long-term (151-300 years) proportional timber supply impact on the step-down variant. This is an update to Table 10 in Section 2.6. The first 10 years impact is already shown in Figure 64 graphically.

Table 48 Updated Short/Mid/Long-term Timber Supply Impacts of Revised Data and Assumptions Since MP #5

		Percentage Impact from the Previous Scenario		
	Current AAC (m^3/yr.)	793,600		
Scenario	**Issue Tested**	**Harvest Interval (years)**		
		0-10	**11-150**	**151-300**
MP5 Benchmark	Downward: TFL inventory/SI Source/OAF/THLB reduction Upward: LiDAR road width, LiDAR Future Roads	-7.2%	-6.1%	-5.8%
MP #5 New MHA	Minimum Harvest Age	-9.1%	-6.2%	-1.0%
MP 5 New MHA Spatial	Spatial Model Mechanics	1.5%	-5.5%	-0.5%
MP#6 Base Case	Economic Partition	2.6%	-0.1%	0.2%
MP#6 Adjusted LiDAR inventory Attributes	Adjusted LiDAR inventory Attributes	5.5%	-0.2%	-1.7%
MP#6 AAC Recommendation (Step-Down)	Modified Minimum Harvest Age	7.4%	8.4%	1.1%

4.23 Use Adjusted LiDAR-based inventory attributes with alternative minimum harvest criteria - Non-Declining Even Flow

The adjusted LiDAR inventory attribute scenario provides a more accurate estimate of the forest inventory volumes, as indicated in Appendix A. The 95% culmination MAI age as the minimum harvest age is widely implemented in BC coastal management units. In addition, using DBH criteria based on TFL 44 forecasted blocks as the minimum harvest age corresponds well with 95% culmination MAI age in the timber supply projections. To further explore this sensitivity, an even harvest flow was modelled to utilize the timber supply results from the adjusted LiDAR inventory attribute scenario with the 95% culmination MAI age as the minimum harvest age. Table 49 and Figure 65 show the projections when establishing an even harvest flow for using 95% CMAI Age MHA on the adjusted LiDAR inventory. The difference between this scenario and the step-down scenario described in Section 4.22 is the pattern of the harvest flow and the allowed level of fluctuation between different modelling periods. Despite an even harvest flow objective being set up, the modelled harvest schedule has some minor (up to 0.14%) fluctuations in the short-term. The 300-year average even-flow harvest rate is 727,200 m^3/year. The harvest schedule for the NDEF starts about 100,100 m^3/year lower (-12.1%) than the step-down scenario, averaging 79,350 m^3/year less for the first 10-years (-9.8%). By Year 20, harvest levels in the NDEF scenario become higher than the step-down scenario and maintain that position for the next 100 years. The NDEF's short-term and mid-term harvest during these periods is about 23,530 m^3/year (3.3%) more than the step-down scenario, with the widest gap of 29,500 m^3/year (4.2%) at Year 90. Once the THLB GS for existing managed stands become merchantable in the step-down scenario, the gap in harvest levels between the NDEF scenario and the step-down scenario starts shrinking in Year 100. By Year 120, the

NDEF harvest levels drop below the step-down scenario, and is 0.9% less over the long term. Over the 300 years, 0.12 million m^3 (-0.06%) less volume is harvested in the NDEF scenario compared to the step-down scenario.

Table 49 Harvest Levels Comparison between the Step-Down and the Non-Declining Even Flow on 95% Culmination MAI as Minimum Harvest Age using Adjusted LiDAR Inventory Attributes

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Step-down - 95% CMAI Age MHA on Adj. LiDAR Inventory	NDEF - 95% CMAI Age MHA on Adj. LiDAR Inventory	Difference	
1	2020	2024	828,800	728,600	100,100	12.1
2	2025	2029	786,300	727,600	58,600	7.5
3	2030	2034	745,900	727,400	18,400	2.5
4	2035	2039	707,600	727,000	-19,400	-2.7
5	2040	2049	705,800	726,900	-21,100	-3.0
6	2050	2059	701,300	727,000	-25,700	-3.7
7	2060	2069	698,900	727,000	-28,100	-4.0
8	2070	2079	698,200	727,100	-28,900	-4.1
9	2080	2089	697,900	727,100	-29,300	-4.2
10	2090	2099	697,800	727,100	-29,400	-4.2
11	2100	2109	697,800	727,200	-29,500	-4.2
12	2110	2119	710,000	727,200	-17,200	-2.4
13	2120	2129	720,600	727,200	-6,700	-0.9
14	2130	2139	731,100	727,200	3,800	0.5
15	2140	2149	742,200	727,300	14,900	2.0
16	2150	2159	745,200	727,300	17,900	2.4
17	2160	2169	745,100	727,300	17,800	2.4
18-32	2170	2319	733,500	727,200	6,200	0.9

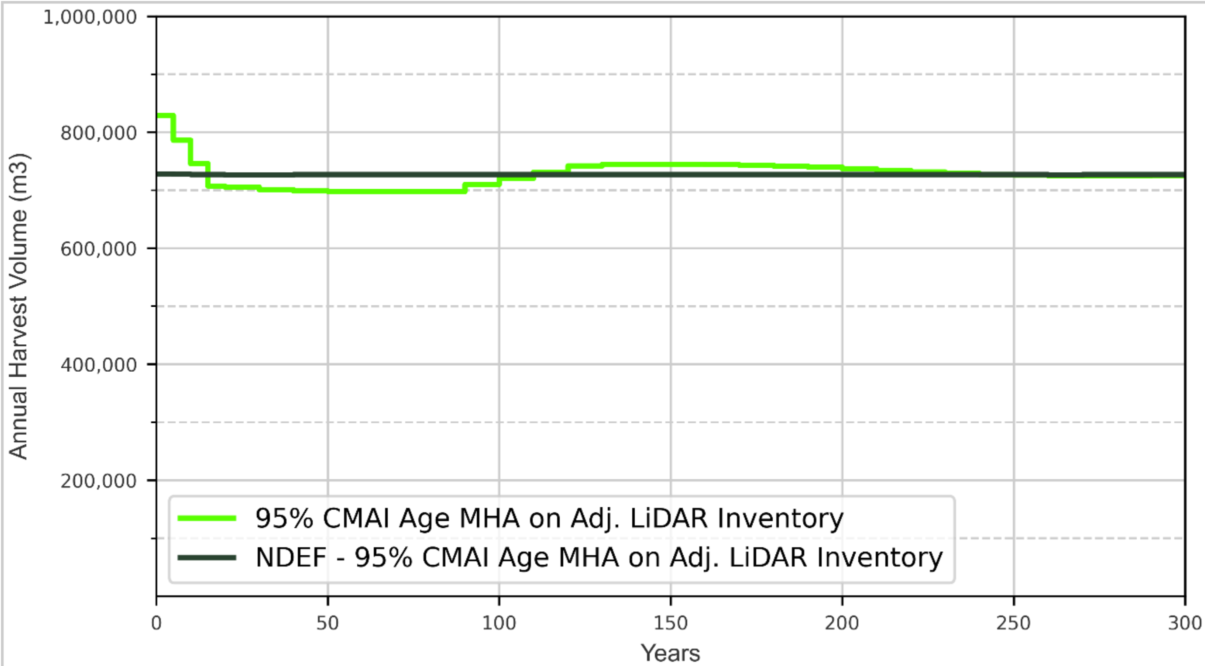


Figure 65 Harvest Levels Comparison between the Step-Down and the Non-Declining Even Flow on 95% Culmination MAI as Minimum Harvest Age using Adjusted LiDAR Inventory Attributes

Table 50 and Figure 53 compare the Base Case with the NDEF on adjusted LiDAR inventory attributes with 95% culmination MAI age scenario. Due to the adjusted LiDAR inventory sources and the minimum harvest criteria, the even-flow sensitivity starts with 1.9% higher harvest level than the Base Case. As the Base Case harvest rate reduces gradually in the next 15 years while the even-flow sensitivity holds the steady harvest level, the gap between the two scenario increases to more than 19%. Between Year 20 to Year 60, however, the Base Case harvest level stabilizes, and this 19% gap is maintained during these periods. The harvest level differences start to shrink at Year 70 because the Base Case harvest level rebounds. The turning point is Year 150 when the Base Case achieves slightly higher (1.5%) harvest level than the even-flow sensitivity. For the long-term (Year 160 to Year 300), the Base Case harvests 10,500 m^3/year (1.4%) more than the even-flow sensitivity. But the wide gap in the short-term and the mid-term leads to 7.8 million m^3 (3.7%) more volume harvested in the NDEF sensitivity over the 300 years.

Table 50 Harvest Levels Comparison between the Base Case and the Non-Declining Even Flow on 95% Culmination MAI as Minimum Harvest Age using Adjusted LiDAR Inventory Attributes

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	NDEF - 95% CMAI Age MHA on Adj. LiDAR Inventory	Difference	
1	2020	2024	715,200	728,600	-13,500	-1.9
2	2025	2029	678,900	727,600	-48,800	-7.2
3	2030	2034	644,500	727,400	-83,000	-12.9
4	2035	2039	611,900	727,000	-115,100	-18.8
5	2040	2049	611,300	726,900	-115,700	-18.9
6	2050	2059	610,000	727,000	-117,000	-19.2
7	2060	2069	609,500	727,000	-117,600	-19.3
8	2070	2079	609,500	727,100	-117,700	-19.3
9	2080	2089	635,700	727,100	-91,500	-14.4
10	2090	2099	654,900	727,100	-72,300	-11.0
11	2100	2109	668,900	727,200	-58,300	-8.7
12	2110	2119	680,100	727,200	-47,100	-6.9
13	2120	2129	689,300	727,200	-38,000	-5.5
14	2130	2139	700,000	727,200	-27,300	-3.9
15	2140	2149	711,000	727,300	-16,300	-2.3
16	2150	2159	724,300	727,300	-3,100	-0.4
17	2160	2169	738,700	727,300	11,300	1.5
18-32	2170	2319	737,800	727,200	10,500	1.4

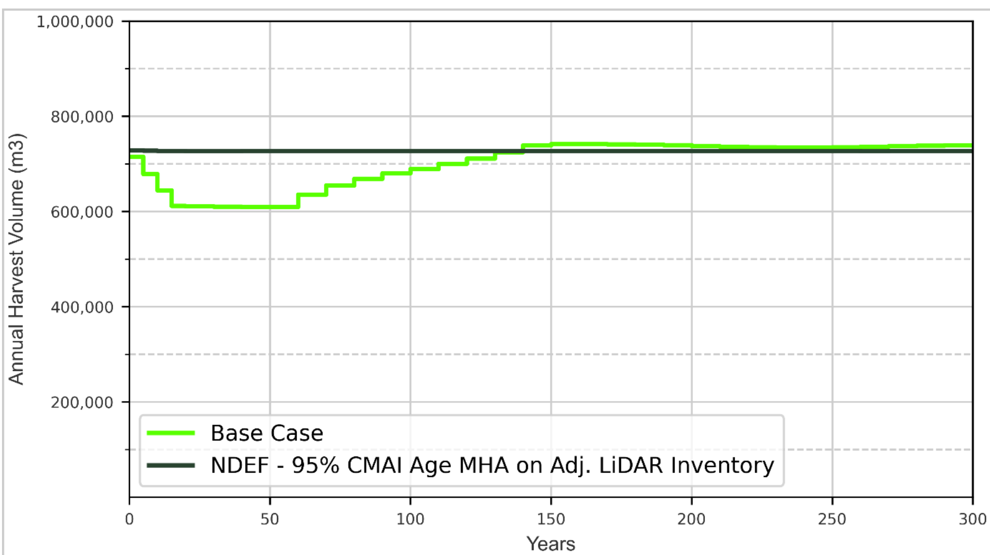


Figure 66 Harvest Levels Comparison between the Base Case and NDEF on 95% Culmination MAI as Minimum Harvest Age using Adjusted LiDAR Inventory Attributes

The THLB growing stock for the Base Case and NDEF sensitivity are compared in Figure 67. The initial state is the same as Figure 47 in Section 4.21 and Figure 53 in Section 4.22, with 5.4% more total THLB growing stock, 23.3% less 121+ years old THLB growing stock, and 24.9% more less or equal to 120 years old THLB growing stock than the Base Case. Due to the even harvest flow, the overall growing stock level is much more stable across the entire planning horizon than the Base Case, ranging between 19.4 million m³ to 22.4 million m³. The long-term THLB growing stock for this sensitivity is 6.4 million m³ (-24.4%) less than the Base Case.

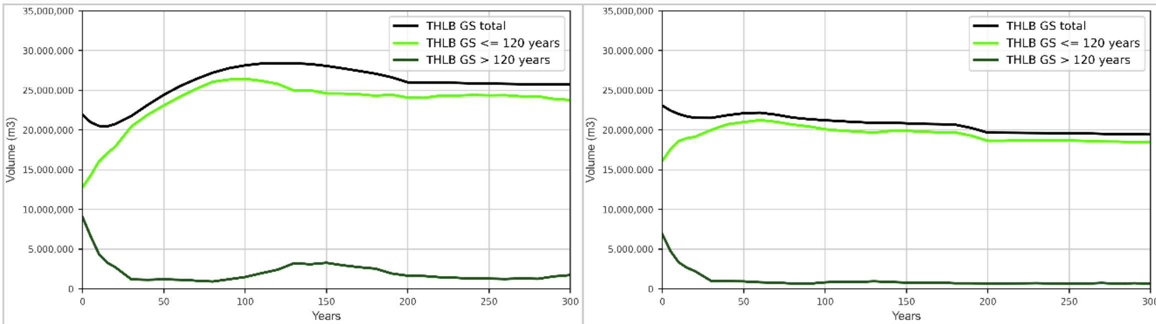


Figure 67 THLB Growing Stock by 120-Years-Old Cut-Off Comparison: Base Case (left) vs. NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA (right)

The merchantable THLB growing stock for harvest systems between the Base Case and the even-flow sensitivity is compared in Figure 68. The initial merchantable THLB growing stock is the same as Figure 54 in Section 4.22, with 1.8 million m³ extra (13.8% more) merchantable volume than the Base Case. For the first 50 years, higher merchantable THLB growing stock in this sensitivity supports higher harvest level than the Base Case. After the harvest fully transitions into second growth harvesting, the harvest rate for the Base Case gradually recovers. This is indicated in the improving merchantable THLB growing stock as well. For the last 150 years when the harvest levels for both scenarios are maintained at the similar even-flow level (1.4% difference), similar pattens are also observed in the merchantable THLB growing stock.

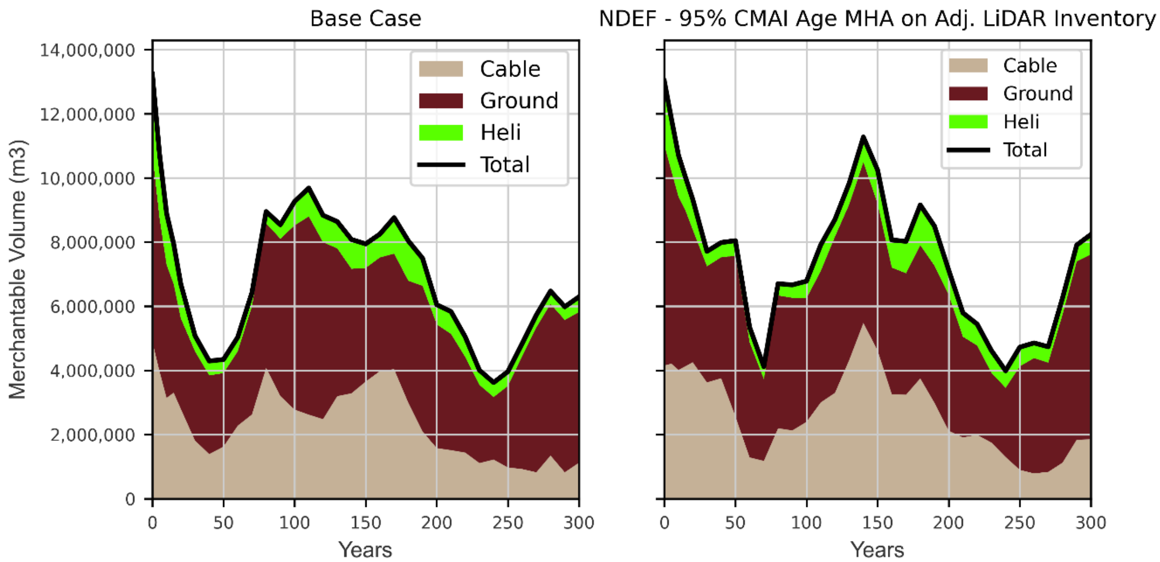


Figure 68 Merchantable THLB Growing Stock of Base Case (left) and NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA (right)

Figure 69 shows the contribution to the total harvest volume by period from the three stand eras used to define the analysis units for the Base Case and the even-flow sensitivity. Despite the differences in harvest flow pattern and inventory, the contribution profile in this sensitivity is similar to the Base Case for the 300-year planning horizon. The existing natural stands account for more than half of the projected harvest for the first 15 years for both scenarios, but the existing natural stands further drop to below 10% of the harvested volume at Year 40, 10 years earlier than the Base Case. After that, the land base fully transitions to second growth harvesting. Using 95% culmination MAI as the minimum harvest age makes more second growth stand available for harvesting. This is evident in the faster transition (steeper drop for line green areas in Figure 69) to harvesting future managed stands in this sensitivity.

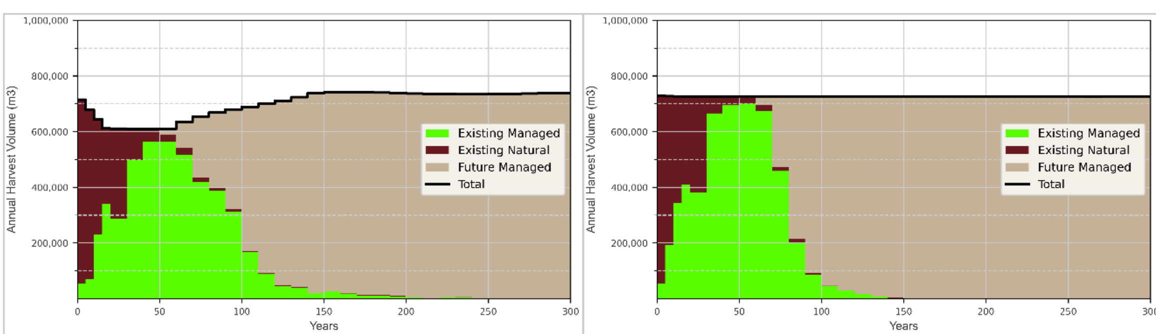


Figure 69 Stand Eras' Contribution to Base Case (left) and NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA (right)

Figure 70 shows the productive forest age class distributions over time for the even-flow sensitivity every 50 years. The age class distribution follows the same pattern and has only very subtle differences from the Base Case, with 32% of the productive forest is currently in the oldest age class and 76% of the productive old area is outside of the THLB. As harvesting continues, the older THLB stands move over to the younger age classes. At the end of the 300-year planning horizon, the total productive old area is also expected to grow to 39% of the productive forest. Similar to the Base Case, once the relatively balanced age class distribution is achieved by Year 150, the age class distribution is stable - with more than 74,000 hectares of fully regulated forest renewed over time in the THLB, and more than 48,000 hectares of old (251+ years old) forest protected for the productive forests.

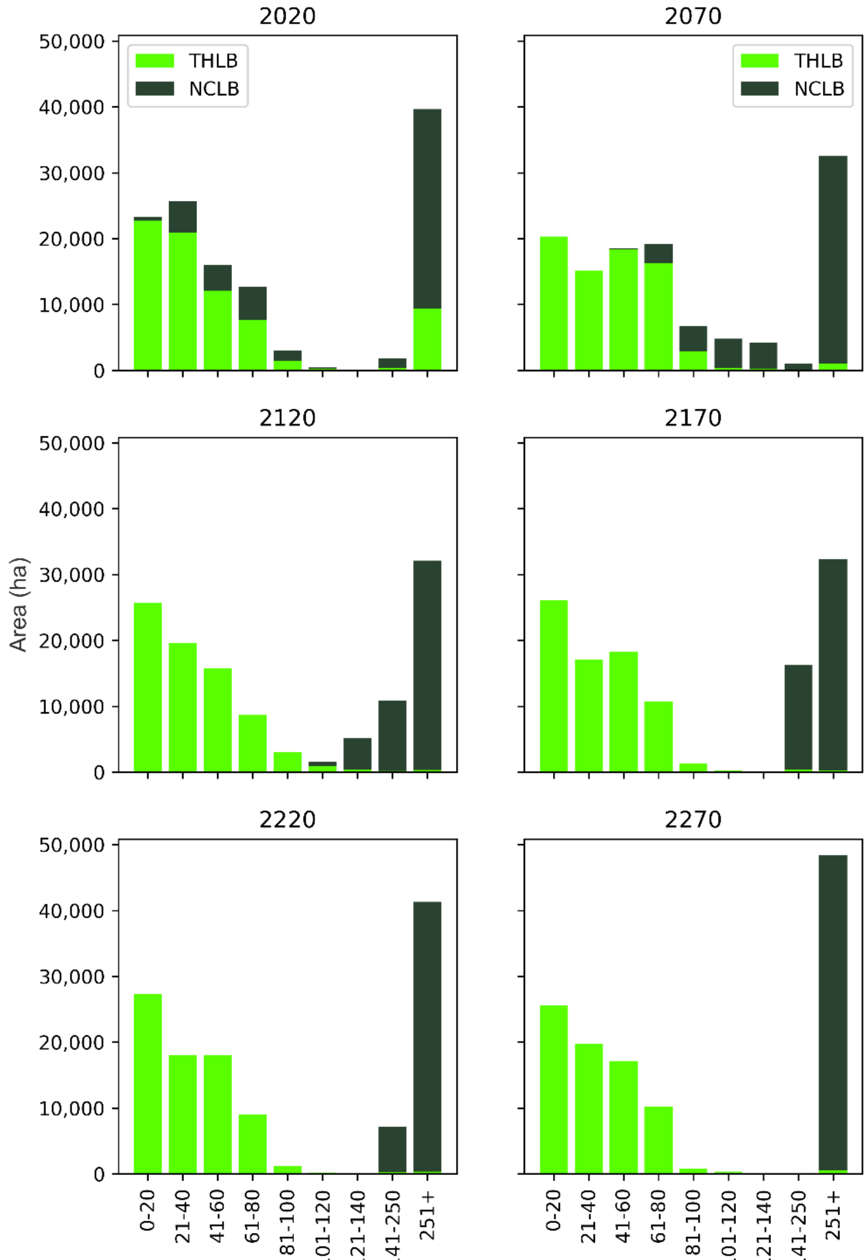


Figure 70 NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario Age Class Distribution of Productive Forest Area (120,970 ha)

Table 51 and Figure 71 show the economic profile comparison for the first 20 years. Since the economics is one of the modelling objectives, the economic partition in this sensitivity is increased to more than 80% of the overall harvest level, which is higher than the economic partition for the current AAC. The adjusted LiDAR inventory and modified minimum harvest age make the economic volume higher than the Base Case. When compared to the economic partition for the step-down harvest flow (shown in Table 47), the economic volume for stands greater than 120 years old is the same, due to the establishment of the landscape-level net value objective ($/m^3) in the model. The lowered total harvest level in the even-flow sensitivity is reflected in the economic volume for stands less or equal to 120 years old and the marginal volume. With a higher overall harvest level of this sensitivity than the Base Case, on average for the first 10 years, the economic partition is 82,000 m^3/year higher. Similar to the step-down harvest flow, the transition away from accessing existing natural stands is expected to occur soon. The harvest flow consists of 52% of the economic mature stands for the first 5 years, then the contribution drops to 25% in the subsequent 5 years, whereas the proportion for the Base Case remains at 52% for the same period. From Year 10 to Year 20, existing natural stands are only supplemental (below 20%) in the economic partition in both cases. The economic mature stands account for 19% and 9% of the harvest in the Base Case for each of the 5-year intervals during this period; the corresponding proportion is only 6% and 4% for this sensitivity (though the overall harvest level in this sensitivity is higher).

Table 51 Economic Partition of NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario and Difference Against the Base Case

Year	NDEF on Adjusted LiDAR Inventory Attributes - 95% CMAI MHA (m3)						Difference vs. Base Case	
	Harvest Level	Economic > 120 years	Economic <= 120 years	Total Economic	Economic %	> 120 years within Economic %	Economic (m^3)	> 120 years within Economic (m^3)
AAC	793,600	425,000	110,000	535,000	67%	79%	N/A	
2020-2024	728,600	343,100	310,800	653,900	90%	52%	115,000	49,000
2025-2029	727,600	148,100	438,200	586,300	81%	25%	74,100	-120,000
2030-2034	727,400	34,800	580,600	615,400	85%	6%	81,400	-69,300
2035-2039	727,000	24,700	623,500	648,200	89%	4%	109,400	-23,100

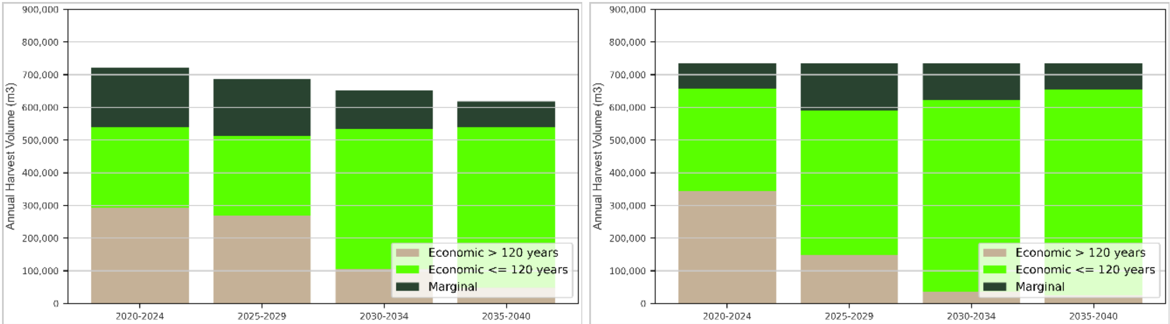


Figure 71 Economic Partition of Base Case (left) and NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right) From Year 0 to Year 20

Figure 72 illustrates the harvest system break-down for the modelled harvest rate over 300 years. Like the Base Case, the conventional harvest system (cable and ground) accounts for 90% of the harvest system used in the harvest projections. The even-flow sensitivity generally follows the trend in the Base Case, with an average of about 50%, 45% and 5% contributions from cable, ground, and helicopter harvest system, respectively.

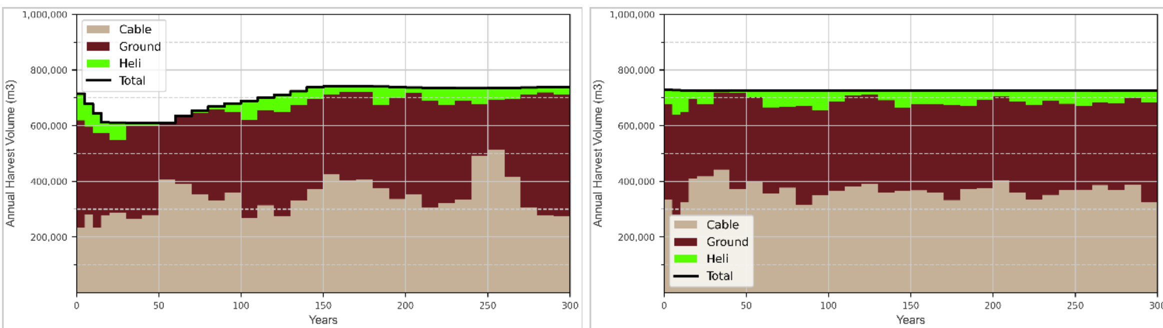


Figure 72 Harvest System for Base Case (left) and NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right)

Figure 73 compares the average harvest age, harvest area and harvest volume per hectare between the Base Case and the even-flow sensitivity. Compared to the step-down variant of the sensitivity (see Figure 59), the even-flow sensitivity presents a very similar picture for all three aspects. On a 300-year basis, the even-flow has the same average harvest age, 11 m^3/ha less in average volume/ha harvested and 7 hectares more in average harvested area than the step-down sensitivity. The higher initial harvest level and the lower mid-term harvest level for the step-down scenario cancel each other out in the 300-year average harvest statistics. Compared to the Base Case, this even-flow sensitivity follows the same pattern. It has 86 hectares more area harvested annually, 8 years younger in average harvest age, and 45 m^3/ha lower average volume per hectare. The lower average harvested stand volume in this sensitivity is primarily due to more flexible minimum harvest criteria. The higher area harvested is due to higher harvest level in the sensitivity.

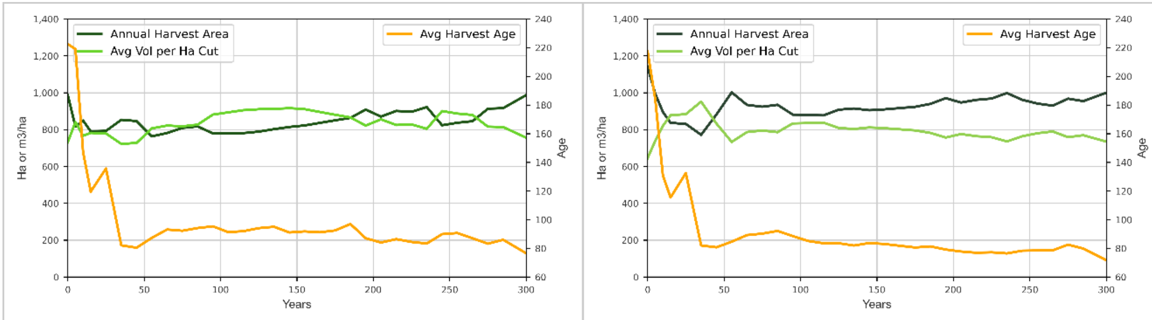


Figure 73 Harvest Statistics for Base Case (left) and NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right)

Figure 74 shows the species composition of the modelled harvest levels for the Base Case and the even-flow sensitivity. Despite the different flow patterns, the overall species profile for the harvest level is similar, especially for the mid-term and long-term after Year 100. Similar to the step-down scenario (shown in Figure 60), the species composition difference in the harvested volume is concentrated in the short-term period when the initial inventory and the harvest levels deviate between the Base Case and this sensitivity. Overall, HemBal, western red cedar, Douglas-fir, and yellow cedar contribut approximately 44%, 25%, 25% and 3% of the harvest, respectively (with 1% variance in Douglas-fir). The rest of the 2-3% is made up from other species (e.g., Sitka spruce).

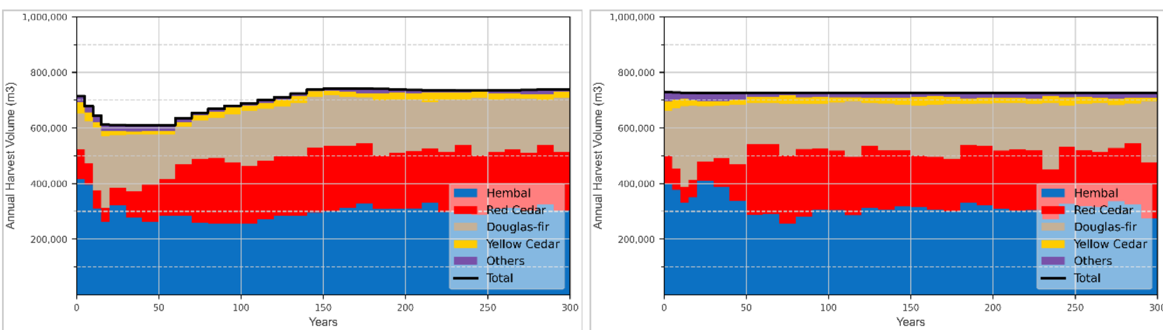


Figure 74 Species Composition for Base Case (left) and NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right)

Figure 75 compares both the THLB and NCLB cedar volumes over 300 years. Similar to the comparison against the step-down variant shown in Figure 60, the initial cedar inventory in this sensitivity is 1.7 million m^3 less (-16.1%) than the Base Case, largely due to the 23.7% less starting NCLB cedar inventory. Because there is no harvest in the NCLB, this gap is difficult to fulfill. In addition, the harvest level for the even-flow variant of this sensitivity is higher than the Base Case, which means the carrying cedar inventory in the THLB is generally lower in this sensitivity. Despite the volume differences, the 300-year patterns between the two scenarios are similar due to the similar harvested cedar components illustrated in Figure 74. After a short period of decline due to the short-term harvest targeting older stands first, both Cw and Yc inventory is projected to increase for the first 50 to 60 years as existing second growth cedar stands in THLB continue to grow with rapid growth rates. Cedar inventory remains relatively stable for the rest of the 200+ years.

Overall, there is a net increase in cedar volume for both scenarios at the end of the 300-year planning horizon with the projected harvest levels. Specifically, Yc volume is projected to increase by 18.7% from today in this sensitivity after 300 years, whereas the increase is expected to be 35.2% in the Base Case. The increase for Cw volume at the end of 300 years is similar: 76.0% for this sensitivity and 78.0% for the Base Case. But due to the reasons explained above, the Base Case has 17.6% more Cw volume. The cedar growing stock for the Base Case eventually stabilizes around 17.8 million m^3 (15.3 million m^3 for Cw and 2.5 million m^3 for Yc), whereas the cedar THLB growing stock for this sensitivity stabilizes around 14.3 million m^3 (12.4 million m^3 for Cw and 1.9 million m^3 for Yc).

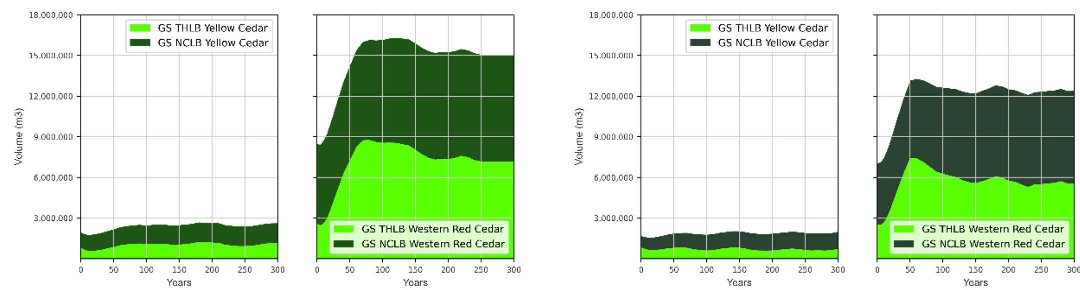


Figure 75 Cedar Inventory for Base Case (left) and NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right)

As for the old cedar stands, Figure 76 provides an overview of the productive old cedar volume over 300 years. It is the same story for the step-down variant shown in Figure 62 in terms of 24% lower initial total cedar volume for this sensitivity. However, the pattern of reducing old cedar volume for the first 30 years is the same as the Base Case due to harvest occurrence in older stands. Once the land base enters second growth harvesting, the old cedar volume becomes relatively stable in both scenarios, though the approximately 24% volume difference between the two scenarios is also maintained. At Year 150, the amount of old cedar begins to increase steadily in both scenarios, as today's existing managed stands start to enter old seral stage. The old cedar volume differences between the two scenarios start to shrink as well. At Year 300, the Base Case has approximately 9.5 million m^3 of old cedar, which is 23% more than today's old cedar volume. The sensitivity has 8.2 million m^3 old cedar volume at Year 300, which is 13.5% less than the Base Case. But due to the lower starting old cedar volume estimate, this represents a 40.3% increase when comparing against today's old cedar volume.

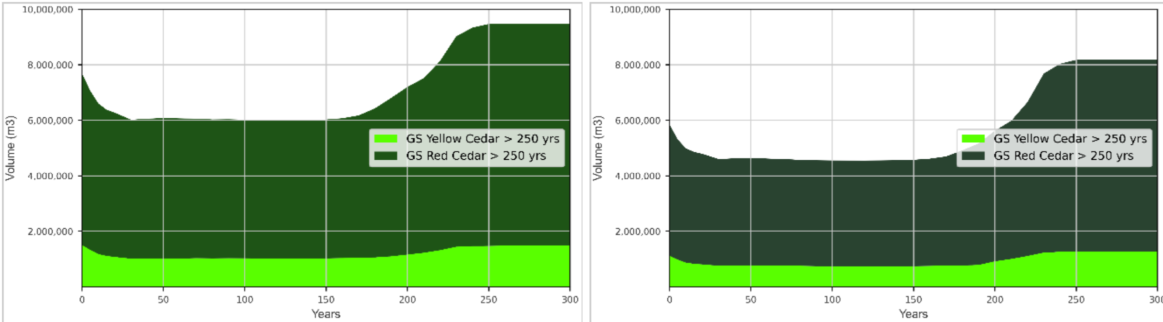


Figure 76 Old Cedar Volume for Base Case (left) and NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right)

Detailed harvest schedule distribution on the three elevation bands (less than 300m, 300m – 800m, and greater than 800m) is compared in Figure 77. The even-flow variant has 2% to 3% differences in each band proportion compares to the step-down variant shown in Figure 63, but the deviation is minor overall. The Base Case has harvest distributed in these three elevation bands at an approximate proportion of 40%, 56% and 4%, respectively. The even-flow sensitivity has the corresponding distribution of 37%, 58% and 5%.

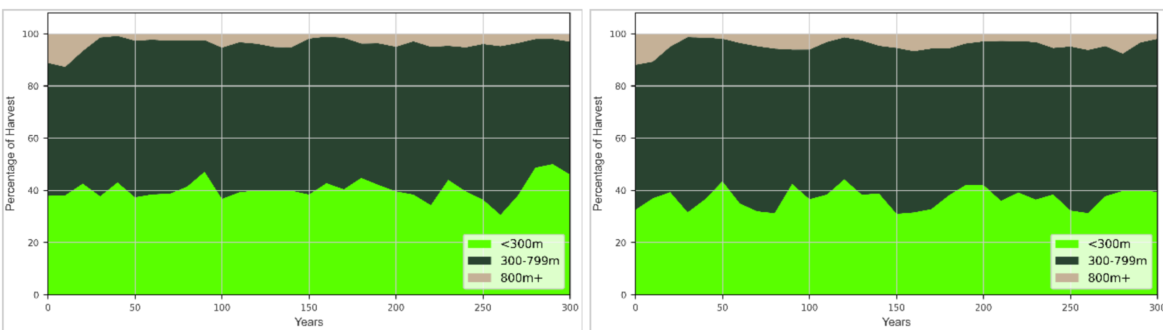


Figure 77 Harvest percentage by elevation range for Base Case (left) and NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario (right)

The even-flow variant of the adjusted LiDAR inventory attribute scenario with the 95% culmination MAI age as the minimum harvest age provides more stability over time compared to the scenario described in Section 4.22 that maximizes the short-term AAC, then steps down gradually. Despite the lower short-term AAC in this scenario, the 300-year total harvested volume is the same (0.06% volume difference) as the step-down scenario. Therefore, the AAC recommendation proposes to utilize the even-flow timber supply results from the adjusted LiDAR inventory attribute scenario with the 95% culmination MAI age as the minimum harvest age, in lieu of the Base Case. In terms of the actual modelled harvest level, there are some minor (up to 0.14%) fluctuations in the short-term, the average even-flow harvest level for the projection is 727,200 m^3/year.

When quantifying the timber supply impact since MP #5, Figure 78 shows an updated illustration in terms of 10-year AAC change for the even-flow variant of the adjusted LiDAR inventory attributes with 95% Culmination MAI MHA. This is an update to Figure 20 in Section 2.6 for the Base Case and Figure 64 in Section 4.22. The adjusted LiDAR inventory attributes provide an extra 38,600 m^3/year to the Base Case. Due to the harvest flow shift, the modified minimum harvest age indicates a drop of 7,600 m^3/year. However, as quantified in the "Modified MHA" bar in Figure 64, the land base can support 54,200 m^3/year increase in AAC. Therefore, this 7,600 m^3/year drop is more about the harvest flow difference than the AAC capacity of the land base.

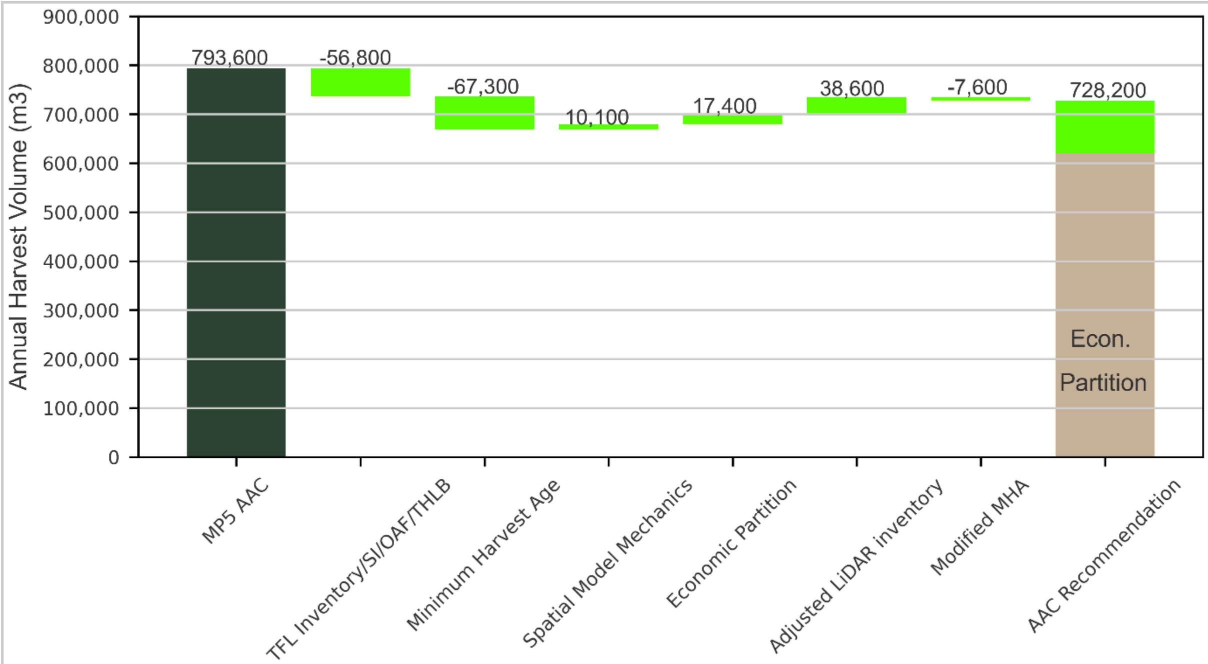


Figure 78 Updated Timber Supply Impacts of Revised Data and Assumptions Since MP #5 for NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario

Table 52 provides the updated short-term (first 10 years), mid-term (11 to 150 years) and long-term (151-300 years) proportional timber supply impact for the even-flow variant. This is an update to Table 10 in Section 2.6 and Table 48 in Section 4.22. The first 10 years impact is already shown in Figure 78 graphically.

Table 52 Updated Short/Mid/Long-term Timber Supply Impacts of Revised Data and Assumptions Since MP #5 for NDEF on Adjusted LiDAR Inventory Attributes with 95% Culmination MAI MHA Scenario

		Percentage Impact from the Previous Scenario		
	Current AAC (m^3/yr)	793,600		
Scenario	Issue Tested	Harvest Interval (years)		
		0-10	11-150	151-300
MP5 Benchmark	Downward: TFL inventory/SI Source/OAF/THLB reduction Upward: LiDAR road width, LiDAR Future Roads	-7.2%	-6.1%	-5.8%
MP #5 New MHA	Minimum Harvest Age	-9.1%	-6.2%	-1.0%
MP 5 New MHA Spatial	Spatial Model Mechanics	1.5%	-5.5%	-0.5%
MP#6 Base Case	Economic Partition	2.6%	-0.1%	0.2%
MP#6 Adjusted LiDAR inventory Attributes	Adjusted LiDAR inventory Attributes	5.5%	-0.2%	-1.7%
MP#6 AAC Recommendation (Even-Flow)	Modified Minimum Harvest Age	-1.0%	10.4%	0.3%

4.24 Use Provincial VRI as Base Inventory

The VRI for the South Island District where TFL 44 resides was re-interpreted based on aerial photos acquired in 2014. The VRI reference year is relatively new. An analysis of available inventories in TFL 44 (VRI, TFL 44 forest cover and ITI) found the VRI to be the least accurate at estimating stand volume (shown in Appendix A). It was shown to consistently underestimate stand volume in both managed and unmanaged stands. This sensitivity utilizes the provincial VRI as an alternative forest attribute source for TFL 44. Growth and yield for stands greater than 20 years old are revised accordingly based on the VRI attributes (stands younger than or equal to 20 years old are RESULTS based and maintain good accuracy). Analysis units are re-assigned as well.

Using VRI forest attributes brings down the starting merchantable volume for the THLB by 1.1 million m^3 (-8.4%) compared to the Base Case that uses TFL 44 forest cover. This is not surprising since VRI was found to considerably underestimate stand volume using both cruise and harvest data. Table 53 and Figure 79 demonstrate that this sensitivity has lower harvest levels than the Base Case for the entire 300-year planning horizon, with a wider gap in the short-term. The harvest levels for the first 30 years where existing natural stands have the greatest contribution is on average 12.2% lower than the Base Case. The lower merchantable volume in this sensitivity makes harvesting more challenging when the volume bottleneck occurs in these periods. When managed stands contribute the majority of harvesting, the gap begins to shrink, with noticeable improvements in the mid-term. At Year 60, the gap is the smallest between the two scenarios at 1.7% apart. But then the gap widens again when the Base Case harvest level gradually recovers. The long-term harvest level is 6.9% lower than the Base Case. The total volume harvested over the 300 years is 14.0 million m^3 (-6.7%) less compared to the Base Case.

Table 53 Harvest Levels with VRI Inventory Attributes

Period	Start Year	End Year	Annual Harvest Volume (m^3)			% Difference
			Base Case	VRI Attributes	Difference	
1	2020	2024	715,200	623,000	92,200	12.9
2	2025	2029	678,900	591,700	87,100	12.8
3	2030	2034	644,500	562,100	82,300	12.8
4	2035	2039	611,900	534,000	77,900	12.7
5	2040	2049	611,300	543,500	67,800	11.1
6	2050	2059	610,000	561,300	48,600	8.0
7	2060	2069	609,500	581,400	28,000	4.6
8	2070	2079	609,500	598,900	10,600	1.7
9	2080	2089	635,700	614,900	20,800	3.3
10	2090	2099	654,900	627,800	27,000	4.1
11	2100	2109	668,900	638,700	30,200	4.5
12	2110	2119	680,100	645,500	34,500	5.1
13	2120	2129	689,300	651,900	37,400	5.4
14	2130	2139	700,000	660,500	39,400	5.6
15	2140	2149	711,000	670,900	40,100	5.6
16	2150	2159	724,300	683,700	40,500	5.6
17	2160	2169	738,700	690,400	48,300	6.5
18-32	2170	2319	737,800	687,100	50,600	6.9

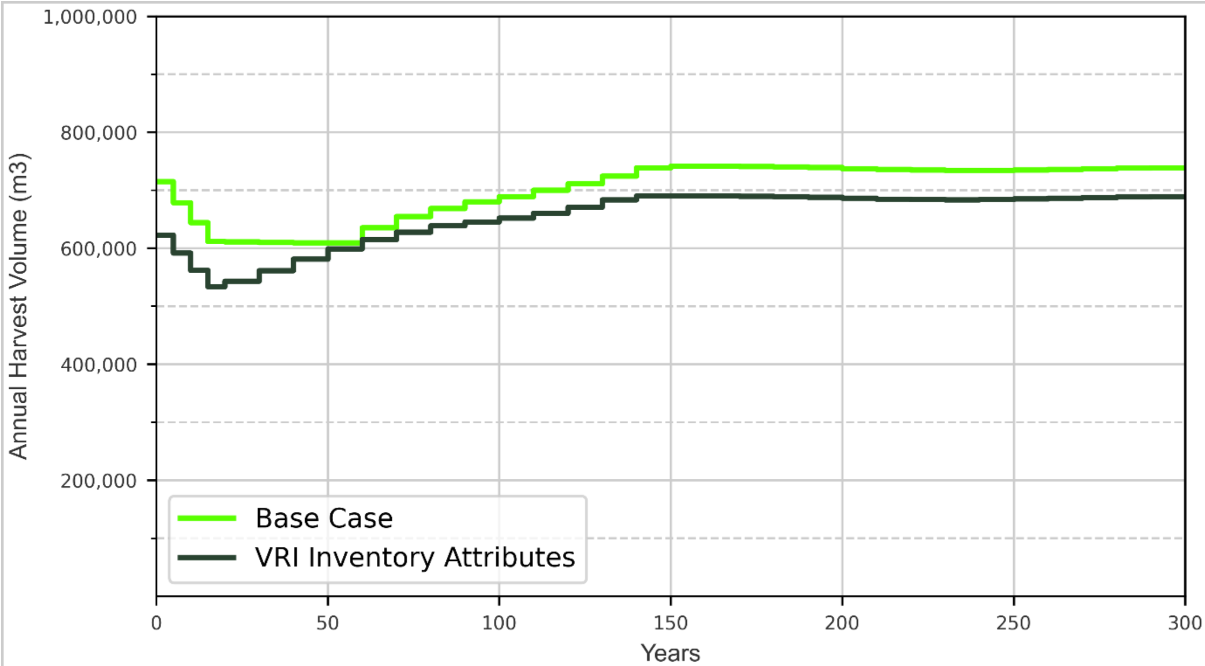


Figure 79 Harvest Levels with VRI Inventory Attributes

4.25 Summary of Sensitivity Impacts

Table 54 provides a summary of the impacts of the sensitivity issues explored comparing against the Base Case. Impacts shown indicate the aggregate differences over the defined time periods and are rounded to the nearest tenth of a percent. A positive percentage number means that the net harvested volume for the sensitivity tested in this period is more than the Base Case. More explanation on each sensitivity is documented in Section 5.3.

Table 54 Summary of Sensitivity Analyses Harvest Impacts vs. Base Case

		Harvest Interval (years)		
		0-10	11-150	151-300
Base Case total net harvest level (m^3)		6,970,852	92,719,332	110,670,426
Issue Tested	**Sensitivity Analysis Summary**	**Percentage Impact**		
Climate Change	Apply predicted 2050 BEC zone variants	-5.0%	-7.5%	-9.2%
Growth and Yield	Increase natural stand volumes by 10%	3.3%	1.3%	0.0%
	Decrease natural stand volumes by 10%	-6.8%	-1.4%	-0.2%
	Increase managed stand volumes by 10%	3.2%	9.1%	9.5%
	Decrease managed stand volumes by 10%	-7.2%	-9.1%	-9.9%
Forest Management / Silviculture	Exclude genetic gain adjustments	-5.6%	-6.4%	-7.8%
OAF	Use default provincial OAF 1	-3.9%	-4.1%	-4.5%
	Use increased OAF 2 to reflect root-rot in Fd-leading managed stands	-2.2%	-1.0%	-1.1%
Minimum Harvest Criteria	Add 2cm to the minimum harvest criteria	-11.7%	-3.2%	-1.3%
	Subtract 2cm to the minimum harvest criteria	6.0%	2.9%	0.4%
	95% of culmination mean annual increment	9.3%	9.1%	1.3%
Area of Traditional Use	Remove Thunder Mountain GAR order area	-3.8%	-0.9%	-1.2%
	Remove potential Ditidaht First Nation Agreement-In-Principle offer lands	-3.4%	-1.9%	-1.6%
Operability	Remove Partition to include economically marginal stands	-2.5%	0.3%	-0.2%
	Remove area within 30m from nearby parks	-1.8%	-0.4%	-0.3%
Watershed Management	Use Equivalent Clear-cut Area (ECA) constraints of 20%	-1.4%	-0.1%	-0.1%
	Apply ECA constraints on 400+m elevation	-1.4%	-0.1%	-0.1%
Visual Management	Use more restrictive visual management constraints	-4.0%	-0.3%	-0.4%
Biodiversity	Apply Marbled Murrelet provincial targets by LU / LU aggregate	-2.5%	0.0%	-0.2%
	Remove WFP Stewardship and Conservation Plan impacts	-1.2%	0.5%	0.3%
Inventory	Use adjusted LiDAR-based inventory attributes	5.5%	-0.6%	-1.7%
	Use adjusted LiDAR-based inventory attributes with alternative DBH minimum harvest criteria	15.7%	5.7%	-0.9%
	Use adjusted LiDAR-based inventory attributes with 95% of culmination MAI age as minimum harvest age	15.8%	8.1%	-0.6%
	Use adjusted LiDAR-based inventory attributes with 95% of culmination MAI age as minimum harvest age (Even-Flow)	4.5%	9.8%	-1.4%
	Use Provincial VRI as base inventory	-12.9%	-6.0%	-6.9%

5 ANALYSIS SUMMARY AND PROPOSED AAC

5.1 Changes since MP #5

There have been considerable changes in the TFL 44 timber supply analysis assumptions since MP #5. The details are described in Section 2.2. And timber supply impacts against MP #5 are elaborated in Section 2.6. The main changes include:

- Use of different forest cover and site index, with different species composition, age, productivity, and volume;
- Improved operability and identification of non-productive and low productive forest area using LiDAR data via Land Base Blocking;
- Application of LiDAR-informed OAF1 value in TIPSY to account for non-productive area within managed stands based on site occupancy;
- Revised spatial THLB netdowns for riparian management zone retention, OGMAs, archaeological sites, recreation sites and stand-level retention, resulting in 5,330 hectares (6.7%) of THLB reduction;
- Use of DBH and harvest system based minimum harvest ages for stronger alignment with operational planning, harvesting, log transportation and milling capacities;
- Use of a different timber supply model with harvest scheduling that uses spatial patch targets, road targets and optimization compared to the aspatial optimization approach in MP #5.
- Application of a landscape-level net value objective ($/m^3) to ensure the economic partition implementation;
- Use of LiDAR data for road width and future roads in the THLB definition process;

5.2 MP #6 Base Case Initial Harvest

The starting harvest level of 715,200 m^3/year for the first 5 years 678,900 m^3/year for the following 5 years and in the Base Case reflects changes since MP #5 elaborated above.

- The current TFL 44 AAC of 793,600 m^3/year does not account for many of the changes highlighted in Section 2.2;
- Between 2011 and 2021, 7.8 million m^3 was harvested, including waste and residue;
- The initial THLB growing stock in MP #5 was estimated at 27.65 million m^3 compared to 21.88 million m^3 for MP #6.

5.3 Sensitivity Analyses

Sensitivity analyses have explored timber supply impacts of several uncertainties individually, as Table 54 indicates the short-term (Year 0-10), mid-term (Year 11-150) and long-term (Year 151-300) timber supply impact when comparing against the Base Case. These include:

- A sensitivity analyses examined the impacts of varying the timber supply contribution of the economically marginal landbase:

   - Including the economically marginal landbase reduces the short-term timber supply by 2.5% due to different harvest patterns and focuses. However, it does slightly enhance the mid-term harvest level by 0.3%. The impact to long-term harvest is negative 0.2%.
   - The 300-year net timber supply impact of including the economically marginal land base is an increase of 0.05%, or 363 m^3/year annualized. This indicates that the current setup of the landscape-level economic objective has almost a neutral timber supply impact.
   - The overall helicopter contribution in the Base Case is consistent with the overall proportion of THLB area classified as helicopter harvest system via LiDAR and performance in the helicopter operable landbase during MP #5. Having the economic objective embedded in the modelling can ensure the economic operability of accessing helicopter HwBa stands is reflected in the timber supply projection.
 - Several sensitivity analyses examined the timber supply impacts of higher and lower volume projections or of management and other factors contributing to uncertainty on forest growth:
   - Initial harvest level is moderately sensitive to natural stand yield estimates. A (plus or minus) 10% change in yield results in an 3.3% and -6.8% change respectively to initial harvest in the next 10 years. Mid-term and long-term harvest levels are more or less unaffected (<1.4% for mid-term and <0.2% for long-term).
   - A (plus or minus) 10% change to managed stand are sensitive (+/- 9% plus changes) in the mid-term and long-term, but still substantial (-7.2% and 3.2%) in the short-term.
   - Excluding genetic gain adjustments in the managed stand yields are more sensitive in the mid-term (-6.4%) and long-term (-7.8%). Short-term harvest is less responsive, but the impact is still meaningful (-5.6%).
   - Using the default OAF 1, effectively an extra 4.1% reduction in the managed stand yields, reduces harvest by -3.9%, -4.1% and -4.5% in the short-term, mid-term and long-term harvest, respectively.
   - Use of increased OAF 2 (from 5% to 12.5%) in Douglas-fir leading managed and future stands in CWHmm1, xm1 and xm2 zones to reflect root-rot brings -1.0% impact to the mid-term and long-term. The initial harvest level is more sensitive with -2.2% reduction.
- Sensitivity of timber supply to minimum harvest age was tested by varying the minimum DBH specifications and by applying 95% culmination MAI. Decreasing minimum DBH criteria by 2cm increased short-term timber supply by 6.0% whereas increasing DBH criteria by 2cm also has a significant impact (-11.7%) in the short-term. Applying 95% culmination MAI as minimum harvest age increases short-term (9.3%) and mid-term (9.1%) timber supply, but less so (1.3%) in the long-term.

- Alternative forest cover constraints, such as 20% ECA limit and 400m elevation band, within the fishery sensitive watersheds and community watersheds respectively have more short-term impacts (-1.4%). The mid-term (-0.1%) and long-term (-0.1%) timber supply impacts are minimal.
- Increasing visual constraints by 2% to 8% for different VQO classes have more short-term (-4.0%) timber supply impact than in the mid-term (-0.3%) and long-term (-0.4%).
- Potential sensitivity of climate change is tested via applying modelled 2050 BEC zones. The timber supply impact is most severe in the long-term (-9.2%), but short-term and mid-term impact are also considerable (-5.0% and -7.5%).
- Multiple sensitivity analyses examine the timber supply impacts on the removal of areas in THLB:
    - Initial harvest level is the most sensitive (-3.8%) to the 0.9% THLB exclusion of the Thunder Mountain GAR order area. The mid-term (-0.9%) and long-term (-1.2%) sensitivity is relative to the proportion of the THLB removal.
    - Similar behaviours are observed in the THLB exclusion of DFN AIP offer land and area within 30m from nearby parks, where the initial harvest levels are the most sensitive, with the mid-term and long-term harvest impacts closer or less than the proportional THLB reduction.
- Several sensitivities examined forest management strategies changes:
    - December 2021 Marbled Murrelet Order is observed to have minor (<-0.2%) mid-term and long-term timber supply impact, but the short-term is more sensitive (-2.5%).
    - Not implementing additional stand-level retention required by WSCP increases the mid-term and long-term timber supply by 0.5% and 0.3%, respectively. This is achieved by reserving extra timber from harvesting in the short-term. Thus, a -1.2% reduction is observed in the short-term harvest.
- The uses of alternative forest inventories, such as adjusted LiDAR-based inventory and provincial VRI, are tested:
    - Using VRI causes 8.4% decrease in the initial merchantable THLB volume compared to the Base Case. More sensitivity is observed in the short-term (-12.9%). Mid-term and long-term sensitivities are moderate (-6.0% and -6.9%, respectively), but still significant.
    - The direct application of LiDAR-derived inventory attributes has a known under-estimation in mature and older stands. The use of adjusted LiDAR-based inventory attributes fixed the known under-estimation in mature and older stands, increasing the starting THLB growing stock by 5.4%. But this greater THLB growing stock is combined with a lower existing natural stand proportion. With the alternative optimized harvest scheduling in the timber supply model, the short-term harvest level experiences a 5.5% improvement over the Base Case, at the modest cost of mid-term (-0.6%) and long-term (-1.7%) timber supply impact.

- The alternative DBH minimum harvest criteria used in the adjusted LiDAR-based inventory is sensitive (15.7%) in the short-term and moderately sensitive (5.7%) in the mid-term. Applying 95% culmination MAI as minimum harvest age in the adjusted LiDAR-based inventory also delivers the same short-term timber harvest impact (15.8%), but with more mid-term sensitivity (8.1%). Changing the harvest to even flow will provide a flat line harvest level. This lowers the short-term timber harvest impact from 15.8% to 4.5%, but it improves the mid-term harvest impact from 8.1% to 9.8%.

5.4 LiDAR Data Review of Assumptions

LiDAR data acquired in 2016 for TFL 44 provides detailed information of the ground shape (e.g., slope, elevation) and vegetation (e.g., canopy extent and tree height). The greatest advantage of LiDAR data is that the full population of interest is measured rather than relying on inference based on a sample. LiDAR informs multiple assumptions used in the Base Case, including OAF 1, improved THLB exclusion of non-productive forest, low-productive forests, roads, and improved operability mapping using Land Base Blocking.

The availability of ITI inventory showcases a LiDAR application at the individual tree level that was summarized up to an area-based forest inventory. Known issues regarding volume under-estimation in mature and old stands can be mitigated, as shown in the Appendix A. All these LiDAR improvements further advance the horizon for LiDAR to be used in timber supply modelling, with more confidence in data accuracy.

Applying adjustments in LiDAR-based inventory and requesting a step-down harvest flow resulted in an initial harvest level of 755,100 m^3/year for the first 5 years, and 716,200 m^3/year for the following 5 years. This is 5.5% greater than the Base Case. The lowest harvest level during mid-term has also been significantly improved by stabilizing the “bottom” period longer. The long-term timber supply is slightly lower (-1.7%) than the base case.

In summary, analysis verified that LiDAR-based inventory volumes were more accurate than the forest cover inventory. LiDAR data indicates the Base Case schedule under-estimates TFL 44 timber supply in the short-term.

5.5 Review of Minimum Harvest Age Assumptions

The minimum harvest age in the Base Case is defined by the harvest system in conjunction with DBH thresholds (another part of the minimum harvest criteria is the minimum volume of 350 m^3/ha). These minimum harvest criteria are established to have more alignment with operational planning, given the accurate harvest system assignment derived from LiDAR and availability of stand/AU-level growth and yield information. However, the area-weighted future stand average minimum harvest ages for the land base shows a meaningful 20 to 40-year delay when comparing against 95% culmination MAI age. It indicates that the DBH thresholds of 30cm/37cm/42cm for ground/cable/helicopter harvest system used in the Base Case under-estimates TFL 44 timber supply.

Analysis of DBH for TFL 44 forecasted blocks suggests modified DBH thresholds of 31cm/31cm/37cm for ground/cable/helicopter harvest system is a better match of the operational practice. The area-weighted future stand average minimum harvest ages for the conventional harvest land base are similar to the 95%

culmination MAI age (Table 44). This is also supported by their corresponding timber supply forecasts (Table 45). 95% culmination MAI age as minimum harvest age is widely used in other BC coastal management units. Therefore, 95% culmination MAI age is suggested to use for the minimum harvest age to reflects the timber supply capacity for TFL 44.

5.6 Conclusions and Recommendations

Compared to the MP #5 analysis forecast, better data (e.g., LiDAR), better practices (e.g., spatial modelling), better information (economic partition) and land use changes (e.g., smaller THLB due to increased conservation) have been incorporated into this MP# 6 timber supply analysis. However, the improved LiDAR inventory estimates and modified minimum harvest criteria cannot fully offset the impacts of multiplicative changes. In the mid-term and long-term, the reduced THLB and different minimum harvest age necessitates lower harvest levels.

An economic partition is achieved via establishing a tenure-wide landscape-level net value objective (expressed in $/m^3) that is equivalent to the EBITDA margin indicated in the 2020 Economic Analysis and accounting for an average long-term stumpage rate. This ensures the economic operability of the projected timber supply harvest levels and a better managed transition from old stands to managed stands.

The analysis shows that the initial harvest level for the Base Case is robust across the individual sensitivities. The base indicates an AAC of 715,200 m^3/year during the next five years, and 678,900 m^3/year for the 5 years to follow.

However, the adjusted LiDAR-based inventory and minimum harvest age infer that short-term and early portion of the mid-term timber supply may be greater than indicated by the Base Case.

Therefore, the initial harvest level of the adjusted LiDAR-based inventory with 95% cumulation MAI age as minimum harvest age sensitivity is selected to be the recommended AAC. The timber supply modelling was conducted in two manners: maximizing short-term and step-down harvest flow and the even-flow.

Although the step-down harvest flow indicates that the current AAC can be maintained for five years, long-term sustainability is improved with a constant harvest rate for the next 300 years. Converting to an even-flow harvest rate provides certainty to the business and local communities,and avoids up to approximately 30,000 m^3/year mid-term harvest shortfalls indicated in the step-down flow. Since the contribution from economic > 120 years old stands are very sensitive in the 5-year interval, the AAC proposal includes two 5-year periods for economic partition. Therefore, an AAC of 727,200 m^3 is proposed for TFL 44 during the next five years. The AAC proposal includes:

- 652,500 m^3 of the AAC to be attributed to the economic land base, defined in the TFL 44 timber supply modelling spatial output;
- 309,400 m^3 of the AAC to be attributed to the economic land base in stands with an age less than 121 years.

An AAC of 727,200 m^3/year is proposed for the following five years.

- 585,900 m^3 of the AAC to be attributed to the economic land base, defined in the TFL 44 timber supply modelling spatial output;

The 727,200 m^3 AAC includes 11,118 m^3 allocated to First Nations.

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APPENDICES

Appendix A: EVALUATION OF INVENTORY ESTIMATES USING CRUISE PLOTS IN TFL 44

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EVALUATION OF INVENTORY ESTIMATES USING CRUISE PLOTS IN TFL 44

February 23rd, 2021

EXECUTIVE SUMMARY

This study tested the accuracy of three different forest inventories in TFL 44. WFP Forest Cover, Vegetation Resource Inventory (VRI) and individual tree inventory (ITI) were evaluated using both cruise plot and harvest data for 101 blocks that were cruised after WFP's LiDAR acquisition in 2016. This was to help inform which inventory estimates to use for the Timber Supply Review (TSR) process in TFL 44.

VRI was the least accurate inventory tested using both cruise and harvest data and consistently underestimated volume across the range of forest ages. It was also consistently the least accurate at determining species composition.

Forest Cover was generally accurate at predicting volume, however the accuracy varied by age class. It underpredicted volume in stands <120 years old and overpredicted in stands ≥120. As a result, forest cover volume estimates were generally less precise than VRI, indicating that while the results should be more accurate at a land base scale, at the stand level accuracy is likely to be mixed. Forest Cover was more accurate at predicting species composition than VRI.

ITI significantly underestimated volume, particularly in stands ≥120 years old. However, it was the most precise estimator of volume and also the most accurate predictor of species composition. This volume underestimation is common in LiDAR derived inventories, which tend to miss understory trees, which will be more common in older stands.

Linear regressions were fitted to adjust the ITI volume estimates to account for these missing trees. These correction factors increased the accuracy and precision of the volume estimates. They were tested against an independent set of 28 cut blocks which confirmed that the adjusted ITI was both accurate and precise at predicting volume.

The recommendations are as follows:

1. Use forest cover as the base case for the TFL 44 TSR to be consistent with the previous TSR.
2. Develop a new inventory using ITI by calculating volume within the existing forest cover polygons and adding a correction factor of 0.624 m^3/ha/year (the average of the CGNF and LF correction factors). Use this inventory as a sensitivity analysis for the TFL 44 TSR.
3. Develop a new area-based inventory by deriving new polygons from the adjusted ITI and summing the ITI attributes within, adding a correction factor of 0.624 m^3/ha/year.
4. Evaluate the accuracy of forest cover, VRI and ITI in all TFLs managed by WFP using the same methodology as used in this analysis.
5. Review the accuracy of the different inventory products using cruise data prior to any TSR and/or after major updates to VRI.

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OVERVIEW

Accurate forest inventories are critical for sustainable forest management. The forest inventory provides starting estimates of forest composition from which growth projections are made for Timber Supply Reviews (TSR) and Allowable Annual Cut (AAC) determinations.

In TFL 44 there are three different forest inventories available:

1. Vegetation Resource Inventory (VRI) is maintained by the Province and is updated annually,
2. Forest Cover is WFP's area-based inventory that is an annually updated version of the legacy inventory that originated with MacMillan Bloedel, and
3. WFP's individual tree inventory (ITI) is a LiDAR derived inventory developed by Object Raku and Forsite, and represents the predicted volumes and species of individual trees at the time of LiDAR capture in 2016.

This analysis was conducted to evaluate the accuracy of volume and species predictions using VRI, Forest Cover and ITI in TFL 44. Both cruise plot data and scaled harvest data were used to assess the accuracy of the three inventories for all blocks that had been cruised since LiDAR capture.

METHODS

Cut blocks were used as the base unit for comparison of the three inventories. 101 blocks, representing 1192 ha that had been cruised since LiDAR capture in TFL 44 were used in this analysis. The cut block data was separated into two datasets: 1) training and 2) testing. The training dataset consisted of 73 blocks that corresponded to the January 2020 analysis comparing the three inventories at the VRI polygon level. The testing dataset consisted of an additional 28 blocks that had been cruised since. The training dataset was used to evaluate the inventories and to develop a regression to adjust ITI volumes to account for missing trees. The testing dataset was used to test the accuracy of this ITI adjustment.

The blocks used in this analysis had a good geographic coverage across TFL 44, with samples in every operating area other than Henderson Lake (Figure 1). The blocks also had a good representation by BEC class, with representation in all seven BEC variants in TFL 44 (Figure 2).

