CANADIAN FOREST PRODUCTS LTD.
RADIUM DIVISION
TREE FARM LICENSE #14

MANAGEMENT PLAN #10

Dated for Reference: July 30, 2018

CANADIAN FOREST PRODUCTS LTD.
RADIUM DIVISION

Terry Lazaruk, R.P.F.
Strategic Planning Coordinator

Peter Baird R.P.F.
General Manager, Forest Planning,
Planning Administration

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1 INTRODUCTION

1.1 PURPOSE OF THE PLAN

This Management Plan (MP) prepared for Tree Farm Licence 14 (TFL 14) meets 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. These content requirements (in regulation) replace the MP content requirements listed in the tree farm license document and reduce the duplication of Forest Stewardship Plan matters (objectives and strategies).

1.2 OVERVIEW OF PROCESS

This Management Plan is now submitted to the Chief Forester, Ministry of Forests, Lands and Natural Resource Operations for approval. Coincident with the approval of the MP, the Chief Forester will make an independent determination of the Allowable Annual Cut (AAC) for TFL 14.

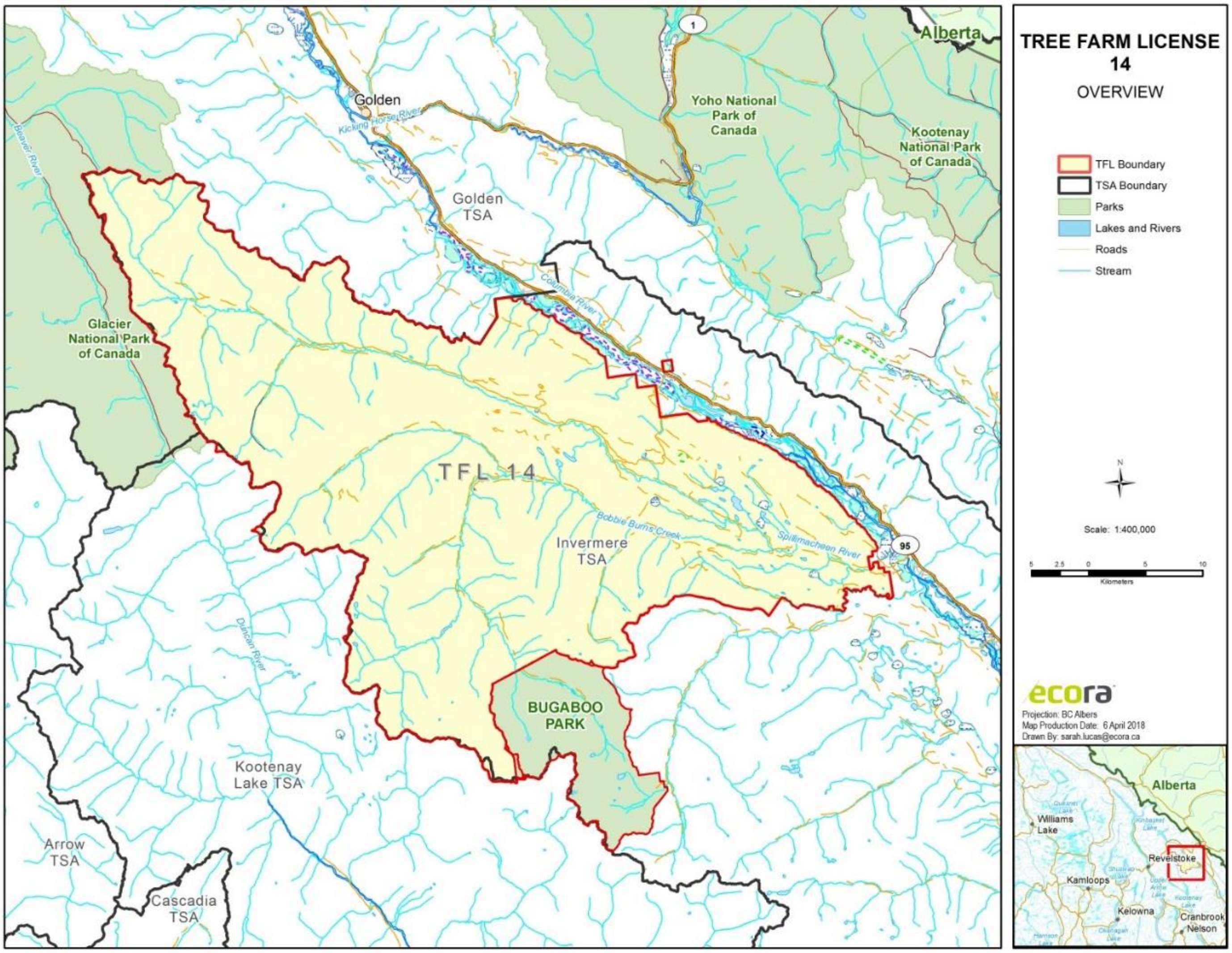
1.3 DESCRIPTION OF TREE FARM LICENSE 14

The Tree Farm License 14 (TFL 14) is within the Southern Interior Forest Region - Rocky Mountain Forest District (RMFD) and is administered out of the district office in Cranbrook. The TFL covers approximately 150,000 hectares within the RMFD.

TFL 14 is situated between the height of land of the Purcell Mountains, to the west, and the Columbia River valley, also known as the Rocky Mountain Trench, to the east. TFL 14 is bounded by the Invermere TSA to the south and east, the Golden TSA to the north, and the Kootenay Lake TSA to the west. It also borders three protected areas (Glacier National Park, Bugaboo Alpine Recreation Area, and the Columbia Wetlands Wildlife Management Area).

The major streams in the TFL are the Spillimacheen, Bobbie Burns and Vowell Creeks. These generally drain east and then south-east from the Purcell Mountains into the Columbia River, which forms a large portion of the eastern boundary of the TFL. The Columbia River flows north to Golden, through a large, complex wetland ecosystem called the Columbia Wetlands.

Figure 1 TFL 14 – Proximity to Radium and Surrounding Community



1.4 HISTORY OF TREE FARM LICENCE 14

TFL 14 was awarded as a Forest Management License (FML) in 1953 to Cranbrook Sawmills Ltd. On September 29, 2000, Crestbrook and Tembec Industries Inc. amalgamated to form Tembec Industries Inc. (the licensee), which is a wholly-owned subsidiary of Tembec Inc. In 2012, Canadian Forest Products Ltd. purchased the Tembec operations in the Kootenay region and is now the holder of the license for TFL 14. The current license document term began on March 1, 2017 and is for a 25 year term.

There has been no material change to the gross area of the Tree Farm since MP #9.

An overview map of the TFL boundary is provided in Appendix I.

Since award, the allowable annual cut (AAC) for TFL 14 is as specified in Table 1.

Table 1 – Historical AAC for TFL 14

YEAR OF DETERMINATION	AAC
1953	67,961 m^3
1968	111,852 m^3
1971 (exact date unknown)	140,000 m^3
1980	122,500 m^3
1990	178,926 m^3
1996	164,000 m^3
2001	160,000 m^3
2008	180,000 m^3

2 PLANNING

2.1 TFL 14 PLANNING DOCUMENTS

The following table indicates the publicly available planning documents used by Canfor to guide management and operations within TFL 14**:**

Table 2 – Planning Documents for TFL 14

Plan Type	Plan Title	Description	Web Link (as of Date)
LRMP	Kootenay-Boundary Higher Level Plan Order	The Kootenay-Boundary Higher Level Plan Order is a higher level plan approved by Order in Council on October 26, 2002. The Order identifies Resource Management Zones (RMZ's) and details goals, objectives, and strategies within these zones	https://www.for.gov.bc.ca/tasb/slrp/plan50.html & https://www.for.gov.bc.ca/tasb/slrp/pdf/lrmp/Kootenay%20Boundary%20Land%20Use%20Plan%20Implementation%20Strategy.pdf (10_08_2017)
SFMP	CSA/FSC – Sustainable Forest Management Plan	This Sustainable Forest Management Plan was produced to achieve Canadian Standards Association (CSA) certification to the CSA Z809-08 standard as well as Forest Stewardship Council Certification to the FSC-BC Oct. 2005 standard	http://www.canfor.com/docs/default-source/responsibility/sfmp-final-dec_2017.pdf?sfvrsn=e17feb91_2 (30_07_2018)
FSP	Forest Stewardship Plan	A Forest Stewardship Plan shows areas on a map where a forest licensee may carry out forest development activities over a period of up to five years. The areas included in the FSP are called Forest Development Units. The plan also states the results, strategies or measures that the forest licensee will achieve in order to be consistent with government objectives for forest values.	Copies of the FSP can be made available upon request

2.1.1 Proposed Harvest Rates

For the period of MP #10, the requested harvest rate is 180,000 m^3 on TFL 14. The Chief Forester will set the AAC and this section will be updated to reflect that determination.

2.1.2 Rationale for Recommending AAC

The rationale for the requested MP #10 AAC of 180,000 m^3 is documented in detail in the Timber Supply Analysis Report, dated for reference June 21, 2018.

3 CONSULTATION WITH OTHER RESOURCE USERS

All licensed resource users and known public user groups with an interest in TFL 14 were sent a letter notifying them when the plan will be available for review and comment. All correspondence, comments, and responses are copied into Appendix VIII.

A sample letter and a full list of referral groups and individual tenure holders are provided in Section 5.

4 Key DIFFERENCES BETWEEN MP 9 AND MP 10

Key differences between MP #9 and MP #10 include (see Analysis Report for further details, Appendix IX):

- FSC certification is now a part of the current management practices
- Growing stock: the initial growing is approximately 12% lower than MP #9's
- The current THLB is 1% smaller than the FSC Option scenario in MP #9.
- Vegetation Resource Inventory data has been updated and has incorporated LiDAR height information
- Non-recoverable losses are 3,500 m^3/year greater than in MP #9.
- Partial retention VQOs are highly constraining in this analysis unlike in MP #9 where they were modelled as a partial cutting regime
- MP #9 analysis modelled disturbance of the non-THLB while the current analysis does not
- MP #9 added a 30% operational adjustment factor (OAF 2) for Armillaria to Fd leading stands in the ICH while the current analysis applied 10.8%
- Old seral targets in low biodiversity emphasis areas had 1/3 of the required target met in the first rotation, 2/3 in the second rotation, and full target on the third rotation as prescribed in Canfor's Sustainable Forest Management Plan (SFMP). MP #9 modelled full seral targets starting in the first year of the modelling period
- MP#9 used Forest Planning Studio (FPS), where MP#10 used the Patchworks model system

5 PUBLIC REVIEW

AGENCY AND PUBLIC REVIEW

This section includes the Public Review Strategy which includes sample referral letters and copies of advertisements, referrals and responses from the management planning process.

SUMMARY OF COMMENTS RECEIVED

Only one letter was received during the review opportunities. The following table summarizes the comments and questions received.

Table 3. – Public and First Nation Comments Received

Draft Data Package Review in 2017	
Comment Provider	**Comment(s) / Question(s) Summary**
Toby Creek Adventures c/o Scott Barsby	Canfor received a request for a hard copy of the Data package which was provided. No further questions or input were received.
CMH Heli-skiing c/o Dave Butler	No specific input regarding Data Package. One comment made about the operational planning completed between Canfor and CMH not having any timber supply impacts. No further questions or input were received.
Kootenay Rockies ATV club c/o Ken Gauthier	Meeting held on June 5th, 2017 (hard copy of Data Package provided). No specific concerns or comments provided. No further questions or input were received.
Akisqnuk First Nation c/o Adrian Bergles	Canfor received a request for a hard copy of the Data package which was provided (June 6th, 2017). No further questions or input were received.

Draft Management Plan / Timber Supply Analysis Review in 2018	
Comment Provider	**Comment(s) / Question(s) Summary**
To be Completed prior to Final Submission	

Summary of Revisions in Response to Comments Received

The comments received from the public and First Nations review of the Data Package or Management Plan did not necessitate any revisions to either document.

Public Review Strategy

Tree Farm Licence 14 – Management Plan 10

As part of the preparation of Management Plan 10 (MP 10) for Tree Farm Licence 14 (TFL 14), this strategy has been developed to address legislation and policy requirements for the stakeholder and public review and involvement in the preparation of MP 10.

The public review strategy of MP 10 will be completed in accordance with the actions and approximate timelines in the following table (Table 1).

Table 1 - Public Review Timelines

Step #	Action	Approximate Date(s)
1	Canfor submits review strategy (this document) to RED	September, 2016
2	RED approves review strategy	October, 2016
3	Canfor submits, refers and advertises for review a draft Info Package (IP)	March, 2017
4	Review period occurs over 60 days	April – May, 2017
5	Canfor considers any comments received and submits a final IP	June, 2017
6	IP accepted by FAIB	July, 2017
7	Canfor submits, refers and advertises for review the draft Management Plan (MP), including the timber supply analysis	September, 2017
8	Review period occurs over 60 days	October- November, 2017
9	Canfor considers any comments received and submits a final MP	December, 2017
10	Chief Forester approves the MP and determines the AAC	March, 2018

Advertisements

In March 2017, the attached advertisement (Appendix A) will appear twice in the Kootenay Advertiser, Columbia Valley Pioneer and the Golden Star Newspapers, to inform the public that the Info Package will be available for review at the local Canfor and Ministry of Forests, Lands and Natural Resource Operations offices, as well as on Canfor's public website.

This same process will be initiated in September 2017 with regard to the draft MP10, with the advertisement as per Appendix B.

First Nations Referrals

The attached letter (Appendix C) will be sent to First Nations as per Table 2 below:

Table 2 – First Nations Contacts

First Nation	Phone/Fax	Chief	Main Contact
Adams Lake Indian Band P.O. Box 588 6453 Hillcrest Road Chase, BC V0E 1M0	Ph: 250-679-8841 Fax: 250-679-8813	Robin Billy	Referrals: administrator@@alib.ca
Ktunaxa Nation 7468 Mission Rd, Cranbrook, BC V1C 7E5	Ph: 250-417-4022	Kathryn Teneese (Chair)	Referrals: Kerri Garner, Danielle Gravelle referrals@ktunaxa.org
Neskonlith Indian Band 461 1st Nations Road Salmon Arm, BC V1E 2Z6	Ph: 250-679-3295 Fax: 250-679-5306	Judy Wilson	Referrals: referrels@neskonlith.net
Shuswap Band RR#2 – 3A, 492 Arrow Rd Invermere, BC V0A 1K2	Ph: 250-341-3678 Fax: 250-341-3683	Barbara Cote	Referrals: Sierra Stump info@shuswapband.net

NOTE: the above represents Bands with Traditional Territory within or directly adjacent to TFL14.

Agency and Stakeholder Notification Letters

The attached letter (Appendix D) will be distributed to those identified in the agency (Table 3) and stakeholder contact lists (Table 4). Agency contacts will be sent the documents and maps; the Rocky Mountain Resource District, Cranbrook office, will also be provided with a paper copy. All other stakeholders will be directed to a website or to view a paper copy at either Canfor or the District office.

Table 3 – Agency Contacts

Ministry of Forests, Lands and Natural Resource Operations	Forest Analysis and Inventory Branch	Jim Brown, Lee Zhu
Ministry of Forests, Lands and Natural Resource Operations	Rocky Mountain Resource District	Scott Hicks, Rick Fraser

Table 4 – Stakeholder Contacts

Group	Contact Name	Email/Mailing Address	Comments
Range	Rick Tegart	rktegart@telus.net	Lower Spillimacheen- N & S pastures
	Peter Mason	Box 100, Parson, BC V0A1L0	TFL 14/Woodlot 446
BC Parks	Brett Yates	Brett.Yeates@gov.bc.ca	EK North
Guides	Tom Kotlarz	silentmtn@gmail.com	TFL 14
Recreation	Ken Gauthier	k.gauthier@telus.net	Kootenay Rockies ATV club
	Mark Starr	sledradium@gmail.com	Windermere Snowmobile Society
	Doug Latimer	rd@purcellmountainlodge.com	Purcell Mountain Lodge
	Herb Jenzen	hgjanzen@yahoo.ca	Kootenay Horsemen
	Aaron Bernosconi	info@goldensnowmobilerentals.com	Golden Snowmobile club
	Russ Hendry	russ.hendry@gmail.com	Columbia Huts Association
	Roy and Dorrie	roycedev@telus.net	Columbia Sno Drifters Society-Snowmobilers
	Scott Barsby	scott@tobycreekadventures.com	Toby Creek Adventures
	Barrie Hawes/Doug Yukes	summittrailmakers@gmail.com	Recreation Trails Trails
	Carl Trescher	ctrescher@cmhinc.com	Canadian Mountain Holidays
	Dave Butler	dbutler@cmhinc.com	Canadian Mountain Holidays
Mining	Brian Kostiuk	ekcm3@shaw.ca	Chamber of Mines
	Ross Stanfield	Ross@ekcm.org	Prospectors
	Fiona Katay	Fiona.Katay@gov.bc.ca	Ministry of Energy and Mines
Trappers	Bob Ferris	melbooks@telus.net	President EKTA
	Gilles Rondeau	Gillesmr@davincibb.net	Vowell
	Jeff Baltrus	kbuilder@shaw.ca	TFL 14
Municipalities/RDEK/CSRD	Mark Read	mark.read@radiumhotsprings.ca	Radium
	Rory Hromadnik	planning@invermere.net	Inveremere
	Gerry Wilkie	gdwilkie@cyberlink.bc.ca	RDEK Area G
	Karen Cathcart	kcathcart@csrd.bc.ca	CSRD Area A
NGO	Joan Delinsky	joandolinsky@gmail.com	Wildsight- Golden
	Baiba Morrow	baiba@patmorrow.com	Wildsight-Invermere
Hunting	Jeff Berdusko	jeffberdusco@hotmail.com	East Kootenay Wildlife Association
	Rick Hoar	info@lwdrodgun.com	Lake Windermere Rod and Gun Club
	Grant Arlt	gjarlt@telus.net	Golden District Rod and Gun Club
Private Land	Axel Schmidt	2531, 19th St. SW, Calgary, AB T2T4X4	Billy Goat Domestic Watershed
	Lil & Bob Cacaci	Box 1442, Parson, BC V0A1L0	Billy Goat Domestic Watershed
	Infinity & Rhonda Smith	Box 75, Parson, BC V0A1L0	Billy Goat Domestic Watershed
	William Hamilton	b_hamilton@shaw.ca	Casals Creek Domestic Watershed

Public Review Summary

Canfor will reply in writing to each person who took the opportunity to comment on MP 10.

As input is received by Canfor, this correspondence will be shared with MFLNRO staff. To ensure information is shared at regular intervals, conference calls will be held between Canfor and applicable MFLNRO staff on a biweekly basis during the comment and review periods.

A public review summary report will be included in the final Management Plan 10 document, noting the following:

- Name
- Organization (if applicable)
- Medium and date of communication
- Comments and follow-up
- Actions taken to accommodate
- Outstanding concerns

APPENDIX A
NEWSPAPER ADVERTISEMENT – INFO PACKAGE

CANADIAN FOREST PRODUCTS LTD.

Draft Timber Supply Analysis Information Package
Tree Farm Licence 14 Management Plan 10

Notice is hereby given, under section 6 (1) of the *Tree Farm Licence Management Plan Regulation*, that Canadian Forest Products Ltd. (Canfor) is seeking public review and comment on the Draft Timber Supply Analysis Information Package, relating to Management Plan 10 (MP 10) for Tree Farm Licence 14 (TFL 14). MP 10 is being prepared in order to meet the requirements of the *Tree Farm Licence Management Plan Regulation*. This regulation includes content requirements, submission timing and public review requirements for TFL Management Plans. These content requirements replace the Management Plan content requirements previously listed in the Tree Farm Licence document and reduce duplication with associated Forest Stewardship Plan results and strategies.

The Management Plan consists of a summary of the TFL along with the Timber Supply Review Analysis report and Data Package with a reference to the other guiding legislation (i.e Forest Stewardship Plans, Sustainable Forest Management Plans and other Higher Level Plans). This information is provided to the Ministry of Forests, Lands and Natural Resource Operations to set a new Annual Allowable Cut for the TFL.

All interested parties are invited to view and comment on the Draft Timber Supply Analysis Information Package for MP 10, from ___________, 2017 through to _______________, 2017. Viewing appointments can be arranged by calling our office at (250) 426-9252, or by visiting http://www.canfor.com/responsibility/environmental/plans . Comments will be accepted until 4:00 pm ____________, 2017.

For further information, please contact:

Grant Neville, RPF
Planning Coordinator,
Canadian Forest Products Ltd.
Forest Management Group,
1000, Industrial Rd. #1,
Cranbrook, BC V1C 4C6

APPENDIX B
NEWSPAPER ADVERTISEMENT – DRAFT MP10

CANADIAN FOREST PRODUCTS LTD.

Draft - Tree Farm Licence 14 Management Plan 10

Notice is hereby given, under section 6 (1) of the *Tree Farm Licence Management Plan Regulation*, that Canadian Forest Products Ltd. (Canfor) is seeking public review and comment on Draft Management Plan 10 (MP 10) for Tree Farm Licence 14 (TFL 14). MP 10 is being prepared in order to meet the requirements of the *Tree Farm Licence Management Plan Regulation*. This regulation includes content requirements, submission timing and public review requirements for TFL Management Plans. These content requirements replace the Management Plan content requirements previously listed in the Tree Farm Licence document and reduce duplication with associated Forest Stewardship Plan results and strategies.

The Management Plan consists of a summary of the TFL along with the Timber Supply Review Analysis report and Data Package with a reference to the other guiding legislation (i.e Forest Stewardship Plans, Sustainable Forest Management Plans and other Higher Level Plans). This information is provided to the Ministry of Forests, Lands and Natural Resource Operations to set a new Annual Allowable Cut for the TFL.

All interested parties are invited to view and comment on MP 10, from month day, year through to month day, year. Viewing appointments can be arranged by calling our office at (250) 426-9252, or by visiting http://www.canfor.com/responsibility/environmental/plans. Comments will be accepted until 4:00 pm month day, year.

For further information, please contact:

Grant Neville, RPF
Planning Coordinator,
Canadian Forest Products Ltd.
Forest Management Group,
1000, Industrial Rd. #1,
Cranbrook, BC V1C 4C6

APPENDIX C
FIRST NATIONS REFERRAL LETTER

<insert date>
Chief >>>
First Nation>>>

Address>>>

RE: Draft Management Plan 10 for TFL 14 Available for Review and Comment

Dear Chief>>>:

Canadian Forest Products has prepared a Draft Management Plan (MP 10) for TFL 14. The Management Plan is a legislative requirement as well as a requirement of the TFL Agreement with the Provincial Government. The Management Plan consists of a summary of the TFL along with the Timber Supply Review Analysis report and Data Package with a reference to the other guiding legislation (i.e Forest Stewardship Plans, Sustainable Forest Management Plans and other Higher Level Plans). This information is provided to the Ministry of Forests, Lands and Natural Resource Operations to set a new Annual Allowable Cut for the TFL.

Tree Farm License #14 (TFL 14 or the TFL) covers approximately 150,000 hectares in the south-eastern corner of British Columbia situated between the height of land of the Purcell Mountains, to the west, and the Columbia River valley, also known as the Rocky Mountain Trench, to the east. TFL 14 is bounded by the Invermere TSA to the south and east, the Golden TSA to the north, and the Kootenay Lake TSA to the west. It also borders three protected areas (Glacier National Park, Bugaboo Alpine Recreation Area, and the Columbia Wetlands Wildlife Management Area).

Canadian Forest Products Ltd. requests that the <insert band name> review and provide comments on MP 10 by xx date, a copy of which is enclosed on CD. A paper copy of MP 10 and all maps will be provided at your request.

To facilitate information sharing between Canfor and the <insert band name>, we are interested in meeting to discuss MP 10. Given the fiduciary responsibility of the Crown to First Nations, Canfor will be requesting the Ministry of Forests, Lands and Natural Resource Operations to coordinate any such meeting. If you are interested in participating in a meeting, please contact Grant Neville, Planning Forester, at (250) 426-9252.

Sincerely,

Grant Neville, RPF
Planning Coordinator,
Canadian Forest Products Ltd.
Forest Management Group,
1000, Industrial Rd. #1,
Cranbrook, BC V1C 4C6
Encls.
Draft Management Plan 10 for TFL14, including maps (CD)
cc: Rick Fraser, Ministry of Forest Lands and Natural Resource Operations

APPENDIX D
STAKEHOLDER REFERRAL LETTER

<insert date>

Name>>>
Address>>>

RE: Draft Management Plan 10 for TFL 14 Available for Review and Comment

Dear Sir or Madam:

Canadian Forest Products has prepared a Draft Management Plan (MP 10) for TFL 14. The Management Plan is a legislative requirement as well as a requirement of our TFL Agreement with the Provincial Government. The Management Plan consists of a summary of the TFL along with the Timber Supply Review Analysis report and Data Package with a reference to the other guiding legislation (i.e Forest Stewardship Plans, Sustainable Forest Management Plans and other Higher Level Plans). This information is provided to the Ministry of Forests, Lands and Natural Resource Operations to set a new Annual Allowable Cut for the TFL.

Tree Farm License #14 (TFL 14 or the TFL) covers approximately 150,000 hectares in the south-eastern corner of British Columbia situated between the height of land of the Purcell Mountains, to the west, and the Columbia River valley, also known as the Rocky Mountain Trench, to the east. TFL 14 is bounded by the Invermere TSA to the south and east, the Golden TSA to the north, and the Kootenay Lake TSA to the west. It also borders three protected areas (Glacier National Park, Bugaboo Alpine Recreation Area, and the Columbia Wetlands Wildlife Management Area).

We are seeking public input on MP 10, which will be available for review and comment from 9 am to 3 pm from <insert dates> at the Canfor office, located at 1000, Industrial Rd. #1, Cranbrook. Alternatively, MP 10 is available for viewing on Canfor's website at http://www.canfor.com/responsibility/environmental/plans, or at the Ministry of Forests, Lands and Natural Resource Operations Rocky Mountain Resource District office, located at 1902 Theatre Rd, Cranbrook.

If you are unable to view the proposed plan at the above times or locations, please contact us at (250) 426-9252 to make alternative arrangements.

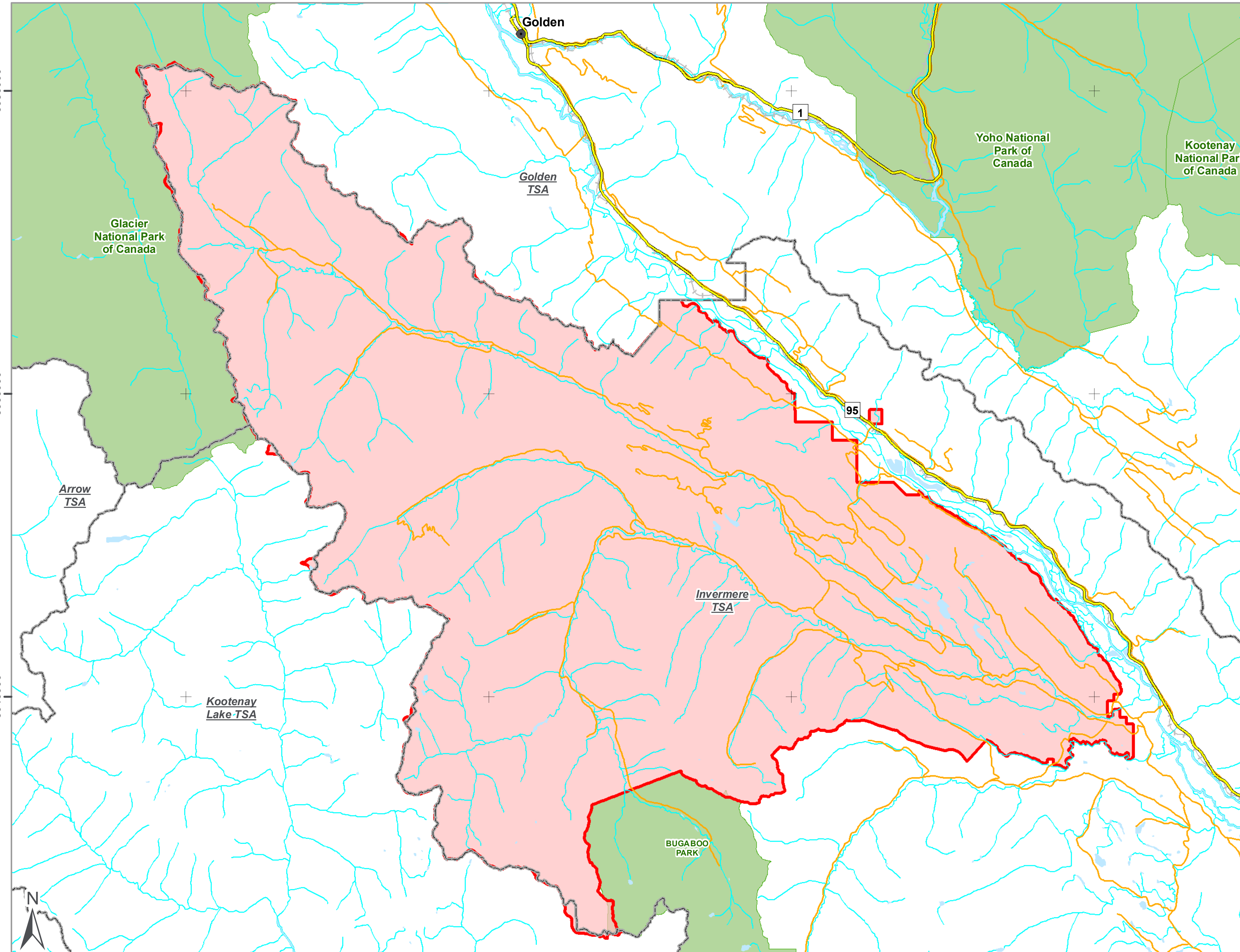
Sincerely,

Grant Neville, RPF
Planning Coordinator,
Canadian Forest Products Ltd.
Forest Management Group,
1000, Industrial Rd. #1,
Cranbrook, BC V1C 4C6

6 APPENDICES

Appendix I	Description of TFL 14 Boundary
Appendix II	Old Growth Management Areas for TFL 14
Appendix III	UWR/Caribou
Appendix IV	Visual Inventory
Appendix V	Terrain Mapping Overview
Appendix VI	Watersheds
Appendix VII	Wetland WMA's
Appendix VIII	Copy of Referral Comment Submission
Appendix IX	Copies of Information Package, Analysis

APPENDIX I: TFL 14 BOUNDARY

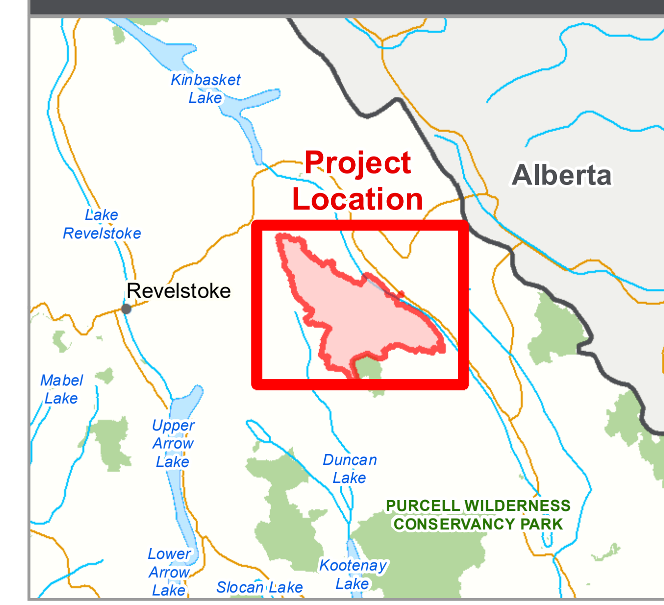


TREE FARM LICENSE 14 OVERVIEW MAP

Legend

- Streams
- Roads
- TFL Boundary
- Parks and Protected Areas
- TSA Boundaries

LOCATION MAP



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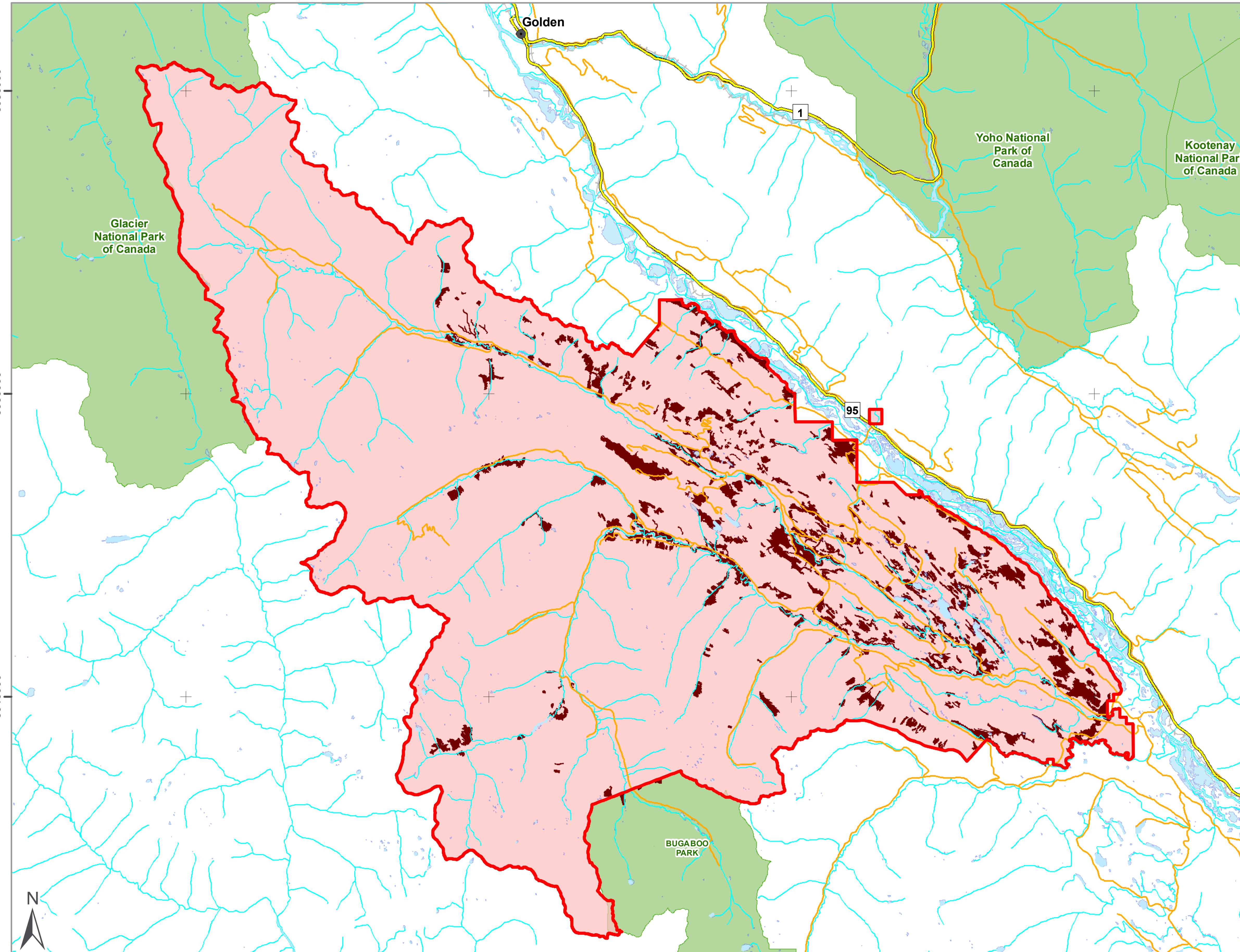
Project No.: FG-16-500
Date: 2018/07/04
Client: Canfor
Drawn: DET Check: LR

NAD 1983 UTM Zone 11N

APPENDIX II: Old Growth Management Areas for TFL 14

TREE FARM LICENSE 14 OLD GROWTH MANAGEMENT AREAS



Legend

- Streams
- Roads
- Old Growth Management Areas
- TFL Boundary
- Parks and Protected Areas

