Integrated Stewardship Strategy for the Cranbrook TSA

Analysis Report

Version 1.0

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Project 419-38

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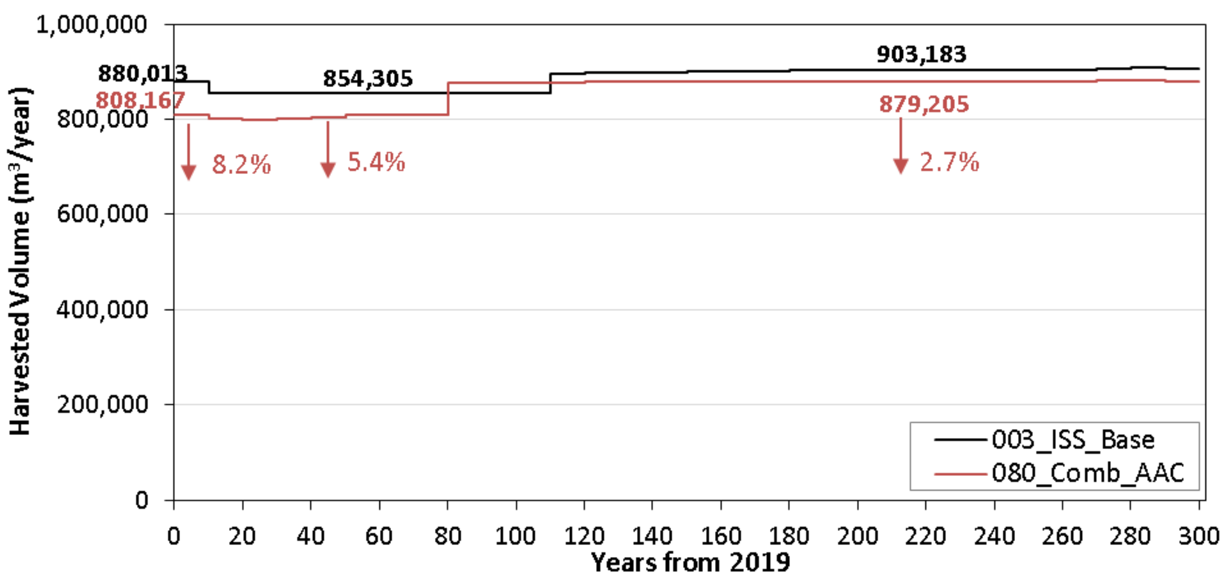
Executive Summary

This report summarizes the analysis results for five scenarios conducted under the Integrated Stewardship Strategy (ISS) Cranbrook Timber Supply Area:

- ISS Base Case Scenario - mimics current management practices and most modelling assumptions applied in the recent Timber Supply Review. Results from this scenario provide the baseline from which to compare other scenarios.
- Silviculture Scenario - designed to explore alternative silviculture practices that would benefit long-term timber and non-timber objectives. In particular, this scenario aimed to enhance timber quantity and quality over the mid- and long-term, as well as, improve biodiversity, wildlife habitat, and cultural interests.
- Wildlife Scenario - designed to assess habitat quality and quantity for a range of wildlife species while continuing to meet all other timber and non-timber objectives. In this ISS iteration, the Project Team elected to explore two tactics: wildlife habitat and species at risk.
- Reserve Scenario - aimed to identify where and how we should reserve forested stands to address landscape-level biodiversity and where possible, non-timber values, while minimizing impacts to the working forest.
- Combined Scenario - aimed to guide development, implementation, and monitoring of tactical plans over the first 20 years of the planning horizon. Key elements from the three scenarios (ISS Base Case, Silviculture, and Reserve) were included to provide an integrated strategy to this first iteration of the ISS process.

After more than 40 model runs, this work culminated with a Combined Scenario that considered key elements from the other scenarios to develop an appropriate timber harvest flow that reflects the interactions of all the tactics explored. Compared to the ISS Base Case Scenario, this harvest flow was 8.2% less in the first decade (i.e., set at the current AAC), 5.4% less over the mid-term, and 2.7% less over the long-term. Meanwhile, the forest-level model addressed all non-timber objectives within their assigned parameters.



Results from the Combined Scenario were used to develop a tactical plan to monitor activities over the first 20 years of the planning period; thus providing an integrated strategy with guidance to forest resource planners and decision makers.

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List of Acronyms

BCTS	BC Timber Sales
BEC	Biogeoclimatic Ecosystem Classification
BIOD	Biodiversity
ECA	Equivalent Clearcut Area
ERDZ	Enhanced Resource Development Zone
FMER	Fire-Maintained Ecosystem Restoration
FMLB	Forest Management Land Base
FPPR	Forest Planning and Practices Regulation
FRPA	Forest and Range Practices Act
FSC	Forest Stewardship Council
IRMZ	Integrated Resource Management Zone
ISS	Integrated Stewardship Strategy
KBLUPO	Kootenay-Boundary Land Use Plan Order
LU	Landscape Units
MINDY	Maximum Initial Non-Declining Yield (timber harvest flow)
MMA	Mature Management Area
NDT	Natural Disturbance Type
NDY	Non-Declining Yield (timber harvest flow)
NHLB	Non-Harvestable Land Base
NRL	Non-Recoverable Losses
OGMA	Old Growth Management Area
THLB	Timber Harvesting Land Base
TSA	Timber Supply Area
TSR	Timber Supply Review
UWR	Ungulate Winter Range
VEG	Visually-Effective Green-Up
VRI	Vegetation Resource Inventory

Document Revision History

Version	Date	Notes/Revisions
0.1	Aug 29, 2018	○ First version distributed to project team for review and comment. ○ Only included results for Base Case Scenario plus twelve sensitivity analyses (including Mature/Old Seral and Landscape Unit Grouping scenario elements).
0.2	Dec 21, 2018	○ Described results for the Silviculture Scenario (section 4) and incorporated comments/suggestions from the project team.
0.3	May 7, 2019	○ Described results for the preliminary Wildlife Scenario (section 5) that mimicked – as a first step - other processes for modelling wildlife habitat for 14 species/habitat types and aspects of the federal caribou recovery strategy.
0.4	Oct 6, 2019	○ Reorganized some of the subsections in section 3. ○ Described results for the Reserve Scenario (section 6) that aimed to identify Candidate Reserves that address landscape-level biodiversity and where possible, non-timber values, while minimizing impacts to the working forest. ○ Described results for the Combined Scenario (section 7) that aimed to guide development, implementation, and monitoring of tactical plans over the first 20 years of the planning horizon. ○ Added key observations and recommendations in section 8.2.
0.5	Nov 25, 2019	○ Corrected minor errors throughout the document. ○ Included discussion for two additional sensitivities (i.e., silviculture tactics off and business as usual) in the Combined Scenario (section 7).
1.0	Nov 28, 2019	○ No further edits at this time. Made available for distribution on website. https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/silviculture/silviculture-strategy-areas

1 Introduction

This document summarizes the results for the Integrated Stewardship Strategy (ISS) scenarios conducted for the Cranbrook Timber Supply Area (TSA). This includes the following scenarios: Base Case, Wildlife, Reserve, Silviculture, Forest Health, and Carbon.

The ISS Base Case Scenario was developed as a two-step process that first developed a model to mimic the assumptions applied in the latest Timber Supply Review (TSR). The TSR Benchmark Scenario was used to compare results and confirm that the model configuration is consistent with TSR. Some TSR assumptions were adjusted to correct errors and include new or updated information. These adjustments aimed to better-reflect the current situation while improving model configuration for other ISS scenarios. These ISS scenarios introduced and explored tactics aimed to achieve the following objectives:

- Silviculture Scenario - enhance timber quantity and quality over the mid- and long-term, as well as, improve biodiversity, wildlife habitat, and cultural interests.
- Wildlife Scenario – mitigate adverse impacts that timber extraction activities can have on key wildlife species populations.
- Reserve Scenario - maintain the harvest area while providing a wide range of values on the land base (i.e. co-location).
- Forest Health – mitigate adverse impacts to forest resources significant high-risk pests and climate change.
- Carbon - develop strategies to sequester carbon and/or reduce emissions.

The Combined Scenario included tactics from each of the previous scenarios to develop a comprehensive tactical plan that can be used to monitor activities over the first 20 years of the planning period and to provide further guidance to forest resource planners and decision makers.

Assumptions for these forest-level modelling exercises were described in a separate document called a data package[1].

Note that some graphs presented below were copied directly from reports generated by the model and were intentionally kept small as they are intended to easily compare and demonstrate how the target levels (red/blue) are being respected and how patterns continue over time. They are not intended to focus on actual numbers – hence the small font – but target levels are described in the text or data package.

1.1 Project Area

The Cranbrook TSA is located in the southeastern corner of British Columbia within the boundaries of the Rocky Mountain Natural Resource District (Figure 1). It is bordered by the Skookumchuk Valley (and Invermere TSA) to the north, the Alberta border to the east, the Canada-U.S. border to the south and the southern Purcell Mountains to the west. It includes the cities of Cranbrook, Kimberley, and Fernie

[1] Forsite Consultants Ltd. 2018. Integrated Stewardship Strategy for the Cranbrook TSA – Data Package. Version 0.3. Project 419-38. August 8, 18, 2018. 45 pg.

and the smaller communities of Sparwood and Elkford. The project (Cranbrook TSA) covers an area of approximately 1.485 million hectares.

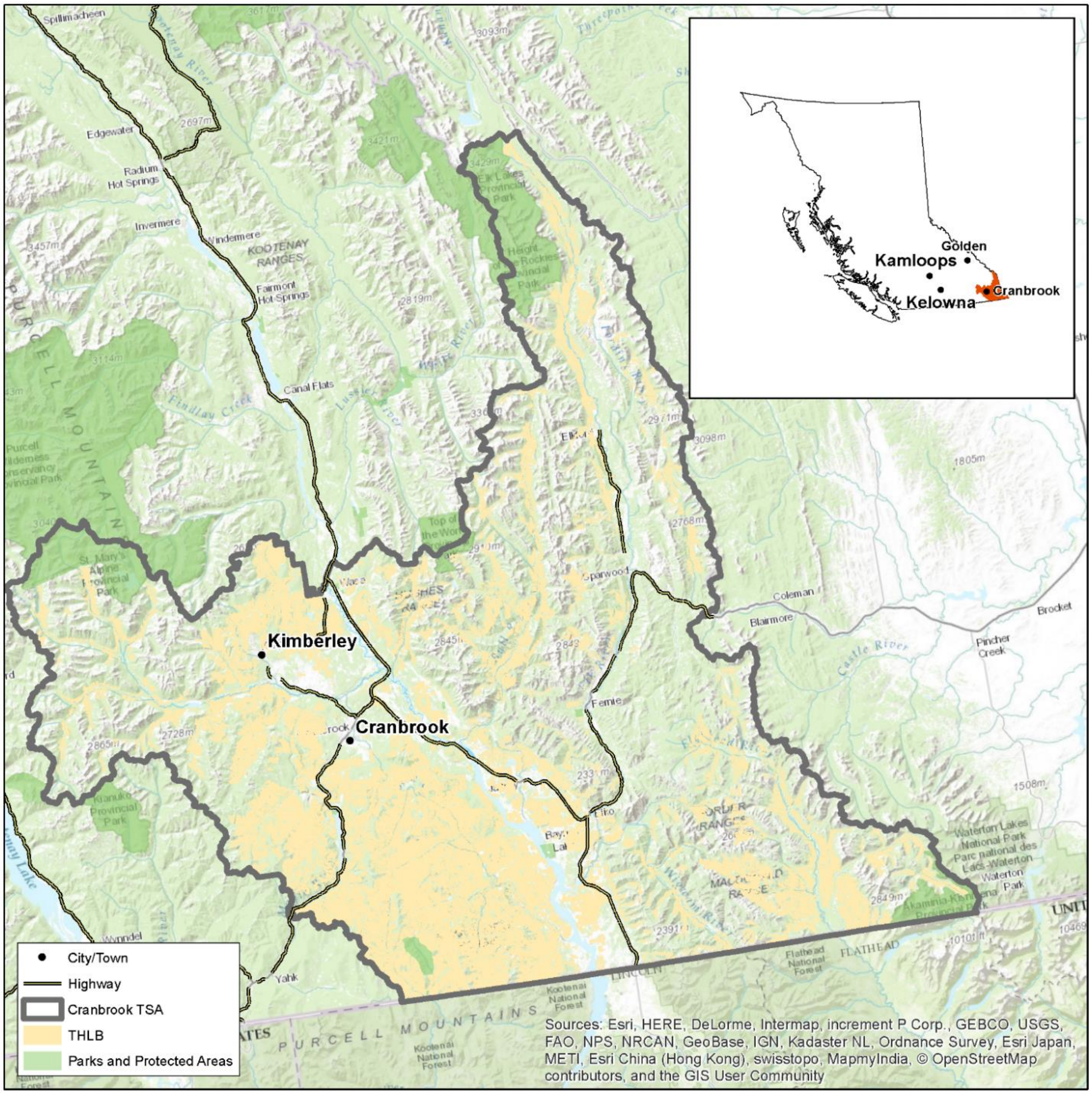


Figure 1 Cranbrook TSA

1.2 Context

This document is the fourth in a series of documents developed through the ISS process.

1) Situation Analysis – describes in general terms the situation for the project area – this could be in the form of a PowerPoint presentation with associated notes or a compendium document.
2) Scenario Development - describes the development of a Combined Scenario based on multiple scenarios explored through forest-level modelling and analysis scenarios.

3) Data Package – describes the information that is material to the analysis including the model used, data inputs and assumptions.
4) **Analysis Report** – provides modeling outputs and rationale for choosing a preferred scenario.
5) Tactical Plan – direction for the implementation of the preferred scenario.
6) Implementation Monitoring Plan – direction on monitoring the implementation of the ISS; establishing a list of appropriate performance indicators, developing monitoring responsibilities and timeframe, and a reporting format and schedule.
7) Final Report – summary of all project work completed.

1.3 Land Base Definition

The land base definition of the ISS Base Case (Table 1) shows the Forest Management land Base (FMLB) is 865,665 ha; approximately 84,000 ha (10.8%) more than the TSR Benchmark Scenario. The long-term effective Timber Harvesting Land Base (THLB) is 318,721 ha; approximately 21,000 ha (or 6.3%) less than the TSR Benchmark Scenario. The current effective THLB is 5.5% below the TSR Benchmark Scenario. Differences between the two land bases are mentioned throughout this document.