Inventory estimates were evaluated using both cruise data and harvest data. All cruise plots within a block were compiled using both call grade net factor (CGNF) and loss factor (LF) using CruiseComp. A total of 1037 cruise plots were used: 748 in the training set of blocks and 289 in the testing set of blocks. The net merchantable volume by species for each block was used in this analysis.

Harvest data was extracted from WFP's Log Inventory Management System (LIMS) for blocks that were conventionally harvested and where harvesting was complete. Helicopter harvested blocks were excluded since the harvest is more selective and average waste volumes are less likely to be representative. A total of 44 blocks from the training dataset met these criteria. Only 4 blocks from the testing dataset met these criteria, which was deemed an insufficient sample size for testing. As LIMS reports scaled volume, volume was added to account for residual merchantable volume left on site. The average waste percent from conventionally harvested blocks from TFL 44 in 2018 and 2019 was extracted from the Harvest Billing System. Factors were calculated for stands <120 (15% waste) and ≥120 years (20% waste) and applied to the LIMS volume for each corresponding block to give an estimated harvest volume including waste.

South Island VRI data was obtained from the VEG_COMP_LYR_R1_POLY layer downloaded in June 2018. The attributes used were live stand merchantable volume to 12.5 cm, which was applied to stands <120 years and live stand merchantable volume to 17.5 cm, which was applied to stands ≥120 years. Polygons were intersected with the cut block net boundaries (excluding retention areas) and the net merchantable volumes by species calculated by area weighting the results for each polygon within a block.

WFP's 2016 Forest Cover was used in this analysis, as it was the most recent version where all of the blocks in this analysis were in a pre-harvest state. Forest Cover polygons were intersected with the net block boundaries and attributes calculated by area-weighting the resulting polygons.

ITI estimates of net merchantable volume by species were calculated by summing the individual tree attributes within the net block area using the WFP's ITI Analysis ArcMap planning tool.

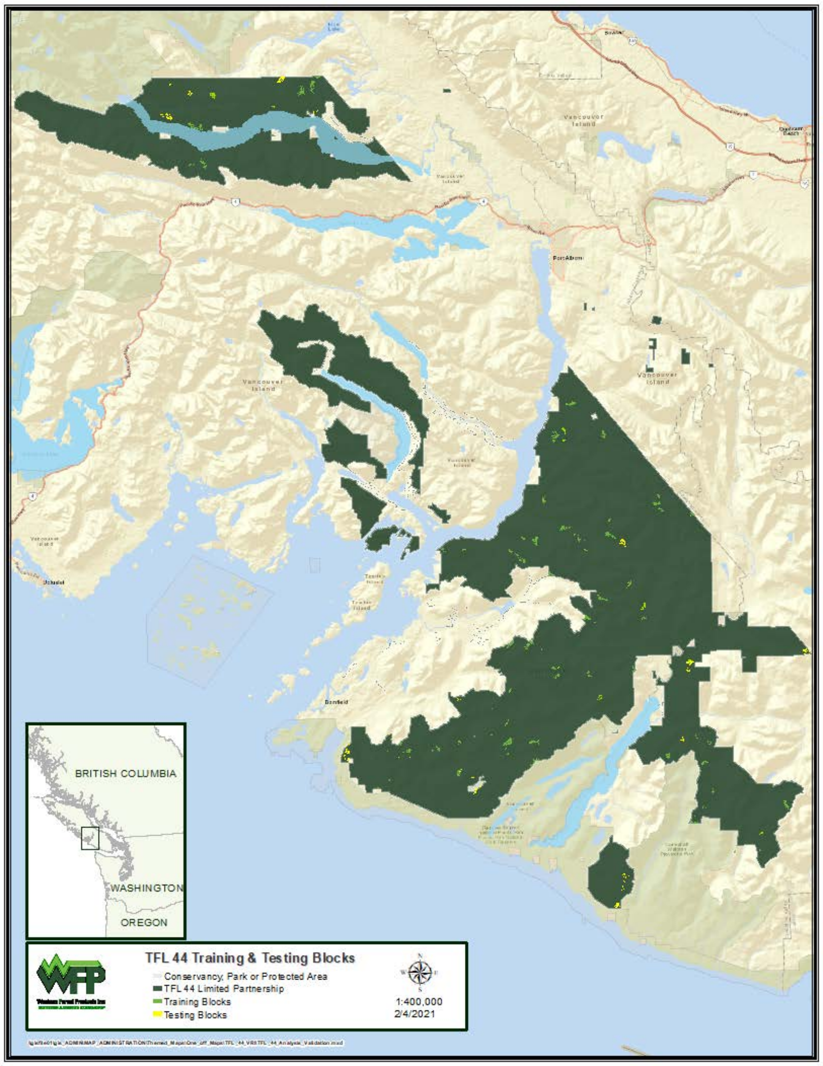


Figure 1 ***Geographic coverage of 101 blocks used to evaluate inventory predictions in TFL 44.***

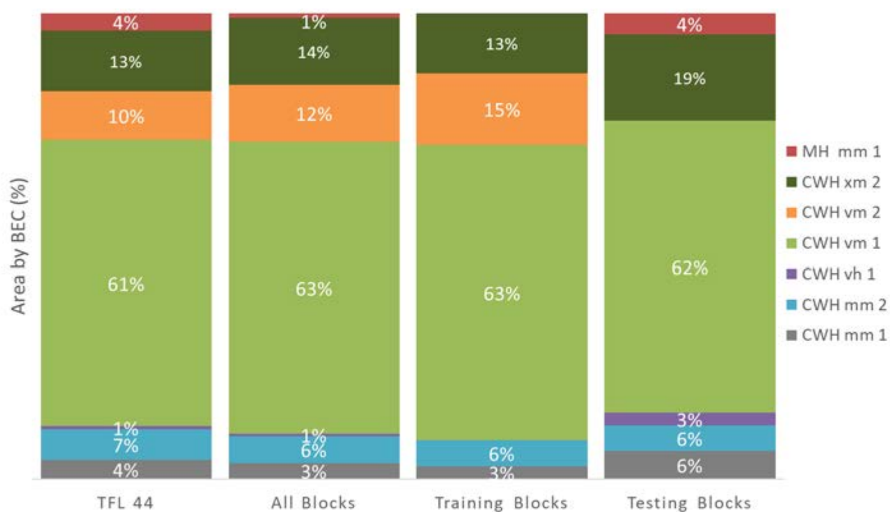


Figure 2 ***Ecological representation of TFL 44 by BEC compared to blocks used in analysis, including in the training and testing datasets.***

RESULTS

Training Data

Predicted Volume Versus Cruise

Using both call grade net factor (CGNF) and loss factor (LF) compilation methods, VRI was the least accurate inventory tested (Table 1, Figure 3). It underestimated volume using both compilation methods in blocks <120 years old and in blocks ≥120 years old.

Forest Cover was the most accurate the three inventories tested, overestimating volume by an average of 32.9 m^3/ha using CGNF and by 95.3 m^3/ha using LF. However, it was the least precise estimator, recording the highest standard deviation using both compilation methods.

Forest Cover's poor precision was a result of varied accuracy by age; it underpredicted volume in blocks <120 years old and overpredicted volume in blocks ≥120 years old. While it was accurate overall, it was not particularly accurate for either age category.

ITI was less accurate than forest cover but more accurate than VRI. On average it underpredicted volume, which was primarily driven from blocks ≥120 years old. In blocks <120 years old, ITI was the most accurate inventory tested. ITI was the most precise of the three inventories tested using both compilation methods and for both age categories.

Table 1 Comparison of inventory and cruise volumes for training set of cut blocks.

	VRI		Forest Cover		ITI		ITI Adjusted	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Call Grade Net Factor	**-243.2**	**263.6**	**32.9**	**289.1**	**-197.9**	**209.3**	**10.3**	**180.4**
<120 years	-213.2	239.4	-193.2	249.9	30.1	138.4	85.6	138.8
≥120 years	-250.3	270.5	86.5	273.0	-252.0	185.9	-7.6	185.4
Loss Factor	**-180.8**	**257.6**	**95.3**	**312.7**	**-135.5**	**196.1**	**-2.5**	**190.5**
<120 years	-272.6	253.6	-252.6	248.4	-29.2	155.9	6.2	157.9
≥120 years	-159.1	255.9	177.8	267.3	-160.7	197.3	-4.5	198.6

LiDAR derived inventories such as ITI typically underestimate volumes due to missing trees that are obscured by the canopy. This would be expected to be more significant in older stands which have a more varied stand structure. The underprediction by ITI in older stands confirms this expectation. As it has the highest precision, ITI presents the best opportunity of the three inventories to meet the goal of high accuracy and high precision. This could be accomplished by developing a correction factor to account for missing trees in older stands.

To account for ITIs tendency to underpredict volumes in older stands, linear regression models were fitted to ITI residual volumes and age for both CGNF and LF compilation using R version 3.6.2. A two-parameter linear model was initially fitted but the intercept parameter was not significantly different from zero. A single parameter model was highly significant against both the CGNF and LF datasets and satisfied the assumptions of linear regression: linearity, homoskedasticity, lack of autocorrelation and normality (Appendix 1, Appendix 2).

After applying these correction factors, the adjusted ITI performed well against the training dataset, showing the highest accuracy and precision using both CGNF and LF and for both young and old stands (Table 1, Figure 3).

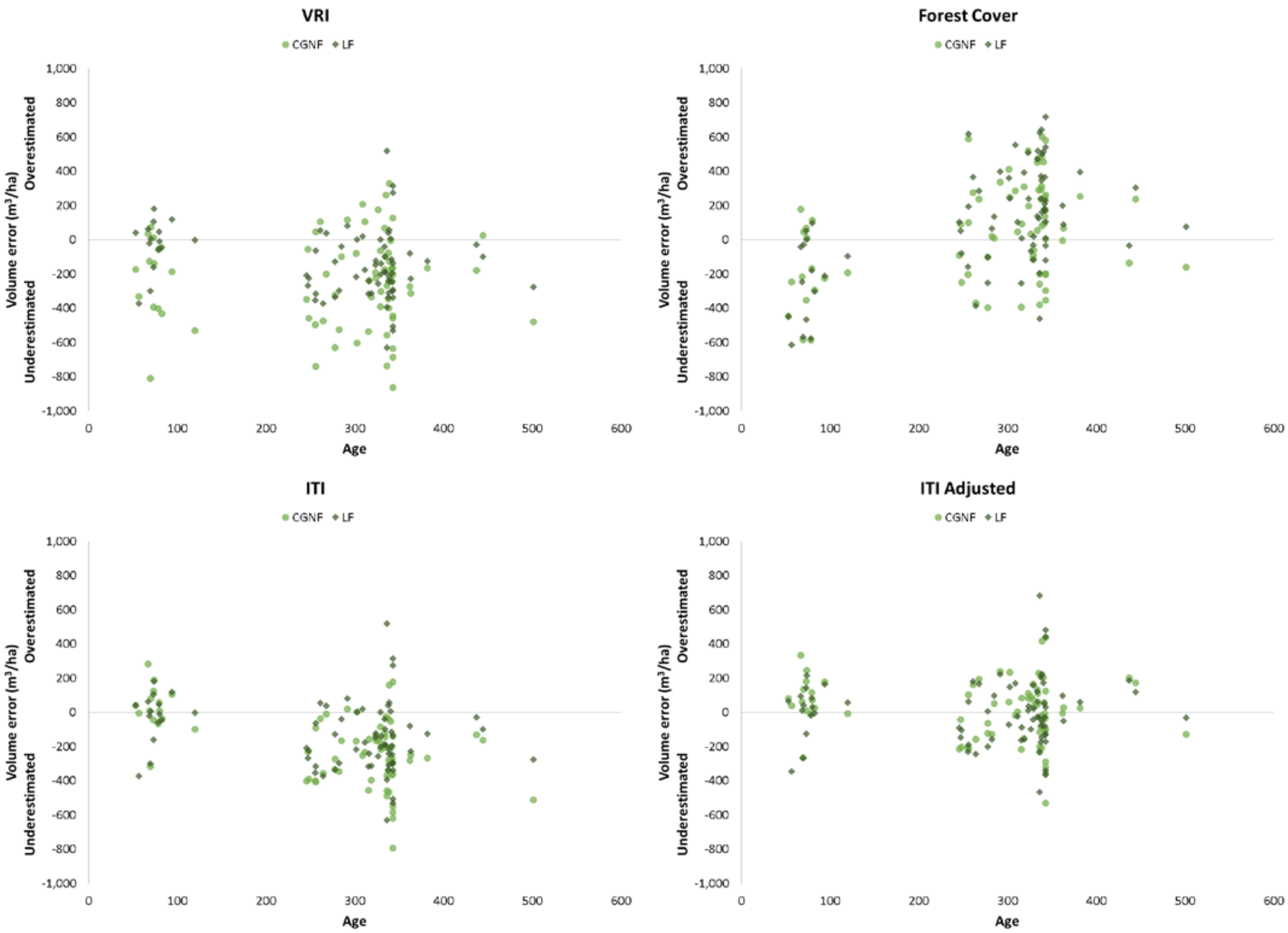


Figure 3 ***Difference between predicted and cruised volume (CGNF and LF) by age using VRI, forest cover, ITI and adjusted ITI using training set of cut blocks.***

Predicted Species Composition Versus Cruise

VRI was the poorest predictor of species composition, recording a coefficient of determination (r^2) of 0.6451 compared to cruise (Figure 4). It showed a weak correlation for all major species (Figure 5).

Forest Cover was a better predictor of species composition than VRI, recording an r^2 of 0.7054. It showed a positive correlation between observed and predicted for all major species.

ITI was the best predictor of species composition, recording an r^2 of 0.7625 and showing good correlation against all major species. It did show a tendency to underpredict the most prevalent species, rarely predicting more than 70% of one species in a cut block.

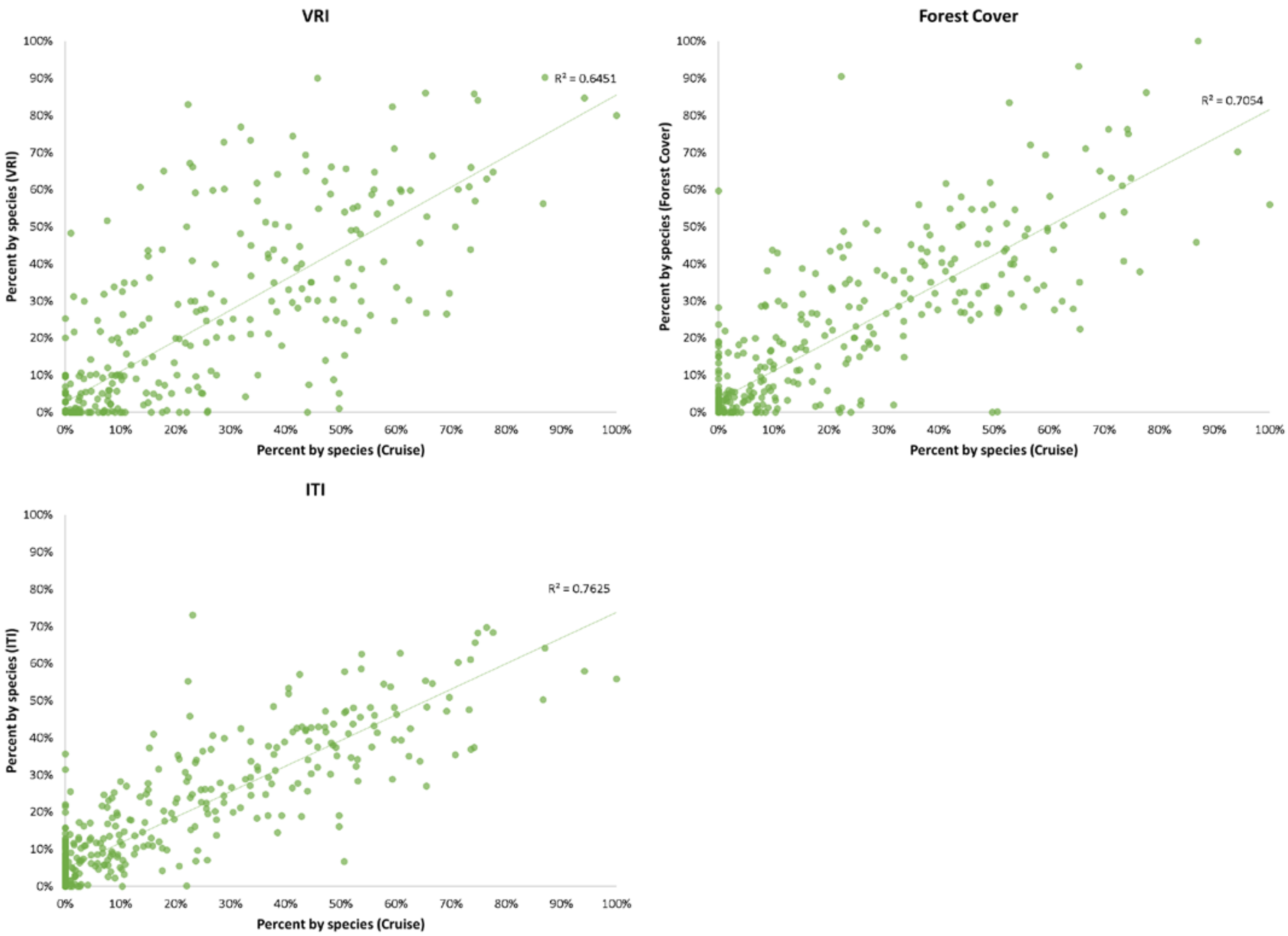


Figure 4 ***Percent of cruised block volume by species versus predictions by VRI, forest cover and ITI using training set of cut blocks.***

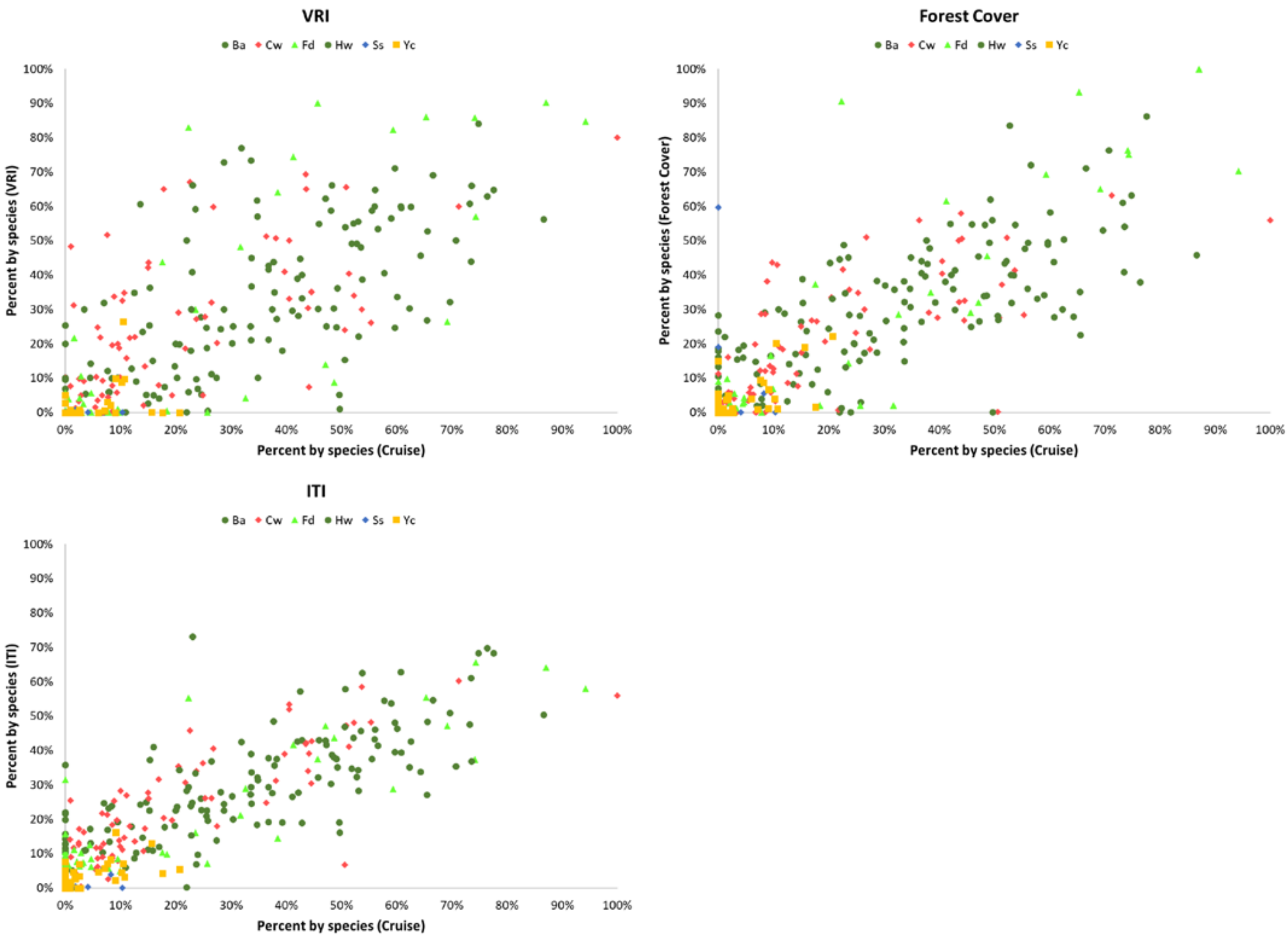


Figure 5 ***Percent of cruised block volume for main species versus predictions by VRI, forest cover and ITI using training set of cut blocks.***

Predicted Volume Versus Harvest

For the 44 conventionally harvested blocks in the training dataset where harvesting was complete, the results were very similar using harvest rather than cruise data. VRI was the least accurate, underpredicting volume in both young and old stands (Table 2, Figure 6). Forest Cover was the most accurate but least precise, underestimating volume in stands <120 and overestimating in stands ≥120 years old. ITI underestimated volume in old stands but was the most precise. When including the CGNF and LF correction factors to account for missing trees, the adjusted ITI was the most precise estimator. It was less accurate than forest cover however and tended to underestimate volume.

Table 2 ***Comparison of inventory and harvest volumes for training set of cut blocks.***

	VRI		Forest Cover		ITI		ITI Adjusted (CGNF)		ITI Adjusted (LF)	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Total	**-339.2**	**254.8**	**-89.4**	**291.1**	**-314.6**	**214.8**	**-112.1**	**188.0**	**-108.6**	**149.7**
<120 years	-355.8	251.7	-338.8	240.9	-123.5	148.2	-69.9	147.4	-64.4	105.5
≥120 years	-334.9	259.1	-25.3	269.9	-363.8	202.6	-123.0	197.5	-120.0	158.3

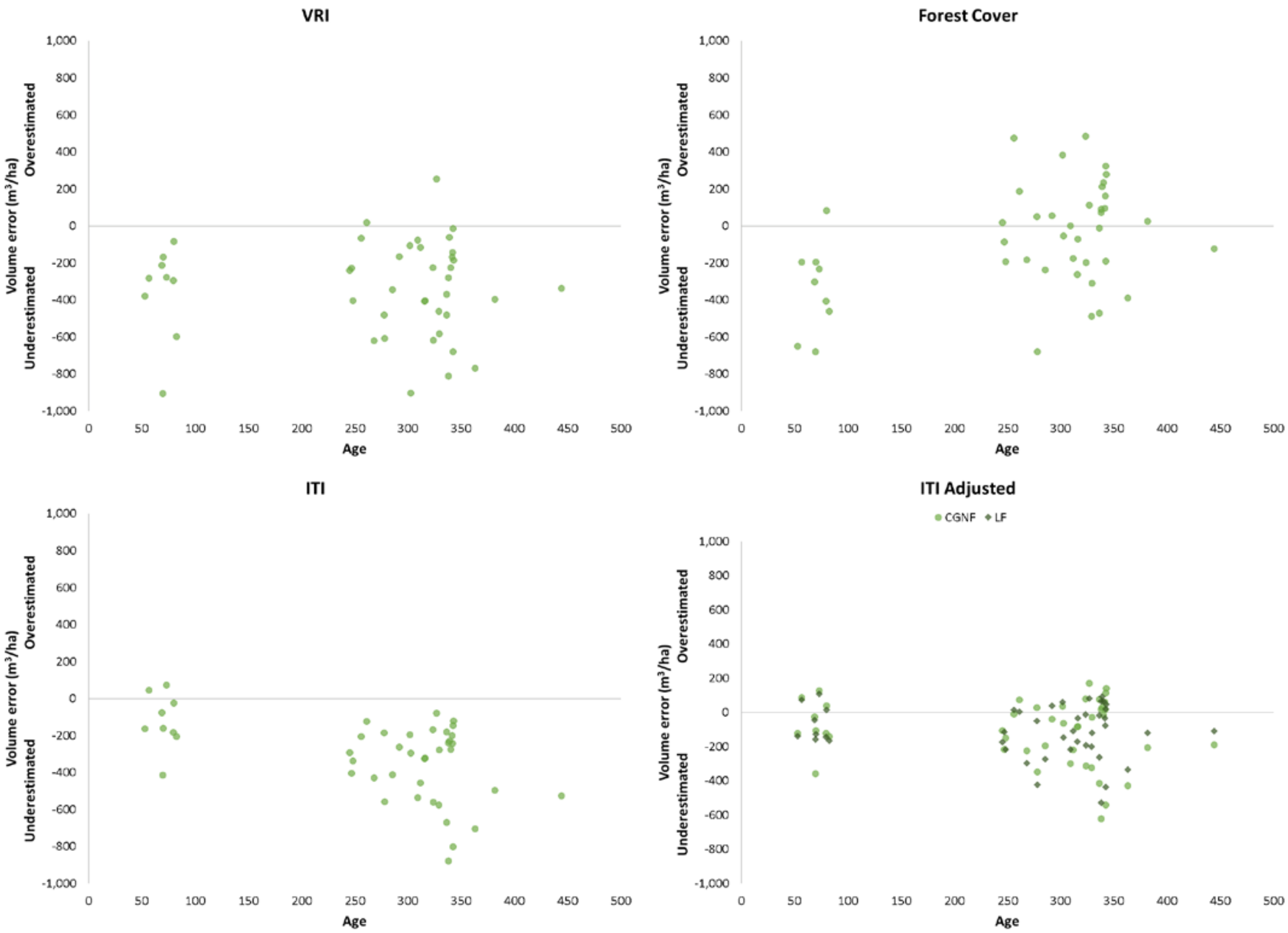


Figure 6 Difference between predicted and harvest volume by age using VRI, forest cover, ITI and adjusted ITI (CGNF and LF) using training set of cut blocks.

Predicted Species Composition Versus Harvest

Harvest data also mirrored the results from cruise data when evaluating species predictions. VRI was the least accurate species predictor while ITI performed the best (Figure 7). ITI showed a strong correlation between predicted and actual across the range of major species (Figure 8).

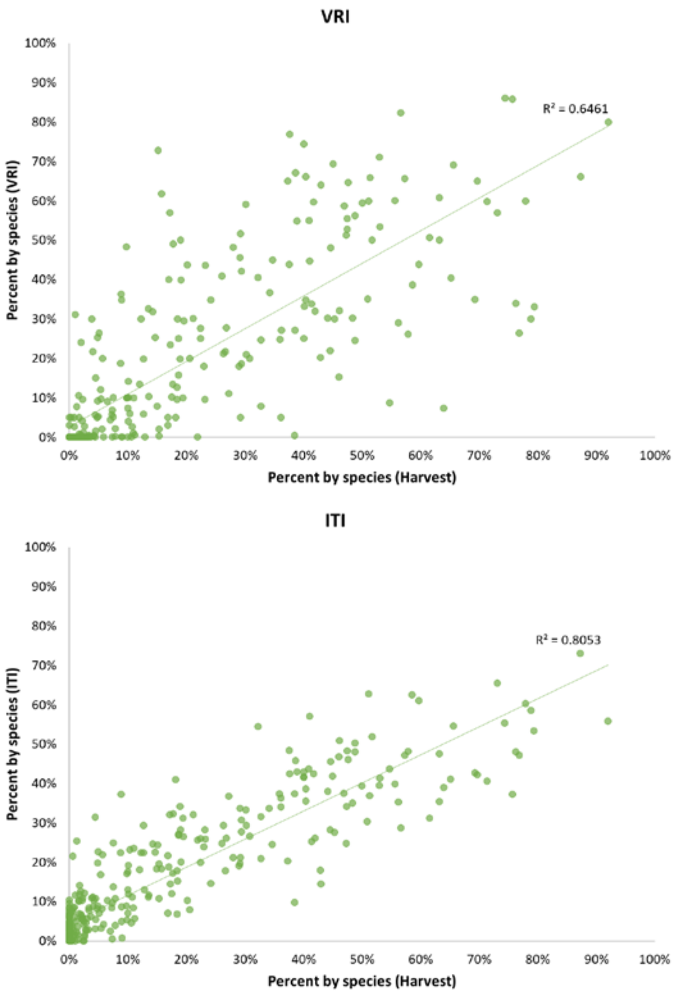


Figure 7 Percent of block harvest volume by species versus predictions from VRI, forest cover and ITI using training set of cut blocks.

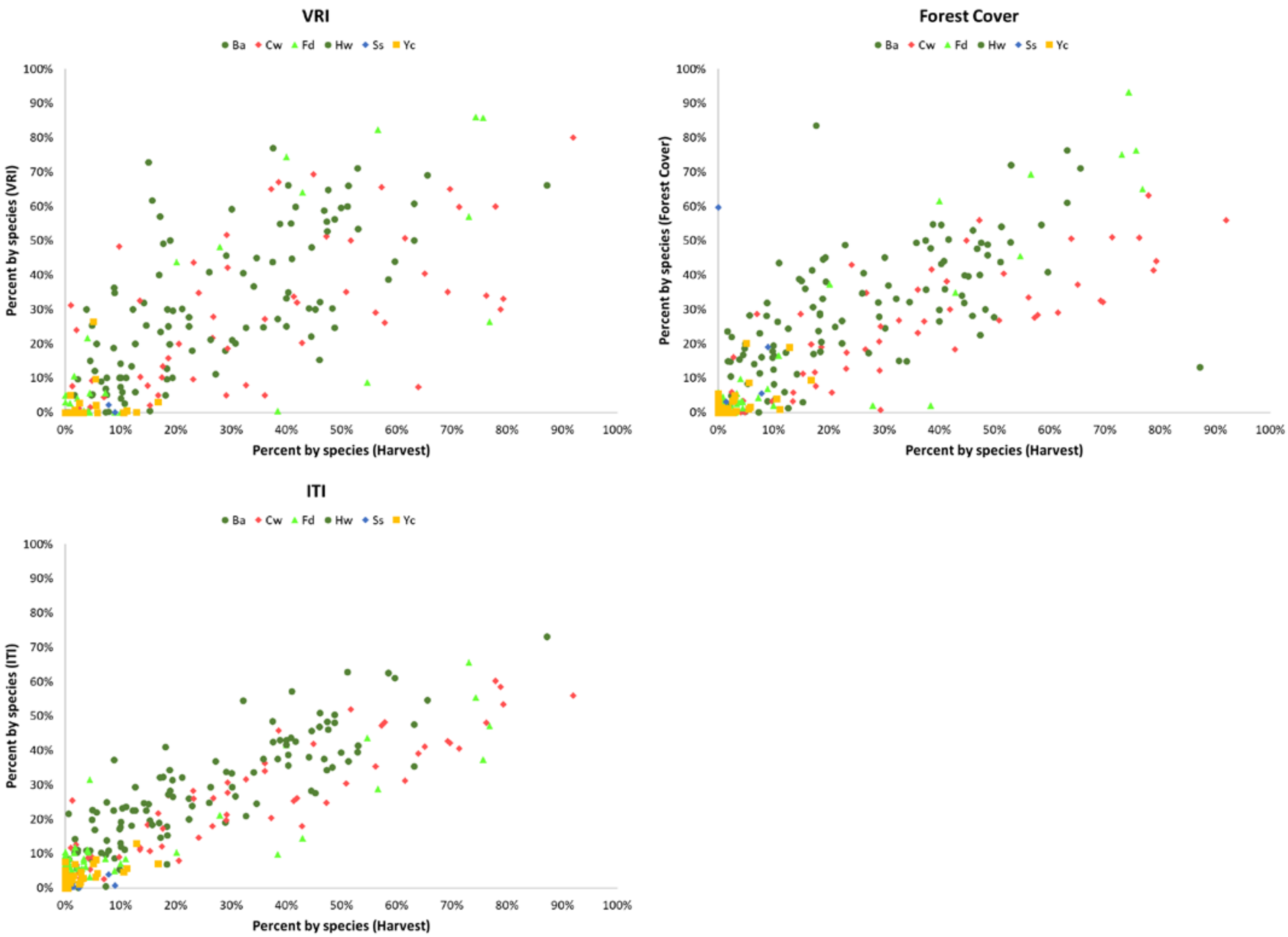


Figure 8 Percent of block harvest volume by major species versus predictions from VRI, forest cover and ITI using training set of cut blocks.

Testing Data

Predicted Volume Versus Cruise

The 28 blocks set aside for testing validated the results from the training dataset. VRI underpredicted volume using both CGFN and LF and for young and old stands alike (Table 3). Forest Cover was accurate, particularly against LF but its precision was poorer than ITI. ITI underpredicted volume, particularly for older stands although had better precision than VRI and forest cover.

The testing data confirmed that the adjustments to correct ITI for missing trees improved accuracy and precision. It was the most accurate inventory compared to CGNF cruise data and the second most accurate compared to LF cruise data, after Forest Cover. The adjusted ITI was the most precise inventory tested.

Table 3 Comparison of inventory and cruise volumes for testing set of cut blocks.

	VRI		Forest Cover		ITI		ITI Adjusted	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Call Grade Net Factor	**-191.4**	**397.9**	**-79.2**	**397.3**	**-268.2**	**365.5**	**-57.7**	**330.2**
<120 years	-83.6	254.5	-69.8	202.0	95.9	130.8	156.0	136.3
≥120 years	-215.9	427.1	-81.4	391.9	-351.0	390.4	-106.2	356.6
Loss Factor	**-125.3**	**330.9**	**6.5**	**319.1**	**-191.3**	**263.2**	**-56.5**	**241.7**
<120 years	-107.8	253.2	-94.0	192.1	71.7	144.4	110.1	148.4
≥120 years	-129.1	347.9	28.3	302.1	-248.5	283.4	-92.7	262.6

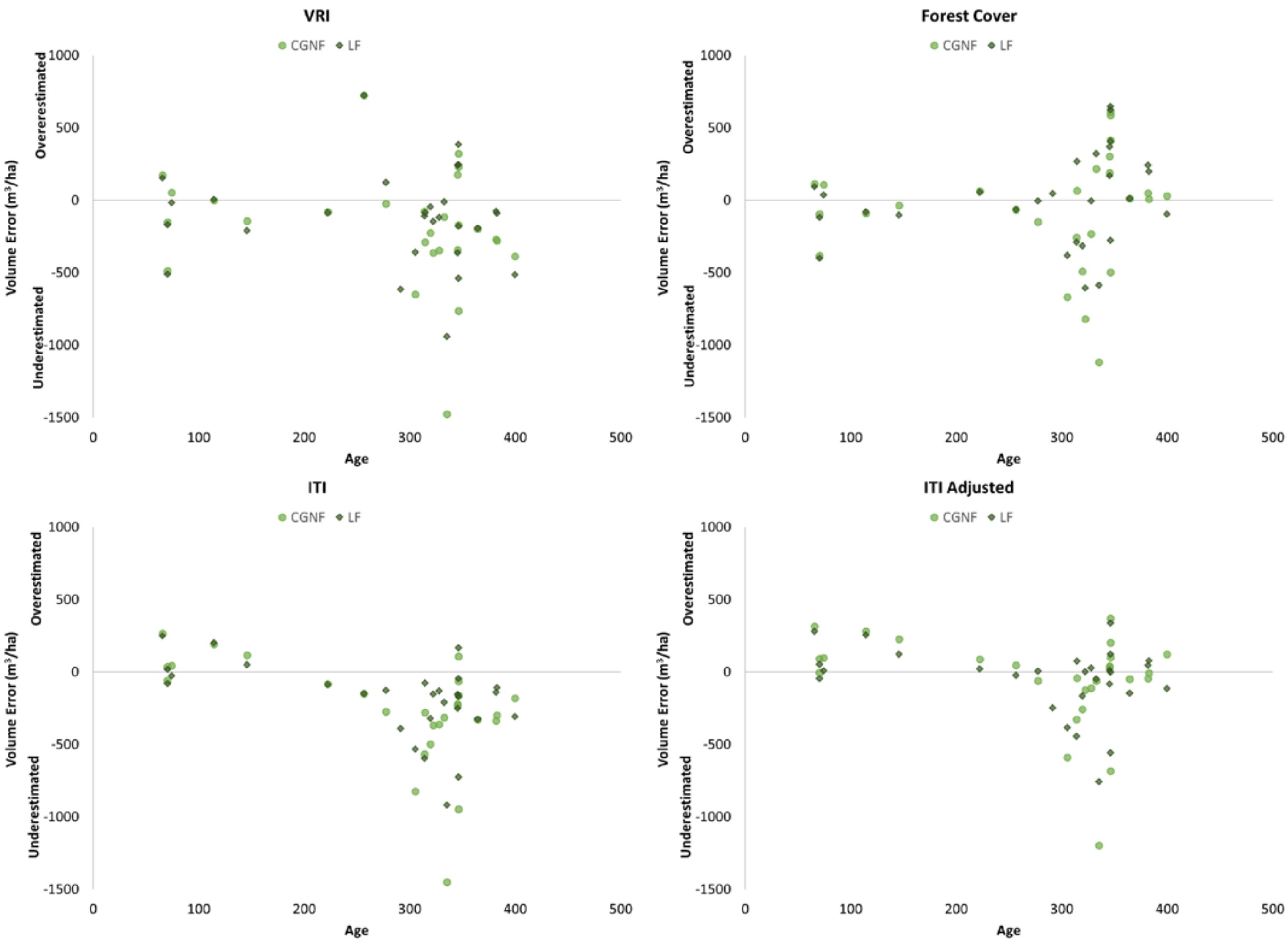


Figure 9 Difference between predicted and cruised volume (CGNF and LF) by age using VRI, forest cover, ITI and adjusted ITI using testing set of cut blocks.

Predicted Species Composition Versus Cruise

The testing data also confirmed results of the training dataset at the species level. ITI returned the highest correlation coefficient and showed good correlation across the range of major species (Figure 10, Figure 11).

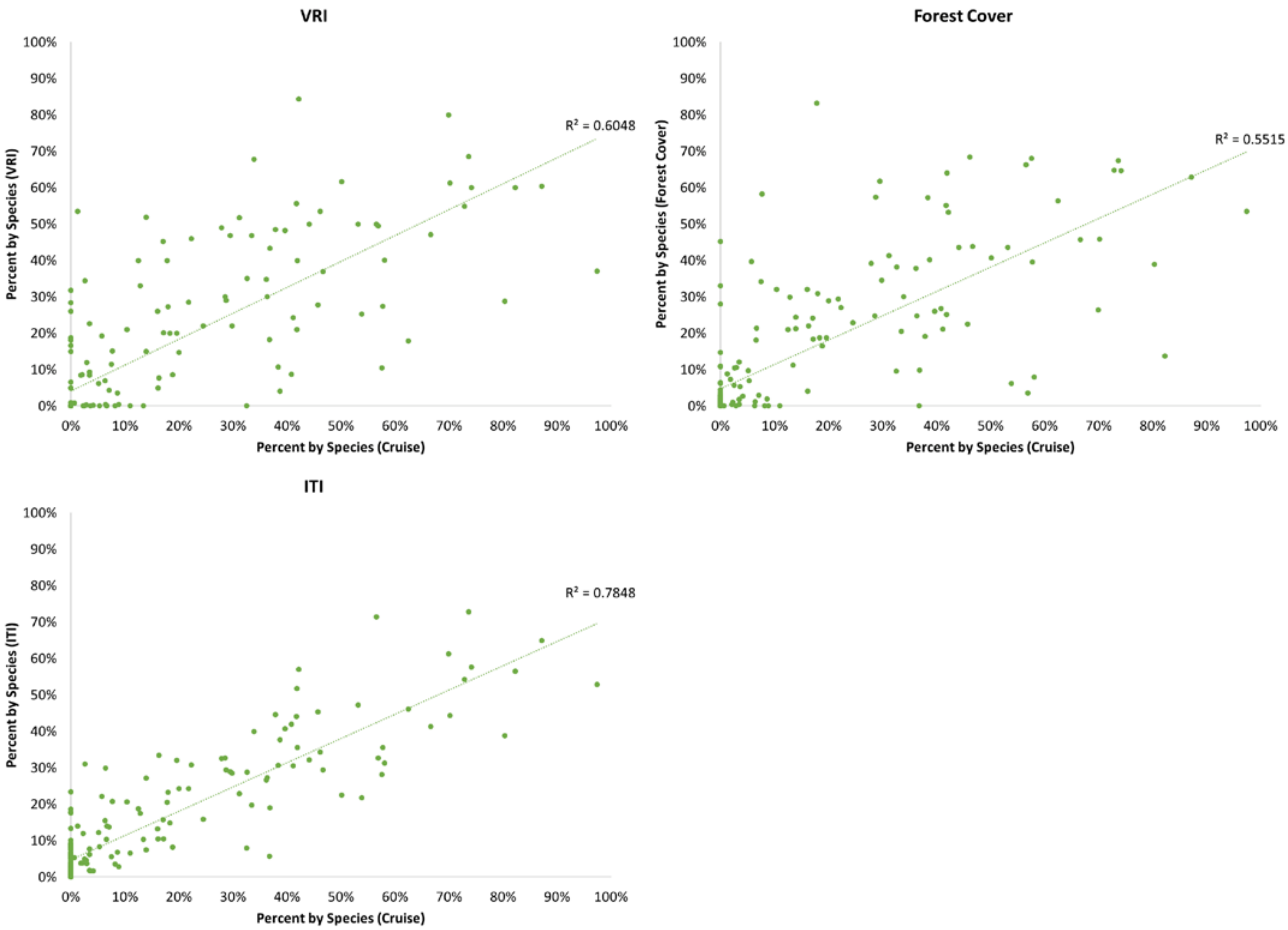


Figure 10 Percent of cruised block volume by species versus predictions by VRI, forest cover and ITI using testing set of cut blocks.

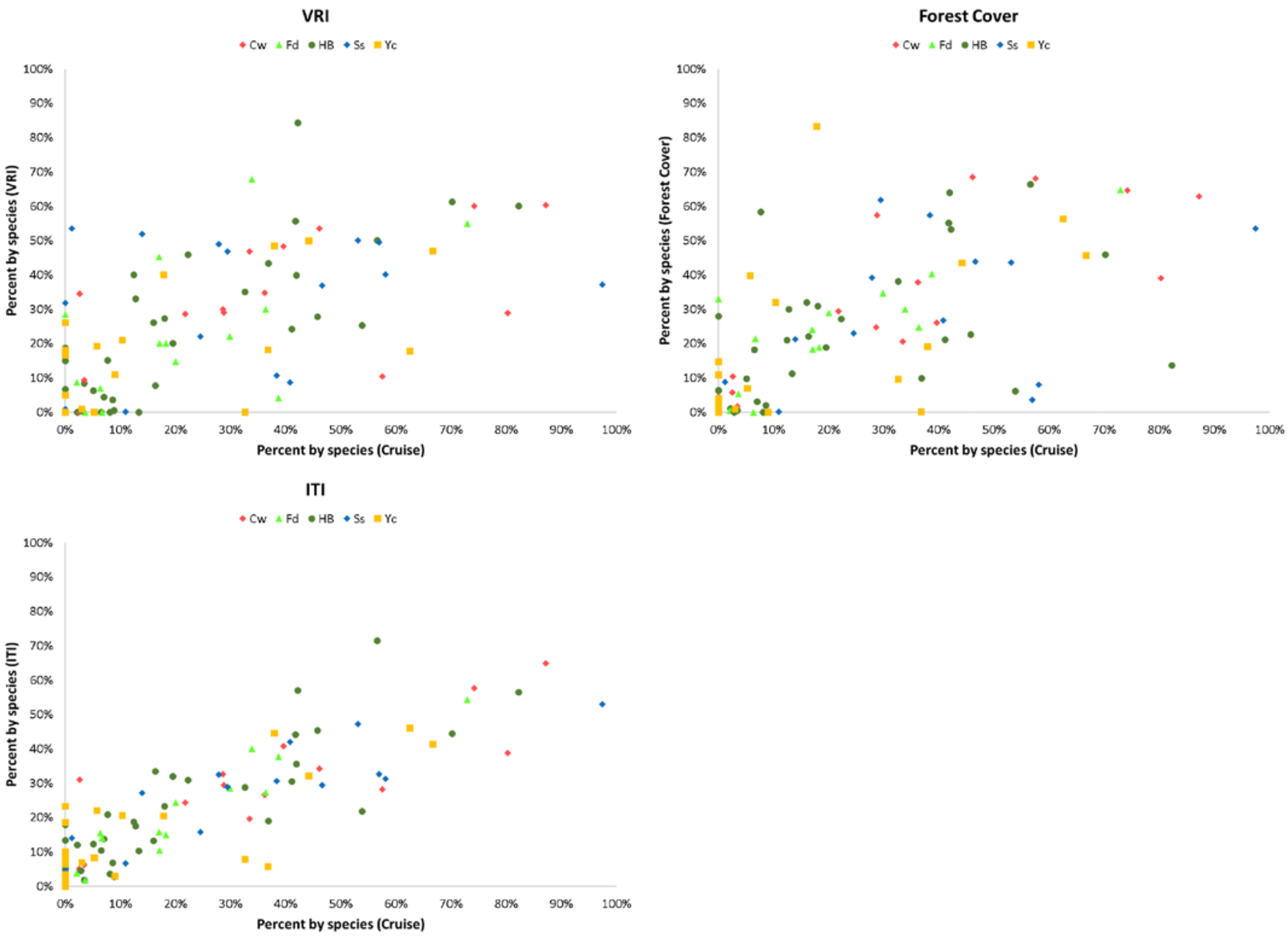


Figure 11 Percent of cruised block volume by major species versus predictions by VRI, forest cover and ITI using testing set of cut blocks.

DISCUSSION

VRI was the least accurate estimator of stand volume and species composition in recent cut blocks from TFL 44. It consistently underestimated volume using both cruise data and harvest data and across age classes. If VRI were used for the TFL 44 timber supply review (TSR), it would likely significantly underestimate volume.

On average, Forest Cover provided more accurate volume estimates than VRI when tested against both cruise and harvest data. However, its accuracy varied by age, underpredicting volumes in blocks <120 years of age and overpredicting in blocks ≥ 120. Forest Cover tended to be a slightly better species predictor than VRI. If used for the TFL 44 TSR, it would likely provide more accurate volume estimates in aggregate, although it is less precise than VRI so on a stand-by-stand basis volume estimates would be more variable.

The most promising option appears to be ITI. While ITI consistently underestimated volume, it provided the most precise estimates and was the best predictor of species composition when tested against both cruise and harvest data. The underestimation is likely caused by missing understory trees. This is a well-known limitation of LiDAR derived inventories, as the laser pulses are reflected by the canopy and therefore have difficulty differentiating sub-canopy trees. The relative accuracy of ITI volumes in stands <120 years of age and underestimation in stands ≥ 120 years of age supports this argument, as older stands have more varied stand structure.

Correction factors were developed to adjust the ITI volume predictions to account for the missing trees using both CGNF and LF cruise data. These factors add 0.49 m^3/ha/year (LF) and 0.76 m^3/ha/year (CGNF) to predicted ITI volumes. Using the training dataset, this resulted in both accurate and precise volume predictions. When tested against an independent set of 28 blocks, the adjusted ITI was again found to be accurate and precise. The independent testing set of blocks also confirmed that ITI resulted in the most accurate species predictions.

RECOMMENDATIONS

1. Use forest cover as the base case for the TFL 44 TSR, as it is accurate overall and for consistency with the previous TSR.
2. Develop a new inventory using ITI by calculating volume within the existing forest cover polygons and adding a correction factor of 0.624 m^3/ha/year (the average of the CGNF and LF correction factors). Use this new inventory as a sensitivity analysis for the TFL 44 TSR.
3. Develop a new area-based inventory by deriving new polygons from the adjusted ITI and summing the ITI attributes within, adding a correction factor of 0.624 m^3/ha/year.
4. Evaluate the accuracy of forest cover, VRI and ITI in all TFLs managed by WFP using the same methodology as used in this analysis.
5. Review the accuracy of the different inventory products using cruise data prior to any TSR and/or after major updates to VRI.

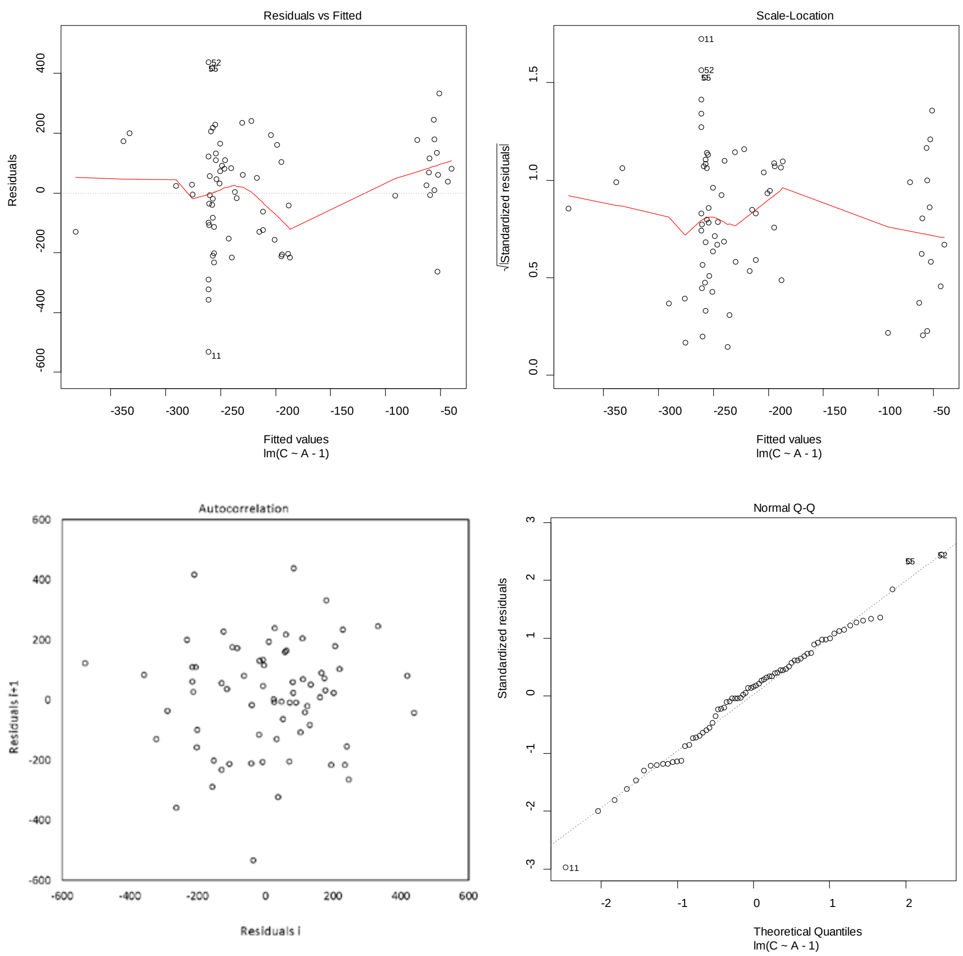
APPENDICES

Appendix 1 Outputs from CGNF single parameter linear regression

Table 4 Single parameter CGNF linear regression outputs.

Coefficient	Standard Error	t Stat	P-value
-0.7612	0.0719	-10.5936	<0.0001

Figure 12 Residual, standardized residual, autocorrelation and normality plots from single parameter CGNF linear regression.

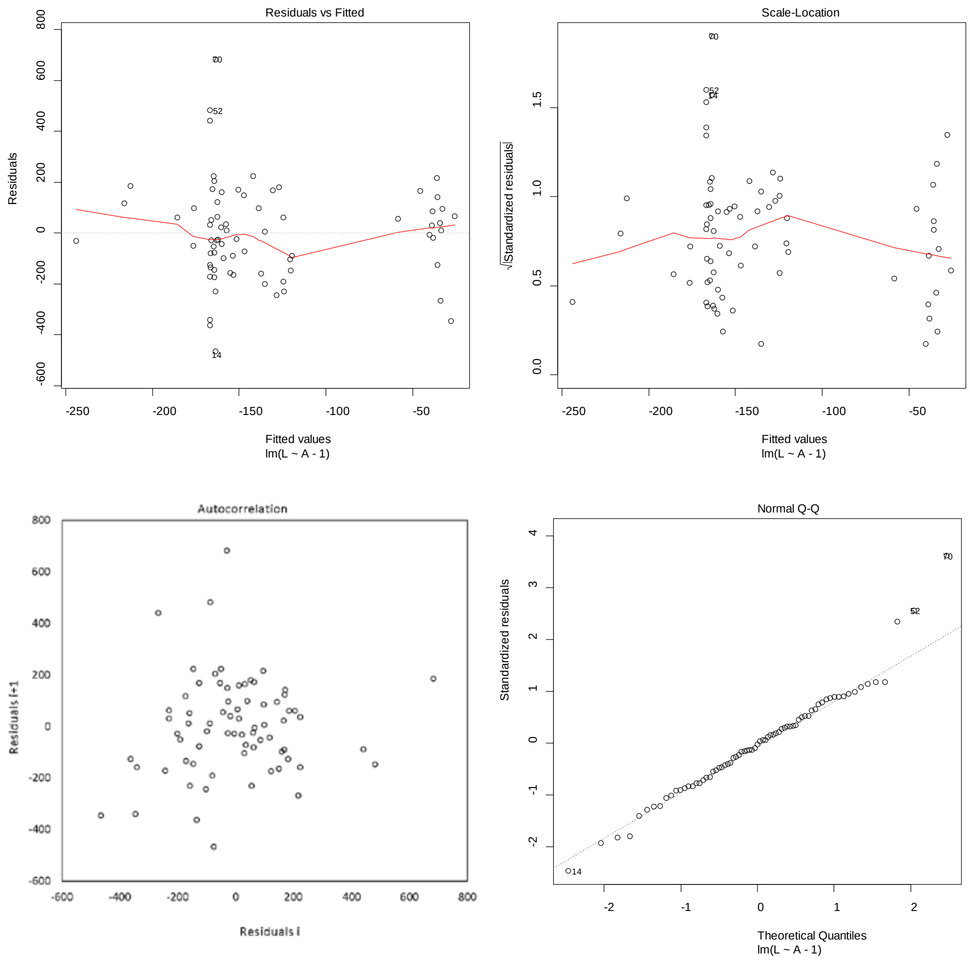


Appendix 2 Outputs from LF single parameter linear regression

Table 5 Single parameter LF linear regression outputs.

Coefficient	Standard Error	t Stat	P-value
-0.4865	0.0758	-6.4210	<0.0001

Figure 13 Residual, standardized residual, autocorrelation and normality plots from single parameter LF linear regression.



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Appendix B: TIMBER SUPPLY ANALYSIS INFORMATION PACKAGE

C̓AWAK ʔQIN
FORESTRY

Tree Farm Licence 44

Timber Supply Analysis Information Package

In Preparation of

MANAGEMENT PLAN 6

Submitted to the Ministry of Forests
Forest Analysis & Inventory Branch
Victoria, BC

Version 2.1
February 2022

Ye Huang, RPF
Timber Supply Forester
Western Forest Products Inc.

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Revision History

The following revisions were made to Version 1 (May 2021) of the Information Package:

Version	Date	Description
2.1	May 2022	• Updated Table 39 in Section 8.1 and the associated descriptions. • Updated Section 3.1 descriptions in economic partition and deferral. • Updated Section 10.3.7 to reflect ongoing changes. • Updated new licensee name and logo. • Updated Appendix A to the latest version.

2.0	Sept. 27, 2021	• Updated TIPSY yields from Version 4.4 to Version 4.5 based on the endorsement from FAIB.
		  ○ Updated Sec. 8.6 Yields for Managed Stands, Sec. 8.7 Yields for Unmanaged Stands and Sec. 10.3.1 Minimum Harvest Criteria to reflect new TIPSY yields.
		• Updated VDYP yields from Version 7.32d to 7.33b based on the endorsement from FAIB.
		  ○ Updated Sec. 8.5 Yields for Natural Stands to reflect new YDYP yields.
		• Added Sec. 10.3.7 Central Walbran old-growth designated area based on the latest announced Ministerial Order.
		  ○ Updated Sec. 3.1 Base Case to include harvesting deferral for the first decade on stands greater than 211 years old of age (corresponding to the 212 years old requirement in the Ministerial Order since the forest inventory dataset is updated to December 31, 2019).
		• Updated Sec. 10.2.3 Adjacent Cutblock Green-up to clarify 1.3m green-up height for Enhanced Forestry Zones and the modelling approach based on feedback from FAIB.
		• Added Sec. 3.6 to discuss the implementation instructions from the current AAC determination rationale based on feedback from South Island Natural Resources District.
		• Updated Sec. 6.16 Cultural Heritage Resource to discuss Thunder Mountain Government Actions Regulation (GAR) order area based on feedbacks from South Island Natural Resources District.
		  ○ Updated Sec. 3.2 Sensitivity Analyses to include new sensitivity analysis to exclude GAR order area from the timber harvesting land base (THLB).
		• Added Sec 3.7 Potential Ditidaht First Nation Offer Lands and Sec. 10.3.8 Timber Harvesting around Nearby Parks based on feedback from operational staff.
		  ○ Updated Sec. 3.2 Sensitivity Analyses to include new sensitivity analyses to 1) remove potential Ditidaht First Nation Agreement-In-Principle offer lands; 2) remove THLB area within 30m from nearby parks.
		• Updated Sec. 10.3.3.1 Second-growth Contribution to remove specific number on second growth contribution based on initial trial of modelling.
		• Updated Sec. 10.3.3.2 Non-conventional Harvesting Contribution to removed outdated language on non-conventional harvesting for the base case.
		• Fixed various typos and updated document formatting.

1.0	**May 19, 2021**	**Initial version**

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Acknowledgements

The signatory greatly appreciates the following for their contributions to the preparation of this document:

- Mike Davis, RPF of WFP for his rich tenure history knowledge, tremendous timber supply analysis support, past management plan experience and overall direction;
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1 INTRODUCTION

1.1 Background

Tree Farm Licence (TFL) 44 is located in the South Island Natural Resource District, near the City of Port Alberni. TFL 44, previously managed as Forest Management Licence (FML) 20 and 21, was first awarded to MacMillan Bloedel Limited in 1955. Through a series of corporate restructurings, the TFL came under the management of Tsawak-qin Forestry Limited Partnership (Tsawak-qin Forestry LP) in 2022. Since 1984, there have been five Management Plans for the TFL. An overview of geographical location for TFL 44 current tenure boundary can be found in Figure 1.

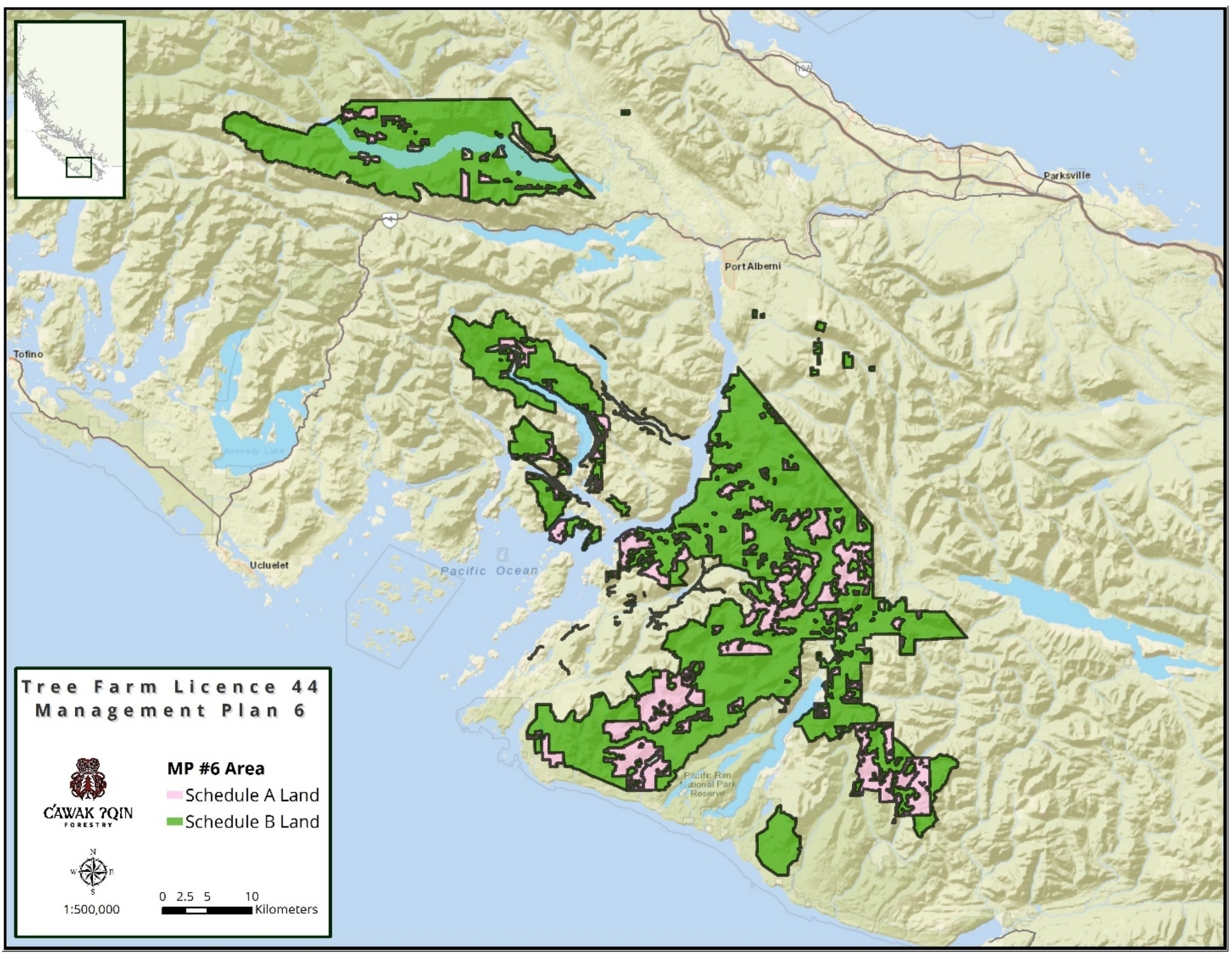

Figure 1 TFL 44 Overview

This Information Package (IP) provides a summary of data, assumptions, and modelling procedures to be used in the Timber Supply Analysis (TSA) for Tsawak-qin's Management Plan (MP) #6. The IP outlines the factors related to timber supply and how these factors will be applied in the analysis for the provincial Chief Forester to determine the allowable annual cut (AAC) under the Section 8 of the *Forest Act*.

The most recent TSA for this area was completed in 2010, documented in TFL 44 MP #5 submitted by Western Forest Products Inc. (WFP). The corresponding AAC was set at 800,000 m^3/year. The AAC was reduced to 793,600 m^3/year in December 2015 due to the creation of Hupacasath First Nations Woodland Licence. This AAC remains in effect at the completion of this IP document. On December 8, 2020, a geographic and timber profile partition to this AAC came in effect, based on an economic analysis conducted by WFP (Western Forest Products Inc., 2020). Specifically, a spatially delineated economic operability dataset was supplied in the analysis for classifying the economic and uneconomic land base. 535,000 m^3/year of AAC is attributed to the economic land base, 110,000 m^3/year of AAC is attributed to stands less than 121-year-old in the economic land base. Further details are provided in Section 6.1.

There has been a tenure holder change since the completion of the previous TFL 44 MP #5. WFP was the single tenure holder of TFL 44. On March 16, 2019, WFP announced that the management of the TFL 44 changed to TFL 44 LP. TFL 44 LP is a limited partnership between Huumiis Ventures Limited Partnership (Huumiis) and WFP. Huumiis is a limited partnership beneficially owned by Huu-ay-aht First Nations (Huu-ay-aht). On March 29, 2019, Huumiis completed an acquisition of a 7% interest in the TFL 44 LP. On March 16, 2020, a subsequent announcement was made that Huumiis is to acquire a majority ownership interest in TFL 44 LP, but the purchase is delayed due to the COVID-19 pandemic, and a gradual approach is adopted to gain the majority ownership. On April 10, 2021, Huumiis's proposal to purchase an additional 28% interest in TFL 44 LP was approved during a Special People's Assembly of the Huu-ay-aht First Nations. This purchase transaction was completed on May 3, 2021. This deal brought Huumiis's share on TFL 44 LP to 35%. WFP currently owns the remaining 65% of the limited partnership. In October 2021, TFL 44 LP changed the name to Tsawak-qin Forestry Limited Partnership (Tsawak-qin Forestry LP), to be referred to as C̓awak ʔqin Forestry (Tsawak-qin is the anglicized spelling for legal and informational purposes). This is to reflect the culture and spirit of the limited partnership between Huumiis and WFP. The name change is in effect on January 1st, 2022.

Despite the tenure owner change from WFP to Tsawak-qin, at the completion of this IP document, Tsawak-qin is currently applying the same forest management standards as WFP. WFP will complete the timber supply analysis on behalf of Tsawak-qin to estimate timber harvest over a 250-year planning horizon (in ten-year planning periods) based on the current harvestable land base, existing timber volumes, and regenerating forest growth rates. The harvest forecast will project the timber supply impacts of current environmental protection and management practices including higher level plans, operational requirements of the *Forest and Range Practices Act* (FRPA), approved Forest Stewardship Plan (FSP), orders, other regulations and guidelines with significance to timber supply. Sensitivity analyses will be used to investigate the expected impacts of different management scenarios, and to examine the relative importance of variations in assumptions. These may include the removal of area from the timber harvesting land base (THLB), imposing forest-cover harvest constraints, or changes in growth & yield (G&Y) estimates. The timber supply forecast will attempt to achieve the long-term harvest potential and minimize the rate of change during the transition from the current level of harvest to the mid- and long-term sustainable levels.

1.2 First Nations Interests

First Nation values and interests are key to inform modern forestry practices in TFL 44, especially for Huumiis that owns shares in the partnership. First Nations interests have been identified through various information-sharing processes. Table 1 highlights the sections in this document that First Nations interests are discussed.

Table 1 Sections Discussing First Nation Interests

First Nations Interests	Section
Cultural Heritage	3.6 Implementation Instructions from Previous AAC Determination Rationale
	3.7 Potential Ditidaht First Nation Offer Lands
	6.16 Cultural Heritage Resources
Fish Habitat	6.9 Riparian Management Areas
	10.2.6 Fisheries Sensitive Watersheds
Wildlife	6.10 Ungulate Winter Ranges
	6.12 Wildlife Habitat Areas
Old Growth and Biodiversity	5.5 Current Age Class Distributions
	6.11 Old Growth Management Areas
	6.17 Existing Stand-Level Reserves
	6.19 Future Stand-Level Retention
	7.1 Resource Management Zones
	7.2 Landscape Units
	10.3.4 Silviculture Systems
	10.3.7 Old Growth Deferral Areas

1.3 Analysis Area

Communities within or near TFL 44 include:

- Port Alberni,
- Bamfield,
- Anacla
- Nitinaht

Nearby parks include:

- Pacific Rim National Park Reserve of Canada
- Strathcona Park,
- Carmanah Walbran Park,
- Thunderbird's Nest (T'iitsk'in Paawats) Protected,

- Klanawa River Ecological Reserve,
- Nitinat River Park.

TFL 44 is located within 15 Landscape Units (LU) and 14 Resource Management Zones (RMZs) established by the Vancouver Island Land Use Plan (VILUP). These LUs and RMZs are outlined in Table 2.

Table 2 Landscape Units and Resource Management Zones

Landscape Unit (Biodiversity Emphasis)	Resource Management Zone (Type)
Ash (Intermediate)	Alberni Canal (Special)
Caycuse (Intermediate)	Ash-Central-Sprout (General)
China (Intermediate)	Barkley Sound (Special)
Corrigan (Intermediate)	Cameron-China (General)
Effingham (Intermediate)	Corrigan (Enhanced)
Gordon (Intermediate)	Effingham (Enhanced)
Great Central (Intermediate)	Gordon-Caycuse-San Juan (General)
Henderson (Low)	Henderson (General)
Klanawa (Intermediate)	Klanawa (Enhanced)
Nahmint (High)	Nahmint (Special)
Nitinat (Intermediate)	Nitinat (General)
Sarita (Low)	Sarita (Enhanced)
Somass (Low)	Strathcona-Taylor (Special)
Sproat Lake (Intermediate)	Walbran Periphery (Special)
Walbran (Intermediate)	

The Special and Enhanced Zones were assigned by the VILUP effective December 1, 2000. Other FRPA objectives and planning requirements apply across the entire land base, including the General Management Zones.