LOCATION MAP

1:260,000

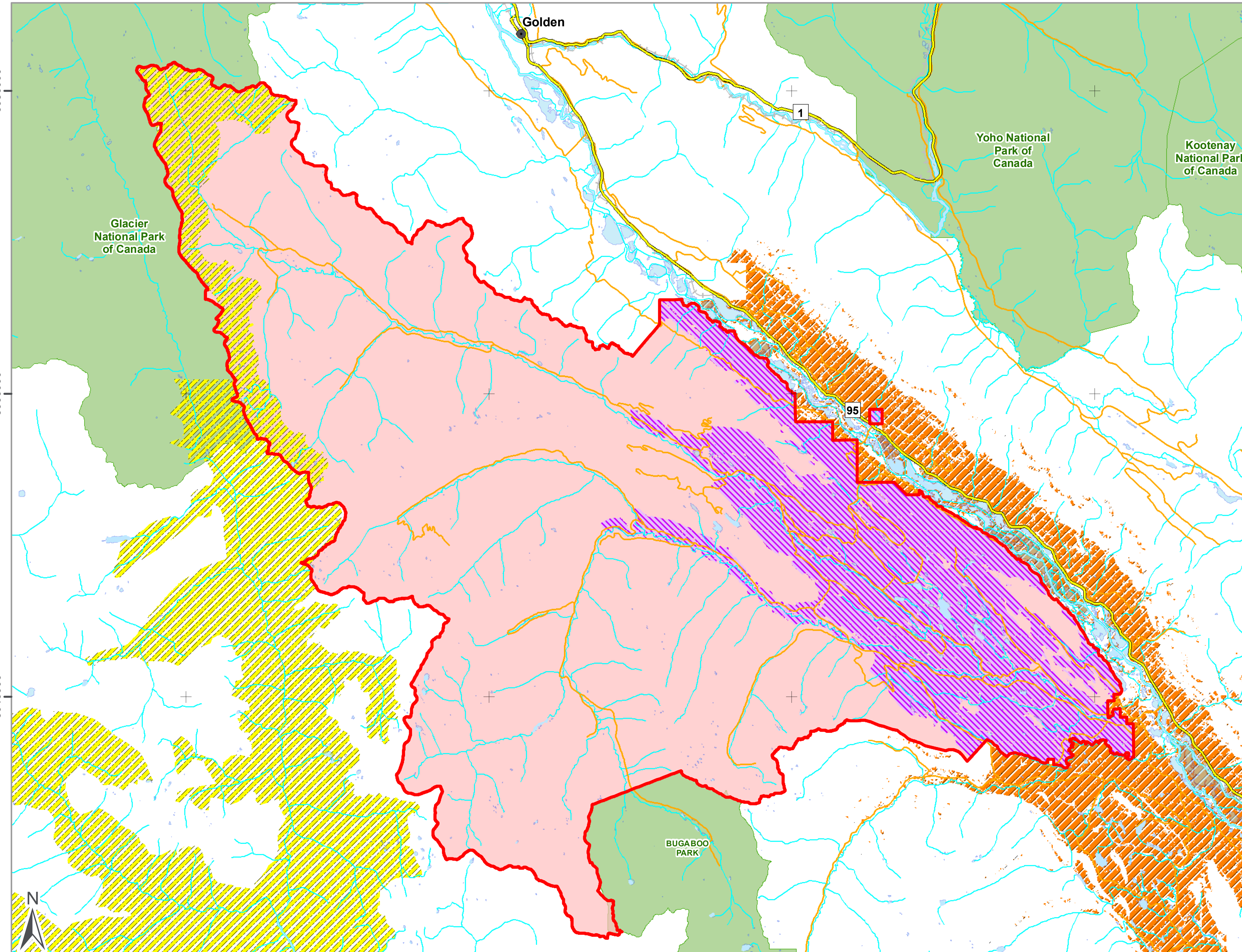
0 5 10 15 KM

Project No.: FG-16-500
Client: Canfor
Date: 2018/07/04
Drawn: DET Check: LR

NAD 1983 UTM Zone 11N

APPENDIX III: Ungulate Winter Range / Caribou

ecora



TREE FARM LICENSE 14 UNGULATE WINTER RANGE

Legend

- Streams
- Roads
- u-4-014
- u-4-008
- u-4-008 Non-Legal
- TFL Boundary
- Parks and Protected Areas

LOCATION MAP

1:260,000

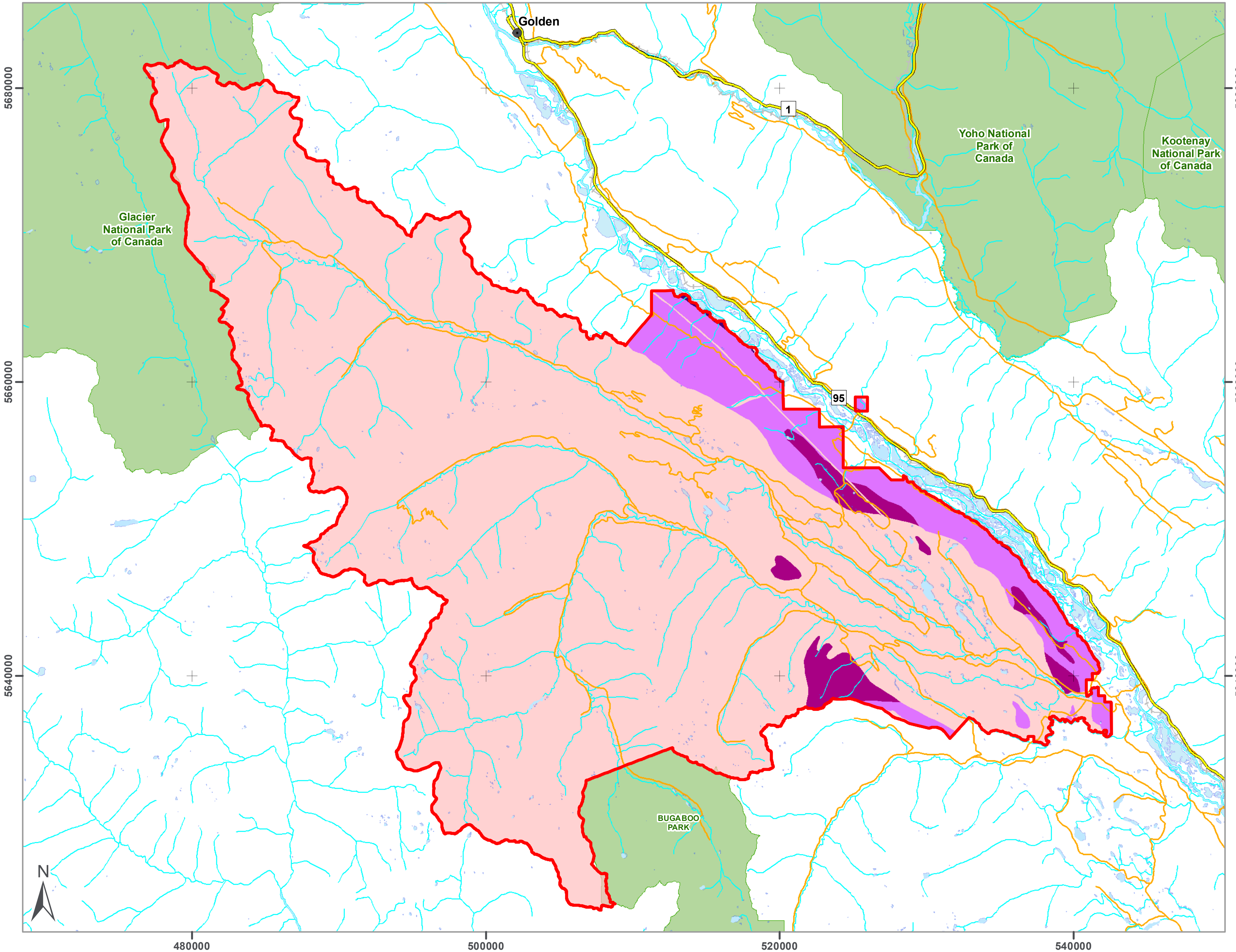
0 5 10 15 KM

Project No.: FG-16-500
Date: 2018/07/04
Client: Canfor
Drawn: DET Check: LR

NAD 1983 UTM Zone 11N

APPENDIX IV: Visual Inventory

TREE FARM LICENSE 14
VISUAL QUALITY OBJECTIVES



Legend

- Streams
- Roads
- Modification
- Preservation
- Partial Retention
- TFL Boundary
- Parks and Protected Areas

LOCATION MAP

1:260,000

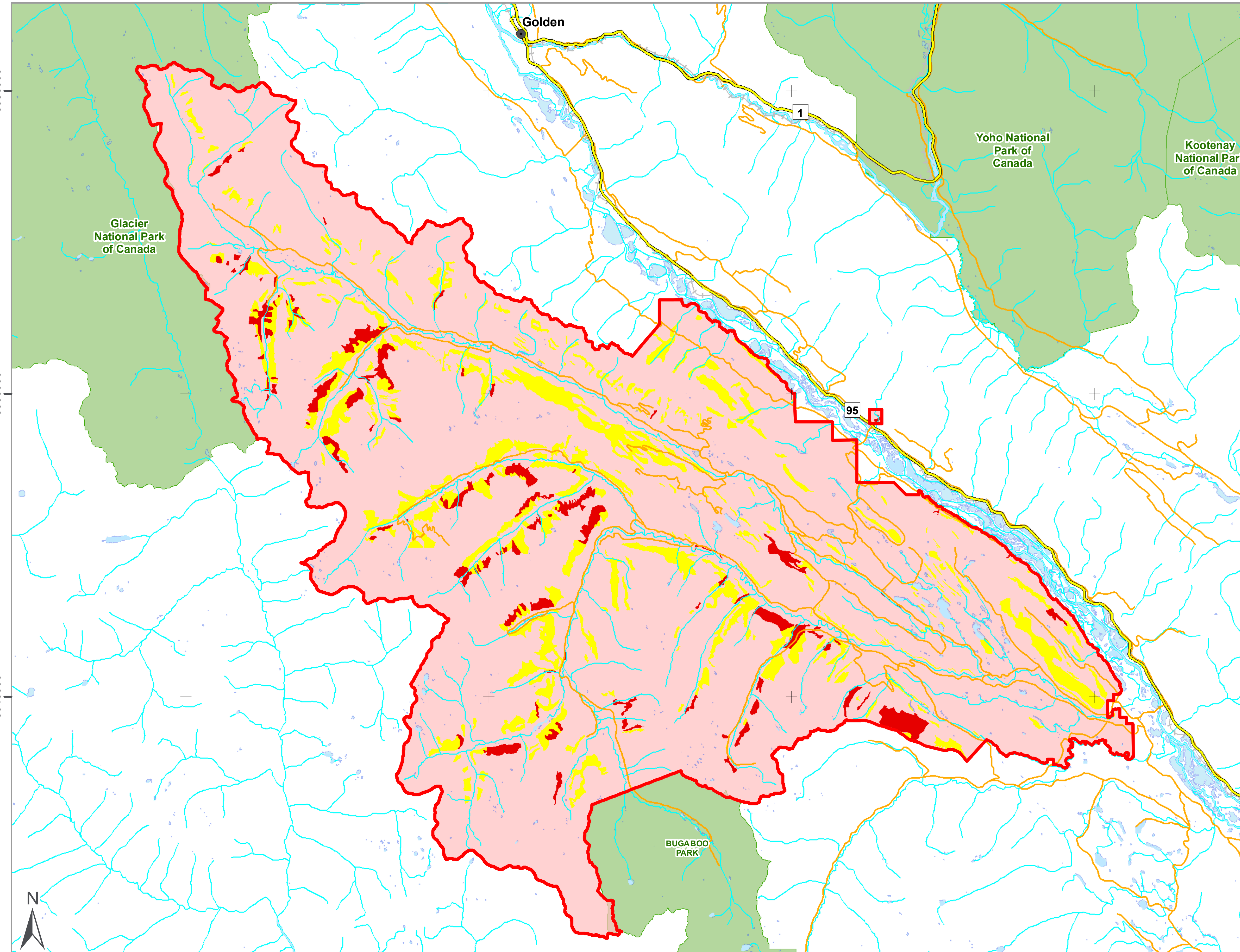
0 5 10 15 KM

Project No.: FG-16-500
Client: Canfor
Date: 2018/07/04
Drawn: DET Check: LR

NAD 1983 UTM Zone 11N

APPENDIX V: Terrain Mapping Overview

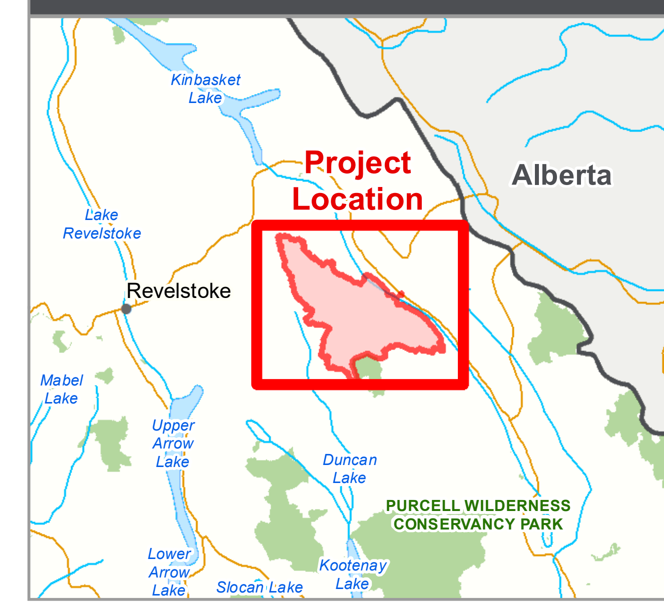
TREE FARM LICENSE 14 TERRAIN STABILITY



Legend

- Streams
- Roads
- Potentially Unstable
- Unstable
- TFL Boundary
- Parks and Protected Areas

LOCATION MAP



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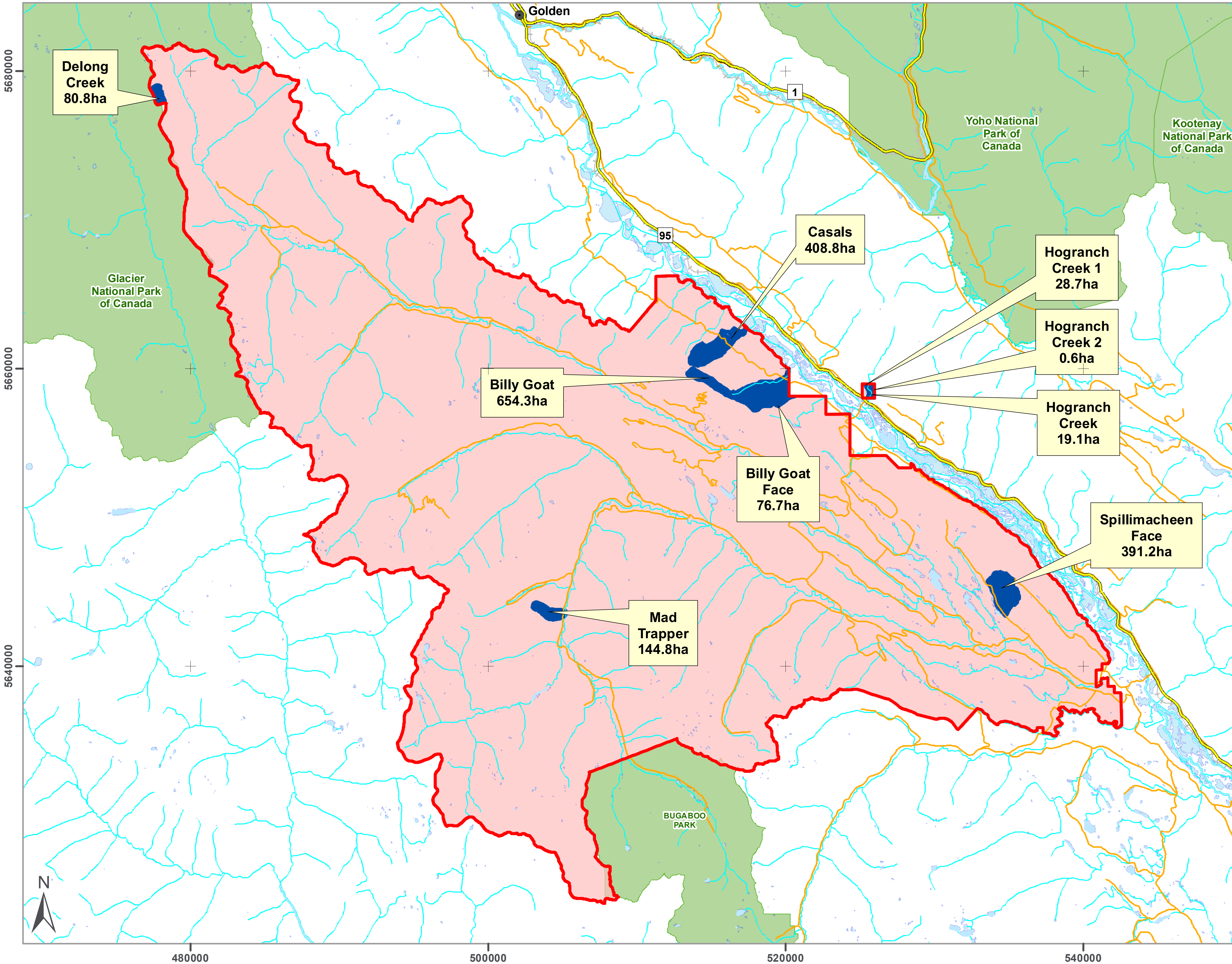
Project No.: FG-16-500
Date: 2018/07/04
Client: Canfor
Drawn: DET Check: LR

NAD 1983 UTM Zone 11N

APPENDIX VI: Watersheds Overview

TREE FARM LICENSE 14 DOMESTIC WATERSHEDS



Legend

- Streams
- Roads
- Domestic Watersheds
- TFL Boundary
- Parks and Protected Areas

LOCATION MAP

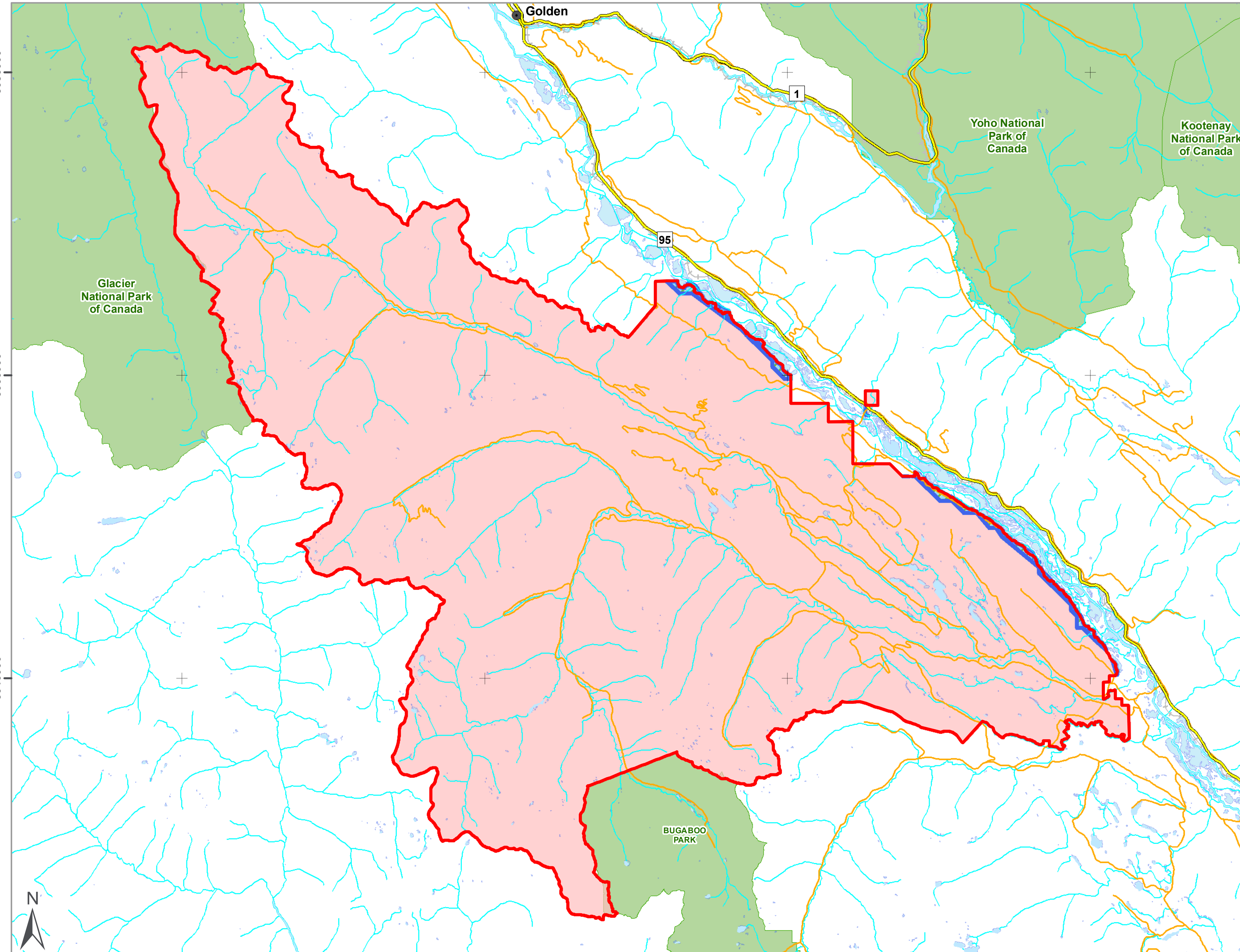
1:260,000

0 5 10 15 KM

Project No.: FG-16-500
Date: 2018/07/04
Client: Canfor
Drawn: DET Check: LR

NAD 1983 UTM Zone 11N

APPENDIX VII: Wetland Wildlife Management Areas

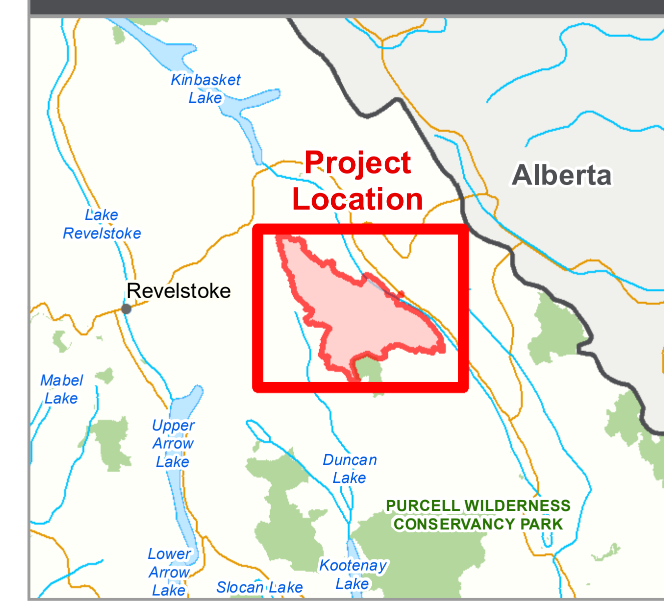


TREE FARM LICENSE 14
COLUMBIA WETLAND WMA'S

Legend

- Streams
- Roads
- Columbia Wetland WMA's
- TFL Boundary
- Parks and Protected Areas

LOCATION MAP



1:260,000

0 5 10 15 KM

Project No.: FG-16-500
Client: Canfor
Date: 2018/07/04
Drawn: DET Check: LR

NAD 1983 UTM Zone 11N

APPENDIX VIII: Copy of Referral Comments and Responses

TO BE COMPLETED PRIOR TO FINAL SUBMISSION

APPENDIX IX: Copies of Information Package, and Analysis Report

ecora
a resourceful company

Tree Farm Licence 14 Management Plan # 10 Timber Supply Analysis Updated Data Package

Presented To: **Canadian Forest Products Ltd**
Attention: Grant Neville, RPF
1000 Industrial Rd #1
Cranbrook, BC V1C 4C6

CANFOR

Dated:	November 2017
ECORA File No.:	FG-16-500-CFP
Version:	4

OQM | Organizational Quality Management Program

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OQM | Organizational Quality Management Program

Version Control and Revision History

Version	Date	Prepared By	Reviewed By	Notes/Revisions
1	24-Nov-2016	Liza Rodrigues	Jay Greenfield	Initial draft to Canfor
2	29-Nov-2016	Liza Rodrigues	Jay Greenfield	Draft for review at kick-off meeting
3	15-May-2017	Liza Rodrigues	Jay Greenfield	Version for review prior to public review
3.1	17-May-2017	Liza Rodrigues	Jay Greenfield	Version for Public Review
4	24-Nov-2017	Liza Rodrigues	Jay Greenfield	Updated Data Package post Public Review

Limitations of Report

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Acronyms and Abbreviations

AAC	Allowable Annual Cut
AOA	Archaeological Overview
AIA	Archaeological Impact Assessments
BEC	Biogeoclimatic Ecosystem Classification
BEO	Biodiversity Emphasis Options
CP	Cutting Permit
DRA	Digital Road Atlas
ECA	Equivalent Clear-cut Area
ERDV	Enhanced Resource Development Zone
FPPR	Forest Planning and Practices Regulation
FRPA	Forest and Range Practices Act
FSC	Forest Stewardship Council
GAR	Government Action Regulation
HA	Hectares
HVCF	High Value Conservation Forest
IRM	Integrated Resource Management Zone
KBHLPO	Kootenay-Boundary Higher Level Plan Order
KBLRMP	Kootenay Boundary Land and Resource Management Plan
LU	Landscape Unit
LUO	Land Use Orders
LRDW	Land Resource Data Warehouse
MFLNRO	Ministry of Forests Lands and Natural Resource Operations
MHA	Minimum Harvest Age
MHV	Minimum Harvest Volume
MP	Management Plan
MPB	Mountain Pine Beetle
MOE	Ministry of Environment
MOF	Ministry of Forests
NRL	Non-Recoverable Loss
OAF	Operational Adjustment factor
PEM	Predictive Ecosystem Mapping
PFLB	Productive Forest Land base
RMZ	Riparian Management Zone
RRZ	Riparian Reserve Zone
RTL	Roads, Trails and Landings
UWR	Ungulate Winter Range
SIBEC	Site Index by BEC
SFMP	Sustainable Forest Management Plan
SPAR	Seed Planning and Registry Application
SPH	Stems Per Hectare
TEM	Terrestrial Ecosystem Map
TFL	Tree Farm License
THLB	Timber Harvesting Land base
TIPSY	Table Interpolation for Stand Yields
TSR	Timber Supply Review
TSA	Timber Supply Area
VAC	Visual Absorption Capacity
VEG	Visually Effective Green–Up
VLI	Visual Landscape Inventory
VQO	Visual Quality Objective
VRI	Vegetation Resource Inventory
VDYP	Variable Density Yield Projection
WTP	Wildlife Tree Patch

1. Introduction

The timber supply analysis in support of Management Plan #9 (MP #9) for Tree Farm Licence #14 (TFL 14) was completed in 2007, followed by the allowable annual cut (AAC) determination that became effective April 7th, 2008 and set the AAC at 180,000 m^3/year.

Canfor is currently preparing Management Plan #10 (MP #10) for TFL 14. As part of the management plan process, Canfor is responsible for preparing a timber supply analysis showing the long-term, strategic timber supply for the land base. Since 2004, TFL 14 has been managed in accordance with Forest Stewardship Council (FSC) standards and will continue to maintain its FSC certification. Accordingly, this data package reflects the management assumptions associated with FSC certification and these assumptions will form the base case for this analysis. This data package documents the procedures, assumptions, and data used in the analysis. Ecora Engineering & Resource Group has been engaged to prepare the data package and conduct the timber supply analysis on behalf of Canfor.

In addition to FSC, this data package is prepared in accordance with the Kootenay Boundary Land and Resource Management Plan (KBLRMP), Kootenay-Boundary Higher Level Plan Order (KBHLPO) and subsequent land use orders (LUOs) for the plan area. The assumptions used in this data package will guide the development of the timber supply analysis, which will include sensitivity analyses, alternative harvest flows, and management options to test the influence of various factors on the harvest level.

2. Land Base Information and Data Sources

2.1 Data Sources

Table 2-1 lists the spatial data sources for this analysis. Data is sourced from internal Canfor layers, standard provincial data from the Land Resource Data Warehouse (LRDW) or from the Ministry of Forests Lands and Natural Resource Operations (MFLNRO). Layers indicated as 'Ecora' are calculated from other inputs, and are discussed in the relevant sections below.

Table 2-1: Data Sources

Description	Layer Name	Source	Vintage
Avalanche Path Habitat Inventory	tfl_avb	Canfor	Pre-2007
BC Fires	Whse_land_and_natural_resource_prot_historical_fire_polys	LRDW	2016
Biogeoclimatic Zone v6	BEC_version6	Canfor	Pre-2007
Canfor Blocks	Kootenay_block	Canfor	2016
Classified Streams	tfl14_str (line)	Canfor	2014
Columbia Wetlands	WILDLIFE_MGMT_AREAS_SVW	LRDW	2016
Community Watersheds	water_management_wls_community_ws_pub_svw	LRDW	2016
Consolidated Cut Blocks	Forest_vegetation_veg_consildated_cut_blocks	LRDW	2016
Crown Tenures	Tantalis_ta_crown_tenures_svw	LRDW	2016
Domestic Watershed	Dom_water_kbhlpo	Canfor	Pre-2007
Endangered Forest (EF)	Hcvf_ef	Canfor	2014
Environmentally Sensitive Areas	t14_thm	Canfor	Pre-2007
Forest Tenure Cut Blocks	ften_cb_pl	LRDW	2016
High Conservation Value Forest (HCVF)	Hcvf_ef	Canfor	2014
Landscape Units	Landscape_units_tfl14	Canfor	Pre-2007
Merchantability Classes	Tfl_mrch	Canfor	Pre-2007
Old Growth Management Areas	tfl_ogma	Canfor	2014
Operability	Operability	Canfor	Pre-2007
Operating Areas	Wim_operating_area_kootenays	Canfor	2016
Ownership	F_OWN	LRDW	2016
Parks and Protected Areas - Bugaboo	tantalis_ta_park_ecores_pa_svw	LRDW	2016
Permanent Sample Plots	Forest_vegetation_gry_psp_status_all	LRDW	2016
Planning Cells	Wim_planning_cells	Canfor	2016
Private Land - ICIS	Private_land_ICIS	Canfor	2014
Proposed Roads	prop_rd	Ecora	2017
Rare Ecosystems	t14_rar	Canfor	2014

Description	Layer Name	Source	Vintage
Recreational Areas	ften_recreation_poly_svw	LRDW	2016
Resource Management Plan	Rmp_plan_non_legal_poly_svw	LRDW	2016
Right of Way	ROW	Canfor	2016
Riparian Buffers FRPA	FPC_BUFF	Canfor	2014
Riparian Buffers FSC	T14_rib	Canfor	2014
Road Network	Kootenay_ff_roads	Canfor	2016
Slope Classes	Slp_cls	Ecora	2017
Terrain Stability	terrain_stability_kootenays	Canfor	Pre-2007
Terrestrial Ecosystem Mapping	Ste_tem_attribute_poly_svw	LRDW	1999
Tree Farm Licences	admin_boundaries_fadm_tfl	LRDW	2016
Ungulate Winter Range	Wildlife_management_wcp_ungulate_winter_range_s	LRDW	2016
Ungulate Winter Range - Habitat Types	tfl_uwr2	Forsite*	Pre-2007
Vegetation Resource Inventory	VRI_Update	Ecora	2017
Vegetation Resource Inventory - Bugaboo Park	t14_thm	Canfor	Pre-2007
Visuals	Rec_vims_vli_svw	LRDW	2016
WTP's	tfl14_reserves	Canfor	2016

* UWR habitat types were provided by Forsite Consultants as it is not a standard WHA layer.

2.1.1 Vegetation Resources Inventory

The MP #9 analysis was completed in 2007 using the 1986 version of the forest cover inventory. This inventory was updated for harvesting and fires in September 2006 and was projected to January 1st 2007. In 2013, a new vegetation resources inventory (VRI) was completed for the entire TFL. Canfor identified some concerns with the new VRI and consequently has not fully adopted the new VRI into their harvesting and planning operations. Concerns identified include:

1. Generalization of silviculture polygons, and
2. Substantial differences in polygon delineation and species composition across the entire TFL between the two forest inventories.

Ecora has undertaken a general review of the VRI and comparison with the old forest cover inventory. Through this review, it was determined that a very generalized version of the harvest history layer was incorporated into the VRI and therefore the VRI does not accurately reflect the current status of the land base in and around where harvesting has occurred. For example, the gross block boundary (including WTP and road) has been used to delineate harvested areas. The polygon label is then calculated over a very diverse area, as is shown in the example provided in Figure 2-1 below.

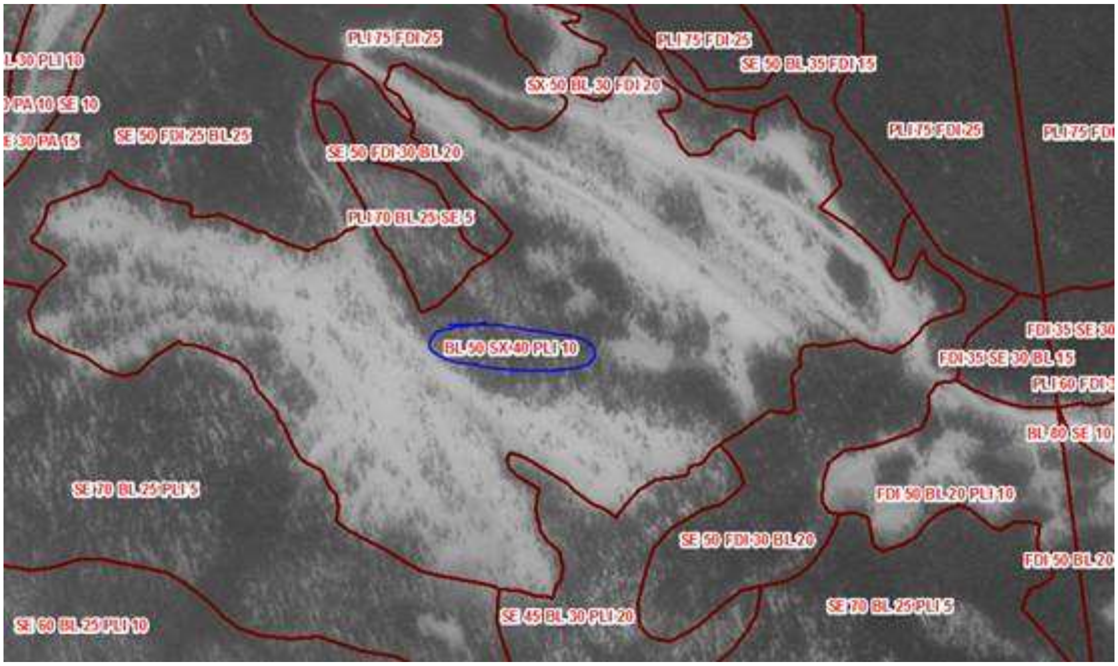

Figure 2-1: Generalized VRI Polygons

As a result of not being utilized regularly, there have been little or no updates (harvesting or natural disturbance) applied to this VRI since 2013. With a significant focus on the salvage of susceptible pine over the last five to 10 years, the overall species composition of the TFL has changed substantially.

To address the concerns with the generalization of silviculture polygons in the 2013 VRI, Canfor has contracted Ecora to update the VRI with the best available silviculture information. This update involves the following steps:

1. Add all existing silviculture line work (include WTPs and other reserves) to the VRI,
2. Reconcile polygon line work where new polygons are created,
3. Update VRI attributes wherever reliable silviculture information exists, and
4. Adjust the VRI attributes for any residual polygons affected by the silviculture data.

These updates were completed in a 3D softcopy environment using the Summit software package. Although this update will not likely fix all of the VRI issues identified, it is anticipated that it will result in a substantial improvement in the overall reliability and usability of the VRI.

Therefore the VRI used in this analysis ('VRI 2017') is a partial update of the 2013 VRI. A review of attributes and line work occurred for 12,430 ha while a reconciliation of line work was applied to 6,693 ha. There were minimal changes to the area by British Columbia Land Cover Classification Scheme (BCLCS), with movement between the 'Vegetated-Treed' and 'Vegetated-Non-treed' categories (Table 2-2). The 'VRI 2017' resulted in changes to forest age and volume. The forest is younger; with 5% more area between the ages 1 and 50 (see Table 2-3). For this reason, there is 3% more stands within the 0 to 49 m^3/ha volume class as shown in Table 2-4. VRI summaries do not include the Bugaboo Park area.

Table 2-2: BCLCS Distribution

BCLCS Level 1	BCLCS Level 2	Gross Area (ha)		Representation	
		VRI 2013	VRI 2017	VRI 2013	VRI 2017
No data		298	0	0%	0%
Non-vegetated	Land	16,193	16,150	11%	11%
	Water	1,040	1,039	1%	1%
Unknown		110	170	0%	0%
Vegetated	Non-treed	42,670	40,732	28%	27%
	Treed	91,039	93,259	60%	62%
Total		151,350	151,350	100%	100%

Table 2-3: Age Class Distribution in the Productive Forest

Age Class (yrs)	Productive Area (ha)		Difference
	VRI 2013	VRI 2017	
0	1,801	1,936	0%
1 to 50	16,111	20,796	-5%
51 to 100	21,688	21,087	1%
101 to 200	42,863	39,184	4%
> 200	10,765	10,127	1%
Total	93,228	93,130	0%

Table 2-4: Volume Class Distribution in the Productive Forest

Volume Class (m3/ha)	Productive Area (ha)		Representation	
	VRI 2013	VRI 2013	VRI 2013	VRI 2017
< 50	31,568	34,124	34%	37%
50 to 100	10,858	8,597	12%	9%
101 to 150	8,988	10,262	10%	11%
151 to 200	7,974	7,946	9%	9%
200 to 250	7,914	7,675	8%	8%
251 to 300	7,763	7,456	8%	8%
300+	18,164	17,069	19%	18%
Total	93,228	93,130	100%	100%

2.1.2 Inventory Adjustment

An inventory audit project was completed by Timberline in 2000 to assess and later to adjust, the age, height and inventory volumes used in the MP #9 analysis. According to the MP #9 Information Package, “the net effect of all adjustments was a 21% increase in merchantable volume”. These adjustments were applied to the 1986 forest cover inventory. This inventory adjustment project pre-dates formal Phase II Inventory Adjustment standards, but was approved by Government staff as part of the analysis process.

As this was not a formal Phase II Inventory Adjustment project, the original plot data was not stored in the MFLNRO corporate data base. The original inventory adjustment report contains a portion of the data as an appendix, however, this data is incomplete and does not include specific plot location information beyond the original mapsheet and polygon in which the plot was located.

It is suggested that the 2013 VRI attributes used in Variable Density Yield Projection (VDYP) 7 underestimates stand volumes for the TFL. However, attempts to locate the source data used in the adjustment have been exhausted, and there is not a complete data set available to allow for a new inventory adjustment at this time.

2.1.3 Terrestrial Ecosystem Mapping

Terrestrial ecosystem mapping (TEM) was completed in 1999 by JMJ Holdings Inc. and plays a significant role in several aspects of this analysis including:

- Facilitating the use of SIBEC site index estimates;
- Defining managed stand analysis units; and
- Identifying rare and endangered ecosystems.