Table 1 Cranbrook ISS Base Case Scenario Land Base Definition

Factor		Total Area (ha)	Effective Area (ha)	% of Total Area	% of FMLB
Total Area		**1,484,998**	**1,484,998**	**100.0%**	
Less	Community Forests	20,197	20,197	1.4%	
	Private	223,286	223,286	15.0%	
	Christmas Trees Permit	5,508	5,508	0.4%	
	Indian Reserves	20,282	20,282	1.4%	
	Woodlots	8,469	8,469	0.6%	
	Misc leases	70	70	0.0%	
	Special Permit	226	141	0.0%	
	Mines	18,670	8,212	0.6%	
	Vegetated, non FMLB	151	151	0.0%	
	Non-treed	106,895	68,706	4.6%	
	Non-vegetated	283,994	260,736	17.6%	
	Not typed	115,337	2,849	0.2%	
	Factored Roads		726	0.0%	
Total Forest Management land Base (FMLB)		***(in FMLB)***	**865,665**	**58.3%**	**100.0%**
Less:	Parks	28,663	28,663	1.9%	3.3%
	Inoperable	347,462	321,600	21.7%	37.2%
	Steep Slopes (>70%)	53,866	2,959	0.2%	0.3%
	Terrain Class V in CWS	1,417	68	0.0%	0.0%
	ESA	93,452	8,199	0.6%	0.9%
	Non Merchantable	84,576	11,406	0.8%	1.3%
	Low Sites	148,840	4,962	0.3%	0.6%
	Misc Reserves	254	167	0.0%	0.0%
	Crown UREP	658	519	0.0%	0.1%
	UWR Caribou	72,521	11,274	0.8%	1.3%
	WHA	3,246	2,548	0.2%	0.3%
	OGMA +MMA	102,025	27,065	1.8%	3.1%
	FSC Endangered Forests	41,389	927	0.1%	0.1%
	FSC Rare and Uncommon Ecosystems	7,512	3,129	0.2%	0.4%
	Existing WTRAs	8,163	4,759	0.3%	0.5%
	100% InBlock Retention	4,028	4,028	0.3%	0.5%
Gross Timber Harvesting Land Base (THLB)			**433,392**	**29.2%**	**50.1%**
Less:	Partial Removals				
	Slopes 40-70% (50%)	238,760	42,137	2.8%	4.9%
	Terrain Class V outside CWS (95%)	13,877	1,507	0.1%	0.2%
	Terrain Class IV outside CWS (5%)	102,438	3,024	0.2%	0.3%
	Terrain Class IV in CWS (95%)	6,178	419	0.0%	0.0%
	PFT Pine >80yrs (29%)	61,085	6,183	0.4%	0.7%
	PFT Pine 61-80yrs (18%)	39,280	2,546	0.2%	0.3%
	PFT Pine 41-60yrs (35%)	3,269	645	0.0%	0.1%
	PFT Pine <40yrs (80%)	9,037	968	0.1%	0.1%
	Isolated	648	648	0.0%	0.1%
	In-Block Retention*		36,971	2.5%	4.3%
Current Effective THLB			**338,343**	**22.8%**	**39.1%**
Less:	Future Reduction				
	Open Range Conversion		9,512	0.6%	1.1%
	Future Roads (3.8%)		10,110	0.7%	1.2%
Long-term Effective THLB			**318,722**	**21.5%**	**36.8%**

** In-Block Retentions include FSC Rare Ecosystems, (50%), WTRA (6% for existing natural stands and 3.5% for existing managed stands), and Riparian (% determined spatially for each polygon).*

2 Key Differences between TSR Benchmark and ISS Base Case Scenarios

Table 2 summarizes key differences observed between the TSR Benchmark and ISS Base Case Scenarios. The harvest impact is depicted as increasing (green up arrow), decreasing (red down arrow), or relatively neutral (yellow circle). The important differences between the TSR Benchmark and latest TSR 4 (2016) are summarized in the TSR Benchmark report[2].

Table 2 Summary of key differences between TSR Benchmark and ISS Base Case Scenarios

Assumption/Factor	TSR Benchmark Scenario	ISS Base Case Scenario	Harvest impact
Land Base Definition			
Over-depletion	Depletion of fire/insects disturbances from RESULTS. Ignoring VRI field "REFERENCE_YEAR" relative to Disturbance year from RESULTS.	Only clear- and partial-cuts were depleted. In addition, depletions were applied where disturbance year from the consolidated cutblocks layer was more recent than the VRI field "REFERENCE_YEAR". While this did not impact THLB, there was a positive impact in initial growing stock and harvest rate compared to the TSR Benchmark Scenario.	↑
Non-Forest and Non-Productive	Used Forest Management Land Base (FMLB) field from the VRI and logged history as the only criteria.	More complex algorithm using the BC Land Classification Level fields in the VRI, logging history, height, and crown closure from all layers (except 'D'). TSR Benchmark Scenario removed approximately 93,000 ha more than ISS.	↑
Existing Roads	Applied as aspatial reduction of 5.3% to FMLB area <70 yrs	Spatially explicit, then factored in for each FMLB polygon. TSR Benchmark Scenario removed approximately 13,000 ha more than ISS.	↑
Partial Netdowns	Slopes 40-70%, unstable terrain, and problem forest types were aspatially removed.	A spatially explicit algorithm to meet the partial netdown quota by selecting the closest to existing THLB and the most productive stands. Expect a better spatial representation of the THLB could have a negative impact on the harvest, compared to an aspatial representation.	↓
Riparian	Used FPPR rules, and spatially netted out.	FSC rules, and factored in for each THLB polygon. THLB decreases by 3.1% due to application of FSC standards in Canfor operating areas.	↓
OGMA + MMA	Used DataBC data source.	Consolidated dataset from the licensees which was approximately 21,000 ha (gross) more than the TSR Benchmark Scenario.	↓
FSC (Forest Stewardship Council) No Harvest Areas	Not applied.	Endangered Forests and Rare and Uncommon Ecosystems within Canfor operating areas are excluded from the THLB (approximately 4,000 ha).	↓
Isolated stands	Not applied.	Approximately 648 ha identified as isolated stands and excluded from THLB.	●
WTRA	6% applied to entire THLB (existing and future)	Existing WTRAs were spatially identified from RESULTS. In addition, a 2.5% WTRA was applied to reflect current practice. The WTRA for unharvested stands was 6%.	●
FMER	Used DataBC source.	TSR4 layer applied as the DRM staff considered it more accurate. TSR Benchmark Scenario identified approximately 9,500 ha more area within the FMER Open Range.	↑
Non-Timber Objectives			
Landscape-Level Biodiversity	Implemented KBLUPO targets for mature plus old, and for old forests.	Only OGMA+MMA to meet landscape-level biodiversity. The sensitivity analyses indicated that KBLUPO targets were more constraining compared to OGMA+MMA.	↑

[2] Forsite Consultants Ltd. 2018. TSR Benchmark Scenario for Cranbrook and Invermere TSAs – Analysis Report. Version 1.0. Project 419-38. January 18, 2018. 8 pg.

Assumption/Factor	TSR Benchmark Scenario	ISS Base Case Scenario	Harvest impact
BEC dataset	Presumably BEC v10 or older.	BEC v11 (draft version).	
ECA	The ECA targets were not prorated relative to the FMLB area. Used the Biodiversity Guidebook ECA curve.	The ECA targets were prorated relative to the FMLB area, which overall were more restrictive. Used ECA curves from Winkler and Boon (2015) where a maximum height of 25m was assumed. These ECA curves are generally more restrictive than Biodiversity Guidebook ECA curves.	
UWR (Management)	Disregarded the young seral objective.	Applied the young seral objective, maximum 33% <21 years for each habitat class and LU combination. Overall, this was not constraining because of the overlap with IRM Green-up requirements.	
TIPSY	V 4.3., Ministry Standard Database, January 2016.	v. 4.4, Ministry Standard Database, September 2017. One to one comparison of yield curves indicated that TIPSY 4.4 estimated overall lower volumes than 4.3.	
Non-Recoverable Losses (NRL)	32,745 m³/year.	47,476 m³/year.	
NHLB (non-THLB) Disturbance	Considered static and not modelled.	Random disturbance of 1,746 ha/year (0.36% of all NHLB).	

3 ISS Base Case Scenario

3.1 Timber Objectives

3.1.1 Even-Flow Harvest Profile

Even-flow harvest profiles were compared for TSR Benchmark and ISS Base Case in Figure 2. The harvest rate for the ISS Base Case was approximately 5,000 m³/year (0.6%) higher than the TSR Benchmark, resulting mainly from differences in FMLB and NRLs.

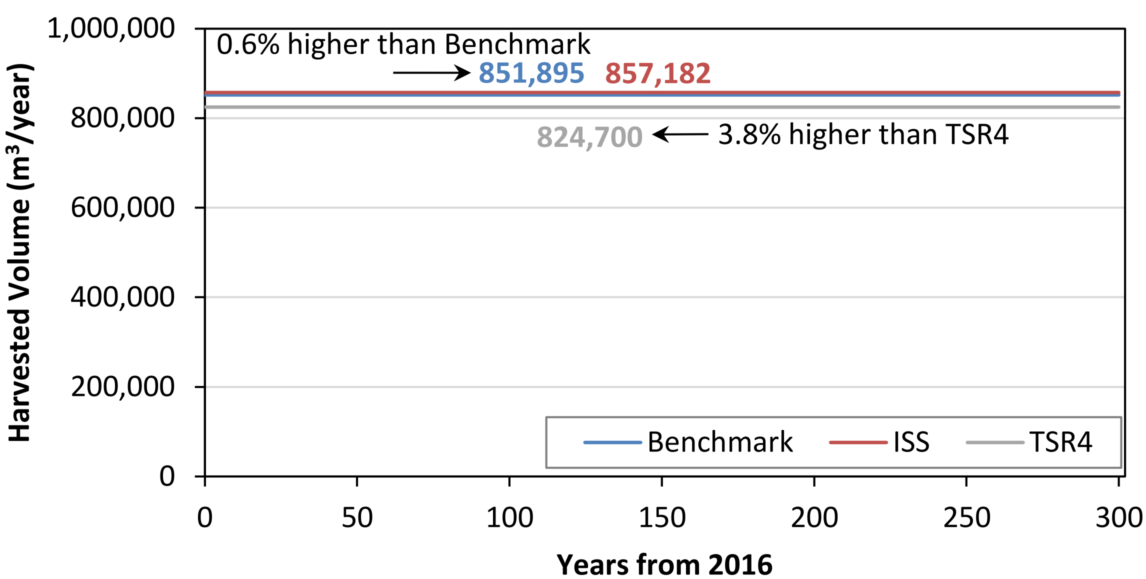


Figure 2 ISS Base Case Scenario – Harvest Flow (Even-Flow)

Compared to the TSR Benchmark, the ISS Base Case FMLB was 10.8% larger while the long-term THLB was 6.3% smaller. The model applied the larger NHLB (25.3%) in the ISS Base Case to meet non-timber objectives while the smaller THLB was used more efficiently to meet the timber objectives. The latter was confirmed by the growing stock trend, which declined significantly more than the TSR Benchmark over the 300-year planning horizon, despite the similar starting values (Figure 3). Note that, while NHLB disturbance was modelled in the ISS Base Case scenario, it still resulted in higher harvest rate, despite the lower THLB than TSR Benchmark Scenario.

The even-flow harvest profiles accounted for NRLs of 32,745 m³/year in the TSR Benchmark, and 47,476 m³/year in the ISS Base Case. The higher NRLs applied in the ISS Base Case reduced the harvest flow difference by 1.6% (i.e., without NRLs, the ISS Base Case harvest rate would be 2.3% higher than the TSR Benchmark).

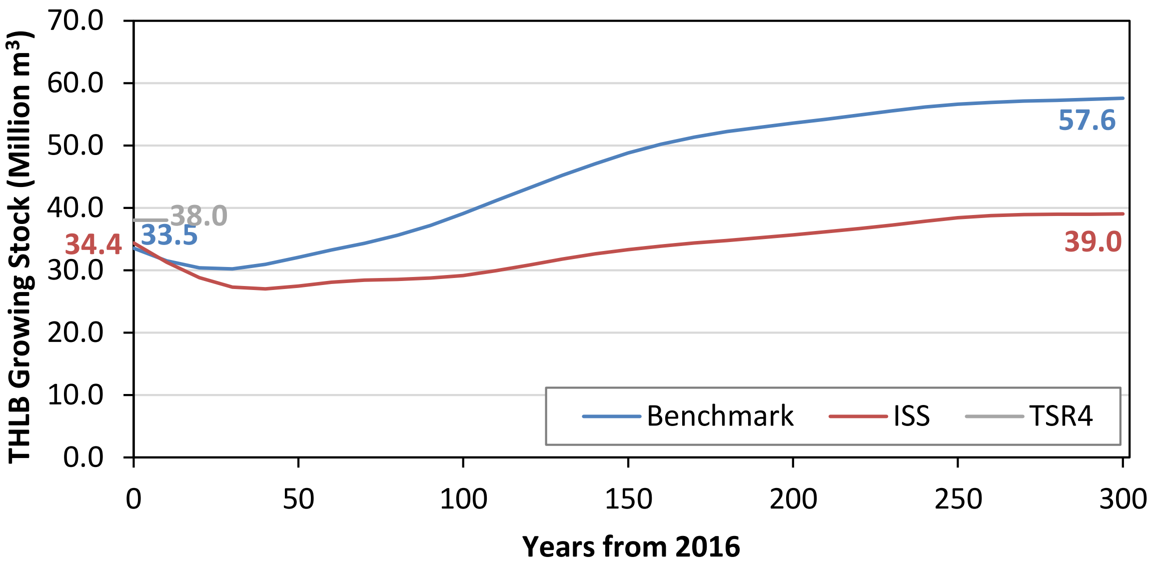


Figure 3 ISS Base Case Scenario –THLB Growing Stock (Even-Flow)

3.1.2 MINDY Harvest Profile

Due to the wide range of factors involved, an even-flow harvest rate, adopted initially in TSR4, is not suitable for the complex analyses developed for the ISS, as it only examines the impact of one key factor over the period(s) where all constraints converge to the lowest harvest rate (i.e., the "pinch point", which occurs in 50 to 70 years). Typically, the lowest harvest rate becomes the even-flow harvest rate. Harvest opportunities that exist before and after the pinch-point are not fully examined, leaving many questions unanswered. Therefore, these ISS scenarios will focus on the maximum initial, non-declining yield (MINDY) harvest flow that can fully explore a range of factors. The MINDY harvest profile is shown below; ***it was used to compare subsequent analyses as the ISS Base Case harvest flow***.

The MINDY harvest profile was developed in 3-stages:

1) An even-flow harvest profile was determined, similar to the TSR4 and ISS Base Case discussed above in section 3.1.1.