Noted that some LUs and RMZs only have small overlap with TFL 44 boundary. In addition, boundaries may differ in the GIS data used to construct the master database, even though in reality they are defined by the same height-of-land. Therefore, some management restrictions associated with the RMZ types may be difficult to apply to “slivers.” Detailed descriptions on RMZs and LUs are outlined in Section 7.1 and Section 7.2, respectively.

Climate within TFL 44 is dominated by maritime variants of the Coastal Western Hemlock (CWH) Biogeoclimatic Ecosystem Classification zones (BEC zones), with Mountain Hemlock (MH), and Coastal Mountain-heather Alpine (CMA) at high elevation.

2 PROCESS

2.1 Overview

This IP is submitted for review to the Timber Supply Forester at the Forest Analysis and Inventory Branch (FAIB) within the British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD). Upon acceptance, the IP will guide the timber supply analysis and, with the timber supply analysis report, be appended to MP #6. These reports will be considered by the Chief Forester in determining the new AAC for TFL 44. Two review and comment opportunities will be provided to First Nations, general public, and other interested stakeholders: 1) review of this draft IP and 2) review of the draft MP.

2.2 Analysis Approach

A series of modelled forecasts will be developed in the analysis to demonstrate impacts and dynamics of various uncertainties in the timber supply process or alternative management practices:

- Base Case: The Base Case represents the current knowledge, performance and forest management practices in TFL 44. Other forecasts will be compared against the Base Case.

- Sensitivity Analyses: Sensitivity analyses are used to quantify the risk associated with uncertainties in the assumptions or data used in the analysis. Sensitivity analyses are conducted by variable-controlling method, modifying one area of uncertainty and examining the implications of the change on timber supply.

2.3 Data Preparation and Missing Data

WFP compiled a Geographic Information System (GIS) geo-database from various resource inventory spatial datasets through a series of ArcGIS geo-processing procedures. In this master database, each polygon has a unique identification number. All summaries and values in this document were derived from this database.

The data described in this document is as reliable as the source data used in processing. Data source will be listed at each section throughout the IP document. Though efforts were made to ensure data accuracy, an exact match was not always possible amongst various datasets that have overlapping coverages. Some had to be manipulated to approximate a best fit. For instance, watersheds and landscape unit boundaries may differ in the GIS data used to construct the master database, even though in reality they are defined by the same height-of-land. Although the final resultant is a close approximation of the actual landscape, caution should be used when viewing geographic data results at a large scale. WFP may modify any data, netdown order, or calculation in the future if it will enhance the accuracy of the analysis. Any modifications to the dataset will be documented in subsequent versions of the IP.

3 TIMBER SUPPLY FORECASTS AND SENSITIVITY ANALYSES

This section describes the management scenarios to be included in the timber supply analysis. The details, assumptions, and sensitivities of each are also described.

3.1 Base Case

The Base Case represents the current operational requirements and management practices for the TFL. The forecast of current management plans incorporates existing land use designations, including Resource Management Zones, current regulations, and guidelines including the FRPA and the approved FSPs. This option is used as the basis for analysing various timber supply projections.

Current management of TFL 44 includes:

- The operable land base of forested area accessible using conventional (ground and cable) and non-conventional (helicopter) harvesting methods, based on the spatially delineated economic operability dataset via Land Base Blocking (LBB) process. A landscape-level economic metric that is consistent with the 2020 Economic Analysis for TFL 44 (Western Forest Products Inc., 2020) is established to define economic land base. Projected harvest flow in the Base Case will present volumes from the economic land base, profiled by mature (>120-year-old) and immature stands for the first 20 years.
- Exclusion of uneconomic forest stands (Section 6.13).
- Harvesting of both mature and immature stands; Performance in the non-conventional land base is address via economic land base partition (see Section 10.3.3).
- Silviculture carried out on all regenerated stands to meet free growing requirements.
- Known tree improvement gains will be applied to existing stands established since 1999 and future regenerated stands.
- Visual quality objectives (VQOs) are modelled with upper range disturbance assumed based on the VQOs Government Action Regulation (GAR) order established on December 15, 2005 and amended on December 30, 2011 for the South Island Natural Resource District.
- Green-up heights for cutblock adjacency are assigned based on Resource Management Zones established in the Vancouver Island Higher Level Plan. Special and General Zones have a 3m green-up requirement while Enhanced Zones have a 1.3m green-up height.
- Future Wildlife Tree and other stand-level retention within the THLB are accounted for by a percentage area reduction.
- Biodiversity and Landscape Units – Established Old Growth Management Areas within the Caycuse, Gordon, Great Central, Nitinat, Sproat Lake and Walbran landscape units are not included in the THLB. Also excluded are draft OGMAs in Ash, Corrigan, Effingham, Great Central, Henderson, Klanawa, Nitinat, and Sarita landscape units (Section 6.11). For the Effingham, Henderson and Sarita landscape units, old seral stage targets are applied to each BEC variant based on the *Order Establishing Provincial Non-Spatial Old Growth Objectives*

effective June 30, 2004 (NSOG). Mature seral targets are incorporated for the four Special Management Zones within TFL 44 (Section 10.2.4).

- Established Ungulate Winter Ranges (UWRs) and Wildlife Habitat Areas (WHAs) are excluded from the THLB (Section 6.10 and Section 6.12).
- Suitable Marbled Murrelet Habitat in East Vancouver Island (Great Central/Ash/Corrigan/China Caycuse LUs) are excluded from the THLB (Section 6.12.3).
- Limited rate of harvest is employed on Community Watersheds (Section 10.2.5). Equivalent Clearcut Area limitation and hydrological recovery curves are used for Fisheries Sensitive Watersheds (Section 10.2.6).
- Varying netdowns for terrain stability management depending on mapping type and relative climatic environment (Section 6.18) and applying ECA limit on various important fisheries watersheds to co-manage hydrologic/geomorphic response to prevent landslides (Section 10.2.7).
- Riparian management based on the approved FSP results/strategies, targets within the Sustainable Forest Management Plan (SFMP) developed for Canadian Standards Association (CSA) certification standard CAN/CSA-Z809-16 and a review of riparian management applied on more than one thousand cutblocks harvested or planned between 2000 and 2019.
- Minimum harvest age criteria based on minimum average stand diameter-at-breast-height (DBH) that varies by harvest system and minimum 350 m^3 per hectare (Section 10.3.1). Both minimum age and minimum volume requirements must be met before a stand can be harvested.
- The Operational Adjustment Factor 1 (OAF1; designed to capture non-productive areas within a stand) is 10.9%, based on inventory created using LiDAR captured in 2016 (Section 8.3).
- Attempts will be made to incorporate forest carbon modelling to produce forest carbon projection under the Base Case harvest flow projection over the entire planning horizon using Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) created by Natural Resources Canada (Section 3.5).

3.2 Sensitivity Analyses

Sensitivity analyses will be conducted for the current Base Case to examine the potential impact of uncertainty in various key attributes. These include the exclusion of operability classification from the THLB, imposing forest-cover harvest constraints, or changes in growth & yield estimates. Proposed sensitivity analyses are listed in Table 3. Note that other issues not included in Table 3 may be investigated and reviewed as they emerge during the modelling process.

Table 3 Proposed Sensitivity Analyses

Issue To Be Tested	Proposed Sensitivity Analysis
Growth and Yield	• Adjust natural stand volumes +/-10% • Adjust managed stand volumes +/-10%
Climate Change	• Apply predicted 2050 BEC zone variants (Wang, 2020)
Forest Management / Silviculture	• Exclude genetic gain adjustments
Operability	• Remove Partition layer to include economically challenged stands • Remove Partition layer and restrict harvesting in helicopter HwBa operable land base • Remove area within 30m from nearby parks
Visual Management	• Use more restrictive visual management constraints
Inventory	• Use LiDAR-based inventory attributes • Use adjusted LiDAR-based inventory attributes • Use Provincial Vegetation Resources Inventory (VRI) as base inventory
OAF	• Use default provincial OAF 1 • Use increased OAF 2 to reflect root-rot in Fd-leading managed stands.
Watershed Management	• Use ECA constraints of 20% • Apply ECA constraints on 400+m elevation
Biodiversity	• Marbled Murrelet provincial targets by LU/LU aggregate • Remove Stewardship and Conservation Plan impacts (area and yield)
Unused Volume	• Disposition of 2016-2020 Unused Volume
Area of Traditional Use	• Remove Thunder Mountain GAR order area • Remove potential Ditidaht First Nation Agreement-In-Principle offer lands
Minimum Harvest Criteria	• Add 2cm to the minimum harvest criteria • Subtract 2cm to the minimum harvest criteria • 95% of culmination mean annual increment

3.3 Alternate Harvest Flow

The harvest level in the Base Case will adjust each decade in the short and mid-term towards the estimated long-term harvest level (LTHL) and will change at a rate that minimizes the length of time (if any) where harvest levels are less than the LTHL. The results of the base case will determine potential alternate harvest flows. One option may be to maintain the current AAC as long as possible while still minimizing the length of time (if any) where harvest levels are less than the LTHL. Another option is a non-declining harvest level.

During preparation of the timber supply analysis, the need for further sensitivity analyses or harvest flows may become apparent. If warranted, additional analyses will be included in the final timber supply analysis for consideration by the Chief Forester.

3.4 Climate Change

Climate change is a definite factor to be considered in the forest management planning process and is a source of uncertainty in timber supply modelling. Although there is not a direct way to project climate change and its impact, WFP has incorporated multiple discussion points and sensitivity analyses to best account for climate change.

The effect of climate change on timber supply is partially accounted for in this analysis through the proposed 1% yield reduction for non-recoverable losses (refer to Section 9). This 1% reduction is meant to reflect unsalvaged timber lost to wind, insects, disease and fires that are not addressed by other yield factors. Given the current AAC for TFL 44 is approximately 793,600 m^3, a 1% reduction equates to 79,360 m^3/decade or approximately 90 ha/decade. The amount of timber lost to these biotic and abiotic factors can be increased in subsequent analyses if climate change results in increases to the number of timber-damaging events where the timber is not recoverable.

In addition, a spatially delineated GIS layer with projected Biogeoclimatic Ecosystem Classification zone, subzone, and variant for Vancouver Island in 2050s was obtained from Climate BC model developed by Dr. Tongli Wang's team at the University of British Columbia (Wang, 2020). This layer will be used in a sensitivity analysis to substitute the current BEC variant to quantify climatic impacts on growth and yield.

Outside of the timber supply review process, Tsawak-qin is actively addressing climate change via forest management practices, including, but not limited to:

- Engaging in the provincial forest fertilization program, which includes a carbon sequestration initiative. Stands identified for treatment in this program will not be harvested for a minimum of 10 years post-treatment so that the trees take full advantage of the single fertilization treatment and remove additional carbon from the atmosphere.

- Adopting the Climate Based Seed Transfer (CBST), led by the Forest Improvement and Research Management Branch of the Provincial Government (Province of British Columbia, 2017). Under CBST, seed is selected based on the present and modelled future climates of the regeneration sites. The objective of CBST is to match the current new climate of the regeneration site to the climate of the seed source. By doing this, we expect the planted seedlings to develop into productive forests that support healthy and resilient ecosystems. Changes in seed transfer limits to date have been modest, but they will expand as climate continues to change.

- Managing forest fuels to reduce wildfire risks actively. The management of logging residue provides multiple benefits such as abating potential fire hazards by burning roadside accumulations and increasing the number of sites available for planting along roadsides.

- Employing qualified forestry professionals who will consider climate change impacts when developing regeneration strategies. Species are selected based on ecological suitability in the new present and modelled future climates as determined by qualified Tsawak-qin/WFP professionals. Additional information about ecological suitability will be acquired from provincial ecologists. Forestry practices will continue to be modified to ensure the best outcomes.

As timber supply analyses are conducted at least every 10 years, the forest inventory is regularly updated to reflect the most recent disturbances and silviculture practices. As well, analysis methodology continues to evolve as new information is made available.

3.5 Forest Carbon

In the previous Section 3.4, the uncertain outcome of climate change is due to various levels of greenhouse gas emission scenarios. These emissions are usually quantified as CO_2 equivalents (CO_2e) for comparison reasons. CO_2e includes carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (Organization for Economic Co-operation and Development, 2001). The ability of forest ecosystems to capture CO_2e, primarily CO_2 from the air, and store it in the plants and soil makes forests an important factor in the global carbon cycle (The Intergovernmental Panel on Climate Change, 2007).

The forests managed by Tsawak-qin are an enormous carbon bank and store carbon in the form of live trees, dead trees, branches, leaves, roots, and soil. Year after year, the forest ecosystem increases its carbon bank with new growth from trees, and from forest litter which is in part decayed and in part stored in the soil. Harvesting transfers much of the forest carbon to long-lived products, while replanted stands quickly grow to sequester more carbon from the atmosphere. Forestry activities, transportation and manufacturing create emissions, but these are negligible compared to the production of alternative building materials such as steel and concrete. Therefore, the use of wood products also benefits the climate through product substitution. Incorporating full life-cycle carbon accounting, which accounts for each of these effects, and co-managing carbon with timber supply forecasts can have huge potential to affect long term forest management planning.

In this timber supply analysis, Tsawak-qin will endeavour to model forest carbon for the Base Case and sensitivity analyses. If the required resources and capacity can be rendered, the modelling details are discussed in Section 8.8.

3.6 Implementation Instructions from Previous AAC Determination Rationale

In the 2011 TFL 44 AAC Determination Rationale, the Chief Forester identified two implementation items of note: 1) accurate localized OAF 1 and OAF 2, and 2) monumental cedar strategy based on continued work with local First Nations. Actions to address these two implementation instructions are detailed below.

In the previous timber supply analysis, localized OAF 1 and OAF 2 values were used. OAFs used in this analysis are explained in Section 5.4.2. In summary, LiDAR data with full coverage of TFL 44 is used to derive a localized OAF 1. LiDAR canopy height models are very efficient in identifying non-productive voids inside a forested stand. The detailed methodology is documented in Appendix C: LIDAR REVIEW OF OAF1 IN MANAGED STANDS. As for OAF 2, the base case now uses the provincial average OAF 2. An increased OAF 2 will be applied to Douglas fir leading managed and future stands in CWHmm1, xm1 and xm2 zones to address the risks associated with laminated root rot issues. The details of this sensitivity analysis are documented in Section 9.2 Insects and Disease.

With regard to monumental cedar, strategies have been developed at the strategic planning level as well as the operational planning level. Since LiDAR data acquisition for TFL 44 in 2016, more advanced LiDAR-derived inventory products have been developed such as the ability to predict individual tree species and their diameter at breast height (DBH). This sets the foundation for proactively identifying potential monumental cedar trees, that would otherwise remain unknown prior to field assessment. It also unlocks the ability to conduct landscape level assessments on the potential monumental cedar candidates to inform various management strategies.

As for monumental cedar conservation for future cultural use, especially for monumental cedar on the larger end of the spectrum, a robust big tree retention policy has been developed by WFP (Western Forest Products Inc., 2019) that Tsawak-qin also follows. A big tree is defined as a live tree greater or equal to 80m or Western redcedar meeting 300cm DBH and yellow cedar meeting 210cm DBH. This policy is above and beyond the current provincial big tree eligibility to protect big cedar trees (Province of British Columbia, 2019). If the LiDAR-derived individual tree inventory identifies potential candidates, measurements of big trees are conducted using LiDAR point cloud data, followed by field verifications and assessments. The two-step approach expands the definition of big trees to include tree height, which is difficult to obtain by traditional methods. The big tree policy can ensure the protection of larger monumental cedar. For potential monumental cedar candidates that do not meet the big tree standards, the vigorous verification measures taking advantage of LiDAR-derived individual tree inventory and point cloud data can also provide guidance for incorporating additional retention areas. The verified monumental cedar trees are retained and buffered, becoming stand-level reserves. Details on how existing and future stand-level retention is treated in the timber supply analysis is described in Section 6.17 and Section 6.19, respectively.

Harvested monumental cedar are also highly valued for cultural uses. Initiatives were created to support local First Nations with log delivery. A standard operating procedure was developed for cultural wood request from local First Nations. Since the previous AAC determination, the licensee (WFP/ Tsawak-qin) has supported approximately $62,000 CAD worth of cultural wood requests for various First Nations whose traditional territories include portions of TFL 44. Furthermore, additional cultural wood was sourced from TFL 44 to support First Nations First Nations whose traditional territories are outside the TFL.

Tsawak-qin is committed to actions that further enhance the understanding of monumental cedar with local First Nations, particularly with initiatives brought by the FRPA amendments in 2019. These include improved information sharing and transparency in forest planning with First Nations, as well as ongoing lessons learnt from Forest Landscape Planning Pilot Projects that WFP is participating elsewhere on BC Coast. Through these initiatives, positive continuous improvement on monumental cedar management is established for better forest management decisions and furthers efforts for reconciliation.

3.7 Potential Ditidaht First Nation Offer Lands

Ditidaht First Nation is engaging with the Government of British Columbia in the British Columbia treaty process. The current stage for the negotiation is at Stage 5 - negotiating to finalize a treaty. If the treaty settlement land is established, the area overlapping with TFL 44 will be removed from the TFL. Based on the best available information to date, the overlapping area for the potential Ditidaht First Nation Agreement-In-Principle Treaty offer lands is estimated to be 1,621 hectares (Table 4), located in the Nitinat and Caycuse landscape units. Therefore, a sensitivity analysis is planned to evaluate the impact with this anticipated land use decision.

Table 4 Potential Ditidaht First Nation Offer Lands within TFL 44

Description	Total Area (ha)	Productive Area (ha)	THLB Area (ha)
Potential Ditidaht First Nation Offer Lands within TFL 44	1,621	1,572	1,017
Total	***1,621***	***1,572***	***1,017***

4 HARVEST MODEL

The TFL 44 timber supply analysis, including harvest level and forest inventory projections, will be conducted using Patchworks™ software developed by Spatial Planning Systems Inc. based out of Deep River, Ontario (https://spatial.ca/). Patchworks has been utilized in multiple Management Units across British Columbia.

Patchworks is a spatial timber supply model that projects harvesting activities following the current forest management practices across a land base over a specific period of time. Patchworks deploys a goal programming formulation to schedule activities that best balance multiple objectives and targets specified within the planning process. A spatially explicit model allows locational information to be incorporated in the strategic planning process. This flexibility allows management objectives in different units of measurements to be represented simultaneously, such as harvest volume (m^3/year), cutblock size (ha), distributions adjacency and green-up requirements (m) and patch size targets (% area/size class/period) using this type of model.

For this analysis, optimization will be used in Patchworks to develop the base case harvest schedule that incorporates non-timber objectives such as visual quality, cultural heritage resources, recreation, biodiversity, and wildlife habitat with the objective of timber harvest. Harvest flow is maximized for long-term timber supply, but also subject to the maintenance of other values on the land base. The timber supply forecast will attempt to achieve the long-term harvest potential and minimize the rate of change during the transition from the current level of harvest to the mid- and long-term sustainable levels.

5 FOREST COVER INVENTORY

The first forest inventory for TFL 44 was completed in 1956. Since then, it has been maintained and improved by new cruises of both mature and immature forest. The base for this analysis is a forest cover inventory updated for harvesting, silviculture activities, and survey results to December 31, 2019.

WFP has invested in Light Detection and Ranging (LiDAR) data to improve strategic inventory for TFL 44. In addition to the conventional bare earth (Hillshade) dataset and canopy height model (CHM), WFP's LiDAR research and development efforts had also been extended to creation of an individual tree inventory (ITI). ITI dataset includes individual tree locations with estimates of species, diameter at breast height (DBH), tree height, gross and net merchantable volume/piece size, basal area, crown closure, and other forest stand attributes. The granularity of detailed information across the entire land base enables WFP foresters to locate productive forests, future road locations and candidates for future harvesting opportunities. Specifically, future blocks and roads were assessed and spatially delineated by professionals. Block and road designs for harvestable stands were assigned with the suitable harvest system. This process is called Land Base Blocking (LBB).

LBB polygons are the basic building block of the timber supply model dataset for natural stands (stands established prior to 1962), with the forest cover inventory providing stand attributes. As a result, each LBB polygon is identified by the following variables:

- From Forest Cover:

  1. A measure of site productivity: expressed by site index (SI) classes.
  2. Age of stands by year established.
  3. Up to six species identified: presented in descending order of stocking.
  4. A measure of stocking projected using the provincial growth and yield programs: Table Interpolation Program for Stand Yields (TIPSY) for immature stands and Variable Density Yield Projection (VDYP) for mature stands:
     - Height
     - Volume
     - Basal area
     - DBH
     - Crown Closure
     - Number of stems per hectare (sph)

- From LBB:

  1. Forested/ Productive Area (spatial)
  2. Projected primary harvest system (i.e. ground/cable/helicopter) and roads

These measures of inventory enable the timber supply analysis to be more aligned with how operational forest practices would be implemented on the ground. Thus, projections from the modelling exercise are highly specific and relatable.

5.1 Mature Inventory

The mature inventory is defined as stands greater than 100 years of age in the 1970s (1973-1977) inventory of TFL 44. Today stands greater than 151 years old are classified as mature.

Since the original cruise in 1956, the inventory has been continuously upgraded and updated as follows:

- In 1958, a more intensive cruise was made of Douglas-fir forests.
- In 1963, more cruising was completed, and all volumes were recompiled.
- In 1966, mature volumes were recompiled, as required by BC Forest Service, to close utilization standards (15 cm top diameter for trees 22.5 cm and larger to be harvestable).
- In 1972, mature volumes were recompiled using new MacMillan Bloedel (MB) decay factors.
- Between 1973 and 1977, the TFL was re-inventoried.
- In 1987 and 2000, operational cruising was combined with the inventory to improve the less intensive original inventory on these areas.
- In addition, the inventory has been updated annually to reflect areas and volumes harvested, to incorporate silviculture survey data for young stands and to project the growth of stands.

5.2 Immature Forest Inventory

During the 1970s inventory, all the immature forest was cruised and mapped. Each stand was described according to age, species, site index class, and stocking. Stand information for new planted and natural stands is added to a forest information management system (currently Cengea Forest Resources). Updates are added for any changes found by assessment of survival and free-growing status. Up until the early 2000s, the practice was to re-inventory new stands as they reach “pole size”, generally between 30 and 40 years: At this stage, site index is measured based on growth of the new stand and volume and basal area are obtained as measures of stocking.

5.3 Vegetation Resources Inventory

A Vegetation Resource Inventory (VRI) update project was initiated in 2014 for the South Island Forest District. Aerial photo imagery was acquired by FLNRORD for Crown land, including TFL 44. Subsequently, photo interpretations were conducted to re-delineate stand boundary and the associated attribute information. The updates were gradually incorporated into the Provincial VRI dataset.

WFP conducted a study to test the difference and relative accuracy of three different forest inventories in TFL 44: Tsawak-qin Forest Cover (described in Section 5.1 and Section 5.2), VRI, ITI based on LiDAR data acquired in 2016 (Western Forest Products Inc., 2021). These inventory datasets were evaluated using both cruise plot and harvest data for 101 blocks that were cruised after WFP's LiDAR acquisition in 2016.

The study found that VRI was the least accurate inventory dataset of the three tested using both cruise and harvest data. VRI consistently underestimated volume across the range of forest ages and was consistently the least accurate at determining species composition.

Tsawak-qin Forest Cover was generally accurate at predicting volume, however the accuracy varied by age class. It underpredicted volume in stands <120 years old and overpredicted in stands ≥120 years old. As a result, forest cover volume estimates were generally less precise than VRI, indicating that while the results should be more accurate at a land base scale, at the stand level accuracy is likely to be mixed. Forest Cover was more accurate at predicting species composition than VRI.

ITI significantly underestimated volume, particularly in stands greater than 120 years old. However, it was the most precise estimator of volume and also the most accurate predictor of species composition. This volume underestimation is common in LiDAR derived inventories (Jarron, *et al.*, 2020), which tend to miss understory trees, which will be more common in older stands.

Based on the results from this comparison study, Tsawak-qin Forest Cover was chosen for the Timber Supply Review (TSR) process in TFL 44 due to its overall accuracy and for consistency with the previous TSR. It is acknowledged that cutblock data used in the test only reflects economically operable stands that meet the operable harvest criteria in TFL 44. Stands that do not contribute to the timber objective but are equally important for various non-timber objectives are not fairly represented in evaluation. Having said that, the purpose of the timber supply analysis is to explore a sustainable harvest level that satisfies all the other objectives on the land base. Therefore, the recommendation to use Tsawak-qin Forest Cover is valid for the TSR purpose. The detailed report on this comparison study is attached in Appendix A.

Despite the finding from the study described above, a sensitivity analysis using VRI as alternative inventory base data will be completed. Additionally, to evaluate the impact of using ITI, two sensitivity analyses may be performed: 1) using ITI height, ITI volume and ITI-Based Site Index; 2) using ITI height, ITI adjusted volume by adding a correction factor derived from regression analysis and ITI-Based Site Index.

5.4 LiDAR

WFP acquired LiDAR data for TFL 44 in 2016. LiDAR can remotely sense height information on the ground by measuring the time it takes a laser pulse from the sensor on an aircraft, to hit a ground object and return to the sensor. Typically, LiDAR is acquired by a fixed wing airplane or a helicopter, the exact location of which is tracked by a GPS satellite, and supplemented by calibration from ground base stations. Modern LiDAR scanners used for forestry operation can transmit and receive as many as 500,000 pulses of laser light per second. The detailed three-dimensional laser point cloud information translates to very specific mapping of the forest and ground conditions.

In its early use within forestry, LiDAR was primarily used to generate an accurate digital elevation model (DEM) of the earth's surface for operational planning, largely on forest road engineering and cutblock development. More recently, as described at the beginning of this chapter, LiDAR has become a powerful tool for assessing large-scale forest inventory attributes such as tree height, density and volume. LiDAR usage in the timber supply analysis include:

5.4.1 Road Buffer width determination

Using LiDAR canopy height data, a review of vegetation gaps in road surface right-of-way area was conducted to determine the effective buffer for THLB determination. Further details are in Section 6.5 and Appendix B.

5.4.2 Operational Adjustment Factor

Using LiDAR data, a review of gaps in tree crown cover within 41 to 100-year-old operable polygons was conducted to determine the proportion of these stands not supporting tree growth. This factor is applied within TIPSY when generating managed stands yield tables to account for non-productive inclusions within the stands that are too small to be mapped in the forest inventory, known as Operational Adjustment Factor (OAF 1). Further details are in Section 8.3 and Appendix C: LIDAR REVIEW OF OAF1 IN MANAGED STANDS.

5.4.3 Land Base Blocking

As described at the beginning of this chapter, using LiDAR data, the LBB process was conducted to review the entire land base in terms of opportunity for timber harvesting and road development. Non forested area, low productive forest area, harvestable area, harvest system, and road locations are spatially delineated by WFP's forest professionals. This LBB dataset, in addition to the forest cover dataset, forms the basic building block of the inventory for the timber supply analysis.

Additional forest attributes are gathered from the LiDAR based ITI. However, these attributes will not be utilized in the base case. Rather, they will be tested as sensitivity analyses to evaluate their potential impacts on TFL 44 timber supply.

5.4.4 Stand Heights

To calculate LiDAR tree height at stand level, WFP has reviewed various methodologies demonstrated in the past Timber Supply Analysis reports for other Management Units in BC. These include:

- LiDAR Enhanced Forest Inventory (LEFI) methodology (Forsite Consultants Ltd., 2018; Province of British Columbia, 2019)
- Haida Gwaii Timber Supply Review Data Package that utilized LEFI methodology (Technical Working Group, 2019)
- TFL 37 (Western Forest Products Inc., 2017)
- TFL 14 (Canadian Forest Products Ltd., 2018)

- TFL 61 (Forsite Consultants Ltd., 2019)

Given the consideration on technology development, geographical proximity and applicability, LiDAR heights were generated by following a simplified version of LEFI implementation.

The LEFI methodology was developed by FAIB in 2018 to update VRI attributes by leveraging available LiDAR dataset. Heights for these stands were generated using LiDAR CHM data. In TFL 44, LiDAR tree location points were generated from the LiDAR CHM dataset. A 20m x 20m grid was placed over the CHM dataset, and the average height of the top 4 trees was computed (Ht_top4) and then summarized to the base inventory polygon for the timber supply model (refer to Section 5.1). Ht_top4 is the default LiDAR height. The following indicators are calculated for further verification: coefficient of variation (CV), roundness index (length to area index to indicate long, skinny polygons) and number of grid cells used to calculate HT_top4 mean. For stands that are highly variable (CV> 40%), highly irregular (roundness index < 0.05) or too small (number of cells < 20), the tree height value for the 50th percentile of the tree list (sorted descending (PolyHt50) for the polygon) becomes LiDAR tree height. It is acknowledged that LEFI has futher processes to assign 5th /10th /20th/ 30th percentile of the tree height based on different crown closure, but the proportion of these options applied to forest stands is insignificant. In the original analysis that formed the LEFI methodology, 89% of the LiDAR tree heights was determined using Ht_top4 and 10% was using PolyHt50 (C. Robinson personal communication, June 8, 2020). Table 5 shows the LiDAR tree height source break down for TFL 44.

Table 5 LiDAR Height Source for TFL 44

LiDAR Height Source	Gross Area (Ha)	Percentage of Gross Area	THLB Area (Ha)	Percentage of THLB Area
Ht_Top4	81,716	60%	48,363	65%
Poly_Ht50	54,959	40%	25,878	35%
Unclassified	225	0%	19	0%
Total	***136,900***	***100%***	***74,260***	***100%***

5.4.5 Site Index

For stands greater than 30 years old, site index was recalculated using LiDAR height and stand age at the time of LiDAR acquisition (2016) using Site Tools version 4.1.

5.4.6 Volume

LiDAR derived ITI volume was summarized at polygon level to represent LiDAR volume. However, there is a scientific and industry consensus on a systematic under-estimation in tree volume on older stands, as LiDAR data collected from above tend to miss understory vegetation that are obscured by the canopy (Jarron *et al.*, 2020). Following the methodology from the study referred to in Section 5.3 (Western Forest Products Inc., 2021), a correction factor of 0.624 m^3/ha/year was added to the ITI volume to account for this intrinsic drawback for ITI volume.

5.5 Current Age Class Distributions

Table 6 shows the current age class distribution of the productive forest land base (See Section 296.6 for definition) and the timber harvesting land base (THLB) for TFL 44 as of December 31, 2019. Areas and volumes listed as zero years old are overstated because they include areas planted in 2019 but for which the species information was not yet available, and areas harvested in 2019 but to be planted in 2020. Figure 2 and Figure 3 illustrate the age class distribution by area for productive forest land base and THLB. Figure 4 and Figure 5 display the age class distribution by volume for productive forest land base and THLB.

Table 6 Age Class Distribution for TFL 44

		Area (ha)		Volume ('000 m^3)	
Age Class	**Age range (years)**	**Productive Forest**	**THLB**	**Productive Forest**	**THLB**
0	0	986	984	19	19
1	1-20	22,345	21,738	1,007	956
2	21-40	25,600	20,677	3,050	2,444
3	41-60	15,971	11,988	6,366	4,682
4	61-80	12,552	7,563	6,505	3,910
5	81-100	2,854	1,465	1,726	875
6	101-120	406	247	221	141
7	121-140	73	17	35	10
8	141-250	1,511	336	951	213
9	>250	38,672	9,245	34,775	8,185
Total		**120,970**	**74,260**	**54,655**	**21,435**

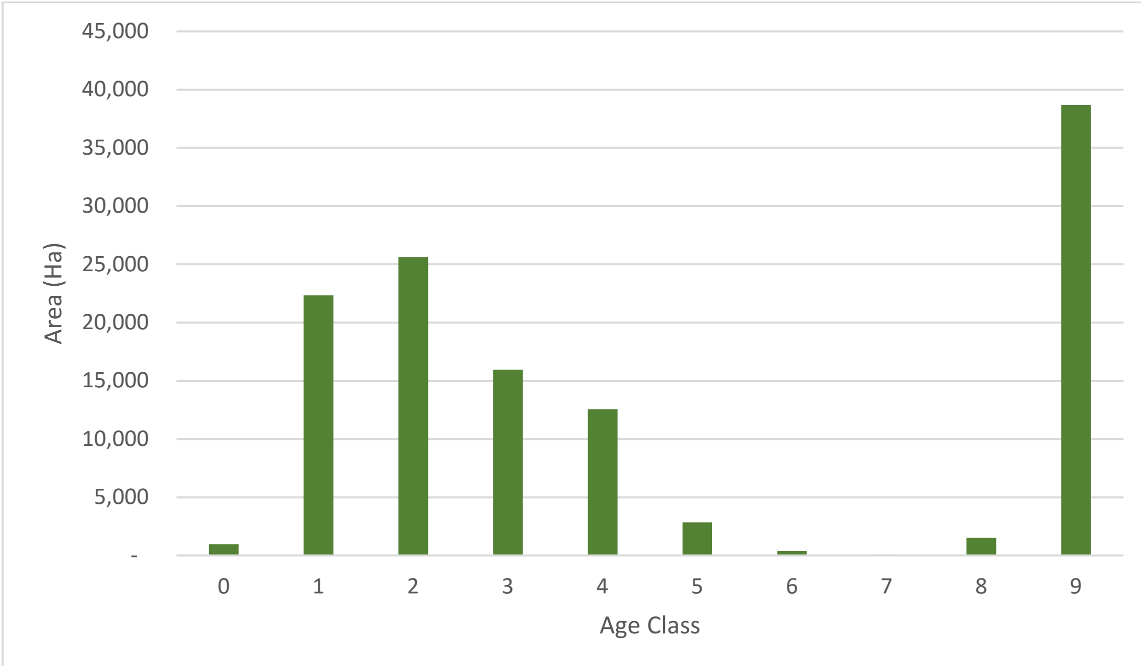

Figure 2 Productive Forest Age Class Distribution - Area

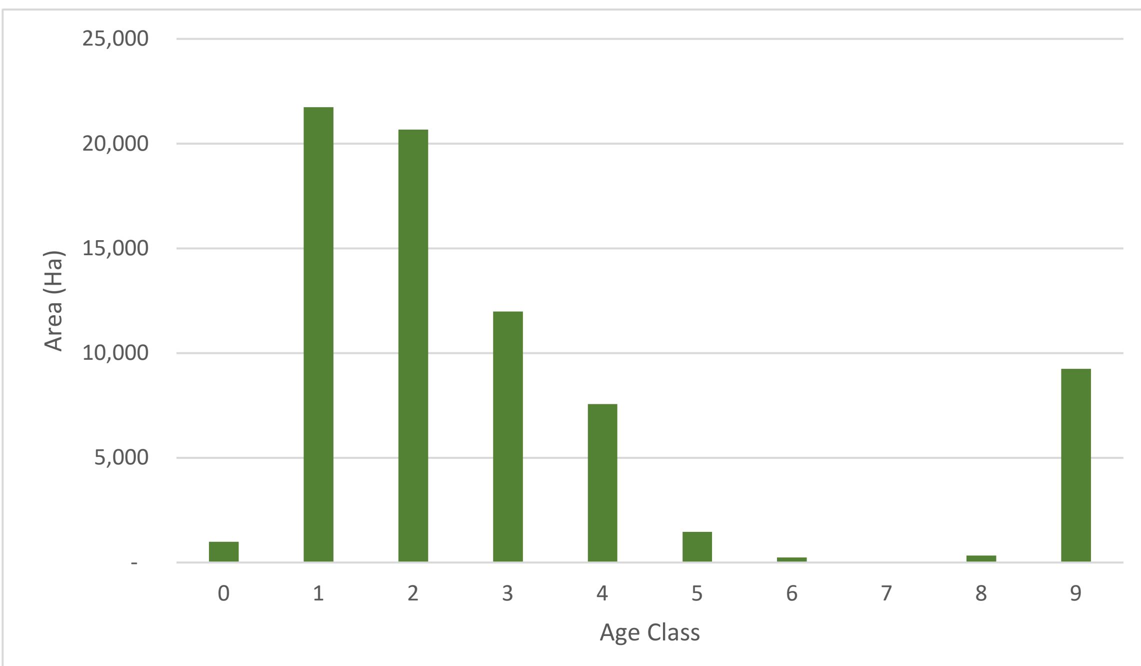

Figure 3 THLB Age Class Distribution - Area

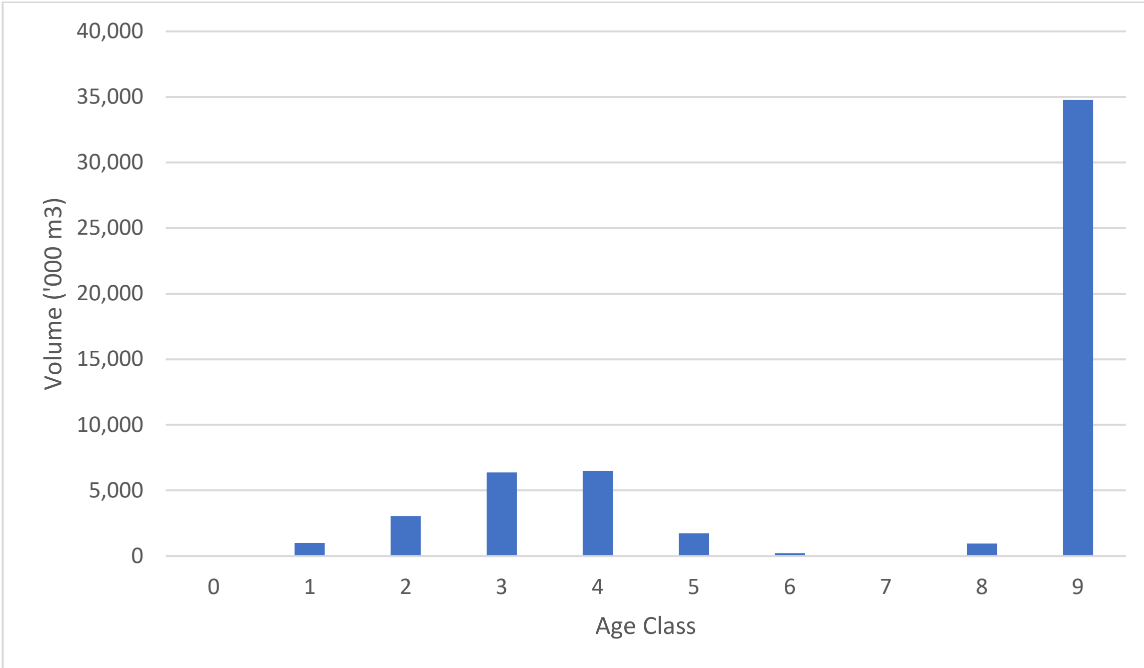

Figure 4 Productive Forest Age Class Distribution - Volume

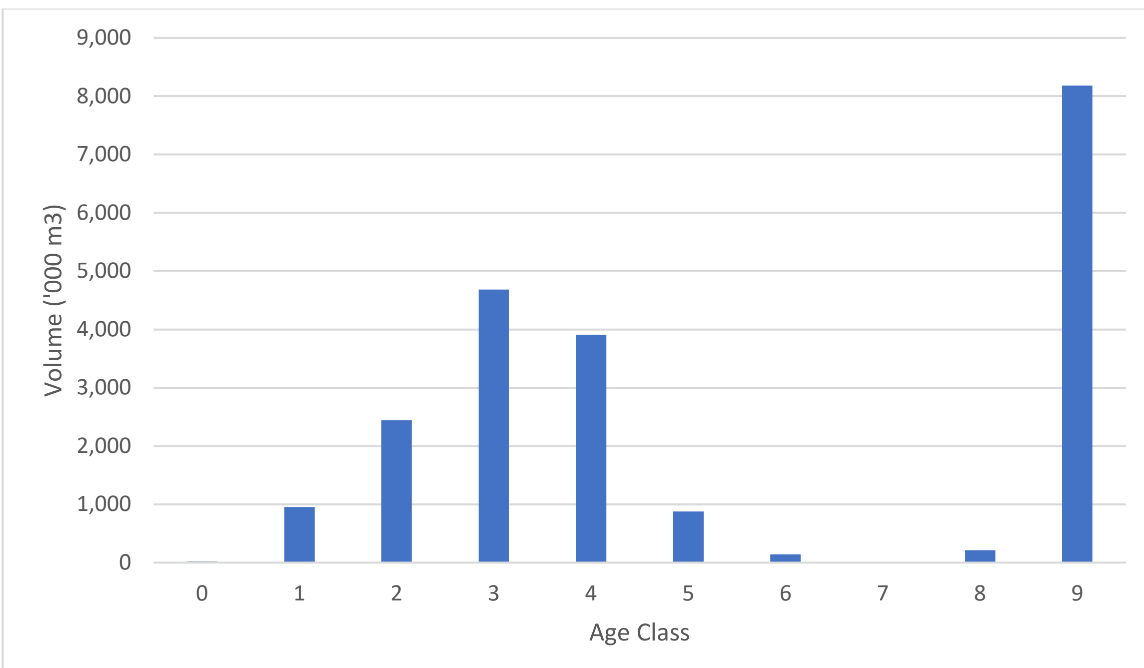

Figure 5 THLB Age Class Distribution - Volume

6 DESCRIPTION OF LANDBASE

This section describes the TFL 44 land base and the methods used to determine the portion of the land base that contributes to timber harvesting – the Timber Harvesting Land Base (THLB). Some portions of the productive land base, while not contributing to harvest, are crucial in meeting the demands for non-timber resource sustainability. These areas are defined as Non-Contributing Land Base (NCLB). Noted that areas and volumes within all tables in this section may not be summarised perfectly due to rounding to the nearest hectare.

6.1 AAC Allocation and Land Base Changes

The AAC determined (May 2011) based on the MP #5 was 800,000 m^3. In December 2015, the AAC was adjusted to 793,600 m^3 according to areas removed from TFL 44 as per Ministerial Order # 3(4) 27-4. In December 2020, an AAC partition decision was made, instructing that 535,000 m^3 of the AAC come from the economic land base, with 110,000 m^3 of the AAC in stands less than 121 years.

For the current AAC of 793,600 m^3, 782,482 m^3, or 98.6%, is allocated to Tsawak-qin. The remaining 11,118 m^3, or 1.4%, is allocated to Ditidaht Forestry Ltd. (Ditidaht First Nation) and Uchucklesaht Forestry Ventures Inc. (Uchucklesaht First Nation) via forest licences.

At the time the timber supply analysis dataset was compiled, the total area of TFL 44 is 136,900 hectares. The total area at the time of the last AAC determination (May 2011) was 141,566 hectares. The total area in 2002 was 321,941 ha. The net decrease is due to the deletion of areas documented in:

- Instrument 54 (October 2014): Special Use Permit for Maa-Nulth First Nations' Final Agreement (treaty).
- *Forest Revitalization Act* Order 3(4)27-4 (December 2015): creation of Hupacasath First Nations Woodland Licence.
- *Forest Act* Section 60.2 Order (October and December 2016): creation of the Thunderbird's Nest (T'iitsk'in Paawats) Protected Area.
- Instrument 55 (March 2020): removal of 73.3 ha within the Malachan Block B parcel.

6.2 Timber Harvesting Land Base Determination

For timber supply analysis purpose, the entire land base of TFL 44 has been further classified. The productive forest land base (PFLB) is the area of productive forest within the TFL that contributes to landscape-level objectives (e.g., biodiversity) and non-timber resource management. It excludes non-forested areas, non-productive forest area and existing roads.

The THLB is the portion of the TFL where harvesting is modelled to occur. It is a subset of the PFLB as areas that are for non-timber resources management, inoperable, or uneconomic for harvesting are excluded. Operationally, harvesting may occur outside the modelled THLB as the THLB used in the analysis is a GIS-based estimate of an operational reality. The THLB/NCLB definitions are for timber supply modelling. The inclusion or exclusion of a specific site in the THLB does not necessarily relate to how it will be managed. Consequently, the estimate of the THLB has limited utility outside of the timber supply analysis.

The THLB and the total long-term land base in TFL 44 are presented in Table 7 Areas are reported for both Schedule A (Timber Licences within the TFL) and Schedule B (Crown land) land classes. Merchantable volume estimates are indicated in Table 8. Areas and volumes have been compiled from databases constructed for the preparation of this information package. A spatial presentation of the THLB is illustrated in Figure 6.

The following sections show total area/volume classified in each category noted in Table 7 / Table 8 and serve to summarise the area/volume deducted from the land base in the order the categories appear in Table 7 / Table 8 (i.e. overlapping constraints are addressed in a hierarchy).

Table 7 Timber Harvesting Land Base Netdown (ha) for TFL 44

Classification	Total Area (Ha)	Net Area (Ha)			% Total	% PFLB
		Schedule A	Schedule B	Grand Total		
		Timber Licence	Crown			
Total Land Base	**136,900**	**25,327**	**111,573**	**136,900**	**100.0%**	**-**
Less Non-forest	11,089	279	10,810	11,089	8.1%	-
Less Existing Roads & Powerlines	1,592	451	1,141	1,592	1.2%	-
Total Forested	**124,219**	**24,597**	**99,622**	**124,219**	**90.7%**	**-**
Less Non-productive	3,249	67	3,182	3,249	2.4%	-
Total Productive	**120,970**	**24,530**	**96,441**	**120,970**	**88.4%**	**100.0%**
Low Sites	8,629	1,029	5,429	6,458	4.7%	5.3%
Less Inoperable	36,384	3,094	13,065	16,160	11.8%	13.4%
Total Operable	**-**	**20,406**	**77,946**	**98,352**	**71.8%**	**81.3%**
Reductions:						
Riparian Management	10,872	621	3,376	3,998	2.9%	3.3%
Ungulate Winter Ranges	2,145	0.6	1,727	1,727	1.3%	1.4%
Old Growth Management Areas	16,300	1,037	6,444	7,481	5.5%	6.2%
Wildlife Habitat Areas - Legal	3,447	-	47	47	0.0%	0.0%
Wildlife Habitat Areas - Proposed	547	-	131	131	0.1%	0.1%
Marbled Murrelet Habitat	990	15	549	564	0.4%	0.5%
Uneconomic	39,129	405	1,107	1,511	1.1%	1.2%
Deciduous-leading	751	-	-	-	0.0%	0.0%
Recreation	6	-	6	6	0.0%	0.0%
Known Archaeological Sites	126	55	45	99	0.1%	0.1%
Existing Stand-level Reserves	5,877	877	1,885	2,762	2.0%	2.3%
Terrain Stability	44,303	992	2,984	3,975	2.9%	3.3%
Future Stand-level Reserves	-	283	1,507	1,790	1.3%	1.5%
Total Operable Reductions	**-**	**4,285**	**19,807**	**24,092**	17.6%	19.9%
Current THLB	**-**	**16,121**	**58,139**	**74,261**	54.2%	61.4%
Less future roads	203	20	183	203	0.1%	0.2%
Long-term Land base	**-**	**16,101**	**57,957**	**74,058**	54.1%	61.2%

Table 8 Timber Volume Netdown ('000 m^3) for TFL 44[1]

Classification	Total Volume	Net Volume			% Total	% PFLB
		Schedule A	Schedule B	Grand Total		
		Timber Licence	Crown			
Total Land Base	**55,785**	**10,285**	**45,500**	**55,785**	**100.0%**	**-**
Less Non-forest	100	31	69	100	0.2%	-
Less Existing Roads & Powerlines	321	63	257	321	0.6%	-
Total Forested	**55,365**	**10,191**	**45,174**	**55,365**	**99.2%**	**-**
Less Non-productive	709	42	667	709	1.3%	-
Total Productive	**54,656**	**10,149**	**44,507**	**54,656**	**98.0%**	**100.0%**
Low Sites	4,193	735	3,375	4,109	7.4%	7.5%
Less Inoperable	17,583	2,833	9,922	12,755	22.9%	23.3%
Total Operable	**-**	**6,581**	**31,210**	**37,792**	**67.7%**	**69.1%**
Reductions:						
Riparian Management	6,369	240	1,388	1,628	2.9%	3.0%
Ungulate Winter Ranges	1,757	0	1,408	1,408	2.5%	2.6%
Old Growth Management Areas	14,026	1,013	5,881	6,894	12.4%	12.6%
Wildlife Habitat Areas - Legal	3,400	0	37	37	0.1%	0.1%
Wildlife Habitat Areas - Proposed	341	0	55	55	0.1%	0.1%
Marbled Murrelet Habitat	814	12	438	450	0.8%	0.8%
Uneconomic	19,781	287	795	1,082	1.9%	2.0%
Deciduous-leading	313	0	0	0	0.0%	0.0%
Recreation	3	0	3	3	0.0%	0.0%
Known Archaeological Sites	75	35	23	58	0.1%	0.1%
Existing Stand-level Reserves	4,407	623	1,109	1,732	3.1%	3.2%
Terrain Stability	27,067	704	1,584	2,288	4.1%	4.2%
Future Stand-level Reserves	-	110	612	722	1.3%	1.3%
Total Operable Reductions	**-**	**3,024**	**13,333**	**16,357**	29.3%	29.9%
Current THLB	**-**	**3,557**	**17,878**	**21,435**	38.4%	39.2%

[1] Data updated to the December 31, 2019 for harvest history and ages; therefore, volumes listed represent estimates at the end of 2018

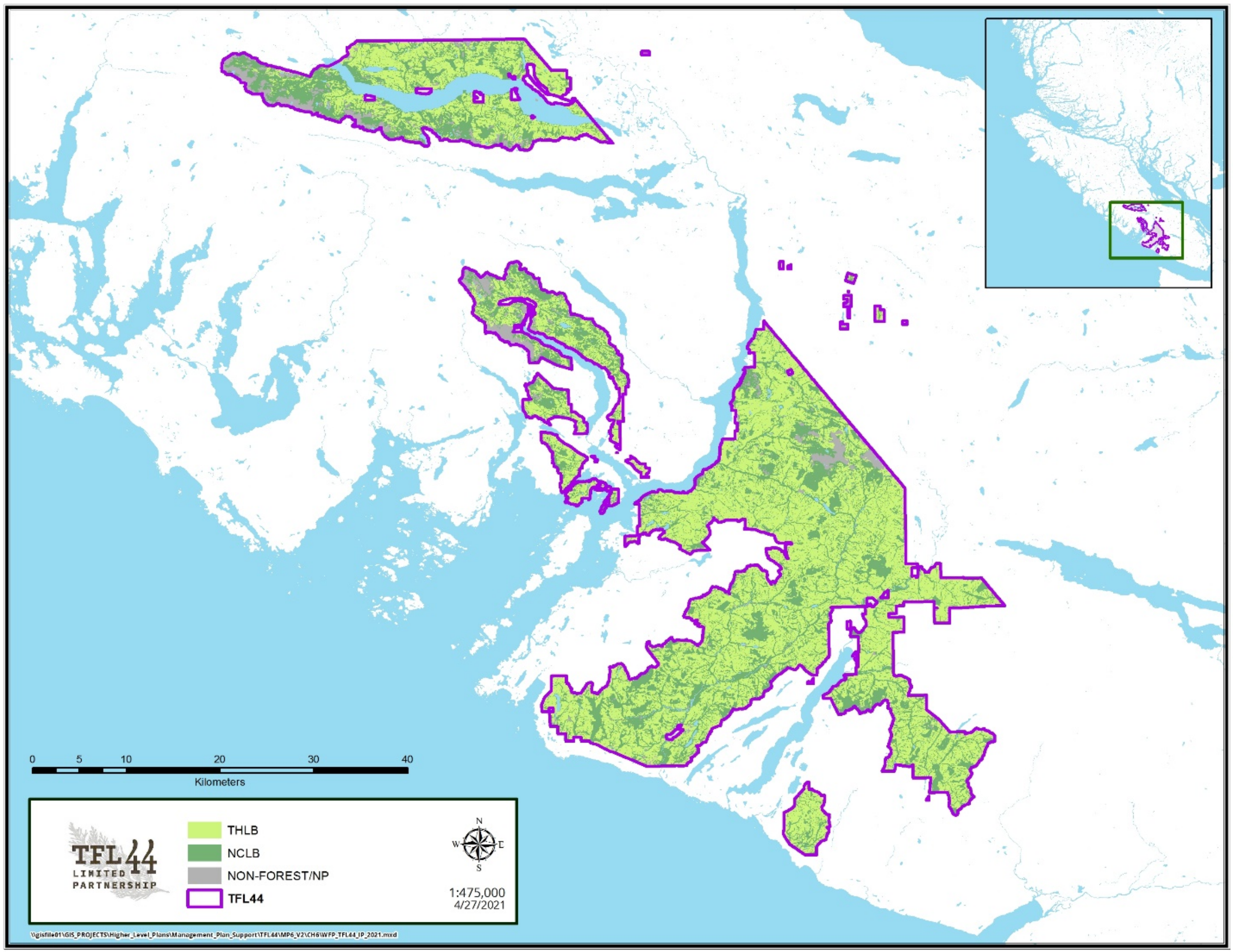

Figure 6 TFL 44 Land Base Classification

For MP #5 in 2010, the total land base reductions were 59,574 ha, which was 42.7% of the total area. For MP #6, the reductions are 62,639 ha or 54.2% percent of the total area, resulting in a THLB area of 74,261 ha. There are multiple factors that resulted in an increased level of THLB netdown. The largest changes are due to utilizing LiDAR datasets and inventory to identify non-productive patches, low productivity patches and inoperable areas. In addition, more non-timber resources features became spatially available, or more explicitly defined (rather than being an aspatial forest cover constraint).

6.3 Recently Harvested Cutblocks

Within cutblocks harvested or planned before 2019 for which Site Plan Standard Unit (SU) spatial data is available, the productive forest area (net area to reforest (NAR)) will be designated as 100% THLB. The roads and reserves for these cutblocks (e.g. Wildlife Tree patches (WTPs) and Wildlife Tree Retention Areas (WTRAs) etc.) will be designated as 0% THLB.

For the rest of the land base, the following land base netdowns will be applied to derive the THLB. Netdowns are listed in the order applied such that THLB impact values listed are the incremental impact accounting for all previously applied netdowns. Tabular summaries as well as spatial locations of each land base netdown factor will be presented. Noted that some land base netdowns are quite small in nature, and therefore the spatial locations may be difficult to see in an TFL-level overview.

6.4 Non-Forest Area

The non-forest portion of TFL 44 includes area where merchantable tree species are largely absent. They do not contribute to timber objective in the timber supply analysis and are excluded from THLB. Detailed area reduction is listed in Table 9. And Figure 7 shows the location.

Table 9 Non-forest Area in TFL 44

Description	Gross non-forest area (ha)	Area Reduction (ha)
Non-Forest	10,920	10,920
Waterbody	169	169
Total	***11,089***	***11,089***

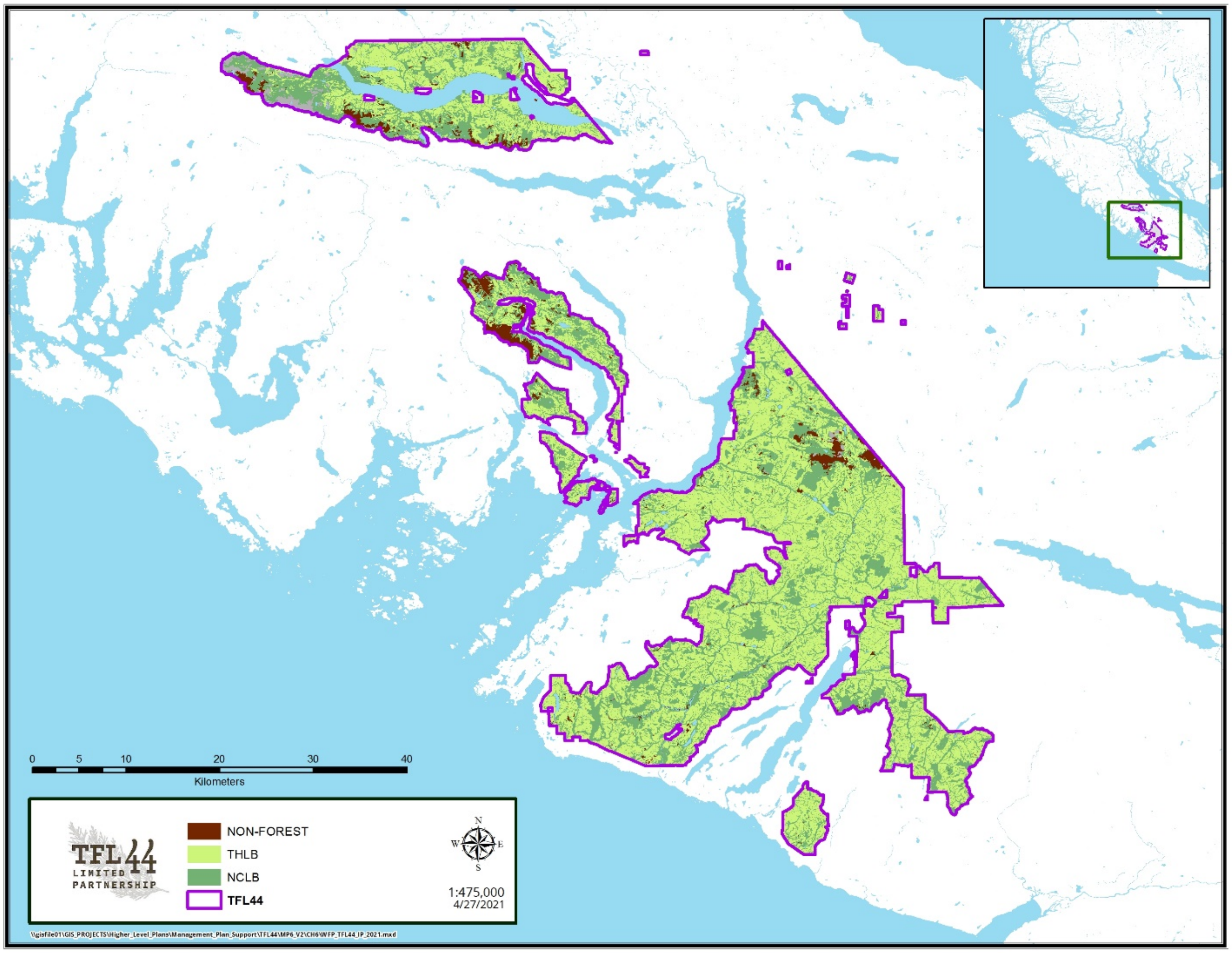

Figure 7 Non-Forest Area in TFL 44

6.5 Existing Roads and Powerlines

Existing roads are excluded from the timber harvesting land base. This reduction is due to the combination of classified and unclassified roads. Classified roads are those that are mapped as forest cover polygons distinctly separate from adjacent polygons. Unclassified roads have been represented by a polyline feature in GIS. The buffer widths for different road classes were determined based on a review conducted using LiDAR data acquired for TFL 44. The rationale and methodology can be found in Appendix B: LIDAR REVIEW OF ROAD WIDTHS IN MANAGED STANDS.

As all trails and the majority of the landings are rehabilitated and restocked following logging, the associated area reduction is considered to be insignificant in the modelling process. Table 10 summarizes the areas of existing roads in the TFL.

Table 10 Existing Roads in TFL 44

Feature Class	Length (km)	Total Buffer Width (m)	Area Reduction (ha)
Highway/FSR/Mainline	451	11	278
Spurs/Unclassified	3,319	3	1,237
Powerlines	131	15	76
Total	***3,901***		***1,592***

6.6 Non-Productive Forests

TFL 44 includes 3,249 ha of non-productive forest (Table 11 and Figure 8). These areas are mostly forest growing on poor sites. These areas are from two sources: 1) The inventory indicates mature stands defined as having an inventory volume of less than 200 m^3/ha or immature stands with SI less than 5m; 2) The LBB process described in Section 5.4.3 where various LiDAR derived inventory data are used to determine if stands are productive or not by forest professionals.

Non-productive forests contribute to landscape level biodiversity. While not incorporated into the biodiversity calculations, these components provide a margin of safety around biodiversity requirements.

Table 11 Non-Productive Area in TFL 44

Description	Gross non-productive area (ha)	Area Reduction (ha)
Non-productive / Scrub Forest - Inventory	1,426	1,426
Non-productive / Scrub Forest - LBB	1,823	1,823
Total	***3,249***	***3,249***

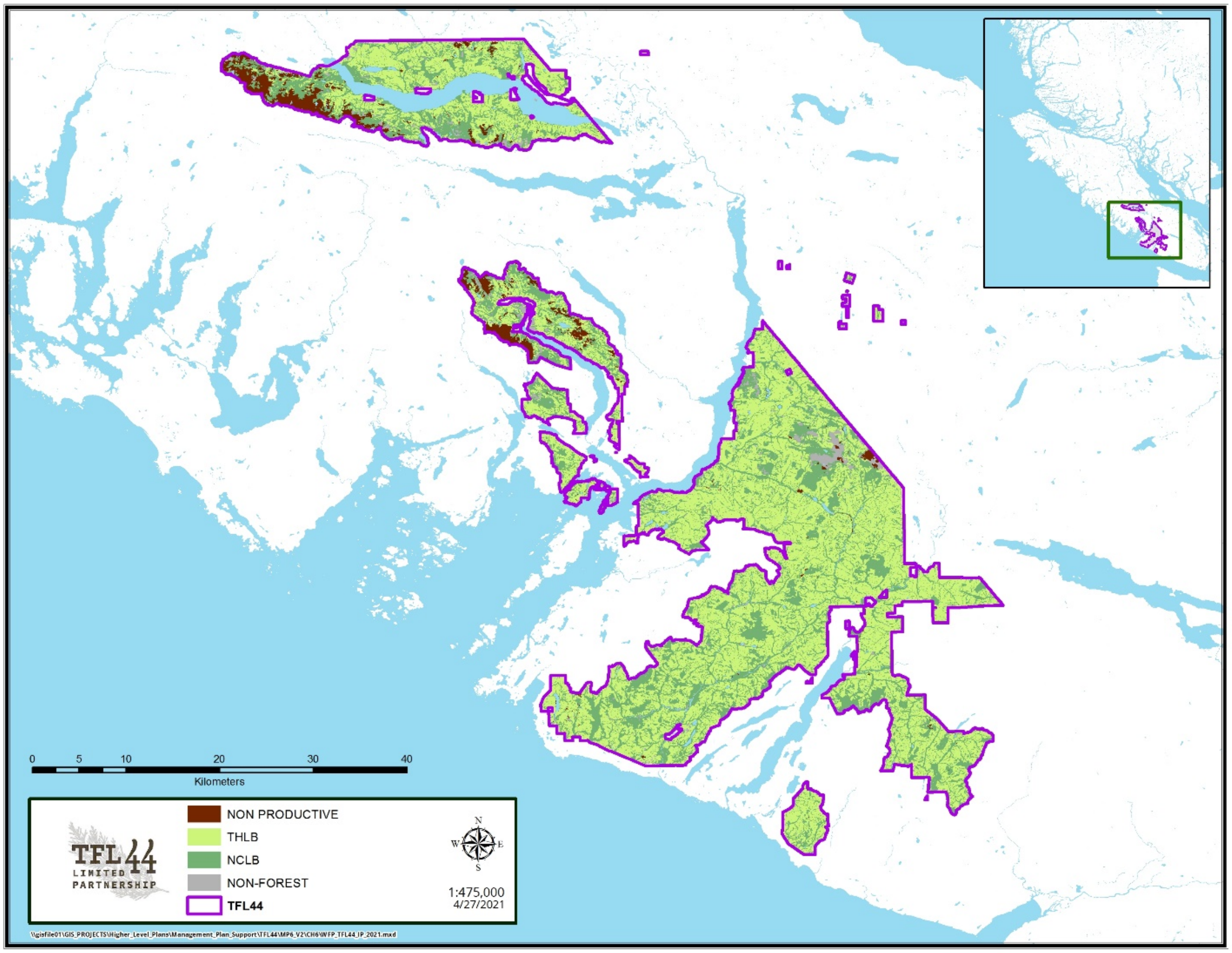

Figure 8 Non-Productive Area in TFL 44

6.7 Low Sites

Low sites are defined as old forest with volume less than 300 m^3/ha, based on the original forest cover as well as LBB process using LiDAR datasets. These stands are considered as productive forest but inoperable due to low stand volume. Note that there are overlapping timber harvesting constraints with the previously discussed factors, and the THLB area reduction are calculated in a hierarchy. Table 12 describes the total non-productive area and THLB impact for low sites, and Figure 9 Low Sites in TFL 44Figure 9 shows the spatial presentation of these low sites.

Table 12 Low Sites in TFL 44

Description	Gross Non-Productive Area (ha)	Area Reduction (ha)
Low Sites - Inventory	1,596	756
Low Sites - LBB	7,033	5,702
Total	***8,629***	***6,458***

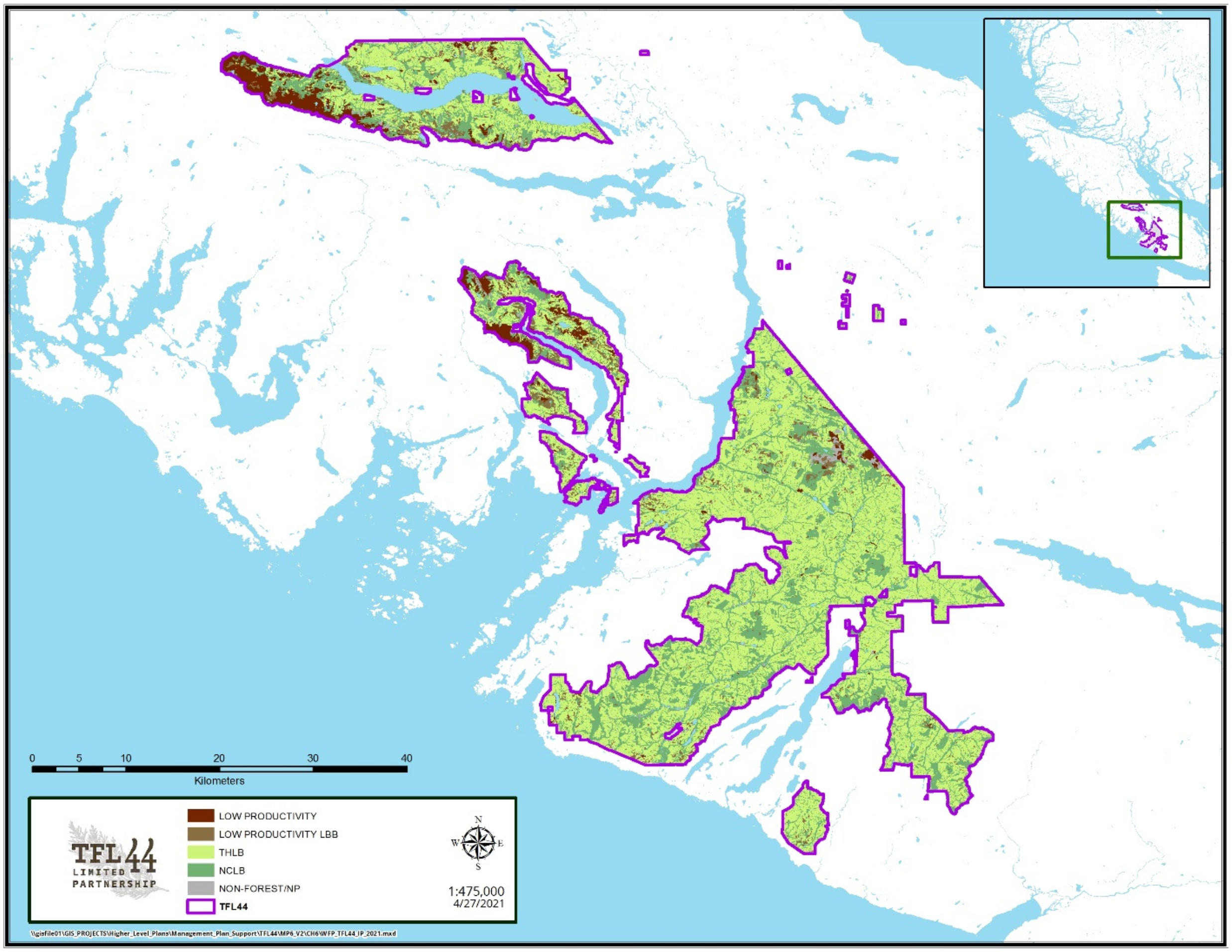

Figure 9 Low Sites in TFL 44

6.8 Physical Operability

Physical operability mapping was used to classify areas as:

- Conventional - accessible by ground-based harvesting systems;
- Non-conventional - access limitations suitable for aerial systems such as helicopter; or
- Inoperable.

In preparation for MP #6, in 2019 - 2020, mapping of physical operability was updated utilizing LiDAR data via LBB process described in Section 5.4.3. Table 13 shows the productive area and productive volume under each physical operability class. Only the inoperable areas are removed from the THLB. Figure 10 shows the physical operability classifications in TFL 44.

Table 13 Area by Physical Operability Classes in TFL 44

Description	Productive Area (ha)	Volume (000 m^3)	% of Productive Area	% of Productive Volume
Conventional	85,629	28,135	71%	51%
Non-conventional	12,723	9,656	11%	18%
Operable (subtotal)	***98,352***	***37,792***	***81%***	***69%***
Inoperable + Low Sites	22,618	16,864	19%	31%
Total	***120,970***	***54,655***	***100%***	***100%***

Physically inoperable areas were identified based on safety considerations, operational performance, environmental sensitivity, and local knowledge. Harvesting in physically inoperable areas is unrealistic for reasons of accessibility, soil sensitivity, or worker safety. A comparison between the harvested area from 2009 to 2019 by different harvest system and the overall TFL 44 THLB area is shown in Table 14.