Since the TEM was completed, there have been significant modifications to the provincial biogeoclimatic ecosystem classifications (BEC) and biogeoclimatic (BGC) mapping. This has resulted in inconsistencies between site series and site series map codes used in the TEM and the provincial BEC. Within the ESSFwm subzone, the 1999 TEM utilized an ecosystem classification that was not correlated to the existing BEC and hence used site series numbers of 00. We have identified 11,923 ha within the THLB with a site series of ‘00’. Apart from the ESSFwm site series 00 codes, the 00 code is generally used to describe non-forested ecosystems. However, many of the polygons attributed to ‘00’ site series have VRI attributes that meet all the minimum merchantability specifications required for inclusion in the THLB. In order to utilize SIBEC estimates associated with established BEC site series, the polygons that were coded as 00 were reattributed to the recognized site series classification. Changes to the TEM and THLB are described below and in the final analysis report.

After initial publication for public review of the data package, Ecora’s senior ecologist, Tom Braumandl examined all large polygons with site series 00 polygons within the THLB using Google Earth® and aerial imagery. In the analysis, he reclassified or confirmed site classification according to *LMH 20 parts 1 and 2 A Field Guide for Site Identification and Interpretation for the Nelson Forest Region site series interpretation* (Braumandl, 2002) and BGC mapping Version 10. Site series were assigned on the basis of slope position, aspect, inferred soil moisture regime, tree size and canopy closure features. The area analyzed covered 11,224 ha and was found primarily in the ESSFwm subzone. The forested map codes within this area included: FG: Bl-Pa-Grouseberry, FH: Bl-False Azalea-Horsetail, FP: Bl-Black Huckleberry – Red-stemmed Feathermoss, FR: Bl-White-flowered Rhodonendron-White Mountain-heather, FS: Bl-Sedge-Sphagnum and FV: Bl-Rhododendron-Black Huckleberry. For these codes, a pattern was established based on the photo interpretation of the larger polygons, so that smaller polygons and slivers could be reclassified. The logic for assigning the smaller polygons follows:

- If site series 00 and map code FV, then convert to ESSFwm/01 when on a cool aspect; or convert to ESSFwm/03 on a warm aspect;
- If site series 00 and map code FG, then convert to ESSFwm/02;
- If site series 00 and map code FH, then convert to ESSFwm/04;
- If site series 00 and map code FP, then convert to ESSFwm/01, or ESSFwm/04 if close to major creeks; and
- If site series 00 and map code FS, then convert to ESSFwm 04.

The remaining 699 ha had a non-forested map code such as AC for avalanche chute and TA for talus. Polygons larger than 1 ha were analyzed and reclassified according to the methodology described above. No patterns were established as these polygons had to be analyzed on an individual basis. Slivers and small polygons maintained their 00 non-forested classification. Table 2-5 summarizes the changes to the TEM.

Table 2-5: Area Distribution of Final Classified TEM 00 Site Units (ESSFwm)

Site series 00	Reclassified Site Series (ha)								Total (ha)
Map Code	00	01	02	03	04	05	06	07	
FG		19	300						319
FH					117				117
FP		1,425			450				1,875
FR	54	59		21					134
FS					61				61
FV		6,728		1,994	17				8,739
AC	149	75	8	9	66	51	5		363
RI	40	6			51	5	8		111
RO	40	6	14	7	1				69
Other non-forested	87	11		8		17	8	5	132
Subtotal	371	8,328	322	2,039	764	73	21	5	11,923

2.1.4 Recent Logging

For recent cut-blocks, all available silviculture information and harvest history is incorporated into the data set. Logging history is derived from VRI (disturbance_end_date and disturbance_type_code fields), Canfor blocks, RESULTS and consolidated cutblocks data sets. This analysis includes harvest history and fire information up to December 31st, 2016.

2.2 Follow-up to Chief Forester's Comments

Following the last AAC rationale, the Chief Forester identified several topics to address or monitor prior to the next timber supply analysis. This section describes Canfor's response to each of those topics:

- **Mountain pine beetle (MPB):** Since 2007 the MPB epidemic has been controlled and no longer represents a significant consideration in harvest planning.

- **Silvicultural systems used in pine-leading stands:** Harvesting performance in pine leading stands is comparable with other species. On steep slopes, 34% of pine leading stands have been harvested in comparison with 40% of stands leading in other species. In flat terrain, 62% of pine leading stands and 60% of stands leading in other species have been harvested. Partial cutting had been used and modeled in the TFL in the past; however, it is no longer a management practice. Attributes from existing partial cut stands are included in the analysis, but any harvesting applied by the forest estate model will be using a clear-cut system.

- **Review the approach used to determine productivity reductions associated with future roads, landings and in-block disturbance:** Roads, trails and landing methodology has been reviewed and improved to utilize better and more up-to-date data. The current methodology is detailed in section 3.4.

- **Low productivity pine stands on steep slopes**: Low productivity stands on steep slopes that do not meet the minimum merchantable criteria are removed from the THLB. Any stands that remain within the THLB are considered economically viable and are considered part of future harvesting operations. Refer to section 3.11 for further explanation.

- **Complete stream inventory:** See comments in Section 2.3 below.

- **Regeneration on partially cut pine stands**. Through the inventory update process, the inventory attributes for partially harvested stands have been reviewed and updated. Previously partially harvested stands will remain on natural stand yield curves. These curves will be developed using VDYP and the updated VRI attributes for the post-treatment stand conditions are described in Section 6.1.1.

2.3 Updates since Management Plan #9

This section provides a summary of the changes in input data and management assumptions that have occurred since MP #9 was completed. These may be the result of changing management assumptions, changing practices or the use of improved and updated information.

MP #9 used a 1986 forest cover inventory updated and projected to 2006, while an updated version of the 2013 VRI is used in this analysis.

TFL 14 was awarded FSC certification in 2004. This resulted in changes to the management practices and objectives for the TFL that are now part of current management practices for the land base. Not all of these practices were considered “current management” when the last management plan analysis was completed. Specifically, the following management assumptions can be attributed to FSC certification and were not reflected in the base case in the 2007 analysis:

- Increased riparian buffers as described in section 3.12 below,
- The designation of high conservation value forests (HCVF) with modified management practices,
- The designation of endangered forest (EF) that are unavailable for harvesting, and
- The designation of buffered avalanche paths for wildlife.

In MP #9 ungulate winter range (UWR) was addressed through a section 7 notice. However, an agreement was made with the Ministry of Environment to manage TFL 14 according to requirements listed in the UWR U-4-008 Order. This agreement remains in place for MP #10, in addition to the agreement for UWR U-4-008 there was an additional order put in place for UWR 4-014 Government Actions Regulation (GAR). UWR 4-014 enacted for the TFL adds a no harvest zone (netdown) for MP #10.

In addressing the Chief Forester’s recommendation to improve stream class information, Canfor has worked to update and enhance its stream inventory layer to the point where the entire stream layer has been classified. As such, riparian netdown information has been significantly improved over the MP #9 data and assumptions. Important distinctions, such as the difference between S5a and S5b streams are now part of the inventory and can be addressed in the analysis.

Forest Planning Studio (FPS) was the forest estate model used to complete the timber supply analysis in MP #9. FPS is a spatial simulation model and harvest scheduling decisions are made on a period by period basis with little or no consideration of how decisions in one period might affect the available harvest volume in other periods.

As additional constraints are applied to the model, the ability of a simulation model to maintain harvest levels can be further compromised. The forest estate model *Patchworks* is being used for this analysis. *Patchworks*, a spatially explicit optimization model, examines the overall impact of harvest scheduling decisions across all periods and can evaluate trade-offs based on their effect on the overall harvest level. In doing so, the model can explore opportunities to overcome temporary shortages in available volume that simulation models cannot. Because *Patchworks* is a fully spatial model, it can provide a spatially explicit harvest schedule to facilitate implementation of the optimized schedule.

Other changes from MP #9 include:

- Road data has been continually updated and the most up-to-date information has been included in the analysis,
- As discussed above, the 2000 inventory audit data is not available for use in this analysis and therefore will not be applied,
- 12 permanent sample plots are identified in TFL 14 currently, but MP #9 found 51, and
- MPB was a significant consideration in MP #9. Since 2007, the epidemic has been managed and no longer represents a significant consideration.

3. Land Base Classification

The land base classification process starts with the gross area of the TFL and removes area in a stepwise fashion according to the detailed classification criteria below. Through this process, area is systematically removed to establish both the crown forest land base (CFLB) and the timber harvesting land base (THLB). The CFLB is the forested land that contributes towards meeting non-timber objectives, whereas the THLB is defined as the area available for harvest. The land base classification process classifies area into three broad categories:

1. **Non-Productive**: areas that are not managed for forest values, non-forested or non-productive and unable to grow viable timber;
2. **Productive Non-THLB**: productive land base that is unlikely to be harvested for reasons such as inoperability or special environmental protection; and
3. **THLB**: productive land base that is expected to be available for harvest over the long-term.

Table 3-1 lists each classification step (gross overlapping area and net area) and the sections below describe how each step is determined. The total area within the TFL 14 boundary is 162,263 ha, of which 97,151 ha (60%) is classified as productive and 45,470 ha (28%) is harvestable.

The assumptions and data used to define the THLB are documented in section 3.1 to section 3.20.

Table 3-1: Land base Classification

Classification	Overlapping Area (ha)	Net Area (ha)
Total TFL 14 Gross Area (including Bugaboo Park)	**162,263**	**162,263**
Non-TFL and Private Land	1,250	1,250
Non-Productive and Non-Forested	64,975	62,023
Existing Roads, Trails, and Landings	1,910	1,839
Crown Forested Land Base (CFLB)		**97,151**
Bugaboo Park	10,912	4,022
Non-Commercial Cover	2,916	1,693
Inoperable and Inaccessible	81,274	27,766
Unstable Terrain	3,843	1,131
Non-Merchantable	26,879	3,129
Low Productivity Sites	61,368	377
Riparian Management	10,020	6,450
Ungulate Winter Range	8,340	616
Avalanche Tracks	8,636	238
Old Growth Management Area (OGMA)	7,069	4,324
Endangered Forests (EF)	35,070	299
Rare and Uncommon Ecosystems	1,343	250
Wildlife Tree Patches	3,067	1,323
Recreation Sites	122	56
Timber Harvesting Land Base		**45,470**
Future Roads, Trails, and Landings	748	488
Future Timber Harvesting Land Base		**44,982**

3.1 Total Area

TFL 14 total area is 162,263 ha including Bugaboo Park (10,912 ha) and schedule A areas (79 ha).

3.2 Non-TFL and Private Land

Areas not managed by Canfor within the TFL are excluded from the CFLB. The exception to this is the Bugaboo Park, which is included in the CFLB, as it contributes to meeting seral stage objectives within the TFL. There are 455 ha of private lands (ownership code 40 in layer name F_OWN) and 821 ha of utility line right of way (layer name ROW) that is removed from the CFLB. Note that there is 26 ha of overlap between private land and utility line right of way, so the total removal for both these items is 1,250 ha.

Table 3-2: Non-TFL Lands

Class	Overlapping Area (ha)	THLB (ha)
Private ownership	455	0
Right of way	821	0

3.3 Non-Productive and Non-Forest

Non- productive and non-forest areas are identified and removed from the THLB using VRI data. This land base reduction step removes area such as rock, water, or vegetated areas that cannot sustain forest growth. British Columbia Land Cover Classification Scheme (BCLCS) is used to identify non-forested polygons (BCLCS level 2 <> T), which are removed from the THLB where no logging has occurred. This step also removes area without any tree attributes (leading species is null) in the Bugaboo Park in replacement of BCLCS data, which is not available there. The BCLCS level 1 code of ‘U’ (unreported) is not removed from the THLB, and consequently at the end of the classification process there is 27 ha BCLCS level 1 = ‘U’.

Table 3-3: Non-Forest Removals

Tenure	BCLCS Level 1	BCLCS Level 2	BCLCS Level 3	Gross Area (ha)	THLB (ha)
TFL 14	Unreported			170	27
	Non-vegetated	Land	Alpine	15,856	0
			Upland	294	2
	Non-vegetated	Water	Alpine	33	0
			Wetland	1,006	2
	Vegetated	Non-treed	Alpine	24,636	0
			Upland	15,863	1,986
			Wetland	234	0
	Vegetated	Treed	Upland	93,241	42,959
			Wetland	18	6
Bugaboo Park	No data	No data	No data	10,912	0
Total		-	-	**162,263**	**44,982**

3.4 Existing and Future Roads Trails and Landings

Often only a small portion of the classified roads are large enough to be accounted for as non-forest in the VRI. For all other roads, the TFL’s licensee has kept an updated inventory of road classes and landings and their estimated widths. This inventory has been maintained separately from the provincial digital road atlas (DRA) and TRIM road inventory. These inventories were used to classify existing and future roads, trails and landings (RTL). Buffers according to road classification (Table 3-4) were applied to each road line, and a circular buffer (52 m diameter) applied to the point indicating a landing in the spatial layer. RTL widths (hatched blue in Figure 3-1) were found to be accurate when overlaid and compared manually to aerial imagery. Lastly, the chosen buffer widths do not significantly differ from the average widths calculated for Invermere TSA (Timberline, 2008) shown in Table 3-4.

Table 3-4: Road Classification

Road Class	TFL 14 Buffer Width (m)	Invermere TSA Buffer Width (m)
Highway	20	n/a
Mainline	18	12.19
Logging	10	10.13
Trail	4	n/a
Landings	52	54

Figure 3-1: Buffered Roads over Imagery

Much of Canfor's operations have moved towards roadside processing and therefore very few landings are created through existing operations. However, Canfor maintains a spatial layer identifying all the area occupied by existing and proposed landings. Areas occupied by mapped landings have been removed from the CFLB. Based on this change in operations, there are no future aspatial reductions applied to account for additional future landings.

A large percentage of the current THLB within the TFL is already accessible using the existing road network. To estimate the amount of future road reductions that would be required to access the remaining ("non-roaded") THLB, a future road network was developed (digitized) to ensure that all THLB within 300 m of future proposed road is accessible. Future roads were then buffered by 10 m and removed from the CFLB after being harvested by the forest estate model, a total area of 748 ha. As a result, no aspatial reductions for future roads are required.

In summary, TFL 14 RTLs are estimated to represent 5.9% of the THLB in comparison to 7.9% representation in Invermere TSA (Timberline, 2008). Existing RTLs are removed from the CFLB (refer to Table 3-1) while the current forest that will be occupied by future RTLs is included in the forest estate model. This forested area will be harvested once in the planning horizon and the volume contributes to the AAC.

3.5 Crown Forested Land Base

The gross area with the TFL 14 boundary is reduced by non-productive and non-forested areas, as well as existing roads, trails and landings to create the crown forested land base (CFLB) area of 97,151 ha. This is the area that supports tree growth and can contribute to meeting non-timber objectives for seral stage distribution, visual quality objectives, integrated resource management and wildlife habitat requirements within the analysis.

3.6 Parks

This reduction step sets the treed area of the Bugaboo Park (4,022 ha), which is located within landscape unit (LU) I-34 (Bob Burns), as CFLB (summarized in Table 3-5). The VRI for Bugaboo Park provided by Canfor (Layer Name: t14_thm, vintage 2007) was used to identify areas containing tree species attributes. The productive park area will contribute to satisfying biodiversity targets within LU I-34.

Table 3-5: Bugaboo Park

Bugaboo Park	Gross Area (ha)
Non-forested	6,890
Treed	4,022
Total	10,912

3.7 Non-Commercial Cover

Deciduous, whitebark pine and western white pine leading stands (identified by species code 1) without logging history are removed as non-commercial cover (refer to Table 3-6). Whitebark pine and western white pine are not commercialized for conservation purposes while deciduous stands are not economically viable.

Table 3-6: Non-Commercial Cover

Non-Commercial Leading Species	Species code 1	Gross Area (ha)
Deciduous	At, Ac, Act, Ep	1,441
Whitebark pine	Pa	1,475
Western white pine	Pw	0
Total		2,916

3.8 Inoperable and Inaccessible

Productive areas not available for timber harvesting due to physical inaccessibility, or economic limitations related to steep slopes, road access or other logistical components are considered inoperable. A thorough review of the operability through the lens of a full systems profile including cable, long cable and helicopter systems has been completed and an operability spatial layer created. Areas identified as ‘I’ (inoperable), which include economic and accessibility factors, are removed from the THLB. The operability line is not entirely determined by slope percentage as demonstrated in Table 3-7 showing slope distribution by operable and inoperable areas. The 206 ha of THLB in the inoperable category have previously been harvested.

Table 3-7: Slope Distribution by Operability Class

Operability	Slope (%)	Gross Area (ha)	THLB (ha)
Operable	No data	595	136
	<45	52,745	34,340
	45 to 69	15,003	9,351
	70+	1,734	925
Inoperable	No data	51,564	8
	<45	13,186	94
	45 to 69	12,471	88
	70+	4,052	16
Total		151,350	44,982

TFL 14 licensees have historically performed well on slopes greater than 45%. The performance was measured by comparing the ratio of THLB to area logged in each slope class. The goal is to determine how much logging has occurred on steep slopes relative to the flatter ground. Table 3-8 shows the harvest performance for documented logging history. Based on the harvest performance, no additional areas are netted out as inoperable.

Table 3-8: Harvest Performance per Slope Class

Description	Area Ratio per Slope Class		
	< 45	45 to 69	70+
THLB	77%	21%	2%
Historic Harvest (1940 to 2016)	85%	14%	1%

3.9 Unstable Terrain

Areas without a harvest history and that are identified as ‘U’ (unstable terrain) in Canfor’s slope stability layer (terrain_stability_kootenays, pre-2007) are removed from the THLB (all by 103 ha). There are 13,651 ha of “potentially unstable” terrain, of which 4,760 ha are part of the THLB (Table 3-9) and 8,891 ha have been netted out in previous land base classification steps. Significant harvest history has occurred within “potentially unstable” (2,210 logged ha) suggesting that no further reductions are required.

Table 3-9: Terrain Stability Distribution

Terrain Stability Class	Gross Area (ha)	THLB (ha)
Unstable 'U'	3,843	103
Potentially unstable 'PU'	13,651	4,740

3.10 Non-Merchantable

Mature stands without a harvest history that have not reached the minimum volume per hectare shown in Table 3-11 are classified as non-merchantable forest types. In the MP #9 analysis, the minimum merchantable volume per hectare for mature stands was set at 100 m3/ha on slopes <45% and 130 m3/ha on slopes >= 45%. In the MP #9 determination it as noted that,

> *"MFR staff indicate that minimum criteria for pine-leading stands on slopes greater than 45 percent of 150 cubic metres per hectare and a SI higher than 10 metres at 50 years of age are more representative of current practice".*

Subsequent analysis indicated that there were only 20 ha of pine-leading stands with site index values between 9 and 10 m and therefore this was not a significant issue. In summarizing the non-merchantable assumptions used in the MP #9 analysis (not just pine-leading), the Deputy Chief Forester states,

> *"I have reviewed and discussed the information regarding non-merchantable and low productivity stands with MFR staff. While the SI of low productivity pine stands and the low volume limit for stands on steep slopes may be too low, the impact on the size of the THLB assumed in the analysis is slight. For this determination, I accept that non-merchantable and low productivity stands were adequately modelled and make no adjustments on account of this factor."*

As part of this analysis, Canfor undertook a review of the non-merchantable assumptions summarizing the VRI volume per hectare value for all harvest blocks proposed over the next 5 years. These blocks represent 2,725 ha of proposed harvest. The results of this summary are shown Table 3-10 and indicate that 5% of the proposed harvest will include stands with less than 150 m^3/ha. Expectedly, the data shows a preference for higher volume stands however it also supports a demonstrated performance in stands below 150m3/ha.

Table 3-10: Proposed Blocks Performance

Era	Slope (%)	< 100 m^3/ha	100-150 m^3/ha	150-200 m^3/ha	200-250 m^3/ha	250-300 m^3/ha	300+ m^3/ha
2017-onward	<45	2%	1%	6%	9%	9%	44%
2017-onward	>=45	1%	1%	3%	5%	4%	15%

Based on this review and in consultation with operational staff the minimum merchantable volume threshold values were increased from 100 m3/ha to 120 m3/ha on slopes < 45% and from 130m3/ha to 150m3/ha on slopes >=45% as shown in Table 3-11. Stands outside this parameter without a harvest history are removed from the THLB.

These same standards will be used to define the minimum harvestable age (in section 5.5) within the forest estate model. It is important to note that these values are just minimum values and that through the optimization process the actual harvest volumes per hectare will generally far exceed these minimums.

Table 3-11: Non-Merchantable Criteria

Class	Leading Species	Mature Age (Years)	Volume (m^3/ha)	Gross Area (ha)	THLB (ha)
Low volume	Fir	>=150	< 120	73	29
Low volume	All others	>=100	< 120	17,498	110
Low volume on slopes >= 45%	Fir	>=150	< 150	119	5
Low volume on slopes >= 45%	All others	>=100	< 150	9,189	117
Total				26,879	261

3.11 Low Productivity Stands

This land base classification step excludes immature stands (refer to Table 3-11 for the definition of mature age) not suitable for timber production due to low growth potential. Low productivity stands are identified by site index thresholds. In this analysis, the site index threshold definition for each leading species follows the low productivity indices used in *Invermere TSA TSR Updated Data Package* (MFLNRO, 2016). The methodology applied by MFLNRO staff was based on a review of the non-merchantable criteria and VDYP model runs. The VDYP results were generalized to define a reduction criteria based on leading species, site index and slope (MFLNRO, 2016). Immature stands without a harvest history and with a site index lower than the values displayed in Table 3-12 are excluded from the THLB. Note that 'Fd-S' denotes stands with leading species of Douglas-fir and second species of Spruce.

Table 3-12: Low Productivity by Slope and Leading Species

Leading Species	Slope	Site Index (m)	Gross Area (ha)	THLB Area (ha)
Fd, except in Fd-S	< 45%	< 10	34	7
	>= 45%	<13	270	8
Pl	< 45%	< 10	94	27
	>= 45%	<12	279	49
S, Pw, Fd-S	All	< 8	149	6
All others	All	< 10	60,542	1,735
Total			61,368	1,832

3.12 Riparian Management

Riparian buffers are defined according to the classification of streams, wetlands and lakes. In this analysis, riparian requirements are assessed according to FSC guidelines for Riparian Management Zones (RMZ). For each classification, an effective buffer width is calculated by adding the riparian reserve zone (RRZ) width to the product of the RMZ width and the retention percent. The effective buffer widths are presented in Table 3-13.

Riparian buffers according to Sections 47 to 53 of the Forest Planning and Practices Regulations (FPPR) of the *Forest and Range Practices Act* (FRPA) will be assessed through sensitivity analysis. Note that the 'Gross Area' column in Table 3-13 is associated with the base case FSC riparian buffers.

Table 3-13: Riparian Buffers

Riparian Class	FSC				FPPR				Gross Area (ha)	THLB Area (ha)
	RRZ Width (m)	RMZ Width (m)	Retention percent (% basal area)	Effective Buffer (m)	RRZ Width (m)	RMZ Width (m)	RMZ Retention (% basal area)	Effective Buffer (m)		
S1-A	30	40	65	56	0	100	20	20	1,348	0
S1-B	-	-	-	-	50	20	20	54		0
S2	30	40	65	56	30	20	20	34	560	0
S3	30	20	65	43	20	20	20	24	940	0
S4	30	20	65	43	0	30	10	3	3,609	0
S5a	20	20	65	33	0	30	10	3	279	0
S5b	0	15	30	4.5	0	30	10	3	332	0
S6 and S6a	20	20	65	33	0	20	-	0	934	0
S6b	0	15	10	1.5	-	-	-	-	562	0
L1	20	15	30	24.5	10	10	10	11	231	0
L3	20	15	30	24.5	0	30	10	3	235	0
W1	15	15	30	19.5	10	40	10	14	554	0
W3	15	15	30	19.5	0	30	10	3	358	0
W5	15	15	30	19.5	10	40	10	14	77	0
Total									10,019	0

Using this information, all streams, lakes and wetlands are classified and buffered according to the effective buffer width from Table 3-13. In the case of streams, this buffer is applied to each side of the stream. Areas in Table 3-13 are removed from the THLB and represent the combined impact of both the RRZ and RMZ management practices.

3.13 Ungulate Winter Range

The Order for Ungulate Winter Range (UWR) U-4-014 has been established under the Government Actions Regulation (GAR) and was implemented in 2009 to protect mountain caribou winter habitat in the Central Kootenay planning unit. Caribou management zone 1 (or unit 1) is currently the only unit in the TFL. As per this Order, timber harvesting or road construction must not occur unless for: accessing areas outside of the unit, the maintenance of forest health, or for other special reasons. Therefore, a gross area of 8,340 ha has been removed from the THLB.

3.14 Avalanche Tracks

As part of Canfor's FSC certification and to further protect grizzly bear and ungulate species, important avalanche paths were identified by biologists. Mapped avalanche tracks were buffered and indexed according to biological significance. A gross area of 8,636 ha for avalanche paths classed as high or moderate habitat value are excluded from the THLB.

3.15 Old Growth Management Areas

There are no provincial legal or non-legal old growth management areas (OGMAs) in TFL 14. All 7,069 ha of mapped OGMAs have been defined by TFL 14 licensees in response to aspatial targets set in the KBHLPO and are reserved from harvesting. The impact of allowing OGMA movement to occur through the application of aspatial old growth constraints will be assessed through sensitivity analysis.

3.16 Endangered Forests

High conservation value forest (HCVF) is a component of FSC certification used to identify important forested areas that contain one of the following:

- High and pristine biodiversity, or
- Containing rare/endangered ecosystems, or
- Provision of basic services of nature in a critical situation such as preventing erosion, or
- Significance to local communities.

Extensive research has been conducted on TFL 14 to identify HCVF. Recognizing and preserving the values of these areas is part of acquiring FSC certification. A gross area of 35,070 ha of HCVF identified as endangered forests (EF) are removed from the THLB. Most of this area was removed in previous land base classification steps, resulting in a net removal of 238 ha. For all other HCVF areas on the land base, a series of conservation strategies were established to guide management and harvesting in these areas. These strategies are detailed in site plans because these strategies only affect harvesting on the operational level.

3.17 Rare and Uncommon Ecosystems

The East Kootenay Conservation Project defined rare ecosystems (BEC-site series) as having less than 0.1% represented across the project area and uncommon ecosystems ranging between 0.2% and 0.5%. The rar_eco spatial layer displays attributes for rare and uncommon ecosystem groups, which are also described in the *Sustainable Forest Management Plan Canfor Kootenay Operations Version 4.0*. (Canfor, 2016). The ecosystems listed in Table 3-14 require 100% forest retention and are therefore removed from the THLB.

Table 3-14: Rare and Uncommon Ecosystem Groups

Ecosystem group	Description	Gross Area (ha)	THLB (ha)
Rare Ecosystem Groups			
15	IDF dm2 07 IDF dm2 XB	15	0
19	MSdk 07 IDFdm2A-SB	18	0
24	ESSFdm2/FS	313	0
Uncommon Ecosystem groups			
10	ICH mk1 06	0	0
17	ICH mk1 07 ICH dm-SD	18	0
18	MSdk 06 IDFdm2a-SH	286	0
29	ESSFwm 04	1	0
35	ESSFdku-FH ESSFdmu1-FH ESSFwmu-WE ESSFdmu2-WE	692	0
Total		1,343	0

3.18 Existing Wildlife Tree Patch Retention

A net area of 1,323 ha from a gross area of 3,067 ha has been removed from the THLB to account for existing wildlife tree patches (WTP). Reductions to account for future WTP are addressed as yield curve reductions and are described in Section 6.6.1.

3.19 Recreation Sites

Most recreation sites overlap with FSC riparian buffers and therefore do not affect timber supply. A net are of 56 ha has been removed from the THLB to account for recreation areas outside of riparian zones.

3.20 Other Considerations

The following factors were considered, but did not require specific netdown assumptions beyond those already identified above.

3.20.1 Permanent Sampling Plot Reserves

There are 12 permanent growth and yield sample plots (PSP) located within TFL 14, each buffered by 300 m. FAIB staff have confirmed that these PSP are no longer active, and are therefore not removed from the THLB.

3.20.2 Wildlife Habitat Areas

There are no known Wildlife Habitat Areas (WHAs) within TFL14 as of December 2016.

3.20.3 Culturally Significant Areas

Archeological overview assessment (AOA) mapping has been completed for all of TFL 14. As development proceeds, detailed archaeological impact assessments (AIA) are completed. To date, the areas reserved from forestry activities for protection of heritage resources at the site-specific level have been very small and generally overlap with riparian zones. Accordingly, no further reductions have been applied to account for these values.

3.20.4 Environmentally Sensitive Areas

Environmentally sensitive area (ESA) mapping is an old and often outdated spatial layer associated with the old forest cover inventory. In this TSR, any soil issues are addressed through the terrain stability survey, and potential regeneration issues are captured in the low productivity and non-merchantable land base classification steps (sections 3.10 and 3.11).

4. Current Forest Management Assumptions

The following sections describe modelling strategies for management objectives not captured through the land base reductions described above.

4.1 Non -Timber Resource Management

Non-timber resource requirements in TFL 14 were determined by the KBHLPO and provincial orders. These requirements are met by setting harvesting constraints within the THLB. Table 4-1 shows the modeled non-timber resource management zones. Each management strategy is further described in the sections below.

Table 4-1: Non-Timber Resource Management Zones

Resource Management Type	CFLB (ha)	THLB (ha)
Cut-block adjacency and green-up	44,982	44,982
Biodiversity	97,151	44,982
Visual Quality Objectives	13,360	8,727
Watersheds	1,492	848
Wildlife	27,105	19,150

4.2 Cut-block Adjacency and Green-up

Cut-block adjacency and green-up will be modeled by applying maximum disturbance constraints. The KBHLPO enhanced resource development (ERDV) timber zone and the integrated resource management (IRM) zone fall within TFL 14 and require different modelling approaches as described in Table 4-2. IRM zones within the THLB are grouped by LU-BEC combination, and do not overlap with ERDV timber zones. Green-up constraints are consistent with the *Invermere TSA TSR Updated Data Package* (MFLNRO, 2016).

Cut-block adjacency and green-up can be modeled explicitly using the patch size criteria identified in the *Biodiversity Guidebook* (MoF, 1995), which varies according to natural disturbance type. The application of specific cut block and patch size objectives may be explored through sensitivity analysis.

Table 4-2: Green-up Requirements

Management Zone	Green-up Requirement	Modeled Green-up Constraint
KBHLPO ERDV timber zone	Successful regeneration (fully stocked) of cut-blocks provided this is consistent with LU patch size objectives	Max 33% < 2 years within LU-ERDZ
IRM	2.5 m tall trees (areas fully stocked) or 3 m tall trees (areas not satisfactorily stocked)	Max 33% < 12 years within each LU/IRM

4.3 Biodiversity

Biodiversity requirements follow the KBHLPO guidelines. Biodiversity rules are applied within the LU and at the stand level. The following sections outline how retention of old and mature forest and wildlife trees/patches are modeled.

4.3.1 Seral Stage Requirements

Seral stage requirements refer to the maintenance of areas of old and mature forest on the land base. In this analysis, these requirements are defined by BEC zone, natural disturbance type (NDT) and biodiversity emphasis option (BEO) (where L = low, I = intermediate and H = high) from the *Biodiversity Guidebook* (MOF, 1995) as shown in Table 4-3 and Table 4-4. A minimum percentage (from Table 4-4) of stands 100 years and older is retained throughout the planning horizon by LU-BEC combination. In the base case analysis, mapped OGMAs are assumed to fulfill the majority of old and 'mature + old' seral targets. In addition, old and 'mature + old' targets are applied as an aspatial percentage by LU-BEC, and any targets not met by mapped OGMAs will be augmented by the preservation of other mature stands in the model. In the low BEO units 1/3 of the required seral target is met in the first rotation, 2/3 in the second rotation, and full target on the third rotation.

Table 4-3: Seral Stage Definitions by BEC Zone and NDT

BEC	NDT	Seral stage	
		Mature	Old
ICH	1	> 100	> 250
EESF	1	> 120	> 250
ICH	2	> 100	> 250
ESSF	2	>120	> 250
ICH	3	> 100	> 140
MS	3	> 100	> 140
ESSF	3	>120	> 140
IDF	4	> 100	> 250

Table 4-4: Recommended Seral Stage Distribution

BEC	NDT	Mature + Old (%)			Old (%)		
		L	I	H	L	I	H
ICH	1	> 17	> 34	> 51	> 4.3	> 13	> 19
ESSF	1	> 19	> 36	> 54	> 6.3	> 19	> 28
ICH	2	> 15	> 31	> 46	> 3	> 9	> 13
ESSF	2	> 14	> 28	> 42	> 9	> 9	> 13
ICH	3	> 14	> 23	>34	> 4.7	> 14	> 21
ESSF	3	> 14	> 23	> 34	> 4.7	> 14	> 21
MS	3	> 14	> 26	> 39	> 4.7	> 14	> 21
ICH	4	> 17	> 34	> 51	> 4.3	> 13	> 19
IDF	4	> 17	> 34	> 51	> 4.3	> 13	> 19
PP	4	> 17	> 34	> 51	> 4.3	> 13	> 19

* L = low BEO, I = intermediate BEO and H = high BEO

Table 4-5: Landscape Unit Biodiversity Emphasis Option

Landscape Unit Name	Landscape Unit Number	Biodiversity Emphasis	CFLB (ha)	THLB (ha)
Bobbie Burns (includes Bugaboo Park)	I34	Low	33,411	10,794
Lower Spillimacheen	I35	Low	10,947	6,632
		Intermediate	12,328	8,420
Upper Spillimacheen	I37	Low	30,141	11,789
Twelve Mile	I38	Intermediate	10,324	7,347
Total			97,151	44,982

4.4 Visual Quality Objectives

To manage visual quality objectives (VQOs), visually sensitive areas are mapped as part of the visual landscape inventory (VLI). VQOs are applied to each visually sensitive area. In this timber supply analysis, visual modelling is implemented according to the *Procedures for Factoring Visual Resources into Timber Supply Analyses* (MOF, 1998) and the update bulletin *Modelling Visuals in TSR III* (MOF, 2003).

Polygons with a VQO have been identified in the VLI and have been classified based on their permissible visually effective disturbance level. Within these classifications, categories of visual absorptive capacity (VAC) help define the maximum percent (%) alteration allowed in each VLI polygon. The numbers in Table 4-6 are applied to clear-cut harvesting.

A digital elevation model (DEM) is used to derive average slope for each VLI polygon and the perspective to plan (P2P) ratios. Visually effective green–up (VEG) heights were derived for each VLI polygon based on the P2P slope classes shown in Table 4-6.

Table 4-6: P2P Ratios and VEG Height Requirements by Slope Percentage

Category	Slope Classes (%)														
	0-5	5.1-10	10.1-15	15.1-20	20.1-25	25.1-30	30.1-35	35.1-40	40.1-45	45.1-50	50.1-55	55.1-60	60.1-65	65.1-70	70.1+
P2P	4.68	4.23	3.77	3.41	3.04	2.75	2.45	2.22	1.98	1.79	1.6	1.45	1.29	1.17	1.04
VEG (m)	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	6.5	7.0	7.5	8.0	8.5	8.5	8.5

The maximum % alteration in plan view for each VLI polygon is calculated based on the assigned VQO and P2P ratio. For example, a maximum % alteration of 7% is assigned to a VLI polygon classified as 'PR', which is then multiplied by the P2P ratio depending on average polygon slope. The VEG height is determined for each VLI polygon based on slope using the same methodology as summarised in Table 4-7.

Table 4-7: VQO Assumptions

VQO Class	% Alteration by VAC (Perspective View)			CFLB (ha)	THLB (ha)
	Low	Medium	High		
P (Preservation)	0	0	0	112	28
PR (Partial Retention)	1.6	4.3	7.0	10,272	6,978
M (Modification)	7.1	12.5	18.0	2,976	1,721

4.5 Watersheds

In TFL 14 there are 6 domestic watersheds (Casals, Billy Goat, Billy Goat Face, Spillimacheen Face, Mad Trapper and Delong Creek) and no community watersheds. The latter three watersheds are outside of the operability line and harvesting is not a priority in these areas. For this analysis, harvesting may occur in domestic watersheds to a maximum disturbance of 25% less than 6m tall (see Table 4-8).

Table 4-8: Forest Cover Requirements for Watersheds

Watershed Type	Forest Cover Requirement
Domestic (Casals, Billy Goat, and Billy Goat Face)	Max 25% < 6 m tall trees

4.6 Wildlife

The following sections describe the management assumptions applied to address wildlife management objectives. There are 2 different commitments for managing UWR.

4.6.1 Ungulate Winter Range

UWR are completely or partially reserved from harvesting. There are three types of UWR in the TFL as shown in Table 4-9 and the following paragraphs.

Table 4-9: UWR Areas

UWR	Modeled Constraint	Modeled area (ha)
HCVF 1102	As a PR and high VAC VQO	353
U-4-014	Excluded from THLB	8,340
U-4-008	See Table 4-10	26,752

The 20 to 50 m buffer surrounding the Columbia Wetlands (HCVF-1102) is an important winter range for ungulate species. This area has been identified in the *TFL 14 High Conservation Value Forest / Endangered Forest Management Strategies* (Tembec, 2009) and small patch cutting is the prescribed silvicultural system. Because Canfor does not carry out partial cutting, for the purpose of this analysis, HCVF 1102 will be modeled as a PR and high VAC VQO polygon by setting a maximum alteration % and VEG according to the average slope for the area.

Harvesting is not permitted within GAR U-4-014 mapped areas, which was addressed in Section 3.13 as a netdown step.

Canfor has made a commitment to manage areas of TFL 14 according to U-4-008 (established under a GAR that went into effect on February 10, 2005) even though this order does not directly overlap with the TFL. U-4-008 was established to protect winter habitat for moose, white-tailed deer, mule deer, elk, bighorn sheep and mountain goat. Habitat types are defined by the layer ‘tfl_uwr2’ and forest cover retention is applied by habitat type and LU combinations as detailed in the ‘Modelled Constraint’ column of Table 4-10.