2) A non-declining yield (NDY) was imposed, such that the harvest rate was always above the even-flow harvest rate determined in stage 1 and it does not decline over the planning horizon. In addition, to ensure long-term sustainability, the THLB growing stock does not decline over the last 100 years of the 300-year planning horizon.
3) A maximum harvest rate was developed over the first period without decreasing the harvest rates developed in stage 2. Again, the THLB growing stock does not decline in the last 100 years of the planning horizon.

3.1.3 Harvest Flow and THLB Growing Stock

Compared to the TSR Benchmark, the ISS Base Case (MINDY) harvest profile was approximately 4.2% less in the first decade, nearly identical over the mid-term (0.2% less), and 14.5% less over the long-term (Figure 4). Factors contributing to these differences included the land base, non-timber objectives, NHLB disturbances, and NRL. To meet non-timber objectives, the ISS Base Case had to use the reduced THLB area more efficiently. This also resulted in significantly lower levels of total and merchantable growing stock (Figure 5), despite similar initial values. Note that approximately 94% of the THLB falls into reporting units that require a range of non-timber objectives (i.e., Green-up, UWR, ECA, and VQO). The remaining THLB (6%) is within FMER open forest/open range with no non-timber objectives. As discussed in section 3.2, VQOs and ECAs were the most constraining non-timber objectives.

Disturbance in the NHLB of approximately 1,700 ha/year did not appear to impact the harvest rate in the short- and mid-terms, as the ISS Base Case was similar to the TSR Benchmark Scenario harvest rate. Recall that NHLB disturbance was not modelled in the TSR Benchmark Scenario. However, as more NHLB was disturbed, more THLB had to be allocated to meet non-timber objectives so in the long-term, the harvest rate was restricted by this factor. Meanwhile, the continuous aging of the NHLB into the long-term helped the TSR Benchmark Scenario to meet non-timber objectives without affecting the THLB.

Note that the even flow harvest rate in Figure 2 did not exactly match the mid-term harvest rate in Figure 4. This was likely due to the heuristic nature of the forest estate model used in this analysis, which requires significantly more solving time to improve solutions by <1%. Thus, any variations within 1% are generally accepted as insignificant. To achieve more realistic solutions, the solving time could be adjusted for selected scenarios used for tactical and operational planning purposes. The significant long-term difference of 13.9% (14.5% - 0.6%) can be explained by the relatively smaller THLB and complex interaction of factors that constrained the model to achieve the non-timber objectives.

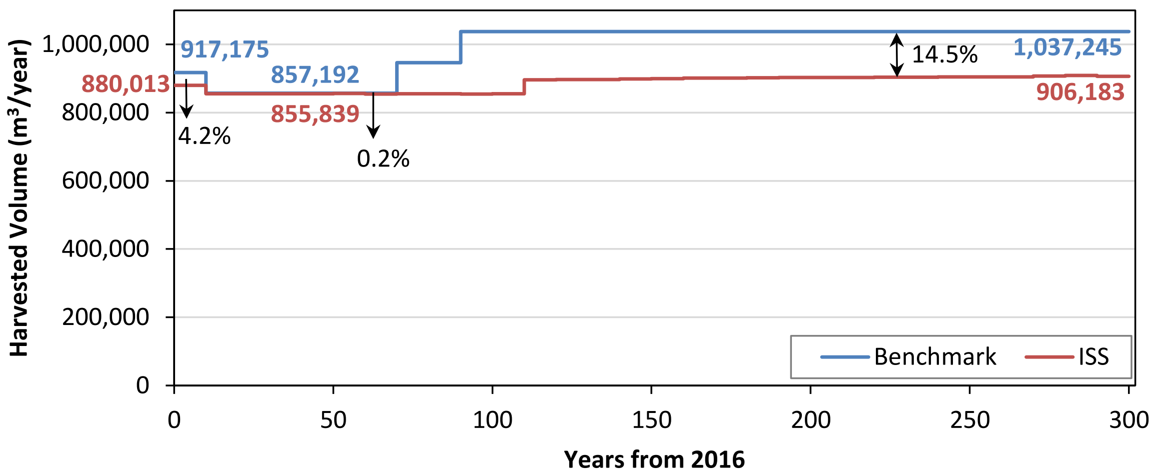


Figure 4 ISS Base Case Scenario – Harvest Forecast (MINDY)

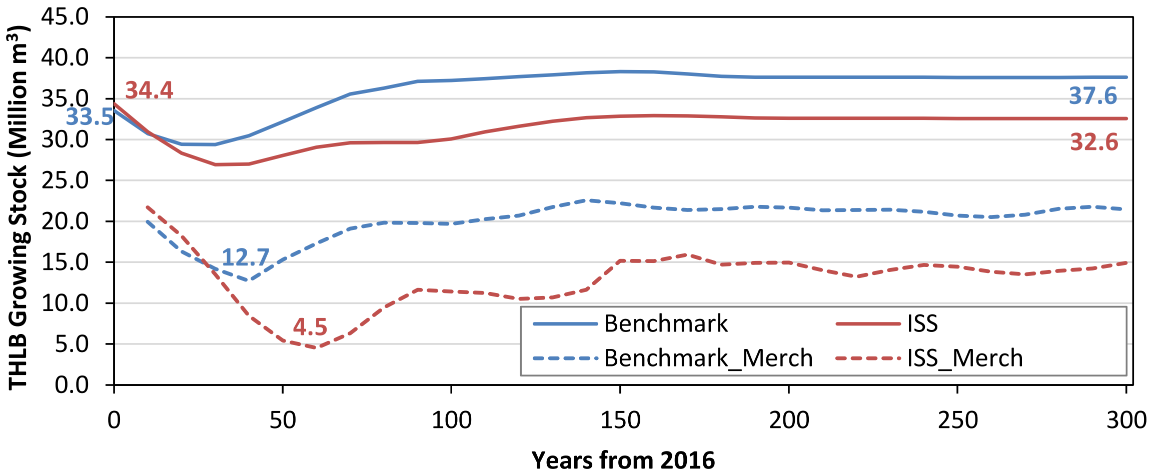


Figure 5 ISS Base Case Scenario – THLB Growing Stock (MINDY)

3.1.4 Management State

The harvest profile reported by management state (Figure 6) indicates that for the first 40 years, the harvested volume was sourced exclusively from existing natural (EN) stands. Existing managed (EM) stands started to significantly contribute to the harvest rate in the fifth decade. By the twelfth decade, most of the harvested volume came from future managed stands (FM). The stands impacted by wildfires in 2017 contributed to the harvest rate mostly between years 51 and 120. In the long-term, some minor volumes were still sourced from existing stands that the model likely recruited to achieve non-timber objectives, or were poor stands with relatively old minimum harvest ages.

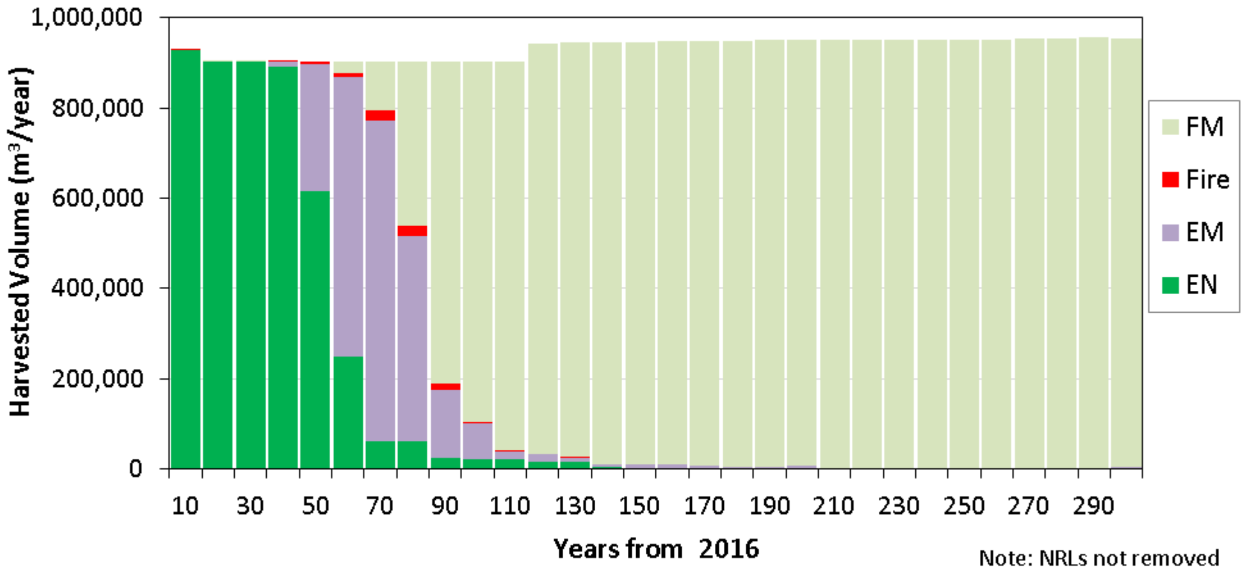


Figure 6 ISS Base Case Scenario – Harvest Volume by Management State

3.1.5 Age Class Distribution

The age class distribution over time (Figure 7) shows that the THLB transitions from a relatively mature and old structured forest to a relatively young forest structure where most of the THLB is evenly distributed in age classes under 80 years. This aligns with expected changes over time, as the model converts the THLB to a regulated forest estate. Disturbance in the NHLB area (approximately 1,700 ha/year) cycles through age classes over time and by the end of the 300-year planning horizon, most of the NHLB area (70%) was evenly distributed in age classes under 240 years. Exceptions include in-block retention, which is never disturbed, so by year 300, it all becomes older than 240 years. Note that by the end of the planning horizon there are over 15,000 ha of THLB older than 240 years. These areas were likely retained to address ECA and VQO objectives within heavily constrained reporting units.

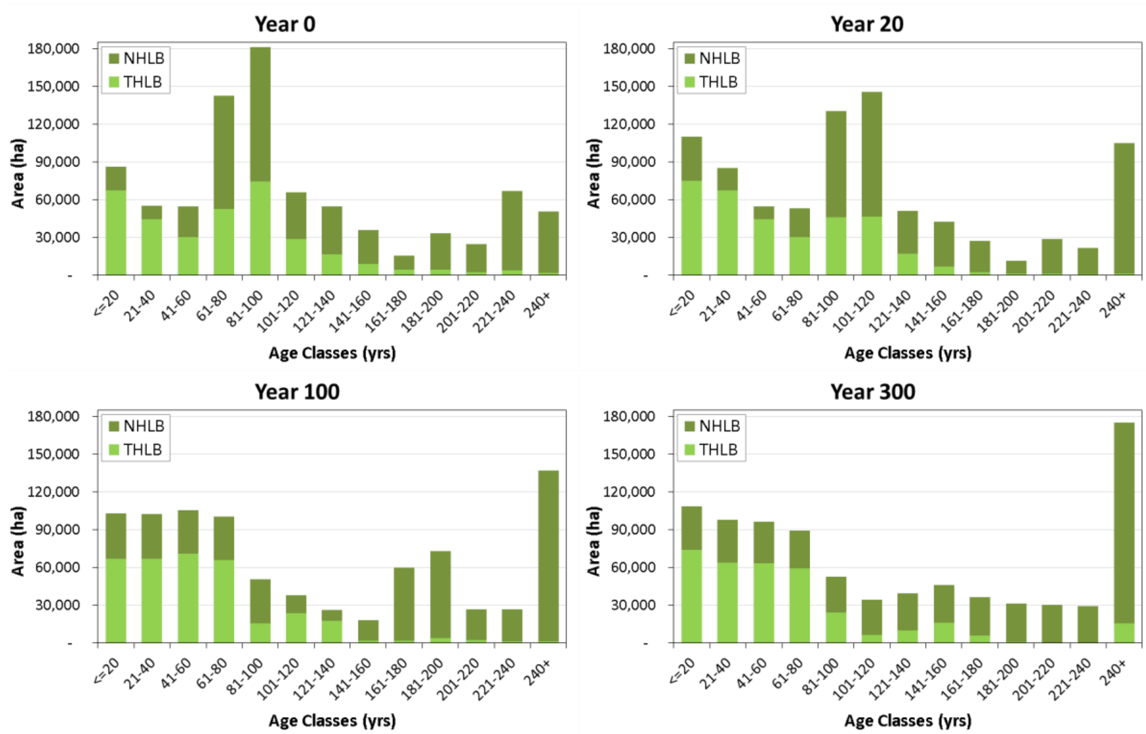


Figure 7 ISS Base Case Scenario – Age Class Distribution at Years 0, 20, 100, and 300

3.1.6 Age Class

The harvest profile reported by age class (Figure 8) shows that a significant amount of harvest from stands <80 years (green colour) began after 40 years, which is consistent with results observed in Figure 4 and the observed 'pinch-point' period (year 50-70). By year 20, most of the volume was harvested from stands aged 80-120 years; consistent with the minimum harvest ages applied. However, yield curves estimates for future managed stands continued to increase significantly 10-20 years past these minimum harvest ages. This explains the visibly higher volumes at harvest and suggests that the minimum harvest criteria may be revised to include an indicator of annual growth, such as mean annual increment.

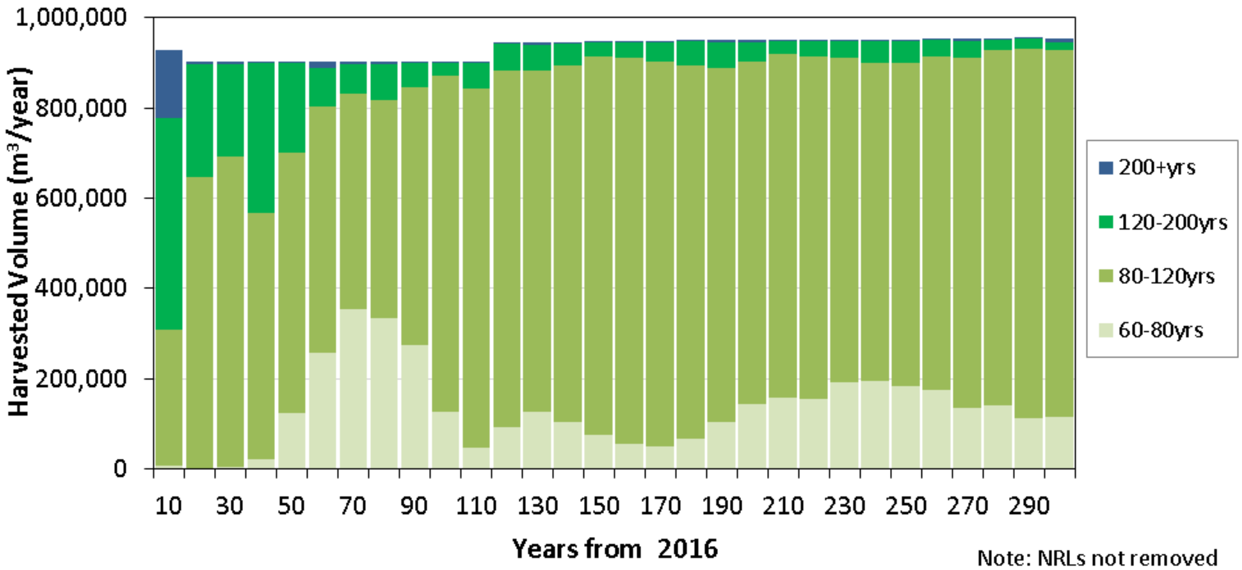


Figure 8 ISS Base Case Scenario – Harvest Volume by Age Class

3.1.7 Average Volume and Age

The average volume at harvest (solid black line and left axis in Figure 9) fluctuated over time, while the general trend showed it increases from approximately 215 m^3/ha to 261 m^3/ha by year 100, and becomes fairly stable at around 250 m^3/ha for the rest of the 300-year planning horizon. Note that these values are considerably higher than the minimum harvest volume criterion set between 100 m^3/ha and 200 m^3/ha based on slope and leading species.