Table 14 2009-2019 Harvest Area by MP #6 Operability Type

Harvest System	% of Harvest Area	% of THLB Area
Conventional	89.4%	93.5%
Non-conventional	8.9%	6.5%
Operable (subtotal)	***98.4%***	***100.0%***
Inoperable + Low Sites	1.6%	0.0%
Total	100.0%	100.0%

There are some concerns regarding whether western hemlock (Hw) or amabilis fir (Ba) leading operable stands marked with non-conventional harvest system is economically viable. The economic analysis that set up the foundation for the December 2020 Chief Forester's partition decision concluded that 79% of the uneconomic profile is deemed to be non-conventional harvest grounds; of which, 68% is HwBa leading (Western Forest Products Inc., 2020). Timber supply modelling will track these stand types. If the proportion of this type of stand contributed to harvest flow is significant, a sensitivity analysis excluding HwBa non-conventional stands will be performed.

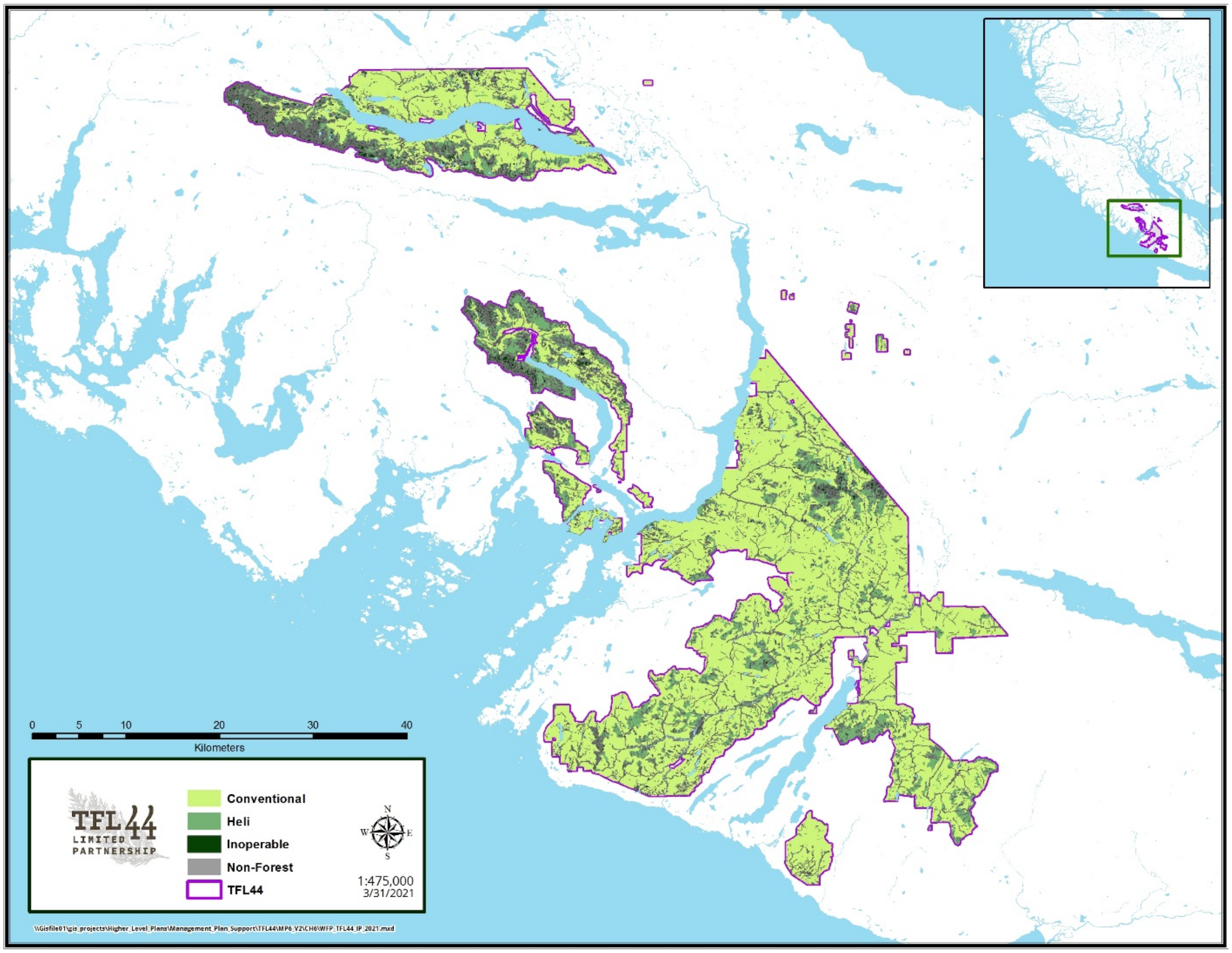

Figure 10 Physical Operability Classes in TFL 44

6.9 Riparian Management Areas

Detailed riparian feature mapping is ongoing for TFL 44 through cutblock development. Operational stream inventories associated with development planning have been conducted since 1988 (with the introduction of the *Coastal Fisheries Forestry Guidelines*) and various reconnaissance (1:20,000) fish and fish habitat inventory projects have been completed. This detailed information provides the basis for estimating riparian classes and reserve areas for waterbodies.

The timber supply analysis utilizes available GIS stream classification data and applies Riparian Management Areas (RMAs) to known streams, lakes and wetlands based on FRPA Riparian Reserve Zone (RRZ) widths and assumed levels of retention within Riparian Management Zones (RMZs). The assumed RMZ retention levels and effective RMAs are listed in Table 15. Retention levels were estimated based on a review of cutblocks harvested between 2000 and 2019 plus classification of riparian features in and adjacent to the harvest area. In total, 1,061 cutblocks totalling 24,835 hectares were reviewed. As most S2-S6 streams are represented by a line, effective management area widths also account for the stream body width. Double line streams – Within the GIS data all double-lined streams (i.e. polygons) are assigned a riparian reserve based on their classification.

These riparian management areas also protect other values such as riparian vegetation, wildlife habitat features and often culturally modified trees (CMTs).

Operationally, riparian management areas are established using slope distance; these zones are modelled using horizontal distance. Therefore, the area removed from the THLB for riparian management in the GIS data used in the timber supply analysis is slightly greater than the area that would be removed operationally using the same RMA widths.

Compared to MP #5, the THLB area reduction detailed in this Section is less than half. This is because the detailed operability review assisted with LiDAR data (LBB Process – Section 5.4.3) have already classified the land base as inoperable. Thus, the remaining non-contributing areas specific to riparian become less.

Table 15 Riparian Management Areas – TFL 44

Riparian Feature Class	Size Class	Reserve Zone (m)	Management Zone		Effective Management Area (m)[1]	Area Reduction (ha)
			Width (m)	Netdown (%)		
Ocean	*N/A*	40	0	100	40	83
Streams	*Width (m)*					
S1-A	>=100	0	100	60	60	-
S1-B	>20.0 - 99.9	50	20	50	60	90
S2	>5.0 - 20.0	30	20	75	45	546
S3	>1.5 - 5.0	20	20	50	30	261
S4	<1.5	0	30	67	20	164
S5	>3.0	0	30	67	20	1,946
S6	<3.0	0	20	25	5	863
Lakes	*Area (ha)*					
L1-A	>=1000	0	15	100	15	12
L1-B	>5.0 - 999.9	10	15	50	15	14
L2 (dry zones)	1.0 - 5.0	10	20	25	15	-
L3 (wet zones)	1.0 - 5.0	0	30	33	10	0
L4 (dry zones)	0.5 - 1.0	0	30	33	10	-
Wetlands	*Area (ha)*					
W1	>5.0	10	40	50	30	14
W2 (dry zones)	1.0 - 5.0	10	20	50	20	-
W3 (wet zones)	1.0 - 5.0	0	30	50	15	4.2
W4 (dry zones)	0.5 - 1.0	0	30	50	15	0.3
W5	>5.0	10	40	25	20	-

[1] Effective Management Area = RRZ + (RMZ *(netdown %/100)). This width is applied to both sides of streams and to the perimeter of lakes and wetlands

6.10 Ungulate Winter Ranges

An Ungulate Winter Range (UWR) is an identified area that contains habitat necessary for the winter survival of an ungulate species, and therefore are excluded from THLB. The most recent revised UWRs in TFL 44 were approved in October 2004 (U-1-013) for Columbian black-tailed deer and Roosevelt elk. The original 34 UWR's with a total area of 2,126 ha existed within the portion of TFL 44 at the point of establishment. As with most landscape-level reserves, a coarse scale approach was used in UWR design without detailed knowledge of development challenges in the immediate vicinity. As more accurate field work is completed, boundary discrepancies may arise at the operational scale and/or unforeseen timber impacts may become apparent. For this reason, the UWRs have been amended through time, with all amendments requiring government approval. Specifically, two UWRs were amended slightly in July 2005 and July 2006 to accommodate adjacent cutblocks. Table 16 shows the productive area and area reduction for the current UWRs. The spatial locations of the current UWRs are displayed in Figure 11.

Table 16 Ungulate Winter Ranges in TFL 44

Ungulate Species	Productive UWR Area (ha)	Area Reduction (ha)
Mule Deer	2,138	1,727
Total	***2,138***	***1,727***

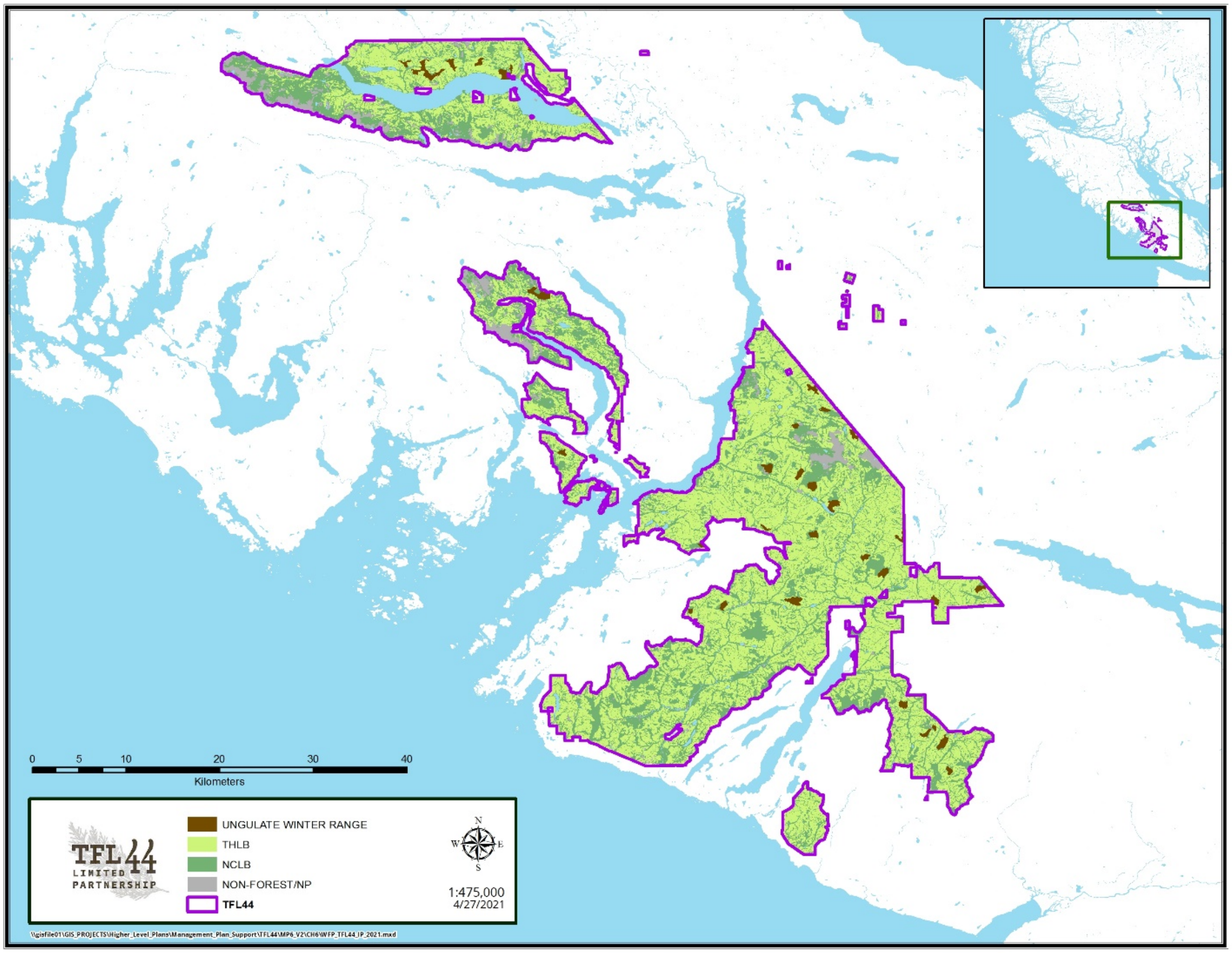

Figure 11 Ungulate Winter Ranges in TFL 44

6.11 Old Growth Management Areas

Landscape Units (LUs) are areas of land used for long-term planning of resource management activities. They are usually 50,000 to 100,000 hectares in size. LUs, Biodiversity Emphasis Options (BEOs) and old forest retention targets were designated through the *Order Establishing Provincial Non-Spatial Old Growth Objectives* effective June 30, 2004 (NSOG order). This order is in effect until Old Growth Management Areas (OGMAs) are spatially determined through Landscape Unit planning. The NSOG order specifies that the old forest retention target for landscape units with a Low BEO can be reduced by up to two-thirds to the extent necessary to address impacts on timber supply.

For TFL 44, OGMAs have been established within the Caycuse, Gordon, Great Central, Nitinat, Sproat Lake and Walbran landscape units at the time the timber supply analysis dataset was compiled. Draft OGMAs in the Ash, Corrigan, Effingham, Great Central, Henderson, Klanawa, Nitinat, and Sarita landscape units have been identified. These proposed OGMAs will be used in the timber supply analysis but must complete a public and First Nations' review process before becoming legal. China and Somass LU do not have any OGMAs because TFL 44 only has very small portion in these two LUs.

These established and draft OGMA areas do not contribute to the THLB in the model. Table 17 shows the productive areas and the THLB area reductions by LU and Figure 12 illustrates their corresponding spatial locations.

Table 17 OGMA Status and Areas in TFL 44

Landscape Unit	BEO	OGMA Status (Dec 2020)	OGMA Area (ha)	
			Productive	Area Reduction
Caycuse	Intermediate	Established	1,179	498
Gordon	Intermediate	Established	1	1
Great Central	Intermediate	Established	379	253
Nitinat	Intermediate	Established	2,096	1,001
Sproat Lake	Intermediate	Established	1	0
Walbran	Intermediate	Established	540	318
Established OGMAs (subtotal)			**4,196**	**2,070**
Ash	Intermediate	Draft	23	10
Corrigan	Intermediate	Draft	2,884	1,710
Effingham	Intermediate	Draft	258	70
Great Central	Intermediate	Draft	1,922	811
Henderson	Low	Draft	1,191	413
Klanawa	Intermediate	Draft	4,115	2,171
Nitinat	Intermediate	Draft	1	1
Sarita	Low	Draft	896	225
Draft OGMAs (subtotal)			**11,290**	**5,411**
OGMAs Total			**15,486**	**7,482**

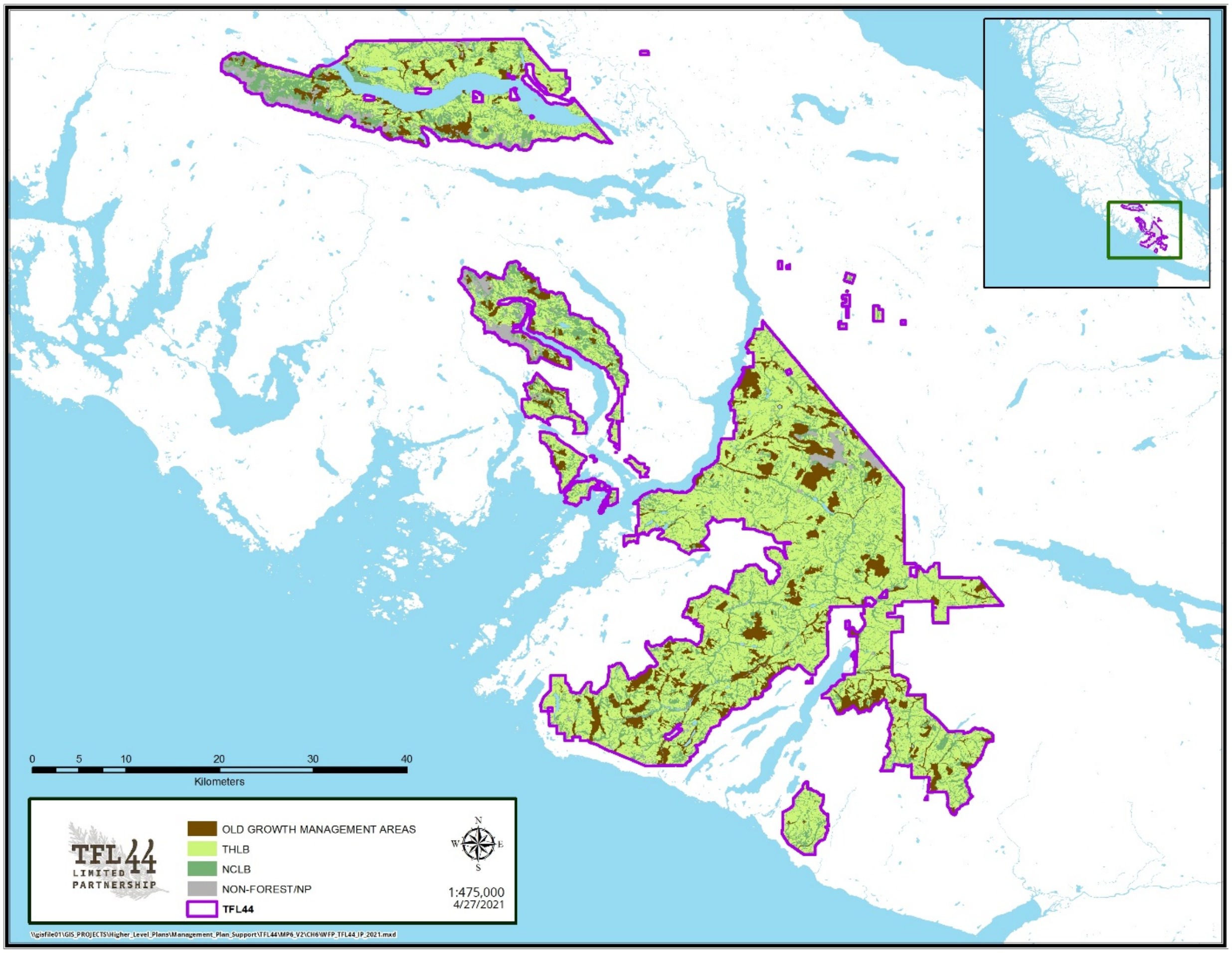

Figure 12 Old Growth Management Areas in TFL 44

6.12 Wildlife Habitat Areas

Wildlife Habitat Areas (WHAs) are established to conserve habitat of species at risk. In the absence of WHAs, Section 7 of the *Forest Planning and Practices Regulation* (FPPR) requires holders of a Forest Stewardship Plan (FSP) to specify a result or strategy to address species at risk habitat if a notice has been issued under section 7 of the FPPR.

6.12.1 Legally Established WHAs

There are 43 legally established WHAs within TFL 44 at the time the timber supply analysis dataset was compiled (Table 18 and Figure 13). The WHAs have a total area of 3,447 hectares and encompass 3,279 hectares of productive forest. The majority of the WHAs was established for Marbled Murrelet. Other focal species for WHAs in TFL 44 include Red-legged Frog and Scouler's Corydalis. A significant proportion of WHAs have been excluded from THLB due to factors discussed in the previous sections, mainly OGMAs, thereby reducing the incremental THLB netdown. Therefore, the incremental THLB impact for the legally established WHAs is 47 hectares.

Table 18 Legally Established Wildlife Habitat Areas in TFL 44

Description	Productive Wildlife Habitat Area (ha)	Area Reduction (ha)
Wildlife Habitat Area - Red-legged Frog	21	-
Wildlife Habitat Area - Marbled Murrelet	3,189	30
Wildlife Habitat Area - Scouler's Corydalis	68	17
Total	***3,279***	***47***

6.12.2 Pre-Approval WHAs

At the time the timber supply analysis dataset was compiled, there were three pre-approved WHAs which focused on the Northern Goshawk species within TFL 44. The BC Northern Goshawk Implementation Plan was released in February 2018. The key short-term action item is increasing the number of WHAs on Vancouver Island by 30. Other than the three identified pre-approved WHAs, there are currently no new WHAs being discussed. The pre-approval WHAs are moving through the approval process and should be approved soon. Like the legally established WHAs, the majority of the pre-approved WHAs has been accounted for in the previous netdown processes, thus the total THLB impact is limited to 131 ha. Details of the productive area and THLB impact can be found in Table 19.

Table 19 Pre-Approved Wildlife Habitat Areas in TFL 44

Description	Productive Wildlife Habitat Area (ha)	Area Reduction (ha)
Wildlife Habitat Area - Northern Goshawk	539	131
Total	***539***	***131***

In the future, additional WHAs may be established to conserve habitat for these species at risk or other species (as listed above). Currently, no further netdowns will be applied because the allocation of additional areas to IWMS is unknown. Figure 13 shows the location of these legal and pre-approved WHAs in TFL 44.

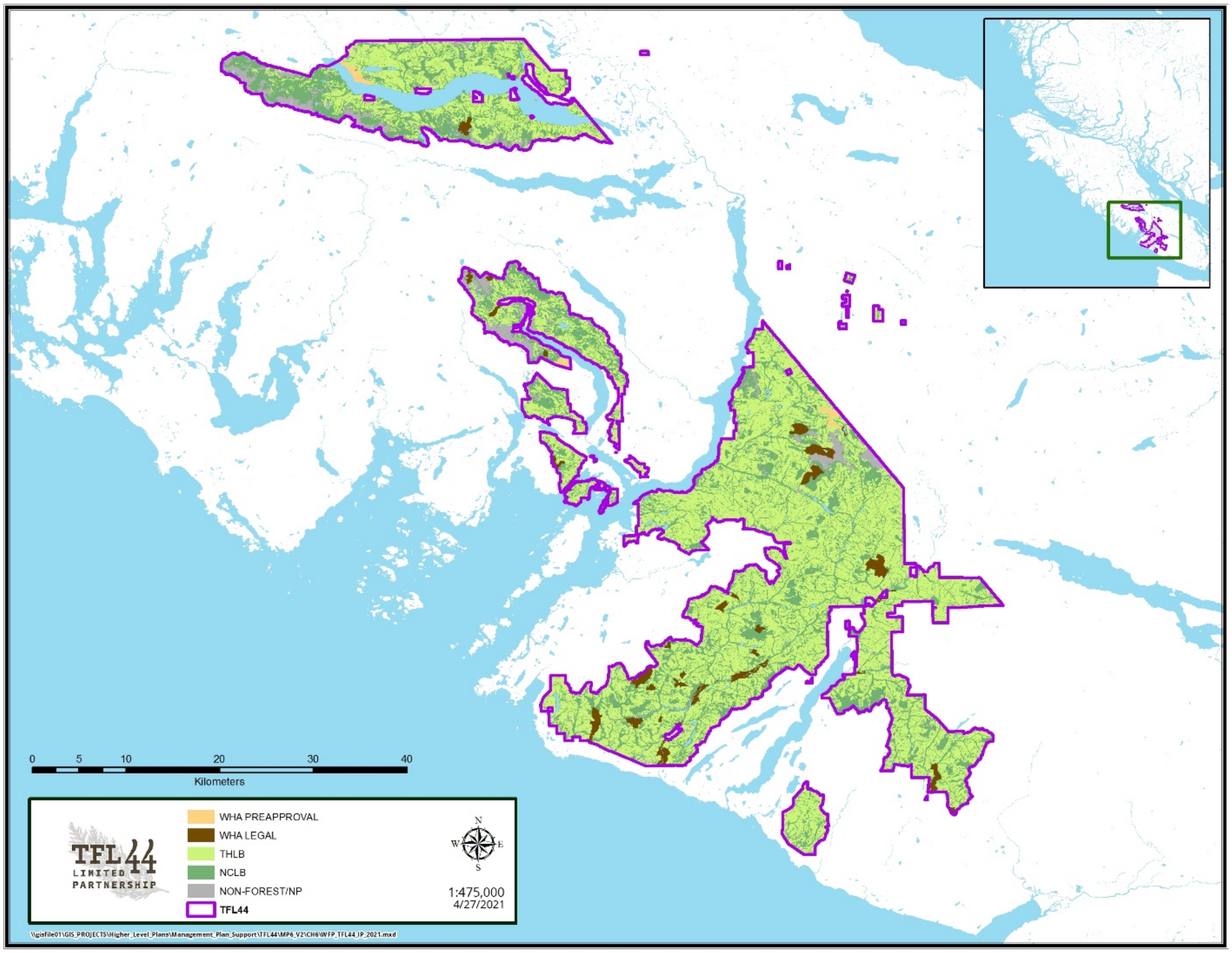

Figure 13 Legal and Pre-Approved Wildlife Habitat Areas in TFL 44

6.12.3 Impending Land Use Order for Marbled Murrelet

The BC Marbled Murrelet Implementation Plan was released in February 2018. One of the key actions is issuing an Order under the *Land Use Objectives Regulation* for suitable Marbled Murrelet habitat protection. The amount of suitable habitat being retained will increase with the Order. There will also be a requirement for 80% of the habitat to be spatialized and a currently undetermined proportion of the spatial polygons will have to be in patches greater than 20 ha with forest interior conditions. This Order will trigger a redesign of OGMAs to replace those OGMAs that only have a representation value with OGMAs of sufficient size to be suitable Marbled Murrelet habitat. For the base case, suitable Marbled Murrelet habitat was reviewed using a habitat inventory dataset that was compiled from low-level aerial (helicopter) surveys. All locations with habitat ranking greater than 3 on East Vancouver Island (Great Central/Ash/Corrigan/China/ Caycuse LUs) were excluded from the THLB. The total productive area and THLB impact are listed in Table 20. Spatial locations of the THLB exclusion area for Marbled Murrelet are illustrated in Figure 14.

Based on the available information on the draft Order, the spatial and aspatial targets for the Marbled Murrelet WHA and OGMA suitable habitat by LU at the time of the timber supply analysis dataset was assembled, a sensitivity analysis will be conducted to estimate the timber supply impact of the impending Order.

Table 20 Suitable Marbled Murrelet Habitat Areas in TFL 44

Species	Productive Wildlife Habitat Area (ha)	Area Reduction (ha)
Marbled Murrelet	983	564
Total	***983***	***564***

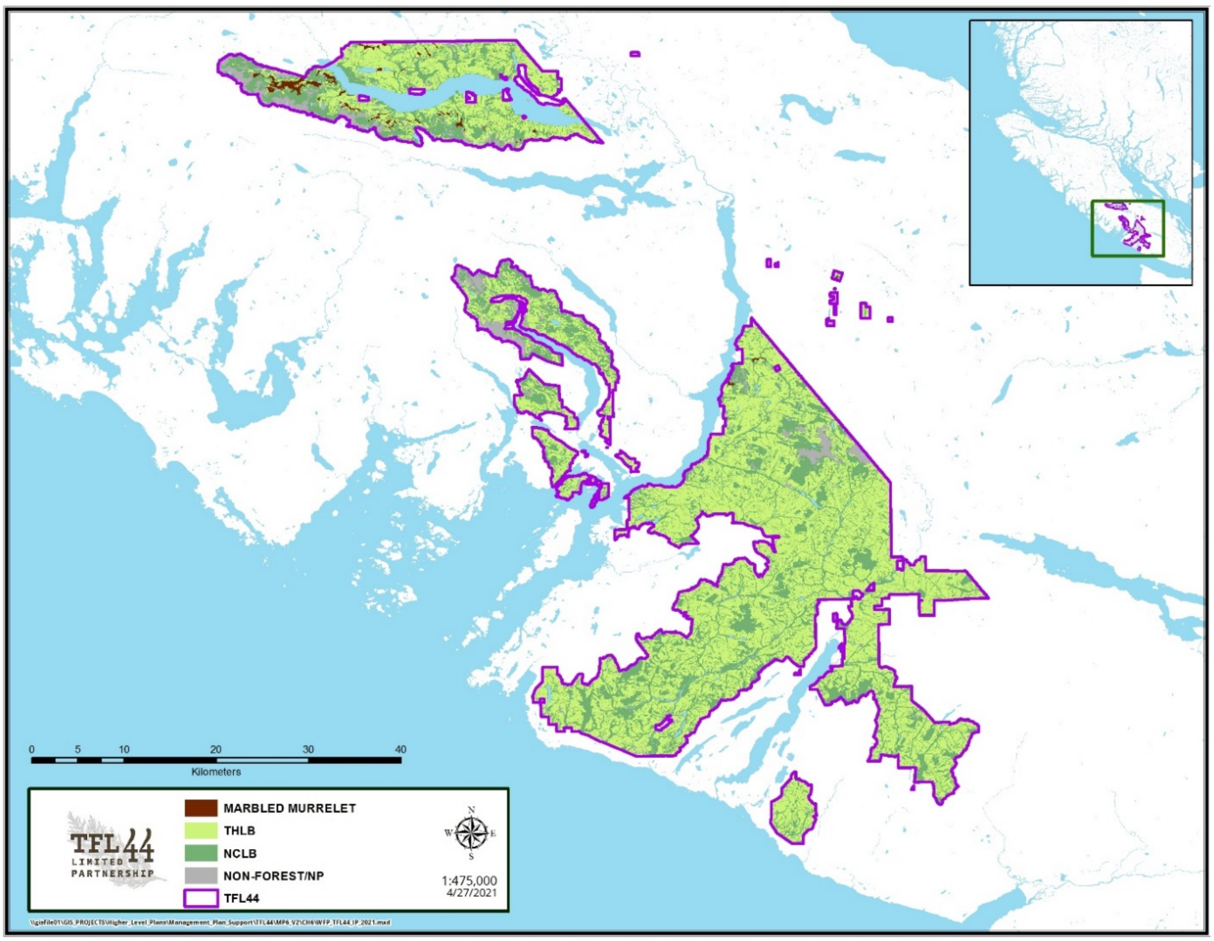

Figure 14 Marbled Murrelet Habitat Areas in TFL 44

6.13 Economic Operability

Delineation of the economic operability area was updated in preparation for MP #6. The mapping classifies areas as:

- Economic—available for harvest;
- Marginally economic—available for harvest under favourable market conditions, particularly where adjacent to economically operable stands; or
- Uneconomic—stand value is not expected to offset harvesting costs.

The process for updating operability utilizing LiDAR data, Land Base Blocking, is described in Section 5.4.3. The delineation of physical operability is described in Section 6.8. For this analysis, all conventionally operable area is assumed to be economic to harvest at some point in the market cycle once minimum harvest criteria is met. To determine economically operable non-conventional area, an analysis of forest inventory attributes and flight distances for areas harvested by helicopter between 2015 and 2019 was conducted. This time period was selected as it was the peak of the market cycle and should indicate the lowest value stands that can be expected to be harvested using non-conventional systems. The analysis results are presented in Table 21. Non-conventional areas that fail to meet these standards are deemed uneconomic.

Table 21 Inventory Attributes for Non-conventional Economic Operability in TFL 44

	Marginal		Economic	
Flight Distance (m)	**Minimum Volume (m3/ha)**	**Minimum Cw+Fd+Yc component**	**Minimum Volume (m3/ha)**	**Minimum Cw+Fd+Yc component**
0 - 499	350	15%	400	20%
500 – 999	370	25%	410	30%
1000 +	400	30%	500	30%

Stands removed from the THLB as uneconomic are summarized in Table 22 and indicated in Figure 15. A sensitivity analysis will test the impact of removing marginally economic stands from harvest.

Table 22 Area and Volume by Economic Operability Type in TFL 44

Description	Productive Area (ha)	Productive Volume ('000 m^3)	Area Reduction (ha)	Volume Reduction (000 m^3)
Economic	93,272	34,412	-	-
Marginal	1,255	1,176	-	-
Operable (subtotal)	***94,527***	***35,587***	***-***	***-***
Uneconomic	26,442	19,068	1,511	1,082
Total	***120,970***	***54,655***	***1,511***	***1,082***

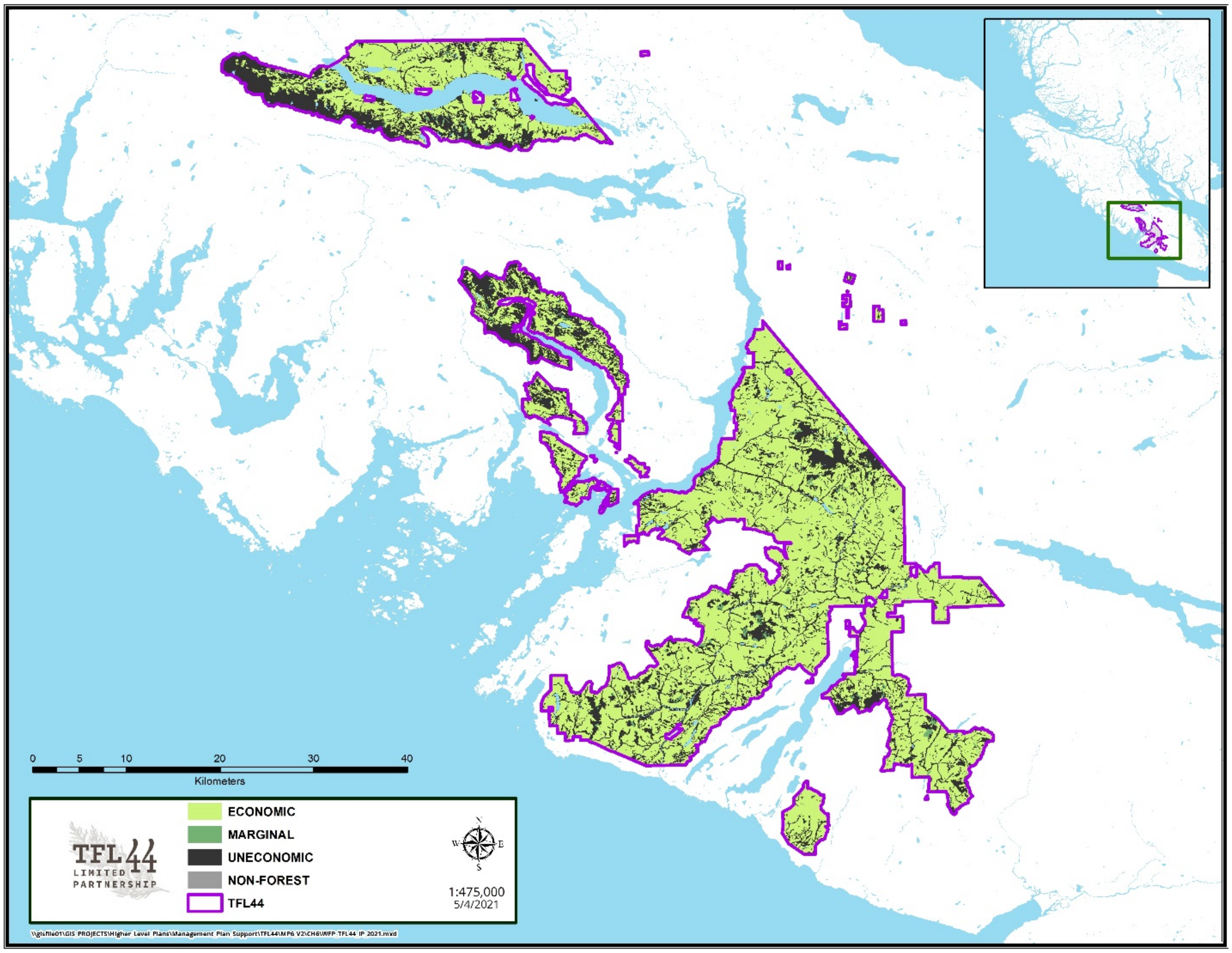

Figure 15 Economic Operability Classification for TFL 44

6.14 Deciduous-leading Stands

Table 23 and Figure 16 show the area and location of stands defined as deciduous leading in the inventory. This represents about 0.58% of the total productive area. All of which have been excluded from THLB due to other factors described above already.

Table 23 Deciduous-leading Stands in TFL 44

Description	Productive Deciduous Area (ha)	Area Reduction (ha)
Deciduous-leading stands	706	-
Total	***706***	***-***

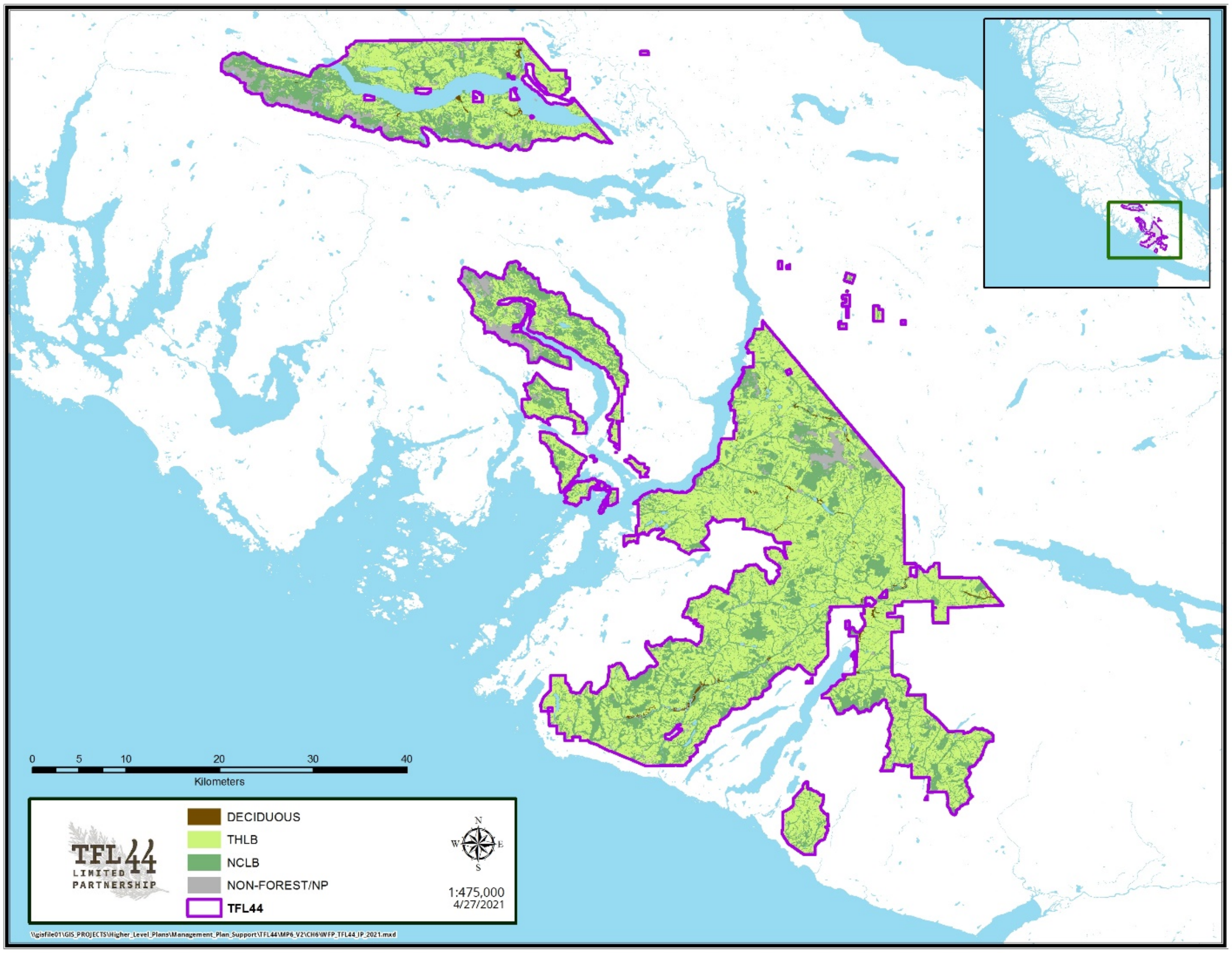

Figure 16 Deciduous-leading Stands in TFL 44

6.15 Recreation Features

On December 1, 2005, a Government Actions Regulation (GAR) Order was established to identify Recreation Sites, Trails and Interpretive Forest Sites as Resource Features for the South Island Forest District. All GAR recreation sites (REC3129 - Lowry Lake and REC5750 - Scout Beach) were removed from the THLB. Table 24 and Figure 17 shows the area and location for the recreation features.

Table 24 Recreation Features in TFL 44

Description	Productive Recreation Area (ha)	Area Reduction (ha)
Sites	6	6
Total	***6***	***6***

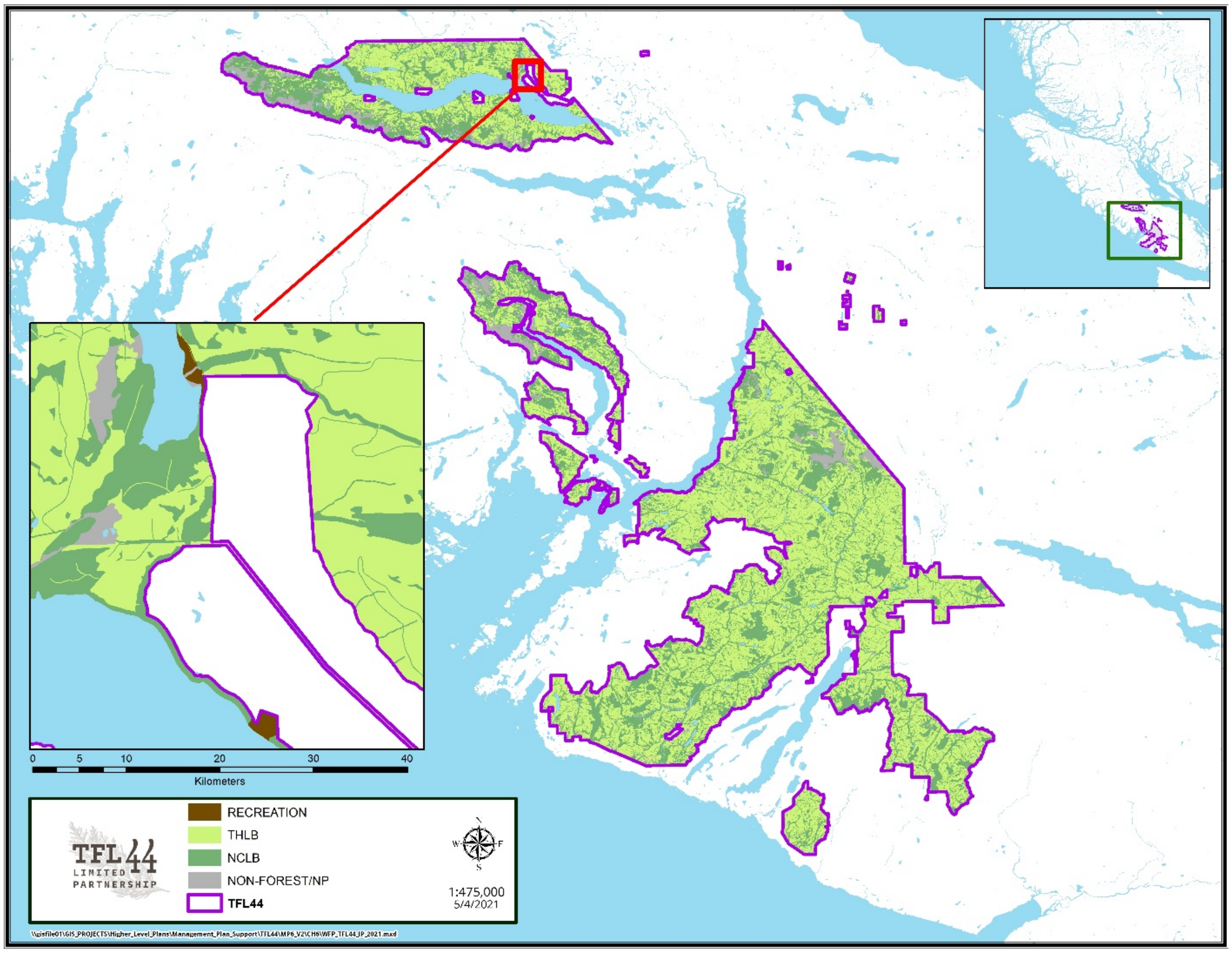

Figure 17 Recreation Features in TFL 44

6.16 Cultural Heritage Resources

The First Nations of British Columbia have varied cultures, histories and traditions. The *Heritage Conservation Act* provides protection and conservation of archaeological sites that contain evidence of human habitation or use before 1846. In accordance with the Act, archaeological sites may not be damaged, excavated or altered without a permit issued by the Minister responsible for the Act or a designate. The term “cultural heritage resources” applies to a variety of heritage resources defined in the *Forest Act* as “an object, a site or the location of a traditional societal practice that is of historical, cultural or archaeological significance to British Columbia, a community or an aboriginal people.” Under FRPA, the objectives set by government for cultural heritage resources are to conserve, or, if necessary, protect cultural heritage resources that are:

a) the focus of a traditional use by an aboriginal people that is of continuing importance to that people, and
b) not regulated under the *Heritage Conservation Act*.

Traditional knowledge and indigenous values are extremely important in forest practices on TFL 44, especially for Huumiis that is a partial owner of the TFL44 LP. WFP has signed agreements with First Nations in an effort to gain a fuller understanding of their interests in land and resources within their traditional territory and to seek reasonable ways to integrate those interests into WFP's forest resource management and planning processes. First Nations who have completed Traditional Use Studies (TUS) retain the detailed information regarding traditional use sites and values identified within their asserted traditional territories. TUS information is not typically shared with forest licensees, but where this information exists it is considered by decision-makers when making statutory decisions

The most common cultural heritage resources found within TFL 44 are culturally modified trees (CMTs). These are trees that have been modified by indigenous people as part of their traditional use of the forest. Examples of CMTs include trees with bark removed, stumps and felled logs, trees tested for soundness and trees with scars from plank removal. The most common and important species of tree used is western redcedar. In the past, an archaeological overview assessment (AOA) for TFL 44 was completed in the 2008/2009 financial year by I.R. Wilson Consultants Ltd. via Forest Investment Account (FIA) funding. The purpose of the AOA is to identify and assess archaeological resource potential with particular attention to sites that contain CMTs. Specifically, the AOA will provide a basis for predictions regarding archaeological site variability, density and distribution and provide a framework within which to judge the significance of sites. This assessment draws upon previously recorded archaeological sites in and around TFL 44, plus environmental and geographic variables.

TUS, AOA and Archaeological Inventory Studies (AIS) are landscape level inventories that have been completed for various portions of TFL 44. Numerous proposed cutblocks within TFL 44 have been intensively surveyed for CMTs. This stand level information has been entered into WFP's GIS database and is used for planning purposes. Retention of timber to protect these resources is addressed via stand-level retention netdowns (Section 6.17 and 6.20) and other landscape-level netdowns such as riparian management (Section 6.9). Archaeological sites registered with the provincial government will be removed from the THLB.

On March 14, 2013, a GAR Order was established to designate Thunder Mountain area as a cultural heritage resource - Resource Feature for the South Island Forest District. But the practice requirements or harvesting constraints are not specified in the GAR Order. A sensitivity analysis that excludes the Thunder Mountain GAR Order area from the THLB will be conducted to evaluate the overall timber supply impact in TFL 44.

Table 25 and Figure 18 shows the area reduction, location of the registered archaeological sites and the cultural heritage resource GAR Order area in TFL 44.

Table 25 Cultural Heritage Resources in TFL 44

Description	Productive Area (ha)	Area Reduction (ha)
Archaeological Sites	120	99
Total	120	99

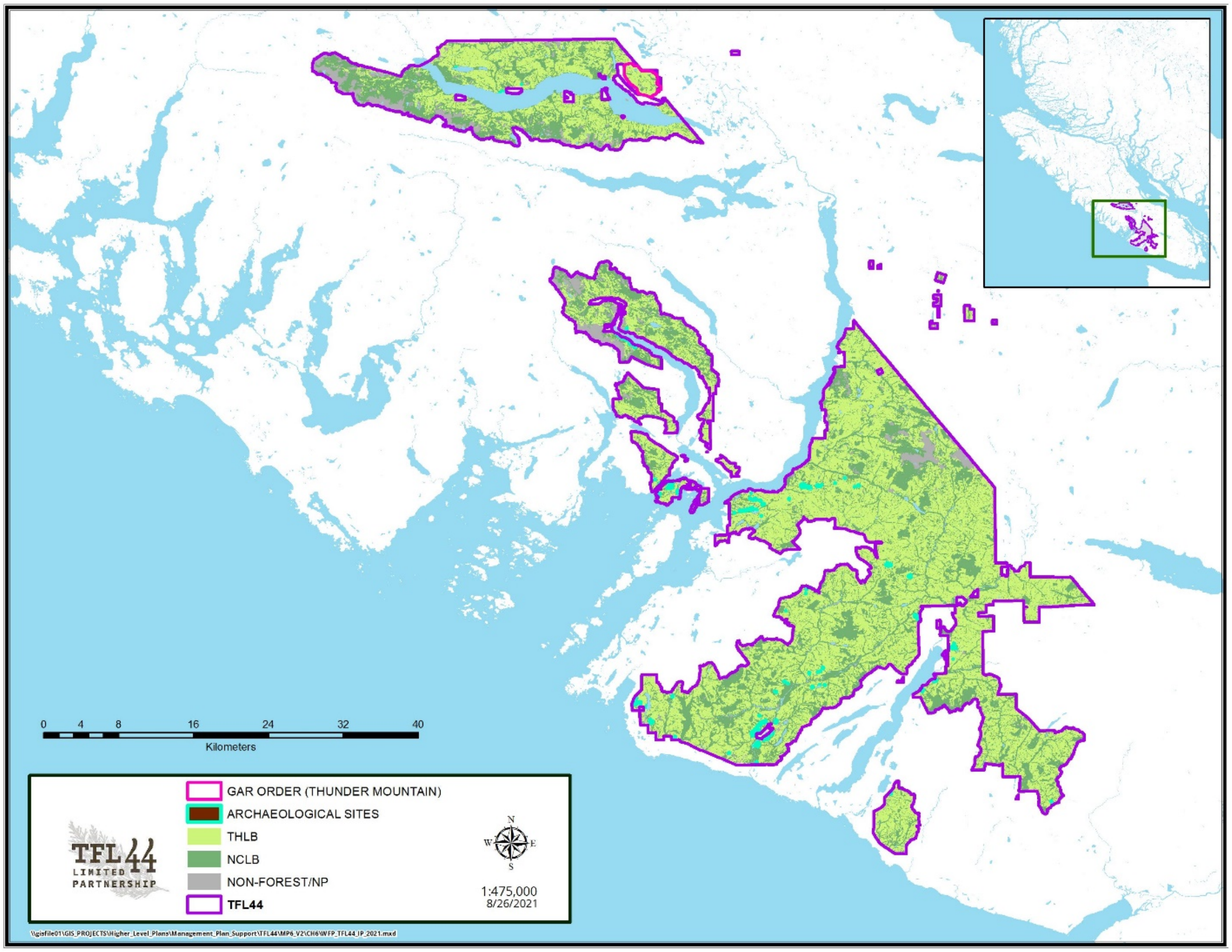

Figure 18 Cultural Heritage Resources in TFL 44

6.17 Existing Stand-Level Reserves

Stand-level reserves are important for maintaining biodiversity and wildlife habitat. Policy direction for wildlife tree management was initiated in 1985 with the release of *Protection of Wildlife Trees*. In 1995, with the introduction of the *Forest Practices Code of British Columbia* and the associated *Biodiversity Guidebook*, wildlife tree patches (WTPs) were designated for nearly every harvested cutblock. This requirement was continued under FRPA as wildlife tree retention areas (WTRAs). Landscape Unit Plans usually establish a WTP/WTRA objective by BEC variant.

Licensee forest management policies and/or strategies may dictate additional stand-level retention beyond those specified in legislation. Section 6.19 and Section 10.3.4 have further discussion on future stand-level retention.

The quantity and spatial location of the existing long-term stand-level retention areas excluded from the THLB are shown in Table 26 and Figure 19.

Table 26 Existing Stand-level Retention in TFL 44

Description	Productive Retention Area (ha)	Area Reduction (ha)
Existing stand-level retention	5,819	2,762
Total	5,819	2,762

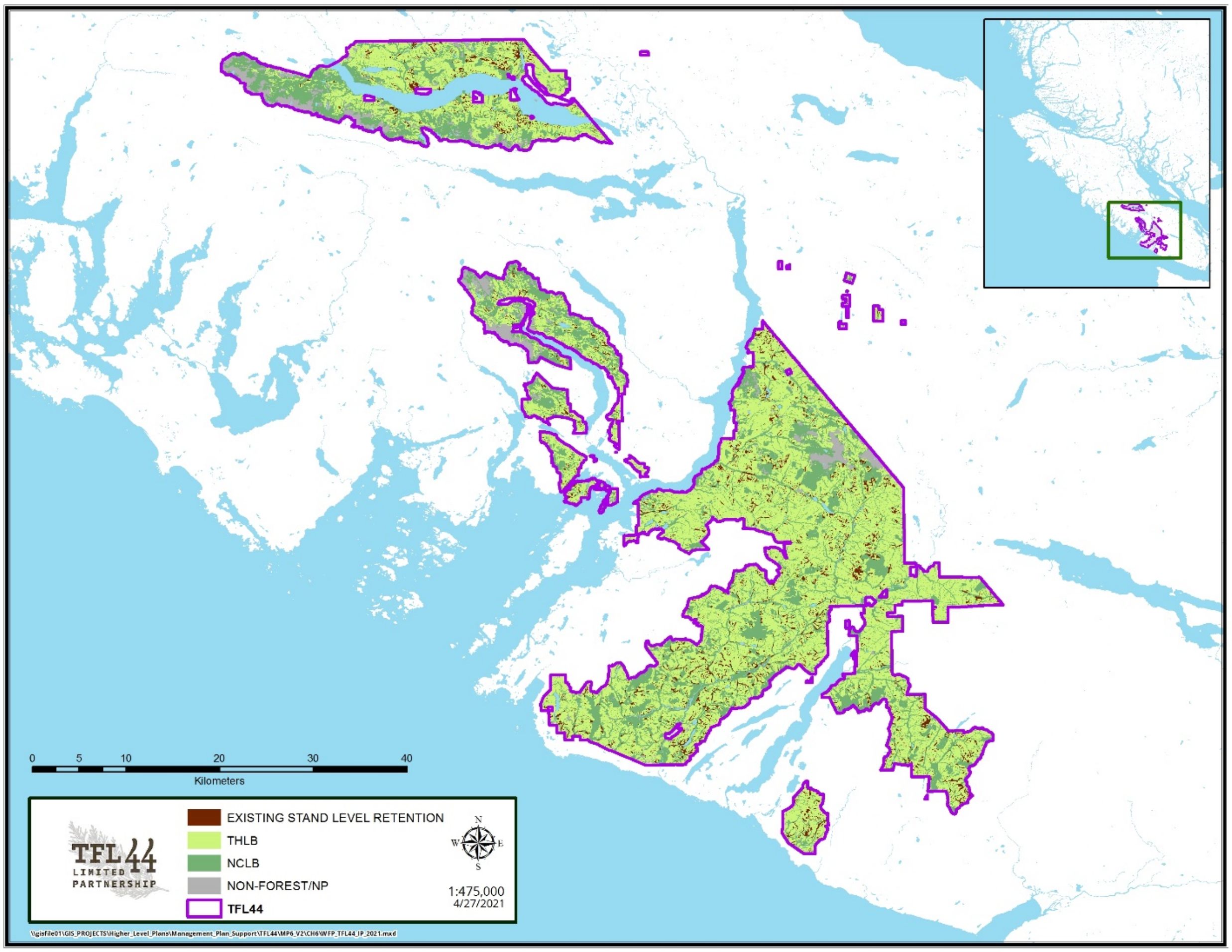

Figure 19 Existing Stand-level Retention in TFL 44

6.18 Terrain Stability

There are several different types of terrain stability mapping in TFL 44.

The majority of the Alberni East area has had new terrain stability mapping done during MP #4 under different FRBC/FIA projects completed in 2001 - 2003. There is Detailed Terrain Stability Mapping (DTSM or 5-class) in the community watersheds (Malachan, Sugsaw, and Cousteau Creeks) and in the Caycuse and Walbran watersheds south of Caycuse Creek. A pilot project encompassing the Klanawa and Darling watersheds and extending partway into South Sarita, Pachena, and Nitinat watershed units was completed by Denny Maynard & Associates and Golder Associates. The pilot project used DTSM and landslide inventory data to define statistically-based terrain stability polygons for both landslides from roads and within cutblocks. The rest of Alberni East has reconnaissance terrain stability mapping (RTSM – Potentially unstable (P), Unstable (U)).

The Great Central Lake area has earlier Environmentally Sensitive Area (Es1/Es2) mapping before MP #5 was produced. The Henderson Lake area has earlier DTSM in the Clemens Creek watershed and old Es1/Es2 mapping for the rest. There is a very small area of DTSM in the Haggard community watershed. The pilot project explained above was expanded to include the Nahmint watershed and therefore covers the Maa-Nulth treaty lands in the lower Nahmint.

As a result, in MP #5, a review was conducted to develop terrain stability netdowns in support of timber supply analysis. Landslide occurrence data was reviewed (see Appendix D: Terrain Stability Mapping Review). The outputs of this review include a refreshed terrain mapping was produced, and netdowns for areas covered by older mapping. The same methodology will be followed in this timber supply analysis. Table 27 indicates the netdowns recommended by this review. Table 28 indicates the areas removed from the THLB based on the above netdowns. The spatial representation of these areas is shown in Figure 20.

Table 27 Terrain Stability Netdowns

Terrain Zone	**Terrain Classification Netdown (%)**									
	"Red"	**"Orange"**	**Class V**	**Class IV**	**Old Class 5**	**Old Class 4**	**U**	**P**	**Es1**	**Es2**
Landslide Frequency Mapping Pilot Project	100	20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Alberni East High RLF[1] (outside CWS)	n/a	n/a	90	10	n/a	n/a	90	10	n/a	n/a
Alberni East High RLF (inside CWS)	n/a	n/a	90	20	n/a	n/a	n/a	n/a	n/a	n/a
Alberni East Moderate RLF	n/a	n/a	n/a	5	90	20	50	5	n/a	n/a
Great Central Lake - drier eastern portion	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	36.7	5
Great Central Lake - wetter western portion	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	58	10
Henderson Lake	n/a	n/a	n/a	n/a	24.2	9.3	n/a	n/a	34.7	16.3

[1] RLF – Relative Landslide Frequency

Table 28 Terrain stability netdown areas

Terrain Zone	Terrain Classification Netdown (ha)										
	Red	Orang e	Clas s V	Clas s IV	Old Class 5	Old Class 4	U	P	Es1	Es2	Total
Landslide Frequency Mapping Pilot Project	926	425	-	-	-	-	-	-	-	-	1,35 1
Alberni East High RLF (outside CWS)	-	-	178	97	-	-	510	469	-	-	1,25 4
Alberni East High RLF (inside CWS)	-	-	3	2	-	-	-	-	-	-	5
Alberni East Moderate RLF	-	-	-	-	27	9	115	106	-	-	258
Great Central Lake - drier eastern portion	-	-	-	-	-	-	-	-	131	63	194
Great Central Lake - wetter western portion	-	-	-	-	-	-	-	-	268	133	401
Henderson Lake	-	-	-	0	95	50	-	-	172	196	513
Total	926	425	180	99	122	59	625	576	570	392	3975

In addition to terrain netdowns, an effective clearcut area limit with hydrologic recovery in yields will be placed on watersheds to restrict harvest-related effects on steep slopes in the Nitinat River (excluding Little Nitinat), as detailed in Section 10.2.7 and Appendix E: Hydrologic Recovery Method Review.

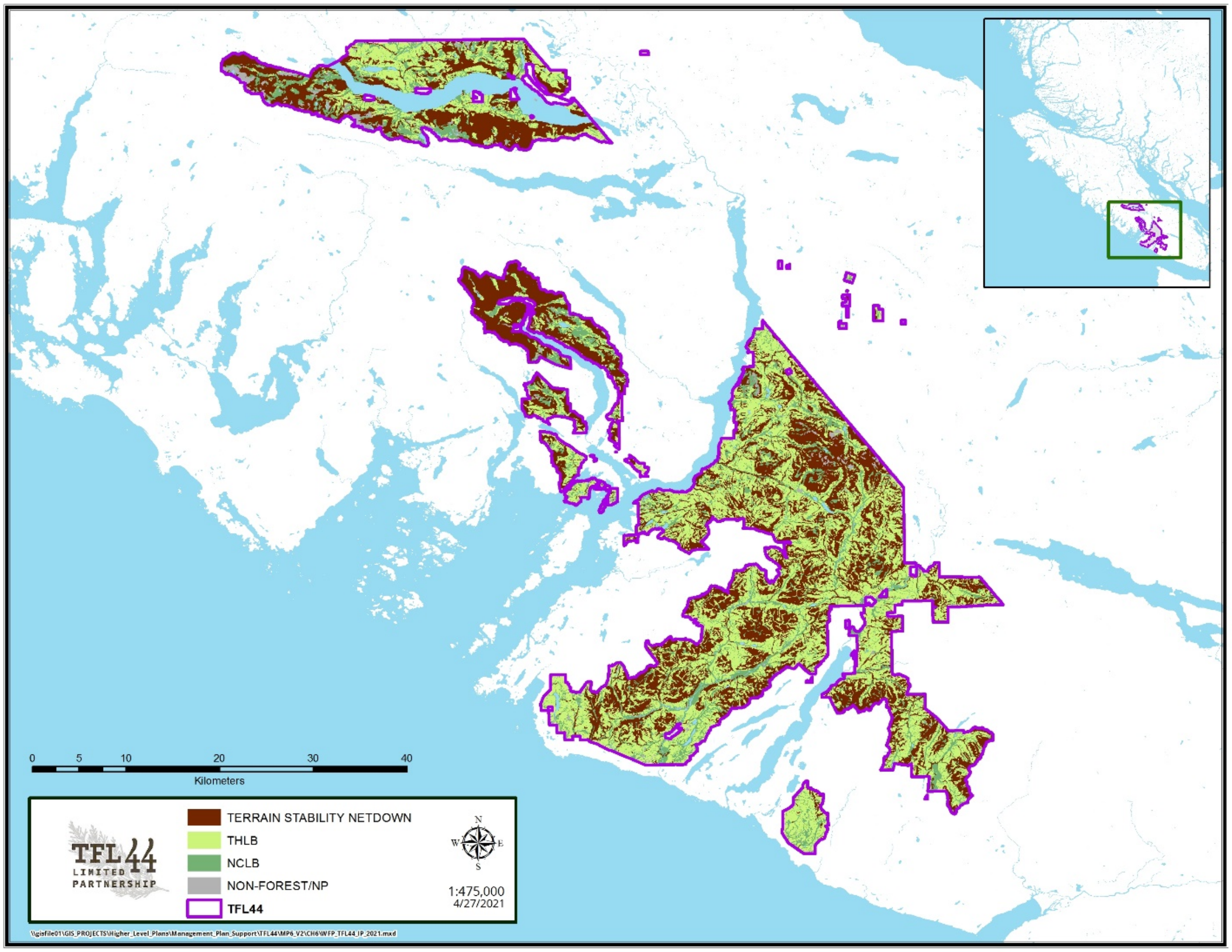

Figure 20 Terrain Stability Netdowns in TFL 44

6.19 Future Stand-Level Retention

6.19.1 Wildlife Tree Retention Areas

Where feasible and wildlife objectives can be met, WTRA are located in constrained areas such as riparian reserves, inoperable stands or unstable slopes. In order to capture those WTRA located in harvestable areas a THLB area reduction is applied. For some LUs (Caycuse, Nitinat and Walbran), future WTRA retention targets are specified in the *Notice of Order Establishing Land Use Objectives for the Renfrew Area on Southern Vancouver Island*. For other LUs, 7% is used as the target for future WTRA retention, as defined by the Forest Planning and Practices Regulations (FPPR).

In order to account for WTRA located in harvestable areas a THLB area reduction is applied. A review of the same harvested or planned cutblocks (2000-2019) used to derive the riparian management areas (Section 6.9) indicated that 30% of the stand-level retention was located on otherwise harvestable land base. Therefore a 2% area netdown (0.3 * 7% ≈ 2%) is applied to account for future WTRA requirements.

6.19.2 Additional Stand Retention

For operational forest practices, Tsawak-qin is currently following WFP's Stewardship and Conservation Plan (WSCP). As detailed in Section 10.3.4, applying the retention silviculture system described in WSCP results in at least 58.8% of the harvest area in TFL 44 being within retention system cutblocks (with the remainder being clearcut or clearcut-with-reserves). As WSCP retention requirements differ by resource management zone and BEC subzone, varying netdowns are applied such that the total THLB reduction is consistent with the results of the review discussed in Section 6.19.1. Table 29 describes the overall stand-level retention targets with WTRA targets and WSCP targets combined for each LU; Table 30 shows the THLB area reduction as a result of these targets.

Table 29 Stand-level Retention Targets by LU

Landscape Unit[1]	BEC	WTRA Target (%)	Weighted Average Retention Target with WSCP (%)
Ash	All	7	13.5
Caycuse	CWHvm	11	16.1
	CWHmm & CWHxm	14	17.3
	MHmm	4	10.6
China	All	7	12.9
Corrigan	All	7	11.8
Effingham	All	7	8.5
Great Central	All	7	16.3
Henderson	All	7	13
Klanawa	All	7	8.5
Nitinat	CWHvh	2	6
	CWHvm	12	13.4
	CWHmm	14	18.2
	CWHxm	15	18.5
	MHmm	4	7
Sarita	All	7	12.3
Walbran	CWHVM	6	15.7
	MHmm	0	9

[1] Gordon/Nahmint/Somass/Sproat Lake LUs are not listed due to the relatively small proportion within TFL 44; Activities on the non-TFL portion of these LUs will outweigh any retention targets applied to the TFL portion.

Table 30 THLB % Netdowns for Stand-level Retention

Western Forest Stewardship Zone	Productive Area (ha)	THLB % reduction for WTRA	THLB % reduction for WSCP	Total THLB % reduction	Area reduction (ha)
Enhanced Basic	20,541	2%	2.6%	4.6%	509
Enhanced Dry	1,086	2%	3.5%	5.5%	37
General Basic	25,386	2%	3.5%	5.5%	842
General Dry	4,222	2%	5.1%	7.1%	186
Special	3,803	2%	6.0%	8.0%	216
Total	***55,038***	**-**	**-**	**-**	***1,790***

A sensitivity analysis will be conducted to remove the impact from WSCP.

6.20 Future Roads

Utilizing LiDAR data, the physical operability inventory for TFL 44 (refer to Section 6.8) was updated by WFP. A key component of this update was the projection of future roads to develop conventional harvest opportunities. Any further conventional harvest development is believed to be achieved using minimal road length; therefore, the projected roads are a practical representation of future roads and will be incorporated into the analysis dataset. The area available for timber production within the road right of way will be reduced when these polygons are modelled to be harvested.

Table 31 indicates future road areas in the TFL that have to be developed to access blocks for conventional harvesting.

Table 31 Future Roads in TFL 44

Description	Productive Area (ha)	Area Reduction (ha)
Future Roads	203	203
Total	203	203

6.21 Caves and Karst

Karst landscapes are sensitive to logging impacts due to safety concerns, the intrinsic value of cave systems, and the presence of karst-associated flora and fauna. With the assistance of local members of the Vancouver Island Cave Exploration Group (VICEG), WFP has created a cave inventory in the GIS database which is kept confidential, but is referenced during development planning. Additionally, data from the provincial Reconnaissance Karst Potential Mapping is available for reference. The impact of protecting karst features on timber supply is uncertain. To date, little area has been reserved during operational planning to protect karst features (the majority of the known caves and karst potential polygons are either on the private lands that were removed from the TFL or the area deleted from the TFL to form part of the Pacific TSA). Estimates of impacts will improve as operational planning proceeds in karst areas. For this analysis, no netdowns for karst management will be made as it is assumed that any reserves required are accounted for by the stand-level retention allowances (see Section 6.19).

7 INVENTORY AGGREGATION

This section describes the delineation of the TFL landbase and definition of stand types needed to complete the timber supply analysis. The TFL area is categorized in a hierarchy of different management zones to allow for a variety of forest cover constraints (e.g., biodiversity). Stand types are grouped in analysis units (AU) based on similar leading species, history and productivity. Areas within all tables in this section may not sum due to rounding to the nearest hectare.