Table 4-10: UWR 4-008 Management Strategy

Habitat type	Landscape and Stand Level Retention Requirement	Forest Cover Retention Requirement	Modeled Constraint
Open Forest/Range	Stocking standards 5-75 stems/ha	Include 5-20 stems/ha of the largest 1/3 of the diameter range	Operationally addressed
Open Forest/Range	Stocking standards 76-400 stems/ha	Include 5-20 stems/ha of the largest 1/3 of the diameter range	Operationally addressed
Managed Forest (Dry)	Mature Cover 10% (min)	>100 years and evergreen CC=> 20%, or layer 1 age >100 years	Minimum 10%>100 years
Managed Forest (Transitional)	Snow interception cover 10% (min),	>60 years and evergreen CC=> 40%	Minimum 10%>100 years in leading Fd and Sx stands, and minimum 10%>60 years in other stands
	Mature cover 10% (min)	>100 years, Fd or Sx leading and evergreen CC => 40%	
Managed Forest (Mesic)	Snow interception cover 10% (min),	>60 years and evergreen CC=> 40%	Minimum 20%>100 years in leading Fd and Sx stands, and minimum 20%>60 years in other stands
	Mature cover 20% (min)	>100 years, Fd or Sx leading and evergreen CC => 40%	
Managed Forest (Moist)	Snow interception cover 20% (min)	>60 years and evergreen CC=> 40%	Minimum 20%>60 years
Managed Forest (Wet)	Snow interception cover 30% (min)	>60 years and evergreen CC=> 40%	Minimum 30%>60 years
Managed Forest (all)	Maximum of 33% < 21 years		Maximum of 33% < 21 years
Avalanche Tracks	50m of forest cover adjacent to high value habitat within avalanche tracks	>60 years old	Operationally addressed

4.6.2 Grizzly Bear Habitat and Connectivity Corridors

KBHLPO requires that mature and old growth forests be kept in areas identified as grizzly bear habitat and as connectivity corridors. These areas are not additional to seral targets, instead KBHLPO suggests that required mature and old stands are placed in identified grizzly bear habitat and connectivity corridors. Forests on slopes greater than 80% do not contribute as connectivity corridors. Consistent with the *Invermere TSA TSR Updated Data Package* (MFLNRO, 2016), this is not modeled explicitly but rather assumed to be managed operationally.

5. Modelling Approach

5.1 Forest Estate Model

Forest estate modelling is conducted using the spatially explicit optimization model *Patchworks*. *Patchworks* is developed by *Spatial Planning Systems* in Ontario (www.spatial.ca) and allows the user to explore trade-offs between a broad range of conflicting management goals while considering operational objectives and limitations into strategic-level decisions. The model provides an interface that allows users to access and understand information in real-time.

The model has been formulated using five-year planning periods over a 250-year planning horizon.

5.2 Harvest Flow Objectives

The biological capacity of the land base, as well as forest cover and green-up requirements, dictate the sustainable harvest level for a particular land base. There are several alternative harvest flows possible. In this analysis, the harvest levels will reflect the following objectives:

- Attempt to maintain the current AAC for as long as possible,
- Decrease to the highest mid-term harvest level that can be sustained as growing stock levels fall, and
- Increase to an even-flow, long-term harvest level that produces a non-declining growing stock over a 250-year planning horizon.

5.3 Silviculture Systems

TFL 14 silviculture systems are predominately clear-cut with reserves, and small clear-cut patches employed in VLI polygons, HCVF 1102 and dry belt Douglas-fir. Planting is the predominant method of regeneration.

5.4 Harvest Systems

Harvesting in the TFL uses primarily ground-based harvest systems. Some steep slope harvesting occurs using cable and winch-assist systems.

5.5 Minimum Harvest Age

Minimum harvest age (MHA) is derived for each analysis unit based on the age at which the stand achieves the required minimum harvest volume (MHV) as described in Table 5-1 (consistent with the non-merchantable criteria set in section 3.10) and 95% of the culmination of the mean annual increment (CMAI).

Table 5-1: Harvest Criteria

Leading Species	MHV	CMAI
All on slope >= 45%	150 m³/ha	95%
All on slope < 45%	120 m³/ha	95%

5.6 Unsalvaged Losses

Unsalvaged losses represent an annual volume of timber losses due to damage caused by environmental conditions, or insects over and above endemic values already captured within the growth and yield models. To calculate unsalvaged losses, a percentage was calculated according to estimates used in the *Invermere TSA TSR Updated Data Package* (MFLNRO, 2016). The prorating was based on the area of the TFL's THLB, which is estimated to be 25% of the Invermere TSA's THLB (177,177 ha) (FAIB, 2016). The prorated losses are shown in Table 5-2. MPB is not included because most of the MPB infested stands have been harvested and new MPB infestations remain at endemic levels.

Table 5-2: Unsalvageable Losses Calculation

Species	Cause	TSA Annual Unsalvageable Losses (m³/y)	TFL Annual Unsalvageable Losses (m³/y)
All	Wildfire	2,341	585
All	Flooding	801	200
All	Wind throw/snow press	32	8
Fd	Douglas-fir bark beetle	1,455	364
Fd	Fir engraver beetle	43	11
Sx/Se	Spruce bark beetle	19,000	4,750
Pl	Western pine beetle	36	9
Bl	Western balsam bark beetle	2,386	597
Total		**26,094**	**6,524**

6. Growth and Yield

TFL 14 licensee's cut-block records go back as far as 1955; RESULTS openings go back as far as 1968. It is assumed that stands harvested since 1986 are treated as managed, and stands with no logging history, or logged prior to 1986 are classified as natural.

6.1 Natural Stand Yield Tables

Attributes from the VRI are used to generate natural stand yield tables for each polygon using Variable Density Yield Prediction model (VDYP) version 7. These polygon-level yield tables are then input directly into the timber supply model. Due to the large number of yield tables produced, it is not feasible to include them in this data package. Digital versions of the natural stand yield tables can be provided.

6.1.1 Partially Harvested Stands

Partial harvesting is not a practice currently utilized to a large degree on the TFL. However, past practices have resulted in approximately 5,000 ha of partially harvested stands. Through the current VRI update process, the attributes for these stands have been updated to reflect their current condition.

Partially harvested stands will remain on natural stand yield curves. These curves will be developed using VDYP and the updated VRI attributes for the post-treatment stand conditions. They will be available for clear-cut harvesting once they have achieved the MHV criteria.

6.2 Managed Stand Yield Tables

Growth and yield for all recently harvested stands and future regenerated stands is modeled using Table Interpolation for Stand Yields (TIPSY) v.4.3. These stands are grouped into analysis units based on their BEC and site series combinations from the Terrestrial Ecosystem Mapping (TEM) (JMJ Holdings Inc, 1999) for the TFL, then further divided into flat or steep slope based on a 45% cut off.

Existing managed stand analysis units are composed of stands that have been logged between 1986 and 2016. Their species composition is the same as expected for future regeneration shown in Table 6-1, except in the ICH BEC zone where Douglas-fir was the leading species instead of Larch. Area weighted genetic gains are also applied as explained in Section 6.4.

Following harvest, all natural stands transition to future managed stands. Regeneration assumptions reflect Canfor's current planting practices and records, and are documented in Table 6-1. According to Canfor's silvicultural records all stands are regenerated by planting and a 2.16-year regeneration delay is expected. For the purpose of this analysis regeneration, delay is rounded to 2 years (consistent with MP #9).

Table 6-1: Base Case Regeneration Assumptions

BGC - Site Series	Sp1	Sp1 %	Sp2	Sp2 %	Sp3	Sp3 %	Sp4	Sp4 %	Initial stems/ha
ESSFdk_01	Pli	55	Sx	35	Lw	7	Fdi	3	1400
ESSFdk_02	Pli	55	Sx	35	Lw	7	Fdi	3	1400
ESSFdk_03	Pli	60	Sx	30	Lw	5	Fdi	5	1400
ESSFdk_04	Pli	55	Sx	35	Lw	5	Fdi	5	1400
ESSFdk_05	Pli	59	Se	36	Lw	5			1400
ESSFdk_06	Pli	55	Sx	45					1400
ESSFdk_07	Pli	55	Sx	45					1400
ESSFdku_03	Pli	60	Sx	30	Lw	5	Fdi	5	1400
ESSFdku_04	Pli	55	Sx	35	Lw	5	Fdi	5	1400
ESSFwm_01	Pli	55	Sx	35	Lw	7	Fdi	3	1400
ESSFwm_02	Pli	60	Sx	30	Lw	5	Fdi	5	1400
ESSFwm_03	Pli	60	Sx	30	Lw	5	Fdi	5	1400
ESSFwm_04	Pli	55	Sx	35	Lw	5	Fdi	5	1400
ESSFwm_05	Pli	55	Sx	35	Lw	5	Fdi	5	1400
ICHmk1_01	Lw	40	Sx	23	Pli	24	Fdi	13	1400
ICHmk1_04	Lw	40	Sx	23	Pli	24	Fdi	13	1400
ICHmk1_05	Lw	40	Sx	23	Pli	24	Fdi	13	1400
ICHmk1_06	Lw	40	Sx	23	Pli	24	Fdi	13	1400
ICHmw1_01	Lw	40	Sx	23	Pli	24	Fdi	13	1400
ICHmw1_04	Lw	40	Sx	23	Pli	24	Fdi	13	1400
ICHmw1_05	Lw	40	Sx	23	Pli	24	Fdi	13	1400
ICHmw1_06	Lw	40	Sx	23	Pli	24	Fdi	13	1400
IDFdm2_01	Lw	38	Pli	29	Fdi	26	Sx	7	1200
IDFdm2_03	Lw	38	Fdi	33	Pli	22	Py	7	1200
IDFdm2_04	Lw	38	Pli	29	Fdi	26	Sx	7	1200
IDFdm2_05	Lw	38	Pli	29	Fdi	26	Sx	7	1200
IDFdm2_06	Lw	38	Pli	29	Fdi	26	Sx	7	1200
IDFdm2_07	Lw	38	Pli	29	Fdi	26	Sx	7	1200
MSdk_01	Pli	35	Lw	30	Sx	25	Fdi	10	1200
MSdk_03	Pli	48	Lw	24	Sx	24	Fdi	10	1200
MSdk_04	Pli	35	Lw	30	Sx	25	Fdi	10	1400
MSdk_05	Pli	48	Lw	24	Sx	24	Fdi	4	1400
MSdk_06	Pli	48	Lw	24	Sx	24	Fdi	4	1200
MSdk_07	Pli	48	Lw	24	Sx	24	Fdi	4	1200

6.3 Site Productivity Estimates

Site Index by BEC Site Series (SIBEC) values are used for existing and future managed stands while VRI site index is used to estimate productivity in natural stands. Localized SIBEC data was collected for TFL 14 in 1998, 1999 and 2000, generating local site index values for tree species in local BEC and site series combinations. These values were reported in *TFL 14 Management Plan No. 9 Ecologically Based Productivity Estimates Sibec Correlation Update* (Timberline, 2002) and used in MP #9. These site index values are used in this analysis for BEC and site series combinations where 7 plots or more were sampled (summarized in Table 6-2). For combinations of BEC-SS where the number of plots didn't meet this requirement, Ministry of Forest and Range Research Branch (MoF) SIBEC data base records for the Nelson Region are used (https://www.for.gov.bc.ca/pscripts/hre/sibec/sibecreports.asp). Lastly, for combinations where MoF data is not available, area weighted average of the VRI site index was used to determine the productivity.

Table 6-2: Localized SIBEC Values

BEC	Number of Plots	MoF SIBEC	TFL SIBEC
ESSFdk03 Bl	7	15	18.6
ESSFdk03 Pl	7	18	18.0
ESSFdk03 Se	7	12	18.6
ESSFdk04 Bl	7	15	16.8
ESSFdk04 Pl	7	18	19.8
ESSFdk04 Se	7	15	15.9
ESSFwm00 Bl	8	n/a	19.7
ESSFwm00 Pl	10	n/a	18.3
ESSFwm00 Se	8	n/a	19.6
ICHmw101 Fd	7	24	22.8
ICHmw101 Pl	8	24	21.5
IDFdm201 Fd	11	15	21.0
IDFdm201 Pl	10	18	20.1
IDFdm203 Fd	1	15	15.8
IDFdm204 Fd	9	18	21.5
MSdk01 Bl	7	15	19.5
MSdk01 Fd	10	21	22.3
MSdk01 Pl	10	18	22.1
MSdk01 Sx	10	18	21.8
MSdk04 Bl	7	15	23.1
MSdk04 Fd	19	18	19.5
MSdk04 Pl	11	18	19.0
MSdk04 Sx	7	18	28.9

6.4 Genetic Gains

Canfor utilizes 100% of the available genetically improved stock on the TFL. Class A and B+ (select) seeds have enhanced genetic traits that improve timber yield and forest health. Genetic worth is a measure of the genetic quality of a seedlot for a specific trait. For example, a seedlot with a genetic worth (GW) for growth of "G+03" has a 3% potential growth gain over natural stand seed (MoF, 1995).

Seed Planning & Registry Application (SPAR) reports were generated for the TFL showing seedlot orders from 2002 to 2011 and the GW of each seedlot. Estimated GW for 2012 to 2016 and future estimated were obtained from species plans (MFLNRO, 2016). Data for the proportion of planted select seeds was gathered from SPAR reports (2002 to 2005) when not available from Canfor.

For existing managed stands, the product of the average GW from 2002 to 2016 and the percent of select seeds planted was used to calculate the net GW proportionally applied to each species in each managed analysis unit as shown in Table 6-3. For future managed stands, net GW was calculated based on the future projected genetic gain for each species and expected planting trends summarized in Table 6-4.

Table 6-3: Estimated Genetic Gains (2002-2016)

Species	Average GW (%) (2002-2016)	% of Select Seeds (2002-2016)	Net GW (%) (2002-2016)
Fdi	0	0	0
Lw	19	96	18
Pli (non-ESSF)	4	43	2
Sx	19	88	17

Table 6-4: Future Genetic Gain Estimates

Species	Future GW (%)	% of Select Seeds	Net GW (%)
Fdi	25	25 *	6
Lw	27	100	27
Pli (non-ESSF)	10	33	3
Sx	22	100	22

*Selected Fdi seeds are expected to be planted only in low elevation.

6.5 Operational Adjustment Factors

Operational adjustment factors (OAF) for managed stand yields are applied using standard values of 15% for OAF 1 and 5% for OAF 2. To account for the impacts of Armillaria, Douglas-fir leading stands within the ICH BEC zone, the OAF 2 value was increased to 10.8% - consistent with the *Invermere TSA TSR Data Package* (MFLNRO, 2016).

6.6 Volume Reductions

All deciduous, whitebark pine and white pine leading stands are removed from the THLB. Additionally, the deciduous component of conifer leading stands has been removed from natural stand yield curves.

6.6.1 Future Wildlife Tree Patch Retention

Through Canfor's FSC certification, spatial requirements for WTP are prescribed according to the LU and BEC variants shown in Table 6-5. For each LU-BEC, the WTP % requirement is based on the % of the unit that has been logged without WTPs, along with the % of the unit that is available for harvest. Gross WTP % reductions are applied as an area reduction to natural analysis units that have not been logged and remain not available for harvest throughout the modelling period. Current WTPs meet the required % for past logged blocks and have been removed from the THLB as a netdown step in section 3.18.

Table 6-5: Wildlife Tree Patch Distribution and Requirements

LU	LU Name	BEC variant	CFLB (ha)	THLB (ha)	WTP Required (%)
I34	Bobbie Burns	ESSFdk	5,709	3,671	6.3
I34	Bobbie Burns	ESSFdkp	297	-	-
I34	Bobbie Burns	ESSFdku	1,896	53	-
I34	Bobbie Burns	ESSFwm	11,458	4,735	4.1
I34	Bobbie Burns	ESSFwmp	1,426	-	-
I34	Bobbie Burns	ESSFwmu	5,262	59	-
I34	Bobbie Burns	MS dk	3,350	2,297	4.9
I35	Lower Spillimacheen	ESSFdk	1,864	1,248	5.1
I35	Lower Spillimacheen	ESSFdkp	78	-	-
I35	Lower Spillimacheen	ESSFdku	494	-	-
I35	Lower Spillimacheen	ESSFwm	11	3	0.9
I35	Lower Spillimacheen	ICHmk1	97	74	5.8
I35	Lower Spillimacheen	IDFdm2	8,342	5,234	4.9
I35	Lower Spillimacheen	MSdk	12,455	8,508	5.3
I37	Upper Spillimacheen	ESSFdk	8,311	4,734	6.5
I37	Upper Spillimacheen	ESSFdkp	487	7	-
I37	Upper Spillimacheen	ESSFdku	1,760	35	-
I37	Upper Spillimacheen	ESSFwm	12,408	6,257	5.3
I37	Upper Spillimacheen	ESSFwmp	1,137	-	-
I37	Upper Spillimacheen	ESSFwmu	5,101	100	-
I37	Upper Spillimacheen	MSdk	945	651	9.0
I38	Twelve Mile	ESSFdk	13	12	7.0
I38	Twelve Mile	ESSFdkp	1	-	-
I38	Twelve Mile	ESSFdku	1	-	-
I38	Twelve Mile	ESSFwm	931	359	2.4
I38	Twelve Mile	ESSFwmp	35	-	-
I38	Twelve Mile	ESSFwmu	367	-	-
I38	Twelve Mile	ICHmk1	2,043	1,538	5.9
I38	Twelve Mile	ICHmw1	1,782	1,563	5.4
I38	Twelve Mile	IDFdm2	2,611	1,989	4.5
I38	Twelve Mile	MSdk	2,509	1,856	4.5

6.7 Utilization Levels

Yield curves have been generated using the standard utilization levels based on leading species as shown in Table 6-6.

Table 6-6: Utilization Criteria

Leading Species	Minimum DBH (cm)	Stump Height (cm)	Minimum Top DIB (cm)
Pine and aspen	12.5	30.0	10.0
All other species	17.5	30.0	10.0

7. Sensitivity Analysis

Sensitivity analyses results help quantify the degree to which uncertainty in analysis assumptions might affect the resulting timber supply for the land base. The sensitivities listed below are being considered in the analysis. This list will be refined in consultation with other stakeholders as the analysis is conducted.

Table 7-1: Sensitivity Analyses

Parameter modeled	Description
FRPA	Modelling FRPA regulation as the base case in place of FSC management.
Aspatial OGMAs	Old and mature seral requirements are modeled using retention requirements by LU-BEC from the *Biodiversity Guidebook* (MoF, 1995).
Columbia Wetlands	Do not allow harvesting in the Columbia Wetlands WHA, which is an area of preservation interest, but not regulated.
Minimum Harvest Age	Assess the impacts of an increase / decrease minimum harvest volume.
Yield Assumption	Increase / decrease both managed and natural stand yields by 10%.
Site Index – no SIBEC	Use site index from VRI for managed stands yield productivity estimates.
Patch size modeling for green-up	Use patch and cut-block size targets based on the *Biodiversity Guidebook* (MoF, 1995) in place of aspatial green-up requirements.

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Tree Farm Licence 14 Management Plan #10 Timber Supply Analysis – Analysis Report

Presented To: Canadian Forest Products Ltd
Attention: Grant Neville, RPF
1000 Industrial Rd #1
Cranbrook, BC V1C 4C6

CANFOR

Submitted By: Ecora Engineering and Resource Group Ltd.
101-1584 7th Avenue
Prince George, BC V2L 3P4
Jay Greenfield, RPF
jay.greenfield@ecora.ca

Dated: July 24, 2018

Ecora File No.: FG-16-500-CFP

ENGINEERS & GEOSCIENTISTS BRITISH COLUMBIA

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Version Control and Revision History

Version	Date	Prepared By	Reviewed By	Notes/Revisions
1.0	June 19th, 2018	Liza Rodrigues	Jay Greenfield	Initial draft to Canfor
1.1	June 21st, 2018	Liza Rodrigues	Jay Greenfield	First draft to FAIB
2.0	July 24th, 2018	Liza Rodrigues	Jay Greenfield	Public Review

Limitations of Report

This report and its contents are intended for the sole use of Canadian Forest Products and their agents. Ecora Engineering & Resource Group Ltd. does not accept any responsibility for the accuracy of any data, analyses, or recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Canadian Forest Products. Any such unauthorized use of this report is at the sole risk of the user.

Executive Summary

Tree Farm License 14 (TFL 14) is undergoing its 10th Timber Supply Review (TSR). Canadian Forest Products (Canfor) has initiated a timber supply analysis in support of a new allowable annual cut (AAC) determination for TFL 14. The current AAC is 180,000 m^3/year. This document describes the results of the recently completed timber supply analysis and should be viewed in conjunction with the detailed description of the data and assumptions provided in the *Tree Farm Licence 14 Management Plan #10 Timber Supply Analysis Updated Data Package* (Ecora, 2017).

Through a land base classification process, area is systematically removed from the gross land base area to establish both the Crown productive forest land base (CFLB) and timber harvesting land base (THLB). The THLB in this analysis is calculated at 45,564 ha.

The base case timber supply analysis includes:

- Non-timber objectives including visually sensitive areas, domestic watersheds, ungulate winter range and biodiversity targets;
- Inventory heights adjusted through the use of available LiDAR data;
- An initial harvest volume of 181,000 m^3/year for the first 20 years;
- The harvest profile is predominantly pine followed by spruce and Douglas-fir; and
- A sustainable long-term growing stock.

This base case finds a balance between the current and future timber supply by minimizing negative social and economic impacts associated with a lower harvest forecast while simultaneously meeting Forest Stewardship Council (FSC) certification standards. The base case harvest forecast is presented in Figure i showing the harvest level starting at 181,000 m^3/year for the initial 20 years, dropping to 163,000 m^3/year in the mid-term, then shifting to a sustainable long-term flow of 157,00 m^3/year.

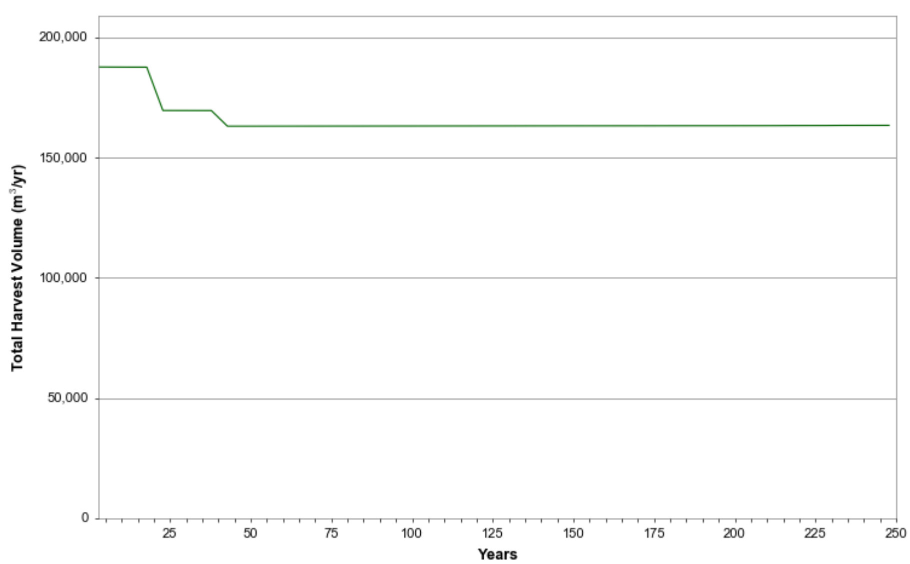

Figure i: Base Case Harvest Forecast

Sensitivity analyses provide information on the degree to which uncertainty in the base case data and assumptions might affect the proposed harvest level for the land base. A summary of the sensitivity analyses results and their variation from the base case are shown in Table i. These scenarios reveal a land base that is highly impacted by changes to the growing stock and THLB size.

Table i: Average Harvest Level – All Scenarios

Sensitivity	Harvest Volume (m^3/yr)			Change from the Base Case		
	1-20	21-40	41-250	1-20	21-40	41-250
Base case	181,000	163,000	157,000			
Non-declining even flow	160,000	160,000	160,000	-12%	-2%	2%
Unadjusted VRI heights	162,000	154,000	155,000	-11%	-6%	-1%
FRPA standards	186,000	186,000	186,000	3%	14%	19%
Aspatial seral targets	191,000	172,000	166,000	5%	5%	6%
Natural stands yield curves + 10%	202,000	182,000	159,000	11%	11%	1%
Natural stands yield curves - 10%	172,000	153,000	153,000	-5%	-6%	-2%
Managed stands yield curves - 10%	179,000	161,000	142,000	-1%	-1%	-9%
Managed stands yield curves + 10%	181,000	163,000	173,000	0%	0%	10%
Inventory SI	177,000	159,000	129,000	-2%	-3%	-18%
+10% harvest target on slp >40%	181,000	163,000	157,000	0%	0%	0%
122 ha/yr cap on slp >40%	171,000	152,000	152,000	-6%	-7%	-3%
Patch targets	177,000	159,000	156,000	-3%	-3%	-1%
Decreased MHV	183,000	164,000	158,000	1%	0%	1%
Increased MHV	180,000	161,000	155,000	-1%	-1%	-1%

Changes to estimated natural stand volume and harvest flow have the highest impact to the initial 20 years of the planning horizon. Modelling Forest Range Practices Act (FRPA) standards instead of FSC has the most meaningful upward shift to the harvest flow from year 21 until the end of the planning horizon. Changes to managed stand yields create significant impact to the long-term harvest level as expected. Aspatially modelling old forest retention (as opposed to Old Growth Management Areas (OGMAs)), not adjusting Vegetation Resource Inventory (VRI) heights with LiDAR data and setting a cap on harvesting from slopes greater than 40% have a moderate, but important impact to the timber supply forecast.

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Appendices

Acronyms and Abbreviations

AAC	Allowable Annual Cut
BC	British Columbia
BEC	Biogeoclimatic Ecosystem Classification
BEO	Biodiversity Emphasis Option
BGC	Biogeoclimatic
Canfor	Canadian Forest Products
CFLB	Crown Forested Land base
CMAI	Culmination Mean Annual Increment
DBH	Diameter at Breast Height
ECA	Equivalent Clear-Cut Area
EVC	Existing Visual Condition
FAIB	Forest Analysis and Inventory Branch
FPS	Forest Planning Studio
FRPA	Forest Range Practices Act
FSC	Forest Stewardship Council
FTEN	Forest Tenure Cutblocks
KBHLPO	Kootenay Boundary High Level Plan Order
ha	Hectares
HCVF	High Conservation Value Forest
ITI	Individual Tree Inventory
LTHL	Long-Term Harvest Level
MFLNRO	Ministry of Forests, Lands and Natural Resource Operations
MHA	Minimum Harvest Age
MHV	Minimum Harvest Volume
MP	Management Plan
MPB	Mountain Pine Beetle
MSYT	Managed Stand Yield Tables
NDT	Natural Disturbance Type
NRL	Non-Recoverable Losses
NSYT	Natural Stand Yield Tables
OAF	Operational Adjustment Factor
OGMA	Old Growth Management Area
PFT	Problem Forest Type
PFLB	Productive Forest Land base
PR	Partial Retention VQO Classification
RESULTS	Reporting Silviculture Updates and Land Status Tracking System
SIBEC	Site Index by BEC
SFMP	Sustainable Forest Management Plan
TEM	Terrestrial Ecosystem Mapping
TFL	Tree Farm License
THLB	Timber Harvesting Land base
TIPSY	Table Interpolation Program for Stand Yields
TSA	Timber Supply Area
TSAR	Timber Supply Analysis Report
TSR	Timber Supply Review
VDYP	Variable Density Yield Prediction Growth and Yield Model
VPH	Volume per hectare
VLI	Visual Landscape Inventory
VQO	Visual Quality Objectives
VRI	Vegetation Resources Inventory
VRIEM	Vegetation Resource Inventory and Ecosystem Mapping

1. Introduction

As part of the ongoing TSR process for TFL 14, Canfor is required to prepare Management Plan #10 (MP #10), which includes a timber supply analysis showing the long-term strategic timber supply for the land base. Since 2004, TFL 14 has been managed in accordance with FSC certification standards and plans exist to maintain this certification. Accordingly, this analysis report presents a base case that reflects the management assumptions associated with FSC certification. This timber supply analysis report documents the procedures, and results of modelling the base case and sensitivity scenarios in support of a new AAC determination.

Canfor has contracted Ecora Engineering & Resource Group Ltd. (Ecora) to assist in the preparation of information to support a new AAC determination for TFL 14. This analysis report should be viewed in conjunction with the recently completed *Tree Farm Licence 14 Management Plan # 10 Timber Supply Analysis Updated Data Package* (Ecora, 2017) (the Data Package) which describes the input data and assumptions used in this analysis.

The last timber supply analysis in support of Management Plan #9 (MP #9) for TFL 14 was completed in 2007, followed by the AAC determination that became effective April 7th, 2008 setting the annual harvest level to 180,000 m^3/year. At that time, Tembec Industries Inc. was the licensee operating in the TFL.

Since MP #9 was completed, changes in input data and management assumptions have occurred. These include:

1. Vegetation Resource Inventory (VRI): MP #9 used a forest cover inventory that was produced in 1986. For use in the 2007 analysis, this forest cover went through a Phase II inventory adjustment and was projected to 2006. Conversely, MP #10 uses a VRI completed in 2013, which has been updated for disturbances, projected to 2017 and polygon height adjusted with LiDAR data.

2. LiDAR based height adjustment: In 2015 Canfor had LiDAR data collected for TFL 14, which was used to produce an individual tree inventory (ITI) (Forsite, 2017). This ITI contains many attributes including height, species, and log profile. Ecora developed a method to use the ITI heights to adjust stand level heights in the 2013 VRI. This process has been detailed in the memo "*Vegetation Resource Inventory Height Adjustment Using LiDAR Data"* (Ecora, 2018), which can be found in Appendix B. This height adjustment proposal has been accepted by the Forest Analysis and Inventory Branch (FAIB) as a way to replace the lost plot data from the last Phase II inventory adjustment that could have been used for the 2013 VRI.

3. Growing stock: the current TSR starts off with a growing stock that is 12% lower than the FSC modelled scenarios in MP #9. This difference mainly results from harvesting over the past decade. This issue has been analyzed and detailed findings are discussed in "Growing Stock and PFT Memo" (Appendix A).

4. THLB: The base case THLB for MP #9 did not account for FSC management assumptions and ungulate winter range (UWR) 4-014, which came into effect in 2008. Accordingly, its modelled base case THLB is 11% larger than the current base case. However, the THLB in MP #9's FSC scenarios is only 1% larger than MP #10 base case.

5. Forest Planning Studio (FPS) was the forest estate model used to complete the timber supply analysis in MP #9 while Patchworks is used in the current analysis.

6. Mountain pine beetle (MPB) was a significant consideration in MP #9. Since 2007, the epidemic has been managed within the TFL and is not part of the modelling assumptions.

7. Canfor has added capacity to harvest on slopes greater than 40%.

8. Forest Planning Studio (FPS) was the forest estate model used to complete the timber supply analysis in MP #9. FPS is a spatial simulation model and harvest scheduling decisions are made on a period by period basis. The forest estate model Patchworks is used for this analysis. Patchworks, a spatially explicit optimization model, examines the overall impact of harvest scheduling decisions across all periods and can evaluate trade-offs based on their effect on the overall harvest level. Patchworks is a fully spatial model and can provide a spatially explicit harvest schedule to facilitate implementation of the optimized schedule.

These changes have an impact on the forecasted timber supply. The next sections describe the land base and the estimated harvest level it can support.

2. Changes from the Data Package

There have been a few changes since the Data Package was published in November, 2017. The key change is an adjustment to the VRI leading heights and minor changes in assumptions. These changes are further described in this Section.

A LiDAR based stand level height adjustment has been applied to 36,247 ha of non-logged productive mature (> 60 year) forests (as detailed in Section 4 and Appendix B). As stand height was altered, some stands that were previously classified as non-merchantable cover or low productivity had an increase in their volume and site index. This resulted in these stands meeting merchantability and productivity criteria, and therefore becoming included in the THLB. The THLB increased by 582 ha (1%) in comparison to the THLB presented in the November 2017 Data Package. The new land base classification is presented in Section 3.1. This increase in productivity also affects the timber supply forecast as detailed in Section 4.

In addition to the LiDAR based height adjustment, some minor changes in assumptions from what is documented in the published Data Package have been found necessary during the timber supply analysis. These changes include redefining analysis units, reducing the crown forested land base (CFLB) by 18 ha, and seral targets modelling. A detailed description follows:

1. Natural analysis units are those with a logging history < 1986 and have a VRI age > 31 years when the VRI reference date is more recent than the log year. This conditional description was not stated in the Data Package and therefore has been reiterated in this report.
2. The CFLB has been reduced by 18 ha by reassigning old logged slivers where no trees are present to existing roads. These slivers were spot checked on imagery, and were confirmed to be roads.
3. The Data Package states that "In the low BEO units 1/3 of the required seral target is met in the first rotation, 2/3 in the second rotation, and full target on the third rotation" implying that 'mature+old' and old seral targets in low BEO units would be modelled using this approach, However, only old seral targets in low BEO units are to be modelled this way. Mature+old targets are modelled to fulfill the same (full) target throughout the planning horizon.

3. Land Base Description

3.1 Land Base Classification

The land base classification process begins with the total area of the TFL 14 and removes area in a stepwise fashion according to the classification criteria detailed in the Data Package. As explained in Section 2, the net areas are different than in the Data Package, but the criteria are unchanged. Through this process, area is systematically removed to establish both the CFLB and the THLB. Table 3-1 summarizes the area removed under each classification to reach a THLB of 45,564 ha.

Table 3-1: Land Base Classification

Classification	Net Area (ha)
Total TFL 14 Gross Area (including Bugaboo Park)	**162,263**
Non-TFL and Private Land	1,250
Non-Productive and Non-Forested	62,023
Existing Roads, Trails, and Landings	1,857
Crown Forested Land Base (CFLB)	**97,133**
Bugaboo Park	4,022
Non-Commercial Cover	1,693
Inoperable and Inaccessible	27,766
Unstable Terrain	1,131
Non-Merchantable	2,443
Low Productivity Sites	260
Riparian Management	6,492
Ungulate Winter Range	616
Avalanche Tracks	257
Old Growth Management Area (OGMA)	4,418
Endangered Forests (EF)	300
Rare and Uncommon Ecosystems	254
Wildlife Tree Patches	1,361
Recreation Sites	56
Timber Harvesting Land Base	**46,064**
Future Roads, Trails, and Landings	500
Future Timber Harvesting Land Base	**45,564**

3.2 Location

TFL 14 is located in the Purcell Range, about 32 kilometres southwest of Golden in the East Kootenays. It encompasses the watersheds of the Spillimacheen River, Bobbie Burns and Vowell Creeks, as well as the benches directly west of the Columbia River. TFL 14 is surrounded to the northwest by Glacier National Park and to the south by Bugaboo Provincial Park. The TFL, which covers approximately 152,000 hectares, is part of the Rocky Mountain Forest District and encompassed by the boundary of the Invermere Timber Supply Area (TSA).

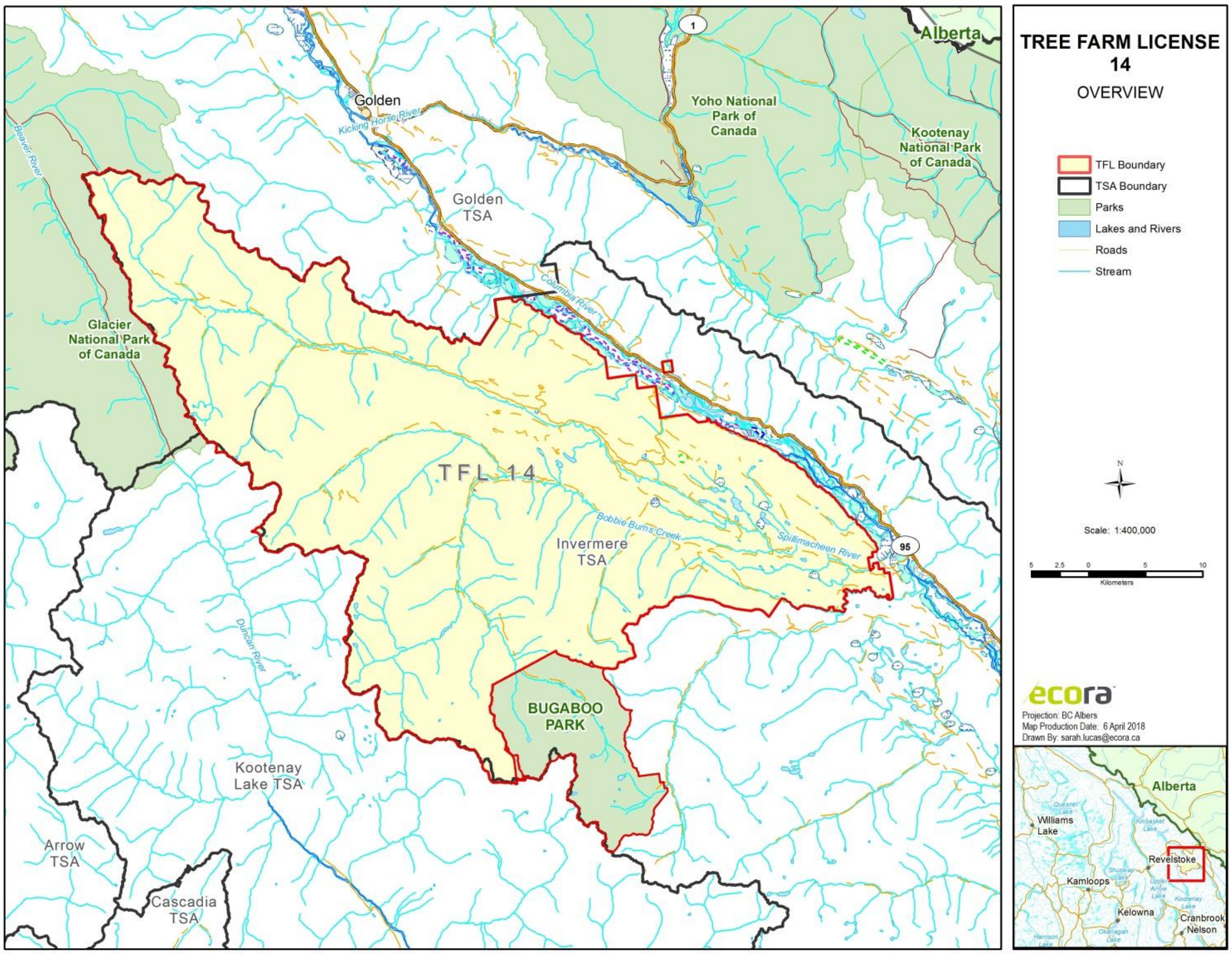

Figure 3-1: TFL14 Location

3.3 Biogeoclimatic Ecosystem Classification

The diversity of topography, climate, and soils is reflected in the forest vegetation found within the TFL and is described by four biogeoclimatic zones: Interior Douglas-fir (IDF), Interior Cedar-Hemlock (ICH), Montane Spruce (MS), and Engelmann Spruce-Subalpine Fir (ESSF). The CFLB includes both the THLB and the productive non-timber harvesting land base (non-THLB). As shown in Figure 3-2, ESSF is the dominant BEC zone in TFL 14 however, the majority of its area falls outside of the THLB. The other 3 zones are proportionally more productive containing most of their productive areas within the THLB.