The average age of harvested stands (dotted black line and left axis in Figure 9) began at 148 years and declined to 99 years after 7 decades, as the harvest transitioned from existing to future stands (i.e., post-harvest regenerated stands). Over the rest of the 300-year planning horizon, the average age at harvest fluctuated between 91 around 107 years.

The average area harvested each year (solid red line and right axis in Figure 9), slowly decreased over the 300-year planning horizon, averaging ~4,100 ha/year over the first century and ~3,600 ha/year over the last century.

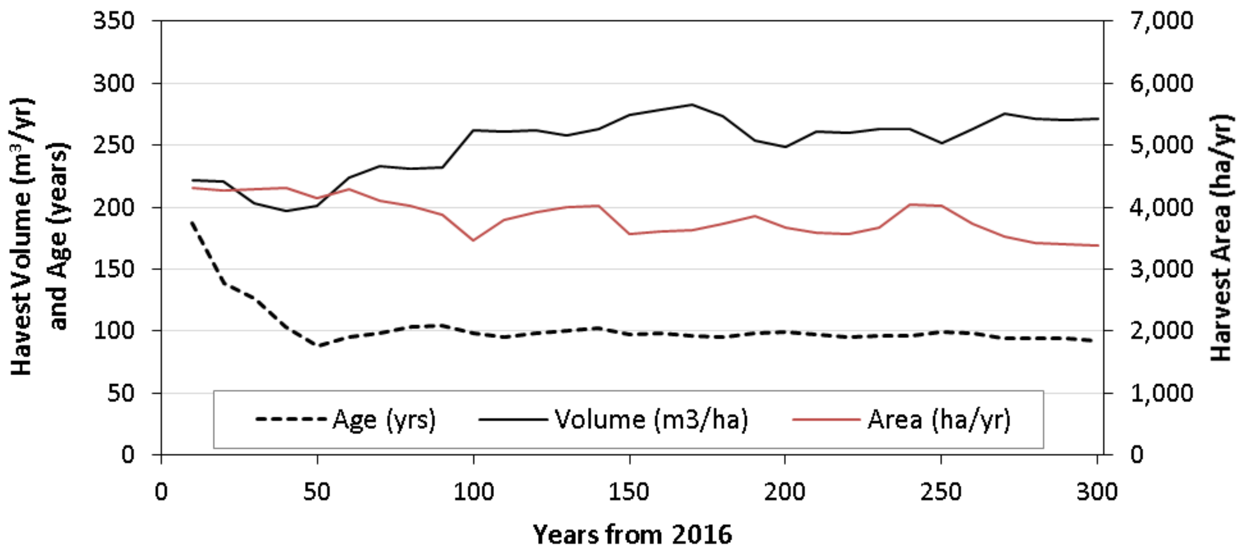


Figure 9 ISS Base Case Scenario – Average Age and Volume at Harvest

3.1.8 Species Groups

The harvest profile reported by species group (Figure 10) shows that most of the harvested volume was white wood from lodgepole pine and spruce, followed by red wood from Douglas-fir and larch, and white wood from subalpine fir and hemlock. There are minor contributions from yellow pine and cedar.

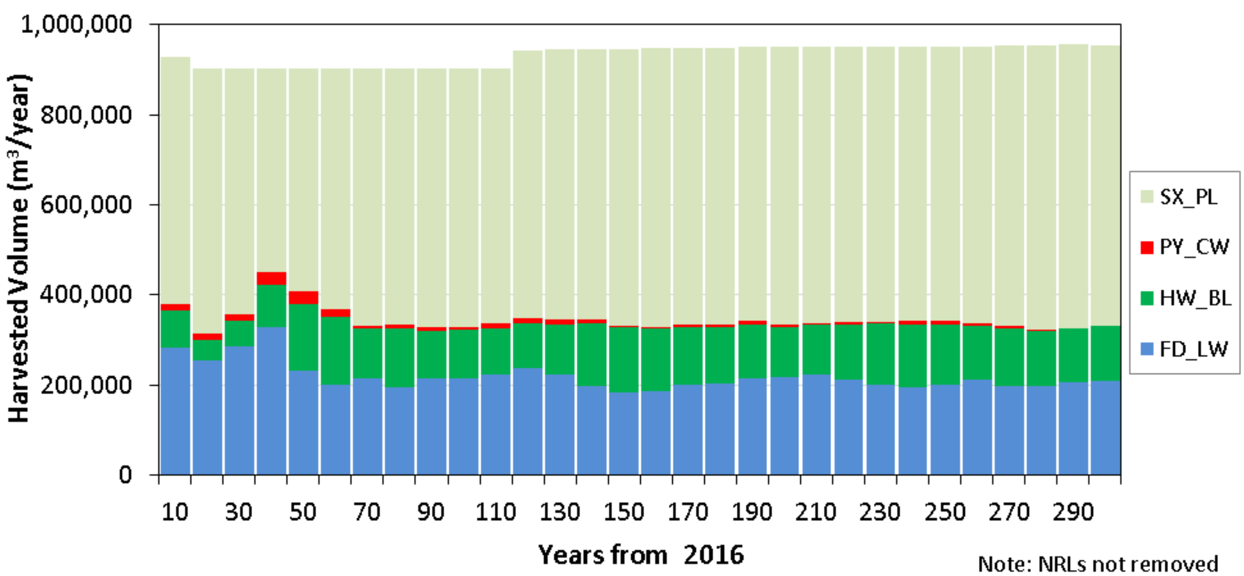


Figure 10 ISS Base Case Scenario – Harvest Volume by Species Groups

3.1.9 Individual Species

The harvest profile reported by individual species (Figure 11) shows that most of the harvested volume was sourced from lodgepole pine and spruce, with important contributions from Douglas-fir, subalpine fir, and western larch.

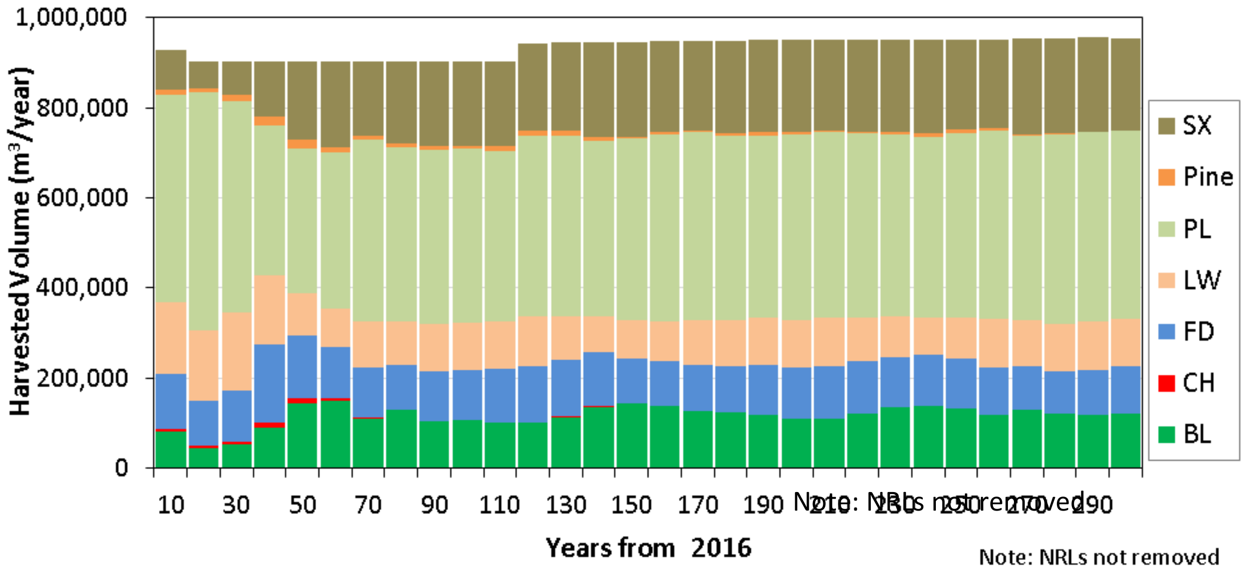


Figure 11 ISS Base Case Scenario – Harvest Volume by Individual Species

3.1.10 Haul Time

The harvest profile reported by one-way haul time (Figure 12) shows that most of the harvested volume came from stands less than one-hour (purple + red) away from a processing facility. Important volume contributions were sourced from stands between 1 and 1.5 hours away (blue).

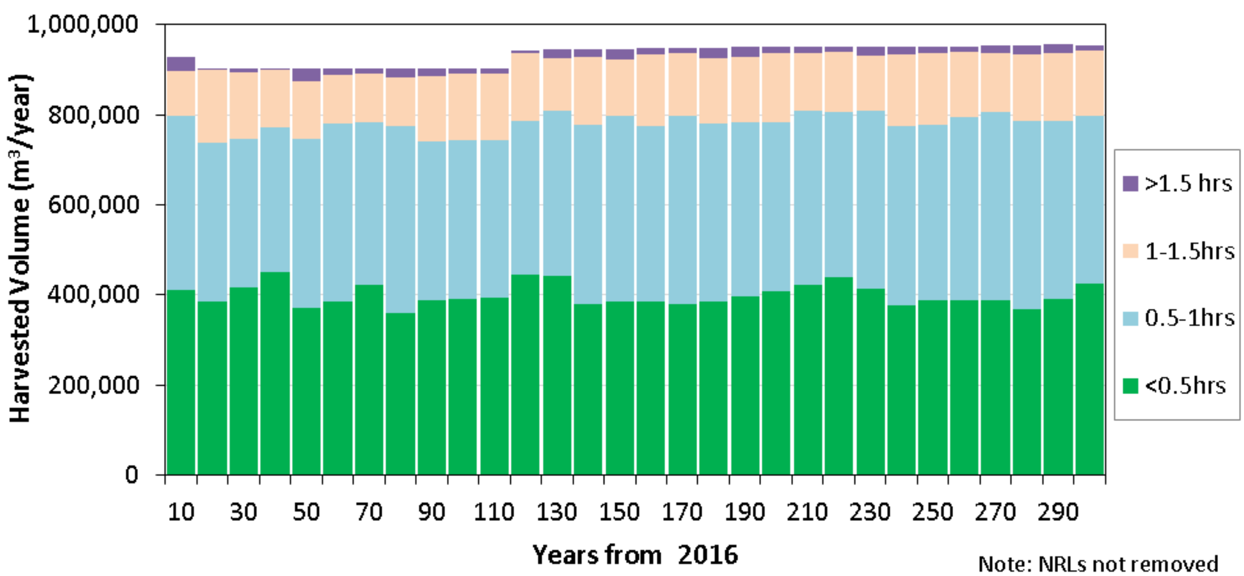


Figure 12 ISS Base Case Scenario – Harvest Volume by Haul Distance (one-way)

3.1.11 Harvest System

The harvest profile reported by harvesting system (Figure 13) shows that most of the harvested volume was sourced from ground-based harvesting system where slopes are <=40%.

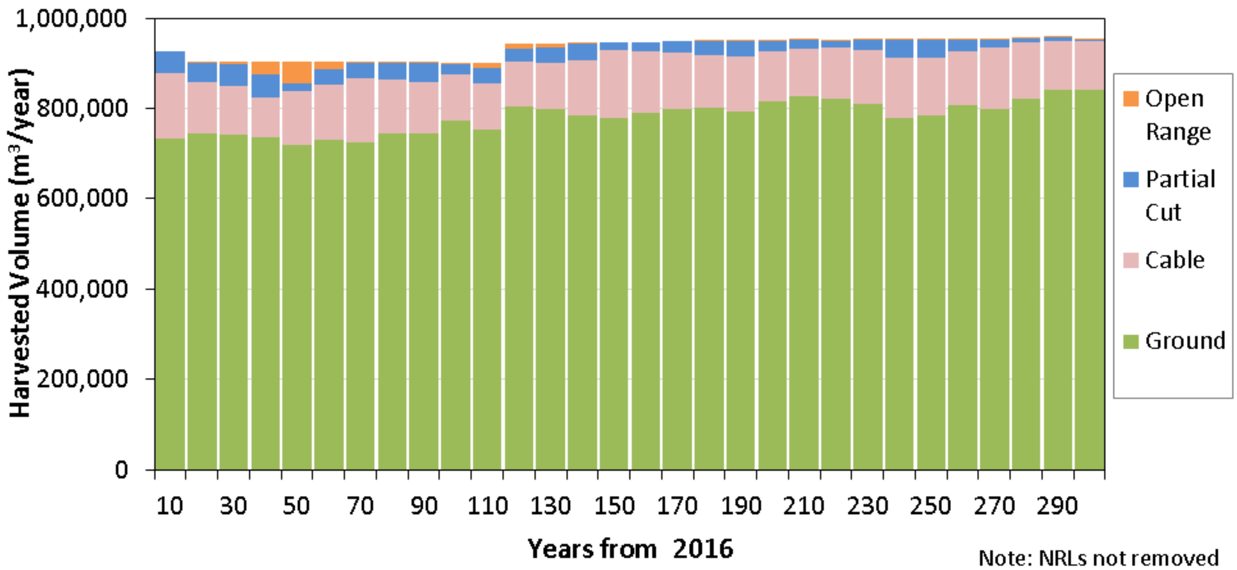


Figure 13 ISS Base Case Scenario – Harvest Volume by Harvest System

3.2 Non-Timber Objectives

3.2.1 Seral Stage

These results described in section 3.1.5 corroborate with the seral stage distribution over the entire 300-year planning horizon (Figure 14), where most of the THLB is evenly distributed in early and mid seral stages. Approximately half of the NHLB is in old seral stage while the other half is well distributed in early, mid, and mature seral stages.