7.1 Resource Management Zones

Unique forest cover objectives will be modelled through the different management zones. There are three VILUP Resource Management Zones:

- Special Management Zones (SMZs),
- General Management Zones (GMZs),
- Enhanced Forestry Zones (EFZs)

These zones are delineated in the data (Table 32 and Figure 21) and will be used to apply forest cover constraints (see Section 10.2 for details). Noted that some LUs and RMZs only have small overlap with TFL 44 boundary. In addition, boundaries may differ in the GIS data used to construct the master database, even though in reality they are defined by the same height-of-land. Therefore, some management restrictions associated with the RMZ types may be difficult to apply to "slivers." Detailed descriptions on RMZs and LUs are outlined in Section 7.1 and Section 7.2, respectively. Noted that RMZs on this list are slightly different from Table 2 as RMZs with relatively small proportion within TFL 44 are excluded - activities and management efforts on the non-TFL portion of these RMZs will outweigh any constraints applied to the TFL portion.

Table 32 Area by Resource Management Zone for TFL 44

Mgmt Zone	Mgmt Unit	SeralStage[1]	Productive Forest (ha)	THLB Area (ha)	Management Considerations (from Vancouver Island Summary Land Use Plan)
SMZ 18	Alberni Canal	Early	485	439	***Special Management Zone*** with emphasis on maintenance of visual quality as seen from marine traffic area, as well as recreation and tourism opportunities associated with marine environment; maintenance of coastal habitats.
		Mid	1,004	785	
		Mature	363	214	
		Old	766	210	
		Total	**2,618**	**1,649**	
GMZ 35	Ash-Central-Sproat	Early	5,417	4,843	***General Management Zone*** with significant timber values and particular suitability for enhanced silviculture and growth and yield management. Due to its proximity to population centres, association with intensively managed roaded resource lands, significant wildlife
		Mid	3,838	2,345	
		Mature	817	305	
		Old	4,821	1,532	
		Total	**14,894**	**9,026**	

[1] Early seral is <40 years old; Mid seral is 40-80 years old in CWH zone and 40-120 years old in MH zone; Mature seral is 81-250 years old in CWH zone and 121-250 years old in MH zone; Old seral is >250 years old.

Mgmt Zone	Mgmt Unit	SeralStage[1]	Productive Forest (ha)	THLB Area (ha)	Management Considerations (from Vancouver Island Summary Land Use Plan)
					and fish values and biodiversity, conservation/restoration is recommended. This is consistent with the intermediate level of significance with an emphasis on active restoration of mature and old seral attributes.
SMZ 14	Barkley Sound	Early	636	561	***Special Management Zone*** with particular emphasis on maintenance of marine/coastal recreation opportunities, as well as marine/coastal habitats; resource management should be guided by the Barkley Sound Planning Strategy (1994).
		Mid	90	46	
		Mature	-	-	
		Old	487	92	
		Total	**1,214**	**699**	
GMZ 41	Cameron-China	Early	67	52	***General Management Zone*** with particular emphasis on maintaining watershed integrity, as well as fish, wildlife, and recreation values.
		Mid	112	75	
		Mature	123	56	
		Old	70	33	
		Total	**371**	**216**	
EFZ 42	Corrigan	Early	4,386	4,200	***Enhanced Forestry Zone*** with particular emphasis on enhanced silviculture and increased growth and yield. Wildlife values require heightened management attention with an intermediate biodiversity significance. Other non-timber and non-forest values are to be addressed at the basic level of stewardship.
		Mid	6,124	4,181	
		Mature	1,447	778	
		Old	3,279	628	
		Total	**15,236**	**9,787**	
EFZ 38	Effingham	Early	634	558	***Enhanced Forestry Zone*** with opportunities for enhanced timber harvesting, and maintenance of ungulate range value. Biodiversity conservation is at the intermediate level.
		Mid	58	44	
		Mature	73	28	
		Old	869	163	
		Total	**1,635**	**793**	
GMZ 46	Gordon-Caycuse-San Juan	Early	5,772	4,946	***General Management Zone*** with significant timber values combined with high fish, wildlife and biodiversity values, as well as recreation values.
		Mid	1,036	715	
		Mature	226	109	
		Old	3,671	893	
		Total	**10,706**	**6,664**	
GMZ 37	Henderson	Early	3,576	2,981	***General Management Zone***, with high proportion of mature timber, to be developed with due concern for fish, hydrological and watershed integrity.
		Mid	511	416	
		Mature	165	52	
		Old	4,784	1,167	
		Total	**9,036**	**4,616**	
EFZ 44	Klanawa	Early	12,956	11,498	***Enhanced Forestry Zone*** with significant opportunities for enhanced timber harvesting and enhanced silviculture; high fish values; conservation of biodiversity at the intermediate emphasis level.
		Mid	3,207	1,820	
		Mature	715	199	
		Old	7,324	1,183	
		Total	**24,202**	**14,700**	

Mgmt Zone	Mgmt Unit	SeralStage[1]	Productive Forest (ha)	THLB Area (ha)	Management Considerations (from Vancouver Island Summary Land Use Plan)
GMZ 45	Nitinat	Early	8,706	7,761	***General Management Zone***, with particular opportunity and suitability for enhanced silviculture and growth and yield; wildlife values require heightened management attention; significant recreation, tourism and scenic values, as well as known cultural heritage values.
		Mid	8,352	6,000	
		Mature	242	157	
		Old	6,114	1,805	
		Total	**23,414**	**15,722**	
EFZ 43	Sarita	Early	5,053	4,524	***Enhanced Forestry Zone*** with particular emphasis on enhanced silviculture and increased growth and yield, as well as limited enhanced harvesting opportunity; fish and wildlife as well as community water values require heightened management attention; other non-timber (including biodiversity) values are to be at the basic level of stewardship.
		Mid	3,860	2,991	
		Mature	53	30	
		Old	2,711	861	
		Total	**11,677**	**8,406**	
SMZ 17	Strathcona-Taylor	Early	977	801	***Special Management Zone*** with emphasis on maintaining fish, wildlife and old growth biodiversity values, while maintaining special timber resource management opportunities.
		Mid	342	130	
		Mature	541	101	
		Old	3,426	643	
		Total	**5,285**	**1,674**	
SMZ 21	Walbran Periphery	Early	241	213	***Special Management Zone*** to be managed as a focal area for old seral forest retention, with emphasis on riparian areas; recreation access management.
		Mid	-	-	
		Mature	4	-	
		Old	295	30	
		Total	**539**	**243**	
SMZ 0	E&N/McBride/Not in Vancouver Island Resource Targets	Early	24	22	***N/A***
		Mid	6	6	
		Mature	58	35	
		Old	55	5	
		Total	**144**	**67**	
Grand Total			**120,970**	**74,261**	

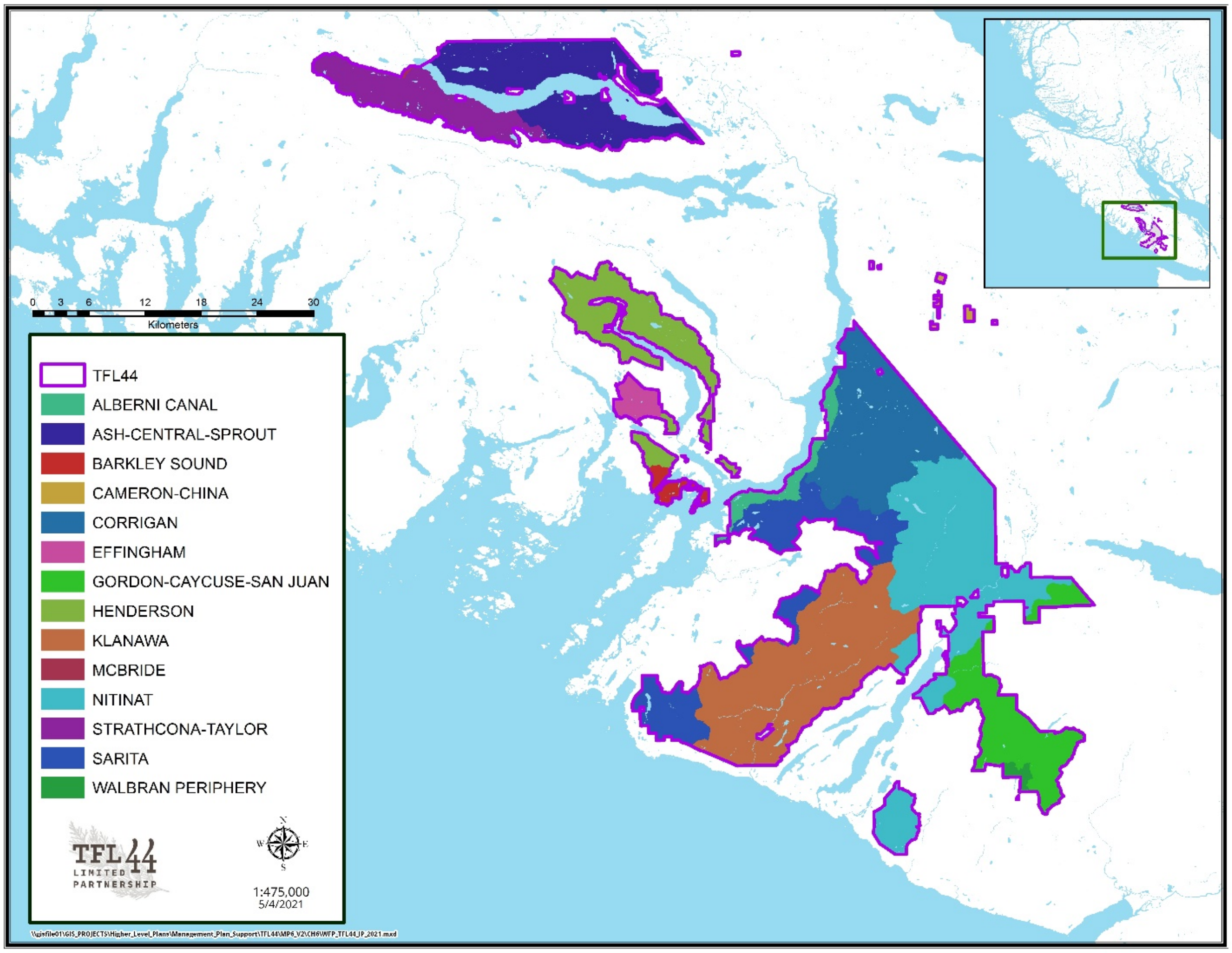

Figure 21 Resource Management Zones for TFL 44

7.2 Landscape Units

As discussed in Section 6.11, fifteen landscape units are found within TFL44:

- Ash
- Caycuse
- China
- Corrigan
- Effingham
- Gordon
- Great Central
- Henderson
- Klanawa
- Nahmint
- Nitinat
- Sarita
- Somass
- Sproat Lake
- Walbran

Old seral targets and corresponding old growth management areas are based on landscape unit and Biogeoclimatic Ecosystem Classification zone, subzone, and variant (BEC). Table 33 presents the seral stage distribution of the productive forest by BEC within each landscape unit while Figure 22 indicates the boundaries of the landscape units.

Table 33 Area by Landscape Unit and BEC variant in TFL 44

Landscape Unit	BEC	Seral Stage[1]	Productive Forest (ha)	Non Contributing Area		THLB Area	
				ha	%	ha	%
Ash	CWHmm1	Early	625	82	13%	543	87%
		Mid	-	-	N/A	-	N/A
		Mature	10	9	91%	1	9%
		Old	457	252	55%	205	45%
	CWHmm1 Total		1,091	342	31%	749	69%
	CWHmm2	Early	336	17	5%	319	95%
		Mid	88	4	5%	84	95%
		Mature	14	12	84%	2	16%
		Old	686	356	52%	331	48%
	CWHmm2 Total		1,124	389	35%	736	65%
	CWHxm2	Early	26	1	3%	25	97%
		Mid	59	8	13%	52	87%
		Mature	7	0	3%	7	97%
		Old	2	0	5%	2	95%
	CWHxm2 Total		94	9	9%	86	91%
	MHmm1	Early	4	0	5%	4	95%
		Mid	-	-	N/A	-	N/A
		Mature	-	-	N/A	-	N/A
		Old	186	98	53%	89	48%
	MHmm1 Total		190	98	51%	92	49%
Ash Total			**2,500**	**837**	**33%**	**1,663**	**67%**
Caycuse	CWHmm1	Early	40	14	34%	27	66%
		Mid	167	45	27%	122	73%
		Mature	-	-	N/A	-	N/A
		Old	-	-	N/A	-	N/A
	CWHmm1 Total		208	59	28%	149	72%
	CWHvm1	Early	2,293	362	16%	1,931	84%
		Mid	359	90	25%	269	75%
		Mature	130	61	47%	68	53%
		Old	1,466	1,101	75%	365	25%
	CWHvm1 Total		4,248	1,614	38%	2,634	62%
	CWHvm2	Early	497	61	12%	437	88%

[1] Early seral is <40 years old; Mid seral is 40-80 years old in CWH zone and 40-120 years old in MH zone; Mature seral is 81-250 years old in CWH zone and 121-250 years old in MH zone; Old seral is >250 years old.

Landscape Unit	BEC	Seral Stage[1]	Productive Forest (ha)	Non Contributing Area		THLB Area	
				ha	%	ha	%
		Mid	201	32	16%	169	84%
		Mature	3	3	100%	-	0%
		Old	560	450	80%	110	20%
	CWHvm2 Total		1,261	545	43%	716	57%
	CWHxm2	Early	203	15	7%	188	93%
		Mid	304	149	49%	155	51%
		Mature	63	24	38%	39	62%
		Old	19	18	95%	1	5%
	CWHxm2 Total		589	206	35%	383	65%
	MHmm1	Early	-	-	N/A	-	N/A
		Mid	-	-	N/A	-	N/A
		Mature	-	-	N/A	-	N/A
		Old	36	28	78%	8	22%
	MHmm1 Total		36	28	78%	8	22%
Caycuse Total			**6,341**	**2,452**	**39%**	**3,890**	**61%**
China	CWHmm2	Early	42	8	18%	35	82%
		Mid	97	36	37%	61	63%
		Mature	104	55	53%	49	47%
		Old	49	22	46%	26	54%
	CWHmm2 Total		293	121	41%	172	59%
	CWHxm2	Early	20	4	17%	17	82%
		Mid	7	1	12%	6	88%
		Mature	49	14	28%	35	72%
		Old	21	14	65%	7	34%
	CWHxm2 Total		96	31	33%	65	67%
	MHmm1	Early	4	3	83%	1	18%
		Mid	-	-	N/A	-	N/A
		Mature	1	-	0%	1	100%
		Old	2	2	100%	-	0%
	MHmm1 Total		6	5	78%	1	22%
China Total			**395**	**158**	**40%**	**238**	**60%**
Corrigan	CWHmm2	Early	72	6	9%	66	91%
		Mid	105	18	17%	87	83%
		Mature	10	3	27%	7	73%
		Old	139	116	83%	23	17%
	CWHmm2 Total		326	143	44%	184	56%
	CWHvm1	Early	2,250	86	4%	2,164	96%
		Mid	4,914	1,494	30%	3,420	70%
		Mature	1,010	411	41%	598	59%
		Old	1,224	1,033	84%	191	16%

Landscape Unit	BEC	Seral Stage[1]	Productive Forest (ha)	Non Contributing Area		THLB Area	
				ha	%	ha	%
	CWHvm1 Total		9,398	3,024	32%	6,374	68%
	CWHvm2	Early	689	39	6%	650	94%
		Mid	343	65	19%	277	81%
		Mature	74	34	46%	40	54%
		Old	1,299	997	77%	303	23%
	CWHvm2 Total		2,405	1,135	47%	1,270	53%
	CWHxm2	Early	1,429	56	4%	1,374	96%
		Mid	1,233	479	39%	753	61%
		Mature	643	336	52%	307	48%
		Old	436	371	85%	65	15%
	CWHxm2 Total		3,742	1,242	33%	2,500	67%
	MHmm1	Early	-	-	N/A	-	N/A
		Mid	5	4	73%	1	29%
		Mature	5	2	31%	3	67%
		Old	361	286	79%	74	21%
	MHmm1 Total		370	291	79%	79	21%
Corrigan Total			**16,241**	**5,835**	**36%**	**10,406**	**64%**
Effingham	CWHvm1	Early	557	69	12%	489	88%
		Mid	58	15	25%	44	75%
		Mature	8	8	100%	-	0%
		Old	662	538	81%	124	19%
	CWHvm1 Total		1,286	630	49%	656	51%
	CWHvm2	Early	67	7	10%	60	90%
		Mid	-	-	N/A	-	N/A
		Mature	65	38	58%	28	42%
		Old	204	164	81%	40	19%
	CWHvm2 Total		336	209	62%	127	38%
Effingham Total			**1,622**	**839**	**52%**	**783**	**48%**
Great Central	CWHmm1	Early	847	131	15%	716	85%
		Mid	122	35	29%	87	71%
		Mature	365	294	81%	71	19%
		Old	1,351	1,041	77%	310	23%
	CWHmm1 Total		2,685	1,501	56%	1,184	44%
	CWHmm2	Early	1,252	132	11%	1,120	89%
		Mid	256	73	29%	183	71%
		Mature	193	156	81%	37	19%
		Old	2,975	2,261	76%	714	24%
	CWHmm2 Total		4,676	2,622	56%	2,054	44%
	CWHxm1	Early	-	-	N/A	-	N/A
		Mid	8	4	55%	4	45%

Landscape Unit	BEC	Seral Stage[1]	Productive Forest (ha)	Non Contributing Area		THLB Area	
				ha	%	ha	%
		Mature	-	-	N/A	-	N/A
		Old	6	6	89%	1	11%
	CWHvm2 Total		14	10	70%	4	30%
	CWHxm2	Early	3,258	383	12%	2,875	88%
		Mid	3,607	1,541	43%	2,066	57%
		Mature	766	482	63%	284	37%
		Old	1,368	1,139	83%	229	17%
	CWHxm1 Total		8,999	3,545	39%	5,454	61%
	MHmm1	Early	43	4	10%	39	90%
		Mid	40	40	100%	-	0%
		Mature	21	17	83%	4	17%
		Old	1,265	968	77%	297	23%
	MHmm1 Total		1,369	1,030	75%	339	25%
Great Central Total			**17,743**	**8,708**	**49%**	**9,035**	**51%**
Gordon	CWHvm2	Early	-	-	N/A	-	N/A
		Mid	-	-	N/A	-	N/A
		Mature	-	-	N/A	-	N/A
		Old	4	2	38%	3	62%
	CWHvm2 Total		4	2	38%	3	62%
	MHmm1	Early	-	-	N/A	-	N/A
		Mid	-	-	N/A	-	N/A
		Mature	-	-	N/A	-	N/A
		Old	2	2	65%	1	39%
	MHmm1 Total		2	2	65%	1	39%
Gordon Total			**7**	**3**	**48%**	**4**	**54%**
Henderson	CMAunp	Early	-	-	N/A	-	N/A
		Mid	-	-	N/A	-	N/A
		Mature	7	4	63%	2	37%
		Old	2	1	80%	0	20%
	CMAunp Total		8	5	66%	3	34%
	CWHvm1	Early	3,616	554	15%	3,062	85%
		Mid	570	126	22%	443	78%
		Mature	89	55	62%	33	37%
		Old	3,211	2,490	78%	722	22%
	CWHvm1 Total		7,485	3,225	43%	4,260	57%
	CWHvm2	Early	605	117	19%	488	81%
		Mid	47	15	31%	33	69%
		Mature	64	49	77%	15	24%
		Old	1,921	1,401	73%	520	27%
	CWHvm2 Total		2,637	1,582	60%	1,056	40%

Landscape Unit	BEC	Seral Stage[1]	Productive Forest (ha)	Non Contributing Area		THLB Area	
				ha	%	ha	%
	MHmm1	Early	-	-	N/A	-	N/A
		Mid	3	3	100%	-	0%
		Mature	-	-	N/A	-	N/A
		Old	132	119	90%	13	10%
	MHmm1 Total		135	122	91%	13	9%
Henderson Total			**10,265**	**4,934**	**48%**	**5,331**	**52%**
Klanawa	CWHvh1	Early	3,381	342	10%	3,039	90%
		Mid	627	462	74%	165	26%
		Mature	390	264	68%	126	32%
		Old	1,751	1,433	82%	318	18%
	CWHvh1 Total		6,148	2,501	41%	3,647	59%
	CWHvm1	Early	8,611	1,018	12%	7,594	88%
		Mid	2,452	893	36%	1,559	64%
		Mature	233	185	79%	48	21%
		Old	4,304	3,757	87%	547	13%
	CWHvm1 Total		15,599	5,852	38%	9,747	62%
	CWHvm2	Early	869	93	11%	776	89%
		Mid	124	31	25%	93	75%
		Mature	92	67	73%	24	27%
		Old	1,197	910	76%	287	24%
	CWHvm2 Total		2,282	1,102	48%	1,180	52%
Klanawa Total			**24,029**	**9,454**	**39%**	**14,574**	**61%**
Nahmint	CMAunp	Early	-	-	N/A	-	N/A
		Mid	-	-	N/A	-	N/A
		Mature	1	1	100%	-	0%
		Old	-	-	N/A	-	N/A
	CMAunp Total		1	1	100%	-	0%
	CWHvm1	Early	2	0	7%	1	93%
		Mid	-	-	N/A	-	N/A
		Mature	1	1	63%	0	38%
		Old	0	0	100%	-	0%
	CWHvm1 Total		3	1	32%	2	68%
	CWHvm2	Early	1	-	0%	1	100%
		Mid	-	-	N/A	-	N/A
		Mature	3	2	55%	1	41%
		Old	7	4	49%	4	51%
	CWHvm2 Total		11	5	47%	6	52%
	MHmm1	Early	-	-	N/A	-	N/A
		Mid	-	-	N/A	-	N/A
		Mature	-	-	N/A	-	N/A

Landscape Unit	BEC	Seral Stage[1]	Productive Forest (ha)	Non Contributing Area		THLB Area	
				ha	%	ha	%
		Old	1	1	77%	0	23%
	MHmm1 Total		1	1	77%	0	23%
Nahmint Total			**16**	**8**	**52%**	**8**	**48%**
Nitinat	CWHmm1	Early	1	0	17%	1	92%
		Mid	142	34	24%	107	76%
		Mature	-	-	N/A	-	N/A
		Old	-	-	N/A	-	N/A
	CWHmm1 Total		143	35	24%	108	76%
	CWHmm2	Early	-	-	N/A	-	N/A
		Mid	-	-	N/A	-	N/A
		Mature	-	-	N/A	-	N/A
		Old	4	4	100%	-	0%
	CWHmm2 Total		4	4	100%	-	0%
	CWHvh1	Early	876	82	9%	794	91%
		Mid	-	-	N/A	-	N/A
		Mature	-	-	N/A	-	N/A
		Old	875	433	50%	442	50%
	CWHvh1 Total		1,751	515	29%	1,236	71%
	CWHvm1	Early	5,852	670	11%	5,182	89%
		Mid	7,810	2,240	29%	5,571	71%
		Mature	223	65	29%	157	71%
		Old	3,242	2,384	74%	858	26%
	CWHvm1 Total		17,126	5,359	31%	11,767	69%
	CWHvm2	Early	1,926	189	10%	1,737	90%
		Mid	400	78	19%	322	81%
		Mature	20	20	100%	-	0%
		Old	1,755	1,315	75%	440	25%
	CWHvm2 Total		4,101	1,602	39%	2,499	61%
	CWHxm2	Early	-	-	N/A	-	N/A
		Mid	0	-	0%	0	100%
		Mature	-	-	N/A	-	N/A
		Old	-	-	N/A	-	N/A
	CWHxm2 Total		0	-	0%	0	100%
	MHmm1	Early	59	5	8%	55	93%
		Mid	-	-	N/A	-	N/A
		Mature	-	-	N/A	-	N/A
		Old	257	184	72%	73	28%
	MHmm1 Total		317	189	60%	128	40%
Nitinat Total			**23,442**	**7,704**	**33%**	**15,739**	**67%**
Sarita	CWHvh1	Early	418	27	7%	391	93%

Landscape Unit	BEC	Seral Stage[1]	Productive Forest (ha)	Non Contributing Area		THLB Area	
				ha	%	ha	%
		Mid	158	29	18%	129	82%
		Mature	5	2	46%	3	54%
		Old	238	178	75%	60	25%
	CWHvh1 Total		819	236	29%	583	71%
	CWHvm1	Early	4,000	449	11%	3,552	89%
		Mid	3,931	889	23%	3,042	77%
		Mature	97	43	45%	53	55%
		Old	2,527	1,764	70%	764	30%
	CWHvm1 Total		10,555	3,144	30%	7,411	70%
	CWHvm2	Early	1,146	103	9%	1,043	91%
		Mid	299	50	17%	249	83%
		Mature	18	9	47%	10	53%
		Old	586	345	59%	241	41%
	CWHvm2 Total		2,050	508	25%	1,543	75%
	MHmm1	Early	6	-	0%	6	100%
		Mid	-	-	N/A	-	N/A
		Mature	-	-	N/A	-	N/A
		Old	-	-	N/A	-	N/A
	MHmm1 Total		6	-	0%	6	100%
Sarita Total			**13,429**	**3,888**	**29%**	**9,542**	**71%**
Somass	CWHxm2	Early	24	2	8%	22	92%
		Mid	-	-	N/A	-	N/A
		Mature	9	3	35%	6	65%
		Old	-	-	N/A	-	N/A
	CWHxm2 Total		33	5	16%	28	84%
Somass Total			**33**	**5**	**16%**	**28**	**84%**
Walbran	CWHvh1	Early	-	-	N/A	-	N/A
		Mid	-	-	N/A	-	N/A
		Mature	-	-	N/A	-	N/A
		Old	1	-	0%	1	86%
	CWHvh1 Total		1	-	0%	1	86%
	CWHvm1	Early	2,303	349	15%	1,954	85%
		Mid	3	3	100%	-	0%
		Mature	6	5	84%	1	18%
		Old	865	734	85%	131	15%
	CWHvm1 Total		3,177	1,090	34%	2,087	66%
	CWHvm2	Early	677	55	8%	623	92%
		Mid	2	2	100%	-	0%
		Mature	28	27	97%	1	3%
		Old	969	672	69%	297	31%

Landscape Unit	BEC	Seral Stage[1]	Productive Forest (ha)	Non Contributing Area		THLB Area	
				ha	%	ha	%
	CWHvm2 Total		1,677	756	45%	921	55%
	MHmm1	Early	-	-	N/A	-	N/A
		Mid	-	-	N/A	-	N/A
		Mature	-	-	N/A	-	N/A
		Old	45	36	81%	8	19%
	MHmm1 Total		45	36	81%	8	19%
Walbran Total			**4,899**	**1,883**	**38%**	**3,017**	**62%**
Sproat Lake	CWHmm2	Early	3	0	3%	3	97%
		Mid	1	-	0%	1	100%
		Mature	-	-	N/A	-	N/A
		Old	1	1	100%	-	0%
	CWHmm2 Total		5	1	17%	5	83%
	MHmm1	Early	0	-	0%	0	100%
		Mid	-	-	N/A	-	N/A
		Mature	1	1	100%	-	0%
		Old	1	0	8%	1	92%
	MHmm1 Total		2	1	38%	1	62%
Sproat Lake Total			**8**	**2**	**23%**	**6**	**77%**
GRAND TOTAL			**120,969**	**46,709**	**39%**	**74,260**	**61%**

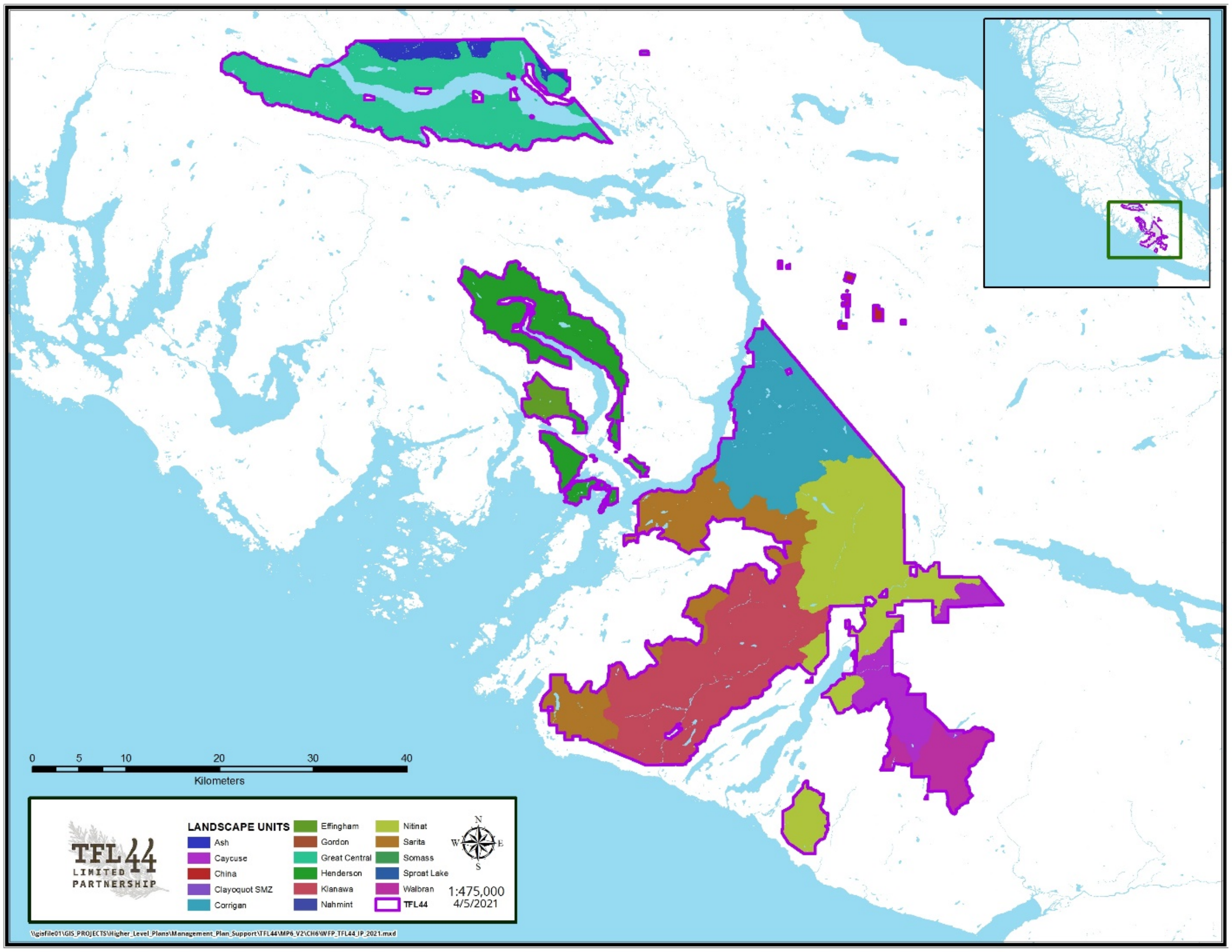

Figure 22 Landscape Units in TFL 44

7.3 Analysis Units

As described in Section 5, LBB polygons are the basic building block of the timber supply model dataset, with the forest cover inventory providing stand attributes. The natural stands within the THLB component will have growth and yield information developed for each polygon for the timber supply model to project and simulate growth. For the non-contributing (NC) component of the TFL and existing managed stands (stand age < = 57 years old) and future managed stands to be established after the timber supply model harvests existing forests, the area is aggregated into groups of similar stands, known as analysis units (AUs). AUs are assigned growth and yield information needed to model timber supply. AUs are based on BEC zone/subzone/variant, site productivity class, age class, and leading species. These grouping are described in more detail in the following sections.

7.3.1 Biogeoclimatic Ecosystem Classification Variant Assignment

Variants were assigned using the TFL 44 Terrestrial Ecosystem Mapping (TEM) with provincial mapping used to fill in gaps in the TEM data. Each polygon in the TFL was assigned to one of seven AU level variants. CWHxm1 was combined with CWHxm2 to limit the number of unique combinations. Summary of the BEC variant assignment and their spatial presentation is shown in Table 34 and Figure 23, respectively.

Table 34 Analysis Units BEC Variant

BEC Variant	Area (ha)		
	Productive Forest	THLB	NCLB
CWHxm2 (inclu. CWHxm1)	13,577	8,521	5,055
CWHmm1	4,127	2,190	1,937
CWHmm2	6,428	3,149	3,279
CWHvh1	8,718	5,466	3,252
CWHvm1	68,876	44,936	23,940
CWHvm2	16,765	9,320	7,444
MHmm1	2,479	677	1,803
Total	***120,970***	***74,260***	***46,710***

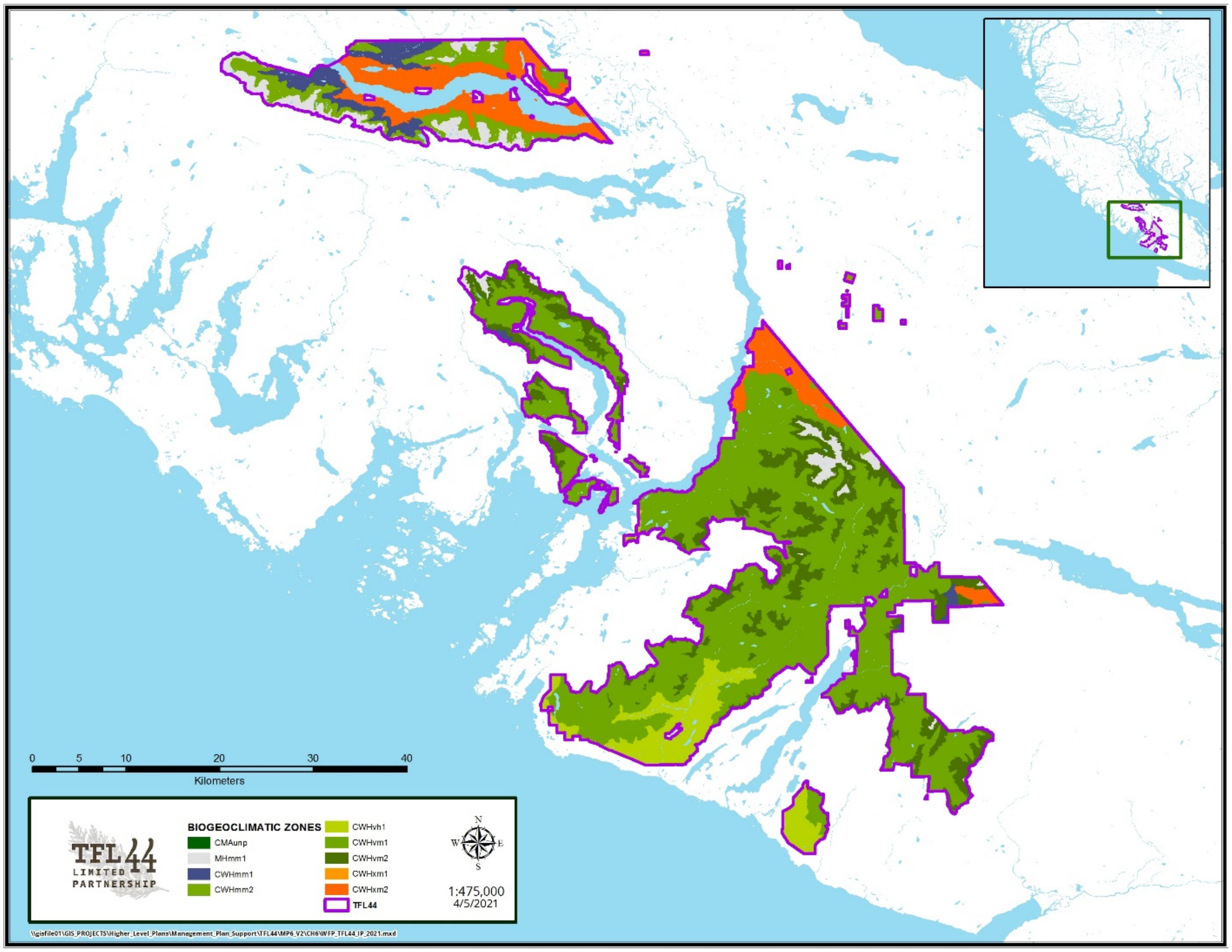

Figure 23 BEC Variant in TFL 44

7.3.2 Productivity Class Assignment

Site productivity (measured via site index) is the next level of aggregation for AUs. Site index values come from two different sources:

- For natural stands established prior to 1962 (i.e. 57 years old and older), Tsawak-qin Forest Cover inventory site index values will be applied.
- For managed stands (established since 1962), area-weighted SIBEC values will be applied.

Site productivity classes are based on the site index value range by variant. The range is defined as indicated in Table 35.

Table 35 Site Index Range by BEC Variant for AU definition

BEC Variant	Site Index Range (m)		
	Poor	Medium	Good
CWHxm2 (inclu. CWHxm1)	< 29	29 - 35	> 35
CWHmm1	< 26	26 - 32	> 32
CWHmm2	< 26	26 - 32	> 32
CWHvh1	< 16	16 - <24	>= 24
CWHvm1	< 26	26 - 32	> 32
CWHvm2	< 16	16 - 24	> 24
MHmm1	< 13	13 - 16	> 16

Areas for these site productivity classes are listed in Table 36.

Table 36 Areas for Site Productivity Classes

BEC Variant	Site Productivity					
	Poor		Medium		Good	
	THLB	NCLB	THLB	NCLB	THLB	NCLB
CWHxm2 (inclu. CWHxm1)	4,777	3,524	970	908	2,774	623
CWHmm1	1,466	1,745	567	160	157	32
CWHmm2	2,072	2,799	964	465	114	15
CWHvh1	789	385	936	1,096	3,742	1,772
CWHvm1	18,646	13,513	19,168	8,208	7,123	2,219
CWHvm2	1,060	1,289	1,996	3,330	6,264	2,826
MHmm1	129	507	83	262	465	1,033
Total	28,938	23,762	24,685	14,428	20,638	8,519

7.3.3 Age class

Existing stands are assigned to five different age classes based on the management standards of that era. Ages are based on known or estimated date of establishment, with ages reported as of December 31, 2019.

7.3.3.1 *Natural stands*

Natural stands are defined as stands greater than 57 years old (i.e. stands established prior to 1962). The assumption is these stands are the result of natural regeneration following harvesting or natural disturbances. Volume in these stands is estimated using FLNRORD's VDYP version 7.33b.

7.3.3.2 *Managed Stands*

Managed stands have been established since 1962 when detailed silviculture records began to be maintained for the TFL. Most of these stands are the result of planting but there are naturally regenerated stands present in this age range, particularly in the upper end of the age range. Volume in these stands is estimated using FLNRORD's TIPSY version 4.5.

7.3.3.2.1 Stands established between 1962 and 1999 (Age 21 –57 years)

These stands have been established since the inception of MacMillan Bloedel's Intensive Forest Management Program but with insignificant genetic gain values and before the implementation of the use of the retention silviculture system. Most of these stands were planted.

7.3.3.2.2 Stands established between 1999 and 2019 (Age 1 – 20 years)

These most recently established stands (ages 1-20 years) have greater genetic gain values and are influenced by higher levels of stand-level retention due to the use of the retention silviculture system (refer to Section 8.4.2 for details on the modelling of this influence).

7.3.3.3 *Future stands*

These stands (including current NSR stands) have genetic gain values greater than the 1 – 20 years old stands and are influenced by higher levels of stand-level retention from the previous harvest due to the use of the retention silviculture system.

7.3.4 Leading species

Existing stands are grouped based on the leading species:

- 'Grouped' to limit the number of unique combinations if applying the above logic results in a minor area (generally less than 10 ha for managed stands and less than 50ha for NC stands) of a species group.
- 'Ba' if the leading species is amabilis fir;
- 'Cw' if the leading species is western redcedar;
- 'Fd' if the leading species is Douglas fir;
- 'Hw' if the leading species is western hemlock;
- 'Hm' if the leading species is mountain hemlock;
- 'Yc' if the leading species is yellow cedar;
- 'Decid' if the leading species is deciduous (alder or maple);

As future stands assumptions are based on BEC variant and site class (refer to Section 8.6.5) no species group is required. Therefore, 'N/A' is applied for future stands species groups.

7.3.5 Analysis unit codes

A 4-digit code identifies the BEC variant, site productivity class, age class and leading species for each analysis unit (Table 37).

Table 37 Analysis Units Legend

First Digit *BEC variant*	**Second Digit** *Site Class*	**Third Digit** *Age Class (2019 Ages)*	**Fourth Digit** *Leading Species*
1 CWHxm2	1 Poor	1 Future	0 Grouped or N/A
2 CWHmm1	2 Medium	2 1 - 20 years	1 Ba
3 CWHmm2	3 Good	3 21 - 57 years	2 Cw
4 CWHvh1		4 58 – 150 years	3 Fd
5 CWHvm1		5 151+ years	4 Hw
6 CWHvm2			5 Hm
7 MHmm1			6 Yc
			7 Decid
			8 Other Conifer

For example, the code 2252 identifies the CWHmm1/Medium Site/Mature Natural/western hemlock analysis unit.

8 GROWTH AND YIELD

This section describes the approach used to develop yield tables for managed and natural stands. The general approach is to develop yield tables for existing and future stands, thus specific yield tables are developed for:

1) Existing natural mature stands;
2) Existing managed stands;
3) Future managed stands;

Table 38 breaks down how the growth and yield information will be generated for this timber supply analysis.

Table 38 Growth & Yield Generation for TFL 44

Stand Type	AU Label	Age Criteria	Growth & Yield Source
Existing Natural	N/A; By LBB Polygon	Age > 57	VDYP 7.33b
Existing Managed	BEC+SI+Age+Spp	Age <= 57	TIPSY 4.5
Future Managed	BEC+SI+1+0	N/A	TIPSY 4.5

8.1 Site Index

Site Index (SI) is a measure of productivity and is based on the stand's height as a function of its age, normally 50 years. The productivity of a site largely determines the time seedlings require to reach green-up conditions, and the volume of timber that can be produced and the age at which a stand will reach merchantable size.

Two approaches to assigning site index are employed:

- For natural stands established before 1962 (i.e. 57 years old and older), site index values are based on Tsawak-qin Forest Cover height and age, then aggregated to LBB polygon (described in Section 5), weighted by area;

- For managed stands (existing and future), site index values by biogeoclimatic site series from FLNRORD's *Site Index Estimates by BEC Site Series* (SIBEC) will be used. SIBEC is a long-term research project intended to provide site index estimates by tree species that reflect the average growth potential in forested site series in British Columbia. Site index values are assigned to all species within a stand where available. Where a site index value is not available, site index conversion equations within TIPSY are employed.

Table 39 shows the mean managed stand site index for the TFL is 26.5m. This average is lower than the SI average of 28.4m from MP #5 which was produced using a combination of biophysical site index model (BSIM) and cruised estimates. The BSIM model uses species, biogeoclimatic variant and geographic location (latitude, longitude as well as operating area) to assign site index based on the leading species for each stand. In MP #5, the site index for the leading species was based on the inventory site index if the cruise age was greater than 20 years in an immature stand; otherwise the leading species site index used the BSIM value. SI values for the non-leading species use BSIM estimates. The BSIM model was not specific to TFL 44 alone. Much of the original model scope areas are now either in private land (i.e. Island Timberlands/ Mosaic Forest Management Corp.), or outside of TFL 44 (i.e. Pacific TSA). No maintenance or enhancement has been done to improve the model, or to localize the model and stratification to fit TFL 44. SIBEC is managed by the Province and the intended usage area covers TFL 44 and so, the decision has been made this time to use SIBEC as the site index source for managed stand for MP #6.

Table 39 THLB area-weighted average Site Index values

BEC variant	Site Class			
	Poor	Medium	Good	Total
CWHxm2 (inclu. CHWxm1)	23.7	33.6	36.6	31.2
CWHmm1	22.5	28.3	36.1	25.0
CWHmm2	22.8	28.0	32.9	24.0
CWHvh1	12.0	16.2	24.5	18.0
CWHvm1	21.1	27.9	35.4	27.6
CWHvm2	13.0	18.6	28.1	24.6
MHmm1	11.4	15.9	20.2	14.1
Total	19.7	26.4	33.6	26.5

The lower site index resulting from switching from BSIM to SIBEC for managed stands has been documented in Section 4.7 of the MP #5 timber supply analysis report. The associated timber supply impact tested in the sensitivity was 10.7% less than the MP #5 Base Case, when the average SI was 25.3m at that time. Given the uncertainty around SI, a sensitivity analysis may be performed to use LiDAR-based site index as alternative SI source.

8.2 Utilization Levels

Timber Merchantability Specifications for TFL 44 is consistent with the specifications outlined in the Provincial Logging Residue and Waste Measurements Procedure Manual (Province of British Columbia, 2019). Table 40 summarizes the utilization standard. The utilization level is 12.5 cm for stands less than 121 years old and for future stands. Stump height for these stands is 30 cm and top diameter inside bark (DIB) is 10 cm. Utilization level for mature stands is 17.5 cm, with stump height of 30 cm and top DIB of 10 cm. In timber supply analysis, utilization is addressed in the yield curves.

Table 40 Utilization Levels

Age Class	Utilization			Firmwood Standard
	Minimum DBH (cm)	Stump Height (cm)	Top DIB (cm)	
Mature (>120 years old)	17.5	30.0	10.0	50%
Immature (<=120 years old)	12.5	30.0	10.0	50%

8.3 Operational Adjustment Factors (OAFs)

Adjustments to managed stand volumes are incorporated into the yield tables. The unadjusted TIPSY output reflects growth relationships observed in research plots generally located in fully-stocked, even-aged stands of uniform site and in forests of little or no pest activity. OAFs are used to account for factors that reflects site conditions in reality that are not uniformly fully-stocked and even-aged. Specifically, OAF 1 is used to account for voids or non-productive areas with a stand; and OAF 2 is used to account for forest health issues associated with the stand. The standard provincial values for OAF 1 and OAF 2 are 15% and 5%, respectively.

In the previous TFL 44 MP #5, non-standard OAF values were used: 5% adjustments for non-productive areas, 2% adjustments for insects and diseases; and 6% adjustments for decay, waste and breakage. These adjustments were applied multiplicatively, resulting in 8% adjustments on cruise stands and 12% adjustments for other stands. The 2011 AAC determination for TFL 44 requested an accuracy assessment of the OAF values in TFL 44. An analysis was undertaken to evaluate voids and non-productive areas within stands using LiDAR data (see Appendix C: LIDAR REVIEW OF OAF1 IN MANAGED STANDS.

To reflect operational environments, two operational adjustment factors (OAFs) are applied to TIPSY outputs to reduce the potential yields:

- OAF 1: 10.9 percent
- OAF 2: 5 percent

A sensitivity analysis of using the provincial default OAF 1 of 15 percent will be conducted.

8.4 Volume Reductions

8.4.1 Natural Stands Volume

Gross stand volumes (close utilization less decay) are reduced to reflect estimates of waste and breakage based on the factors built into VDYP 7.

8.4.2 Managed Stands Volume

8.4.2.1 *Root Diseases*

Existing managed and future Douglas fir leading stands in CWHmm1, xm1 and xm2 BEC subzones are more susceptible for laminated root disease and armillaria root diseases. Therefore, a sensitivity analysis to employ an increased 12.5% OAF 2 adjustment on existing managed and future Douglas fir leading stands in these BEC subzones will be conducted to evaluate the volume loss in TFL 44. Having said that, this change is not to be interpreted as a local OAF adjustment but merely the methodology chosen to model the impact of root rot.

8.4.2.2 *Shading from Retained Trees*

Volume reductions will be applied to stands established since 1999 and all future stands to model the growth impact of stand-level retention in the previous harvest. Unadjusted TIPSY yields are estimated volumes from regenerating stands within a clear-cut environment. Retention of standing trees within the harvest area is expected to reduce the yields of the regenerating stand. TIPSY includes an adjustment factor for variable retention (VRAF). The VRAF has two components: the removal of area from future timber production and the competition influence (shading) of retained areas on the adjacent regenerating portions of the cutblock. Given that the area impact is addressed as a THLB netdown (refer to Sections 6.17 and 6.19), only the yield impact from shading needs to be applied to the subject stands.

The VRAF uses three main variables: percent crown cover, edge length (perimeter) and top height. To determine the yield adjustments to apply, several scenarios were run in TIPSY using Fd and Hw species across a range of site index values and retention levels of 0% (base), 10%, 15% and 20% (refer to Section 10.3.4 for where these retention levels apply). Top height was determined at approximate rotation ages (see Section 10.3.1) from the scenarios run with no VRAF applied. Nearly all retention has been, and is anticipated to be, group retention in varying sizes and shapes. To represent the edge length required for VRAF calculations, the assumption used in the TIPSY scenarios was 0.25 ha groups in a 1x5 rectangular shape.

Table 41 indicates the range and average yield impacts observed in the TIPSY scenarios. The average VRAF applies to the percentage of the harvest area anticipated to be harvested with the retention system where the corresponding retention level applies to generate the average yield impact to apply. This reduction will occur when individual stands are harvested during modelling. Yield curves are left unaltered.

Table 41 Yield Component of Variable Retention Adjustment Factor

Description	**Retention Level**		
	10%	**15%**	**20%**
Range in VRAF in TIPSY scenarios	1.5% - 5%	3% - 6%	4% - 8%
Average VRAF	2%	3.5%	5%
Percent of harvest area	50%	56%	100%
Average yield impact to be applied	***1.0%***	***2.0%***	***5.0%***

8.5 Yields for Natural Stands

Natural stands are greater than 57 years old (i.e. stands established prior to 1962). The assumption is these stands are the result of natural regeneration following harvesting or natural disturbances. Volume for natural stands in the THLB is estimated using VDYP version 7.33b.

As indicated in Section 5, LBB polygons are the basic building block of the timber supply model dataset, with the forest cover inventory providing stand attributes. Natural stand yield curves for each LBB polygon within THLB will be generated.

A sensitivity analysis will be completed to adjust natural stand volumes upwards and downwards by 10%, respectively.

8.6 Yields for Managed Stands

8.6.1 Stocking density

A significant planting program has existed in TFL 44 from at least 1962, the start of MacMillan Bloedel's (a predecessor licensee) Intensive Forest Management Program. For the last 20 to 25 years, most of the harvested area has been planted, typically at planting levels of around 1,000 sph, with many areas also consisting of substantial natural in-growth. TIPSY does not directly model planted stands with natural in-growth so managed stands yields are modelled on generalized planting success alone but with species distributions that reflect natural regeneration of western hemlock.

Stands currently aged 1 to 57 years are modelled as if planted at 1,000 sph. This is supported by recent practice and a review of free-growing stands. The average free growing density from silviculture label is 827 sph for all stands declared free growing from 2010 to 2019 in TFL 44.

8.6.2 Fertilization

At the time of preparing this information package, 5,894 ha of nitrogen fertilization (post-establishment) has occurred on in TFL 44 since 2003. The fertilization treatments have mostly occurred on Douglas fir leading stands. The stand age has varied with more than three quarters of the treatments applied in stands between 21 and 60 years old at the time of application. The fertilization program has been contingent on government funding programs and is expected to continue in the next few years.

The impacts of this management effort and opportunities for late-rotation fertilization of Douglas fir leading stands will be incorporated into the TIPSY yield tables for current managed stands in the 21 - 57 years age class for treated stands. The default TIPSY fertilization response will be used for this adjustment. A sensitivity analysis excluding fertilization will be conducted to evaluate the impact of medium and long-term timber supply for TFL 44.

8.6.3 Volumes for Existing Managed Stands Aged 21 - 57 Years

Silviculture assumptions for existing managed stands aged 21 – 57 include a plantation regeneration method for all stands, species composition from the inventory database, establishment density based on inventory and free-growing stand data and expected relative stocking success. These silviculture assumptions and THLB area-weighted site index estimates by species were used as inputs in Batch TIPSY 4.5 (Table 42). No genetic gain was applied to stands in this age range. Yield curves for each existing managed age 21 – 57 years analysis unit will be included in the final timber analysis report.

Table 42 TIPSY Inputs for Existing Managed Stands Aged 21 – 57 Years

Existing AU	SPH	Spp[1] %	Spp1 SI	Spp2 SI	Spp3 SI	Spp4 SI	Spp5 SI	THLB Area (ha)
1131	1,000	BA56 HW26 FD9 YC5 CW4	22	24	33	24	24	346
1133	1,000	FD67 HW14 CW9 BA7 YC3	32	25	23	23	23	1,060
1134	1,000	HW46 BA20 CW15 FD13 YC6	26	24	24	34	24	256
1136	1,000	YC41 HW33 BA15 FD7 CW4	24	24	21	33	24	32
1233	1,000	FD58 HW16 YC13 CW8 BA5	34	26	24	24	25	218
1234	1,000	HW50 FD42 CW8	27	34	26			19
1333	1,000	FD92 HW7 CW1	33	24	24			24
2131	1,000	BA56 HW31 FD5 YC4 CW4	22	25	30	25	25	168
2133	1,000	FD58 HW25 YC8 BA5 CW4	29	25	24	22	24	153
2134	1,000	HW49 FD18 BA15 YC10 CW8	26	32	23	25	25	471
2231	1,000	BA61 HW21 FD10 CW4 YC4	24	26	35	26	26	141
2233	1,000	FD56 HW13 BA12 CW11 YC8	28	24	22	24	24	204
2234	1,000	HW48 FD22 BA19 CW6 YC5	26	32	24	25	25	126
2333	1,000	FD70 HW24 BA3 YC2 CW1	30	26	23	24	24	118
3131	1,000	BA48 HW23 YC19 CW6 FD4	24	24	23	23	28	314
3133	1,000	FD68 BA14 HW11 YC4 CW3	25	22	22	20	20	59
3134	1,000	HW46 BA24 FD16 CW8 YC6	24	23	27	23	23	232
3231	1,000	BA51 HW20 FD13 YC13 CW3	22	23	27	22	22	194
3233	1,000	FD63 HW15 BA10 YC8 CW4	27	23	23	23	23	221
3234	1,000	HW43 BA18 FD17 YC15 CW7	24	24	28	24	24	137
3333	1,000	FD59 YC16 BA9 HW8 CW8	26	22	21	23	22	4

[1] Ba = balsam; Cw = western red cedar; Fd = Douglas fir; Hw = western hemlock; Hm = mountain hemlock; Pl = pine; Ss = sitka spruce; Yc = yellow cedar

Existing AU	SPH	Spp[1] %	Spp1 SI	Spp2 SI	Spp3 SI	Spp4 SI	Spp5 SI	THLB Area (ha)
4132	1,000	CW61 FD31 HW8	16	18	16			25
4232	1,000	CW80 HW18 BA1 FD1	16	16	12	18		37
4234	1,000	HW48 CW27 BA11 FD10 SS4	17	17	14	19	17	117
4332	1,000	CW53 HW22 FD14 SS6 YC5	17	18	20	17	17	1,154
4334	1,000	HW53 CW22 FD14 SS6 BA5	21	20	24	21	20	340
5131	1,000	BA53 HW23 FD14 YC6 CW4	25	26	35	21	21	53
5132	1,000	CW58 HW22 FD9 YC7 BA4	22	27	35	22	28	506
5133	1,000	FD67 HW18 CW7 BA5 SS3	35	26	22	27	35	1,995
5134	1,000	HW56 CW16 FD14 BA8 SS6	26	22	35	27	26	5,881
5137	1,000	FD77 HW11 CW9 BA3	36	28	23	30		40
5138	1,000	SS56 HW32 CW7 FD3 BA2	16	16	14	22	14	39
5231	1,000	BA54 HW32 CW13 FD1	29	29	23	35		24
5232	1,000	CW53 HW28 FD11 YC4 BA4	22	27	35	22	28	1,925
5233	1,000	FD62 HW20 YC8 CW6 SS4	35	27	22	22	35	2,531
5234	1,000	HW54 CW17 FD14 BA9 SS6	27	22	35	28	27	8,141
5238	1,000	SS66 FD20 HW8 YC4 BA2	27	34	27	23	28	25
5332	1,000	CW51 HW30 FD10 BA7 YC2	22	27	35	28	22	97
5333	1,000	FD61 HW25 CW6 BA5 SS3	35	28	23	28	35	1,205
5334	1,000	HW49 FD21 CW14 BA9 SS7	27	35	22	27	27	346
5338	1,000	SS64 HW31 FD5	28	28	36			15
6134	1,000	HW41 BA22 CW20 FD17	18	16	17	25		8
6231	1,000	BA60 HW20 CW10 YC10	26	28	20	20		58
6232	1,000	CW61 HW20 BA10 YC9	20	24	24	20		15
6233	1,000	FD65 YC15 HW14 CW4 BA2	31	20	26	20	24	44
6234	1,000	HW54 BA21 CW11 FD9 YC5	25	23	19	30	19	597
6331	1,000	BA46 HW24 YC13 FD10 CW7	22	24	19	29	19	152
6332	1,000	CW45 HW23 FD20 BA7 YC5	19	24	29	22	19	67
6333	1,000	FD61 HW18 YC9 BA7 CW5	30	26	19	24	19	613
6334	1,000	HW55 BA14 CW11 YC10 FD10	26	24	19	19	30	2,459
6336	1,000	YC46 HW35 CW10 BA9	19	25	19	23		48

Existing AU	SPH	Spp[1] %	Spp1 SI	Spp2 SI	Spp3 SI	Spp4 SI	Spp5 SI	THLB Area (ha)
7331	1,000	BA46 HW25 FD14 YC12 CW3	12	15	18	14	14	31

8.6.4 Volumes for Existing Managed Stands Aged 1 - 20 Years

Silviculture assumptions for existing managed stands aged 1 – 20 years (established between 1999 and 2019) includes a plantation regeneration method for all stands, species composition from the inventory database and stand assessments, establishment density reflecting stocking success. Genetic gain for Cw, Yc, Fd and Hw was applied to stands in this age range based on average values for the most common seedlots planted in TFL 44 since 2000. The species composition and genetic gain values were obtained from the Reporting Silviculture Updates and Land Status Tracking System (RESULTS) database based on the planting and silviculture records. Expected genetic gain values for Hw are reduced to reflect a component of natural regeneration expected in the harvested stands. Specifically, Gain for Hw is reduced 100% in CWHxm2, CHWmm2, CWHvm1 poor, and Mh variants; reduced 50% in CHWmm1, CHWvh1 good, and CWHvm2 variant; reduced 33% in CWHvm1 medium and good variant. A sensitivity analysis excluding the genetic gains will be conducted to evaluate the impact.

In the timber supply model, yields for these stands will be reduced to account for the impact on growth by trees retained in the previous harvest (see Sections 8.4.2 and 0 for more details). TIPSY inputs for existing managed stands aged 1 – 20 years are shown in Table 43. Yield curves for each existing managed age 1 – 20 years analysis unit will be included in the final timber analysis report. Another sensitivity analysis will be completed to adjust managed stand volumes upwards and downwards by 10%, respectively.

Table 43 TIPSY Inputs for Existing Managed Stands Aged 1 – 20 years

Existing AU	SPH	Spp%	Spp1 SI	Spp2 SI	Spp3 SI	Spp4 SI	Spp5 SI	Genetic Gain %					THLB Area (ha)
								Spp1	Spp2	Spp3	Spp4	Spp5	
1122	1,000	FD72 CW18 HW7 YC3	33.3	23.7	24.3	23.7		7.8	11.5				76
1123	1,000	FD72 CW18 HW7 YC3	33.2	23.9	25.4	23.9		7.8	11.5				320
1124	1,000	FD72 CW18 HW7 YC3	33.5	23.7	26.8	23.7		7.8	11.5				63
1223	1,000	FD81 CW12 HW5 YC2	32.5	24.1	26.0	24.1		6.2	4.2				153
1224	1,000	FD81 CW12 HW5 YC2	35.0	23.3	29.7	23.3		6.2	4.2				53

Existing AU	SPH	Spp%	Spp1 SI	Spp2 SI	Spp3 SI	Spp4 SI	Spp5 SI	Genetic Gain %					THLB Area (ha)
								Spp1	Spp2	Spp3	Spp4	Spp5	
1322	1,000	FD85 CW10 HW2 PW3	34.4	24.0	25.1	24.3		8.0	7.3				44
1323	1,000	FD85 CW10 HW2 PW3	33.9	24.3	26.1	34.0		8.0	7.3				2,310
1324	1,000	FD85 CW10 HW2 PW3	35.2	24.0	28.7	28.7		8.0	7.3				15
2121	1,000	CW33 HW28 YC23 FD16	25.9	25.9	25.9	33.7		12.0	2.9		11.4		16
2123	1,000	CW33 HW28 YC23 FD16	24.0	24.0	24.0	28.0		12.0	2.9		11.4		12
2124	1,000	CW33 HW28 YC23 FD16	24.7	24.7	24.7	30.2		12.0	2.9		11.4		48
2221	1,000	HW30 FD27 YC27 CW16	24.0	27.9	24.0	24.0		1.9	4.6		2.0		63
2224	1,000	HW30 FD27 YC27 CW16	24.0	28.0	24.0	24.0		1.9	4.6		2.0		19
2323	1,000	FD72 HW14 YC8 CW6	29.0	24.9	23.4	23.4		4.8	1.0		3.4		39
3121	1,000	FD33 HW33 YC20 CW13 BA1	27.4	23.9	22.3	22.3	23.7	5.9			9.5		136
3123	1,000	FD33 HW33 YC20 CW13 BA1	27.6	23.8	23.6	23.6	23.6	5.9			9.5		30
3124	1,000	FD33 HW33 YC20 CW13 BA1	27.7	23.8	23.6	23.6	23.8	5.9			9.5		73
3126	1,000	FD33 HW33 YC20 CW13 BA1	27.0	23.3	22.6	22.6	22.8	5.9			9.5		46
3221	1,000	HW35 FD33	23.3	26.6	22.4	22.4		-	4.4		5.9		196

Existing AU	SPH	Spp%	Spp1 SI	Spp2 SI	Spp3 SI	Spp4 SI	Spp5 SI	Genetic Gain %					THLB Area (ha)
								Spp1	Spp2	Spp3	Spp4	Spp5	
		YC19 CW13											
3223	1,000	HW35 FD33 YC19 CW13	23.7	27.6	23.6	23.6		-	4.4		5.9		22
3224	1,000	HW35 FD33 YC19 CW13	23.7	27.5	23.4	23.4		-	4.4		5.9		24
3323	1,000	FD57 HW18 CW13 YC12	26.7	23.3	22.5	22.5		4.4		7.8	-		78
3324	1,000	FD57 HW18 CW13 YC12	27.8	24.0	23.0	23.0		4.4		7.8	-		11
3326	1,000	FD57 HW18 CW13 YC12	28.0	24.0	24.0	24.0		4.4		7.8	-		12
4122	1,000	CW84 HW9 BA4 YC2 SS1	16.8	17.3	14.3	16.8	16.8	8.5	8.5	-	-		283
4124	1,000	CW84 HW9 BA4 YC2 SS1	23.9	23.9	23.9	23.9	23.9	8.5	8.5	-	-		55
4222	1,000	CW91 HW7 FD1 YC1	16.1	16.1	18.3	16.1		5.1	5.9	2.0	-		204
4321	1,000	CW75 HW19 SS3 BA3	23.5	24.9	24.6	24.6		5.8	5.9				24
4322	1,000	CW75 HW19 SS3 BA3	17.4	18.0	17.5	15.1		5.8	5.9				1,731
4323	1,000	CW75 HW19 SS3 BA3	19.7	23.1	26.1	22.6		5.8	5.9				20
4324	1,000	CW75 HW19 SS3 BA3	20.4	22.1	22.1	20.9		5.8	5.9				353
4328	1,000	CW75 HW19 SS3 BA3	24.0	24.0	24.0	24.0		5.8	5.9				23
5121	1,000	CW52 HW26	21.2	25.2	34.5	26.0	26.0	8.1		8.5			23

Existing AU	SPH	Spp%	Spp1 SI	Spp2 SI	Spp3 SI	Spp4 SI	Spp5 SI	Genetic Gain %					THLB Area (ha)
								Spp1	Spp2	Spp3	Spp4	Spp5	
		FD13 BA5 SS4											
5122	1,000	CW52 HW26 FD13 BA5 SS4	22.1	26.3	34.1	27.7	22.1	8.1		8.5			954
5123	1,000	CW52 HW26 FD13 BA5 SS4	22.0	26.3	34.1	26.1	34.1	8.1		8.5			227
5124	1,000	CW52 HW26 FD13 BA5 SS4	22.1	26.7	34.9	27.5	26.7	8.1		8.5			1,274
5126	1,000	CW52 HW26 FD13 BA5 SS4	22.6	25.5	31.1	28.1	22.6	8.1		8.5			13
5127	1,000	CW52 HW26 FD13 BA5 SS4	23.2	27.3	33.8	27.1	27.3	8.1		8.5			12
5221	1,000	CW54 HW31 FD10 BA3 YC2	21.3	25.8	34.9	26.0	21.3	6.3	3.9	7.9			173
5222	1,000	CW54 HW31 FD10 BA3 YC2	22.2	26.7	34.9	28.0	22.2	6.3	3.9	7.9			1,374
5223	1,000	CW54 HW31 FD10 BA3 YC2	22.0	23.9	29.3	26.7	22.0	6.3	3.9	7.9			11
5224	1,000	CW54 HW31 FD10 BA3 YC2	22.1	26.8	35.3	27.8	22.1	6.3	3.9	7.9			3,454
5228	1,000	CW54 HW31 FD10 BA3 YC2	22.8	27.8	35.8	29.3	22.8	6.3	3.9	7.9			36
5322	1,000	CW54 HW23 FD21 YC2	22.3	27.1	35.2	22.3		7.6	7.6	1.0			2,421

Existing AU	SPH	Spp%	Spp1 SI	Spp2 SI	Spp3 SI	Spp4 SI	Spp5 SI	Genetic Gain %					THLB Area (ha)
								Spp1	Spp2	Spp3	Spp4	Spp5	
5323	1,000	CW54 HW23 FD21 YC2	22.4	27.3	35.3	22.4		7.6	7.6	1.0			1,009
5324	1,000	CW54 HW23 FD21 YC2	22.5	27.3	35.4	22.5		7.6	7.6	1.0			651
5328	1,000	CW54 HW23 FD21 YC2	23.3	27.6	34.4	23.3		7.6	7.6	1.0			10
6121	1,000	CW45 HW26 YC14 FD6 BA9	17.8	21.3	17.8	27.3	19.1	10.0	2.9		5.7		85
6122	1,000	CW45 HW26 YC14 FD6 BA9	19.8	26.5	19.8	30.0	24.5	10.0	2.9		5.7		93
6124	1,000	CW45 HW26 YC14 FD6 BA9	19.4	24.7	19.4	29.5	22.7	10.0	2.9		5.7		59
6126	1,000	CW45 HW26 YC14 FD6 BA9	18.7	24.1	18.7	29.1	21.8	10.0	2.9		5.7		49
6224	1,000	CW42 HW38 YC12 FD7 PW1	19.5	26.3	19.5	30.5	26.3	8.8	2.3		4.2		145
6321	1,000	CW42 HW36 FD12 YC9 BA1	19.2	25.3	29.8	19.2	23.1	8.5	2.2	7.2			406
6322	1,000	CW42 HW36 FD12 YC9 BA1	19.1	25.1	29.6	19.1	22.9	8.5	2.2	7.2			193
6323	1,000	CW42 HW36 FD12 YC9 BA1	18.9	24.2	29.0	18.9	22.0	8.5	2.2	7.2			77
6324	1,000	CW42 HW36 FD12 YC9 BA1	19.3	25.3	29.6	19.3	23.1	8.5	2.2	7.2			1,475

Existing AU	SPH	Spp%	Spp1 SI	Spp2 SI	Spp3 SI	Spp4 SI	Spp5 SI	Genetic Gain %					THLB Area (ha)
								Spp1	Spp2	Spp3	Spp4	Spp5	
6326	1,000	CW42 HW36 FD12 YC9 BA1	18.4	23.1	28.5	18.4	20.8	8.5	2.2	7.2			77
7321	1000	HW44 YC31 FD20 CW5	15.9	14.0	18.1	14.0		1.9		2.8			73

8.6.5 Future Stand Volumes

Ecologically-based silviculture strategies for future stands were developed by WFP staff based on current practices and a review of surveys for stands established between 2000 and 2019 (And Tsawak-qin is following WFP strategies). Species composition reflects natural ingress of hemlock on most sites. Species and stocking levels are portrayed at a broad average level to simplify modelling.

Stand density is represented by planting at 1,200 sph to reflect the continued practice to plant almost all harvested areas (e.g. new permanent roads will not be replanted until road rehabilitation & reclamation are completed). It is recognized that this includes a range of specific prescriptions that for example might have greater reliance on natural regeneration, or a small proportion of alder establishment on the land base (Hardwood establishment in the coast is referenced in *Hardwood Management in the Coast Forest Region* (Province of British Columbia, 2009).

8.6.5.1 *Regeneration Delay*

Regeneration delay refers to the average time between harvesting and the establishment of the next rotation. Nearly all harvested area is planted and prompt establishment after harvesting continues to be practiced in the TFL. Planted seedlings are typically one year old and early seedling growth is assisted on some sites by the practice of fertilization at time of planting. The regeneration delay from harvest until germination of the next crop of planted trees is generally less than one year. A one-year delay is incorporated into yield tables used in the analyses.

8.6.5.2 *Genetic Gain*

Projections of Genetic Gain were developed from WFP's Saanich Forestry Centre seed inventory and development plans and the Forest Genetics Council business plans. Gain is projected to increase somewhat over the period from 2016 to 2036; however, for future stands within the analysis, values associated with 2017 cone harvest will be used. As very little hemlock is planted, expected gain values for low elevation Hw are reduced and not applied for high elevation to reflect natural regeneration expected in harvested stands. Average values for genetic gain by species and BEC variant listed in Table 44 will be applied to future managed stands.