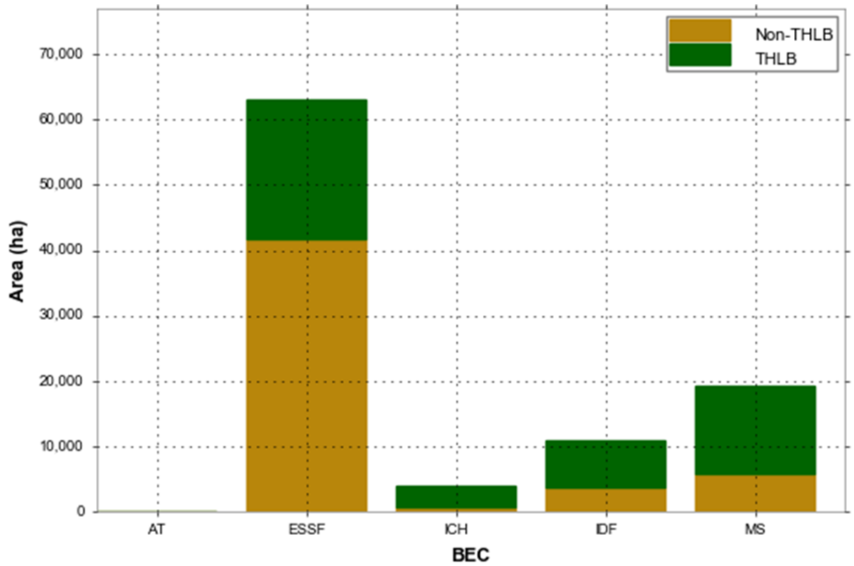

Figure 3-2: Biogeoclimatic Zones Distribution

TFL 14 has a variety of moisture regimes (wet, moist and dry), but is mainly divided in wet and dry zones and temperatures varying from mild to cool as presented in Figure 3-3. Most of the THLB is represented by dry zones (ESSFdk, ESSFdkp, ESSFdkw, and MSdk).

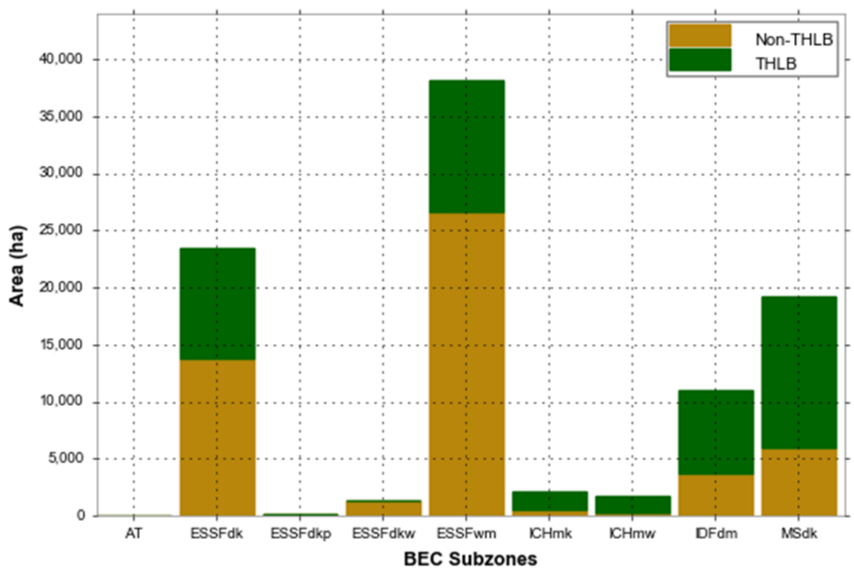

Figure 3-3: Biogeoclimatic Subzones Distribution

3.4 Current Attributes

Current land base attributes are summarized in Sections 3.4.1 through 3.4.5. This information comes primarily from the 2013 VRI while site index and volumes classes reflect the LiDAR height adjustment. Logging information, age and stand attributes have been updated to 2017. The figures presented in these sections display area summaries for the CFLB and include both the THLB and the productive non-timber harvesting land base referenced as the non-THLB.

3.4.1 Leading Species

Figure 3-4 shows the leading species within the CFLB. Most of the stands within the CFLB are pine (Pli) leading, however balsam (Bl) is the primary species in the non-THLB. Pine represents 39% of the THLB followed by spruce (Se and Sx) at 25%, Interior Douglas-fir (Fdi) at 19%, and balsam (Bl) at 15%. The remaining 2% of the THLB is composed of a variety of other minor species (including aspen, western cedar, cottonwood, birch, larch, whitebark pine and black spruce). There are 732 ha of non-commercial leading species in the THLB because stands with an existing logging history are not removed from the THLB as non-commercial cover.

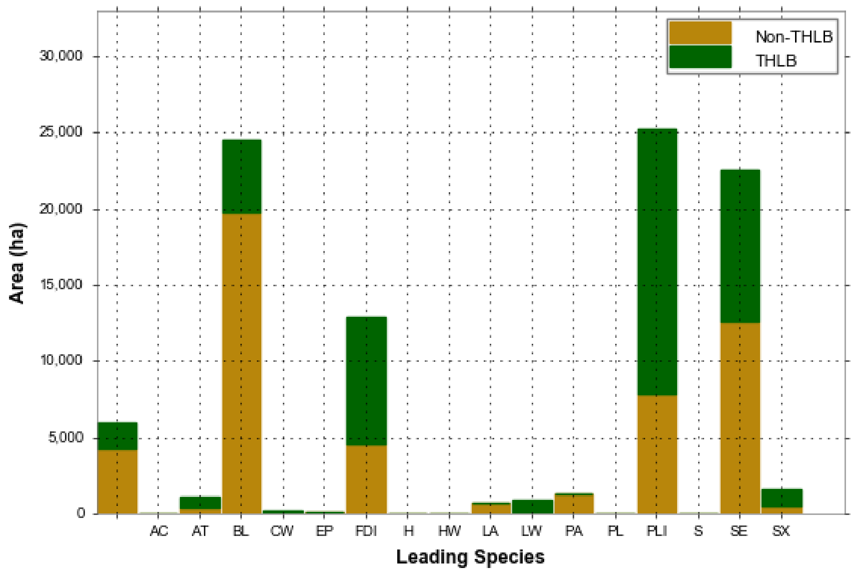

Figure 3-4: Leading Species Summary

3.4.2 Logging History

Logging history has been compiled from the Ministry of Forest, Lands, and Natural Resource Operations (MFLNRO) and Canfor corporate records including:

- Reporting Silviculture Updates and Land Status Tracking System (RESULTS);
- Consolidated cut blocks; and
- Canfor cut blocks.

Figure 3-5 summarizes the THLB and non-THLB by the decade of harvesting activities showing a small initial history of forest management tracing back to the 1940s. Harvesting activities peaked in the 2000s and 2010s with the AAC increase from the last TSR and MPB control operations. There are 23,230 ha in the THLB that have never been harvested, which is described in Figure 3-5 as logging decade 0. Because this base case models FSC certification standards, there are areas that were logged in the past that are now located within preservation areas (mainly riparian) that are no longer part of the THLB. For this reason some logged areas are reported as non-THLB in the graph below.

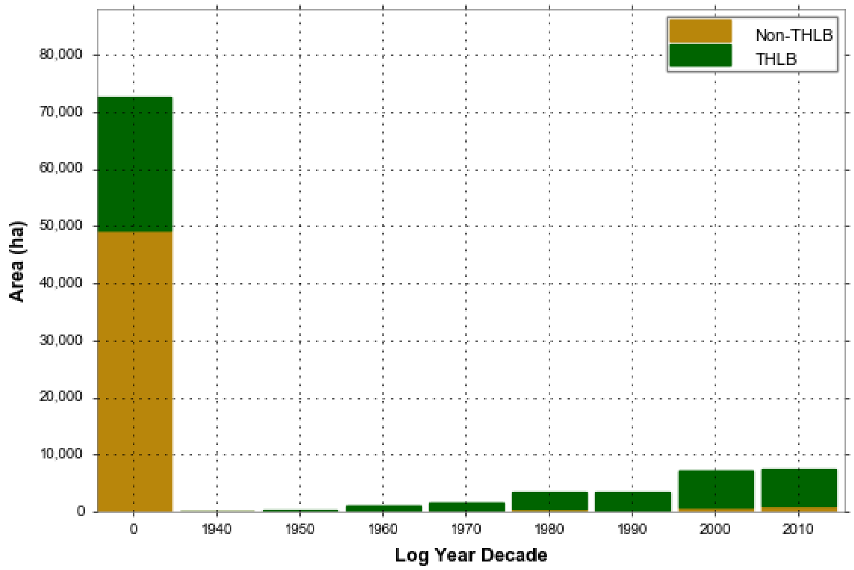

Figure 3-5: Harvested Area per Decade

3.4.3 Initial Age Class Distribution

The analysis uses age updated to January 1, 2017 and has been updated according to VRI reference year and logging activities scheduled or completed by December 31st, 2016. Figure 3-6 shows the current age class distribution. The distribution of age classes one, two and three are largely influenced by harvest history and are mostly part of the THLB. Meanwhile, the distribution of older age classes is a result of inoperability and non-timber harvesting zones.

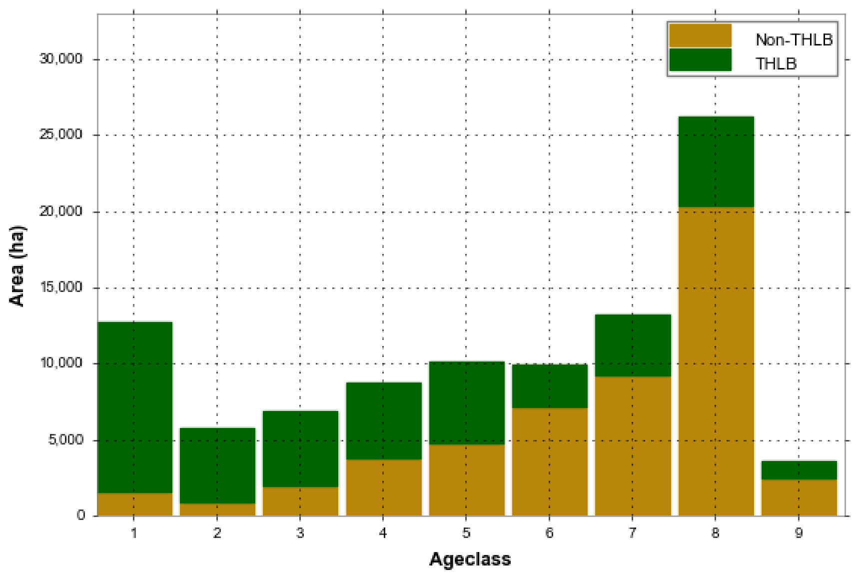

Figure 3-6: Initial Age Class Distribution

Note: Age class one includes ages 0-20, age class two includes ages 21-40, age class three includes ages 41-60, age class four includes ages 61-80, age class five includes ages 81-100, age class six includes ages 101-120, age class seven includes ages 121-140, age class eight includes ages 141-250, and age class nine is described by forest older than 250 years.

3.4.4 Site Index

Site Index by BEC Site Series (SIBEC) values are used for existing and future managed stands while VRI site index is used to estimate productivity in natural stands. Localized SIBEC data was collected for TFL 14 in 1998, 1999 and 2000, generating local site index values for tree species in local BEC and site series combinations. These values were reported in *TFL 14 Management Plan No. 9 Ecologically Based Productivity Estimates SIBEC Correlation Update* (Timberline, 2002) and used in MP #9. Where localized data was not applicable, Ministry of Forest and Range Research Branch (MoF) SIBEC database records for the Nelson Region are used (https://www.for.gov.bc.ca/pscripts/hre/sibec/sibecreports.asp). Lastly, for combinations where MoF data is not available, area weighted average of the VRI site index was used to determine the productivity. Table 3-2: describes the source and site index value for each managed analysis unit.

Table 3-2: Managed Analysis Units Site Index Values and Sources

Analysis Unit	Site Index (m)	Source	THLB (ha)
ESSFdk_01	19.90	SIBEC	1,111
ESSFdk_02	15.00	SIBEC	59
ESSFdk_03	18.00	Localized	3,087
ESSFdk_04	19.80	Localized	5,654
ESSFdk_05	18.00	SIBEC	47
ESSFdk_06	15.00	SIBEC	24
ESSFdk_07	14.29	VRI	9
ESSFwm_01	18.00	SIBEC	8,724
ESSFwm_02	15.00	SIBEC	280
ESSFwm_03	18.00	SIBEC	2,018
ESSFwm_04	18.00	SIBEC	751
ESSFwm_05	17.19	VRI	17
ESSFwm_06	17.64	VRI	16
ICHmk1_01	23.70	SIBEC	1,441
ICHmk1_05	24.40	SIBEC	149
ICHmk1_06	24.00	SIBEC	12
ICHmw1_01	19.14	VRI	1,451
ICHmw1_04	17.24	VRI	2
ICHmw1_05	16.96	VRI	103
IDFdm2_01	18.00	SIBEC	6,365
IDFdm2_02	18.28	VRI	14
IDFdm2_03	15.00	SIBEC	61
IDFdm2_04	18.00	SIBEC	812
IDFdm2_05	21.00	SIBEC	16
IDFdm2_06	19.26	VRI	8
IDFdm2_07	18.86	VRI	9
MSdk_01	22.10	Localized	7,525
MSdk_03	16.70	SIBEC	597
MSdk_04	19.00	Localized	4,762
MSdk_05	19.60	SIBEC	366
MSdk_06	15.00	SIBEC	45
MSdk_07	17.46	VRI	30
Total			45,564

Figure 3-7 shows LiDAR adjusted inventory site index distribution for the TFL 14. Site index values are highly concentrated between 15 and 21 meters within the THLB. The THLB area shown with a site index value of zero represents stands that have been recently logged and do not have an identified leading species.

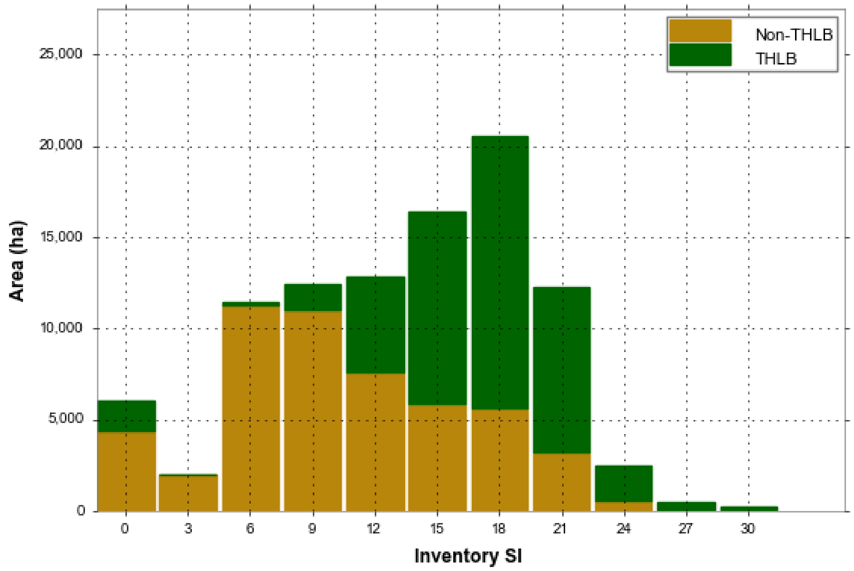

Figure 3-7: Inventory Site Index Distribution

Terrestrial Ecosystem Mapping (TEM) across the land base facilitates the use of SIBEC estimates as measures of managed stand productivity. Figure 3-8 shows the distribution of SIBEC values across the THLB. Most of the SIBEC values range between 18 and 21 meters. No site productivity value was calculated for the non-THLB areas, thus shown as zero in Figure 3-8.

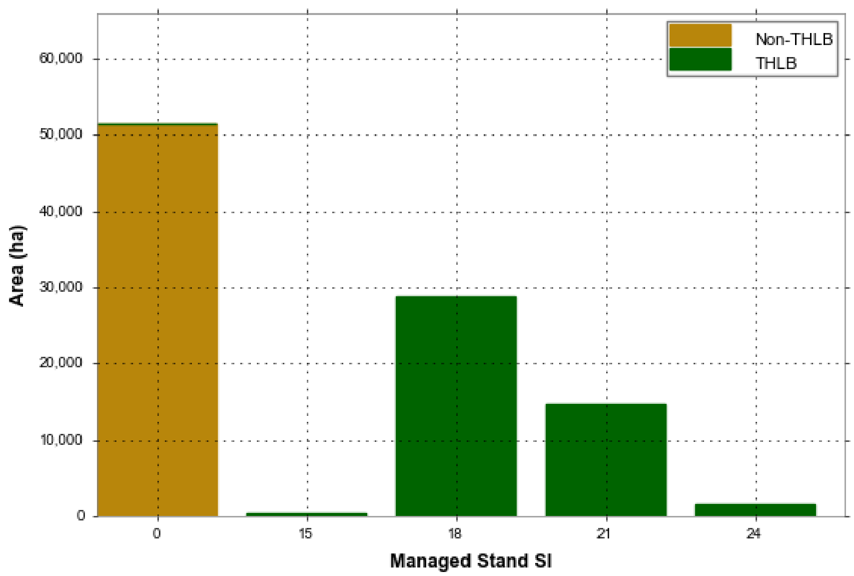

Figure 3-8: Managed Stands Site Index Distribution

3.4.5 Volume Classes

Figure 3-9 illustrates volume per hectare characteristics of the CFLB grouped into 100 m^3/ha classes. This figure shows the distribution of volume per hectare across the TFL 14. Volume distribution is closely correlated with the age class distribution. Young stands are found in the volume class zero along with older low-productivity stands often balsam leading located in ESSF zones.

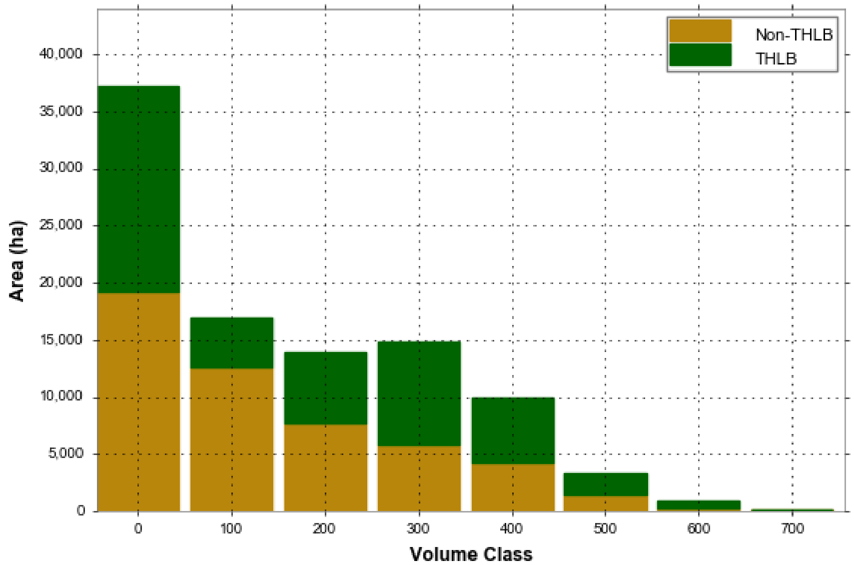

Figure 3-9: Volume Class Distribution

4. Base Case Analysis

In the summer of 2015, Canfor collected LiDAR data for trees above 10m in the physically operable area of TFL 14. From the data, individual tree crowns were identified, verified and calibrated using ground plots to create an ITI (Forsite, 2017). This ITI includes many attributes ranging from height to species and log profile. Ecora developed a method to use the ITI heights to adjust the leading species height attribute in the 2013 VRI. This process has been detailed in the memo "*Vegetation Resource Inventory Height Adjustment Using LiDAR Data"* (Ecora, 2018). This memo can be found in Appendix B. This adjustment has been approved by FAIB experts as a way to improve the overall height and volume estimates of the VRI.

The adjustment to stand-level leading species height based on the ITI data was applied to 36,247 ha of productive never logged mature polygons (> 60 years) that overlapped with the ITI. The ITI did not overlap with 137 ha of the THLB that satisfied the adjustment criteria. This adjustment area represents 41% (18,613 ha) of the THLB and resulted in an average height increase of 15% (3.42m) and an average volume per ha increase of 14%. As a comparison, the inventory adjustment applied to the 1986 Forest Cover inventory increased the overall target population heights by 7% and the volume by 11% (Timberline, 2000).

Table 4-1 shows a snapshot of the adjustment impact stratified by leading species and age class. The height adjustment factor column is defined as the ITI height divided by the VRI height, and the volume adjustment factor is calculated similarly. The last row shows the total THLB area affected by the adjustment and the area-weighted averages of the volume per ha, height and adjustment factors.

Table 4-1: Adjustment Impact Summary

Leading species	Age class (yrs)	THLB (ha)	VRI average height (m)	ITI adjustment average height (m)	Height adjustment factor	VRI average volume (m^3/ha)	Adjusted VRI average volume (m^3/ha)	Volume adjustment factor
BL	60-100	615	17.47	24.08	1.378	148.2	197.5	1.332
BL	100-150	624	20.04	26.74	1.335	203.3	271.7	1.336
BL	150-200	291	22.76	28.88	1.269	232.2	305.6	1.316
BL	200+	64	23.33	28.25	1.211	254.4	299.7	1.178
FDI	60-100	2,230	24.55	26.94	1.097	248.4	262.3	1.056
FDI	100-150	1,494	29.98	31.79	1.060	343.9	361.2	1.050
FDI	150-200	355	32.23	33.01	1.024	389.3	396.3	1.018
FDI	200+	145	32.63	29.09	0.891	393.8	342.9	0.871
PLI	60-100	4,186	20.90	24.82	1.188	257.2	307.9	1.197
PLI	100-150	2,333	23.34	27.19	1.165	278.1	334.7	1.204
PLI	150-200	98	26.79	28.49	1.063	349.0	358.7	1.028
PLI	200+	52	27.05	28.32	1.047	349.4	346.6	0.992
SE	60-100	836	21.95	26.94	1.227	190.2	223.6	1.176
SE	100-150	2,385	27.04	29.99	1.109	286.5	313.1	1.093
SE	150-200	1,183	28.53	32.40	1.136	294.9	331.5	1.124
SE	200+	1,684	30.50	32.87	1.078	336.0	363.8	1.083
SX	60-100	8	22.13	28.35	1.281	146.0	214.2	1.467
SX	100-150	19	28.29	30.32	1.072	288.2	294.3	1.021
SX	150-200	6	31.49	34.57	1.098	281.8	316.3	1.122
SX	200+	4	26.53	28.05	1.058	231.8	234.2	1.010
		18,613	24.82	28.24	1.148	274.5	310.9	1.143

New Variable Density Yield Projection (VDYP) 7 tables were generated for the adjusted polygons using the ITI height and were incorporated into the timber supply model. Because there is a curve for each VRI polygon, we cannot show them all in this document, however Figure 4-1 shows a comparison of the average 2013 VRI and ITI adjusted VDYP curves for all natural stands within the THLB. Average volume at age 80 increases by 37 m^3/ha (20%).

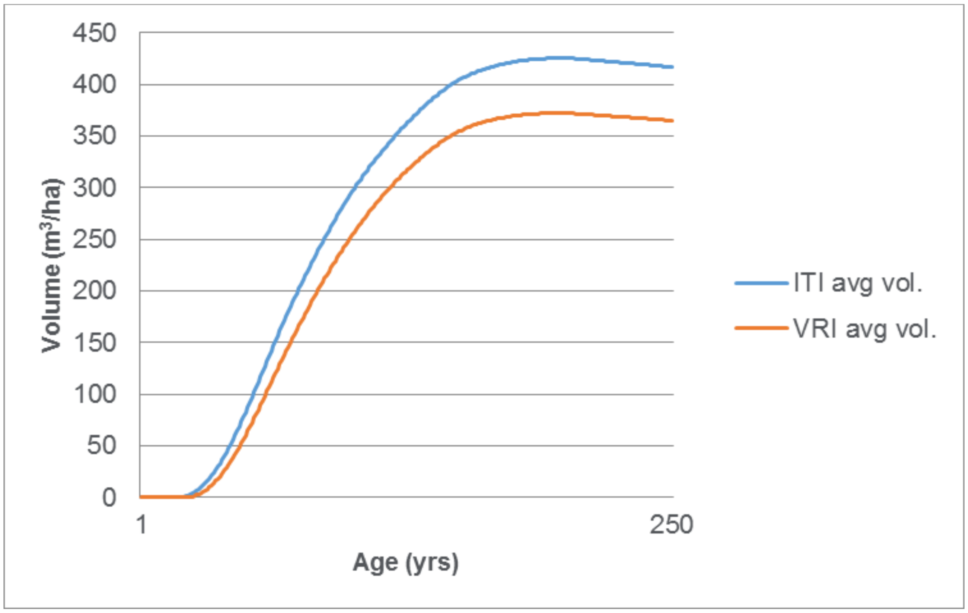

Figure 4-1: Average Volume Curve of Natural THLB Stands

As LiDAR data becomes increasingly available throughout the province of British Columbia, it will become standard practice to incorporate this more accurate data into timber supply models. Currently, there is no standard process recognised provincially. However, the height adjustment methodology that has been accepted and applied in this analysis represents a solid, conservative, and defensible improvement to the data.

4.1 Harvest Characteristics

This base case strives to find a balance between the current and future timber supply that minimizes the negative social and economic impacts a lower harvest level can cause, while meeting non-timber objectives including FSC certification standards. The presented base case best achieves this goal.

All scenarios presented in this document are modelled using the forest estate model Patchworks based on assumptions defined in the Data Package. All harvest levels reported are net of non-recoverable losses (NRL) of 6,524 m^3/year. In the base case scenario, an average harvest level of 181,000 m^3/year can be sustained during the first 20 years of the modelling period. This is 1,000 m^3/year higher than the current AAC. In the mid-term, this level decreases to an average of 163,000 m^3/year. The harvest level further decreases after 40 years and is forecast to remain at 157,000 m^3/year throughout the long-term.as shown in Table 4-2. This harvest flow forecast maintains the current AAC and provides a gradual transition to the more sustainable, long-term harvest level. This trend is demonstrated in Figure 4-2.

Table 4-2: Base Case Average Harvest Level

Years	Base Case m^3/yr
1 to 20	181,000
21 to 40	163,000
41 to 250	157,000

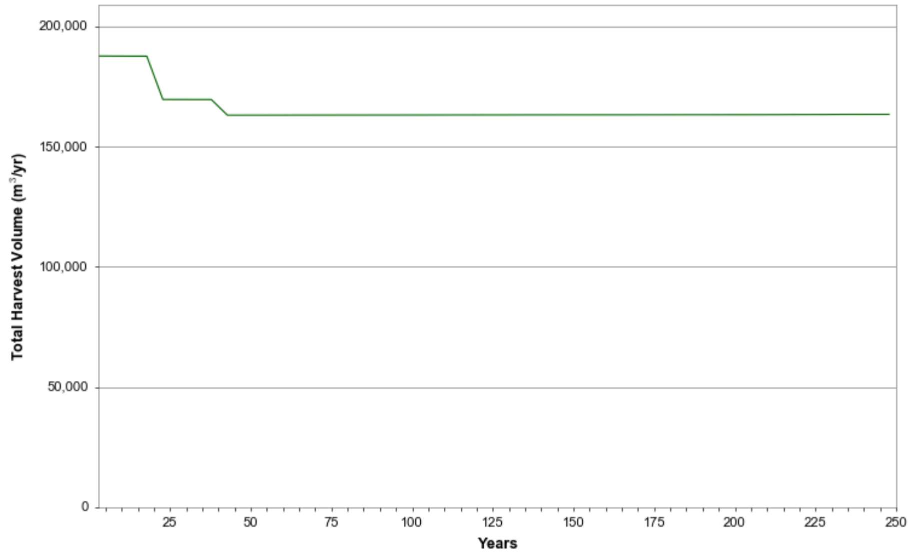

Figure 4-2: Base Case Harvest Flow

In all modelled scenarios for TFL 14 in the current and past TSR, the total growing stock flow follows a similar trend as displayed in Figure 4-3. The total THLB growing stock experiences a significant drop in the initial 30 years, but recovers a small amount as a result of growth from more productive managed stands. At the end of the planning horizon, 3,304 ha of natural stands remain un-harvested. This is primarily due to requirements to satisfy visual quality objective targets along Highway 95 (2,796 ha) and to the inability of some previously logged stands to reach the minimum harvest volume (508 ha). This issue is further explained in Section 4.3. A minimum growing stock level target of 5,500,000 m^3 was set starting in year 150 until the end of the planning horizon to assure a future sustainable and stable growing stock.

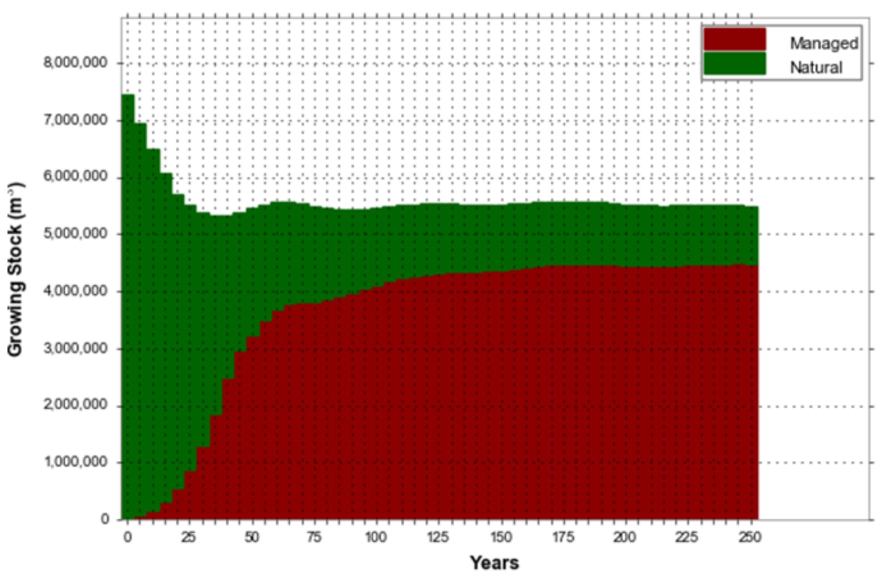

Figure 4-3: Total THLB Growing Stock by Natural and Managed Stands

TFL 14 has an extensive history of harvesting and planting operations. For that reason, managed stands begin to be harvested as early as 45 years into the planning horizon. Compared to natural stands, managed stands are predicted to be more productive, becoming the dominant stand type to contribute to the harvested volume in 60 years. This is demonstrated in Figure 4-4 below.

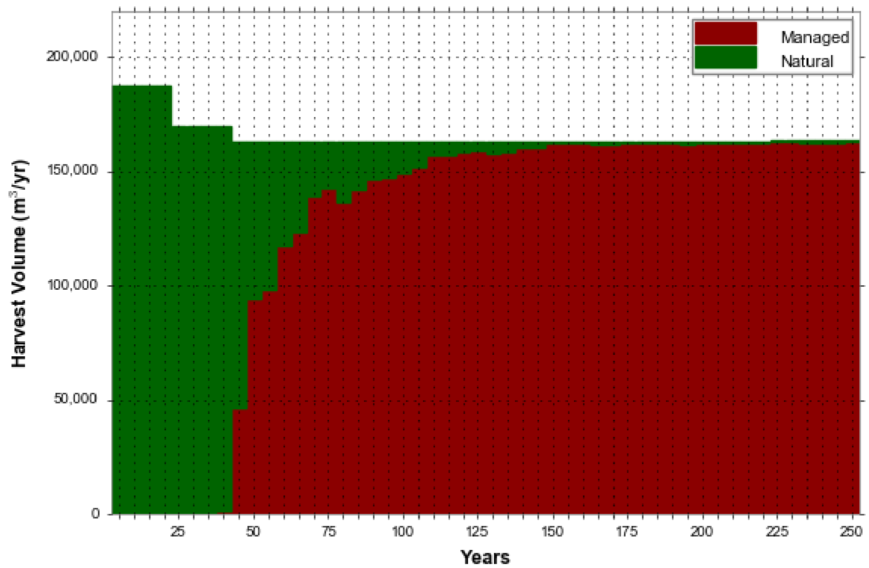

Figure 4-4: Total Harvest Volume by Natural and Managed Stands

For the first 15 years the average harvest age is at its highest (157 years) because Patchworks will generally select many of the oldest stands first in order to get these stands onto productive managed stands. Also, these stands often contain the most volume per ha which helps the model to meet short-term harvest objectives. Starting in year 16 the average harvest age goes through a gradual decline until year 50 when it stabilizes at 81 years minimally fluctuating until the end of the planning horizon. The transition from natural to faster growing managed stands causes the average harvest age to lower as seen in Figure 4-5.

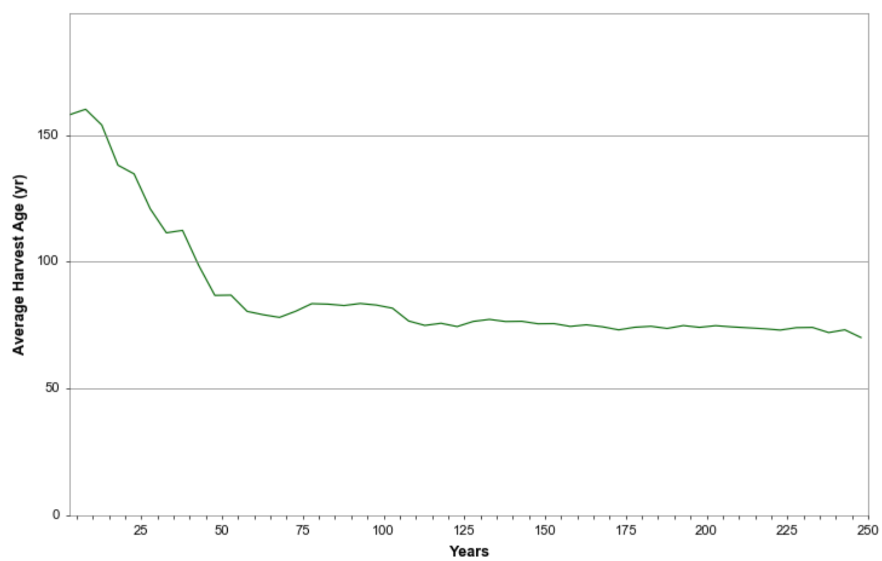

Figure 4-5: Average Harvest Age

When the majority of the volume comes from natural stands, the average harvest volume per hectare (VPH) is 336 m^3/ha. This is displayed in Figure 4-6. Patchworks optimizes all scenarios to achieve a number of rotations yielding the highest harvest volumes while prioritizing the achievement of non-timber objectives. The model accomplishes this goal by harvesting managed stands at a lower average VPH (300 m^3/ha) on shorter rotations (as shown in Figure 4-5) maximizing the total harvest volume across multiple rotations by harvesting close to the culmination of the mean annual increment (MAI).

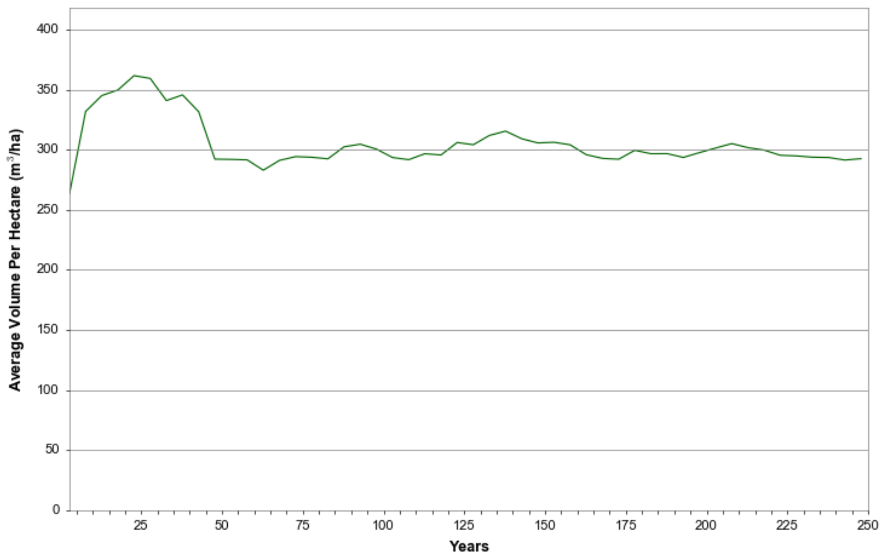

Figure 4-6: Average Harvested Volume per hectare

Total harvest area by leading species is shown in Figure 4-7. This chart shows the area by leading species harvested throughout the planning horizon. Pine stands lead the harvest profile followed by spruce leading stands.