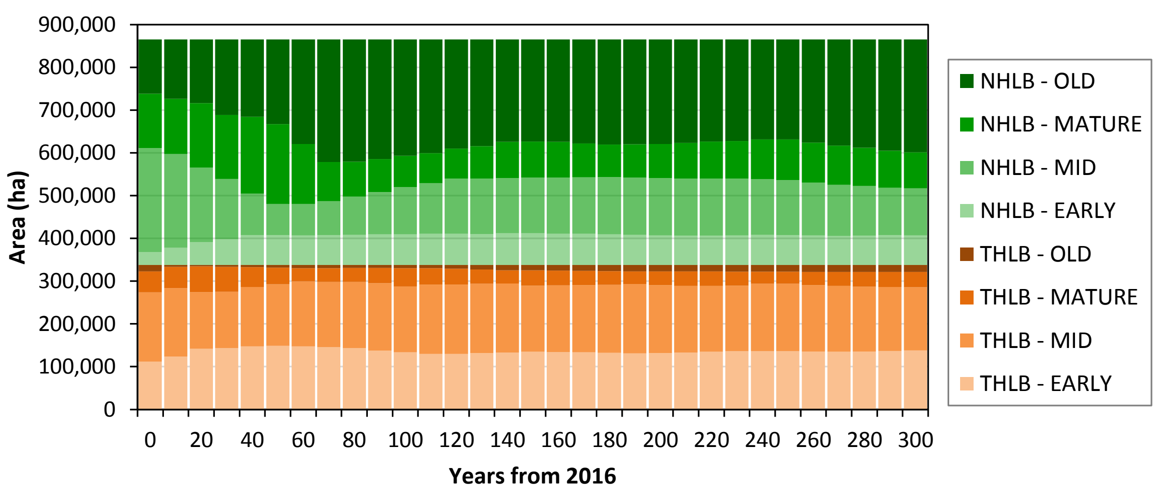


Figure 14 ISS Base Case Scenario – Area Distribution by Seral Stage over the Planning Horizon

3.2.2 Green-up

Block level green-up targets are specified in the KBLUPO based on Operational Planning Regulation (section 68(4)). These targets restrict harvest as follows:

- Maximum 33% at <2 years within each Landscape Unit (LU) and Enhanced Resource Development Zone (ERDZ) (Timber) combination, and
- Maximum 33% at <12 years within each Landscape Unit (LU) and Integrated Resource Management Zone (IRMZ) combination.

The ERDZ is defined spatially by the KBLUPO, while the IRMZ includes the remaining THLB area that is not designated as Fire Management Ecosystem Restoration (FMER) - Open Forest or Open Range.

Results for the ISS Base Case Scenario indicate that these green-up targets were not constraining overall. Targets were closer to being constraining within the relatively small reporting units modelled (combination of LU and ERDZ or IRMZ). Some examples are shown in Figure 15 (largest reporting units in each combination category). Here, the blue-shaded zone indicates the maximum target and the black line shows the actual percentage of THLB area disturbed within the reporting unit; the aim was to remain below the blue-shaded (target) zone.

The model was quite flexible in scheduling the harvest to meet green-up targets because the average THLB area for the 76 reporting units was 4,000 ha, 49% of the THLB area in these reporting units did not overlap with any other non-timber objectives while the average annual harvest area was 3,800 ha/year.

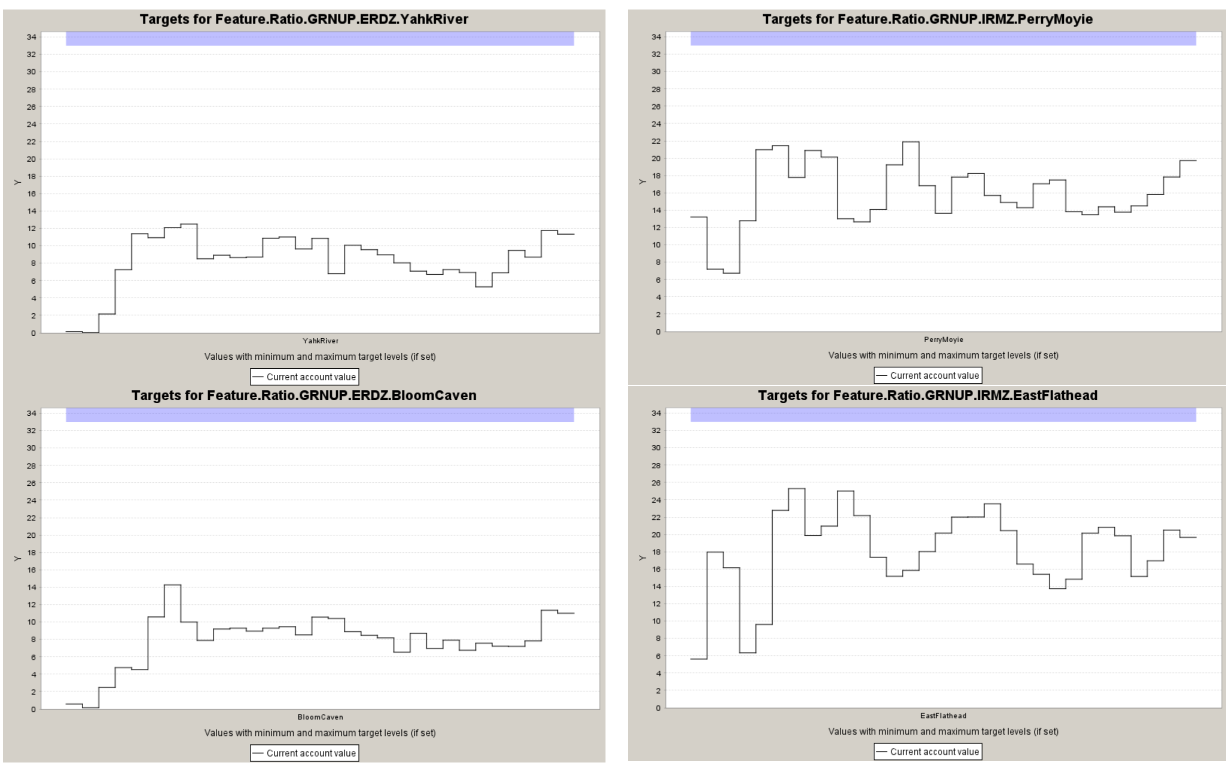


Figure 15 ISS Base Case Scenario – Green-Up Targets (examples)

3.2.3 Ungulate Winter Range

Ungulate winter range (UWR) general wildlife measures require, within each LU and designated UWR, minimum forest cover requirements (i.e., snow interception 10-30% >60 years, and/or mature 10-20% >100 years), including young stands cover (<21 years) should not exceed 33% of the FMLB area. Results show that minimum seral cover targets were not constraining on the harvest rate. Some examples of largest reporting units are included in Figure 16. Here, the red-shaded area indicates the minimum target that must be maintained over time and the black line indicates the actual proportion of FMLB area in each period that was older than the seral cover (60 or 100 years). The target was not achieved where the black line is shown within the red-shaded zone. For some of the largest reporting units (FMLB area >4,000 ha), young seral targets were constraining over some periods in (see examples Figure 17).

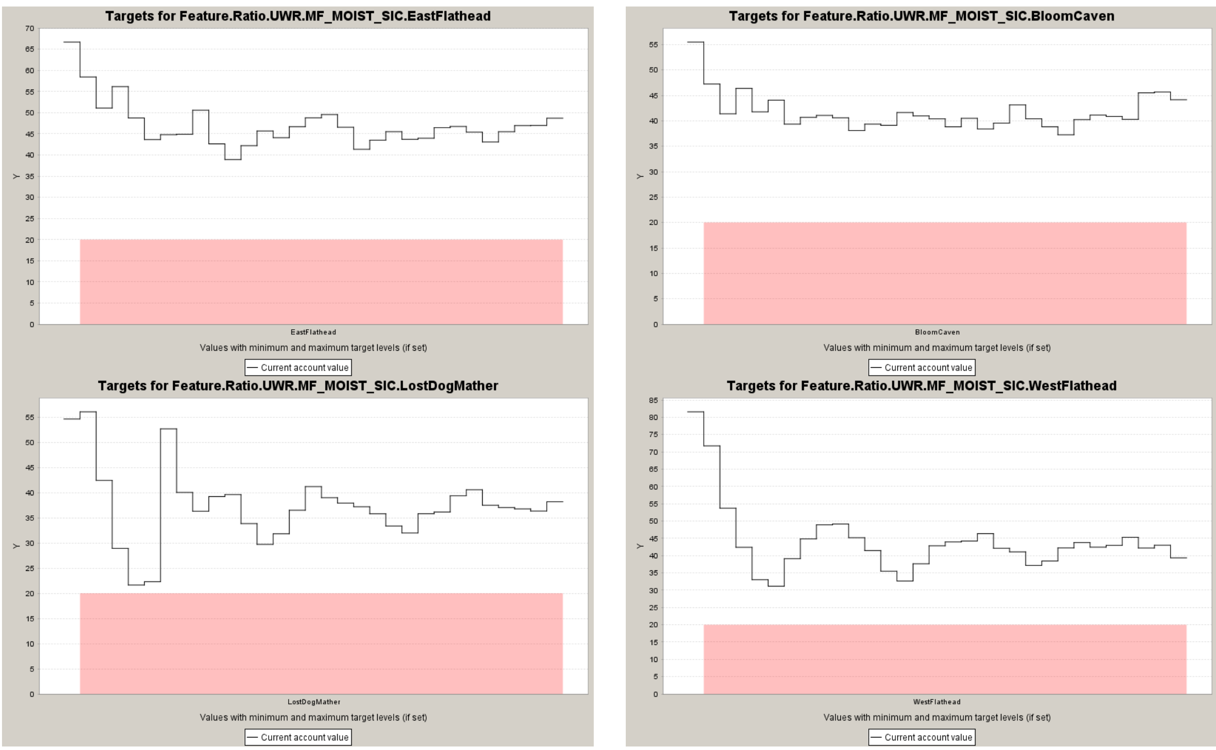


Figure 16 ISS Base Case Scenario – UWR Snow Interception and Mature Cover Objectives (examples)

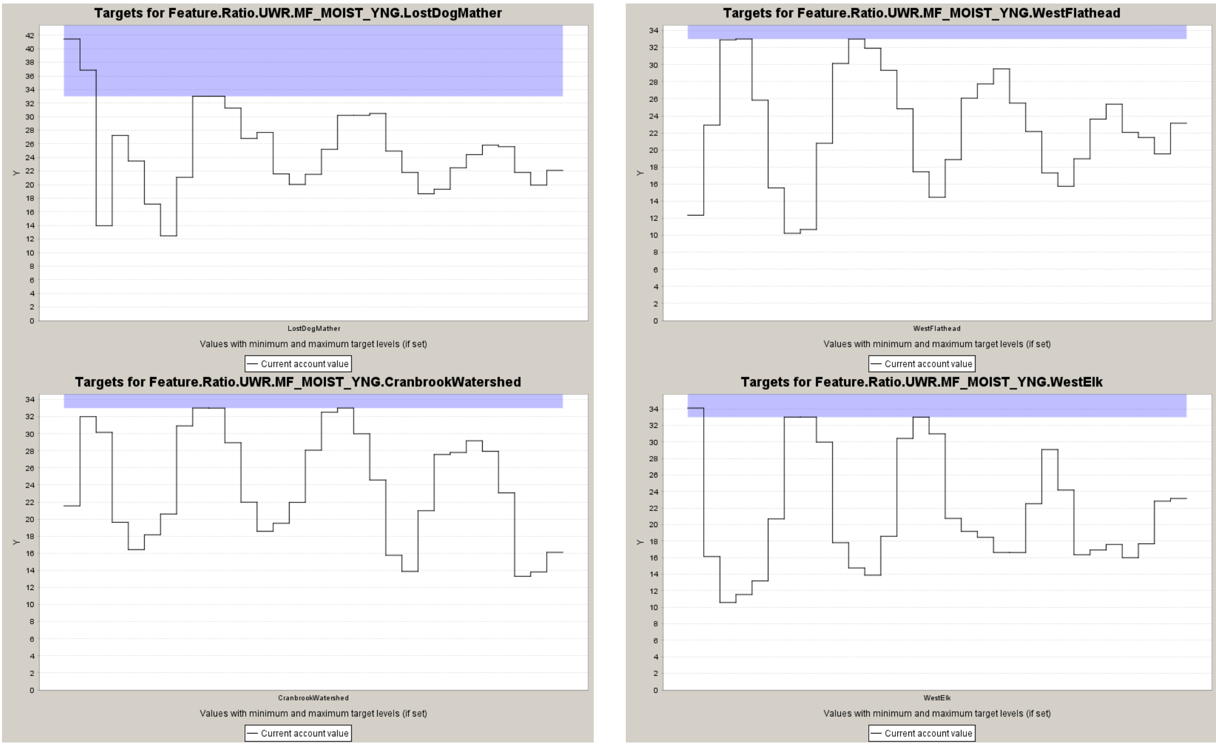


Figure 17 ISS Base Case Scenario – UWR Young Seral Cover Objectives (examples)

3.2.4 Community and Domestic Watersheds

Disturbance (natural and anthropogenic) within the 12 community watersheds and 148 domestic watersheds was modelled with a maximum 30% Equivalent Clearcut Area (ECA). Within each watershed, the ECA was calculated relative to the modelled FMLB area (with targets factored relative to total watershed area). The results showed the Gold (FMLB = 9,249 ha, THLB = 7,064 ha) and Joseph (FMLB = 4,964 ha, THLB = 3,063 ha) Community Watersheds were the most constrained (Figure 18). Note that despite the relatively high THLB component the natural disturbance within the NHLB portion causes these watersheds to be even more constraining. In addition to being disturbed, the NHLB area regenerates to the original existing natural yield, which takes longer to fully recover hydrologically, compared to managed yields.