Table 44 TIPSY Inputs for Future Managed Stands

Future AU	SPH	Spp%	Spp1 SI	Spp2 SI	Spp3 SI	Spp4 SI	Spp5 SI	Genetic Gain %				THLB Area (ha)
								Cw	Fd	Hw[1]	Yc	
1110	1,200	FD80 CW10 HW10	33	24	25			18	19	-	-	4,593
1210	1,200	FD80 CW10 HW10	33	24	26			18	19	-	-	970
1310	1,200	FD80 CW10 HW10	34	24	26			18	19	-	-	2,959
2110	1200	FD35 HW35 CW15 BA15	31	25	25	23		18	19	8	-	1,466
2210	1,200	FD35 HW35 CW15 BA15	31	25	25	23		18	19	8	-	567
2310	1,200	FD40 HW30 CW20 BA10	30	26	24	23		18	19	8	-	157
3110	1200	FD50 YC20 BA15 HW15	27	22	23	24		-	19	-	10	2,072
3210	1,200	HW25 YC20 BA20 FD20 CW15	24	23	23	27	23	-	19	-	10	964
3310	1,200	HW35 FD20 YC20 BA20 CW5	23	27	23	23	23	-	19	-	10	114
4110	1200	CW90 YC10	17	17				18	-	-	10	620
4210	1,200	CW100	17					18	-	-	-	767
4310	1,200	HW55 CW20 BA15 SS10	20	19	17	19		18	-	8	-	4,079
5110	1200	CW40 HW30 FD20 YC5 BA5	22	26	34	22	27	18	19	-	10	17,113
5210	1,200	HW40 CW35 FD15 BA10	27	22	35	27		18	19	11	-	20,701
5310	1,200	HW40 CW30 SS10 FD10 BA10	27	22	29	35	28	18	-	11	-	7,123
6110	1200	HW45 BA20 YC15 FD10 CW10	24	22	19	29	19	-	19	8	10	828
6210	1,200	HW45 BA20 YC15 FD10 CW10	25	23	19	29	19	-	19	8	10	1,996
6310	1,200	HW45 CW20 BA20 YC10 FD5	25	19	23	19	29	-	19	8	10	6,496
7110	1200	HW40 BA40 YC20	14	11	12			-	-	-	10	120
7210	1200	HW40 BA40 YC20	15	11	13			-	-	-	10	83
7310	1,200	HW40 BA40 YC20	15	11	13			-	-	-	10	474

[1] Gain for Hw is reduced to reflect expected natural regeneration component in future harvested stands: reduced 100% to 0% in CWHxm2, CHWmm2, CWHvm1 poor, and MH variants, reduced 50% to 8% in CHWmm1, CHWvh1 good, and CWHvm2 variant, reduced 33% to 10.7% in CWHvm1 medium and good variant

8.6.5.3 *Yields*

In the timber supply model, yields for these stands are reduced to account for the impact on growth by trees retained in the previous harvest to meet stand-level retention targets (see Sections 8.4.2 and 10.3.4 for more details). Yield curves for future stands will be included in the final timber analysis report.

8.6.6 Not Satisfactorily Restocked Areas

The data set prepared for analysis includes 982 ha described as not satisfactorily restocked (NSR) and 971 ha (Table 45) of the "NSR" area is in the timber harvesting land base. The "NSR" area is larger than in operational records as it includes areas planted in 2019 for which planting data was not yet available when the timber supply data set was compiled, or areas harvested in 2019 but to be planted in 2020. NSR areas will be regenerated to the appropriate future Analysis Unit within the model in the first planning period.

Table 45 NSR Area in TFL 44

Description	Productive Area (ha)	THLB Area (ha)
NSR lands	982	971

8.7 Yields for Unmanaged Stands

The timber volume in the non-contributing area of the land base is projected by VDYP ver. 7.33b for existing natural stands; and TIPSY ver. 4.5 for existing managed stands. The yields and volumes from unmanaged stands will not be contributing to the THLB and Base Case projections. TIPSY inputs for AUs with NCLB area are shown in Table 46.

Table 46 TIPSY Inputs for Unmanaged Stands

AU	SPH	Spp[1] %	Spp1 SI	Spp2 SI	Spp3 SI	Spp4 SI	Spp5 SI	NCLB Area (ha)
1223	1,000	FD81 CW12 HW5 YC2	32	24	26	24		9
1233	1,000	FD58 HW16 YC13 CW8 BA5	34	26	24	24	25	42
1323	1,000	FD85 CW10 HW2 PW3	34	24	26	34		68
1333	1,000	FD92 HW7 CW1	33	24	24			3
2124	1,000	CW33 HW28 YC23 FD16	25	25	25	30		4
2134	1,000	HW49 FD18 BA15 YC10 CW8	26	32	23	25	25	108
2221	1,000	HW30 FD27 YC27 CW16	24	28	24	24		4
2233	1,000	FD56 HW13 BA12 CW11 YC8	28	24	22	24	24	90
2323	1,000	FD72 HW14 YC8 CW6	29	25	23	23		1
2333	1,000	FD70 HW24 BA3 YC2 CW1	30	26	23	24	24	23

AU	SPH	Spp[1] %	Spp1 SI	Spp2 SI	Spp3 SI	Spp4 SI	Spp5 SI	NCLB Area (ha)
3124	1,000	FD33 HW33 YC20 CW13 BA1	28	24	24	24	24	2
3221	1,000	HW35 FD33 YC19 CW13	23	27	22	22		12
3233	1,000	FD63 HW15 BA10 YC8 CW4	27	23	23	23	23	46
3323	1,000	FD57 HW18 CW13 YC12	27	23	22	22		4
3333	1,000	FD59 YC16 BA9 HW8 CW8	26	22	21	23	22	0
4132	1,000	CW61 FD31 HW8	16	18	16			8
4222	1,000	CW91 HW7 FD1 YC1	16	16	18	16		9
4234	1,000	HW48 CW27 BA11 FD10 SS4	17	17	14	19	17	37
4322	1,000	CW75 HW19 SS3 BA3	17	18	17	15		69
4332	1,000	CW53 HW22 FD14 SS6 YC5	17	18	20	17	17	174
4334	1,000	HW53 CW22 FD14 SS6 BA5	21	20	24	21	20	120
5124	1,000	CW52 HW26 FD13 BA5 SS4	22	27	35	27	27	30
5132	1,000	CW58 HW22 FD9 YC7 BA4	22	27	35	22	28	141
5133	1,000	FD67 HW18 CW7 BA5 SS3	35	26	22	27	35	431
5134	1,000	HW56 CW16 FD14 BA8 SS6	26	22	35	27	26	1,173
5222	1,000	CW54 HW31 FD10 BA3 YC2	22	27	35	28	22	44
5224	1,000	CW54 HW31 FD10 BA3 YC2	22	27	35	28	22	124
5232	1,000	CW53 HW28 FD11 YC4 BA4	22	27	35	22	28	274
5233	1,000	FD62 HW20 YC8 CW6 SS4	35	27	22	22	35	606
5234	1,000	HW54 CW17 FD14 BA9 SS6	27	22	35	28	27	1,351
5322	1,000	CW54 HW23 FD21 YC2	22	27	35	22		86
5323	1,000	CW54 HW23 FD21 YC2	22	27	35	22		29
5324	1,000	CW54 HW23 FD21 YC2	22	27	35	22		33
5333	1,000	FD61 HW25 CW6 BA5 SS3	35	28	23	28	35	294
5334	1,000	HW49 FD21 CW14 BA9 SS7	27	35	22	27	27	149
6124	1,000	CW45 HW26 YC14 FD6 BA9	19	25	19	30	23	0
6134	1,000	HW41 BA22 CW20 FD17	18	16	17	25		4

AU	SPH	Spp[1] %	Spp1 SI	Spp2 SI	Spp3 SI	Spp4 SI	Spp5 SI	NCLB Area (ha)
6224	1,000	CW42 HW38 YC12 FD7 PW1	19	26	19	31	26	3
6234	1,000	HW54 BA21 CW11 FD9 YC5	25	23	19	30	19	99
6324	1,000	CW42 HW36 FD12 YC9 BA1	19	25	30	19	23	64
6331	1,000	BA46 HW24 YC13 FD10 CW7	22	24	19	29	19	55
6333	1,000	FD61 HW18 YC9 BA7 CW5	30	26	19	24	19	55
6334	1,000	HW55 BA14 CW11 YC10 FD10	26	24	19	19	30	242
7135	1,000	HW56 YC25 BA19	8	6	8			32
7236	1,000	YC70 HW30	10	10				1
7321	1,000	HW44 YC31 FD20 CW5	16	14	18	14		6
7331	1,000	BA46 HW25 FD14 YC12 CW3	12	15	18	14	14	3

8.8 Yields for Forest Carbon

As illustrated in Section 3.5, Tsawak-qin will endeavor to estimate the full life-cycle of carbon, including stocks and emissions as part of the TFL 44 timber supply analysis, with the best information available.

If the required resources and capacity can be rendered, the operational scale Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) will be used to model forest carbon (Kurz, et al., 2009). This model was derived by the carbon accounting team at the Canadian Forest Service and follows the assumptions and methods established by the Intergovernmental Panel on Climate Change (IPCC) (The Intergovernmental Panel on Climate Change, 2003). This is the same model used for National Inventory Reporting (Environment and Climate Change Canada, 2020) and forest management plan in other Western Canada jurisdiction (Canadian Forest Products Ltd., 2015). The model is driven by yields, detailed from Section 8.5 to Section 8.7, to track and calculate carbon stocks and fluxes in various carbon pools in forest ecosystems.

Harvested wood products carbon will be estimated using the FNLORD’s carbon calculator tool (Dymond, 2012). The calculator utilizes outputs from the British Columbia Harvested Wood Products version 1 (BC-HWPv1) model which tracks and calculates the harvested wood products throughout their lifetime, starting from the logs arriving at the mill, to disposing wood products in the landfill. Assumptions used in the model will be appropriate for the B.C. coast region.

Substitution effects will be measured using displacement efficiencies calculated in 2020 by the Consortium for Research in Renewable Industrial Materials (CORRIM) in a report for Oregon’s managed forests (Puettmann & Lippke, 2020).

However, as more localized forest carbon research becomes available, some of the assumptions or tools listed above may be subject to change.

9 NON-RECOVERABLE LOSSES

Windthrow, insects, disease and fire can cause catastrophic losses of whole stands of trees. Over the long-term, the probability of losses to such natural causes can be estimated. Where losses occur in merchantable stands, some dead or dying timber may be salvageable. When modelling timber supply, unsalvaged losses are subtracted from the forecast upon completion of the modelling exercise.

9.1 Windthrow

Historically, windthrow has occurred mainly in relatively small patches. Loss of single trees or small groups of trees are mostly accounted for in inventory sampling for existing timber yield estimates and OAFs applied to young stands. Many windthrow patches are salvageable, meaning that the timber impacted by windthrow events can be harvested, and then the area will be regenerated using planting and silviculture techniques. However, there are patches that are unsalvageable. A review was conducted to quantify the unsalvageable area and volume for TFL 44 with spatially delineated polygons. The review indicated 86.7 ha of productive area was deemed to be not salvageable due to windthrow. Approximately 52% is within the THLB but not recovered through salvage. A very large storm that occurred in the fall of 2006 is the major contributor to the impacted timber in TFL 44. The total non-recoverable losses in THLB volume for these windthrow areas is approximately 38,000 m^3.

Many research studies have been undertaken during the past ten to fifteen years to determine the variables that affect the amount of expected windthrow along cutblock edges following harvest and the effectiveness of various edge treatment techniques (e.g., pruning, topping, and feathering) to reduce the amount of windthrow experienced. Results from these studies have aided in cutblock design and treatment prescriptions so that the amount of windthrow experienced from endemic winds has been greatly reduced. With the planned reduction in the use of the retention silviculture system (see Section 10.3.4), less windthrow is expected in the future.

9.2 Insects and Disease

The forests of TFL 44 have been relatively free of major insect or disease infestations and therefore no losses are associated. There have been no major catastrophic outbreaks causing significant unsalvaged mortality or volume losses. The main active agents have been various defoliators. The last defoliator outbreak was in the mid-1940's when hemlock looper (*Lambdina fiscellaria*) killed mature timber in significant parts of the Nitinat, Pachena, Sarita and Klanawa watersheds. Pockets of timber have been affected by the Balsam Woolly Adelgid (*Adelges piceae*) – generally on drier sites within the CWHmm2 and MHmm1 variants.

Hemlock dwarf mistletoe is widespread throughout merchantable sized stands. Sanitation treatments of advanced regeneration are sometimes required to prevent the spread in newly regenerated western hemlock stands. Usually regenerated stands are not impacted significantly by hemlock dwarf mistletoe.

Root diseases sometimes result in small pockets of mortality. These losses are assumed accounted for by the operational adjustment factors (OAFs) applied to yield curves. Impacts of laminated root rot

(*Phellinus weirii*) in TFL 44 are less than observed in other areas. Additional OAF allowances are not applied in the timber supply base case. For sensitivity analysis, an increased OAF 2 on existing managed and future Fd leading stands in CWHmm1, xm1 and xm2 will be applied to evaluate the timber supply impact of the root disease.

9.3 Fire

The risk of loss of timber due to fire is relatively low within the TFL. The bulk of the TFL has a wet climate characterized by cool, wet summers and fire suppression has been efficient; hence the likelihood of losses to forest fire is small. Despite that, since MP #5, there have been six fires within TFL 44. Five of them were caused by humans and one was caused by lightning. These fires impacted 66.1 ha in total area and 57.7 ha of THLB area. The inventory volume estimate within the fires perimeters is roughly 3,276 m^3 of THLB volume and 4,693 m^3 within the non-contributing land base. Given the insignificant cumulative impacted area and volume in relevance of the totality of TFL 44, fire is assumed to present a negligible downward influence on timber supply.

9.4 Total Non-recoverable Losses

An allowance of one percent of the harvest volume will be made for non-recoverable losses. This volume will be subtracted from the annual harvest in order to remove this volume from the THLB and transition an applicable amount of stand area to age zero. The volume of unrecovered timber will not be included in the reported harvest volumes.

10 INTEGRATED RESOURCE MANAGEMENT

The intent of this section is to give an overview of the resource inventories available and being used for the timber supply review. The section also describes other resource management information that is being utilized for planning within TFL 44.

10.1 Forest Resource Inventories

Table 47 summarizes the forest resource inventories currently being maintained for the TFL. Other inventories are maintained by the provincial government and periodically accessed via Data BC.

Table 47 Forest resource inventory status

Item	Status
Forest Inventory	TFL 44 inventoried in 1970s. Augmented since with operational and second-growth cruising. Inventory was audited during the late 1990s. Updated for growth, harvesting and silviculture to December 31, 2019. LiDAR-derived individual tree inventory was developed for TFL 44 based on LiDAR acquired in 2016 and data models based on collection of ground truth trees. Growth and harvesting after 2016 are not currently being updated to this inventory dataset due to high cost of LiDAR re-acquisition.
Ecosystems	TEM (level 4 survey intensity) funded by Forest Renewal BC (FRBC) was completed for TFL 44 in 2002 / 2003.
Terrain Stability	Various inventories to different standards. Most recently, during 2001 to 2003 FRBC/ Forest Investment Account (FIA) funded projects were completed – included DTSM and landslide inventories in the Klanawa Watershed and a reconnaissance terrain stability mapping for much of the remainder of Alberni East.
Recreation Inventory	Completed in 1995 using the Ministry of Forest and Range standards established in 1991. 2005 GAR Order established to identify designated recreation sites, trails and interpretive forest sites as resource features.
Visual Landscape Inventory	The TFL 44 visual landscape inventory was updated in 2000 using the Ministry of Forest and Range standards established in 1997 Basis for the TFL 44 portion of the GAR Order to establish Visual Quality Objectives for the South Island Forest District.
Ungulate Winter Ranges (UWRs)	UWRs for Columbian black tailed deer and Roosevelt elk (U-1-013).
Wildlife Habitat Areas (WHAs)	43 WHAs established – 33 for Marbled Murrelets, 7 for Scouler's Corydalis, 3 for red-legged frogs; and 3 pre-approved WHAs for Northern Goshawk.
Old Growth Management Areas (OGMAs)	OGMAs have been established in the Caycuse, Gordon, Great Central, Nitinat, Sproat Lake and Walbran LUs. Refinement of draft OGMAs is proceeding for the Ash, Corrigan, Effingham, Great Central, Henderson, Klanawa, Nitinat, and Sarita LUs.
Stream Classification	Terrain Resource Information Management (TRIM)-based streams and operational stream inventories collected during timber development via GPS (updated March 2021).
Archaeological	An Archaeological Overview Assessment (AOA) funded by FIA was completed in March 2009 and other registered archaeological features and sites from the Archaeology Branch (updated in 2020) were included.

Item	Status
Operability	LiDAR based LBB process as described in Section 5.4.3.
Caves and Karst	Caves inventory maintained at operational level with assistance of VICEG. Karst potential mapping is a provincial inventory.

10.2 Forest Cover Requirements

10.2.1 Research Sites

There are 12 active government research sites within TFL 44 associated with studying the growth of stands reforested with trial seedlings, fisheries, and silvicultural treatments. There is also one completed research site and one dormant site. Most of the sites were established in the 1990's. A 50 m buffer will be created around each active research site and the resulting area will not be available for harvest by the timber supply model until 60 years after the research site was established.

10.2.2 Visual Quality

The District Manager of the South Island Forest District in a Government Actions Regulation Order established Visual Quality Objectives (VQOs) for the Forest District on December 15, 2005 and amended on December 30, 2011. This includes VQOs in TFL 44.

Visual Quality Objectives to be modelled in the timber supply analysis are Retention (R), Partial Retention (PR) and Modification (M). The amount of area that can be disturbed (i.e. has not achieved visually effective green-up) is 5%, 15% and 25% for each VQO respectively (Province of British Columbia, 1998). These levels are set at the upper end of the % disturbance range for use in timber supply analyses. The visually effective green-up (VEG) heights for different slope classes are listed in Table 48.

Table 48 Visually Effective Green-up heights by slope (Province of British Columbia, 1998)

Slope (%)	0-5	5.1-10	10.1-15	15.1-20	20.1-25	25.1-30	30.1-34	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

A 5 m visually effective green-up (VEG) height is proposed for TFL 44. Cutblock designs that follow the lines and forms of the viewscape allow more timber to be removed and still meet the VQO when compared to unnatural cutblock shapes. Additionally, the use of the retention silviculture system can result in more timber removal in visually sensitive areas by strategically placing retention patches to act as visual screens. As these practices are common within TFL 44, the maximum allowable disturbance by VQO will set at the upper end of the range typically used to model visual quality management constraints. Table 49 outlines assumptions for dealing with visual quality management within the TFL. A sensitivity analysis will be performed with more restrictive maximum allowable disturbance, moving from the upper end of the range to mid-point. Proposed maximum allowable disturbance in the sensitivity analysis for

Retention, Partial Retention Modification, and Maximum Modification VQO will be set as 32.5%, 20%, 10% and 3%, respectively.

Table 49 Visual Quality Management Assumptions

Visual Quality Objective (VQO)	Productive Forest (ha)	THLB Area (ha)	Maximum Allowable Disturbance (% of productive area)
Retention (R)	623	242	5%
Partial Retention (PR)	13,657	8,298	15%
Modification (M)	14,307	9,210	25%
Maximum Modification (MM)	232	154	40%

10.2.3 Adjacent Cutblock Green-up

Legislation requires trees within plantations to reach specified heights before the adjacent timber can be harvested. A 3 m green-up height in VILUP General and Special Management Zones will be used for areas without visual quality objectives. A 1.3m green-up requirements will be modelled in the Enhanced Forestry Zones (outside of VQO polygons).

Patchworks allows timber supply modelling to be conducted spatially. Therefore, adjacency and block size limitation can be directly implemented. Patches will be used for green-up height controls, with support from stand age for the legislated heights. 5 years and 15 years are selected as corresponding surrogates for 1.3m and 5m green-up heights in the Enhanced Forestry Zones and General and Special Management Zones, respectively. Block size will be limited to 40 hectares in General and Special Management Zones. Enhanced Forestry Zones, however, provides more flexibility on block size, thus the size limit is set to be 80 hectares.

10.2.4 Landscape Level Biodiversity

Landscape Units and Biodiversity Emphasis Options (BEOs) were designated through the NSOG order effective June 30, 2004. This order is in effect until OGMAs are spatially determined through Landscape Unit planning. BEO class, OGMA status for each LU for TFL 44 are explained in Section 6.11 and Table 17. These draft OGMAs will be used in the timber supply analysis but must complete a public and First Nations' review process before coming legal. For the Effingham Landscape Unit, an old seral stage forest cover constraint will be applied based on the designations in the NSOG order.

For the forest types within TFL 44, old forest is defined as stands >250 years old. The old seral target is based on the combination of BEO, BEC variant, and the natural disturbance type (NDT) of the variant. The draft OGMAs for landscape units with a low BEO (Sarita and Henderson) identify enough area to meet the old seral target drawn down to 1/3 for the first rotation (80 years). The target for the end of the second rotation (160 years) will be 2/3 of the full target, with the full old seral target being achieved by the end of the third rotation (240 years). Intermediate and high BEO landscape units will be subject to the full target constraint throughout the analysis period. Table 50 indicates the landscape biodiversity constraints that will be applied for old seral forest. For other LUs, Table 33 breaks down the current forest age by landscape unit and BEC variant.

Table 50 Old Seral Constraints

Landscape Unit	BEO	BEC	NDT	Area (ha)		Old Seral constraint (% of productive)		
				Productive	THLB	1st rotation	After 2nd rotation	After 3rd rotation
Effingham	Intermediate	CWHvm1	1	1,286	656	13	13	13
		CWHvm2	1	336	127	13	13	13
Henderson	Low	CWHvm1	1	7,485	4,260	OGMAs	8.7	13
		CWHvm2	1	2,637	1,056	OGMAs	8.7	13
		MHmm1	1	135	13	OGMAs	12.7	19
Sarita	Low	CWHvh1	1	819	583	OGMAs	8.7	13
		CWHvm1	1	10,555	7,411	OGMAs	8.7	13
		CWHvm2	1	2,050	1,543	OGMAs	8.7	13

10.2.5 Community Watersheds

There are four designated Community Watersheds (CWS) located either completely or partially within TFL 44 (Table 51):

- China Creek (CWS 930.004) – This CWS is the main water supply for the City of Port Alberni. Of the 5,750 ha in this CWS, TFL 44 occupies only 392 ha (6.8%), with the remainder being private forest land.
- Malachan Creek (CWS 930.013) – This 281 ha CWS is a tributary of the Caycuse River located north-east of Nitinat Lake. Of the 281 ha in this CWS, TFL 44 covers 277 ha (98.6%). This CWS is a back-up water supply for the Ditidaht First Nation community at Nitinaht. (The main water supply is from wells).
- Cousteau Creek (CWS 930.006) – This 149ha CWS covers 146 ha of TFL 44 (98%). It is located approximately 5 km south-east of Nahmint Bay, on the east side of the Alberni Canal where it supplies water to the small community at Headquarters Bay.
- Haggard Lake (CWS 930.009) – This 18 ha CWS near Rainy Bay is entirely within TFL 44 and supplies water to the small community at Haggard Cove.

Table 51 Community Watersheds in TFL 44

Community Watershed	Total Watershed Area (ha)	Total Area within TFL 44(ha)	Forested Area (ha)	Productive Forest Area (ha)	Operable Area (ha)	THLB Area (ha)	NCLB Area (ha)
China Community Watershed	5,750	392	387	356	280	202	154
Malachan Community Watershed	281	277	271	271	218	190	81
Cousteau Community Watershed	149	146	142	140	115	82	59
Haggard Lake Community Watershed	18	18	12	12	5	4	8

For the Malachan, Cousteau and Haggard Lake community watersheds, a forest cover constraint will be applied so that no more than 1% of the productive area within each watershed will be harvested in one year. No cover constraints will be applied in the China Creek community watersheds due to the relatively small proportion within TFL 44 – activities on the non-TFL portion of these CWS will outweigh any constraints applied to the TFL portion – especially for China Creek with its high proportion of private forest land.

10.2.6 Fisheries Sensitive Watersheds

A GAR order effective as of December 28, 2005 established Fisheries Sensitive Watersheds (FSWs) on Vancouver Island. FSWs are defined as watersheds with significant downstream fisheries values and significant watershed sensitivity such that the area requires special management to protect fish. Within TFL 44, the Klanawa River and Hatton Creek watersheds were established as FSWs.

Given the fisheries sensitive watershed designation, a forest cover constraint will be applied limiting the equivalent clearcut area (ECA) to 35% in the rain-on-snow zone (defined as above 500 m elevation) of the basin, using a new hydrologic recovery method. This ECA limit was recommended in a 2021 update to WFP's watershed management strategies for TFL 44. The ECA recovery factors listed in Table 52 and TIPSY height projections will be applied to calculate the ECA for the rain-on snow zone within the aforementioned Community Watersheds and a maximum 35% ECA limit will be applied within the timber supply model. Harvested and regenerating areas will contribute to ECA until the regeneration reaches 34m in height, at which time it is assumed the stands will have achieved hydrologic green-up. Details on how the TFL 44 hydrologic recovery method was developed are attached in Appendix E: Hydrologic Recovery Method Review.

For sensitivity analysis, an ECA limit of 20% will be used on these FSWs. This limit is referenced by the *Great Bear Rainforest Order* (GBRO) Division 3 for Important Fisheries Watersheds (3-10.(1), GBRO 2016, p.16).

Table 52 Recovery and ECA factors for TFL 44 Watersheds

Stand Height (m)	Recovery Factor (RF)	ECA Factor (1 – RF)
1	0	1
2	0	1
3	0	1
4	0	1
5	0.11	0.89
6	0.24	0.76
7	0.35	0.65
8	0.45	0.55
9	0.54	0.46
10	0.62	0.38
11	0.68	0.32
12	0.73	0.27
13	0.78	0.22
14	0.81	0.19
15	0.85	0.15
16	0.87	0.13
17	0.89	0.11
18	0.91	0.09
19	0.93	0.07
20	0.94	0.06
21	0.95	0.05
22	0.96	0.04
23	0.97	0.03
24	0.97	0.03
25	0.98	0.02
26	0.98	0.02
27	0.98	0.02
28	0.99	0.01
29	0.99	0.01
30	0.99	0.01
31	0.99	0.01
32	0.99	0.01
33	0.99	0.01
34	1	0

10.2.7 Terrain Stability

During the TFL 44 Hydrologic Recovery Method Review (Appendix E: Hydrologic Recovery Method Review), it was noted that by managing ECA for hydrologic and geomorphic sensitivity at the watershed level also increases the management effectiveness of hillslope processes. This is because in a major rainstorm event, the forest canopy can buffer the increased waterflow going into soil pores. Thus, concerns in landslide-prone slopes or steep slopes within landslide initiation zones can be mitigated by limiting ECA in the timber supply model.

Terrain stability was previously addressed in the THLB netdown process described in Section 6.18 based on the terrain stability mapping review (Appendix D: Terrain Stability Mapping Review). In addition to netdown process, Nitinat River (excluding Little Nitinat) will be subject to an ECA limit of 35% in the rain-on-snow zone (defined as above 500 m elevation) of the basin, using the same hydrologic recovery method described in Section 10.2.6.

To test the sensitivity of this management approach, an alternative elevation threshold of 400m for ECA will be performed to expand this harvest restriction to more areas within one watershed.

10.2.8 VILUP Higher Level Plans

The order establishing Resource Management Zones and Resource Management Zone objectives within the area covered by the Vancouver Island Land Use Plan came into effect as of December 1, 2000. Each Special Management Zone (SMZ) established by the order includes an objective (Section II 1(a)(i)) of maintaining mature seral forest over one quarter to one third of the forested area in the SMZ, with the final target to be set through landscape unit planning.

There are portions of four SMZ's within TFL 44: SMZ 14 (Barkley Sound), SMZ 17 (Strathcona-Taylor), SMZ 18 (Alberni Canal), and SMZ 21 (Walbran Periphery). For this analysis, a constraint will be incorporated that maintains 25% of the productive forest land base in the mature and/or old seral stage within these SMZ's.

10.3 Timber Harvesting

10.3.1 Minimum Harvest Criteria

Minimum Harvest Criteria prescribed in the timber supply analysis contains minimum harvest ages and minimum harvest volume. While actual harvesting may occur in stands below the minimum requirements in order to meet forest level objectives (e.g., maintaining overall timber flows, addressing forest health concerns), many stands will not be harvested until well past the minimum ages because consideration of other resource values may take precedence. To safeguard the long-term sustainable harvest level of the TFL, the minimum harvest criteria applied in the timber supply analysis is adhered to operationally. Internal controls are in place whereby an approved rationale is required to harvest a stand prior to the minimum harvest criteria being reached.

The dataset prepared for this timber supply analysis includes logging systems (e.g., ground, cable or helicopter) derived from the LiDAR-based LBB process as described in Section 5.4.3. Conventionally operable areas with a LiDAR-derived slope between 0 and 40 percent are assumed harvestable by ground-based systems and conventionally operable areas on steeper slopes are assumed harvestable by cable systems. Helicopter operable areas are found across all slope classes as feasible road development determines areas not accessible by conventional harvesting systems.

This analysis will use minimum harvest ages based on average stand diameters that vary by harvesting system:

- 30 cm for ground-based harvesting;
- 37 cm for cable harvesting;
- 42 cm for helicopter harvesting;
- a minimum volume of 350 m3/ha.

The notion being larger diameters in general reflect higher values and cable and heli yarding costs are particularly sensitive to piece (log) size. An economically sustainable harvesting program relies on average stand values being greater than average harvesting costs. Average harvesting costs are lowest for ground-based systems (e.g., skidder and "hoe-chucking") and highest for helicopter, while cable systems (e.g., grapple yarding) costs fall between these. The log size distribution resulting from applying the DBH criteria supports milling requirements at various manufacturing facilities.

If the minimum DBH and/or volume thresholds are not reached by 250 years, a minimum harvest age of 250 years will be applied.

For mature natural stands (150 years and older), there is no age limit as there is no need to delay harvesting of these stands within the timber supply model.

For existing managed stands and future stands, Table 53 and Table 54 indicate the minimum harvest ages by analysis unit and harvest system that will be used in the analysis. Younger ages are on higher productivity sites while older ages are on lower productivity sites. Culmination ages and volumes are provided for comparison purposes.

Table 53 Minimum Harvest Ages (MHA) for Current Stands

Analysis Unit	Current THLB Area (ha)	Culm. Age	Culm. Volume	Ground-based Harvest		Cable Harvest		Helicopter Harvest	
				MHA	Volume at MHA	MHA	Volume at MHA	MHA	Volume at MHA
Managed Stands 21-57 years old (established 1962 - 1999)									
1131	346	100	801	71	526	113	896	150	1,103
1133	1,060	80	785	52	463	79	775	100	948
1134	256	90	884	59	516	90	884	115	1,092
1136	32	100	886	63	489	98	866	130	1,099
1233	218	80	848	50	472	74	783	92	956
1234	19	80	900	50	493	75	841	93	1,024
1333	24	70	739	48	459	72	758	89	908
2131	168	100	830	70	534	112	920	147	1,129
2133	153	90	785	59	477	93	808	120	982
2134	471	90	885	59	517	90	885	115	1,090
2231	141	90	845	63	539	97	907	126	1,117

Analysis Unit	Current THLB Area (ha)	Culm. Age	Culm. Volume	Ground-based Harvest		Cable Harvest		Helicopter Harvest	
				MHA	Volume at MHA	MHA	Volume at MHA	MHA	Volume at MHA
2233	204	90	744	61	469	97	799	128	983
2234	126	90	889	59	525	89	879	114	1,084
2333	118	80	725	57	480	88	793	113	960
3131	314	100	876	66	521	104	907	137	1,125
3133	59	90	595	72	464	123	778	172	942
3134	232	100	829	68	518	108	889	143	1,096
3231	194	100	770	73	525	117	893	156	1,093
3233	221	90	695	64	468	104	792	140	969
3234	137	100	876	65	518	101	883	133	1,094
3333	4	90	642	68	462	113	790	155	964
4132	25	120	463	114	438	250	684	250	684
4232	37	120	526	106	455	237	778	250	790
4234	117	130	576	111	488	216	822	250	874
4332	1,154	120	586	96	454	184	785	250	875
4334	340	110	751	78	500	129	863	177	1,061
5131	53	90	854	61	526	94	887	122	1,091
5132	506	90	814	61	484	92	830	121	1,068
5133	1,995	70	797	47	473	69	784	85	951
5134	5,881	90	917	57	515	85	866	109	1,079
5137	40	70	853	44	467	64	775	77	928
5138	39	130	622	97	435	162	758	232	957
5231	24	80	917	54	551	82	937	104	1,160
5232	1,925	80	762	59	493	88	837	115	1,073
5233	2,531	70	807	47	478	68	781	84	955
5234	8,141	80	860	55	519	81	870	104	1,087
5238	25	80	966	45	435	65	759	81	978
5332	97	90	838	60	493	90	838	119	1,076
5333	1,205	70	831	46	477	67	791	83	971
5334	346	80	849	54	503	81	859	102	1,053
5338	15	80	1,027	45	461	64	790	80	1,027
6134	8	124	595	105	499	192	828	250	932
6231	58	90	850	63	541	98	920	129	1,146
6232	15	100	747	72	481	115	841	162	1,085
6233	44	80	712	57	470	87	770	112	937
6234	597	90	786	67	537	104	900	136	1,112

Analysis Unit	Current THLB Area (ha)	Culm. Age	Culm. Volume	Ground-based Harvest		Cable Harvest		Helicopter Harvest	
				MHA	Volume at MHA	MHA	Volume at MHA	MHA	Volume at MHA
6331	152	100	751	74	517	119	880	160	1,084
6332	67	100	706	73	479	117	809	165	1,016
6333	613	80	700	58	471	90	785	117	957
6334	2,459	90	813	64	526	99	889	130	1,109
6336	48	100	769	71	496	113	859	158	1,099
7331	31	170	490	170	490	250	645	250	645
Managed Stands 1-20 years old (established 1999 - 2019)									
1122	76	70	774	47	463	69	762	86	927
1123	320	70	777	47	465	69	765	86	932
1124	63	70	789	46	458	68	764	85	935
1223	153	70	754	47	453	70	754	88	919
1224	53	70	848	43	457	62	748	77	920
1322	44	70	826	43	449	63	742	78	904
1323	2,310	70	819	44	459	64	747	80	917
1324	15	60	743	42	458	61	755	74	905
2121	16	90	1,014	51	482	76	844	96	1,071
2123	12	90	856	58	482	89	845	118	1,083
2124	48	90	917	55	479	84	847	109	1,083
2221	63	100	897	60	480	94	841	123	1,054
2224	19	100	899	60	481	93	834	123	1,056
2323	39	80	709	56	460	88	774	115	947
3121	136	90	747	64	489	100	829	134	1,036
3123	30	100	866	61	479	97	840	128	1,043
3124	73	100	869	61	481	96	834	128	1,046
3126	46	100	817	64	480	102	832	137	1,037
3221	196	90	721	65	479	104	831	140	1,036
3223	22	100	861	62	486	98	843	129	1,043
3224	24	100	851	62	479	99	842	130	1,038
3323	78	90	700	64	471	103	794	140	980
3324	11	80	666	60	466	96	795	127	978
3326	12	90	774	59	471	93	797	123	986
4122	283	120	598	94	451	190	785	250	849
4124	55	100	1,002	56	466	85	836	112	1,101
4222	204	120	539	101	442	240	763	250	771
4321	24	100	969	58	474	88	840	116	1,096

Analysis Unit	Current THLB Area (ha)	Culm. Age	Culm. Volume	Ground-based Harvest		Cable Harvest		Helicopter Harvest	
				MHA	Volume at MHA	MHA	Volume at MHA	MHA	Volume at MHA
4322	1,731	120	643	90	460	169	807	250	936
4323	20	100	740	71	471	114	826	163	1,064
4324	353	100	745	70	468	113	831	159	1,068
4328	23	100	987	57	470	87	846	114	1,100
5121	23	90	823	59	475	90	823	119	1,046
5122	954	80	767	57	478	86	823	113	1,057
5123	227	80	786	56	481	84	823	110	1,050
5124	1,274	80	788	56	481	84	825	110	1,059
5126	13	100	939	58	478	89	835	116	1,064
5127	12	80	822	54	480	81	832	105	1,066
5221	173	90	820	60	484	92	835	123	1,075
5222	1,374	80	777	58	495	87	841	114	1,077
5223	11	91	792	62	478	98	853	130	1,081
5224	3,454	80	779	57	485	86	834	114	1,081
5228	36	80	821	55	494	82	840	107	1,082
5322	2,421	80	801	55	485	81	810	105	1,027
5323	1,009	80	808	54	477	80	808	104	1,028
5324	651	80	812	54	479	80	812	104	1,032
5328	10	80	832	53	480	79	821	101	1,043
6121	85	110	685	82	480	140	824	218	1,034
6122	93	90	742	66	494	103	843	142	1,081
6124	59	100	768	70	490	111	839	155	1,069
6126	49	100	724	73	486	119	839	170	1,060
6224	145	90	751	66	503	102	846	140	1,080
6321	406	90	726	67	494	105	838	144	1,060
6322	193	90	717	68	497	106	835	146	1,057
6323	77	100	764	70	492	110	828	155	1,055
6324	1,475	90	729	67	496	104	834	143	1,060
6326	77	100	718	73	486	119	832	169	1,045
7321	73	120	423	136	477	250	691	250	691

Table 54 Minimum Harvest Ages for Future Stands

Analysis Unit	Future THLB Area (ha)	Culm. Age	Culm. Volume	Ground-based Harvest		Cable Harvest		Helicopter Harvest	
				MHA	Volume at MHA	MHA	Volume at MHA	MHA	Volume at MHA
1110	4,590	60	719	48	546	69	821	84	959
1210	970	60	736	47	544	67	816	82	963
1310	2,959	60	760	46	548	65	818	79	963
2110	1,466	80	828	60	597	89	912	112	1,080
2210	567	80	830	59	584	89	914	112	1,083
2310	157	80	813	60	586	90	905	115	1,079
3110	2,072	80	681	68	567	107	877	140	1,031
3210	964	100	855	72	597	112	941	147	1,123
3310	114	100	852	73	604	114	946	149	1,126
4110	620	110	605	98	535	250	707	250	707
4210	767	110	596	100	540	250	841	250	841
4310	4,079	110	704	97	616	162	952	229	1,110
5110	17,113	80	815	60	576	91	912	118	1,122
5210	20,704	80	875	58	597	87	938	111	1,146
5310	7,123	80	910	57	604	84	950	105	1,150
6110	828	90	737	77	614	122	953	163	1,143
6210	1,996	90	794	72	615	112	955	149	1,157
6310	6,496	90	760	76	623	119	965	160	1,167
7110	120	150	416	230	590	250	619	250	619
7210	83	140	422	206	594	250	669	250	669
7310	474	140	401	220	590	250	636	250	636

To evaluate the impact of minimum harvestable age, sensitivity analyses will be conducted to increase and subtract 2cm average stand diameters, respectively.

In addition, the minimum DBH criteria in the Base Case is to manage stands on for financial rotation reasons. A tradition concept to maximize yield from a forest over time is to harvest stands when they reach their highest average growth rate or mean annual increment (MAI). This age is often referred to as the culmination age and is the optimal biological rotation age to maximize long-term volume (Province of British Columbia, 2008). Given conflicting forest-level objectives, it is not feasible to consistently harvest all stands at their culmination age. Therefore, achieving 95% of culmination is often seen as a reasonable objective. Another sensitivity analysis that may be performed is to set the minimum harvest age when the mean annual increment (MAI) first reaches 95% of the culmination MAI.

10.3.2 Initial Harvest Rate

The current AAC for the analysis area, 793,600 m^3, includes 782,482 m^3 for Tsawak-qin and 11,118 m^3 for First Nations. December 2020 AAC partition decision specifies 535,000 m^3 attributable to the economic land base and 110,000 m^3 attributable to the economic land base in stands less than 121 years old.

The MP #5 Base Case forecast an even flow across the entire 250-year planning horizon. Given changes to THLB netdowns, AAC partitions and growth and yield factors, the timber supply dynamics for TFL 44 may be different than portrayed in MP #5. As such, various initial harvest rates will be modelled until a Base Case harvest schedule that meets the harvest flow objectives is determined.

10.3.3 Harvest Rules

The analysis will be undertaken with the Patchworks model, leveraging spatial availability to optimize and project harvest schedules. Harvest constraints will be applied to demonstrate the transition from old-growth harvest to second-growth harvest and to reflect performance within the non-conventional portion of the THLB.

10.3.3.1 *Second-growth Contribution*

In the December 2020 Chief Forester's Partition decision, 110,000 m^3 of AAC (13.9%) is attributed to immature stands (i.e., <121 years old) in TFL 44. However, the THLB definition and inventory in this analysis differ from the 2020 Partition analysis. Therefore, second-growth harvest in the base case option will commence at a higher proportion of the total harvest than the 2020 Partition analysis and will gradually increase over time until the transition to second-growth harvest is largely complete, though small volumes of old-growth harvest may continue to be harvested because of the scheduling impacts of forest cover class constraints.

10.3.3.2 *Non-conventional Harvesting Contribution*

As discussed in Section 6.8, recent harvest (2009-2019) within the non-conventional portion of the THLB has been approximately 8.9% of the total harvest area (Table 14) using physical operability classes defined utilizing LiDAR data via LBB process (Section 5.4.3). For comparison, an overall summary of 2009-2019 harvesting performance by operability categories from MP #5 is presented in Table 55, with slightly higher (12.2%) contribution from non-conventional ground.

Table 55 Harvest Area for 2009 to 2019 by MP #5 Operability Class

MP #5 Operability Class	% of Harvest Area (2009-2019)
Conventional	87.2%
Non-conventional	12.2%
Inoperable/Uneconomic	0.6%
Total	***100.00%***

As indicated in Table 14, the non-conventionally operable land base plays a minor but important role in THLB. Table 56 provides details of the THLB area and volume by harvest system. As can be seen, non-conventionally operable land base represents approximately 6.5% of the total THLB but contains 12.2% of the current THLB volume. The level of performance in the non-conventional THLB is not anticipated to increase significantly in the near future.

Table 56 THLB Breakdown by Harvest System

Harvest System	THLB Area (ha)	THLB Volume (000 m^3)	% of THLB Area	% of THLB Volume
Ground	32,631	8,293	43.9%	38.7%
Cable	36,766	10,528	49.5%	49.1%
Non-conventional	4,863	2,614	6.5%	12.2%
Total	***74,260***	***21,435***	***100.00%***	***100.00%***

With the December 2020 AAC economic partition decision made by the Chief Forester, the economic viability of the non-conventional harvesting contribution has been accounted via economic/uneconomic land base classification. The projected harvest flow in the Base Case will present volumes from economic land base, profiled by mature (>120-year-old) and immature stands. The sensitivity of timber supply to assumptions related to the contribution from the heli-operable land base in HwBa stands will be tested.

10.3.4 Silviculture Systems

For operational forest practices, Tsawak-qin is currently following WFP's WSCP. The application of the retention harvest system is one component of WFP's WSCP. The WSCP is designed to maintain values across the landscape through time and components include biodiversity, timber, water, carbon and climate change. Stand-level retention helps address biodiversity elements including, but not limited to:

- ecosystem representation,
- rare ecosystems,
- old forest,
- big trees.

WFP varies the use of retention systems and the amount of stand level retention by Resource Management Zones in the Vancouver Island Land Use Plan and by ecosection that stratifies British Columbia's terrestrial and marine ecosystem complexity. Different Western Forest Stewardship Zones and their corresponding locations can be found on Figure 24.

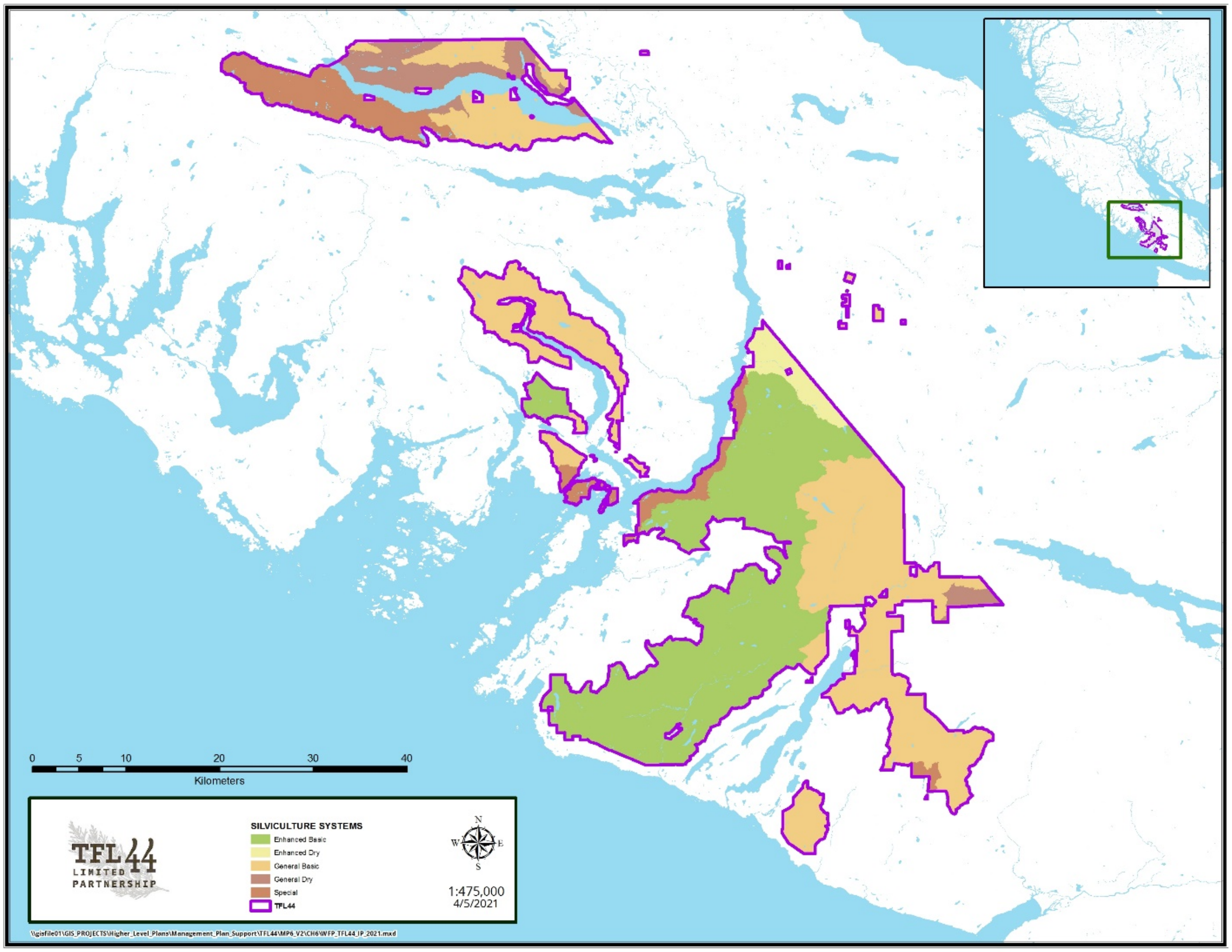

Figure 24 Western Forest Stewardship Zones in TFL 44

In Enhanced Management Zones, the retention system will be used for between 50 and 60 percent (depending on the ecosection with lower levels being used in windy areas and higher levels being used in leeward areas) of the harvested area with minimum long-term stand-level retention targets of 10 and 15 percent (depending on variant with the higher target being used in drier variants).

In General Management Zones, the retention system will be used for between 60 and 70 percent of the harvested area utilizing minimum long-term stand-level retention targets of 15 and 20 percent.

In Special Management Zones, the VILUP Higher Level Plan Order specifies: “applying a variety of silvicultural systems, patch sizes and patch shapes across the zone, subject to a maximum cutblock size of 5 ha if clearcut, clearcut with reserves, or seed tree silvicultural systems are applied; and 40 ha if shelterwood, selection or retention silvicultural systems are applied.” A minimum of 20 percent long-term stand-level retention is recommended in the WSCP. These targets are summarized in Table 57.

Table 57 WSCP Retention Targets

Western Forest Stewardship Zones	Ecosection	Resource Management Zone	Variants	THLB Area (ha)	Retention Strategy Use (% of harvest area)	Long Term Retention (% of harvest area)
General Basic	Windward Island Mountains and Leeward Island Mountains	General	CWHmm1, CWHmm2, CWHvh1, CWHvm1, CWHvm2, CWHxm2, MHmm1	31,183	60%	15%
General Dry			CWHmm1,CWHvm1, CWHvm2, CWHxm1, CWHxm2	5,123	70%	20%
Enhanced Basic		Enhanced	CWHmm2, CWHvh1, CWHvm1, CWHvm2, CWHxm2, MHmm1	31,351	50%	10%
Enhanced Dry			CWHmm2, CWHxm2	2,334	60%	15%
Special	All	Special	CMAunp, CWHmm1, CWHmm2, CWHvh1, CWHvm1, CWHvm2, CWHxm2, MHmm1	4,270	100%	20%
Total				***74,260***	***58.8%***	***13.5%***

This retention is long-term - it must remain for at least one rotation. Applying the above retention system requirements to the Ecosection/VILUP Zone/BEC variant combinations present within TFL 44 results in 58.8% of the total harvest area being in retention system cutblocks (with the remaining being clearcut or clearcut-with-reserves) and an area-weighted average overall minimum stand level retention requirement of 13.5% for TFL 44.

10.3.5 Harvest Flow Objectives

Harvest level projections will maximize volumes harvested subject to the following constraints:

- Gradually adjust harvest levels toward the best estimate of the long-term stable harvest level;
- Minimize the length of time that harvest is less than the long-term harvest level; and
- Achieve a stable long-term growing stock.

Due to the partition classifications established by the Chief Forester in December 2020, harvest flow in the current economic (old growth and second growth) and uneconomic land base will be tracked by the timber supply model. A sensitivity analysis that removes the partition classifications will be conducted.

10.3.6 Unused Volumes

Unused volume is defined as the total cumulative AAC subtracted by total volume attributed to license (e.g. harvested timber, damaged/wasted timber). If any unused volume is to be disposed in the next cut control period, it will overlap with the planning horizon of this timber supply analysis. In the most recent cut control period for TFL 44 (2016 – 2020), the best available estimate of the total unused volume will be used in sensitivity analyses. These sensitivity analyses will be conducted to test the mid and long-term timber supply impacts of disposing of this unused volume with and without conditions on its source (e.g. the established partitions) in the first decade of the planning horizon.

10.3.7 Old Growth Deferral Areas

On June 10, 2021, a Ministerial Order was issued to include the Central Walbran Valley as an Old Growth Designated Area to honour the request of the Huu-ay-aht, Pacheedaht and Ditidaht First Nations. Approximately 339 hectares of the Central Walbran Valley Old Growth Designated Area is within the TFL 44 tenure boundary (Figure 25). According to the Ministerial Order, harvesting in forest stands less than 212 years old within the Central Walbran Designated Area is permitted.

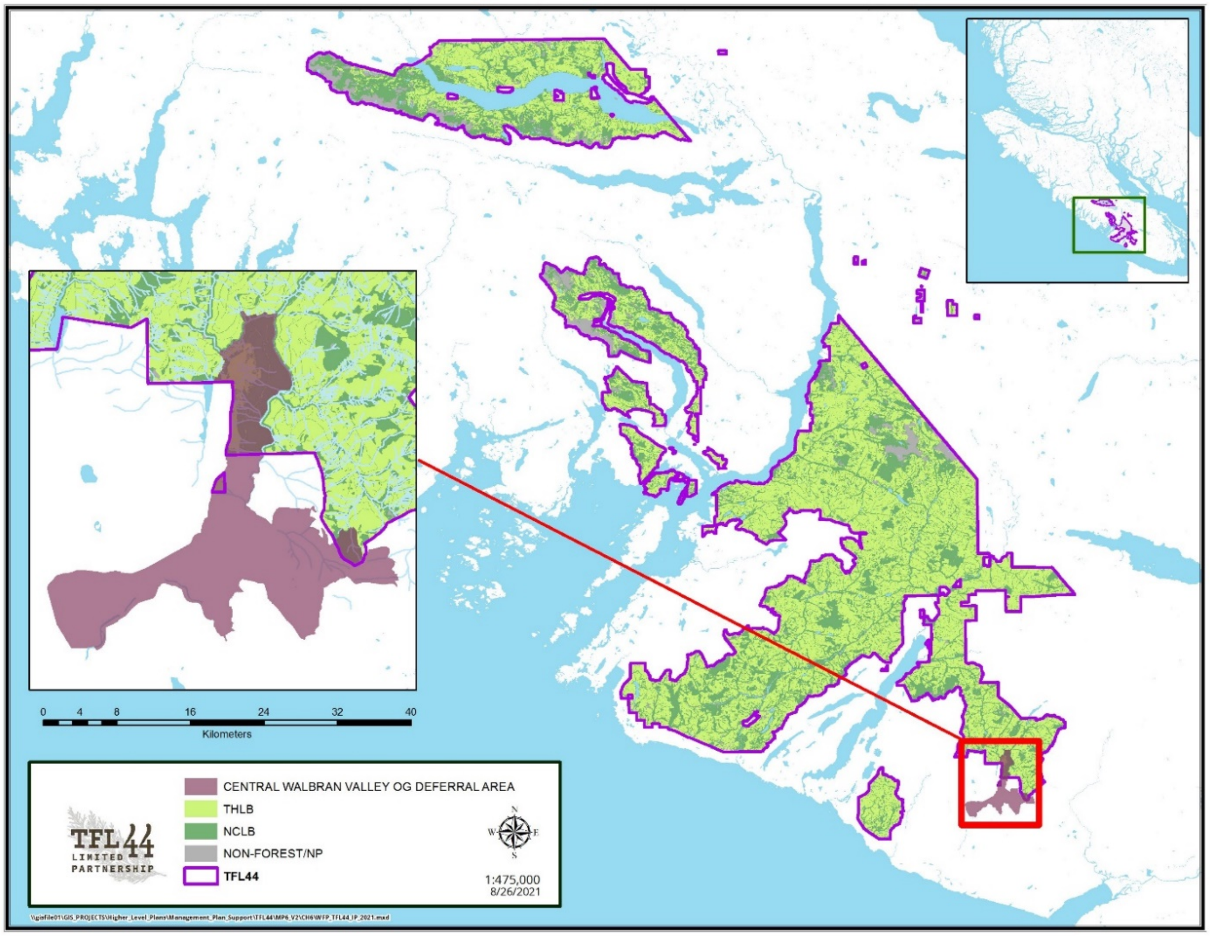

Figure 25 Central Walbran Valley Old Growth Designated Area in TFL 44

Subsequently in In November 2021, the Province of British Columbia announced that 2.6 million hectares of the “ancient, rare and priority large stands of old growth” stands are deferred from harvesting on short-term basis (Province of British Columbia, 2021). This deferral process is still ongoing with the consultation process with applicable First Nations underway across the province. It is anticipated that the Indigenous-led processes will guide future decisions related to the conservation of old growth. For the TFL 44 MP #6 timber supply analysis, the short-term nature of the deferrals does not align with the 300-year modelled planning horizon broken into 5- and 10-year periods. Therefore, it is omitted from the analysis.

10.3.8 Timber Harvesting around Nearby Parks

Nearby parks around TFL 44 are listed in Section 1.3. These federal and provincial parks are excluded from the TFL 44 boundary. In practice, a proposed cutblock often will leave a 30m buffer (approximate one tree length) from the TFL boundary adjacent to nearby parks. This measure provides flexibility for the removal of danger trees for safety purposes outside of the proposed net harvest area for safety purposes and windthrow mitigation treatments to occur within the TFL to protect park boundaries.

A sensitivity analysis that excludes a 30m buffer of surrounding parks from the THLB will be conducted to examine the impact of this operational measure.

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12 Glossary (Province of British Columbia, 2008)

Allowable Annual Cut (AAC)	The rate of timber harvest permitted each year from a specified area of land, usually expressed as cubic metres per year.
Analysis Unit (AU)	A grouping of forest types – for example, by BEC zone, site productivity, leading tree species, and age - done to simplify analysis and the generation of timber yield tables.
Base case harvest forecast (Current Management Option)	The timber supply forecast which illustrates the effect of current forest management practices on the timber supply using the best available information, and which forms the reference point for sensitivity analysis.
Biodiversity (biological diversity)	The diversity of plants, animal and other living organisms in all their forms and levels of organization, including the diversity of genes, species and ecosystems, as well as the evolutionary and functional processes that link them.
Biogeoclimatic Ecosystem Classification zones, subzones and variants (BEC)	A large geographic area with broadly homogeneous climate and similar dominant tree species. There are two main zones within this area, Coastal western hemlock (CWH) and Mountain hemlock (MH) with eight subzones: Eastern very dry maritime (xm1), western very dry maritime (xm2), submontane moist maritime (mm1), montane moist maritime (mm2), southern very wet hypermaritime (vh1), central very wet hypermaritime (vm1), and montane very wet maritime (vm2).
Cutblock	A specific area, with defined boundaries, authorized for harvest.
Cutblock adjacency	The desired spatial relationship among cutblocks. Most adjacency restrictions require that recently harvested cutblocks must achieve a desired condition (green-up) before nearby or adjacent areas can be harvested.
Culmination Age	The age at which a timber stand reaches its highest average growth rate, or mean annual increment (MAI). MAI is calculated as stand volume divided by stand age. Culmination age is the optimal biological rotation age to maximize long-term volume production from a growing site.

12 Glossary (Province of British Columbia, 2008)

Forest inventory	An assessment of timber resources. It includes computerized maps, a database describing the location and nature of forest cover, including size, age, timber volume, and species composition, and a description of other forest values such as recreation and wildlife habitat.
Forest and Range Practices Act	Legislation that governs forest and range practices and planning, with a focus on ensuring management of all forest values.
Forest type	The classification or label given to a forest stand, usually based on tree species composition.
Free-growing (FG)	An established seedling of an acceptable species that is free from growth-inhibiting brush, weeds and excessive tree competition.
Geographic Information System (GIS)	A geographic information system, also known as a geographical information system or geospatial information system, is a system for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to the Earth.
Green-up	The time needed after harvesting for a stand of trees to reach a desired condition (usually expressed as a specific height) - to ensure maintenance of water quality, wildlife habitat, soil stability, or aesthetics – before harvesting is permitted in adjacent areas.
Growing stock	The estimated volume for all standing timber at a particular time.
Harvest forecast	The potential flow of timber harvest over time. A harvest forecast is usually a measure of the maximum timber supply that can be realized over time for a specified land base and a set of management practices. It is a result of forest planning models and is affected by the size and productivity of the land base, the current growing stock, and management objectives, constraints and assumptions.
Inoperable areas	Areas defined as unavailable for timber harvest for terrain-related or economic reasons. Operability can change over time as a function of changing harvesting technology and economics.

12 Glossary (Province of British Columbia, 2008)

Integrated resource management (IRM)	The identification and consideration of all resource values, including social, economic and environmental needs in resource planning and decision-making.
Karst features	Karst is a distinctive topography that develops as a result of the dissolving action of water on carbonate bedrock (usually limestone, dolomite or marble). Karst features include fluted rock surfaces, vertical shafts, sinkholes, sinking streams, springs, complex sub-surface drainage systems and caves.
Landscape-level biodiversity	The *Landscape Unit Planning Guide* and the *Order Establishing Provincial Non-Spatial Old Growth Objectives* provide objectives for maintaining biodiversity at the landscape level and stand level. At the landscape level, objectives are provided for the maintenance of old growth.
Landscape unit	A planning area based on topographic or geographic features, that is appropriately sized (up to 100,000ha), and designed for application of landscape-level biodiversity objectives.
Long-term harvest level (LTHL)	A harvest level that can be maintained indefinitely given a particular forest management regime (which defines the timber harvesting land base, and objectives and guidelines for non-timber values) and estimates of timber growth and yield.
Mean Annual Increment (MAI)	Stand volume divided by stand age.
Management assumptions	Approximations of management objectives, priorities, constraints and other conditions needed to represent forest management actions in a forest planning model. These include, for example, the criteria for determining the timber harvesting land base, the specifications for minimum harvestable ages, utilization levels, and integrated resource management and silviculture and pest management programs.
Model	An abstraction and simplification of reality constructed to help understand an actual system. Forest managers and planners have made extensive use of models, such as maps, classification systems and yield projections, to help management activities.

12 Glossary (Province of British Columbia, 2008)

Natural disturbance type (NDT)	An area that is characterized by a natural disturbance regime, such as wildfires and wind, which affects the natural distribution of seral stages. For example areas subject to less frequent stand-initiating disturbances usually have more old forests.
Non-Contributing Land Base (NCLB)	Forest that is not available for harvesting but can contribute to forest cover objectives for non-timber resources (depending on its structural state).
Non-recoverable losses	The volume of timber killed or damaged annually by natural causes (e.g. fire, wind, insects and disease) that is not harvested.
Not Satisfactorily Restocked	An area not covered by a sufficient number of well-spaced trees of desirable species
Operability	Classification of an area considered available for timber harvesting. Operability is determined using the terrain characteristics of the area as well as the quality and quantity of timber on the area.
Riparian area	Areas of land adjacent to wetlands or bodies of water such as swamps, streams, rivers or lakes.
Riparian habitat	The stream bank and flood plain area adjacent to streams or water bodies.
Sensitivity analysis	A process used to examine how uncertainties about data and management practices could affect timber supply. Inputs to an analysis are changed and the results are compared to a baseline or the base case.
Site index	A measure of site productivity. The indices are reported as the average height, in metres, that the tallest trees in a stand are expected to achieve at 50 years (age is measured at 1.3 metres above the ground).
Site Index by Biogeoclimatic Ecosystem Classification site series (SIBEC)	Site index estimates for tree species according to site units of the Biogeoclimatic Ecosystem Classification system of British Columbia.
Site Series	Sites capable of producing similar late seral or climax plant communities within a biogeoclimatic subzone or variant.

12 Glossary (Province of British Columbia, 2008)

Stocking	The proportion of an area occupied by trees, measured by the degree to which the crowns of adjacent trees touch, and the number of trees per hectare.
TIPSY (Table Interpolation Program for Stand Yields)	A BC Forest Service computer program used to generate yield projections for managed stands based on interpolating from yield tables of a model (TASS) that simulates the growth of individual trees based on internal growth processes, crown competition, environmental factors and silvicultural practices.
Timber harvesting land base (THLB)	Forest land within the TFL where timber harvesting is considered both acceptable and economically feasible, given objectives for all relevant forest values, existing timber quality, market values and harvesting technology.
Timber supply	The amount of timber that is forecast to be available for harvesting over a specified time period, under a particular management regime.
Tree farm licence (TFL)	Provides rights to harvest timber, and outlines responsibilities for forest management, in a particular area.
Ungulate	A hoofed herbivore, such as a deer.
Variable Density Yield Projection (VDYP)	An empirical yield prediction system designed to predict average yields and provide forest inventory updates over large areas (i.e., timber supply areas). It is intended for use in unmanaged natural stands of pure or mixed species composition.
Volume estimates (yield projections)	Estimates of yields from forest stands over time. Yield projections can be developed for stand volume, stand diameter or specific products.
Watershed	An area drained by a stream or river. A large watershed may contain several smaller watersheds (basins).
Wildlife tree	A standing live or dead tree with special characteristics that provide valuable habitat for wildlife.

APPENDICES

Appendix A: EVALUATION OF INVENTORY ESTIMATES USING CRUISE PLOTS IN TFL 44

Appendix B: LIDAR REVIEW OF ROAD WIDTHS IN MANAGED STANDS

Appendix C: LIDAR REVIEW OF OAF1 IN MANAGED STANDS

Appendix D: Terrain Stability Mapping Review

Appendix E: Hydrologic Recovery Method Review

Appendix A: EVALUATION OF INVENTORY ESTIMATES USING CRUISE PLOTS IN TFL 44

EVALUATION OF INVENTORY ESTIMATES USING CRUISE PLOTS IN TFL 44

February 23rd, 2021

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EXECUTIVE SUMMARY

This study tested the accuracy of three different forest inventories in TFL 44. WFP Forest Cover, Vegetation Resource Inventory (VRI) and individual tree inventory (ITI) were evaluated using both cruise plot and harvest data for 101 blocks that were cruised after WFP's LiDAR acquisition in 2016. This was to help inform which inventory estimates to use for the Timber Supply Review (TSR) process in TFL 44.

VRI was the least accurate inventory tested using both cruise and harvest data and consistently underestimated volume across the range of forest ages. It was also consistently the least accurate at determining species composition.

Forest Cover was generally accurate at predicting volume, however the accuracy varied by age class. It underpredicted volume in stands <120 years old and overpredicted in stands ≥120. As a result, forest cover volume estimates were generally less precise than VRI, indicating that while the results should be more accurate at a land base scale, at the stand level accuracy is likely to be mixed. Forest Cover was more accurate at predicting species composition than VRI.

ITI significantly underestimated volume, particularly in stands ≥120 years old. However, it was the most precise estimator of volume and also the most accurate predictor of species composition. This volume underestimation is common in LiDAR derived inventories, which tend to miss understory trees, which will be more common in older stands.

Linear regressions were fitted to adjust the ITI volume estimates to account for these missing trees. These correction factors increased the accuracy and precision of the volume estimates. They were tested against an independent set of 28 cut blocks which confirmed that the adjusted ITI was both accurate and precise at predicting volume.

The recommendations are as follows:

1. Use forest cover as the base case for the TFL 44 TSR to be consistent with the previous TSR.
2. Develop a new inventory using ITI by calculating volume within the existing forest cover polygons and adding a correction factor of 0.624 m^3/ha/year (the average of the CGNF and LF correction factors). Use this inventory as a sensitivity analysis for the TFL 44 TSR.
3. Develop a new area-based inventory by deriving new polygons from the adjusted ITI and summing the ITI attributes within, adding a correction factor of 0.624 m^3/ha/year.
4. Evaluate the accuracy of forest cover, VRI and ITI in all TFLs managed by WFP using the same methodology as used in this analysis.
5. Review the accuracy of the different inventory products using cruise data prior to any TSR and/or after major updates to VRI.

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OVERVIEW

Accurate forest inventories are critical for sustainable forest management. The forest inventory provides starting estimates of forest composition from which growth projections are made for Timber Supply Reviews (TSR) and Allowable Annual Cut (AAC) determinations.

In TFL 44 there are three different forest inventories available:

1. Vegetation Resource Inventory (VRI) is maintained by the Province and is updated annually,
2. Forest Cover is WFP's area-based inventory that is an annually updated version of the legacy inventory that originated with MacMillan Bloedel, and
3. WFP's individual tree inventory (ITI) is a LiDAR derived inventory developed by Object Raku and Forsite, and represents the predicted volumes and species of individual trees at the time of LiDAR capture in 2016.

This analysis was conducted to evaluate the accuracy of volume and species predictions using VRI, Forest Cover and ITI in TFL 44. Both cruise plot data and scaled harvest data were used to assess the accuracy of the three inventories for all blocks that had been cruised since LiDAR capture.

METHODS

Cut blocks were used as the base unit for comparison of the three inventories. 101 blocks, representing 1192 ha that had been cruised since LiDAR capture in TFL 44 were used in this analysis. The cut block data was separated into two datasets: 1) training and 2) testing. The training dataset consisted of 73 blocks that corresponded to the January 2020 analysis comparing the three inventories at the VRI polygon level. The testing dataset consisted of an additional 28 blocks that had been cruised since. The training dataset was used to evaluate the inventories and to develop a regression to adjust ITI volumes to account for missing trees. The testing dataset was used to test the accuracy of this ITI adjustment.

The blocks used in this analysis had a good geographic coverage across TFL 44, with samples in every operating area other than Henderson Lake (Figure 1). The blocks also had a good representation by BEC class, with representation in all seven BEC variants in TFL 44 (Figure 2).

Inventory estimates were evaluated using both cruise data and harvest data. All cruise plots within a block were compiled using both call grade net factor (CGNF) and loss factor (LF) using CruiseComp. A total of 1037 cruise plots were used: 748 in the training set of blocks and 289 in the testing set of blocks. The net merchantable volume by species for each block was used in this analysis.

Harvest data was extracted from WFP's Log Inventory Management System (LIMS) for blocks that were conventionally harvested and where harvesting was complete. Helicopter harvested blocks were excluded since the harvest is more selective and average waste volumes are less likely to be representative. A total of 44 blocks from the training dataset met these criteria. Only 4 blocks from the testing dataset met these criteria, which was deemed an insufficient sample size for testing. As LIMS reports scaled volume, volume was added to account for residual merchantable volume left on site. The average waste percent from conventionally harvested blocks from TFL 44 in 2018 and 2019 was extracted from the Harvest Billing System. Factors were calculated for stands <120 (15% waste) and ≥120 years (20% waste) and applied to the LIMS volume for each corresponding block to give an estimated harvest volume including waste.