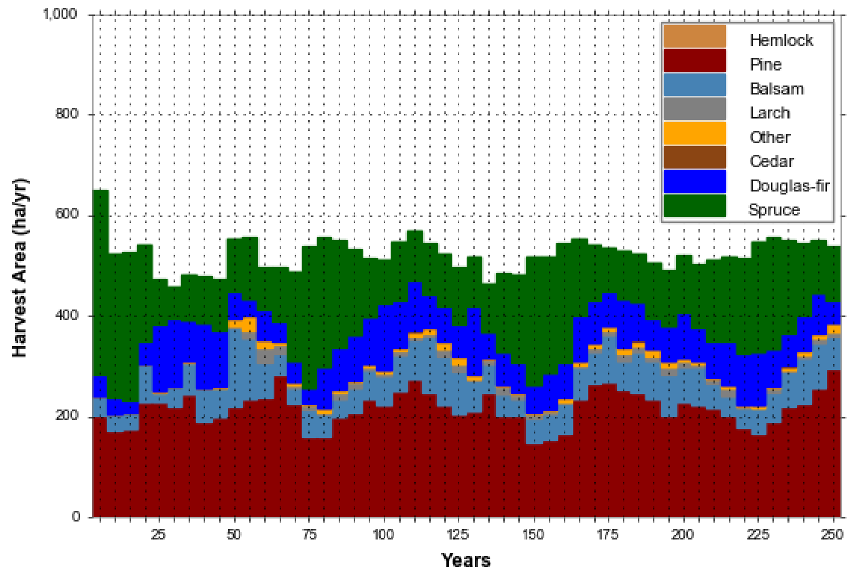

Figure 4-7: Harvest Area by Leading Species

Another important source of information is the forecasted age class distribution of the land base over the planning horizon. Figure 4-8 shows that older THLB is harvested as time progresses, leaving the non-THLB areas to mature. Disturbances are not applied to the non-THLB allowing it to collect at age class 9. The THLB roughly represents one third of the land base and becomes primarily distributed across age classes 1 through 4 as time advances. Old seral targets are met with non-THLB areas while visual quality objectives require the retention of some THLB areas in order to be achieved.

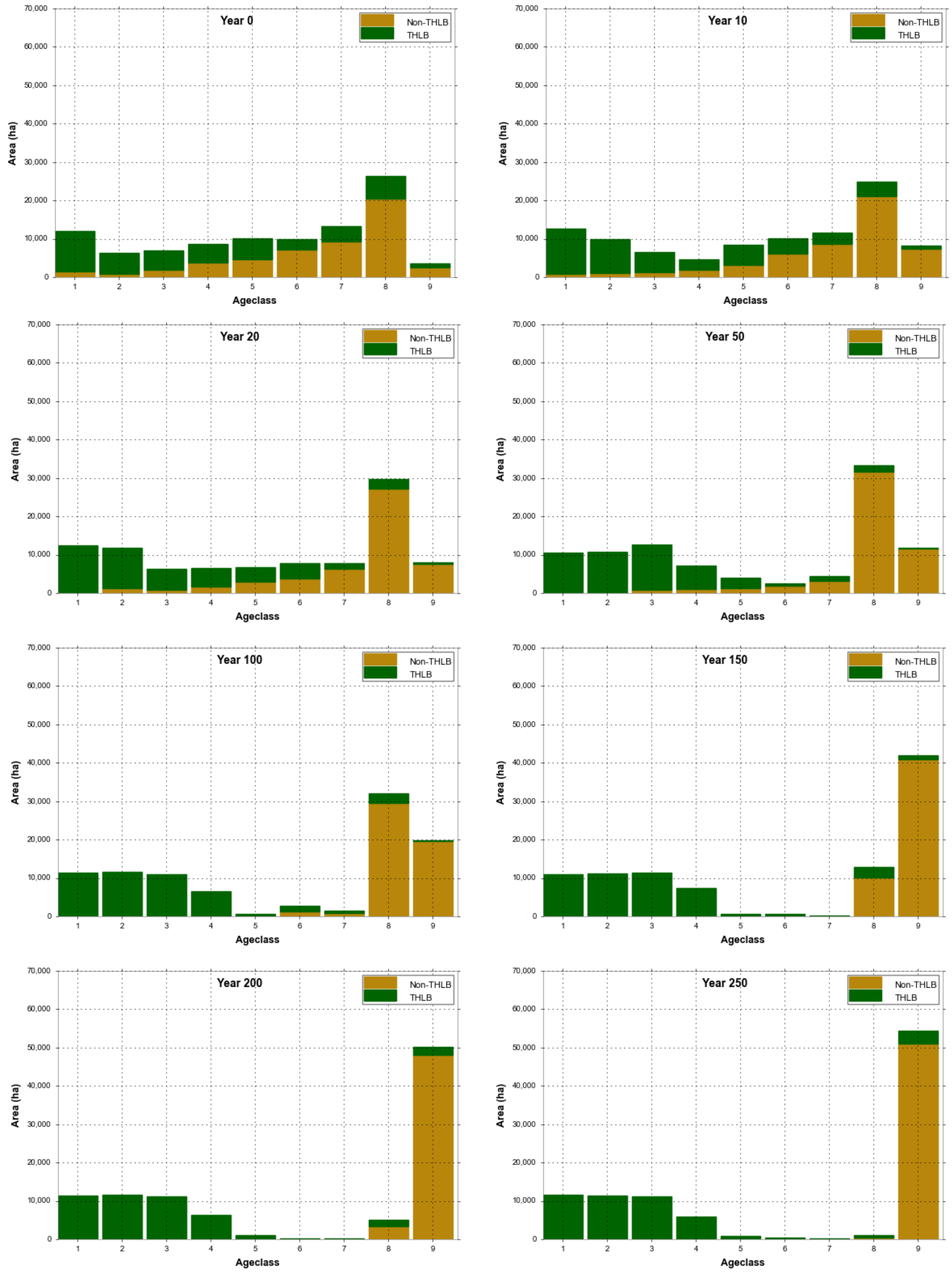

Figure 4-8: Age Class Distribution in the CFLB

4.2 Alternative Harvest Flow

Important information can be learned from modelling different harvest flows using base case assumptions. The characteristics of TFL 14 do not allow for much flexibility in choosing harvest flows. By not prioritizing salvaging MPB affected stands or MPB control in pine stands, one key alternative flow is left to be explored. While the base case focuses on a higher harvest level in the short-term to ease the transition into the mid and long-term levels, the alternative flow emphasizes an even level of harvest volume.

Modelling a non-declining even flow resulted in a harvest level of 160,000 m^3/year (Figure 4-9). This scenario presents a 12% lower harvest level than the base case in the short-term, a 2% lower level in the mid-term, and a 2% higher harvest level in the long-term. The non-declining flow trades off a lower short-term harvest volume for a higher long-term harvest level. Table 4-3 shows the harvest level for the alternative harvest flow scenario.

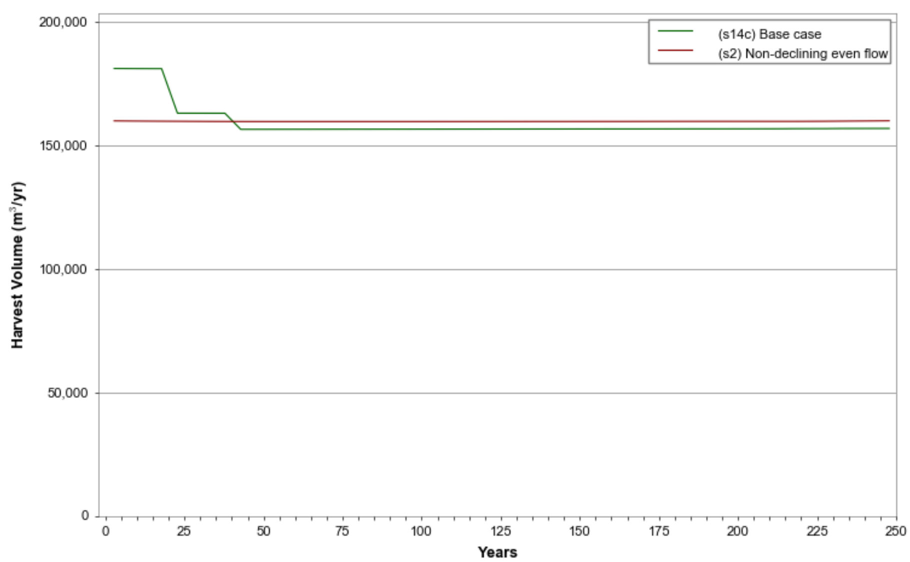

Figure 4-9: Even Harvest Flow

Table 4-3: Even Harvest Flow

Years	Base Case m³/yr	Even Harvest Flow	
		m³/yr	% Change
1 to 20	181,000	160,000	-12%
21 to 40	163,000	160,000	-2%
41 to 250	157,000	160,000	2%

4.3 Non-timber Objectives

The maintenance of non-timber objectives such as wildlife habitat, biodiversity, recreation, and visual quality represent an important component of the overall timber supply for the TFL. Most directives on integrated resource management (IRM) for TFL 14 are specified by the Kootenay Boundary Higher Level Plan Order (KBHLPO), issued in 2001.

Non-timber objectives are modelled in the base case as explained in the Data Package. In the forest estate model these objectives are treated as highest priority targets – the model will not sacrifice non-timber objectives in favor of increased harvest. Some targets start the modelling period in violation; however as the forest matures those targets are met and remain fulfilled throughout the planning horizon. By the end of the planning horizon (year 250) approximately 3,300 ha of THLB remain un-harvested. 500 ha are not harvested because they do not reach minimum harvest volume at mature age despite having a logging history, while the remaining 2,800 ha are not harvested to fulfill non-timber objectives.

A scenario where all non-timber targets were deactivated was conducted to assess the impact on harvesting. In this scenario, all stands above the operability threshold were harvested. However, in the base case stands (red) displayed in Figure 4-10 are recruited by the forest estate model to meet non-timber objectives.

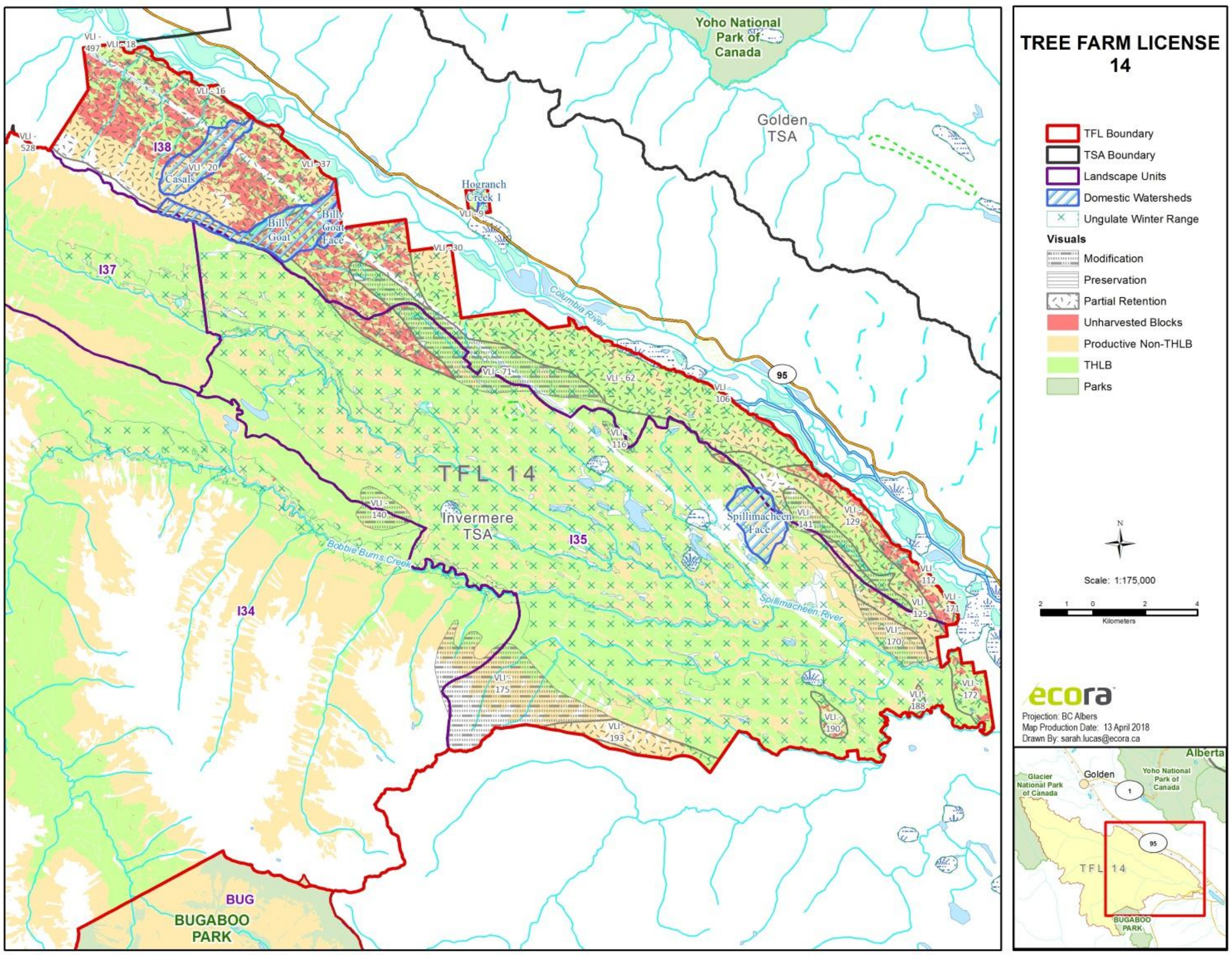

Figure 4-10: Un-harvested Stands

Un-harvested stands are located in landscape units I38 and I35. Despite overlapping resource management zones, visual quality objectives (VQO) are the only truly constraining target. No harvest occurs in preservation VQOs, however, they only total 30 ha of the THLB, not having a significant impact to the timber supply. Partial retention VQOs are the most constraining, specifically polygons 20, 129, 172 and 190 from the visual landscape inventory (VLI). Figure 4-11 (graphs extracted from Patchworks) shows the status of the target through time in these polygons (black line), the maximum target area (purple) and the available target area (white). For example, in VQO polygon 20 (top left graph - PR_L_20) a maximum of 3% (approximately 150 ha) can be of height lower than 6m. In polygon 129 and 190 a maximum area of 2% (10 ha) and 10% (12 ha) can be of height less than 6m.

Finally, in polygon 172 a maximum of 11% (33 ha) of the polygon area can be of height less than 5.5m. These polygons occupy 4,400 ha of the THLB, thus having a significant impact on the harvest level.

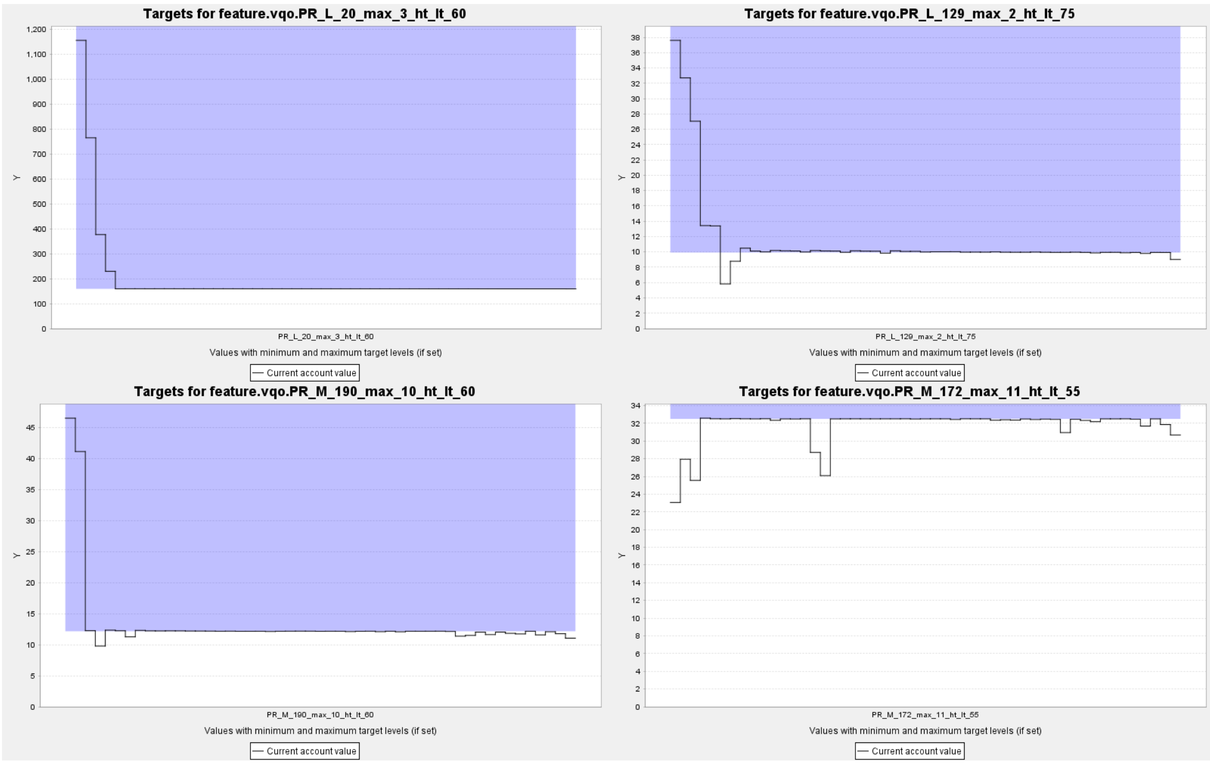

Figure 4-11: Harvest Flow in Constraining VQO Polygons

4.4 Differences from MP #9

This section compares the differences between the current analysis and the results presented in support of MP #9. As stated in the *Tree Farm Licence 14 - Rationale for Allowable Annual Cut (AAC) Determination* (MFLNRO, 2008):

> *"In my review of the harvest forecasts provided, I am also aware that a non-declining harvest flow of 180 000 cubic metres per year is attainable based on the assumptions used in the base case and by changing the harvest sequence to "oldest first". In the event that constraints on the timber harvesting land base increase in a similar manner as assumed in the FSC Options, an initial harvest level of 180 000 cubic metres per year could be maintained for 60 years before decreasing to a similar level as the non-declining harvest flow based on the same assumptions."*

The current AAC was set based on two scenarios presented in MP #9: non-declining even flow under FRPA standards, and the more conservative of the FSC options. The analysis in this section compares the base case in support of MP #10 with MP #9's most conservative FSC options because both scenarios are modelled based on FSC certification assumptions.

The harvest level difference between the MP #10 base case and MP #9 is only significant from year 21 to 60, which currently is 30 years as 10 years has passed since the last TSR. The current base case carries out the initial harvest level proposed in MP #9, drops to a lower mid-term harvest level, and has a 2% higher long-term harvest level. When comparing non-declining even flow scenarios, the MP #10 has a 4% higher overall harvest level than in MP #9. Both scenarios are summarized in Table 4-4 according to available information in *Tree Farm License 14 Management Plan 9* (Forsite, 2007).

Table 4-4: Harvest Level Comparison with MP #9

Years	MP #10		MP #9		% Change	
	Base Case m^3/yr	Even Flow m^3/yr	Base Case m^3/yr	Even Flow m^3/yr	Base Case	Even Flow
1 to 20	181,000	160,000	180,000	153,000	1%	4%
21 to 60	160,000	160,000	180,000	153,000	-13%	4%
61 to 80	157,000	160,000	162,000	153,000	-3%	4%
81 to 250	157,000	160,000	154,000	153,000	2%	4%

The following represent the key factors contributing to the lower harvest level in MP #10:

1. Growing stock: the initial growing is approximately 12% lower than MP #9's FSC option scenario mainly because the growing stock has declined after 10 years of harvesting at the current AAC. This decline was presented in the growing stock chart found in Section 7 of the *Tree Farm License 14 Management Plan 9* (Forsite, 2007).
2. The current THLB is 1% smaller than the FSC Option scenario in MP #9.
3. Non-recoverable losses are 3,500 m^3/year greater than in MP #9.
4. Partial retention VQOs are highly constraining in this analysis unlike in MP #9 where they were modelled as a partial cutting regime. Partial cutting was modelled in partial retention polygons and assumed to fulfill visual quality requirements because *'the three-pass, future "partial" harvest analysis units should always meet or exceed the partial retention (PR) VQO objective throughout their entire cutting cycle since the stand entries remove 33% and 67% volume removal rates in the first two passes, respectively*.' (Forsite, 2007). The approach in MP #9 allows for 33% of the VQO polygon to be harvested every 20 years. Conversely, only up to 11%

of partial retention polygons can be harvested every 20 years (approximately the age the forest reaches 6m) in MP #10.

In contrast, the three main differences that push the current harvest level upwards are:

1. MP #9 analysis modelled disturbance of the non-THLB while the current analysis does not. Modelling disturbances in the non-THLB prevents it from perpetually aging and fulfilling non-timber targets. It is estimated that approximately 200 ha of non-THLB would be annually disturbed having little impact on the fulfillment of seral targets, which would be most affected by modelling these disturbances. It is presumed that the impact of not modelling non-THLB disturbances is low.
2. MP #9 added a 30% operational adjustment factor (OAF 2) for Armillaria to Fd leading stands in the ICH while the current analysis applied 10.8% based on recent studies completed for the Invermere TSA for use in its most recent TSR.
3. Old seral targets in low biodiversity emphasis areas had 1/3 of the required target met in the first rotation, 2/3 in the second rotation, and full target on the third rotation as prescribed in Canfor's Sustainable Forest Management Plan (SFMP). MP #9 modelled full seral targets starting in the first year of the modelling period.

5. Sensitivity Analysis

Sensitivity analysis provides information on the degree to which uncertainty might affect the proposed harvest level for the land base. These uncertainties arise in the base case data and assumptions. The magnitude of the change in the sensitivity variable(s) reflects the severity of risk associated with a particular uncertainty – a very uncertain variable with minimal impact on the harvest forecast corresponds to low risk. By developing and testing a number of sensitivity issues, it is possible to consider uncertainty while determining which variables significantly impact results and provide information to guide management decisions.

Each sensitivity listed in Table 5-1 was modelled as its own scenario to test the impact of changing a variable from the base case. The harvest levels reported in this section are net of NRL of 6,524 m^3/year. The impacts were measured against the base case scenario.

Table 5-1: Sensitivity Analysis Scenarios

Sensitivity	Range Tested	Scenario
VRI unadjusted height	VRI heights are not adjusted and new VDYP yield tables used.	1% smaller THLB and original VRI natural stand curves.
FRPA	FRPA standards instead of FSC certification.	Rare ecosystems, endangered forests, OGMAs and wildlife avalanche tracks are included in the THLB. Riparian zones were modified to FRPA standards, and then removed from the THLB.
Aspatial seral targets	Old and mature seral requirements are modelled using retention requirements by LU-BEC from the KBHLPO.	OGMAs are not removed from the THLB, and seral targets are aspatially modelled.
Yield Assumption	Increase / decrease both managed and natural stand yields.	Natural stand yield tables (NSYT) +/- 10%.
		Managed stand yield tables (MSYT) +/- 10%.
Inventory Site Index	Use of inventory site index instead of SIBEC values.	Average inventory site index is used to generate managed stand curves in TIPSY.
Harvesting on slope > 40%	Set harvesting targets for areas where slope > 40%.	Harvest cap based on past performance is set on slope > 40%.
		Target to increase harvest on slope > 40% by 10% more than in the base case.
Patch size target	Replace green-up targets with Patch size targets.	Sets a maximum and minimum target for early seral patches.
Minimum Harvest Age (MHA)	Assess the impacts of changing MHA.	Increase the minimum harvestable volume.
		Decrease the minimum harvestable volume.

5.1 Original VRI Data

A scenario using the 2013 VRI data is modelled to assess the impact the base case height adjustment has on the timber supply forecast. The THLB in this scenario is the same as published in the Data Package, which is 582 ha smaller than the base case. The original VRI VDYP tables are used in this scenario for natural stands. These curves are on average 20% less productive than the base case at 80 years of age as described in Section 4 and the initial growing stock is 13% lower than the base case. This lower productivity has a large effect to the short and mid-term harvest level when natural stands are harvested as shown in Table 5-2. Figure 5-1 displays the harvest flow comparison with the base case.

Table 5-2: VRI Harvest Level

Years	Base Case m³/yr	VRI Height	
		m³/yr	% Change
1 to 20	181,000	162,000	-11%
21 to 40	163,000	154,000	-6%
41 to 250	157,000	155,000	-1%

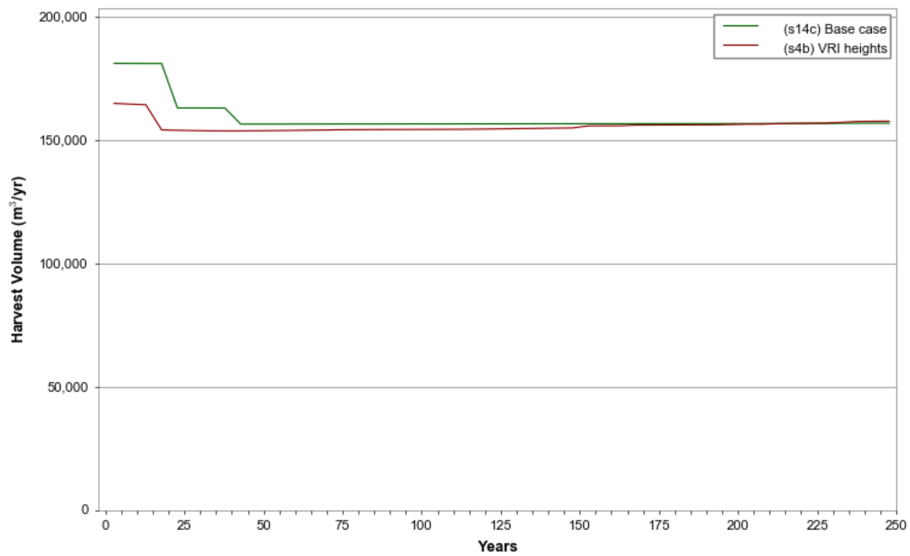

Figure 5-1: Unadjusted Heights Harvest Flow

5.2 FRPA Standards

A sensitivity analysis modelling FRPA standards is conducted. It starts with changing netdown steps to allow the inclusion of avalanche tracks, endangered forest areas, rare ecosystems, and OGMAs in the THLB. Riparian buffers changed to FRPA standards instead of FSC guidelines which adds over 4,000 ha to the THLB. In this scenario, the THLB occupies 53,407 ha and is 17% greater than the base case. The growing stock is 9,250,000 m^3, which is 24% more than the FSC growing stock. Non-timber targets were modelled identically to the base case, except for seral targets being aspatially modelled, and there is no modelling of high conservation value forest 1102 (HCVF 1102).

With the increased THLB, the harvest level surpasses the current AAC by 6,000 m^3/year yielding a non-declining harvest flow of 186,000 m^3/year. The results are summarized in Table 5-3 and Figure 5-2.

Table 5-3: FRPA Standards Harvest Level

Years	Base Case m³/yr	FRPA Standards	
		m³/yr	% Change
1 to 20	181,000	186,000	3%
21 to 40	163,000	186,000	14%
41 to 250	157,000	186,000	19%

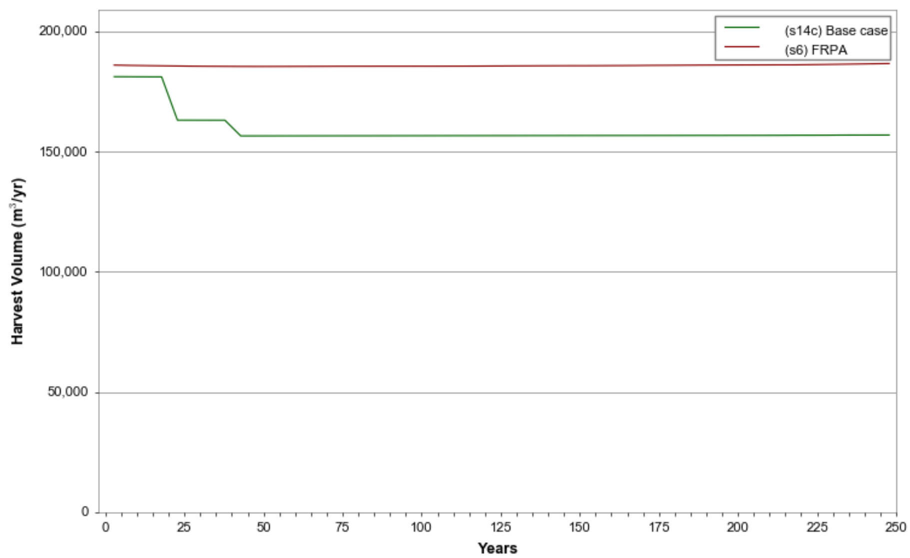

Figure 5-2: FRPA Standards Harvest Flow

5.3 Aspatial Seral Targets

In the base case, mapped OGMAs are excluded from the THLB as a netdown step, and are used to fulfill seral targets described in the KBHLPO. In this sensitivity analysis, 6,866 ha of OGMAs are allowed to be part of the THLB, but due to overlap with other netdown items a total of 3,747 ha are moved into THLB constituting an 8% increase over the base case. Old and mature+old seral targets are then modelled aspatially as set by the KBHLPO and described in the data package. This allows the forest estate model to optimize which stands to retain to fulfill these targets. As a result of this increased flexibility and the addition of high volume OGMAs to the THLB, the harvest level had an overall increase of 5% and 6% as shown in Table 5-4 and Figure 5-3.

Table 5-4: Aspatial Seral Target Harvest Level

Years	Base Case m³/yr	Aspatial Seral Targets	
		m³/yr	% Change
1 to 20	181,000	191,000	5%
21 to 40	163,000	172,000	5%
41 to 250	157,000	167,000	6%

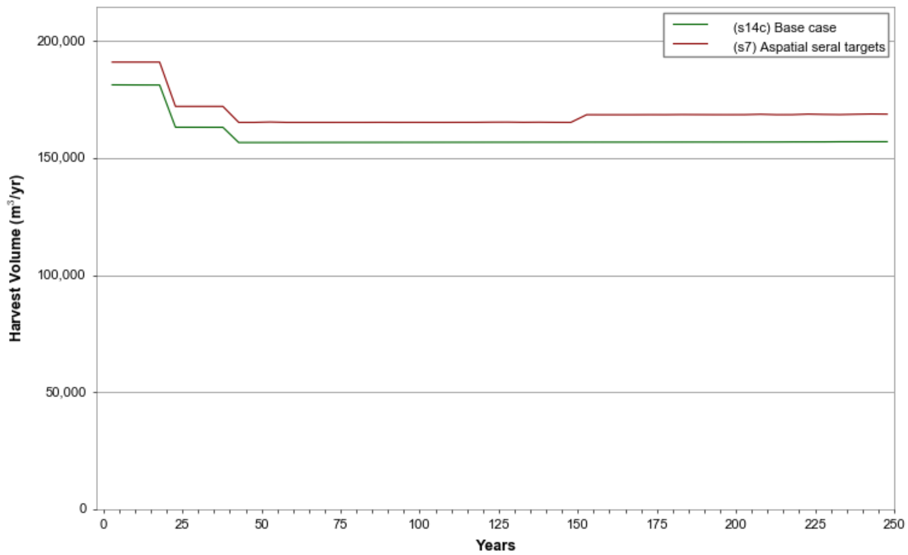

Figure 5-3: Aspatial Seral Targets Harvest Flow

5.4 Yield Assumptions

Sensitivity analyses encompassing natural and managed stand yields help us understand how much uncertainty in yield models and assumptions affects the short, mid and long-term harvest forecasts for TFL 14. This section includes two types of sensitivities: those on natural stand yields and on managed stand yields.

Increasing natural stand yield tables (NSYT) by 10% places the initial growing stock at approximately the same level as MP #9. In this scenario a harvest level of 202,000 m^3/year is achieved in the first two decades, then dropping to 182,000 m^3/year for another 20 years after which it stabilizes at 157,000 m^3/year throughout the long-term. The results of this scenario closely replicate the less conservative SFMP option in MP #9 (Forsite, 2007, p 52). When natural stand yields are decreased by 10%, the harvest level is decreased by an average of 5% in the short-term, 6% in the mid-term and 2% the in long-term when compared to the base case scenario. Both scenario results are depicted in Figure 5-4 and Table 5-5.

Table 5-5: Average Annual Harvest Levels – Natural Stand Yield Tables (NYST)

Years	Base Case m³/yr	NSYT -10%		NSYT +10%	
		m³/yr	% Change	m³/yr	% Change
1 to 20	181,000	172,000	-5%	202,000	11%
21 to 40	163,000	153,000	-6%	182,000	11%
41 to 250	157,000	153,000	-2%	157,000	1%

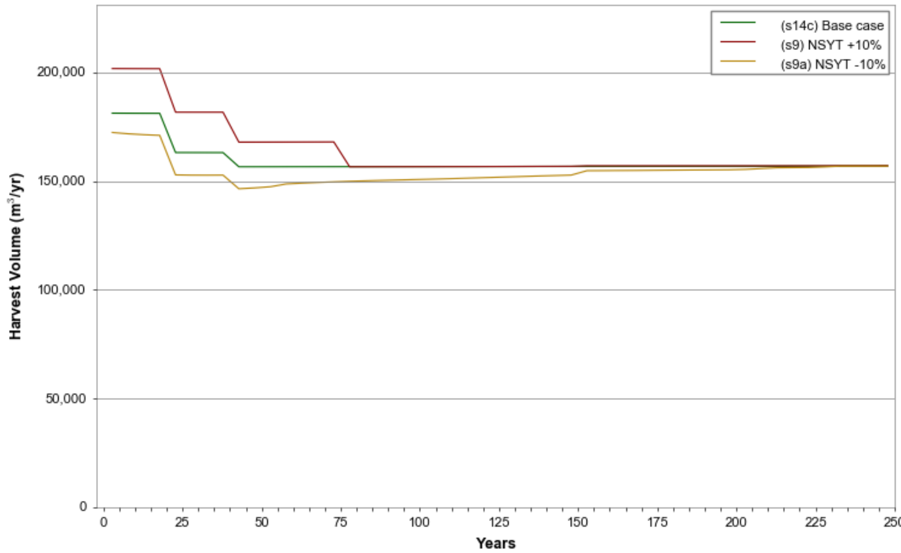

Figure 5-4: Natural Yield Harvest Flow

Figure 5-5 and Table 5-6 show the potential impact that a 10% increase or decrease of managed stand yields may have on timber supply. When managed stand yields are decreased, the harvest level immediately drops because natural volume is retained to mitigate the future decrease in managed stand productivity. On average, the long-term harvest level falls by 9%. On the other hand, increasing managed stand yields by 10% also raises the long-term harvest level by 10% while maintaining the same short and mid-term flows when natural stands are harvested.

Table 5-6: Average Annual Harvest Levels – Managed Stand Yield Tables (MSYT)

Years	Base Case m³/yr	MSYT -10%		MSYT +10%	
		m³/yr	% Change	m³/yr	% Change
1 to 20	181,000	179,000	-1%	181,000	0%
21 to 40	163,000	161,000	-1%	163,000	0%
41 to 250	157,000	142,000	-9%	173,000	10%

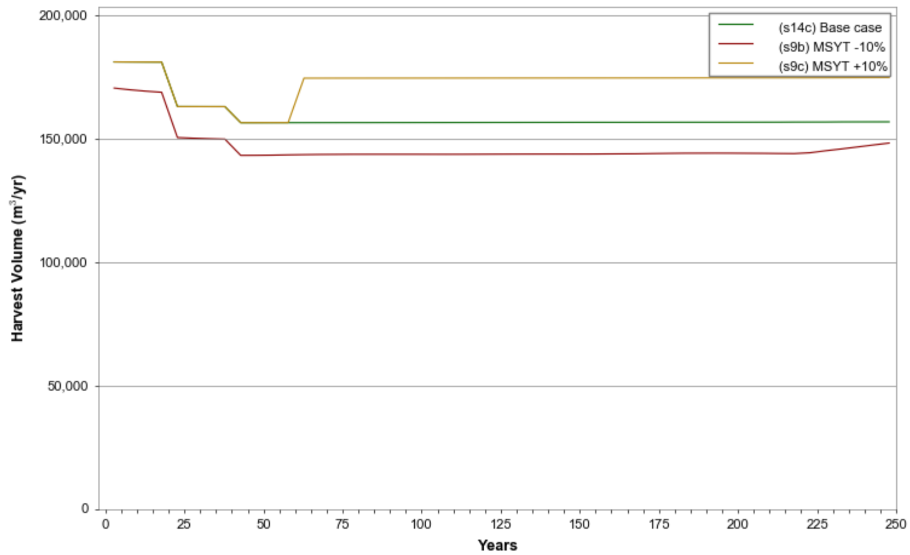

Figure 5-5: Managed Yield Harvest Flow

5.5 Inventory Site Index

In the base case analysis, site productivity for managed stands is derived from SIBEC values and average inventory site index when SIBEC is not available. It is important to gauge the impact SIBEC values have on the timber supply. This sensitivity analysis replaces SIBEC values with the area weighted average of inventory site index to generate managed stand yield curves. This is a likely book-end representing the lower range of possible values. This change has a high impact to harvesting levels because the inventory site index yield tables are on average 19% less productive than the SIBEC based curves. The results are shown in Table 5-7 and Figure 5-6. The harvest flow in this sensitivity is similar to the scenario where managed yield curves are reduced by 10%. In both sensitivities, the forest estate model reserves natural volume to fulfill future harvest targets. This sensitivity results in an 18% decrease of the long-term harvest level.