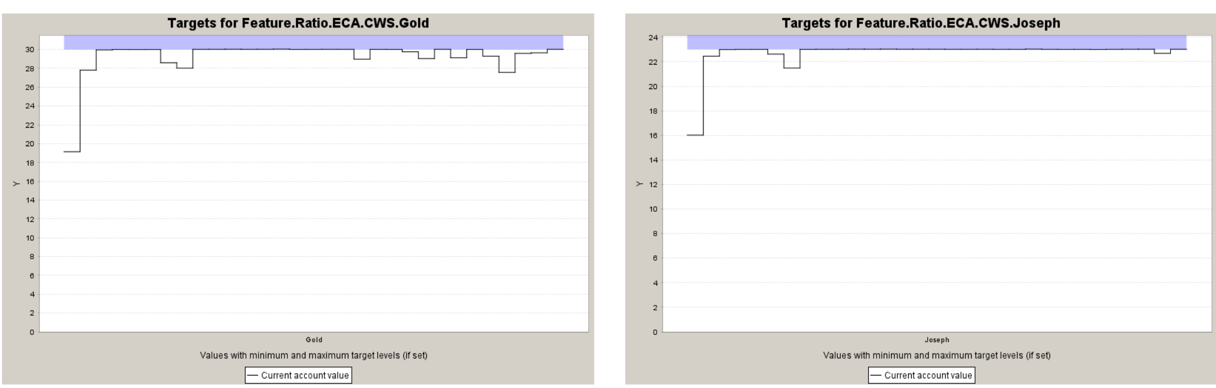


Figure 18 ISS Base Case Scenario – Community Watershed Targets (examples)

Some of the relatively large domestic watersheds (>1,000 ha) were constrained, including: Mather Creek (FMLB = 7,845 ha, THLB = 6,043 ha), Linklater Creek (FMLB = 2,587 ha, THLB = 1,989 ha), Haha Creek (FMLB = 2,142 ha, THLB = 1,503 ha), Arnold Creek (FMLB = 1,243 ha, THLB = 685 ha), Norbury Creek (FMLB = 1,198 ha, THLB = 701 ha), and Linklater Creek 3 (FMLB = 1,099 ha, THLB = 639 ha) (Figure 19.

Note that the THLB for some of the relatively large domestic watersheds prevented harvesting over some periods because the prorated ECA target was zero (e.g., Norbury Creek). A similar trend was observed for domestic watersheds under 1,000 ha. Overall, the ECA thresholds applied to domestic watersheds had a negative impact on the harvest rate. Note that natural disturbance modelled within the NHLB exacerbated the negative impact on harvest rate by reducing the THLB area that could be disturbed.

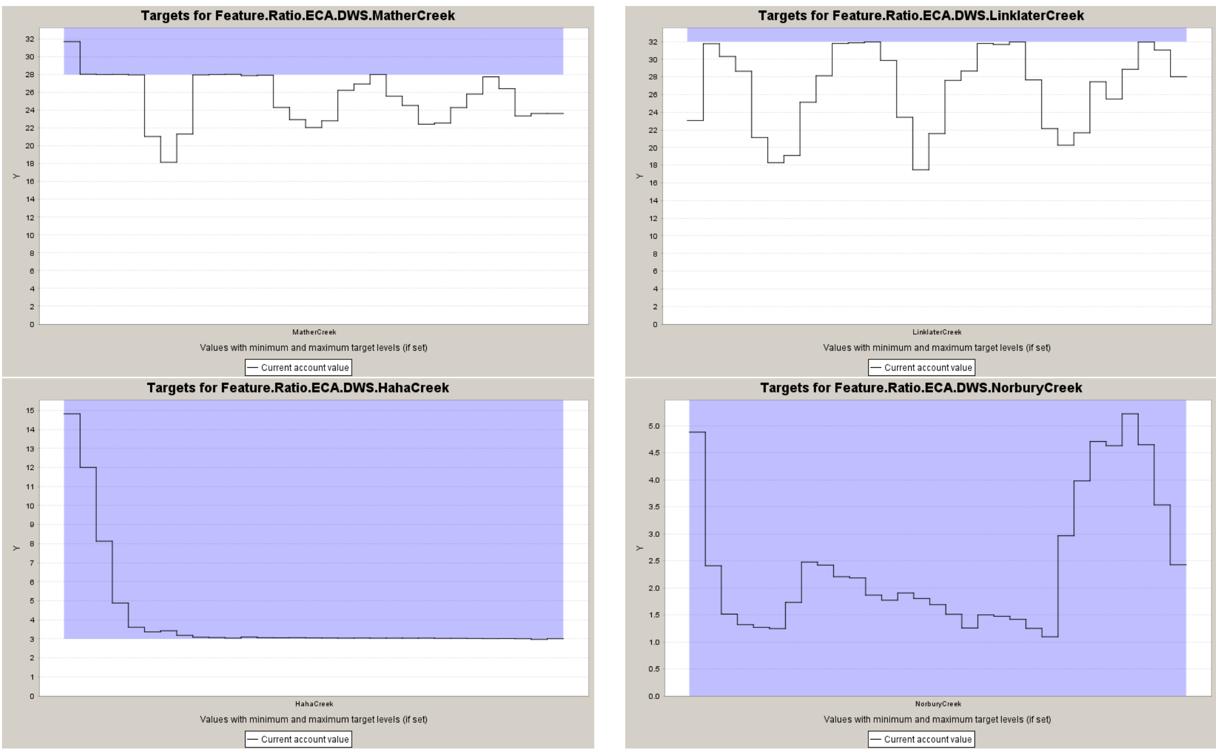


Figure 19 ISS Base Case Scenario – Domestic Watershed Targets (examples)

3.2.5 Visual Quality Objectives

Visual quality objectives (VQO) were applied to restrict the disturbance (natural and anthropogenic) in 471 Visual Landscape Inventory (VLI) polygons, where the maximum target disturbance ranged between 0.2% and 67.9% of the FMLB area. The maximum target disturbance for many of the VLI polygons was not maintained due to the relatively high proportion of disturbance within the NHLB area. Recall that the NHLB area was disturbed at a rate of 1,700 ha/year and then reverted to the same existing natural yield, which took longer to achieve visually effective green-up heights compared to managed yields. For example, only natural disturbance occurred for the two largest VLI polygons (#110669, FMLB = 5,211 ha, THLB = 1,065 ha; #110904 – FMLB = 2,584 ha, THLB = 357 ha), which violated the maximum disturbance target (Figure 20) over the entire planning horizon (i.e., THLB not available).

In many of the VLI polygons with a relatively large component of THLB (500 to 1,000 ha), the maximum target disturbance was overall constraining. Some examples are included in Figure 20 (#111000 – FMLB

= 2,547 ha, THLB = 1,178 ha, #111289 – FMLB = 2,350 ha, THLB = 1,495 ha). While VQOs generally constrained the harvest flow, proper visual landscape design and partial cut harvest systems can be implemented to alleviate these constraints. These specific tactics were not modelled in the ISS Base Case Scenario.

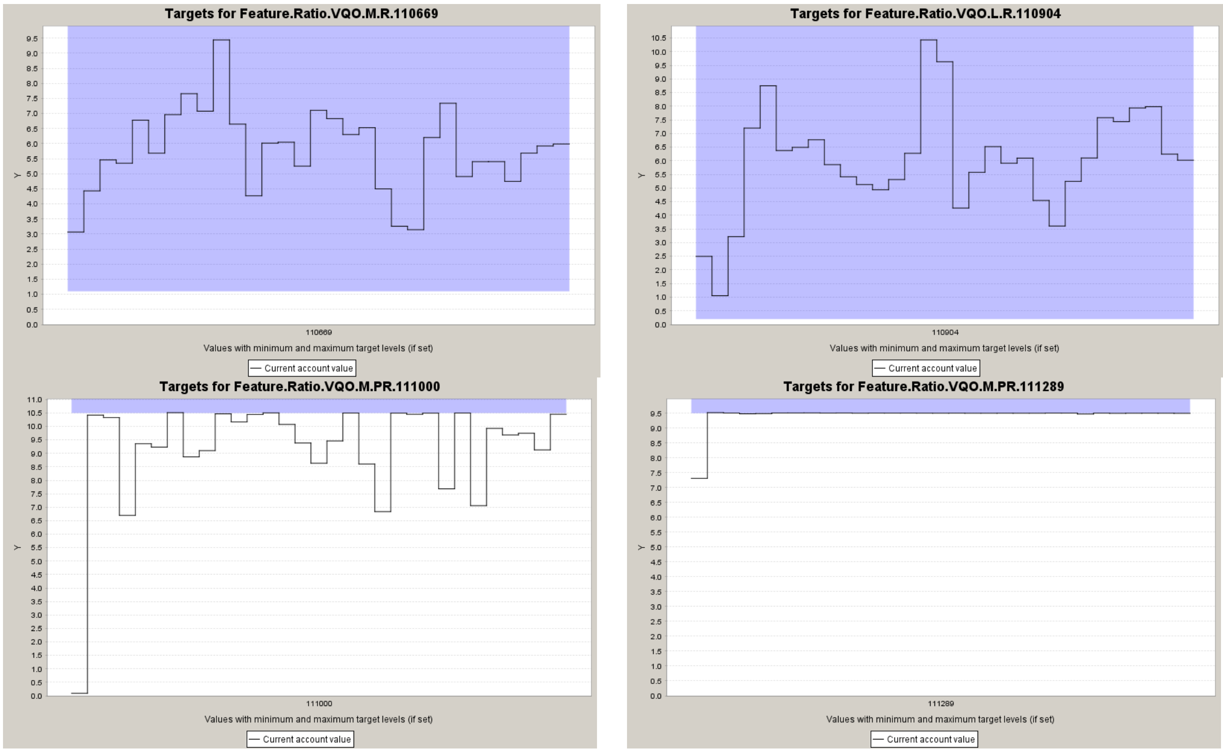


Figure 20 ISS Base Case Scenario – VQO Objectives (examples)

3.3 Sensitivity Analyses

A total of 14 runs were modelled in the ISS Base Case Scenario (Table 3). The first 3 runs explored different harvest flows: even-flow (001), non-declining yield (NDY) (002), and MINDY (003). The other nine sensitivity runs explored adjustments of various assumptions:

- Change the maximum ECA threshold from 30% to 25% (004),
- Apply KBLUPO landscape-level biodiversity (BIOD) full targets (no 2/3 draw-down), in addition to, the established OGMAs and MMAs (005),
- Maintain current slope and hauling distance profiles for the first 40 years (006),
- Turn off OGMAs and MMAs and exploring landscape-level biodiversity objectives by applying:
  - only the old seral requirements, including 2/3 draw-down (007),
  - mature and old seral requirements, including 2/3 draw-down (008),
  - mature, old (including 2/3 draw-down), and very early seral (<=20years) patches (009),
- Turn off FSC requirements for Canfor operating areas (FPPR applies instead) (010),
- Group LUs as detailed in Appendix 3 with the mature and old seral requirements, including 2/3 draw-down (011), and

- Group LUs as detailed in Appendix 3 with all non-timber objectives (mature and old seral (including 2/3 draw-down), green-up adjacency, and UWR objectives) (012).

For consistency, the harvest profiles for runs 004 to 008 and 009 were developed similar to the approach used for 003 MINDY (maximum initial and non-declining), as discussed in section 3.1.2. Here, the THLB growing stock was constrained to be non-declining over the last 100 years of the 300-year planning horizon. Throughout these analyses, it was observed that minor changes to the harvest profile might have resulted in an identical harvest profile as 003 if the model were run longer. However, for consistency, the model was run for a similar number of iterations.

Table 3 ISS Base Case Scenario – Summary of Sensitivity Analyses

Sensitivity ID	Description	THLB		Harvest rate (m³/year)			Harvest rate % from 003		
		(ha)*	%from 003	First decade	Mid-term	Long-term	First decade	Mid-term	Long-term
000a	TSR4 Even Flow	351,773	4.0%	824,700	824,700	824,700	-6.3%	-3.5%	-9.0%
000b	Benchmark MINDY	356,128	5.3%	917,175	857,174	1,037,245	4.2%	0.3%	14.5%
001	Even flow	338,223	0.0%	857,182	857,399	857,544	-2.6%	0.3%	-5.4%
002	NDY	338,223	0.0%	857,969	856,945	906,128	-2.5%	0.2%	0.0%
003	**MINDY**	**338,223**	**0.0%**	**880,013**	**854,895**	**906,183**	**0.0%**	**0.0%**	**0.0%**
004	ECA 25pct	338,223	0.0%	870,204	848,767	904,354	-1.1%	-0.7%	-0.2%
005	Slope/Haul	338,223	0.0%	873,188	845,548	907,627	-0.8%	-1.1%	0.2%
006	BIOD on	338,223	0.0%	845,686	820,816	906,025	-3.9%	-4.0%	0.0%
007	OGMA/MMA off, BIOD old	363,385	7.4%	926,243	897,519	977,820	5.3%	5.0%	7.9%
008	OGMA/MMA off, BIOD mat/old	363,385	7.4%	910,813	892,467	964,240	3.5%	4.4%	6.4%
009**	OGMA/MMA off, BIOD mat/old, very early seral patches on	363,385	7.4%	871,409	856,271	957,506	-4.3% (008)	-4.1% (008)	-0.7% (008)
010	FSC off	348,710	3.1%	905,845	879,141	933,838	2.9%	2.8%	3.1%
011**	Grouped LUs for OGMA/MMA off, BIOD mat/old; all other non-timber objectives with LUs	363,385	7.4%	911,211	894,973	973,573	0.0% (008)	0.3% (008)	1.0% (008)
012**	Grouped LUs for all related non-timber objectives	363,385	7.4%	909,388	893,995	977,207	-0.2% (008)	0.2% (008)	1.3% (008)

**Effective THLB area in the model; it differs slightly from the THLB area reported in Table 1 because of the rounding errors. All percentages are calculated relative to sensitivity ID 003 (i.e., sensitivity ID is the denominator).*
***It was more appropriate to compare these sensitivities to sensitivity 008, as denoted in brackets.*

The sensitivity analyses produced the following outcomes:

- (001-003) Adopting the MINDY harvest profile added 2.6% more harvest volume in the first decade, and 5.4% more in the long-term compared to an even-flow approach. Volume availability in the first decade was heavily constrained by the relatively young and mature (<100 years) age class distribution of the THLB at year zero (Figure 7). The NDY harvest rate was similar to the even-flow (001) in the first decade, and similar to MINDY in the mid- and long-term.
- (004) Decreasing the maximum disturbance threshold permitted within key watersheds (from 30% ECA to 25%) resulted in 1.1% less volume available in the first decade with no significant negative impacts in the mid- and long-term.
- (005) Maintaining the current slope and haul distance profiles for the first 40 years resulted in a decrease of 1.1% in harvest level over the mid-term but very little change in the first decade or long-term. The slope and haul distance (one-way) profiles established for the first 40 years included:
    - Ground harvesting systems constrained to 90% of the harvested area.

- Harvested area within ½ hour constrained to 57%, and between ½ hour and 1 hour, constrained to 32% of the total harvested area.