South Island VRI data was obtained from the VEG_COMP_LYR_R1_POLY layer downloaded in June 2018. The attributes used were live stand merchantable volume to 12.5 cm, which was applied to stands <120 years and live stand merchantable volume to 17.5 cm, which was applied to stands ≥120 years. Polygons were intersected with the cut block net boundaries (excluding retention areas) and the net merchantable volumes by species calculated by area weighting the results for each polygon within a block.

WFP's 2016 Forest Cover was used in this analysis, as it was the most recent version where all of the blocks in this analysis were in a pre-harvest state. Forest Cover polygons were intersected with the net block boundaries and attributes calculated by area-weighting the resulting polygons.

ITI estimates of net merchantable volume by species were calculated by summing the individual tree attributes within the net block area using the WFP's ITI Analysis ArcMap planning tool.

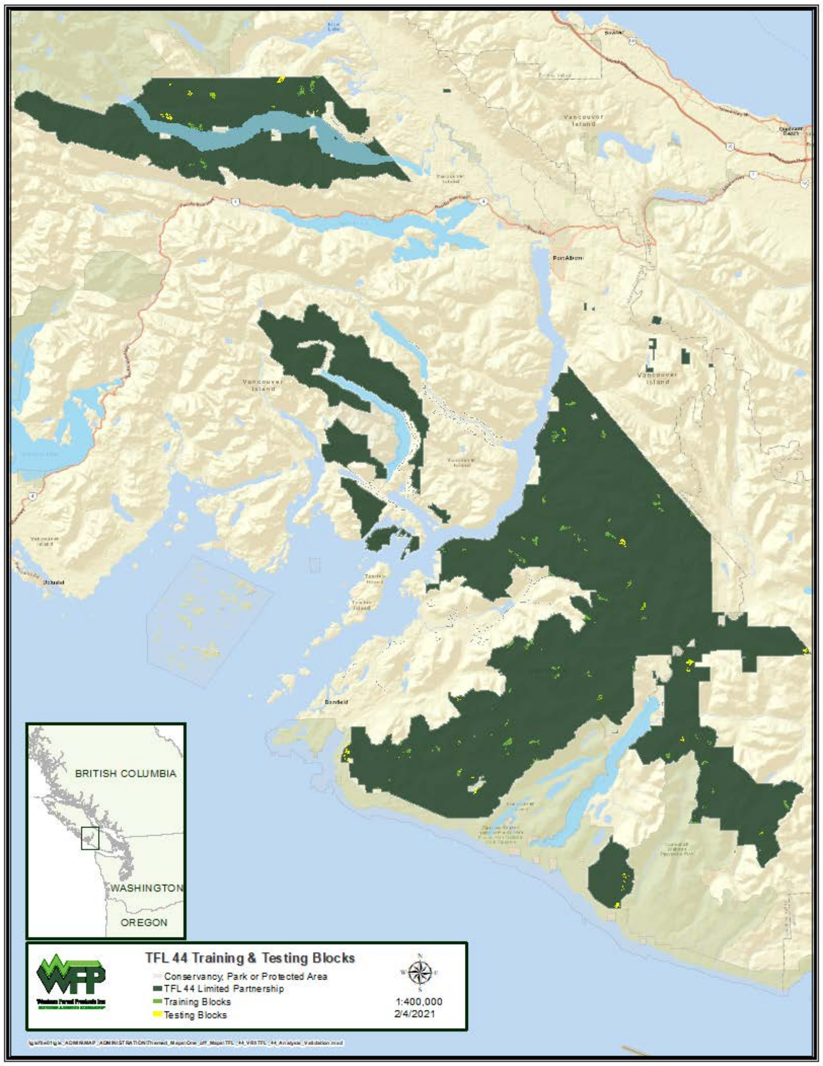


Figure 1 Geographic coverage of 101 blocks used to evaluate inventory predictions in TFL 44.

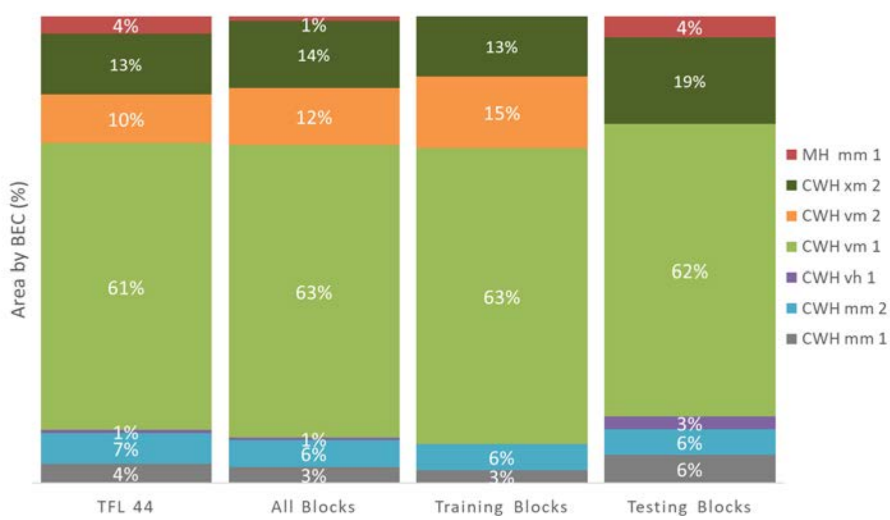


Figure 2 Ecological representation of TFL 44 by BEC compared to blocks used in analysis, including in the training and testing datasets.

RESULTS

Training Data

Predicted Volume Versus Cruise

Using both call grade net factor (CGNF) and loss factor (LF) compilation methods, VRI was the least accurate inventory tested (Table 1, Figure 3). It underestimated volume using both compilation methods in blocks <120 years old and in blocks ≥120 years old.

Forest Cover was the most accurate the three inventories tested, overestimating volume by an average of 32.9 m^3/ha using CGNF and by 95.3 m^3/ha using LF. However, it was the least precise estimator, recording the highest standard deviation using both compilation methods.

Forest Cover's poor precision was a result of varied accuracy by age; it underpredicted volume in blocks <120 years old and overpredicted volume in blocks ≥120 years old. While it was accurate overall, it was not particularly accurate for either age category.

ITI was less accurate than forest cover but more accurate than VRI. On average it underpredicted volume, which was primarily driven from blocks ≥120 years old. In blocks <120 years old, ITI was the most accurate inventory tested. ITI was the most precise of the three inventories tested using both compilation methods and for both age categories.

Table 1 Comparison of inventory and cruise volumes for training set of cut blocks.

	VRI		Forest Cover		ITI		ITI Adjusted	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Call Grade Net Factor	**-243.2**	**263.6**	**32.9**	**289.1**	**-197.9**	**209.3**	**10.3**	**180.4**
<120 years	-213.2	239.4	-193.2	249.9	30.1	138.4	85.6	138.8
≥120 years	-250.3	270.5	86.5	273.0	-252.0	185.9	-7.6	185.4
Loss Factor	**-180.8**	**257.6**	**95.3**	**312.7**	**-135.5**	**196.1**	**-2.5**	**190.5**
<120 years	-272.6	253.6	-252.6	248.4	-29.2	155.9	6.2	157.9
≥120 years	-159.1	255.9	177.8	267.3	-160.7	197.3	-4.5	198.6

LiDAR derived inventories such as ITI typically underestimate volumes due to missing trees that are obscured by the canopy. This would be expected to be more significant in older stands which have a more varied stand structure. The underprediction by ITI in older stands confirms this expectation. As it has the highest precision, ITI presents the best opportunity of the three inventories to meet the goal of high accuracy and high precision. This could be accomplished by developing a correction factor to account for missing trees in older stands.

To account for ITIs tendency to underpredict volumes in older stands, linear regression models were fitted to ITI residual volumes and age for both CGNF and LF compilation using R version 3.6.2. A two-parameter linear model was initially fitted but the intercept parameter was not significantly different from zero. A single parameter model was highly significant against both the CGNF and LF datasets and satisfied the assumptions of linear regression: linearity, homoskedasticity, lack of autocorrelation and normality (Appendix 1, Appendix 2).

After applying these correction factors, the adjusted ITI performed well against the training dataset, showing the highest accuracy and precision using both CGNF and LF and for both young and old stands (Table 1, Figure 3).

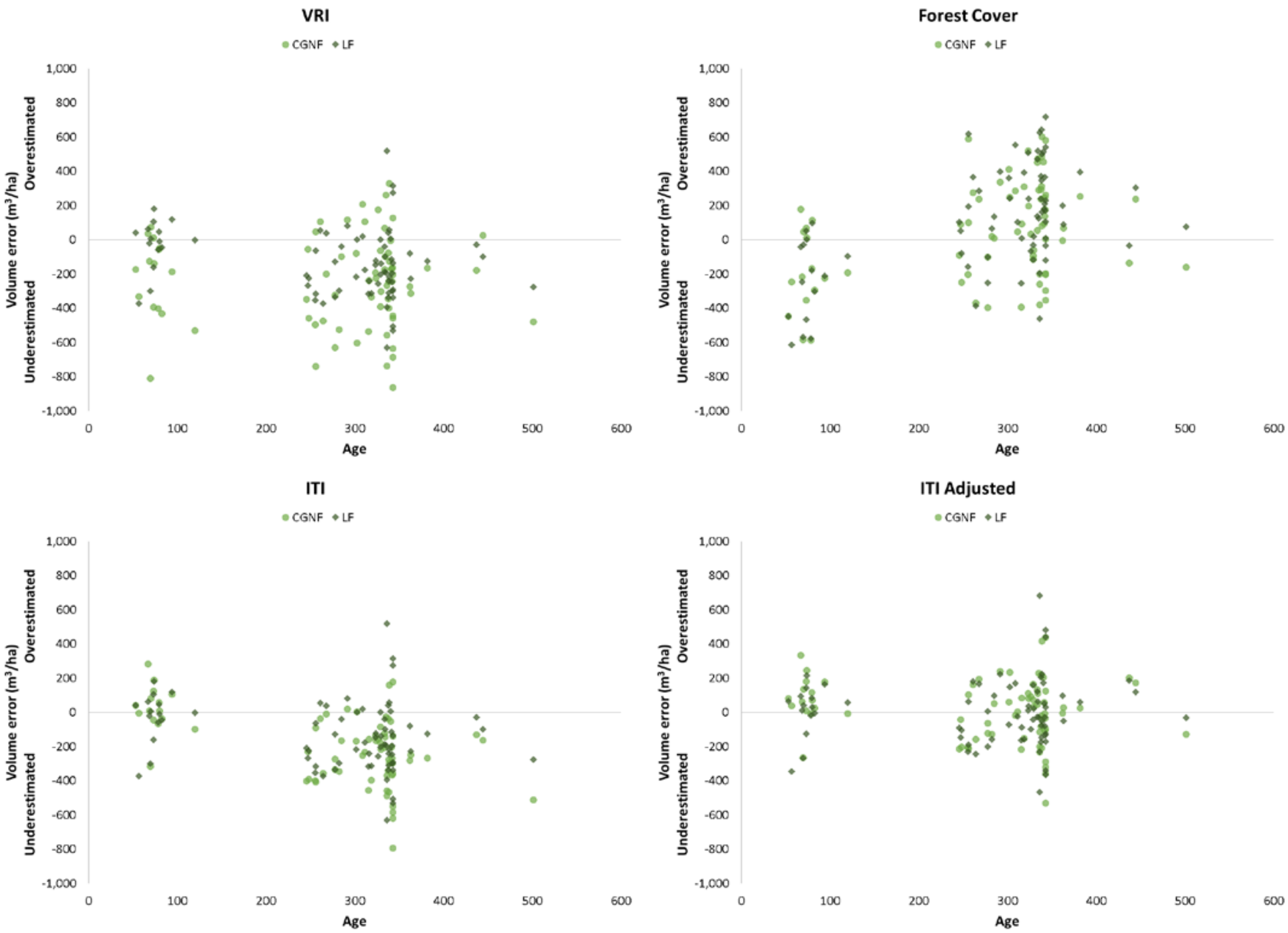


Figure 3 Difference between predicted and cruised volume (CGNF and LF) by age using VRI, forest cover, ITI and adjusted ITI using training set of cut blocks.

Predicted Species Composition Versus Cruise

VRI was the poorest predictor of species composition, recording a coefficient of determination (r^2) of 0.6451 compared to cruise (Figure 4). It showed a weak correlation for all major species (Figure 5).

Forest Cover was a better predictor of species composition than VRI, recording an r^2 of 0.7054. It showed a positive correlation between observed and predicted for all major species.

ITI was the best predictor of species composition, recording an r^2 of 0.7625 and showing good correlation against all major species. It did show a tendency to underpredict the most prevalent species, rarely predicting more than 70% of one species in a cut block.

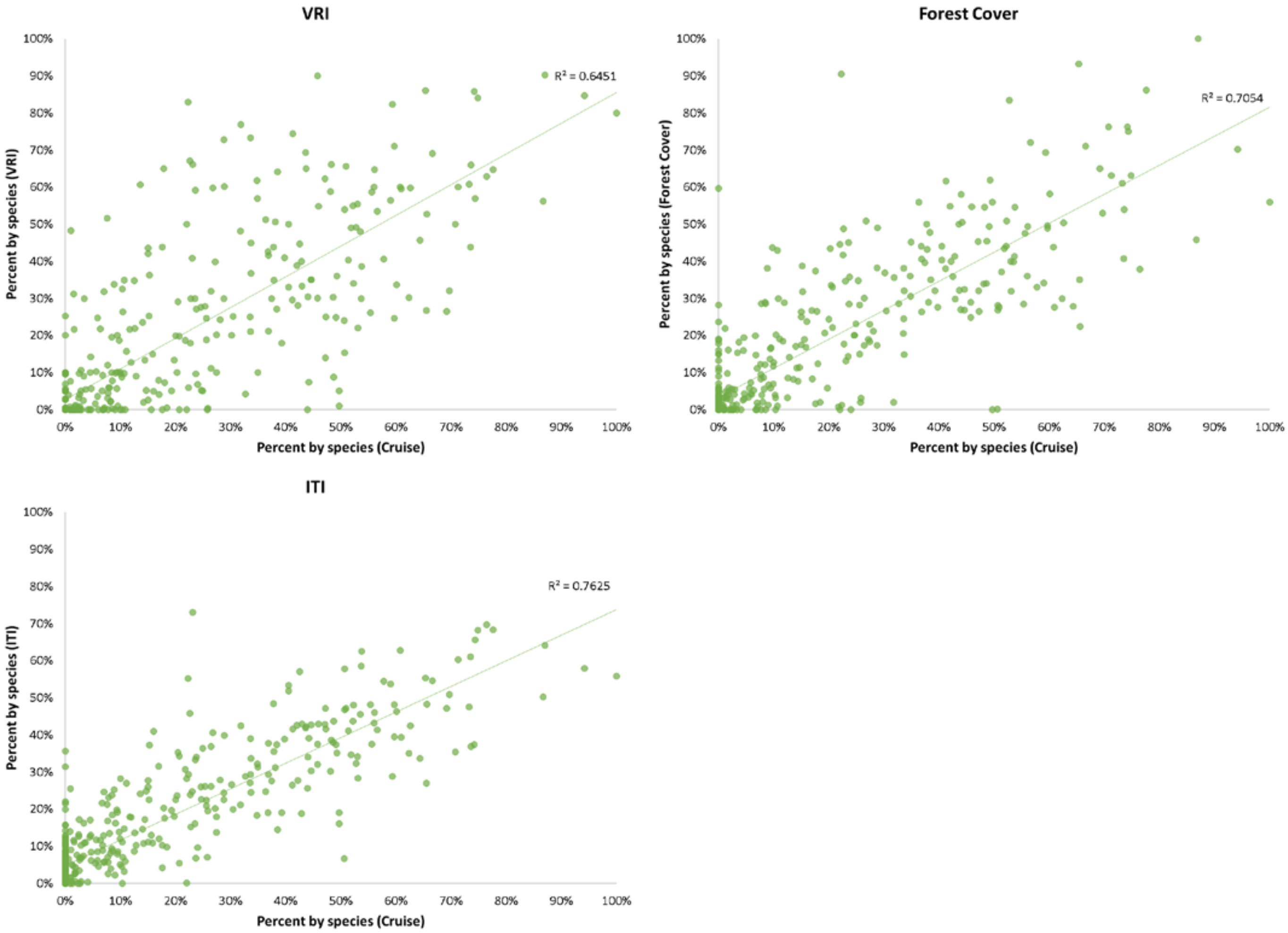


Figure 4 Percent of cruised block volume by species versus predictions by VRI, forest cover and ITI using training set of cut blocks.

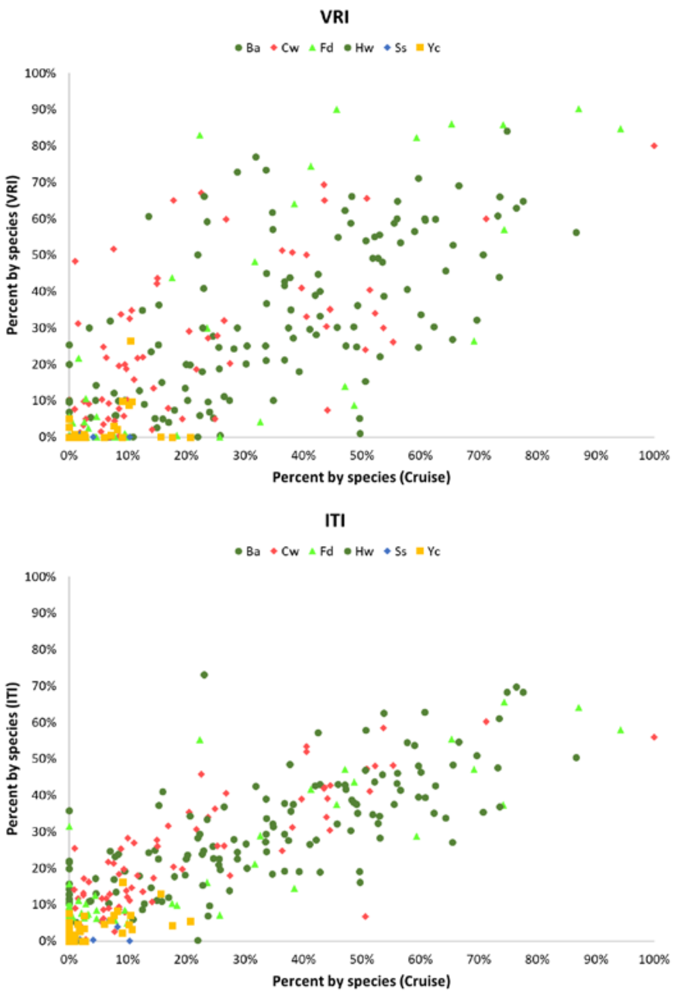


Figure 5 Percent of cruised block volume for main species versus predictions by VRI, forest cover and ITI using training set of cut blocks.

Predicted Volume Versus Harvest

For the 44 conventionally harvested blocks in the training dataset where harvesting was complete, the results were very similar using harvest rather than cruise data. VRI was the least accurate, underpredicting volume in both young and old stands (Table 2, Figure 6). Forest Cover was the most accurate but least precise, underestimating volume in stands <120 and overestimating in stands ≥120 years old. ITI underestimated volume in old stands but was the most precise. When including the CGNF and LF correction factors to account for missing trees, the adjusted ITI was the most precise estimator. It was less accurate than forest cover however and tended to underestimate volume.

Table 2 Comparison of inventory and harvest volumes for training set of cut blocks.

	VRI		Forest Cover		ITI		ITI Adjusted (CGNF)		ITI Adjusted (LF)	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Total	**-339.2**	**254.8**	**-89.4**	**291.1**	**-314.6**	**214.8**	**-112.1**	**188.0**	**-108.6**	**149.7**
<120 years	-355.8	251.7	-338.8	240.9	-123.5	148.2	-69.9	147.4	-64.4	105.5
≥120 years	-334.9	259.1	-25.3	269.9	-363.8	202.6	-123.0	197.5	-120.0	158.3

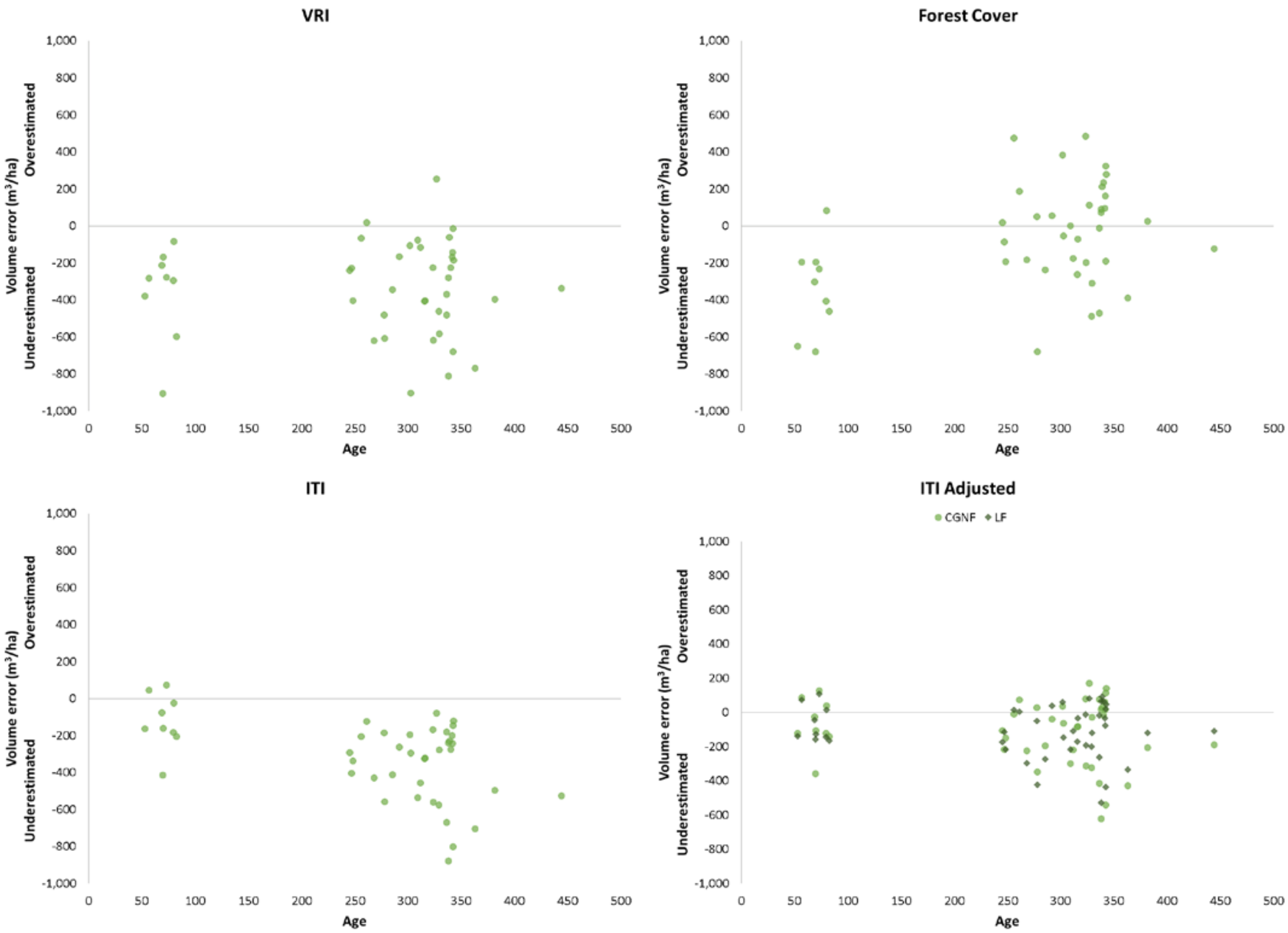


Figure 6 ***Difference between predicted and harvest volume by age using VRI, forest cover, ITI and adjusted ITI (CGNF and LF) using training set of cut blocks.***

Predicted Species Composition Versus Harvest

Harvest data also mirrored the results from cruise data when evaluating species predictions. VRI was the least accurate species predictor while ITI performed the best (Figure 7). ITI showed a strong correlation between predicted and actual across the range of major species (Figure 8).

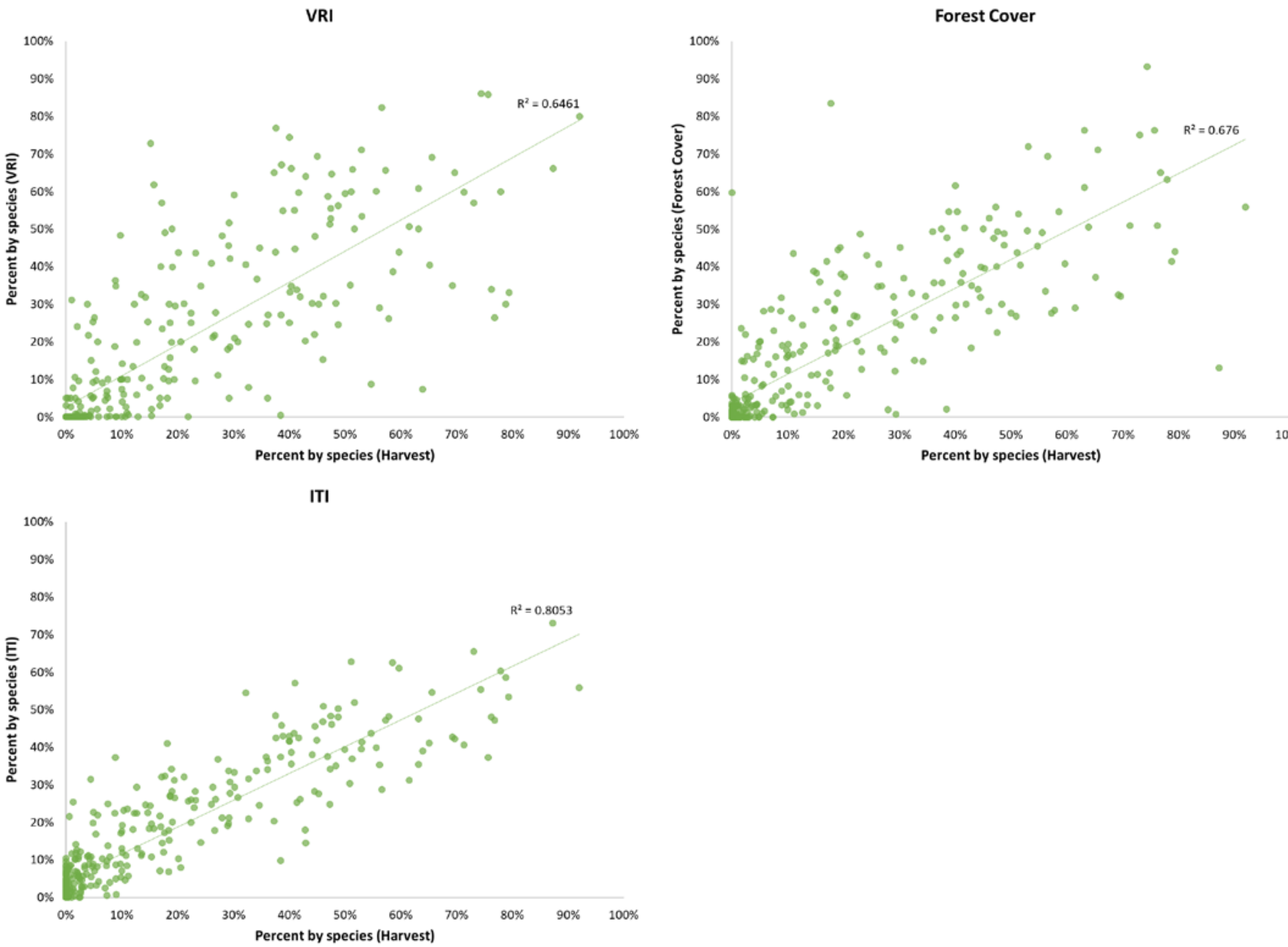


Figure 7 Percent of block harvest volume by species versus predictions from VRI, forest cover and ITI using training set of cut blocks.

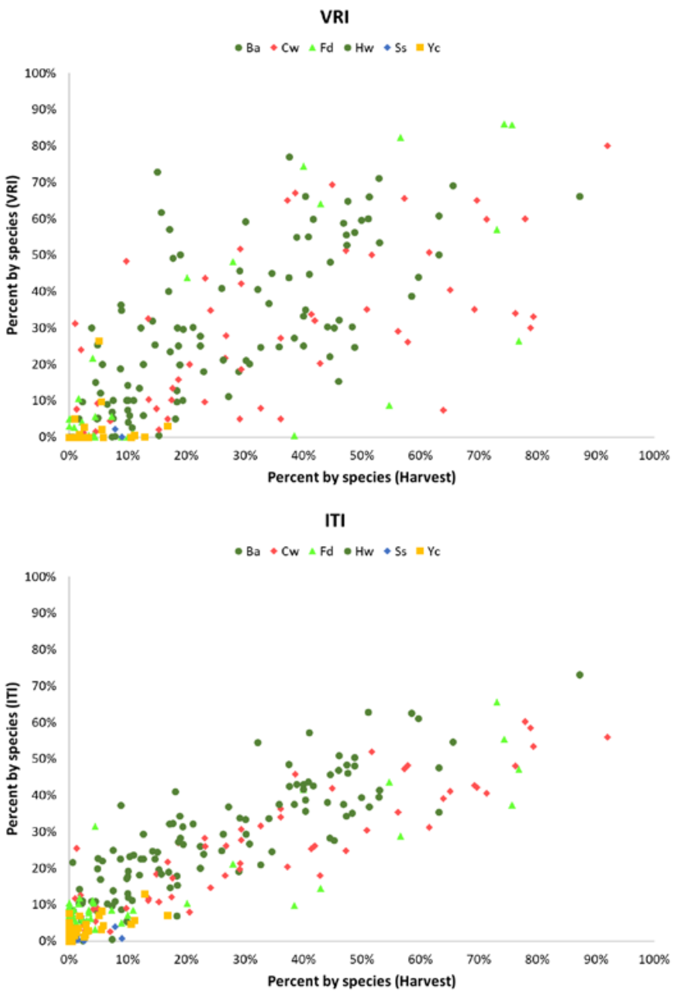


Figure 8 Percent of block harvest volume by major species versus predictions from VRI, forest cover and ITI using training set of cut blocks.

Testing Data

Predicted Volume Versus Cruise

The 28 blocks set aside for testing validated the results from the training dataset. VRI underpredicted volume using both CGFN and LF and for young and old stands alike (Table 3). Forest Cover was accurate, particularly against LF but its precision was poorer than ITI. ITI underpredicted volume, particularly for older stands although had better precision than VRI and forest cover.

The testing data confirmed that the adjustments to correct ITI for missing trees improved accuracy and precision. It was the most accurate inventory compared to CGNF cruise data and the second most accurate compared to LF cruise data, after Forest Cover. The adjusted ITI was the most precise inventory tested.

Table 3 Comparison of inventory and cruise volumes for testing set of cut blocks.

	VRI		Forest Cover		ITI		ITI Adjusted	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Call Grade Net Factor	**-191.4**	**397.9**	**-79.2**	**397.3**	**-268.2**	**365.5**	**-57.7**	**330.2**
<120 years	-83.6	254.5	-69.8	202.0	95.9	130.8	156.0	136.3
≥120 years	-215.9	427.1	-81.4	391.9	-351.0	390.4	-106.2	356.6
Loss Factor	**-125.3**	**330.9**	**6.5**	**319.1**	**-191.3**	**263.2**	**-56.5**	**241.7**
<120 years	-107.8	253.2	-94.0	192.1	71.7	144.4	110.1	148.4
≥120 years	-129.1	347.9	28.3	302.1	-248.5	283.4	-92.7	262.6

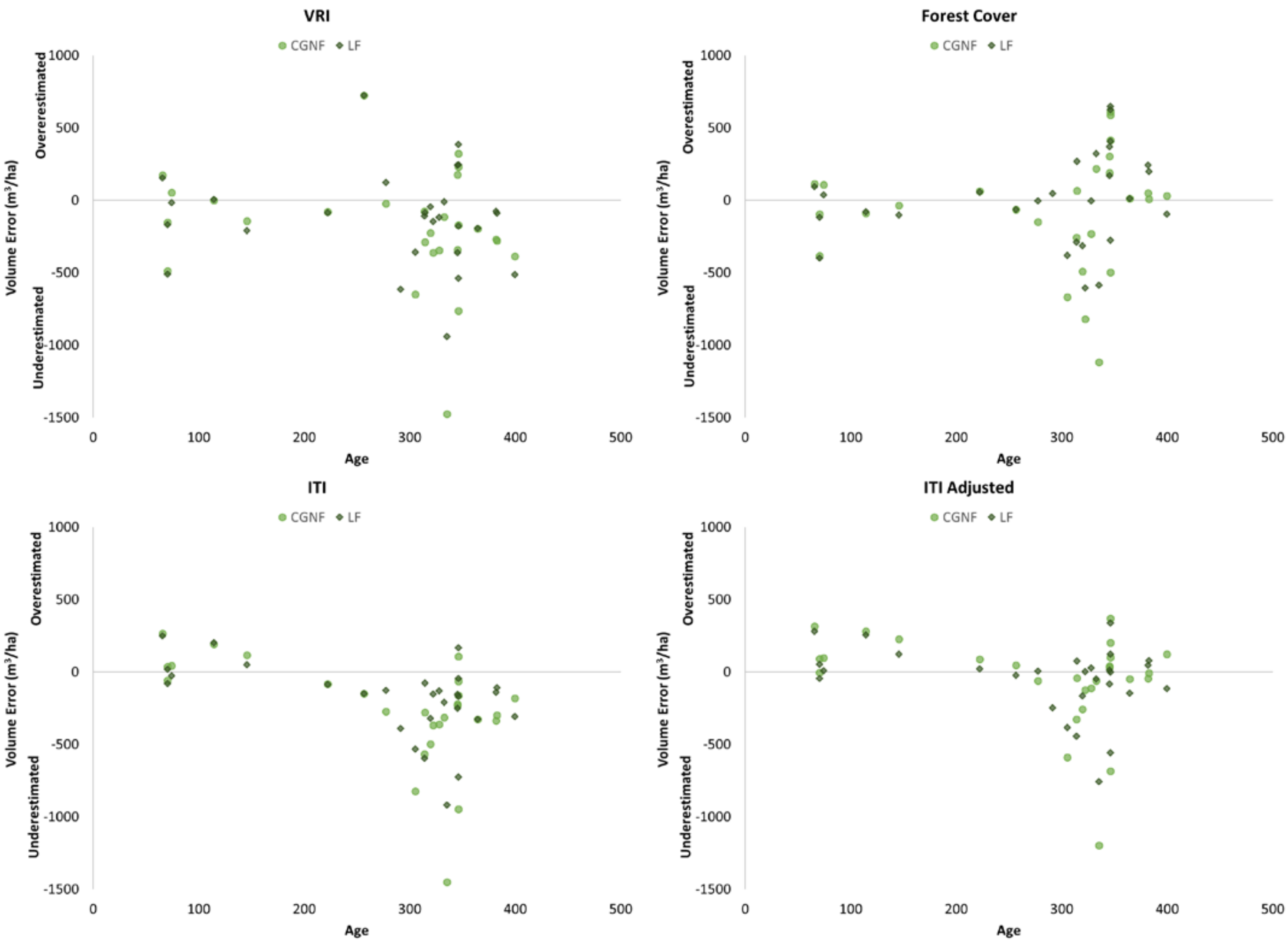


Figure 9 Difference between predicted and cruised volume (CGNF and LF) by age using VRI, forest cover, ITI and adjusted ITI using testing set of cut blocks.

Predicted Species Composition Versus Cruise

The testing data also confirmed results of the training dataset at the species level. ITI returned the highest correlation coefficient and showed good correlation across the range of major species (Figure 10, Figure 11).

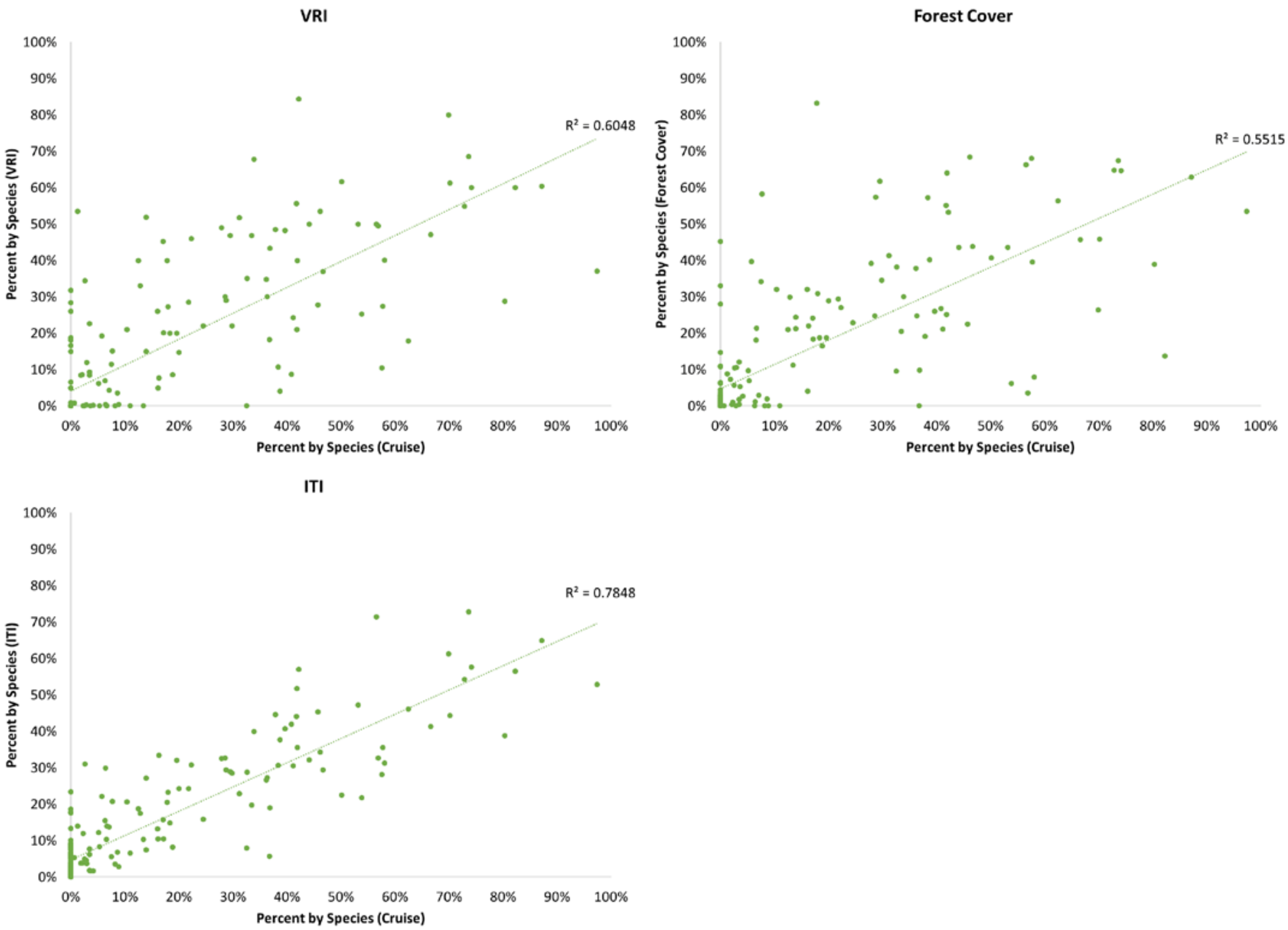


Figure 10 Percent of cruised block volume by species versus predictions by VRI, forest cover and ITI using testing set of cut blocks.

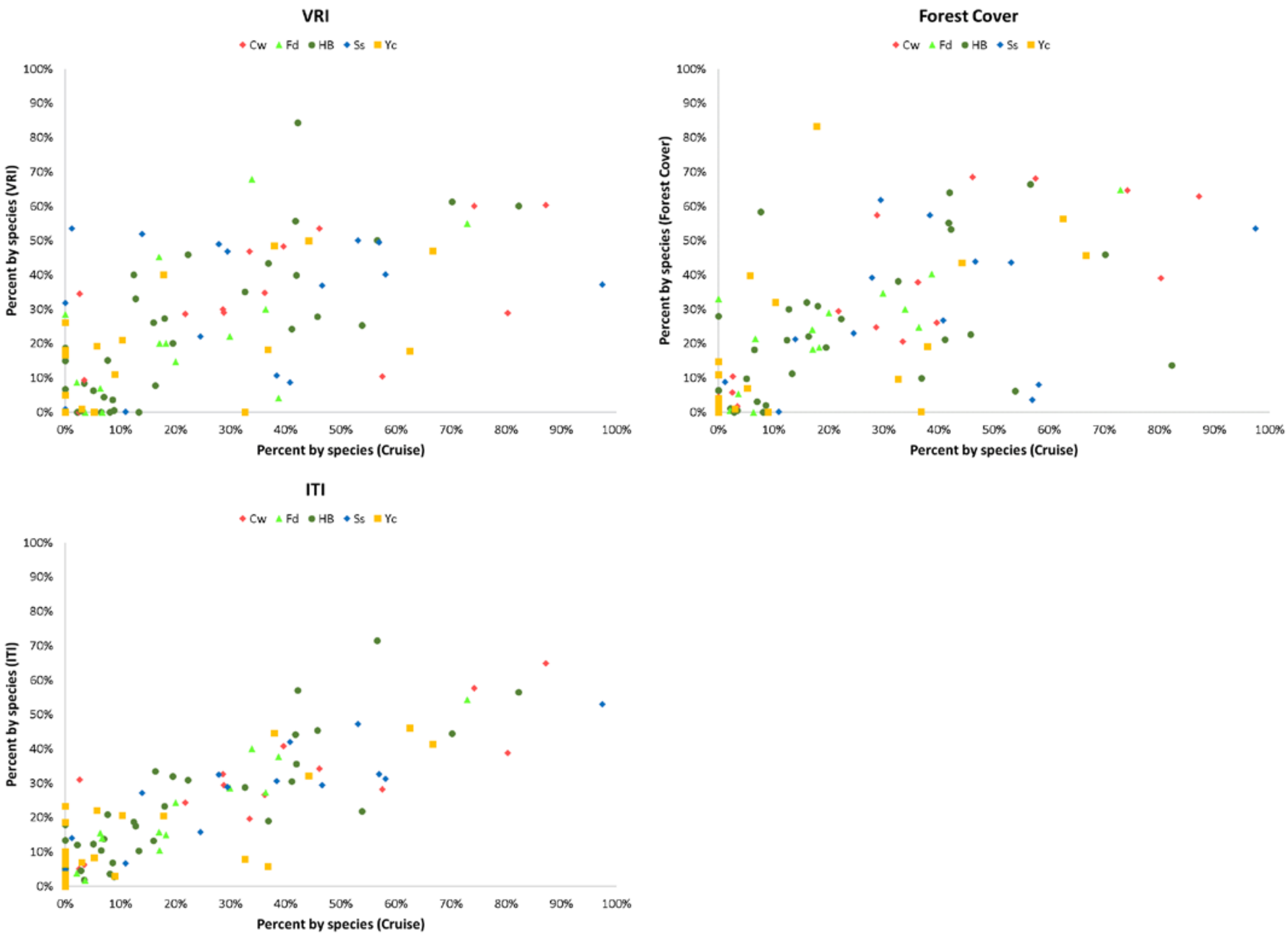


Figure 11 Percent of cruised block volume by major species versus predictions by VRI, forest cover and ITI using testing set of cut blocks.

DISCUSSION

VRI was the least accurate estimator of stand volume and species composition in recent cut blocks from TFL 44. It consistently underestimated volume using both cruise data and harvest data and across age classes. If VRI were used for the TFL 44 timber supply review (TSR), it would likely significantly underestimate volume.

On average, Forest Cover provided more accurate volume estimates than VRI when tested against both cruise and harvest data. However, its accuracy varied by age, underpredicting volumes in blocks <120 years of age and overpredicting in blocks ≥ 120. Forest Cover tended to be a slightly better species predictor than VRI. If used for the TFL 44 TSR, it would likely provide more accurate volume estimates in aggregate, although it is less precise than VRI so on a stand-by-stand basis volume estimates would be more variable.

The most promising option appears to be ITI. While ITI consistently underestimated volume, it provided the most precise estimates and was the best predictor of species composition when tested against both cruise and harvest data. The underestimation is likely caused by missing understory trees. This is a well-known limitation of LiDAR derived inventories, as the laser pulses are reflected by the canopy and therefore have difficulty differentiating sub-canopy trees. The relative accuracy of ITI volumes in stands <120 years of age and underestimation in stands ≥ 120 years of age supports this argument, as older stands have more varied stand structure.

Correction factors were developed to adjust the ITI volume predictions to account for the missing trees using both CGNF and LF cruise data. These factors add 0.49 m^3/ha/year (LF) and 0.76 m^3/ha/year (CGNF) to predicted ITI volumes. Using the training dataset, this resulted in both accurate and precise volume predictions. When tested against an independent set of 28 blocks, the adjusted ITI was again found to be accurate and precise. The independent testing set of blocks also confirmed that ITI resulted in the most accurate species predictions.

RECOMMENDATIONS

1. Use forest cover as the base case for the TFL 44 TSR, as it is accurate overall and for consistency with the previous TSR.
2. Develop a new inventory using ITI by calculating volume within the existing forest cover polygons and adding a correction factor of 0.624 m^3/ha/year (the average of the CGNF and LF correction factors). Use this new inventory as a sensitivity analysis for the TFL 44 TSR.
3. Develop a new area-based inventory by deriving new polygons from the adjusted ITI and summing the ITI attributes within, adding a correction factor of 0.624 m^3/ha/year.
4. Evaluate the accuracy of forest cover, VRI and ITI in all TFLs managed by WFP using the same methodology as used in this analysis.
5. Review the accuracy of the different inventory products using cruise data prior to any TSR and/or after major updates to VRI.

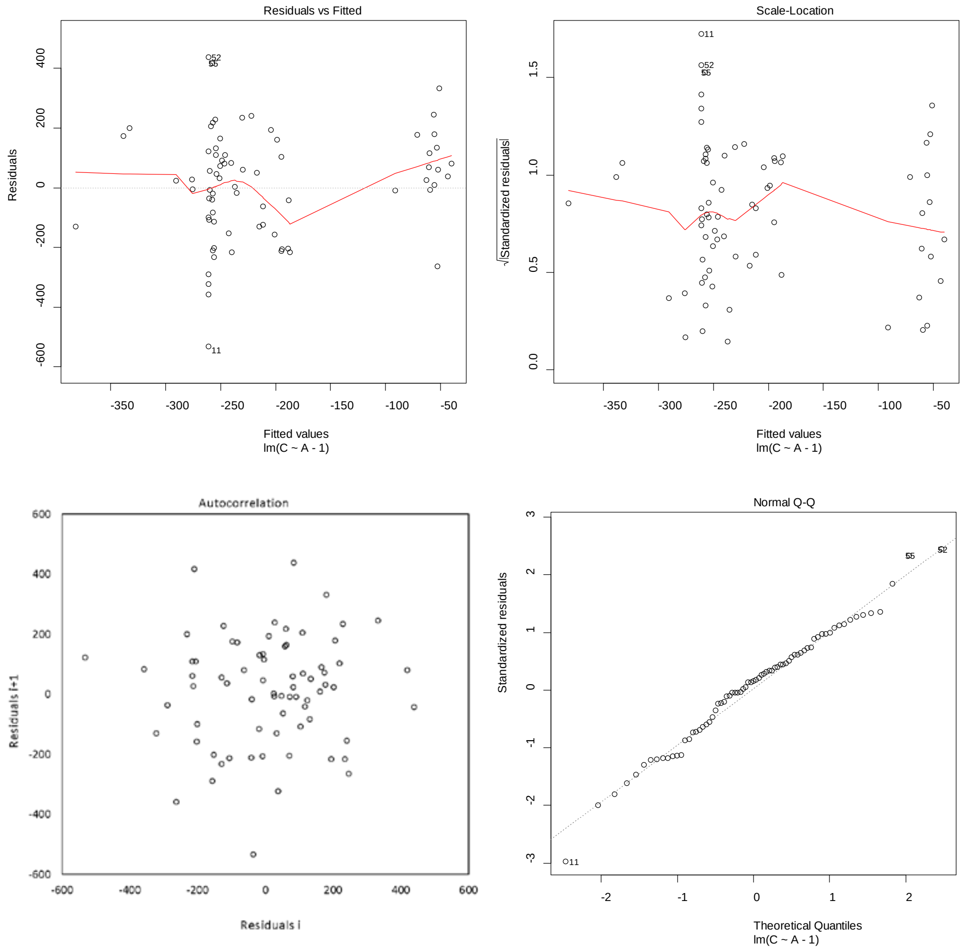
APPENDICES

Appendix 1 Outputs from CGNF single parameter linear regression

Table 4 Single parameter CGNF linear regression outputs.

Coefficient	Standard Error	t Stat	P-value
-0.7612	0.0719	-10.5936	<0.0001

Figure 12 Residual, standardized residual, autocorrelation and normality plots from single parameter CGNF linear regression.

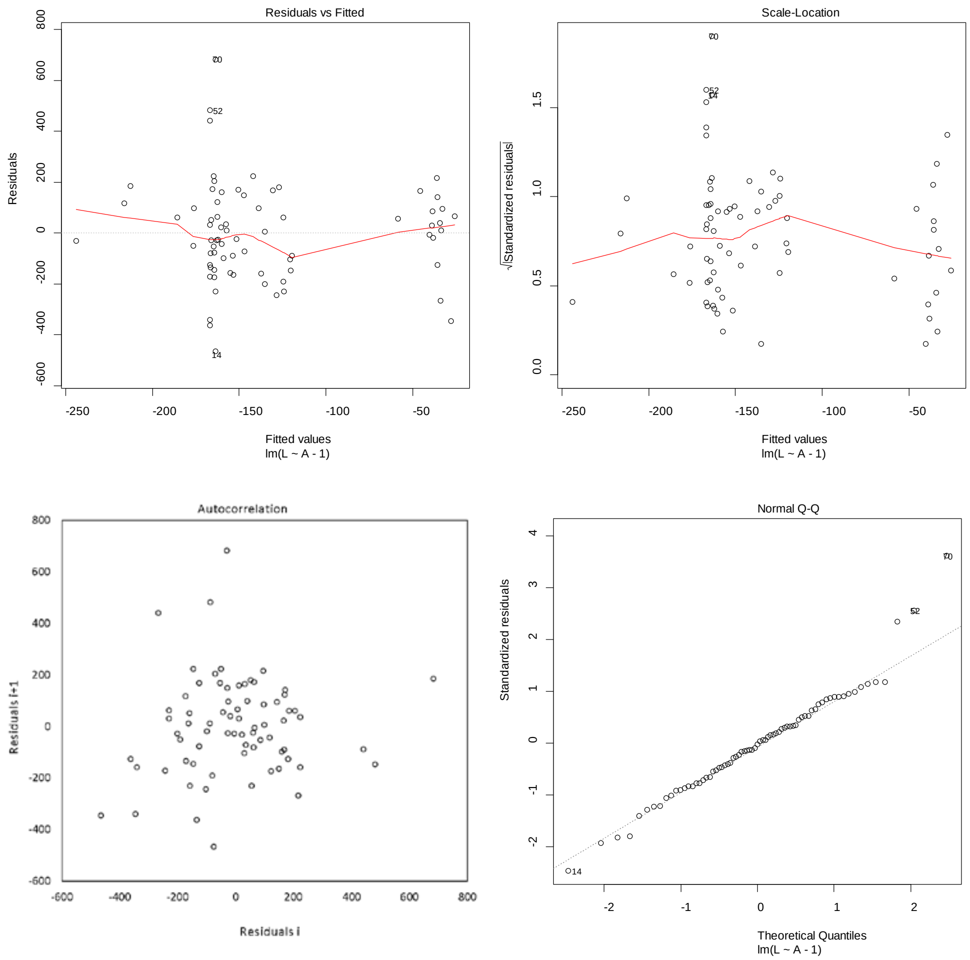


Appendix 2 Outputs from LF single parameter linear regression

Table 5 Single parameter LF linear regression outputs.

Coefficient	Standard Error	t Stat	P-value
-0.4865	0.0758	-6.4210	<0.0001

Figure 13 Residual, standardized residual, autocorrelation and normality plots from single parameter LF linear regression.



Appendix B: LIDAR REVIEW OF ROAD WIDTHS IN MANAGED STANDS

Summary

Quantifying vegetation regeneration and growth for roaded areas is critical in timber supply analysis. In the past, road surface right-of-way (RoW) area are buffered based on past TSR assumptions or operational experience. Empirically, however, when left to nature after completion of road rehabilitation and reclamation activities, a proportion of road RoW area will support tree growth as productive as the adjacent undisturbed area. Finer resolution LiDAR datasets enables the entire landbase and road network to be analysed in order to determining the proportion of effective regeneration and more appropriate buffer width on constructed roads.

For TFL 44, the analysis using LiDAR Canopy Crown Model (CHM) reveals that the vegetated road RoW area with 10+ meter tall tree crown presence is much more than the assumed in MP #5 for managed stands approaching harvestable age. In other words, there are more merchantable trees within or near road RoW area that can contribute to future timber supply. As a result, a new set of road buffer widths for different road classes has been generated using LiDAR and will be used in the MP #6 timber supply analysis.

Process and Methodology

A review of LiDAR data and orthophotos was conducted to update the lines representing roads within TFL 44. Figure 26 shows a mainline (symbolized in black) and a series of spur roads (symbolized in red) in a 56-year-old stand.

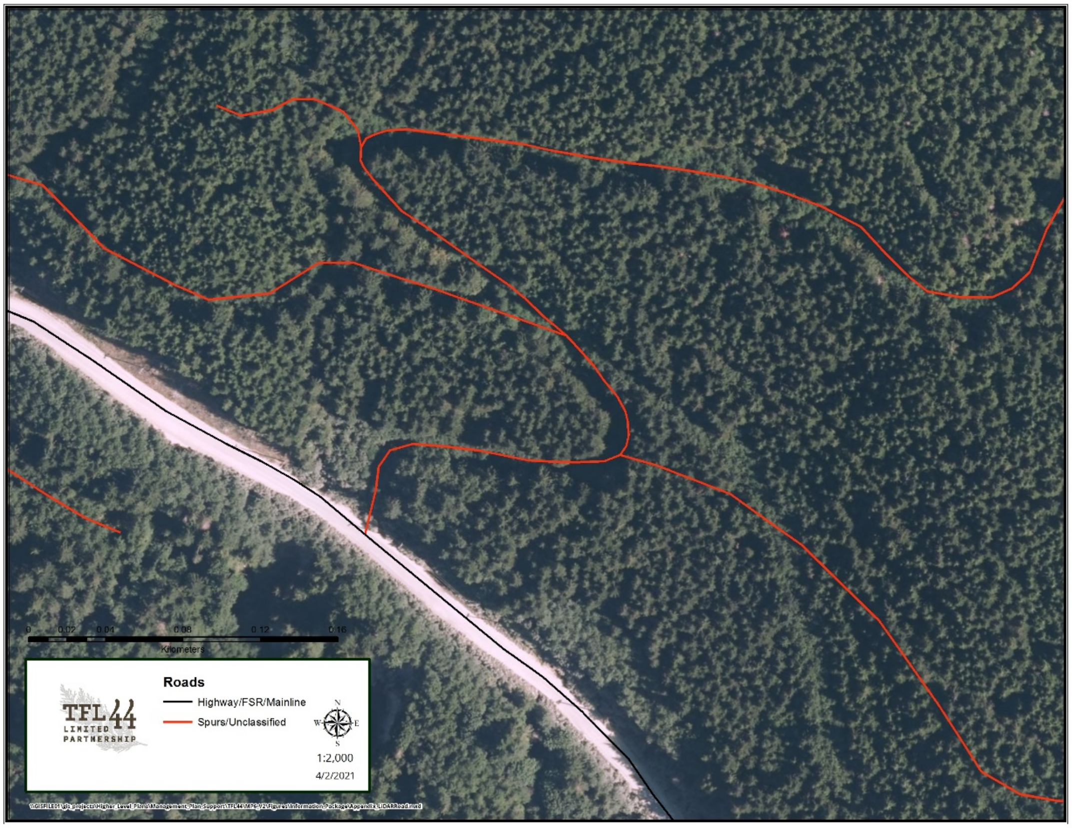


Figure 26 Example Roads with Orthophoto in TFL 44

A 20 m buffer (10 m each side) was applied to the lines representing the roads (Figure 27).

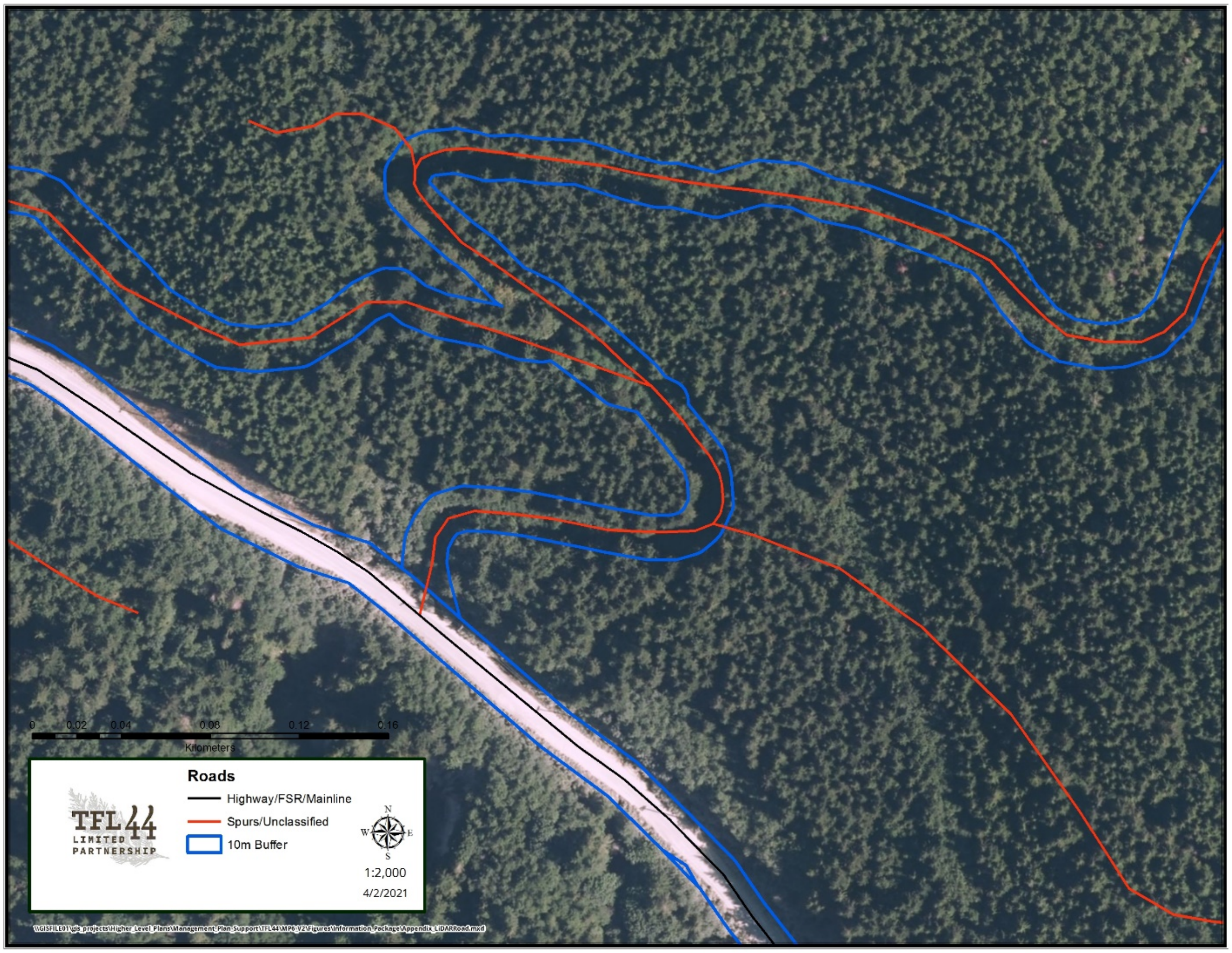


Figure 27 Road Buffers with Orthophoto

Road buffers then were intersected with forest cover and LiDAR CHM datasets. Figure 28 presents the same geographical extent with the CHM layer.

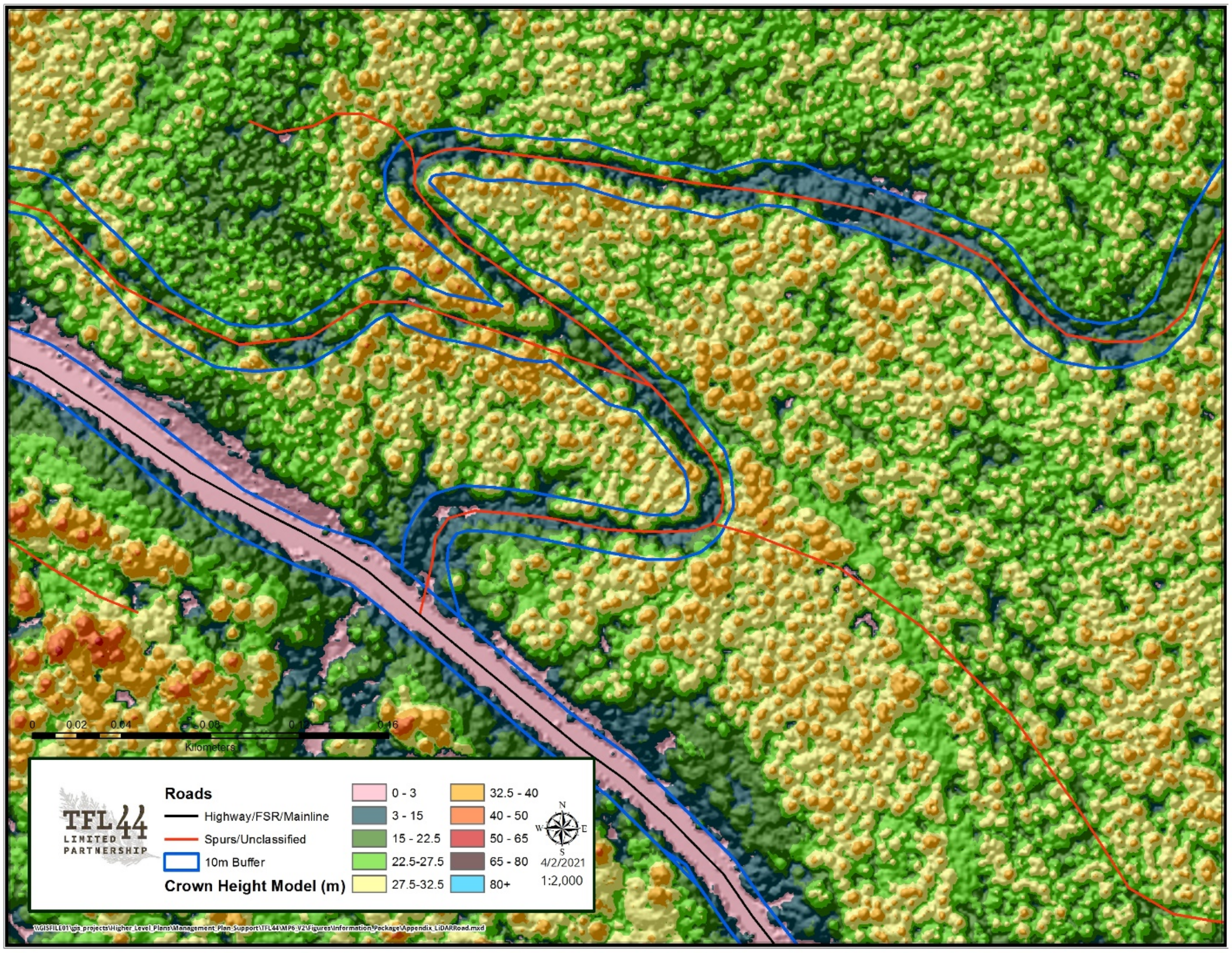


Figure 28 Road Buffers with LiDAR Canopy Height Model

LiDAR CHM dataset was then vectorized to generate areas with less than 10m vegetation in order to determine percentage of road buffer polygon where trees cover is less than 10m in height.

Figure 29 illustrates polygons assigned to crown openings inside the uniform buffer. In this example, 88% of the mainline road buffer polygon has crown cover less than 10 metre. In other words, a 17.6m buffer would accurately represent this area (20m buffer x 88%). For the spur road, 4% of the buffer has crown cover less than 10 metre. Therefore, a 0.8m buffer would accurately represent this area.

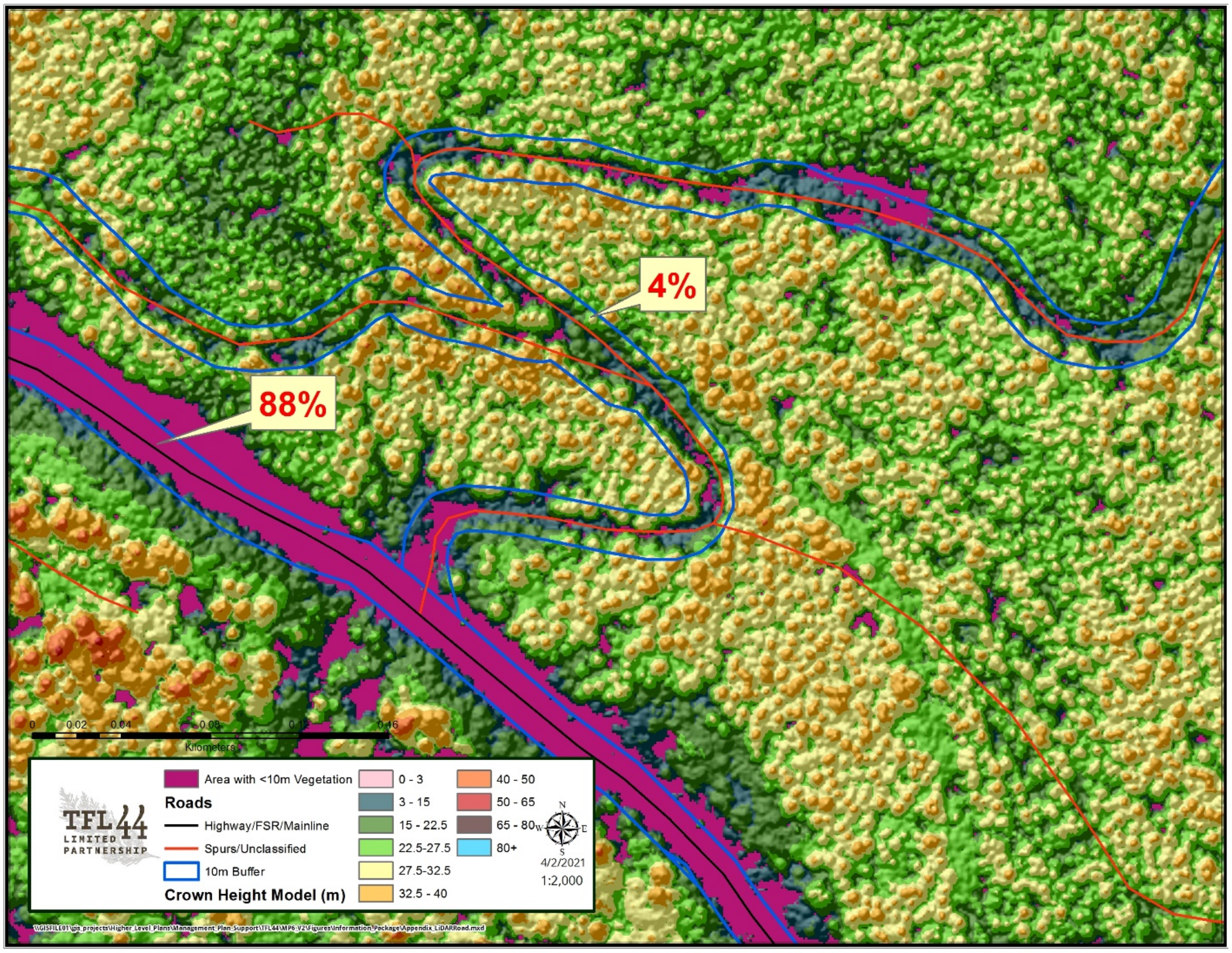


Figure 29 Percentage of Road Buffers with LiDAR CHM Less Than 10m[1]

Results

Only roads within 40 – 100 years old stands were used to indicate the extent to which trees will occupy road buffer areas within managed stands approaching rotation ages. Implied buffer widths were rounded to the nearest metre for creating polygons to represent existing roads. This approach recognizes perpetual roads (e.g. mainlines) within these stands. The results, alongside with the road buffers used in MP #5 are illustrated in Table 58. As can be seen from the results for each road class, the road widths calculated using LiDAR CHM dataset are less than the past Management Plan. In order to balance the results from the best available data while maintaining some level of consistency and providing a conservative estimate, the road buffer widths applied in MP #6 consider both LiDAR and MP #5 assumptions.

[1] Percentages are calculated based on the entire road segment (Area with <10m height / Area of the Road Segment Buffer), which the extent is greater than what the figure shows.