Table 5-7: Inventory Site Index Harvest Level

Years	Base Case m^3/yr	Inventory Site Index	
		m^3/yr	% Change
1 to 20	181,000	177,000	-2%
21 to 40	163,000	159,000	-3%
41 to 250	157,000	129,000	-18%

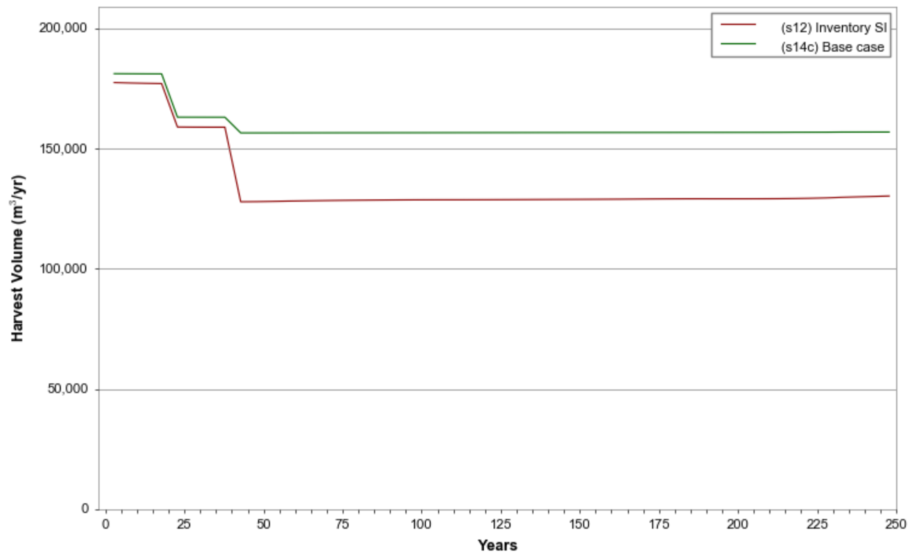

Figure 5-6: Inventory Site Index Harvest Flow

5.6 Slope Targets

Slopes are categorized by the following definitions:

- Class 1 = slope < 40%;
- Class 2 = 40% < slope < 70%;
- Class 3 = slope > 70%.

Canfor is the sole licensee operating in TFL 14, and its recently acquired capacity to harvest on steeper slopes is accounted for in this timber supply analysis. For this reason, no harvest restrictions based on slope class have been modelled in the base case scenario. In light of the discussion around steep slopes in the most recent timber supply analysis for Invermere TSA, sensitivity analyses were conducted to understand the impact of setting targets or limits to harvesting on slope classes 2 and 3.

The THLB in TFL 14 is composed by 68% class 1 slopes, 30% class 2 and 2% class 3. In the past decade, Canfor has harvested an annual average of approximately 20% (122 ha) of the total harvested area in class 2 slopes. This performance reflects a disproportionate amount of conventional harvest ground being targeted to control and salvage MPB affected stands. To model this past performance as a sensitivity scenario, a harvest cap of 122 ha/year was set for slopes greater than 40%.

Another sensitivity scenario was modelled, whereby a higher harvest level on steep slopes was forced. A harvest target of 53,000 m^3/year (average harvest level from base case + 10%) on slopes greater than 40% was placed for this scenario. As expected, this target restricts the forest estate model to schedule harvest blocks freely, not resulting in a higher harvest volume. The harvest flows on the targeted slope classes are displayed in Figure 5-7.

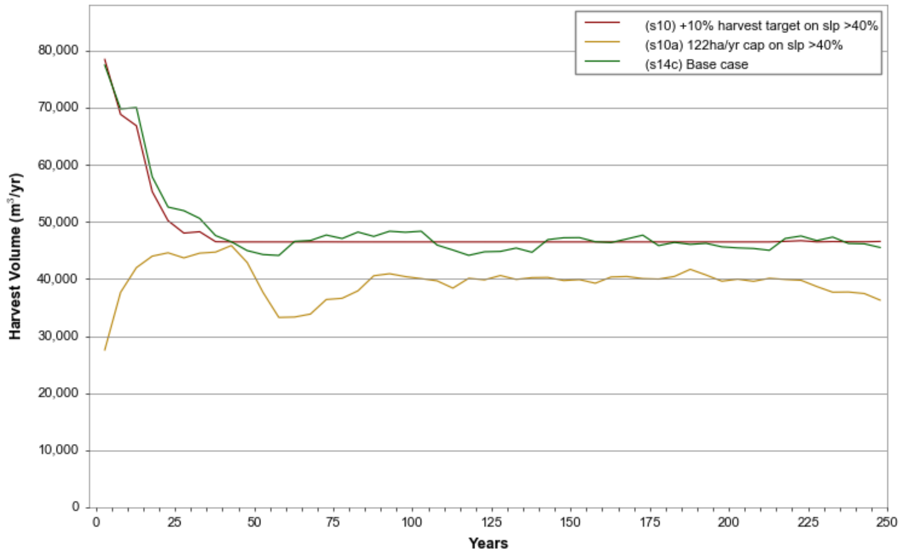

Figure 5-7: Harvest Flow on Slope Class > 40%

Modelling past performance significantly lowers the harvest volume, especially in the short to mid-term horizon, shown in Table 5-8 and Figure 5-8. Understanding this issue and knowing that high volume stands left on the land base are within slope classes 2, Canfor has deliberately invested in its steep slope harvesting capacity.

Table 5-8: Total Harvest Volume Slope Sensitivity

Years	Base Case m³/yr	Target +10%		20% Cap	
		m³/yr	% Change	m³/yr	% Change
1 to 20	181,000	181,000	0%	171,000	-6%
21 to 40	163,000	163,000	0%	152,000	-7%
41 to 250	157,000	157,000	0%	152,000	-3%

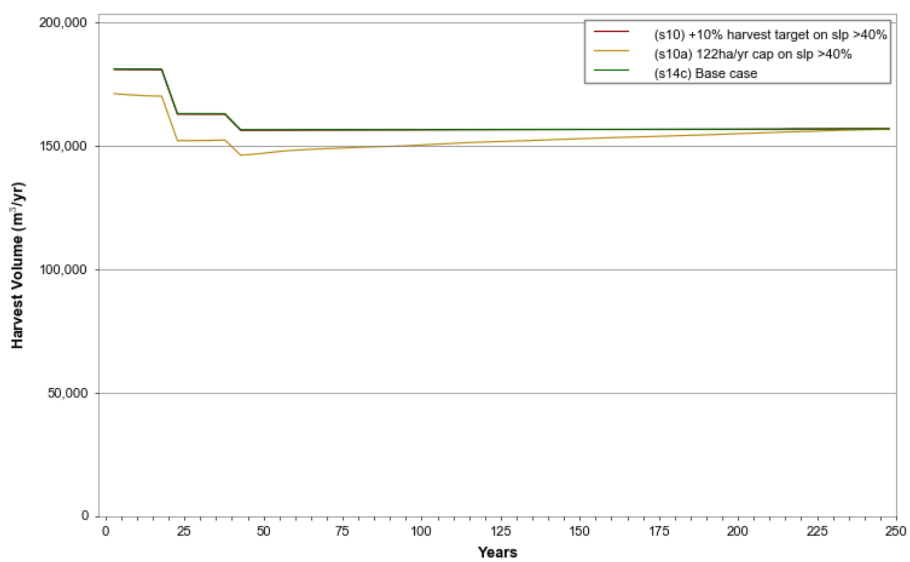

Figure 5-8: Total Harvest Flow for Slope Sensitivity Analysis

5.7 Patch Size

The base case models cut-block adjacency and green-up using a maximum percent disturbance to limit the amount of area harvested simultaneously in each landscape unit. Patch size distribution achieves the same goals but in an explicit approach that better represents harvesting operations. Patch size distribution mimics expected patch sizes occurring from natural disturbances. Patch size targets use the natural disturbance type (NDT) classification which is based on BEC zone and expected patch size distribution from the *Biodiversity Guidebook* (BCMoF, 1995) and Canfor's SFMP. Patch size distribution is modelled as a sensitivity scenario following Canfor's SMFP, where early seral patches (< 20years) are limited by the target percent range shown in Table 5-9. Harvesting is limited by these targets while simulating natural disturbance patterns.

Table 5-9: Target Patch Size Distributions

NDT2		NDT3		NDT4	
Patch Size (ha)	Target Percentage Range (%)	Patch Size (ha)	Target Percentage Range (%)	Patch Size (ha)	Target Percentage Range (%)
< 40	30 – 40	< 40	15 – 25	< 40	30 – 40
40 – 80	30 – 40	40 – 250	20 – 40	40 – 80	30 – 40
80 – 250	20 – 40	250 – 1000	30 – 50	80 – 250	20 – 30
250 +	0 – 5	1000 +	10 – 20	250 +	5 – 15

Canfor applies patch size targets to its licensed areas in the Kootenays region as whole to avoid breaking up NDT zones. Because this analysis only applies to TFL 14, NDT zones are smaller not allowing the largest patch targets to be continuously met during the modelling period. This target violation occurs in all modelled NDT zones. NDT 2 zone covers only 1,500 ha overlapping with most of the constraining VLI polygons (referred to in Section 4.3). VQO targets and the small size within this zone force harvesting to trend towards smaller patches preventing the accomplishment of the desired patch distribution for NDT 2.

The short and mid-term harvest level is moderately impacted by adhering to patch size distribution targets, as summarized in Table 5-10 and in Figure 5-9.

Table 5-10: Patch size Harvest Volume

Years	Base Case m³/yr	Patch Size	
		m³/yr	% Change
1 to 20	181,000	177,000	-3%
21 to 40	163,000	159,000	-3%
41 to 250	157,000	156,000	-1%

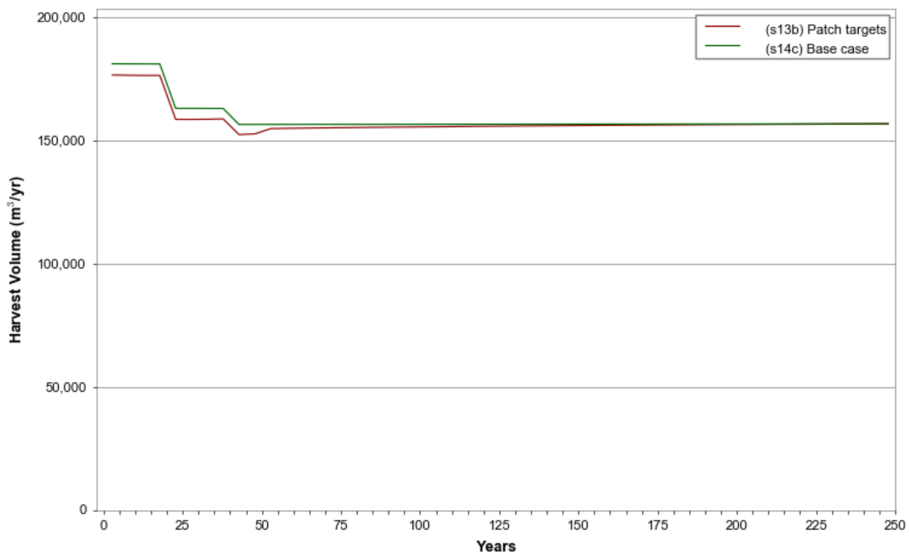

Figure 5-9: Patch size Harvest Flow

5.8 Minimum Harvest Age

The minimum harvest age (MHA) is the earliest age in which a stand can be harvested in the model. These are absolute values that the model cannot violate, and represent the earliest point at which a stand becomes economically viable. In the base case, MHAs are based on the age when a stand reaches 95% culmination age and the minimum merchantable volumes, shown in Table 5-11. The sensitivity scenarios presented in this section analyze the impacts of decreasing the minimum harvest volume (MHV) by 20 m^3/ha and increasing it by 50 m^3/ha. Increasing the MHA grants less flexibility in the model to schedule harvesting. Conversely, decreasing the MHA allows more flexibility in the forest estate model and results in an increased harvest level.

Table 5-11: Minimum Harvest Age Criteria

Class	Minimum Harvest Volume (m³/ha)		
	Base case	Decreased MHV	Increased MHV
Slope < 45%	120	100	150
Slopes >= 45%	150	130	200

Increasing the minimum harvest volume pushes stands to be harvested at a later age while also excluding stands that were marginally above the base case's minimum harvest volume threshold. This scenario has a 1% overall decrease in the harvest level as summarized in Table 5-12.

Decreasing the minimum harvest volume can result in a faster transition to more productive managed stands, thus increasing the mid to long-term timber supply. This transition occurs 10 years earlier than the base case causing the overall harvest level to increase by 1,000 to 2,000 m^3/year. Figure 5-10 shows the harvest flow for both scenarios.

Table 5-12: Average Annual Harvest Levels – MHA Scenarios

Years	Base Case m^3/yr	MHA Decrease		MHA Increase	
		m^3/yr	% Change	m^3/yr	% Change
1 to 20	181,000	183,000	1%	180,000	-1%
21 to 40	163,000	164,000	0%	161,000	-1%
41 to 250	157,000	158,000	1%	155,000	-1%

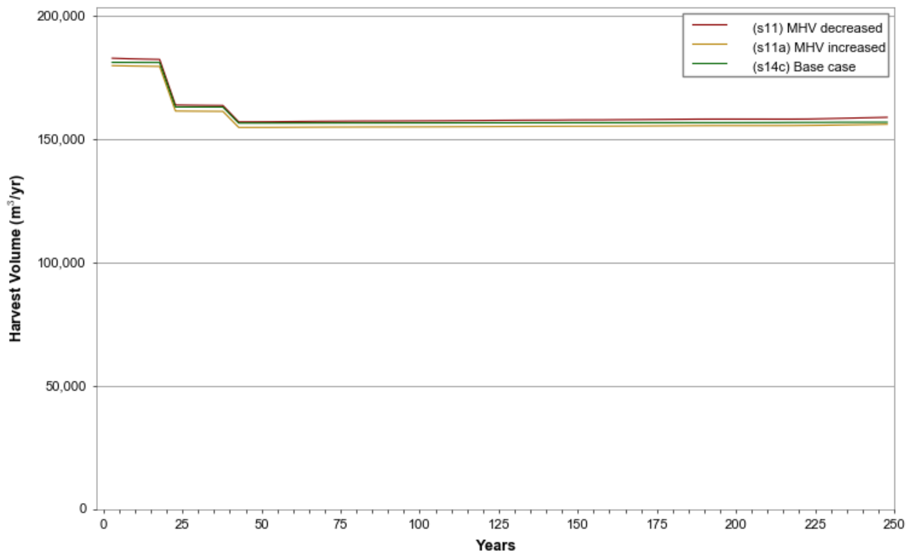

Figure 5-10: Minimum Harvest Age Harvest Flow

6. Discussion

The presented base case forecasts an initial harvest level of 181,000 m^3/year that is 1,000 m^3/year higher than the current AAC. Between 2001 and 2008, TFL 14 supported a harvest level of 160,000 m^3/year, which was then increased to 180,000 m^3/year in April of 2008. The decision to increase the AAC from 160,000 m^3/year to the current level was due to changes in management assumptions and site productivity estimates for managed stands from MP #8 to MP #9. The current base case results are a reflection of the current management practices and the available data including a new VRI (circa 2013) and LiDAR based ITI (circa 2016), the first of its kind for TFL 14.

Canfor has invested in collecting LiDAR data for TFL 14 with the expectation that it provides improved data that supports better management decisions and a better estimation of the existing inventory volumes. As discussed in Section 4 and Appendix B the height information from ITI data for TFL 14 has been incorporated into the timber supply analysis as the best available data, hence becoming the base case. The heights reported in the ITI were generated from the LiDAR data. Using LiDAR data to estimate tree height can provide significant improvements over traditional approaches to tree height estimation because of its increased accuracy, more complete sampling of the stand, and the fact that it is free of interpreter bias and subjective errors. However, there are challenges related to incorporating this data into timber supply analysis. The main challenge is transforming the ITI data into a stand level attribute that mimics VRI interpretation and can be used in VDYP and timber supply models. Other challenges include assessing the impact of not having stems less than 10m being part of the data, properly interpreting the data and applying the height adjustment to adequate stands.

Ecora has developed a methodology to utilize the LiDAR data to address some of the deficiencies in the VRI (described in Appendix B). However, this only represents a small component of how this data might be utilized to further enhance and reduce the uncertainty associated with projecting timber supply. Further work in this area includes:

- Calibrating species identification and adjusting the VRI species composition to reflect the ITI;
- Incorporating ITI basal area estimates into the inventory in a way that maintains consistency with the VRI standards – thereby facilitating the use of VDYP to project yield estimates;
- Incorporating ITI calculated volume;
- Explore opportunities for more detailed growth and yield modelling using individual tree growth models; and
- Using ITI data to better represent the growth potential (site productivity) of managed stands.

TFL 14's timber supply forecast is sensitive to changes in the existing growing stock, thereby highlighting the importance of inventory data. Using the LiDAR data to improve the existing inventory as described in Appendix B has an impact on the existing growing stock and the short to mid–term timber supply for the TFL. While there are certainly other areas for improvement using this information, the best data available at this time has been used in this analysis to assist with the AAC determination.

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Appendix A

PFT and Growing Stock Memo

Memo

To:	Terry Lazaruk, RPF Canadian Forest Products Ltd	**Date:**	January 24, 2018
C:	Jim Brown, RPF Lee Zhu, RPF Jay Greenfield, RPF		
From:	Liza Rodrigues, FIT	**Memo No.**	1
Subject:	TFL 14 Problem Forest Types and Initial Growing Stock		

The purpose of this memo is to address the absence of problem forest types (PFT) in the netdown process for TFL 14 and the growing stock decrease since Management Plan 9 was accepted.

1. Problem Forest Type Analysis

In a recent TFL 14 Management Plan (MP) update meeting, FLNRO identified differences between the TFL 14 and the Invermere TSA netdown assumptions with respect to PFTs. This memo summarizes stands that would be classified as problem forest types (PFTs) according to the Invermere TSA Data Package and provides a rationale for the current set of TFL 14 netdown assumptions.

The Invermere TSA Data Package identifies PFTs as pine leading stands that have merchantable timber but are currently not utilized i.e. (non-merchantable). The criteria for these PFTs are provided in Table 1. In the Invemere TSA, these sites were partially removed from the THLB, whereby a PFT partition was created to encourage opportunities for the rehabilitation of these moderately dense pine stands and to provide harvest opportunities for post- and rail-licensees

For TFL 14 we identified non-merchantable types as stands that at 95% of culmination did not reach a minimum harvest volume (MHV) of 120 m^3/ha on slopes <= 45% and did not reach MHV of 150m^3/ha on slopes > 45%. Any immature stands with low productivity were also netted out based on site index thresholds. In reviewing these assumptions and the resulting THLB with Canfor, we are confident that any PFTs have been removed from the THLB on TFL 14 through the criteria stated above.

As a follow up from the last MP review meeting with FLNRO we further analyzed PFTs by applying the Invermere TSA PFT criteria to TFL 14. Using the Invermere PFT criteria we identified 2,421 ha within the THLB for TFL 14 as shown in Table 1 (column "Area within TFL 14 THLB"). Furthermore when these stands are modelled using VDYP 7, 98% of them achieve minimum harvest volume and minimum merchantability criteria making them available for harvest at a reasonable age. Furthermore, Canfor does not consider the PFT criteria indicative of stands that they would generally avoid harvesting within the TFL, particularly if the minimum volume criteria is achieved. Based on these assumptions we are confident that the minimum merchantability criteria and other netdown categories accurately reflect the THLB for the TFL.

Table 1: Comparison of PFT Classes from Invermere TSA as applied to TFL 14

Criteria from Invemere TSA					Applied to TFL 14		
Description	Age	Height (m)	Reduction percent (%)	Percent (%) extended rotation*	Area within TFL 14 THLB (ha)	AUs reaching MHV (ha)	Area weighted average MHA
Pl leading	>40	< 10.5	80%	0	343	332	118
Pl leading	41-60	16	35%	10	1,601	1,590	72
Pl leading	61-80	16	18%	24	453	433	93
Pl leading	>80	16	29%	57	24	19	124
Total					2,421	2,375	

* Stands with extended rotation have an additional 20 years to meet the minimum harvesting age criteria above regular stands.

2. Growing Stock Analysis

The timber supply analysis in support of Management Plan 9 (MP 9) reports a starting growing stock for its FSC modelled scenario of approximately 8.5 million m^3. The current analysis in support of Management Plan 10 (MP 10) starts with a growing stock level of approximately 6.5 million m^3 for its FSC base case scenario. Despite similar modeling standards (same utilization) that influence growing stock estimations, there is a 2 million m^3 (24%) decrease in the initial growing stock modelled in MP 10 compared to MP 9. There are a large number of potential sources of this difference, including:

1. **New VRI:** The use of a new VRI (circa 2013) in MP 10 has resulted in changes to projected volume. This new VRI was developed using newer standards than the previous inventory (forest cover). It also used different photography which also can influence results.

2. **THLB size:** the MP 10 THLB is 2% smaller. At an average of 145 m3/ha, this represents approximately 166,890 m3.

3. **Volume depletion:** approximately 10,000 ha have been logged from 2008 to 2016 (9 years). Assuming that the harvest volume is close to the set AAC, this represents 9 * 180,000 m3/yr = 1,620,000 m3.

4. **Forest growth**: The THLB forest growth from 2008 to 2016 was estimated using the area weighted average MAI for natural and managed stands (1.89 and 2.84 m^3/ha/year respectively). This calculation estimated forest growth to be 861,939 m^3. Short-term growing stock depletion is to be expected based on the modelled growing stock in the non-FSC base case in MP 9 as shown Figure 1.

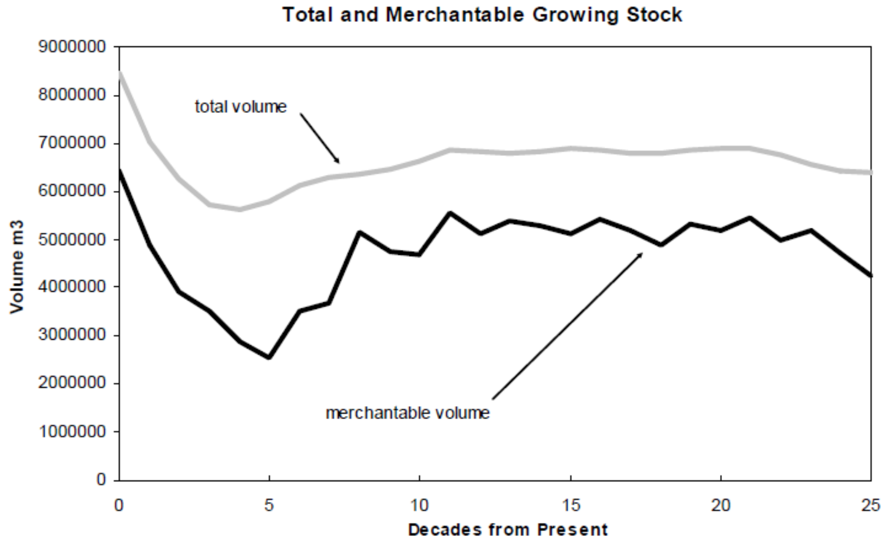

Figure 1: MP 9 FSC Base Case Growing Stock

5 **Phase II inventory adjustment**: MP 9 adjusted volumes up by an average of 11% (TFL 14 MP No. 8 Inventory Audit and Adjustment Strategy, Timberline, 2000, pp.8) based on Phase II sampling. This adjustment added approximately 782,000 m^3 when adjusted for utilization standards referred to in the MP 9 Data Package pp.28. Unfortunately, the original adjustment data is no longer available and therefore this adjustment cannot be applied during MP 10.

6 **MPB volume**: To ensure that the volume difference was not largely due to MPB mortality being implemented in the VRI, we checked the dead volumes in the new VRI. MPB is not a very large factor as dead volume in the 2013 VRI only represents 105,000 m^3.

The growing stock for MP9 and subsequent reduction for each of the above factors and final MP9 growing stock considering the factors are summarized in Table 2.

Table 2: Factors and the growing stock impacts

Initial MP9 growing stock	**8,500,000**
THLB smaller by 2%	-166,890
Minus 9 years harvest at AAC	-1,620,000
Plus 9 years growth at av. MAI	861,939
Minus 11% Phase 2 adjustment	-782,000
MPB – dead volume	-105,000
Estimated MP9 growing stock considering adjustment factors	**6,688,049**

This MP9 growing stock of approximately 6.7 million m3 is only 3% different from the starting growing stock of 6.5 million m3 for MP10.

As an additional step to further confirm that we have identified the factors above correctly, the 2 inventories should have similar volumes. The 2 inventories are described as:

- The MP 9 forest cover was classified in 1986, rolled over into the VRI format, and projected and updated for disturbances to 2006. Also, it was adjusted by +11% based on phase 2 sampling.
- The MP 10 VRI was classified in 2013, and projected and updated for disturbances to 2017.

We don't have access to the specific version of the old VRI used in MP9 or the phase 2 adjustment data, so it is difficult to confirm exactly that the 2 inventories have similar volumes. However, we have the year 2000 version of the MP 9 inventory to use as a proxy. Note that there will be differences between the 2000 and 2006 versions of the MP 9 VRI due to growth and depletions.

Table 3 shows that the MP 9 proxy inventory has a 6% higher volume than the MP 10 inventory. It is important to note that for the simplicity of this comparison, we just used the 12.5 cm utilization data that is included in the two different inventory datasets for the THLB area. This isn't to be confused with the actual utilization standards that were used in the management plans 9 and 10, those utilization standards were the same (12.5 Min DBH for pine leading stands and 17.5 cm for all others). So the reported differences in growing stock between MP9 and MP10 are indeed as stated in the first paragraph of Section 2.

Table 3: Comparison between the proxy MP9 and MP10 Inventories

MP	VRI	THLB volume at 12.5 cm utilization (m^3)	VPH (m^3/ha)
MP9 proxy	1986 forest cover updated and projected to 2000	7,656,446	170
MP 10	2013 VRI updated and projected to 2017	7,175,547	160
Difference		480,899 (6%)	10 (6%)

One would expect that the logged volume would be recovered by the growth of immature and mature stands during the 17 years between inventories, however this doesn't seem to be the case. Looking at age class distributions in Figure 2, the main difference between the 2000 and 2017 inventories is the depletion of area (i.e. harvesting) within age classes 100-120 and 200-220 years. This amounts to a 6% increase in area within the 0-20 year age class of the 2017 inventory when compared to the 2000 inventory.

In addition, Figure 3 is showing volume per hectare within each age class. If the issue was truly just harvesting one would expect similar volume per hectare levels in each age class (again, this notion of similar site productivity and growth occurring within each age class as it ages). There are notable volume per hectare differences within each age class for the two inventories being compared.

There are many potential factors that could cause the 6% difference to the inventory volumes such as different reference sources and interpretations that might impact site productivity, species compositions, crown closure, etc.; however age class seem to be the main factor for this difference.

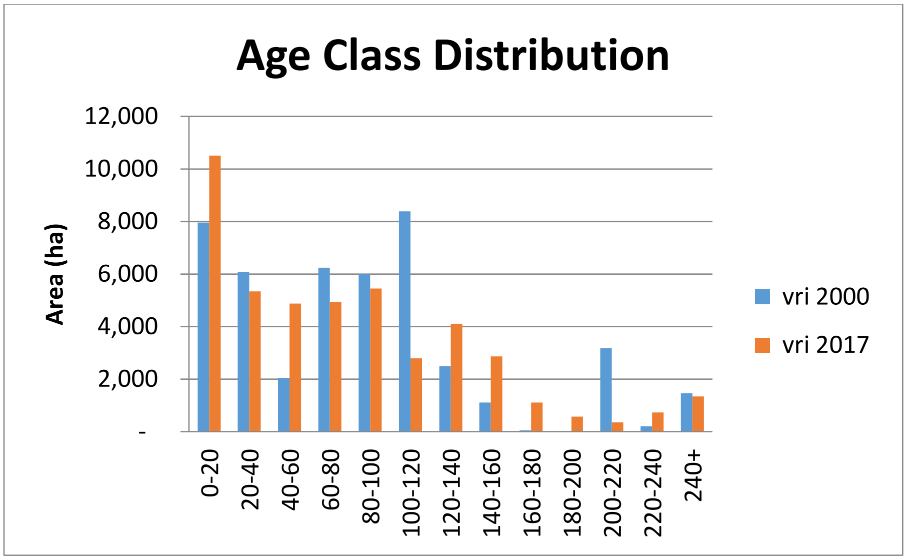

Figure 2: Comparison of age class distribution for each inventory

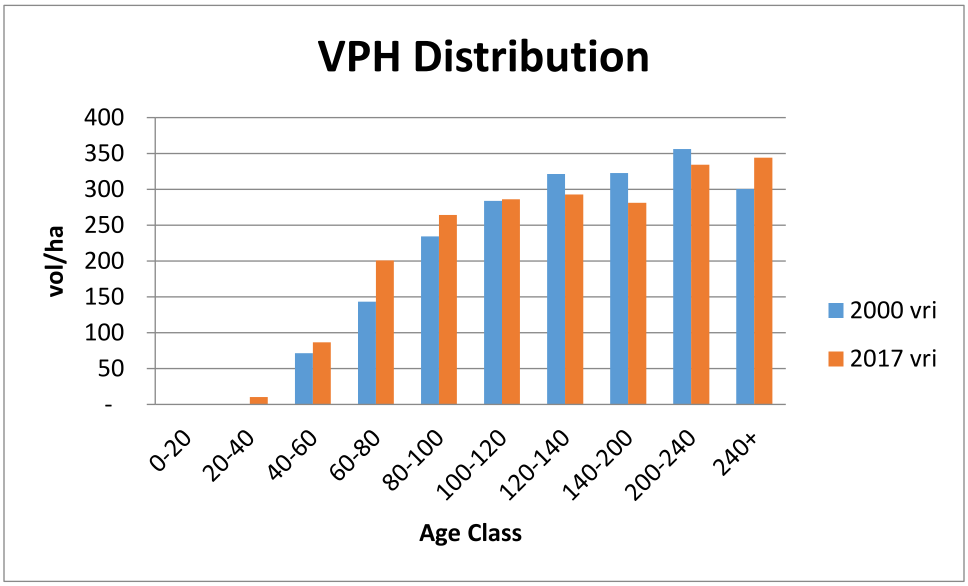

Figure 3: Comparison of volume per hectare for each inventory

In conclusion, it is difficult to calculate exact numbers to account for the growing stock difference, because of missing and unavailable datasets; however a few conclusions can be drawn from this growing stock analysis:

1. The fact that the total growing stock in the unadjusted 2000 VRI is 6% higher than the 2013 VRI confirms that new VRI has not overcome the issue of underestimating stand attributes.
2. The adjustments to inventory ages, heights, and volumes for stands >40 years old had a large impact on the growing stock in the last TSR. It is stated in MP 9 Data Package pp.6 that ‘‘Overall, the adjustment increased heights, decreased ages, increased volumes, and indirectly increased site indices. Across the target population, the net effect of all adjustments was a 21% increase in merchantable volume”.

3 The volume difference between forest growth and logging rates is a large cause of the growing stock depletion, but there are uncertainties in identifying the exact impact because forest growth is relative to forest productivity, which has been underestimated in the 2013 VRI. On the other hand, MP 9 base case analysis showed a drastic drop of growing stock in the initial 50 year period indicating that logging at an AAC of 200,000 m^3/yr would cause depletion. They did not model the current AAC of 180,000 m3/yr, but in our model growing stock behaves the same way at this rate.

The lack of an inventory adjustment remains a significant source of uncertainty in the analysis. Current inventory volumes are 6% lower than MP9 without the adjustment applied. As stated in the year 2000 inventory adjustment document, the previous adjustment increased merchantable volumes by 21% once age, height and volume adjustments were all applied representing a significant difference. In the short term, this could be addressed through sensitivity analysis exploring increased natural stand volumes. However, in the long-term this issue will require a more robust and data-driven solution if uncertainty in natural stand volumes is to be reduced and an accurate timber supply forecast developed.

Appendix B

Vegetation Resource Inventory Height Adjustment Using LiDAR Data Memo

Memo

Vegetation Resource Inventory Height Adjustment Using LiDAR Data

Presented To:	Terry Lazaruk
C:	Lee Zhu, Jim Brown, Scott Hicks, Jay Greenfield
Submitted By:	Ecora Engineering and Resource Group Ltd. Liza Rodrigues

Dated:	April 17, 2018
Ecora File No.:	FG-16-500-CFP

1. Introduction

In the summer of 2015, Canfor collected LiDAR data for objects (trees) above 10m in the physically operable area of TFL 14. From the data, individual tree crowns were identified, verified and calibrated using ground truth plots to create an individual tree inventory (ITI) (Forsite, 2017). This ITI was assembled to comprise of many attributes ranging from height to species and log profile. Recently, using selected ITI attributes has been identified as a potential approach to supplement a Phase II Inventory Adjustment, replacing the lost inventory adjustment data used in the *TFL 14 Inventory Audit* (Timberline, 2002). As discussed in the submitted *"PFT and Growing Stock Memo"* (Ecora, 2018), TFL 14's current growing stock is 24% lower than in the last Timber Supply Review (TSR). There are a few significant factors causing this drop, but one of the most important is the use of the 2013 Vegetation Resource Inventory (VRI). This VRI has not undergone any adjustments, unlike the 1986 Forest Cover Inventory used in the last TSR. The 1986 Forest Cover Inventory was adjusted because it underestimated stand height.

The *TFL 14 Inventory Audit* (Timberline, 2002) states that "The audit showed a difference between ground measured top height and the inventory label height of 1.6 metres, which could account for a significant portion of the error in volume (BC MoF, 1994)." Timberline's audit "indicated the inventory height was underestimated about 7% overall".

In the "*PFT and Growing Stock Memo"* (Ecora, 2018) a comparison between the 2013 VRI (projected to 2017) with the only available version of the 1986 Forest Cover (projected to 2000 and not adjusted for Phase II Adjustment) showed that the 2013 VRI had 6% lower growing stock. The fact that the total growing stock in the unadjusted 2000 VRI is 6% higher than the 2013 VRI confirms that new VRI has not overcome the issue of underestimating stand attributes. This underestimation accounts for approximately 10% of the overall 24% growing stock difference. It is evident that the 2013 VRI needs to go through a Phase II Inventory Adjustment like the 1986 Forest Cover as a replication of bias has occurred. TFL 14 is undergoing its 10th Timber Supply Review (TSR), thus it is an appropriate time to assess the impact that a potentially biased inventory could have on this process.

We examined the capacity for the ITI data to be used as a source to adjust and update the 2013 VRI heights. LiDAR data and its application to segment individual trees and extract their heights have been targeted as a method to decrease sources of error that exist in the current VRI process. In the ITI, each tree has its own height, yielding a more precise estimation of the stand height as opposed to an interpreter estimating the height of a few dominant and co-dominant trees within the stand. Ecora is aiming to prove that the use of LiDAR heights to adjust interpreted heights in the VRI yields more accurate measurements with less variability and bias.

We examined ITI attributes that could be converted into stand level attributes for use in VDYP. This examination suggested height as the only feasible attribute at this point. Height is a challenging attribute for interpreters to measure accurately in the photo interpretation process. We had to take interpretation methods for VRI attributes into consideration and define whether ITI attributes could yield a comparable representation of stand level VRI. The sections that follow will describe the methodology used to adjust VRI heights with ITI data, and the overall impact of this adjustment to the 2013 VRI.

The developed strategy provided a logical adjustment that can be successfully used in the TSR. A snapshot of the results (stand height and volume) is provided in Table 1. They are stratified by leading species and age class. The height adjustment ratio column is defined as the ITI height divided by the VRI height, volume adjustment ratio is calculated similarly. The last row shows the total THLB area affected by the adjustment and the area weighted average of the volume per ha, height and adjustment factors. This adjustment affected 38% of the THLB. The attributes displayed are projected to 2017.

Table 1: Adjustment Impact Summary

Leading species	Age class (yrs)	THLB (ha)	VRI average height (m)	ITI adjustment average height (m)	Height adjustment factor	VRI average volume (m^3/ha)	Adjusted VRI average volume (m^3/ha)	Volume adjustment factor
BL	60-100	580	17.78	24.14	1.358	153.7	203.0	1.321
BL	100-150	509	20.56	26.88	1.308	221.4	291.2	1.315
BL	150-200	251	23.67	29.19	1.233	253.0	326.8	1.292
BL	200+	64	23.32	28.24	1.211	255.0	300.4	1.178
FDI	60-100	2,221	24.58	26.97	1.097	249.3	263.2	1.056
FDI	100-150	1,487	30.03	31.81	1.059	345.4	362.6	1.050
FDI	150-200	346	32.46	33.14	1.021	396.4	402.8	1.016
FDI	200+	127	32.36	28.68	0.886	393.3	338.8	0.861
PLI	60-100	4,163	20.94	24.84	1.186	258.5	309.2	1.196
PLI	100-150	2,133	23.87	27.49	1.152	294.5	348.7	1.184
PLI	150-200	97	26.80	28.49	1.063	349.7	359.2	1.027
PLI	200+	44	27.42	28.63	1.044	362.8	360.2	0.993
SE	60-100	833	22.00	26.96	1.225	190.9	224.4	1.175
SE	100-150	2,330	27.18	30.00	1.104	290.5	316.6	1.090
SE	150-200	1,107	28.94	32.60	1.127	306.2	342.2	1.117
SE	200+	921	29.71	32.66	1.099	321.2	347.4	1.081
SX	60-100	7	23.09	28.65	1.241	153.9	220.5	1.433
SX	100-150	19	28.29	30.32	1.072	288.2	294.3	1.021
SX	150-200	6	31.49	34.57	1.098	281.8	316.3	1.122
SX	200+	4	26.53	28.05	1.058	231.8	234.2	1.010
		17,250	24.74	28.10	1.145	276.5	312.4	1.139

2. Height Adjustment Method

The ITI covers 83,122 ha, which is shown in Figure 1 as the area within the black contour inside the TFL 14 boundary hatched in red (Forsite, 2017). The first step in this analysis was to roll up the ITI data into VRI polygons by overlaying the ITI with the 2013 VRI.