➢ (006) Applying the full landscape-level biodiversity requirements for mature and old seral forests over the entire planning period (i.e., no 2/3 draw-back), as well as, the established OGMAs and MMAs, reduced harvest rates by 3.9% in the first decade and 4.0% in the mid-term, but there was no negative impact in the long-term. This suggests that the established OGMAs and MMAs, alone, are not sufficient to meet the full targets for mature and old seral forest in the short- and mid-terms. To meet these targets, the model recruited stands into the long-term when some of these stands could be released.

➢ (007-008) Turning off the OGMAs and MMAs increased the THLB by 7.4%. Despite this increase, gains in harvest rates were less in the first decade (up to 4.5%) and mid-term (up to 4.3%). In the long-term, as the model successfully recruited stands to meet the mature and old seral forest targets, the harvest rate bounced back closer to the level of the THLB increase.

➢ (009) Results for modelling very early seral patches were more appropriately compared to sensitivity 008 configured with the same THLB area and seral requirements.

- Influencing the model to trend towards desired patch size distributions reduced harvest rates in the first period and mid-term by 4.3% and 4.1, respectively. The long-term harvest rate was reduced by only 0.7%.
- Some examples of very early seral patch objectives were also compared to the 003 ISS Base Case (i.e., top 2 largest units THLB area for Canfor, and top 2 THLB area for BCTS/Galloway) in Figure 21. Detailed results are included in Appendix 1. Without patch targets set on very early seral (ISS Base Case 003), most patches develop into lower patch size ranges; especially the relatively small reporting units (<1,000 ha).
- While old seral patches were not specifically modelled, they were reported as by-products of the analysis. Some examples of old seral patches (003 vs.009) are included in Figure 22 and detailed results in Appendix 2.

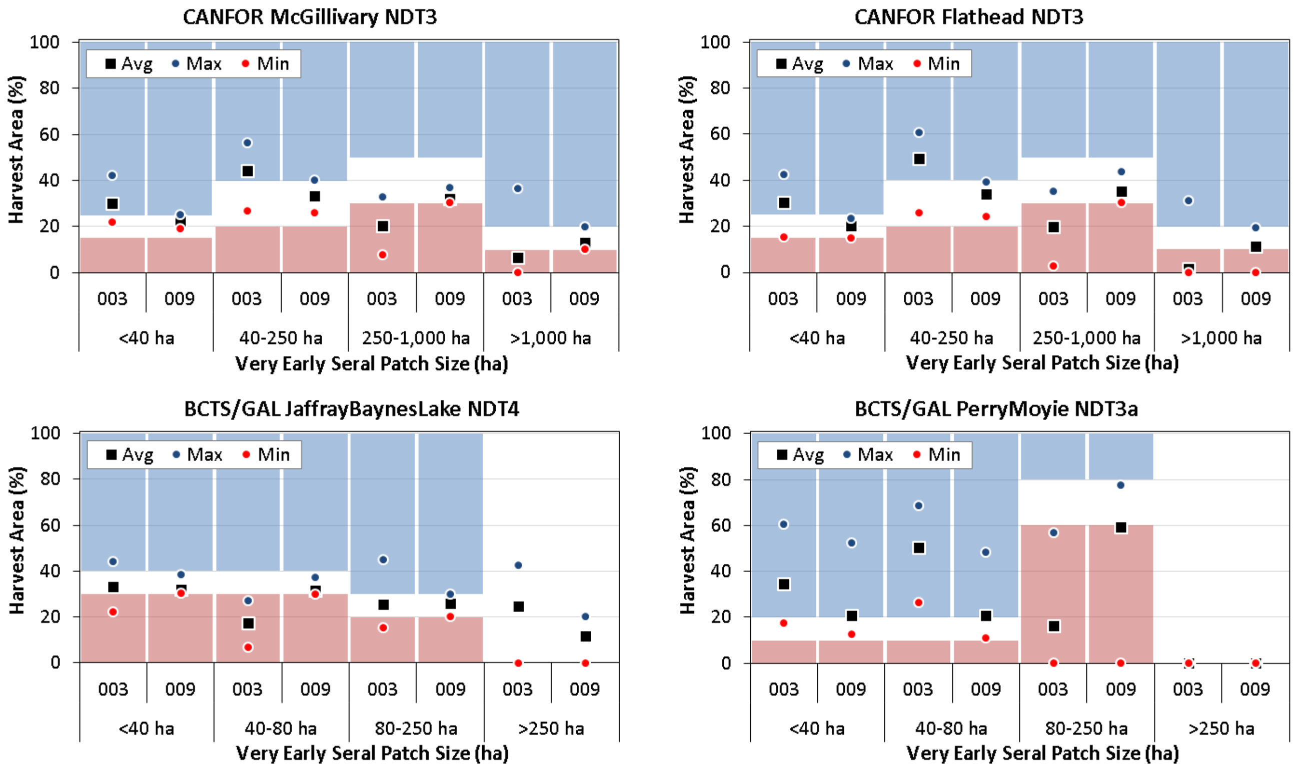


Figure 21 ISS Base Case Scenario – Very Early Seral Patch Objectives (examples)

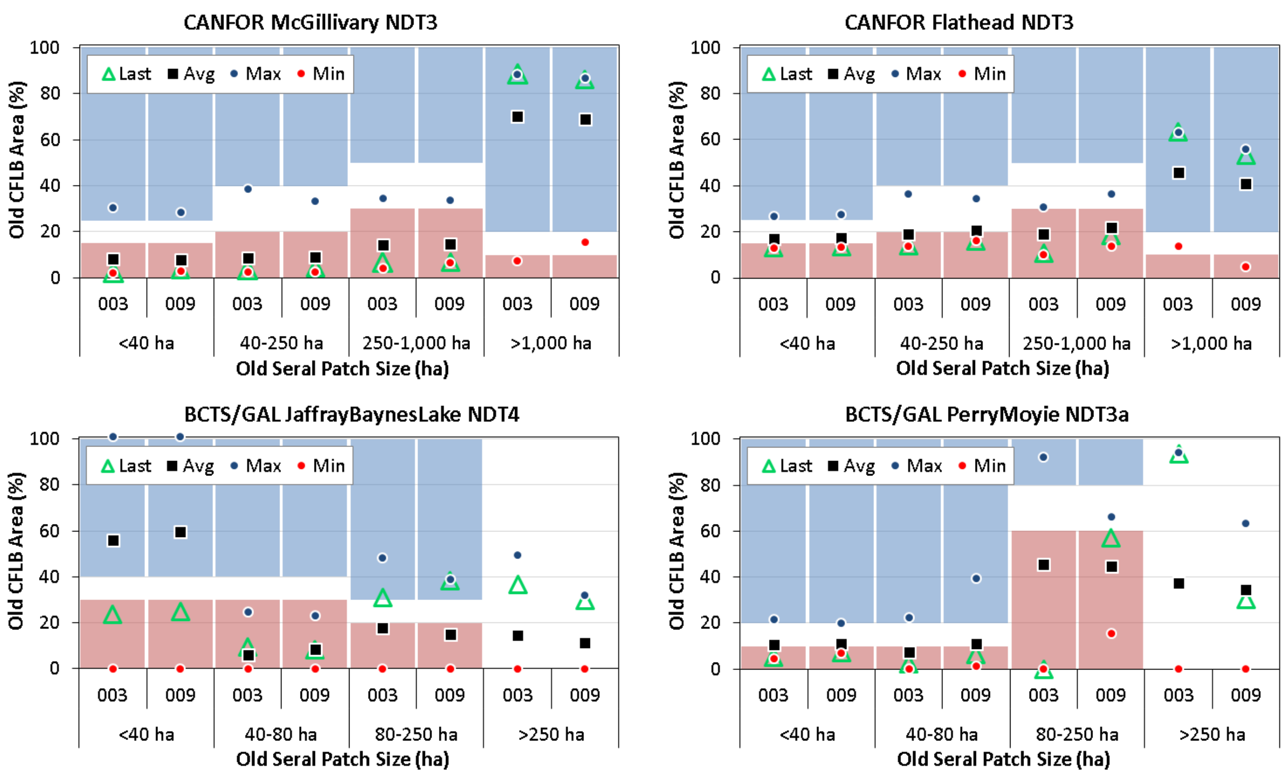


Figure 22 ISS Base Case Scenario – Old Seral Patch Objectives (examples)

- (010) Turning off FSC-related assumptions within Canfor's operating areas and applying FPPR-related assumptions instead, increased the THLB by 3.1%. This gain translated into a positive impact on harvest flow: 2.9% more in the first decade, 2.8% in the mid-term, and 3.1% in the long-term.
- (011-012) Grouping LUs to provide the model with more flexibility to address non-timber objectives had very little impact on the harvest profile over time. A separate discussion on these sensitivities is provided in Appendix 3.

4 Silviculture Scenario

4.1 Description

The Silviculture Scenario explored alternate silviculture tactics to enhance timber quantity and quality over the mid- and long-term, as well as, improve biodiversity, wildlife habitat, and cultural interests. The Project Team allocated an expected funding level of $0.3 over the first 20 years of the planning horizon to explore 3 tactics: 1) enhanced basic silviculture (ENH), 2) commercial thinning (CT), and 3) fertilization (FERT).

Additional sensitivity analyses were explored to better understand how these silviculture tactics interact and where they influence non-timber requirements and harvest flow. These included:

- Increase funding from $0.3 to $1.0 million/year, and
- Extend the $0.3 million per year funding from 20 to 60 years (CT and FERT only available on existing managed stands).

4.2 Treatment Responses

The three tactics (ENH, CT, FERT) were applied in the model as alternative yield curve options. Figure 23 shows an example for managed stands where the three tactics overlap.

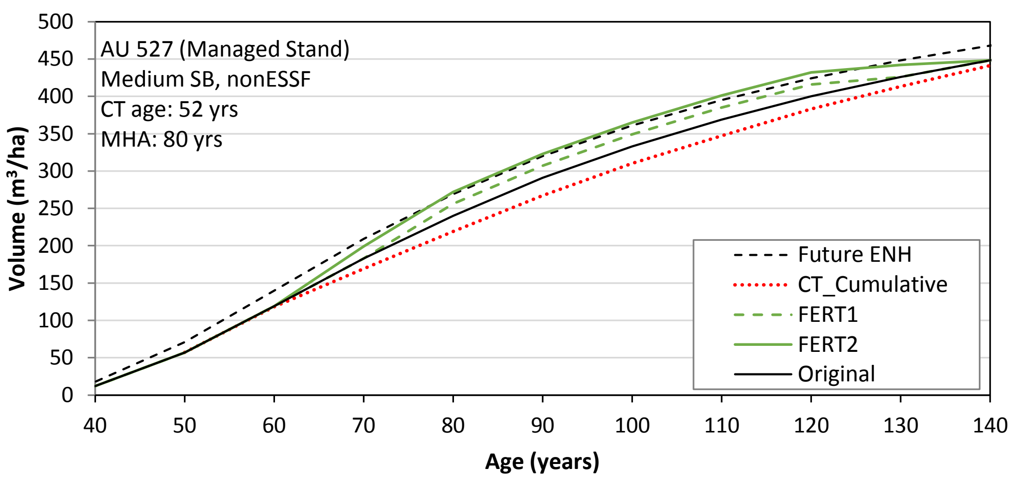


Figure 23 Example of Adjusted Yields for Silviculture Tactics

Note that with this example:

1) The highest gain in yield occurred with the ENH treatment (i.e., ~29 m^3/ha at minimum harvest age (MHA)). Note that the full potential of enhanced yields in Fd-leading stands was not explored because the MHA was restricted to a minimum of 80 years regardless the potentially higher volumes and mean annual increments at younger ages.
2) The next highest gain in yield occurred with the FERT treatment (i.e., ~16 m^3/ha for 1 application and 32 m^3/ha for two applications).
3) The response for CT is shown as a cumulative yield (i.e., CT harvest volume minimum of 40 m^3/ha + volume of remaining stand + growth, including CT response, of remaining stand), which was less than the original, unthinned yield at MHA.

Several key points regarding CT warrant further discussion to better understand the results.

- On richer sites, there was a smaller gap between the cumulative CT yield (i.e., CT harvest volume + volume of remaining stand + growth, including CT response, of remaining stand) and the original, unthinned yield at MHA. In addition, depending on CT eligibility (i.e., timing when a stand becomes eligible for CT), the thinned volume harvested could be significantly higher than the minimum of 40 m^3/ha, especially when CT was applied at the end of the 10-year timing window.
- The gap between original and cumulative CT yield could have been significantly reduced if the timing window was extended to an older age (e.g., closer to the culmination of mean annual increment). This would provide higher thinning volumes of better quality with likely, a higher financial return.
- Equivalent Clearcut Area (ECA) curves to account for disturbances within key watersheds were not applied for managed stands treated with CT.
- The primary opportunity with CT is providing the model with an option to harvest a portion of the stand, while it is still growing well, to address periods when available volume is low. The rest of the stand is then harvested later, when much more merchantable volume is available across the landscape.
- In all cases, the thinned stands experienced a higher growing rate compared to the unthinned stands. However, the cumulative yield typically does not recover to unthinned levels for a very long time (e.g., ~80 years for AU 508 and never for AU 604 as shown in Figure 24).