Table 58 LiDAR Derived Road Buffers within 40 – 100 years old stands in TFL 44

Road Class	Buffer width (m)	Length (km)	Proportion with crown cover < 10m	Implied width (m)	MP #5 Buffer (m)[1]	MP #6 Applied Buffer (m)
Highway/FSR/Mainline	20	189	0.54	11	30/15	11
Spurs	20	627	0.21	4	11	6
Unclassified	20	38	0.09	2	11	6
Total	**-**	***854***				

Conclusion

WFP has invested significantly in LiDAR data acquisition. The detailed canopy and bare earth information derived from LiDAR can reveal important landscape level information that would otherwise be difficult to quantify. Road buffer width is the prime example. LiDAR enables the entire landbase to be reviewed and to measure (rather than estimate) the road area not supporting tree growth. Although the road buffer widths applied to TFL 44 timber supply modelling take a more conservative approach, there are consistencies on road buffer width found in other TFLs that WFP manage in the North Island. As the Province and other licensees gradually develop LiDAR coverage, more accurate road buffer width assumptions can be generated using this manner, providing better input for the timber supply modelling.

[1] In MP #5, 30m buffer widths were applied to Bamfield and Carmanah mainlines. The rest of the mainlines was 15m.

Appendix C: LIDAR REVIEW OF OAF1 IN MANAGED STANDS

Summary

With the availability of LiDAR data acquired for TFL 44, more in-depth analysis was conducted to quantify gaps in crown cover as a proxy for the extent of non-productive area within managed stands. These non-productive areas are known as Operational Adjustment Factor 1 (OAF1). The results indicate that the TIPSY default OAF1 of 15% overstates the extent of non-productive area within stands in TFL 44. Where there is good alignment between the forest inventory polygons and LiDAR data the results indicate that 10.9% is a more appropriate OAF1.

Process and Methodology

Using Forest Cover polygons as base data, operable stands ranging from 41 to 100 years old (near rotation age) were selected for the analysis. The rationale is that tree crowns that have currently occupied the site will regenerate after harvesting. Voids that are not covered by tree crowns within such stands are assumed to represent low/non-productive area within the stand. Operable stands were selected such that the results would be applicable to the THLB. It should also be noted that current reforestation standards result in higher stocking levels (greater site occupancy) than the stands analysed so the outcomes of this analysis are likely conservative when applied to future stand yields. Figure 30 shows the forest cover age and height for a managed stand that fits the criteria for this analysis.

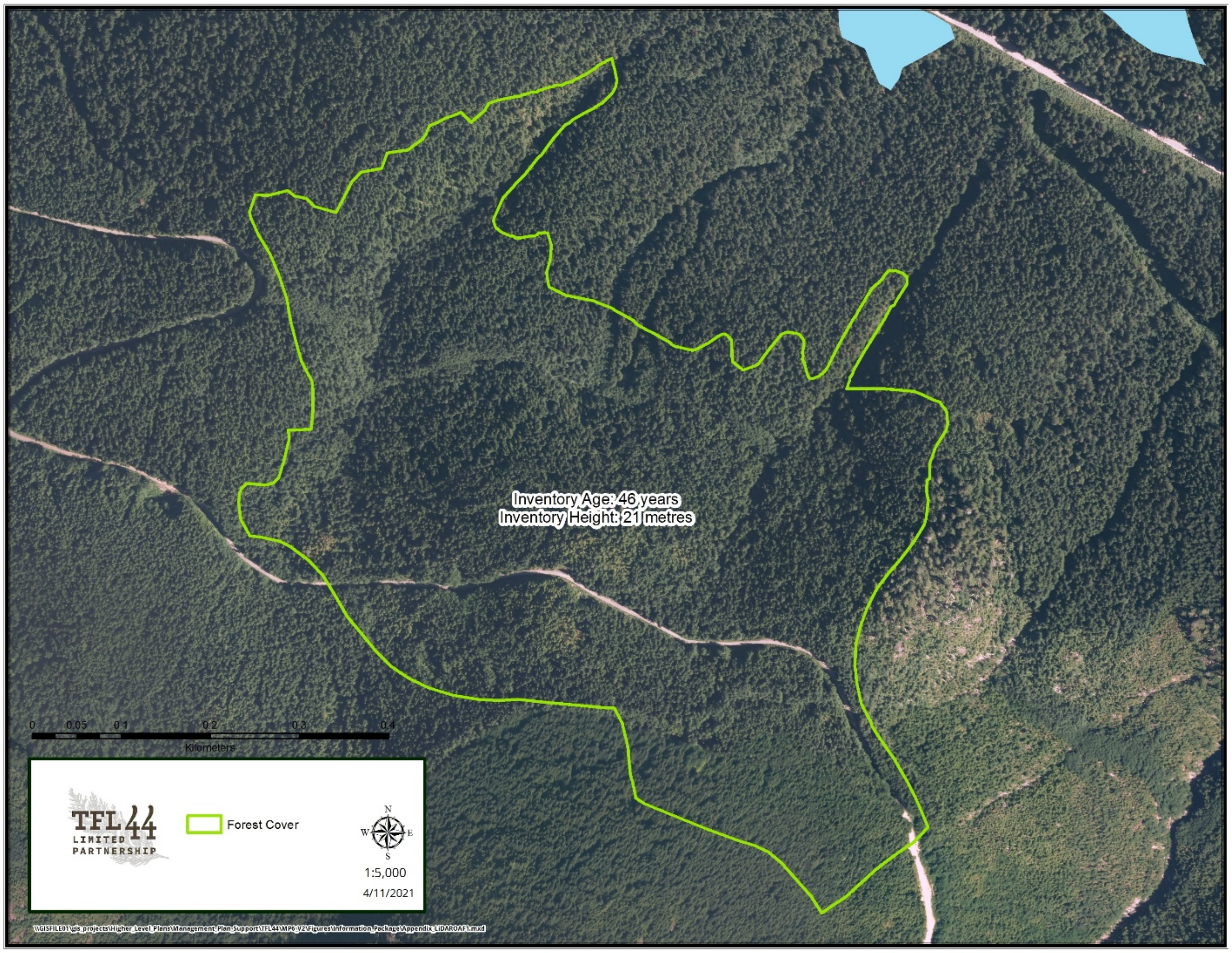


Figure 30 An Example Stand With Orthophoto and Forest Cover Attribute in TFL 44

Stands then were intersected with forest cover and LiDAR Canopy Height Model (CHM) dataset. Figure 31 shows the same geographical extent with the LiDAR CHM layer.

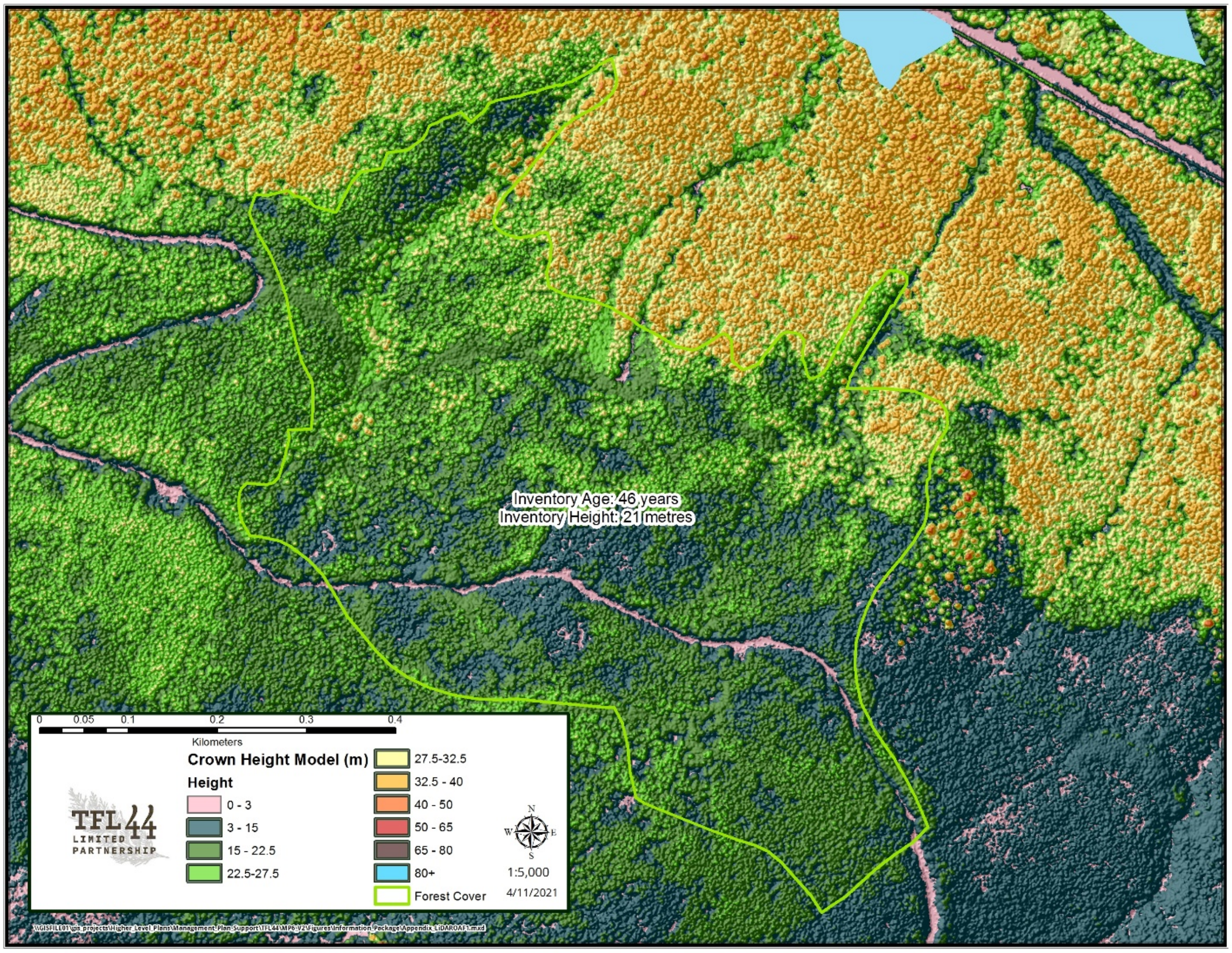


Figure 31 Crown Height Model from LiDAR for The Same Stand

LiDAR CHM dataset was then vectorized to generate areas with less than 10m vegetation in order to determine percentage of the underlying forest cover polygon, accounting for roads (as discussed in Appendix B: LIDAR REVIEW OF ROAD WIDTHS IN MANAGED STANDS) and low/non-productive area within the stand. The 10m height threshold is referenced in the VRI ground sampling procedures (Province of British Columbia, 2018) as the split between the tree layer and the tall shrubs layer. Figure 32 demonstrates the concept for gap identification.

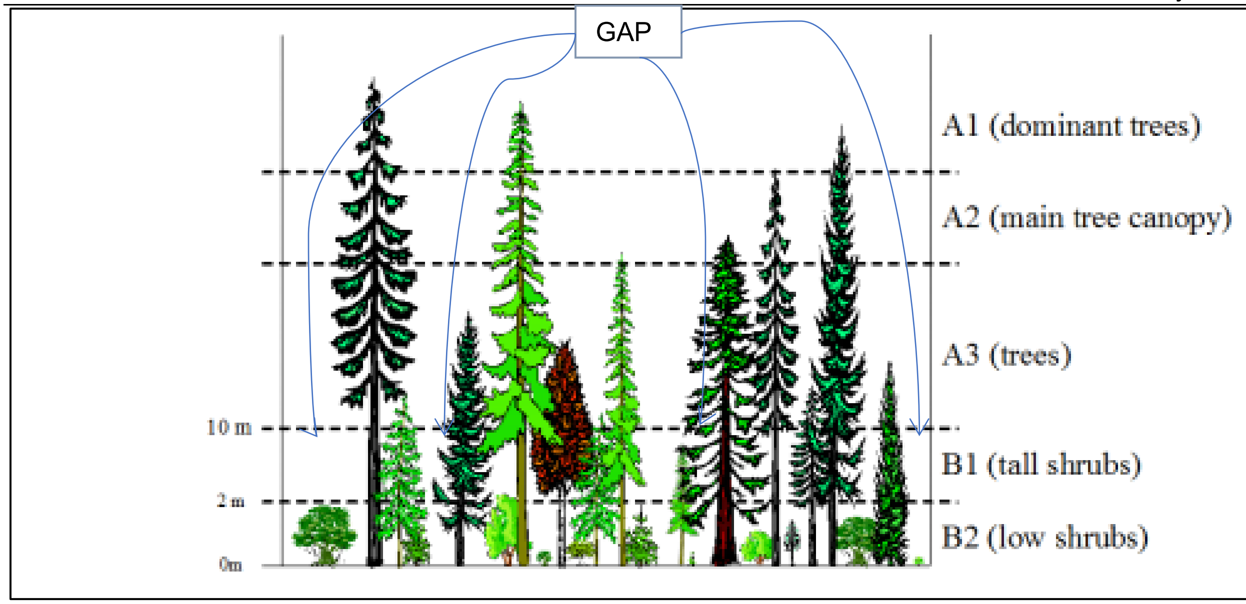


Figure 32 Diagram of Identifying Gaps

(adapted from VRI Ground Sampling Procedures (Province of British Columbia, 2018))

Using the 10m CHM cut-off height, Figure 33 indicates the area where crown cover is less than 10m tall for the same stand. It is noted that roads and the low/non-productive area within the stand that are not quite visible are all revealed by the analysis.

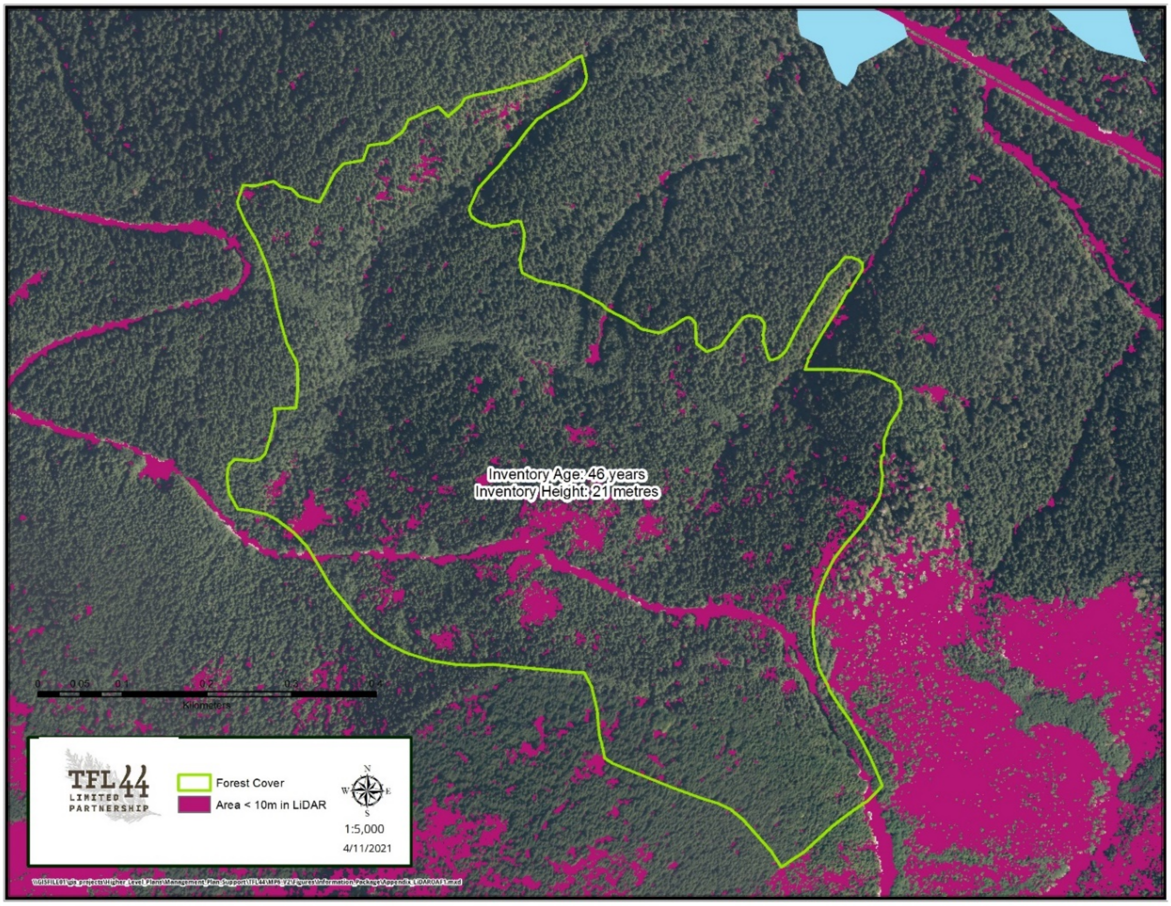


Figure 33 Orthophoto with Inventory Polygon and LIDAR Gap Factor

Results

The results indicate that within 40 to 100-year-old operable stands, the area-weighted average gap factor (i.e. OAF1) is 10.9%. There is little variation between poor, medium and good site productivity classes so a single OAF1 value of 10.9% is suitable.

Conclusion

LiDAR data can provide very detailed tree-level information compared to the traditional photo-interpretation based inventory dataset. This allows accurate stand-level metrics to be derived. In this analysis, the amount of area not supporting trees at least 10m tall within forest cover polygons between 40 and 100-year-old was determined as a proxy for the amount of low/non-productive area within the stand.

When modelling growth and yield for managed stands with TIPSY, OAF1 is intended to account for these non-productive areas. A "default" OAF1 of 15% is applied unless better information is available. The results indicate that on an OAF1 of 10.9% is appropriate for TFL 44. Older stands within the sample are the result of less intensive management practices than have been practiced in recent times and are expected to be used in the future. As such, the overall averages determined are likely conservative relative to current practices.

Appendix D: Terrain Stability Mapping Review

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Phone: 250-722-7166 Email: oesl@shaw.ca

January 30, 2009

Western Forest Products Inc.
#118 – 1334 Island Highway
Campbell River, B.C. V9W 8C9

Attention: Mike Davis, RPF

Re: Proposed timber supply netdowns for terrain stability polygons, Tree Farm Licence 44

As you requested I have reviewed the landslide occurrence data from the 2008 TFL 44 watershed project (Horel 2008) in the context of terrain stability netdowns for the timber supply analysis (TSA). The purpose of the review is to advise whether netdowns used in previous TSAs should be adjusted based on new terrain stability mapping and on new landslide inventory information developed since the last TSA.

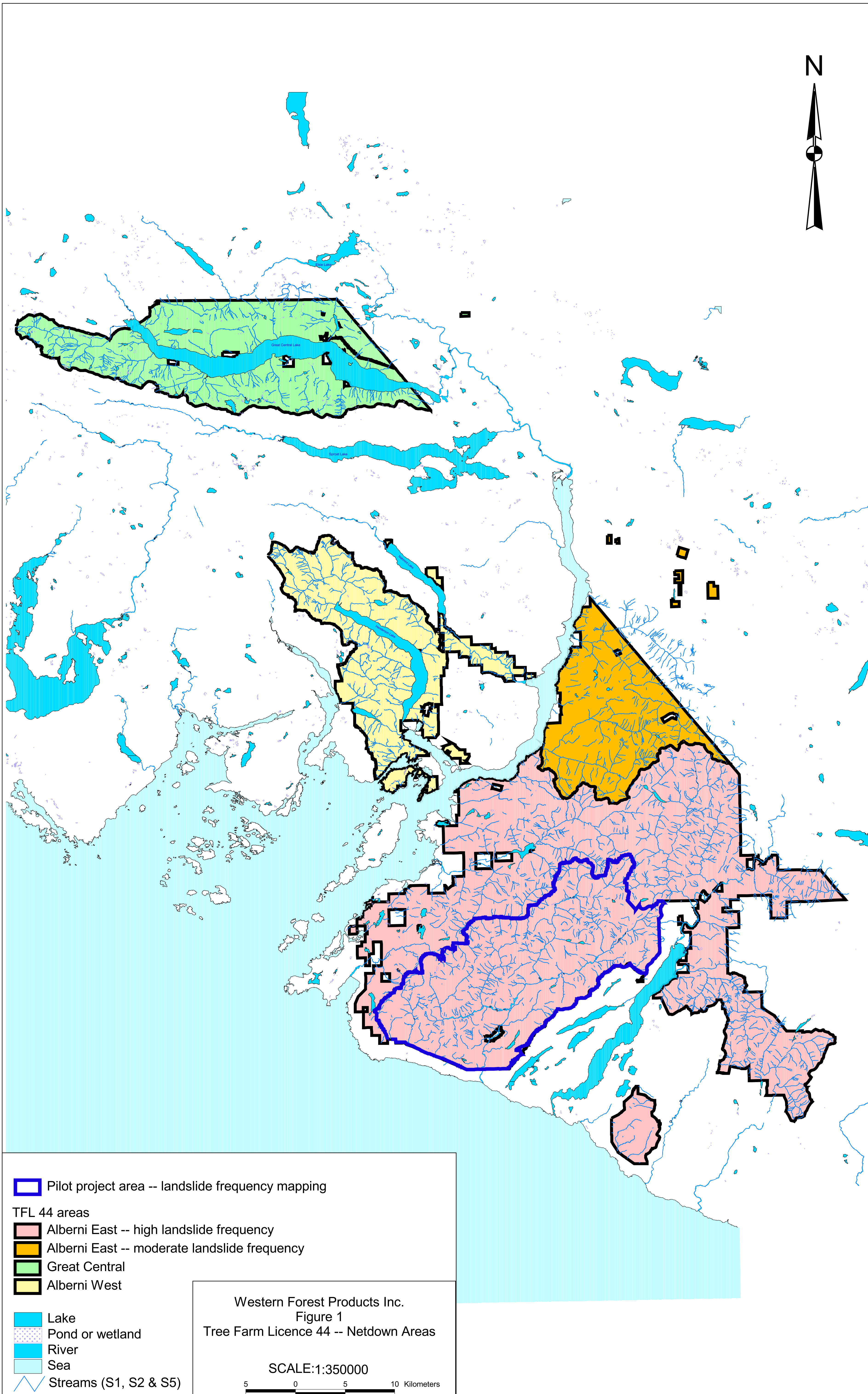
The netdown numbers are not arrived at by calculation. The proposed netdown figures are based on a review of the historic and postCode landslide occurrence, and judgment as to whether the assumptions used previously for selecting netdowns appear reasonable or ought to be changed.

TFL 44 comprises three areas: Alberni East, Great Central and Alberni West (Figure 1). Alberni East is subdivided into areas of high and moderate landslide frequencies as discussed further below.

Summary of Recommendations

1. For Alberni East, almost all of the area has new terrain stability mapping. Based on landslide data intersected with terrain stability polygons, and in consideration of stream impacts identified in the watershed project, significantly higher netdowns are proposed for the High landslide frequency zone than were applied previously (Table 1). In addition to increased netdowns, a rate of cut limit on steep terrain of 2,038 ha in 10 years is recommended for the High landslide frequency zone (Table 4).

   For the Moderate landslide frequency zone, netdowns less than those for the High zone are proposed for the new terrain stability polygons in consideration of the lower rate of landslide occurrence (Table 1).



Western Forest Products Inc.
Figure 1
Tree Farm Licence 44 -- Netdown Areas

2. For Great Central, there has been no change to the terrain stability mapping. The landslide inventory data show an overall low frequency of landslides, and no landslides in postCode blocks (to September 2007) despite considerable harvesting on steep terrain. I suggest no change to the netdowns used previously for Es1 polygons; but given the low landslide occurrence it would be reasonable to reduce the netdowns for Es2 (Table 1).

3. For Alberni West, landslide inventory data are not available, and there has been no change to the terrain stability mapping since the previous TSA analysis. I have no basis for making changes to the netdowns and suggest you use the previous ones.

Background

The 2008 TFL 44 watershed project (Horel 2008) evaluates watershed condition and develops indicators for monitoring watershed trends for all watersheds in TFL 44 larger than 1,000 ha. It incorporates data from the 2006 Road Risk Assessment for TFL 44, which included a landslide inventory that has been updated to September 2007. Alberni West was not part of the 2006 project and so landslide inventory data and other project data are not available for that area.

Terrain stability mapping

There are several different types of terrain stability mapping in TFL 44 (see map, Figure 2). Great Central has old Es1/Es2 mapping. Alberni West has old 5-class mapping in Clemens Creek and Nahmint watershed; and old ES1/Es2 mapping for the rest. There is a very small area of detailed terrain stability mapping (DTSM) in the Haggard community watershed.

Alberni East has DTSM in the community watersheds (Malachan, Sugsaw and Cousteau Creeks) and in the Caycuse and Walbran watersheds south of Caycuse Creek. There is detailed landslide frequency mapping in a pilot project area which encompasses Klanawa and Darling watersheds, and extends partway into South Sarita, Pachena and Nitinaht watershed units (map, Figure 2). The pilot project used landslide inventory data to define terrain stability polygons (Denny Maynard et al, 2004). Table 1 shows the landslide density for terrain polygons intersected with landslide inventory data updated to September 2007. The landslide frequency mapping provides separate coding for landslides from roads (not included in Table 1).

The rest of Alberni East has reconnaissance terrain stability mapping (RTSM – P, U) except for a small area near Hitchie Lake and a small block on the Nitinaht River which have old Es1/Es2 mapping. There are a few small blocks in China Creek with old 5-class mapping.

Landslide occurrence

Table 2 compares landslide occurrence for pre and postCode cutblocks for Great Central and the two zones of Alberni East (the data are not available for Alberni West). The landslide inventory data confirm the difference in landslide occurrence identified on the Regional Landslide Frequency (RLF) map for the Cascadia Terrain Management Code of Practice (Map

Table 1 -- TFL 44 -- Proposed netdowns for terrain stability

TFL 44 -- Landslides intersected with terrain stability polygons

Type of terrain stability mapping	Stability class	No. of landslides*	Total area of polygons ha	Slides/100 ha	Proposed netdown
Alberni East -- pilot project					
Landslide frequency mapping (Klanawa + adjacent areas)	Red	438	5,295	8.3	100%
Total area = 31,249 ha	Orange	164	6,139	2.7	20%+ROC
	Yellow	30	2,003	1.5	ROC
	Green	17	1,904	0.9	ROC
	Grey	51	15,908	0.3	ROC
Alberni East outside of pilot project					
Regional Landslide Frequency = High					
Total area = 73,748 ha					
Old Es mapping	Es1	0	2	-	n/a
Old Es mapping	Es2	0	4	-	n/a
Old 5 class mapping	Class 4	0	61	-	10%
Old 5 class mapping	Class 5	0	1	-	n/a
DTSM *(20% netdown in CWS)*	Class IV	45	3,141	1.4	10%+ROC
DTSM	Class V	59	1,028	5.7	90%
RTSM	P	187	12,483	1.5	10%+ROC
RTSM	U	165	3,131	5.3	90%
outside of typed polygons	other	111			
Regional Landslide Frequency = Moderate					
Total area = 18,413 ha. Includes 424 ha in small blocks, e.g., in China Creek etc.					
Old Es mapping	Es1	0	0	-	n/a
Old Es mapping	Es2	0	3	-	n/a
Old 5 class mapping	Class 4	0	30	-	20%
Old 5 class mapping	Class 5	0	40	-	90%
DTSM	Class IV	0	58	-	5%
DTSM	Class V	0	-	-	n/a
RTSM	P	27	5,326	0.5	5%
RTSM	U	28	1,256	2.2	50%
outside of typed polygons	other	8			
Great Central Lake (2 zones)					
Total area = 30,350 ha					
Old Es mapping *(same netdowns as before)*	Es1	124	4,580	2.7	58%/37%
Old Es mapping	Es2	22	6,143	0.4	10%/5%
outside of typed polygons	other	14			
Alberni West		inventory			
Total area = 22,910 ha		incomplete			use same netdowns as before
Old Es mapping	Es1	n/a	2,971	n/a	
Old Es mapping	Es2	n/a	3,746	n/a	
Old 5 class mapping	Class 4	n/a	2,093	n/a	
Old 5 class mapping	Class 5	n/a	1,866	n/a	
DTSM	Class IV	n/a	7	n/a	

*Landslides include natural slides, cutblock slides (pre and postCode) and windthrow slides N, G, OS, CB, ESC, WT. Landslide inventory to September 2007.

Landslides from roads (R, RC, RF) and forested old naturals (N_F) are not included.

ROC = rate of cut limit (Table 2).

DTSM = detailed terrain stabiity mapping; RTSM = reconnaissance terrain stability mapping.

Atlas May 2005). That is, the north part of Alberni East is in the Moderate RLF zone; the rest of Alberni East is in the High RLF zone (Figure 1).

Table 2 -- TFL 44 areas by Regional Landslide Frequency

Region:	RLF = High	RLF = Moderate	Alberni East total	Great Central
WFP area, ha	93,748	17,988	111,736	30,350
WFP area, km^2	937	180	1,117	304
Harvest history - WFP area				
Total harvested area <60 yrs old	54,966	4,829	59,794	9,054
% of total WFP area	59%	27%	54%	30%
Area harvested before 1995, ha	43,245	3,457	46,702	5,367
Area harvested 1995 & later, ha*	11,721	1,372	13,093	3,687
Total steep terrain, ha	34,700	7,201	41,901	11,672
% of total WFP area	37%	40%	38%	38%
Steep terrain logged before 1995 (<60 yrs), ha	10,510	1,225	11,734	1,719
Steep terrain logged 1995 & later, ha	3,977	273	4,250	1,516
% of total WFP area	4.2%	1.5%	3.8%	5.0%
Slides originating in harvested cutblocks:				
No. of slides in pre-1995 cutblocks	654	35	689	34
No. of slides per 100 ha logged in steep terrain, logged before 1995	6.2	2.9	5.9	2.0
No. of slides in 1995 and later cutblocks	181	2	183	0
No. of slides per 100 ha logged in steep terrain, logged 1995 & later	4.6	0.7	4.3	-
Slides from cutblocks logged >= 1995, no./km^2	0.19	0.01	0.16	-

Notes on table:

1. 2007/08 harvesting data is not complete.
2. "Steep terrain" means Es1/Es2 or Class IV/V or P/U or orange/red, plus slopes steeper than 60% that fall outside these polygons.
3. Landslide inventory data are not available for Alberni West.

Table 3 compares the three areas of TFL 44 with other WFP areas where the same watershed project has been completed. TFL 44 has had a significantly higher rate of cut on steep terrain than WFP's other operations since 1995 and a correspondingly higher landslide density. In particular, the High landslide frequency zone of Alberni East (Table 2) has had more landslides in postCode blocks (181), and has a much higher landslide density (0.19 landslides/km^2) than the other operations, where landslide density ranges from 0 to 0.07 landslides/km^2.

It has been my general observation in these watershed projects that where this landslide density in a watershed unit exceeded 0.10 landslides/km^2, effects in stream channels were likely to be apparent. This is the case in Alberni East; streams have been affected by landslides from postCode blocks. This threshold is not a strict rule and there are many factors, such as size of landslides, connectivity to streams, and so forth; and in some cases a single large landslide has had a profound effect on the stream. As well, landslides from preCode roads and

Table 3 -- Data summary by area

	TFL 44			NVIR				
Operating area	Alberni East	Great Central	Alberni West	TFL 6 + TFL 39-4	TFL 37	TFL 19	TFL 25 Block 2 Stafford	Apple
WFP area, ha	111,736	30,350	22,910	233,413	160,199	176,081	38,270	19,055
WFP area, km^2	1,117	304	229	2,334	1,602	1,761	383	191
Harvest history - WFP area								
Total harvested area <60 yrs old	59,794	9,054	9,550					
% of total WFP area	54%	30%	42%					
Area harvested before 1995, ha	46,702	5,367	6,327					
Area harvested 1995 & later, ha	13,093	3,687	3,223					
Total steep terrain*, ha	41,901	11,672	11,799	50,496	51,687	89,882	20,504	10,650
% of total area	38%	38%	51%	22%	32%	51%	54%	56%
Steep terrain logged before 1995 (<60 yrs), ha	11,734	1,719	2,429	12,723	10,848	8,720	463	558
Steep terrain logged 1995 & later, ha	4,250	1,516	1,872	3,191	2,923	5,138	393	43
% of total area:	3.8%	5.0%	8.2%	1.4%	1.8%	2.9%	1.0%	0.2%
Roads								
Total road length, km	3,345	448	449	5,645	3,359	2,447	127	61
Total length M, MH, H stability hazard, km	700	53	n/a	787	504	425	31	13
Length M, MH, H hazard not perm. deactivated	627	52	n/a	481	398	302	27	0
Roads on steep terrain built before 1995, km	339	58	105	336	229	274	9	8
Roads on steep terrain built 1995 & later, km	225	43	39	202	184	185	19	0
Landslides - to Sep 2007								
Slides originating at roads:								
No. of slides at roads built before 1995	701	45	n/a	623	242	287	1	29
No. of slides/km of road on steep terrain <1995 -- preCode roads	2.1	0.8		1.9	1.1	1.0	0.1	3.6
No. of slides at roads built 1995 or later	21	0	n/a	40	12	3	4	0
No. of slides/km of road on steep terrain >=1995 -- postCode roads	0.1	0.0		0.20	0.07	0.02	0.21	0
Slides originating in harvested cutblocks:								
No. of slides in pre-1995 cutblocks	689	34	n/a	1,135	523	339	10	13
No. of slides per 100 ha logged in steep terrain, preCode blocks	5.9	2.0		8.9	4.8	3.9	2.2	2.3
No. of slides in 1995 and later cutblocks	183	0	n/a	170	27	54	7	0
No. of slides per 100 ha logged in steep terrain, postCode blocks	4.3	0.0		5.3	0.9	1.1	1.8	0
Slides from postCode cutblocks, no./km^2	0.16	0.0	n/a	0.07	0.02	0.03	0.02	0
Slides originating in unharvested timber:								
Fully forested old naturals	719	36	n/a	188	451	442	75	52
No. of slides occurring pre1995, visible in forest cover	399	118	n/a	720	1102	694	400	287
No. of slides occurring 1995 and later *(not all reported)*	59	0	n/a	29	50	27	20	2
Streams*								
Total length of mapped streams, km	2,007	397	357	6457	7269	4611	1094	376
Mapped stream density, km/km^2	1.8	1.3	1.6	2.8	4.5	2.6	2.9	2.0
Length alluvial channels, km	264	39	38	948	683	396	80	30
% of total stream length	13%	10%	11%	15%	9%	9%	7%	8%
Length semi-alluvial channels, km	118.5	28	31	763	377	278	40	13
% of total stream length	6%	7%	9%	12%	5%	6%	4%	3%
Length nonalluvial channels, km	1621	327	285	4356	6019	3930	969	333
% of total stream length	81%	82%	80%	67%	83%	85%	89%	89%
Length channels in wetland, km	1	2	3	54	190	5	5	1.1
% of total stream length	0.1%	0.5%	0.8%	0.8%	2.6%	0.1%	0.5%	0.3%
Riparian condition (alluvial & semi-alluvial streams only)								
Length assessed, km	378	69	n/a	1079	1037	686	913	76
Length CBE, km (riparian forest inadequate to limit bank erosion)	1	0	n/a	1.6	0.05	10	0	0
Length CBE+LWD, km -- unstable alluvial streams	27	0.5	n/a	85	50	80	2.7	11
Length LWD, km (riparian forest inadequate to supply LWD)	168	19	n/a	327	422	252	14	16

"Steep terrain" means Class IV/V, Es1/Es2, P/U or orange/red, plus >60% slopes that fall outside these polygons.

cutblocks continue to occur and to impact streams. Nevertheless, this is a useful threshold to consider for planning-level management purposes.

A review of the timing of landslides following harvesting shows that in TFL 44, more than half of post-harvest landslides occurred in the first five years after harvest, and 74% occurred within 10 years (Figure 3). This pattern is similar to the timing of landslides reported in Horel 2006 for TFL 6 on northern Vancouver Island. The information for timing of landslide occurrence in both cases was taken from landslide event reports where the year of the landslide was known, and sometimes the specific storm in which it occurred.

Rate of cut on steep terrain – High landslide frequency zone of Alberni East

Prediction of post-harvest cutblock landslides is uncertain. This is clearly evident in the number of landslides that have occurred in postCode blocks, despite having terrain stability assessments completed in most cases. Further uncertainties exist in windthrow management of cutblock boundaries at breaks to unstable terrain. For this reason, in view of the existing number of landslides in postCode blocks and the impacts to streams, I recommend that the Timber Supply Analysis also incorporate a rate of cut limit on steep terrain in the High frequency landslide zone of Alberni East. I propose that a rate of cut be set to achieve a maximum landslide density of 0.10 landslides/km^2 over a 10 year period. Using the existing frequency of 4.6 landslides per 100 ha logged on steep terrain, this would give a maximum 2,038 ha of steep terrain harvested over a ten year period (Table 4). This is a significant reduction in rate of cut since 1995 but is not conservative and still assumes a "landslide budget" of 94 landslides in a 10 year period in this zone, assuming landslide occurrence will continue to be similar to the postCode period to date. As well, some landslides do continue to occur beyond 10 years after harvest.

Table 4 – Recommended rate of harvest limits on steep terrain in TFL 44

Watershed Unit	Existing frequency - no. slides/100 ha logged steep terrain postCode	Area of watershed unit, km^2	Max. no. of landslides for <0.10 slides/km^2 in 10 yr period	Recommended max. area of steep terrain harvested <10 years old, ha	Existing area of steep terrain harvested 1998-2008, ha*
Alberni East - total	4.3	1,117	112		2,753
Alberni East - RLF=high	4.6	937	94	2,038	2,573
Alberni East - RLF=moderate	0.7	180	18	no R.O.C.	180

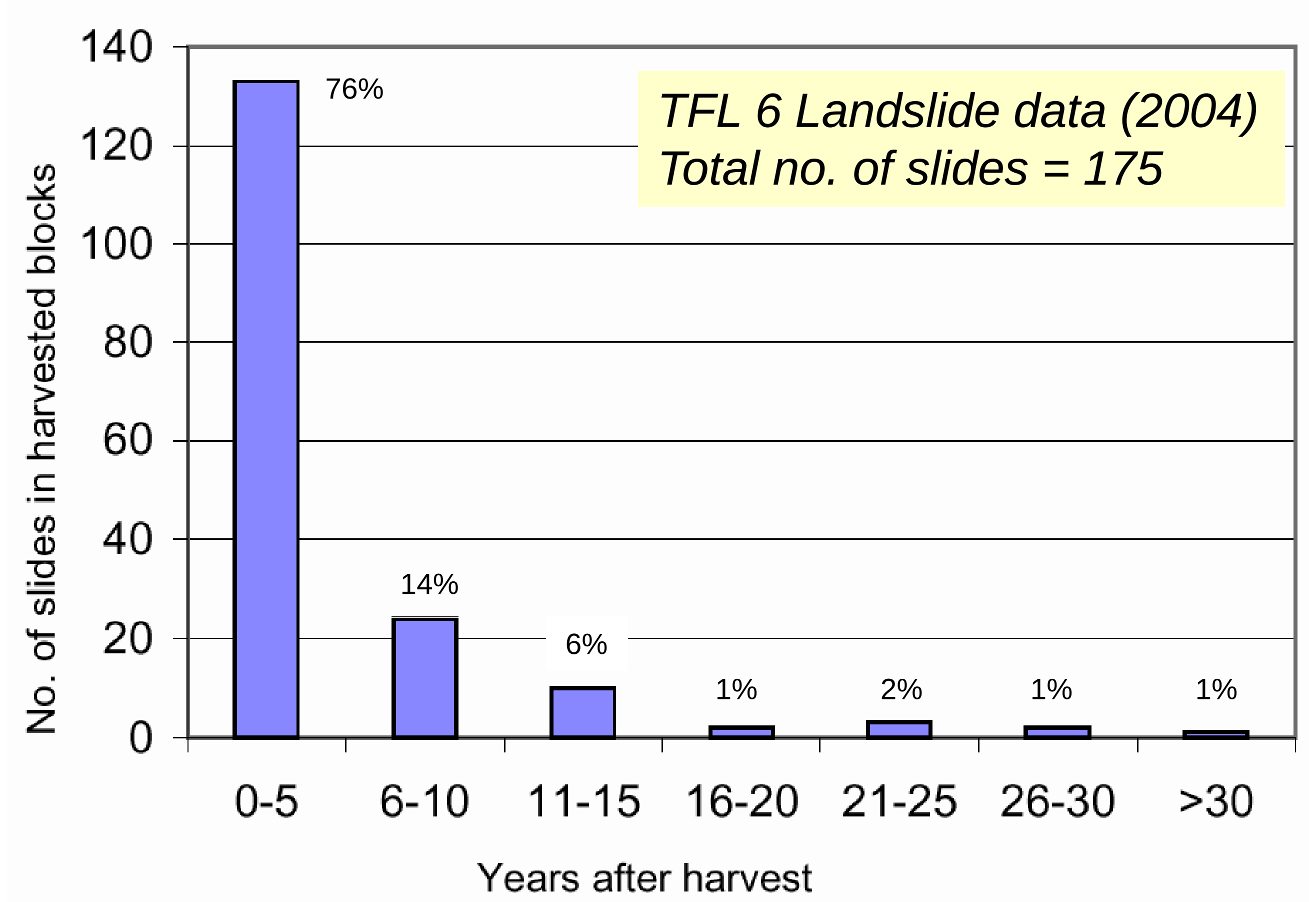
Great Central

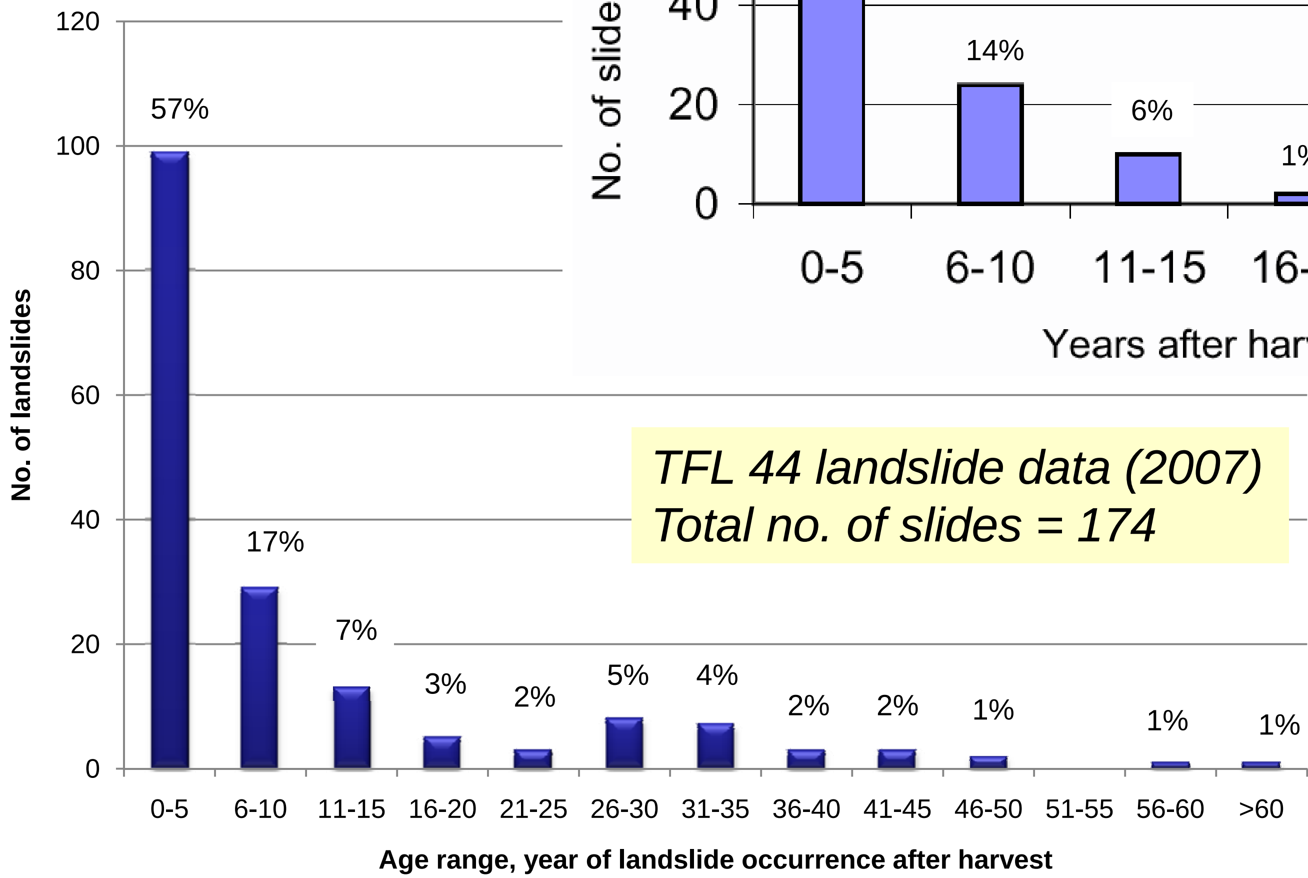
There is no new terrain stability mapping for Great Central since the last TSA. The previous TSA divided Great Central into a wetter west zone and drier east zone, with higher netdowns in the wetter zone. The overall landslide density and landslide frequency on steep terrain is low. No landslides have occurred in postCode blocks (to September 2007). No change is recommended

Figure 3

Timing of landslides following harvesting

(Excludes windthrow slides)





to the netdowns used previously for Es1, but I suggest that it is reasonable to reduce the previous netdowns for Es2 by approximately half (10% and 5% for the two zones).

Alberni West

There is no new terrain stability mapping in this area except for a very small area in the Haggard community watershed. Because no landslide inventory data is available, there is no basis for recommending a change to the netdowns used previously.

Glynnis Horel, P. Eng.

17 February 2009

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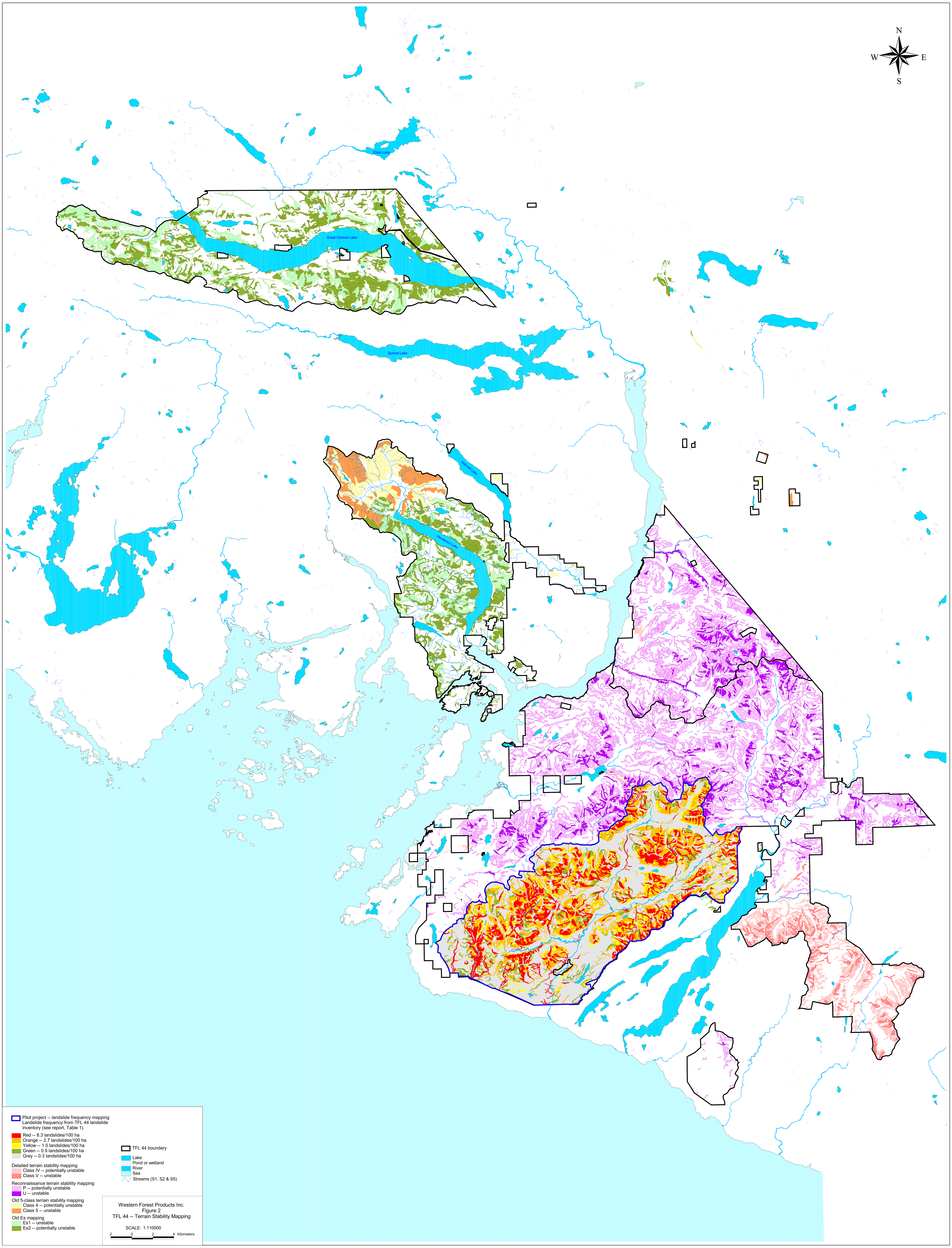

Western Forest Products Inc.
Figure 2
TFL 44 -- Terrain Stability Mapping

Appendix E: Hydrologic Recovery Method Review

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April 12, 2021

Western Forest Products Inc.
118-1334 Island Highway
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Attention: Mike Davis, RPF

Re: Hydrologic recovery method for planning level tracking and timber supply

As we discussed I am suggesting a simplified approach to determining hydrologic recovery and equivalent clearcut area for WFP's planning purposes. In coastal watersheds, the scenario of concern for harvest-related affects on peak flows is a rain-on-snow event where the snowmelt component is increased by increased snowpack depth in clearcuts (Attachment A). For the purpose of determining hydrologic recovery I propose assuming the case of a rain-on-snow event that extends over the full elevation range of watersheds, represented by the R1b curve from Hudson and Horel (2007)[1]. Because there is considerable uncertainty in predicting changes in stream flows in individual watersheds (Attachment B), the intent is that level of risk would be addressed by management measures rather than by selecting different hydrologic recovery curves.

The R1b curve requires selecting a snow depth threshold. From snow data[2] on Vancouver Island and ClimateBC predictions of winter snowfall at varying elevations, I suggest using 4 m in wetter zones (e.g., higher elevations) and 3 m in drier zones (e.g., lower elevations). For example, 4 m could be applied to elevations at or above 500 m, and 3 m to elevations below 500 m. See Attachment C.

April 12, 2021

Glynnis Horel, P. Eng., FEC
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Attachments
A – Background – hydrologic response to forest removal
B – Sources of uncertainty in estimating the likelihood of stream flow change in response to forest harvesting
C – Applying TR032 recovery curves in WFP's watersheds
Information sources

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[1] Hudson,R.,and G.Horel. 2007. An operational method of assessing hydrologic recovery for Vancouver Island and south coastal BC. Res. Sec., Coast For.Reg., BC Min. For., Nanaimo, BC. Technical Report TR-032/2007.
[2] Dr. Bill Floyd, RPF, research hydrologist with BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development. VIU snow monitoring sites: http://graph.viu-hydromet-wx.ca/

Attachment A –Background – hydrologic response to forest removal

Streamflow response in a watershed involves a complex interaction between climatic conditions, physical watershed characteristics and land use (Pike et al. 2010). Factors influencing stream flow response can include:

- Regional climate
- Vegetation (distribution of forest and non-forest areas)
- Dominant peak flow regime (radiation snow melt, rain, rain-on-snow)
- Topographic relief
- Aspect and wind exposure
- Surface catchment size
- Soil depth and permeability
- Bedrock permeability and structure
- Subsurface groundwater catchment
- Water storage (lakes, wetlands, icefields, late-persisting snowpacks)
- Roads
- Non-forest development (agriculture, urban, industrial)
- Artificial flow controls or diversions
- Groundwater or surface water extraction

Forest removal

Trees intercept some portion of rainfall and snowfall. They draw water from the ground, consume part of it in photosynthesis and release the unconsumed water by transpiration. Canopy density, tree type and degree of canopy closure determine the extent of interception. When forests are removed, the loss of interception means that all precipitation hits the ground directly. This can result in increased runoff or infiltration and increased snowpack depth. The extent to which this affects stream flows depends on climate and stand characteristics. In the case of rainfall interception it also depends on antecedent moisture in the canopy, on the nature of the particular storm event, and on the other watershed factors listed above (Pike et al. 2010, Hudson 2003).

Forest removal can elevate groundwater levels in the vicinity of clearcuts because of the loss of evapotranspiration (Hetherington 1987, Pike et al. 2010, Moore et al. 2020). This effect is most pronounced in summer when transpiration rates are highest. Water uptake by large trees is considerable. For example, at a study site in western Washington, Martin et al. (1997) determined that their research stand of *A. amabilis* stored an average of 12.6 kg/tree of water, or 27.2 mm, which they equated to approximately 8 days of transpiration. Water taken up by trees that is not consumed in photosynthesis is transpired into the atmosphere. During periods of extreme drought, transpiration ceases and trees become dormant to preserve stored water. Stand conversion from conifer to deciduous species has also been found to affect low summer flows and groundwater tables in floodplains because evapotranspiration rates are higher in deciduous species such as cottonwood and alder (Moore et al. 2020).

The loss of evapotranspiration and loss of rainfall interception following forest removal can result in increased stream flows, especially in summer rain events for small streams in the vicinity of recent clearcuts (Moore et al. 2020). As forests regenerate this effect disappears, and at advanced stages of regeneration summer flows can be reduced by increased evapotranspiration rates (Coble et al. 2020, Moore et al. 2020). In research watersheds in western and southwestern Oregon, Perry and Jones (2017) found that average daily stream flow in summer (July through September) in basins with 34 to 43-year old Douglas Fir plantations was 50% lower than streamflow in reference basins with 150 to 500 year old coniferous forests.

In rain-dominated climate zones photosynthesis and evapotranspiration continue in the winter months although at a reduced rate. Researchers have found winter evaporation rates to be 20-30% of summer rates (Murakami et al. 2000, Humphreys et al. 2003). Hence, in winter, with reduced evapotranspiration coupled with high seasonal rainfall, the difference in soil moisture content between forested and clearcut sites would be correspondingly reduced and might be eliminated.

Increases in snowpack depth can have the effect of increasing the total water yield from a watershed. Water stored in the snowpack can increase the volume of water available in a rain-on-snow event. Vegetation removal can increase snowpack exposure to wind and rain and also change snowpack albedo[1], which can change the rate and timing of snowmelt. In snowmelt peak flow regimes typical of interior watersheds, high ECAs can result in significant increases in snowpack, and consequent significant increases both in annual discharge and in the magnitude of spring peak flow events. Because of other changes such as greater exposure to wind, spring melt rates can be higher and peak flows may occur sooner (Winkler and Boon 2017). Modelling of snowmelt regimes (Kuras et al. 2011, Schnorbus and Alila 2013) and data re-analysis (Green and Alila 2012) predict that peak flow magnitudes can increase after harvesting at all return periods, even for the largest floods.

In rain and rain-on-snow peak flow regimes, the influence of harvesting is more variable. The rainfall zone is the least likely to experience increased flows because of the absence of snowpack under normal conditions. Forest canopies have finite ability to intercept rain, so in large storms much of the rain goes through the canopy (Hudson 2003). Additionally, in a rainfall event, while forest removal reduces interception it does not increase the total water available in a rainfall event. Increases in peak flow diminish with increasing storm magnitude (Hudson 2003, Grant et al. 2008). In small storms occurring on a dry canopy (such as summer storms), a high percentage of the rain may be retained in the canopy, then subsequently evaporate without reaching the ground. Thus, stream flows from small storms can be significantly increased by forest removal. The greatest increases occur in flows with return periods of less than 1 year (Chapman 2003, Alila and Schnorbus 2005, Grant et al. 2008). Grant et al. (2008) found that in rain-dominated watersheds studied in the Pacific Northwest of the United States, detectable peak flow increases become statistically insignificant at return periods of no more than 6 years. In a study of rain-dominated watersheds on Vancouver Island, Chapman (2003) found that peak flow increases became statistically insignificant at return periods of no more than 2 years. Alila et al. (2009) points out the importance of understanding the shifts in flood frequency that occur with changes in flood magnitudes.

The influence of forest removal diminishes with increasing basin size, with the largest increases recorded in watersheds of less than 100 ha (Grant et al. 2008). In a study in Roberts Creek of small (S6[2]) streams, Hudson (2001) found large flow increases in low return period rain-on-snow events following clearcutting. In large watersheds, especially those of high relief, there is greater potential for variation in other factors that influence runoff such as precipitation, snow accumulation, aspect, topography, vegetation, wind conditions, temperature, soil thickness and permeability, storage in lakes, ponds or wetlands; and therefore greater opportunities for desynchronizing of runoff. So for example, an extreme peak flow can occur in a tributary basin in an event that sees only a normal high flow in the larger watershed. In rain-on-snow basins, roads are predicted to have greater influence than in rain-only basins (Grant et al. 2008).

Studies in large watersheds have recorded smaller to no increase in peak flows after harvesting, or even decreases; but predicting responses in large watersheds is more uncertain because there are few studies on large watersheds. Trubilowicz (2016) in an analysis of five automated snow pillow sites over 10 years in a BC coastal mountain region, noted the importance of understanding the amount of rainfall occurring at high elevations during rain-on-snow; and the relatively consistent enhancement of water available for runoff by 25-30% due to snowmelt in large rain-on-

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[1] Albedo is the fraction of solar energy reflected back from the surface.
[2] S6 – non-fish-bearing stream 3 m or less in width. Ref. Forest Practices Code Riparian Management Area Guidebook, Dec 1995.

snow events. In smaller events a range of antecedent and meteorological factors influenced runoff generation, particularly the antecedent liquid water content of the snowpack. During atmospheric river events, high elevation rainfall was found to be the dominant predictor of runoff response in six study catchments; antecedent snow cover provided only minimal increases in the ability to predict runoff compared to rainfall alone.

Trubilowicz (2016) noted that Chemainus River was primarily dominated by fall/winter rainfall; however, it exhibited a snowmelt component during cold phase ENSO[3] conditions and a significant influence of both rainfall and snowmelt in the annual hydrograph. While annual floods were dominated by winter rain events these were likely associated with rain-on-snow over at least a portion of the watershed. During atmospheric river events, the Chemainus watershed was most commonly snow free or nearly snow free.

In a rain-on-snow event, the volume of the snowmelt contribution depends on weather conditions (temperature, wind, etc.) and the amount of snow that was present during the event (Floyd 2012). While snowpacks are expected to decrease with climate change, cold years with heavy snow will continue to occur periodically. Additionally, less snow with warmer temperatures can produce more melt volume than more snow with cooler temperatures. Harvesting concentrated at higher elevations has greater potential to affect stream flows than the same harvest area at lower elevations. In high risk situations uncommon scenarios should be considered, such as an extreme atmospheric river rain-on-snow event, where snow is present for the entire extent of the watershed.

Management implications of harvest-related stream flow change

With respect to effects on stream channels of harvest-related peak flow increases, based on the magnitude of flow increases observed and the return periods of these events, Grant et al. (2008) concluded the following:

- Channels that may be susceptible to increased sediment transport from peak flow increases are those with gradients of less than 2% and with bed materials that are predominantly gravel or sand.
- Steeper gradient channels or streams with coarse bed material are unlikely to be significantly affected.
- The potential for channel change as a result of peak flow increases from harvesting is much less than for other management effects such as non-forest development, changes in sediment supply, or other physical channel disturbances caused by development.

While increases in peak flows from forest development may have little effect on channel morphology, if there are values that are prone to flood damage downstream of harvest areas, even small increases in the frequency of flood events could be of concern.

The current state of science does not allow a quantitative estimate of stream flow changes as they relate to ECAs. There is no simple relationship to estimate the magnitude of possible streamflow change; each watershed has a unique response. While equivalent clearcut area (ECA) can be a useful indicator of the potential for the snowmelt component of rain-on-snow stream flows to increase, it is not an indicator of watershed condition (Grant et. al. 2008, Forest Practices Board 2014), nor of the consequence of stream flow change. Limiting ECA levels is not a substitute for riparian management, for management of fans and floodplains, or for strategies that manage specific concerns for sediment production (e.g., terrain stability, road construction, road maintenance, wet weather operations, stream crossings, etc.). Limiting ECA is also not a substitute for anticipating and managing the effects of increased storm magnitudes from climate change.

If ECA values are used as an indicator, it is important that they are based on accurate forest cover attributes and stand heights (Hudson 2003). Field plots are advisable to calibrate stand heights determined either from growth curves or from lidar canopy heights.

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[3] El Nino Southern Oscillation, a cyclical ocean temperature pattern in the equatorial region of the Pacific Ocean

Strategically, it seems sensible to delineate watershed zones of hydrologic/geomorphic sensitivity with combinations of factors that could lead to increased effects not only on stream flows but on hillslope processes, for example:

- North aspects and greater wind exposure at higher elevation
- Headwater catchments, gullied slopes, bowls and V-shaped valleys that tend to concentrate runoff
- Steep slopes with landslide initiation zones where the forest canopy acts to buffer spikes in soil pore pressures, and where increased runoff onto landslide prone slopes is a concern
- Maintaining more catchment in a hydrologically recovered condition in high windthrow areas where retention on hillslope streams may have limited success

Risk control measures which may include harvest limits can then be selected as appropriate for the different zones and for the risk elements, consequences and risk tolerance of the particular circumstances.

Roads

Roads can affect hydrologic processes in several ways and can have greater effects on stream flows than forest removal (Grant et al. 2008):

- Compacted road surfaces reduce infiltration and increase runoff.
- Road cuts intercept shallow subsurface groundwater flows and bring it to the surface.
- Road ditches can act as a secondary drainage network, concentrating flows to streams and altering drainage patterns.

These effects can increase stream flows from groundwater brought to the surface and conducted via ditches to streams; and reduce concentration times so that streams peak faster.

Roads on steep slopes with thin soils are more likely to intercept subsurface seepage and increase surface flows than roads on gentle slopes. Cuts on steep slopes are higher, and more likely to intercept seepage; cuts on gentle slopes may be minimal. On gentle slopes with deep permeable surficial deposits, subsurface flows may predominantly be beneath the road, and not intercepted in road cuts.

Good culverting practices, such as maintaining natural surface drainage courses across the road and cross-culverting to discharge ditchwater onto the forest floor, can help to mitigate the influence of roads on stream flows by dispersing and slowing surface flows. The degree to which ditchwater culverts mitigate intercepted seepage depends on distance to streams, slope steepness below the road, soil depth and soil permeability. Ditchwater discharged from roads close to streams onto steep slopes with thin soils may remain as surface flow until it reaches the stream system. Ditchwater discharged distant from streams onto deep permeable soils is more likely to re-infiltrate.

Similarly, cross ditching for road deactivation helps but may not be completely effective for the same reasons that cross-culverting may not be completely effective. Complete debuilding and recontouring of roads is more effective at restoring hillslope drainage patterns; however, Carson (2000) observed that even with recontoured roads, some intercepted seepage continued to flow as surface streams in cross-ditches. This may diminish as roads become overgrown.

Attachment B – Sources of uncertainty in estimating the likelihood of stream flow change in response to forest harvesting

Uncertainty in estimating the likelihood of stream flow change (and the consequent level of risk to values) can arise from a number of sources.

Determining hydrologic recovery

1. Uncertainty in hydrologic recovery curves
   - The hydrologic recovery curves in TR032, which is currently the best available science for the method of determining hydrologic recovery for the coast, are based on limited research data. The recovery curves for the transient snow zone are developed by modelling to combine the rainfall and snowpack recovery curves, and have limitations.

2. Uncertainty in forest cover
   - Stand polygon boundaries and attributes may not be accurate, and forest cover may not be up to date for recent harvesting.
   - Stand polygons may not reasonably represent stands of uniform canopy characteristics that function as a "stand" hydrologically (e.g., large polygons with significant variability in stand characteristics)
     - Fragments, slivers and poor linework can introduce errors or uncertainty
   - Stand heights may not be accurate. Both lidar canopy heights and heights projected from growth curves have uncertainties.
   - Recovery curves from research stands may not represent the characteristics of other forest species for interception and snowpack influence.

3. Uncertainty in accounting for types of disturbance, e.g. how to modify recovery curves or assign hydrologic recovery values for:
   - burned stands
   - beetle-killed stands (or other pathogen mortality)
   - windthrow
   - deciduous stands

4. Variability of the effects of roads with different drainage management and deactivation measures and on different terrain conditions.

Estimating stream flow response to disturbance

5. Uncertainty in relating likelihood and magnitude of stream flow change to varying levels of hydrologic recovery
   - Absence of data from long term coastal research sites that relate stream flow response to changes in vegetation cover, including the scale and extent of disturbance (stand level, non-stand replacing, etc.)

6. Variable stream flow response depending on watershed characteristics
   - relief
   - aspect
   - extent of forest/non-forest
   - distribution of disturbance within the watershed unit
   - soil depth and permeability
   - slope steepness and hillslope connectivity

- presence of water storage (lakes, wetlands, reservoirs)
- flow controls (dams, weirs, etc.)
- water extraction or diversions

7. Climate and hydrometric data
    - There are very limited climate and hydrometric data in zones of particular interest (transient snow zone) to relate stream flow response to forest removal.
    - Precipitation and hydrometric measurements have their own sources of uncertainty

8. Over longer timeframes, uncertainty of climate change effects (shifting peak flow regimes, snowpack, etc.)

Attachment C – Applying TR032[1] recovery curves in WFP's watersheds

Hydrologic recovery means the extent to which a regenerating forest stand compares to a reference stand (typically old growth) with respect to rainfall interception, snowpack development and ablation. TR032 presents the current best available science and methods for estimating hydrologic recovery in coastal B.C. watersheds. While the recovery curves are conceptually sensible they are based on short records of data collected at a small number of sites.

For WFP's coastal tenures it is suggested to assume a rain-on-snow event occurring over the entire elevation range of a watershed. For this scenario the R1b rain-on-snow recovery curve is appropriate. For planning level tracking it is suggested to use a snow depth threshold T of 3 m below 500m elevation and 4 m at or above 500 m elevation.

Stand height Ht, m	R, % T=3 m	R, % T=4 m
1	0	0
2	0	0
3	0	0
4	11	0
5	24	11
6	35	24
7	45	35
8	54	45
9	62	54
10	68	62
11	73	68
12	78	73
13	81	78
14	85	81
15	87	85
16	89	87
17	91	89
18	93	91
19	94	93
20	95	94
21	96	95
22	97	96
23	97	97
24	98	97
25	98	98
26	98	98
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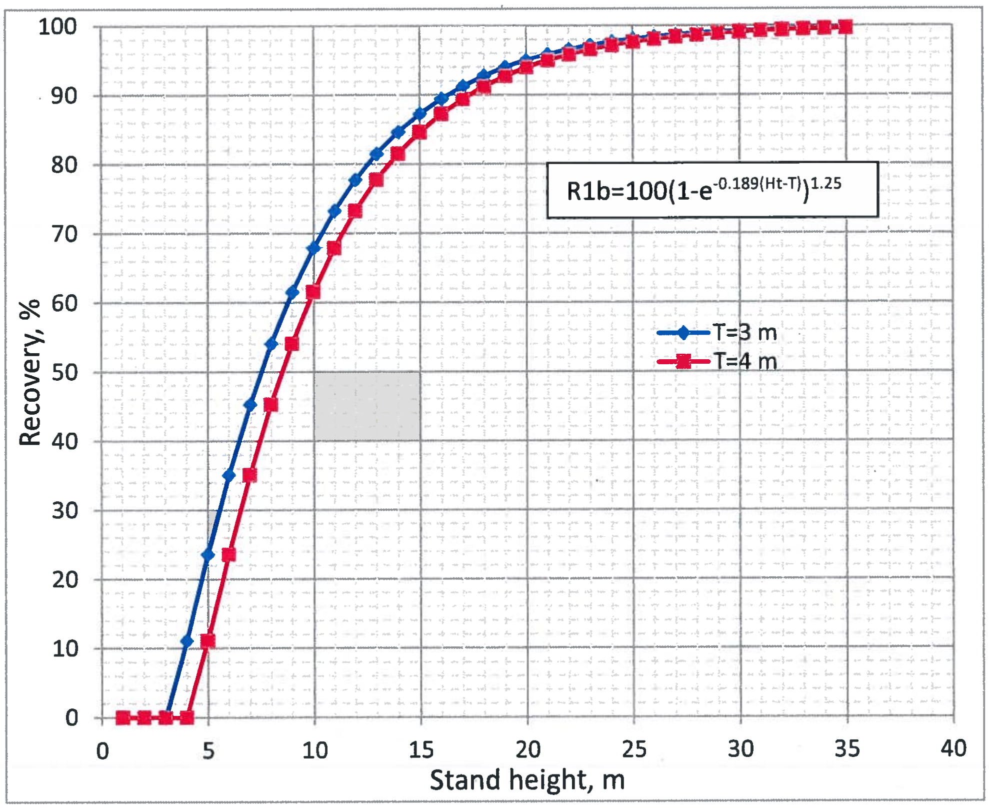
29	99	99
30	99	99
31	99	99
32	99	99
33	100	99
34	100	100



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