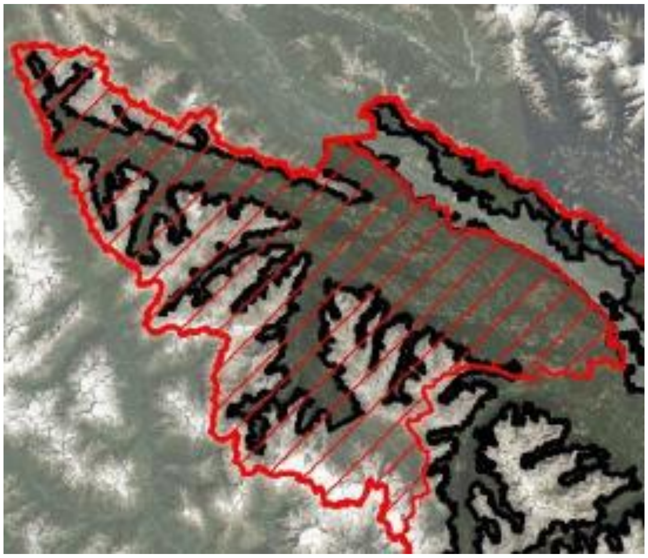

Figure 1: **LiDAR coverage within TFL 14**

In order to use the ITI heights in a TSR process and propose a VRI adjustment methodology, ITI data has to be converted to stand level heights. VDYP is designed for stand level input, and is the only tool used in vegetation resource inventory to estimate natural stand volume. VDYP yield tables are also used in forest estate models, which assist in AAC determinations. Therefore, it was important to use the same methodology applied to inventory interpretation to define stand level height from ITI data.

2.1 VRI height interpretation approach

Ecora's certified VRI classers were consulted for a better description and understanding of the height interpretation process. The goal is to convert the ITI heights to a product that simulates the outcome of a VRI interpretation, but using more precise LiDAR measurements to improve the product. The VRI height interpretation process assigns stand level heights to dominant and co-dominant trees based on estimating the average height of these trees in the upper canopy. As reported by the consulted certified VRI classers these dominant and co-dominant trees are often found within the top 20 percentile range of the canopy (the "top 20"). Based on this information, the ITI trees in each stand were ordered by increasing height and the stand cut-off heights representing the 70th and 80th percentiles (referred to as "top 30th" and "top 20th" respectively) were calculated for use in 2 separate analyses. See Figure 2 below for a visual representation of this.

To maintain an accurate representation of the stand heights, dominant and co-dominant species should fall into height classes 3 and 4. This excludes outliers that would skew the height data, such as veteran trees that should not be included in the height calculations. This assumption was confirmed using spot checks; and vertically layering example polygons to validate the cut-off height.

The graphs of tree height by tree number (sorted by increasing tree height) are shown in Figure 2 below. They show 4 stands, varying in age, outlining the stand height percentiles. Outliers are easy to spot as they are where the blue line becomes close to vertical, corresponding to the top 1 percentile of heights (indicated as 99% line). This analysis proved to be useful in finding the upper percentile cut-off point, to exclude outliers. The graphs also provide a visual indication of the lower proposed cut-off point (80% line).

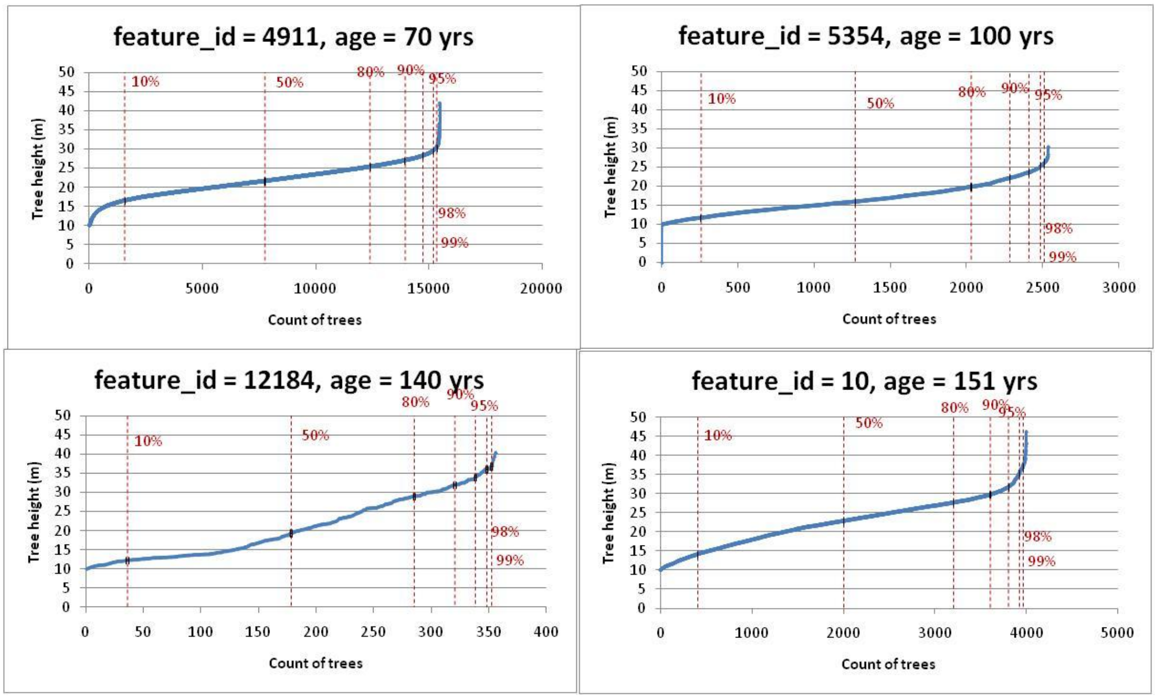

Figure 2: Tree height regression and percentile rank

The 20th percentile was initially chosen as a good representation of dominant and co-dominant trees in the stand, but other height calculation options needed to be explored to assess their differences. Five stand level heights were calculated using 5 different methodologies for 7 polygons. The methodologies used are the following and the results can be found in Table 3:

1. The average height of the top 20th percentile representative trees;
2. The average height of the 1-20th percentile representative trees, which excludes the tallest trees (outliers);
3. The average height of the 1-30th percentile representative trees, also excluding outliers;
4. Lorey height (basal area weighted average) for the leading species within the 1-20th percentile representative trees; and
5. Lorey height for the leading species within the 1-30th percentile representative trees.

2.2 Analysis of ITI and 7 re-interpretation VRI polygons

The accuracy of photo interpretation was tested through the attempted establishment of patterns between photo interpreted heights and the ITI calculated stand level heights. This was carried out by an experienced Ecora VRI interpreter who carefully re-interpreted the heights in the 7 polygons using the same images used in the 2013 VRI. We hoped to identify a pattern in association with vertical complexity and determine whether the ITI calculated stand level heights were within the VRI accuracy range. The process could also serve to identify consistencies in the differences between ITI heights and the re-interpreted heights. Table 2 shows the re-interpreted heights for the dominant and co-dominant species and their accuracy estimates from interpretation, as well as a comparison to the stand level lorey height extracted from ITI data for trees in the 1-20th height percentile of each polygon. The heights were photo interpreted using images with reference years from 2007 – 2012.

Table 2: ITI and Re-interpreted Attribute Comparison for Sample Polygons

Stand ID	VRI species cmp	ITI species cmp	Re-interpreted height	Accuracy of re-interpreted height (+/- m)	ITI lorey ht 1-20th pctl	ITI within accuracy estimate	Interpreter comments
10	Fdi-60%	Sx-37%	32	3	30.41	Y	Terrain is quite steep, with significant variability within tree canopy.
	Se-25%	Pli-33%	28	2	30.22	Y	
3628	Se-80%	Bl-41%	24	1	30.17	N	Old inventory polygon. Could be a species discrepancy. Looks Bl leading.
	At-15%	Sx-31%	23	2	31.00	N	
4911	Fdi-70%	Pli-45%	27	2	26.97	Y	Originally RESULTS data transfer; reference year 2012.
	At-15%	Fdi-28%	22	1	27.37	N	
5354	Pli-100%	Pli-42%	18	1	22.38	N	Was originally RESULTS data transfer. Limited height variability
6861	Fdi-65%, Pli-35%	Pli-46%, Fdi-43%	26	2	22.34	N	Multi-layer stand. Data is from 2011. Only top layer measured. Steep terrain.
9812	Bl-75%	Bl-51%	20	4	25.61	N	Vertical complexity 4. Highly variable.
	Sx-25%	Sx-44%	24	1	26.79	N	
12184	Fdi-75%	Fdi-43%	30	3	32.90	Y	Steep, lots of shadow
	Sx-15%	Pli-40%	27	2	31.80	N	

Table 2 outlines large stand level differences between VRI and ITI species composition, making the explanation of differences in leading and second species heights difficult. The ITI heights are mostly outside of the interpreted height +/- accuracy estimate and are often greater than the interpreted heights. It is important to note that some growth is lost due to differences in the reference years of the image and LiDAR data. The interpreted photos are referenced to 2007, 2011 and 2012, whereas the LiDAR data is referenced to 2015. Re-interpreted heights have been projected to 2015 and are shown in Table 3. The projection has increased the heights by less than one meter and does not impact the conclusion drawn from Table 2. Moreover, based on the interpreter's notes, we further investigated a potential correlation between the ITI and VRI height difference and vertical complexity. This topic is explored in section 3.1.

2.3 Comparison to a previous Ministry approach

We also looked into using an approach to adjust VRI heights that was published by the Ministry in *2015 Attribute Adjustment for MPB and Fire* (MFLNRO, 2016). In this approach, raster tiles containing LiDAR measured heights were used and the adjusted heights were calculated by multiplying the maximum height by 0.8. This approach doesn't work well for individual tree data as it significantly increases the polygon height, shown in Table 3 and in Figure 3. Figure 3 shows this raster LiDAR data height approach compared to the top 20th percentile approach. The comparison demonstrated that the 20th percentile approach is more conservative than the ministry approach adopted in the *Attribute Adjustment for MPB and Fire* (MFLNRO, 2016).

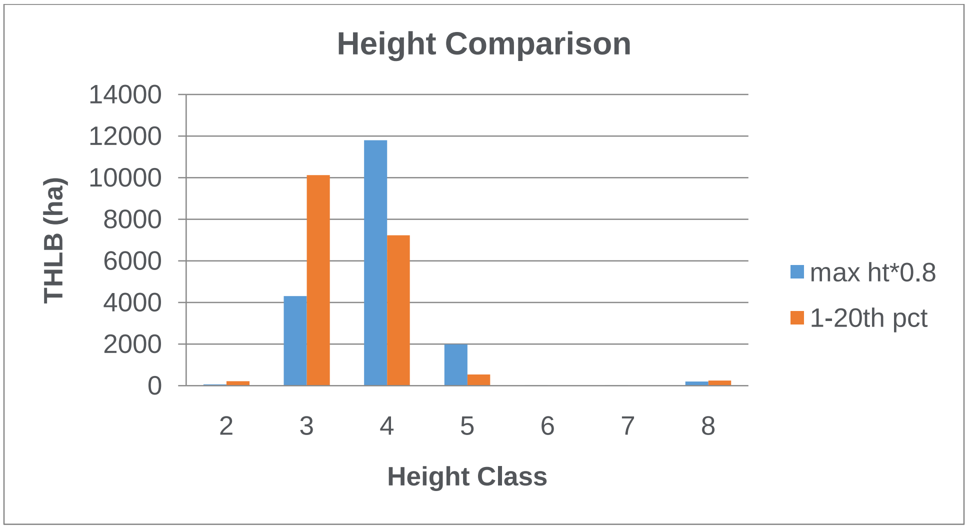

Figure 3: Stand level height comparison

2.4 Investigating the utility of PrognosisBC output

Lastly, stand 12184 was analyzed using graphical outputs from PrognosisBC (Figure 4, Figure 5 and Figure 6). Individual tree information from the ITI (height, species etc.) was input to generate volume tables and graphical outputs for stand 12184 in 2015. We hoped that the detailed output would be able to be used to further refine the tree canopy cut-off point; however, we found that no significant quantitative results could be drawn from the model outputs to distinguish visible trees in the canopy. Profile views and crown closure graphs proved to be useful for qualitative purposes.

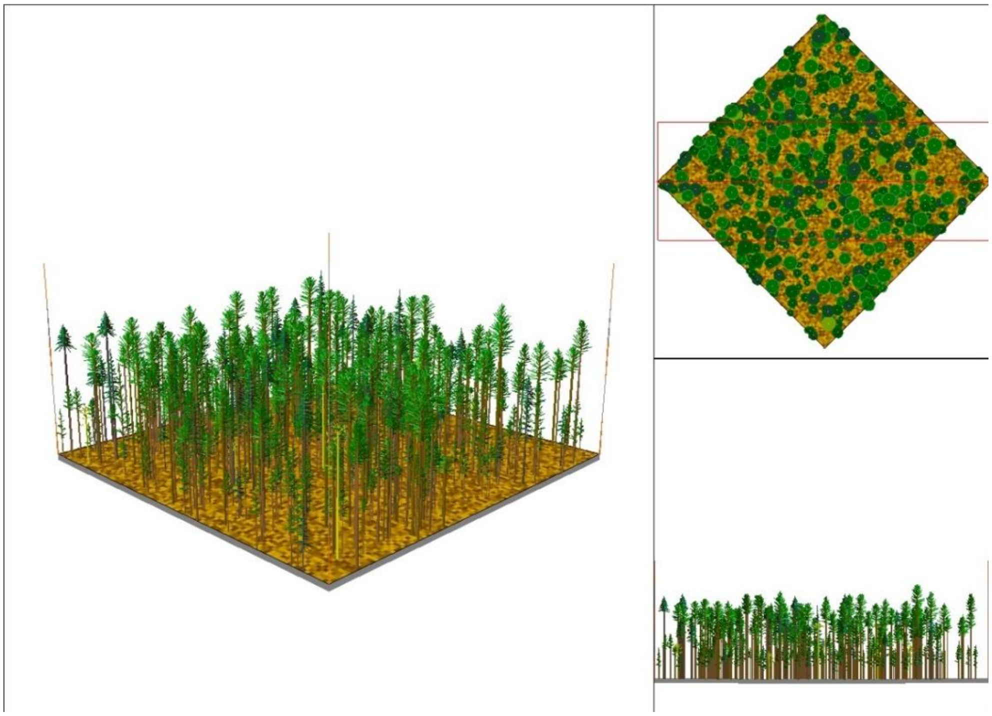

Figure 4: ProgPrognosis

Ecora's certified VRI classer estimated the stand level height in Figure 5 to be 32m; within the range of height class 4. The 1-20th percentile approach also estimated this stand's height to be 32m, possibly indicating that this methodology was successful in identifying dominant and co-dominant trees; the defining trees for VRI height interpretation.

Figure 5 : Prognosis BC output of stand 12184

Figure 6 displays diameter class, height and crown size, and height and species distribution of stand 12184, as interpreted by PrognosisBC. In the height class graph in the upper left corner, a height of 40m represents edge effect trees while dominant and co-dominant trees are closer to 30m.

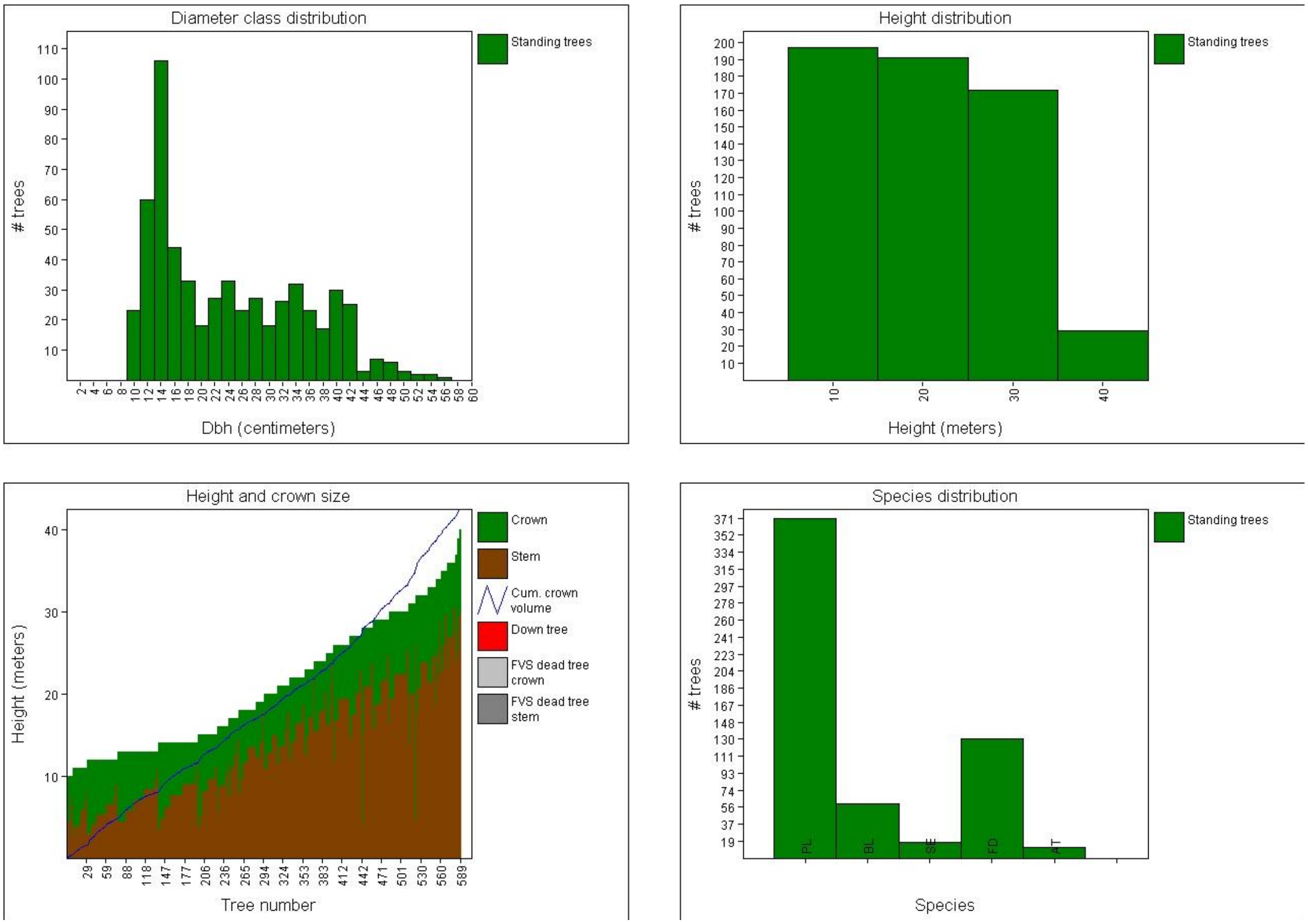

Figure 6: PrognosisBC output attributes of stand 12184

2.5 Summary of height adjustment method

To summarize, six different stand level heights were calculated and compared with photo interpreted (VRI) heights shown in Table 3. Consistencies and inconsistencies between interpreters can be identified by comparing columns “Re-interpreted Height” and “VRI height”. The re-interpreted heights were consistent with the original interpretation (i.e. within the accuracy range) in 5 of the 7 polygons. This re-interpretation exercise highlighted the existence of considerable amounts of variability in the VRI interpretation process and multiple sources of error in that data. However, in order to deduce any concrete conclusions, a much larger sample would have to be analyzed.

The average difference between all ITI calculated stand heights and re-interpreted heights can also be found in the last row of Table 3. The average difference was established from the re-interpreted heights because they have the same projection year as the ITI heights. They should also be more accurate than the 2013 VRI heights because Ecora’s interpreter was able to spend more time carefully interpreting the height for each polygon. Based on this difference, we conclude that the 1-20th percentile stand level height calculation is the most conservative and appropriate method to fix the underestimated height attributes in the 2013 VRI for the stands investigated.

Table 3: Comparison of Height Calculation Methods

Stand ID	Max (height)* 0.8	0-20th pctl	1-20th pctl	1-30th pctl	Lorey SP1 (1-20th pctl)	Lorey SP1 (1-30th pctl)	Re-interpreted Height (2015)	VRI Height (2017)
10	36.9	30.7	30.3	29.1	30.4	29.5	32.37	32.55
3628	33.5	30.6	30.2	28.8	30.2	28.9	24.82	25.21
4911	33.6	27.4	27.2	26.3	27.0	26.1	27.92	25.78
5354	24.1	22.4	22.2	21.1	22.4	21.3	18.27	23.65
6861	34.6	22.5	22.1	20.9	22.3	21.3	27.04	18.08
9812	24.5	26.4	26.1	25.1	25.6	24.6	20.33	21.48
12184	32.3	32.5	32.1	30.5	32.9	31.7	30.84	31.04
Avg. diff. from Re-interpreted height	5.305	1.155	0.8175	-0.3825	0.905	-0.1325		

It is also important to note that omitting the top 1 percentile of tallest trees excludes edge effect trees, but does not have a large impact on the overall height. The difference between the top 20th percentile and the 1-20th percentile for these 7 stands varies at most by 0.4m. Nonetheless, the top 1 percentile trees (outliers) should not be part of the height calculation.

Species composition for each VRI polygon was also calculated using the ITI data, and it was often different than the 2013 VRI. Lorey height is dependent on species composition, which creates inconsistencies in comparing proper species height to adjust the VRI. lorey height adds additional uncertainty to the height adjustment, hence, it was not recommended for this purpose.

As previously mentioned, calculating stand level height by multiplying the maximum height of the polygon by 0.8 causes an overestimation, and it is not the appropriate method for ITI data.

We conclude that the average height of the 1-20th percentile is the most reasonable and conservative approach to estimate stand-level height from an ITI dataset. As demonstrated, it prevents edge effect trees from skewing the average height and it is representative of dominant trees in the stand. This methodology is used to calculate the adjustment height.

3. Population Parameters

Height adjustments were determined to be applied to stands with the following parameters:

1. Must be within the productive area;
2. Must have no logging history;
3. Must be greater than 60 years of age when projected to 2017.

Productive areas were selected rather than the THLB to capture any area that may move into the THLB because of an increased site index and volume estimates. Stands with no logging history were selected in order to exclude the additional uncertainty and increased variability associated with stand types created after logging. In addition, the 10-meter threshold for the existence of LiDAR data means that logged stands (or young stands) are unlikely to be accurately captured. Lastly, a 60-year age cut-off was set because, below this threshold, the difference between the VRI height and adjustment height is greatest and affects a significant number of stands. This is outlined in Figure 7.

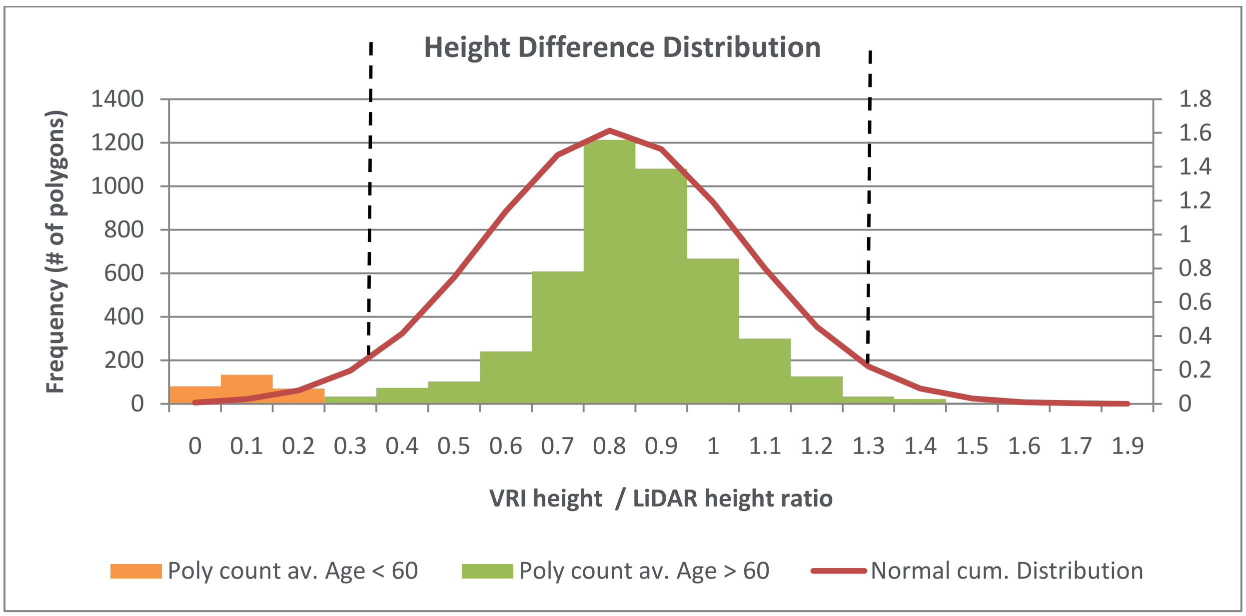

Figure 7: Frequency of VRI to ITI height ratio against a normal distribution

The histogram shows the distribution of VRI polygons by the ratio of VRI heights to adjustment heights (x-axis). When the ratio is 1, the heights are equal. Below 1, the ITI adjustment height is greater than VRI height and above 1, the VRI height is greater. The data is shown to be normally distributed when comparing this histogram to the normal distribution curve. Polygons with an average age less than 60 years have the greatest ratio difference (70%+) and fall outside of the standard 95% confidence intervals (the vertical black-dashed lines). In the upper limit, where the VRI height is 30% greater than the adjustment height, are older stands that have a small representation on the land base. We did not find it meaningful to exclude these stands from the adjustment population.

The 60-year age cut-off is reasonable for this dataset, but there is no set approach. The methodology adopted in the *TFL 14 Inventory Adjustment* (Timberline, 2002) was different than the audit conducted by Ministry of Forests

(MoF) in 1994. As explained, “MoF did the inventory audit on stands greater than 60 years of age consisting of 49 samples in both operable and inoperable portions of the TFL” while the following audit sampled “only the physically operable, productive, coniferous, free-to-grow forest of TFL 14 over 40 years of age”.

3.1 The effect of vertical complexity

Analyzing the vertical complexity interpreted for each stand polygon in the VRI, it was evaluated whether more complex stands would yield a larger difference between LiDAR height and VRI height. Contrary to this expectation, Figure 8 below shows VRI interpreted stands that overlap with the ITI data (all stand ages included), and the ratio calculated by VRI height divided by ITI stand level height on the horizontal axis, where 1 means that the heights are equal, less than 1 means that the ITI height is greater than VRI height and more than 1 means that VRI height is greater. It is possible to conclude from this figure that stands with less vertical complexity have a greater difference between VRI and LiDAR heights. All other vertical complexities are evenly distributed among all other height ratios.

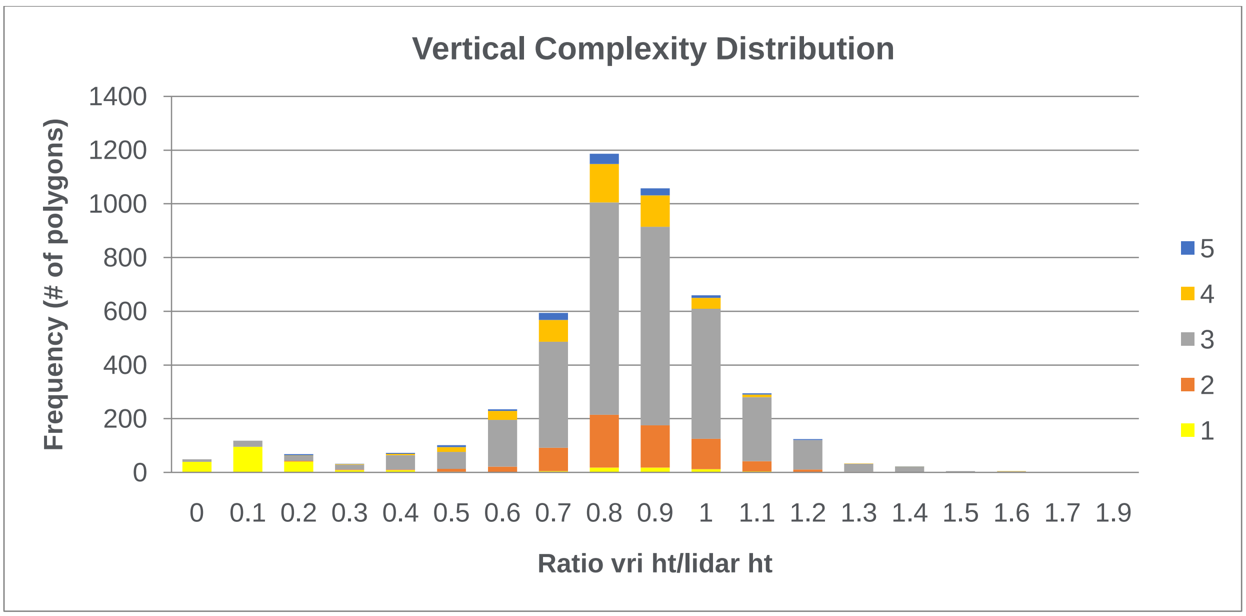

Figure 8: VRI and LiDAR height ratio by vertical complexity

A vertical complexity of 1 is often used for younger stands, and it is the case in the 2013 VRI as demonstrated in Figure 7, where younger stands occupy the same position on the VRI height/ITI height ratio axis. This ratio is large at these stands because the top 20th percentile trees are not representative of the dominant and co-dominant trees of the stand. The LiDAR did not capture any trees below 10 m, which would still be a visual component of a VRI. Also, any wildlife tree patches or seedling trees would be captured and skew the stand average height.

4. VDYP Inputs and Outputs

ITI adjustment height, reference VRI age projected to 2015 (which is the same year LiDAR points were collected) and all other VRI attributes, except for site index and second species height and age, were loaded into VDYP for the polygons for which height adjustment was applied (4,500 natural and non-logged polygons > 60 years). VDYP recalculated site indices and volumes.

Based on the analysis shown in Figure 7 it is expected that recalculated site indices would be higher than the site indices in the 2013 VRI for the height adjusted polygons. Higher site indices also lead to higher volume estimations. This expectation was proven to be correct and is shown in Figure 9, Figure 10, and Figure 11, all portraying attributes projected to 2017 for the adjusted polygons (total of 34,900 ha).

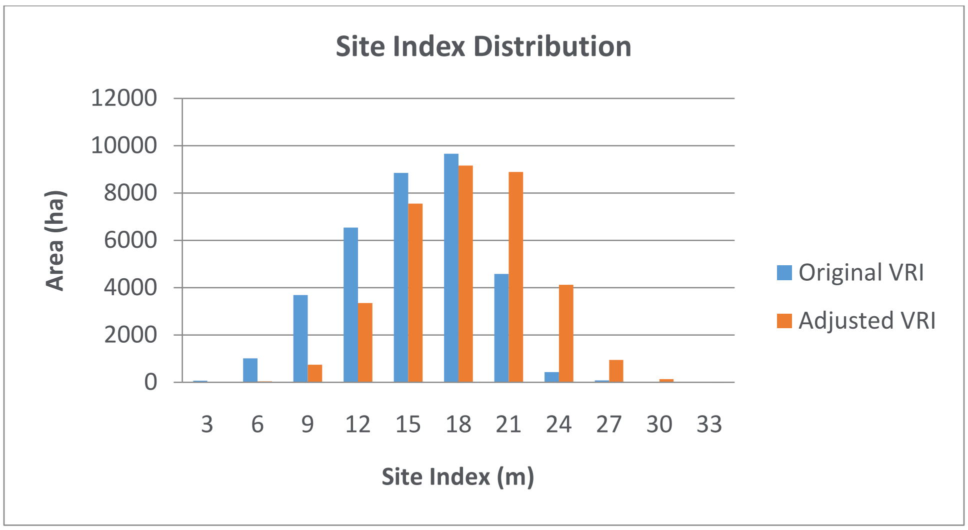

Figure 9: Site index comparison

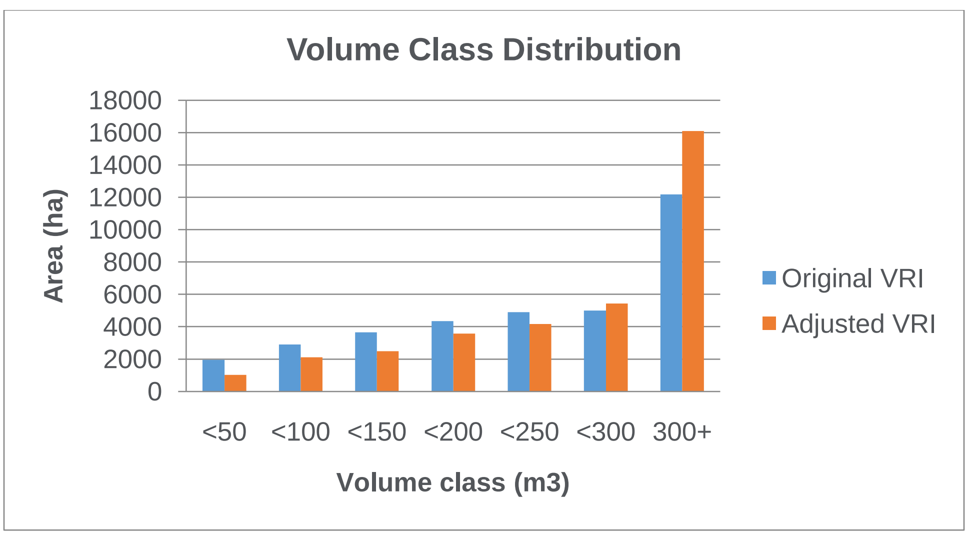

Figure 10: Volume comparison

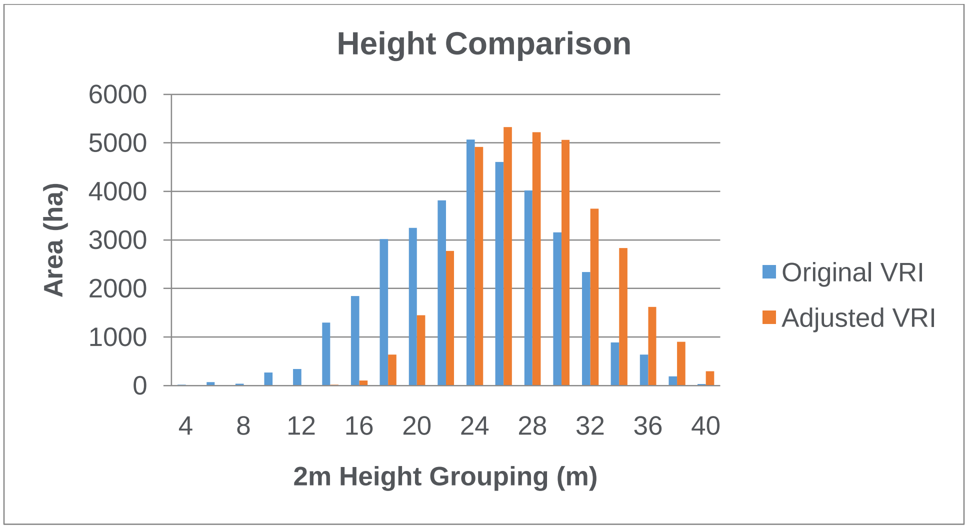

Figure 11: Height comparison

5. Next Steps

We investigated multiple methods of calculating stand-level height from ITI data, finding the one that is best correlated with the methodology of photo-interpretation. After stand level and land base level analyses, we conclude that using the average tree height from the top 20th to the first percentile is the most reasonable and conservative approach. Applying this across the productive land base > 60 years and non-logged yielded (34,900ha), on average resulted in increased heights and therefore increased site index and volume.

A sensitivity analysis using VDYP yield tables for the ITI height adjusted polygons will be conducted and published in the *Tree Farm Licence 14 Management Plan # 10 Timber Supply Analysis - Analysis Report.* This step will assess the impact this adjustment has on the TSR harvest level.

LiDAR provides a tree level estimate of stand height that has significantly lower bias and errors compared to photo-interpreted height - there is a consensus that LiDAR measured height is more precise than VRI interpreted height. This report documents a few (of many) possible methods of rolling up these individual heights to the stand level, with a focus on replicating what a photo-interpreter would see, because this is what VDYP is calibrated to. This tie is critical to consider when the plan is to use the new height to calculate current volumes and yield curves to be used in TSR.

Past practice is BC has been to use ground truth plots to carry out an inventory adjustment; however this method has many drawbacks in comparison to using LiDAR heights. Plot data suffers from human and measurement errors and it is very costly to get a large sample size. The small area covered by plot data is extremely tiny when compared to the wall to wall coverage afforded by using LiDAR. LiDAR can better capture the entire range of variation than a subsample of plot data. LiDAR provides the height of the upper canopy on the land base and should be used to calculate stand level heights where this better information exists. The methodology described in this document is sound and can be used to improve accuracy of in the 2013 VRI on TFL 14 as an inventory adjustment tool.

More studies will be conducted to find more opportunities which additional ITI data can be applied. Once we are more comfortable around the accuracy of other attributes than height (species composition, crown closure, basal area etc.), this will open the door to more opportunities for which the ITI data can be used.

6. References

Ecora Engineering and Resource Group Ltd (2018). PFT and Growing Stock Memo, February, 2018.

Forsite (2017). TSI Model Results Summary, April 04, 2017.

Timberline Natural Resource Group (2002). TFL 14 Inventory Audit.

British Columbia Ministry of Forests and Range (2016). 2015 Attribute Adjustment for MPB and Fire. December 2016.