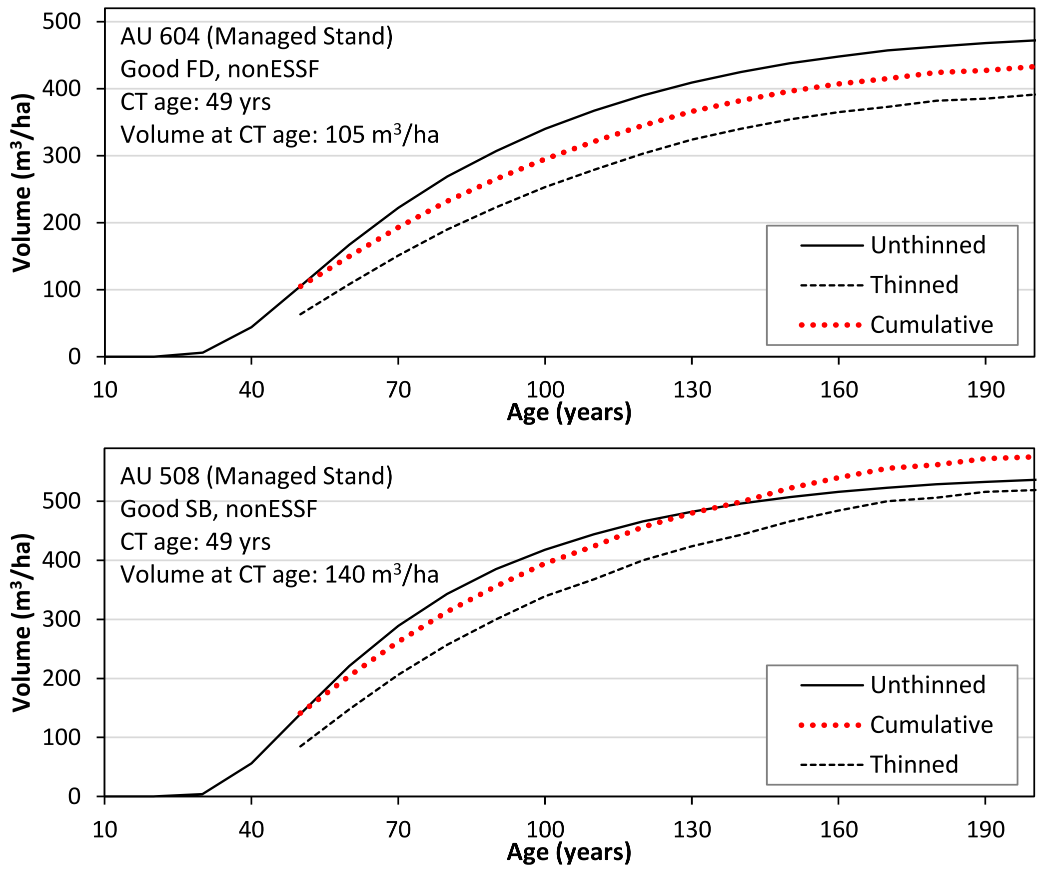


Figure 24 Examples of Commercial Thinning

To compare sensitivities appropriately, it is important to maintain the same modelling criteria except for the one being examined. For instance, when the funding period was extended to 60 years, treatment options were only available to existing stands and opportunities to increase the long-term harvest rate were not explored.

4.3 Results

4.3.1 Funding at $300,000/year

When the funding level was set to $0.3 million per year for the first 20 years of the planning horizon, the harvest rate increased over the short- and mid-term by 1.6 to 2.0% and the mid-term shortage period decreased by 20 years compared to the ISS Base Case (Figure 25). This shift was due to the harvest contribution from enhanced stands beyond the mid-term period, combined with the additional volume from fertilized stands.

Total and merchantable growing stock on the THLB, followed similar patterns as the ISS Base Case; ending in lower levels than the ISS Base Case (~2.3 million m³ lower) to maintain a sustainable, non-declining growing stock over the last 100 years of the planning horizon. To reduce the mid-term shortage period, the model had to use more of the growing stock, which increased to a lower long-term level compared to the ISS Base Case. After applying silviculture tactics, the THLB merchantable growing stock did not improve during the mid-term. This is because any improvement in the THLB merchantable growing stock was used by the model to improve the harvest level in a relatively constrained land-base.

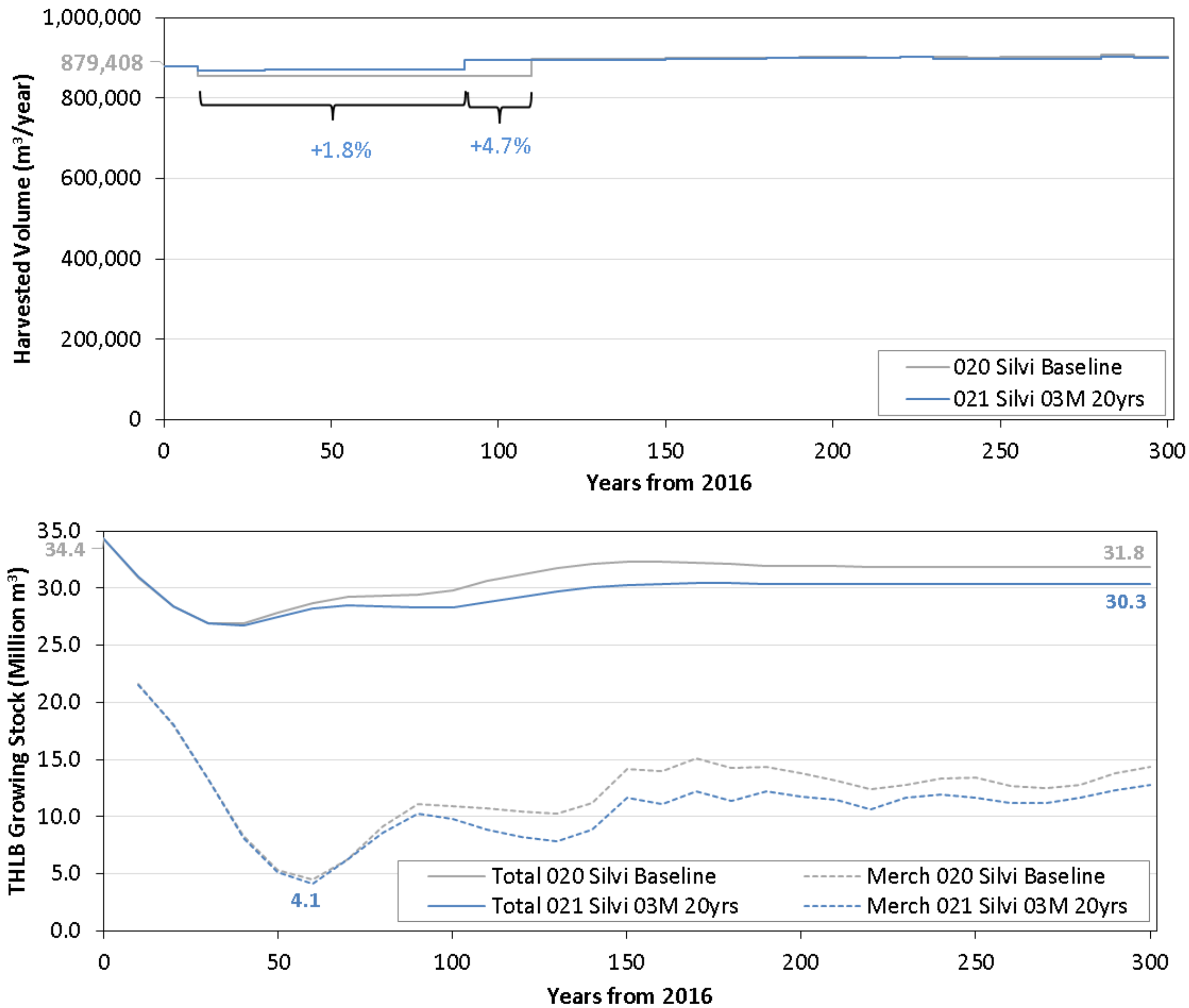
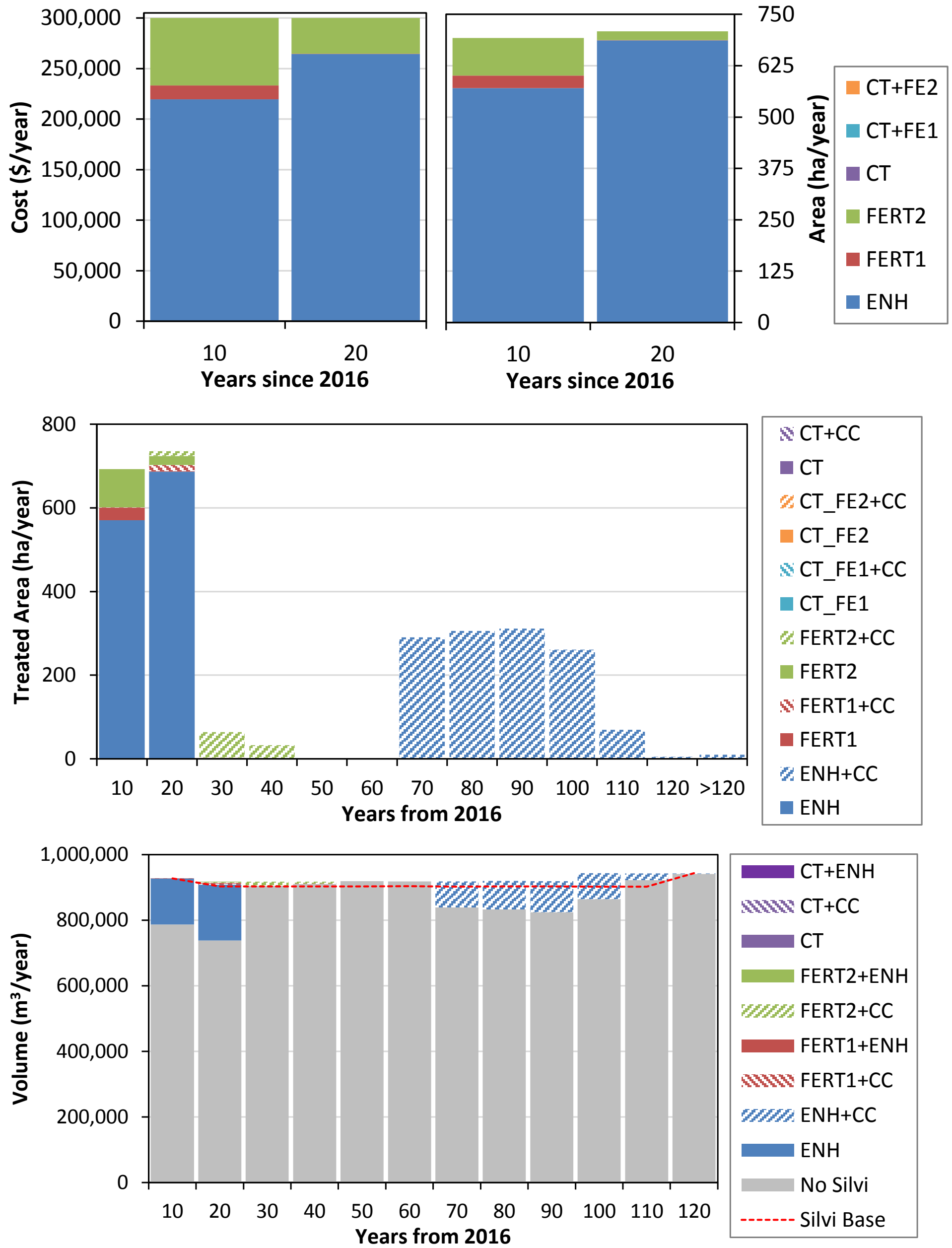


Figure 25 Silviculture Scenario – Harvest Flow and THLB Growing Stock

The model allocated the entire $0.3 million per year budget over the first 20 years ($6 million – Figure 26). Most of the funding was spent on ENH (~$242,000/year), while much less was spent on FERT (~$57,000/year) and $0 on CT. The model treated approximately 628 ha/year for ENH and approximately 72 ha/year to FERT, while CT was not applied. Where stands were eligible for two fertilizer applications the model tended to select two applications over one. This suggests that increased volume on existing stands was a primary driver for this tactic. Fertilized stands were clearcut over the 3rd to 5th decade (~41 ha/year), followed by enhanced stands between the 7th and 12th decade (~207 ha/year) of the planning horizon.



(Note: hatched symbology depicts the timber harvest for each tactic)

Figure 26 Silviculture Scenario – Results, $0.3 million/year for 20 years

The ENH tactic had the most significant impact on improving the harvest rate and shortening the mid-term. To achieve the harvest rate improvements described above, the model treated a relatively small fraction of the eligible stands for the three tactics (i.e., 16% of eligible ENH, 6% of eligible FERT). However, the ENH tactic expanded the harvest scheduling flexibility of the model. Some older stands that were initially delayed to maintain a non-declining harvest rate were scheduled for harvesting to an earlier time in the planning horizon. In place of these older stands, the stands growing on enhanced yields were scheduled for harvesting starting in year 70 of the planning horizon. Recall, the enhanced stands had higher yields and younger MHAs. This dynamic is illustrated by the average age and volume at harvest (Figure 27). Note that from the 7th decade on, the average harvest age in the ISS Base Case was older with lower average harvest volumes. The increased harvest rate beginning in the 2nd decade and throughout the mid-term was attributed to the additional volume from harvesting fertilized stands (decades 3 and 4), as well as, enhanced stands (decades 7 to 10 illustrated by the higher volume and younger age at harvest).

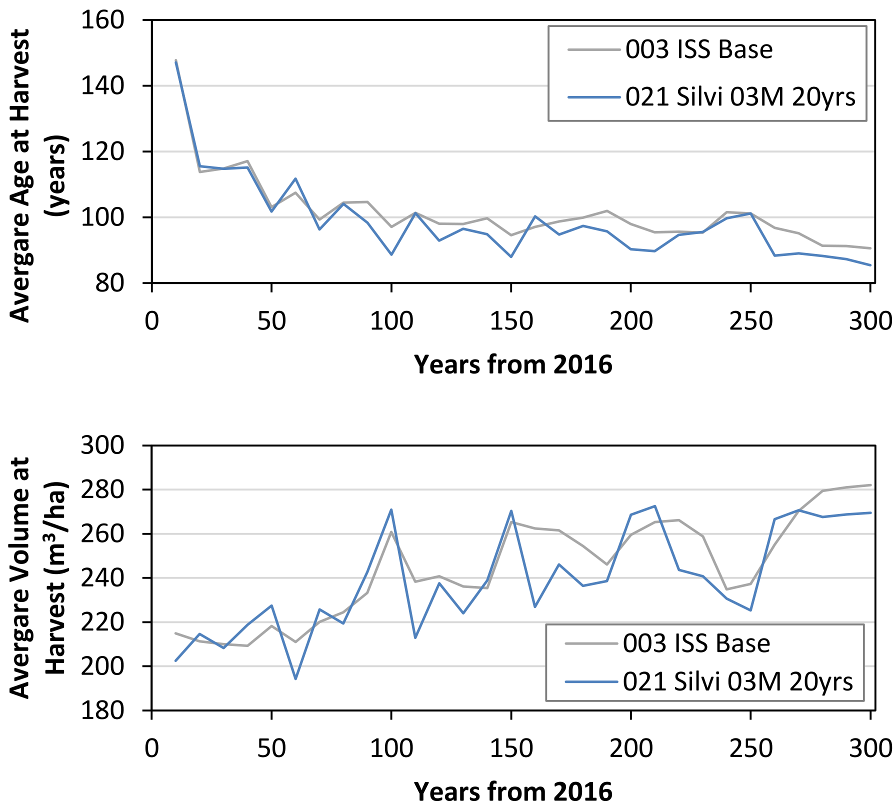


Figure 27 Silviculture Scenario – Average Age and Volume at Harvest

4.3.2 Funding at $1 Million/year

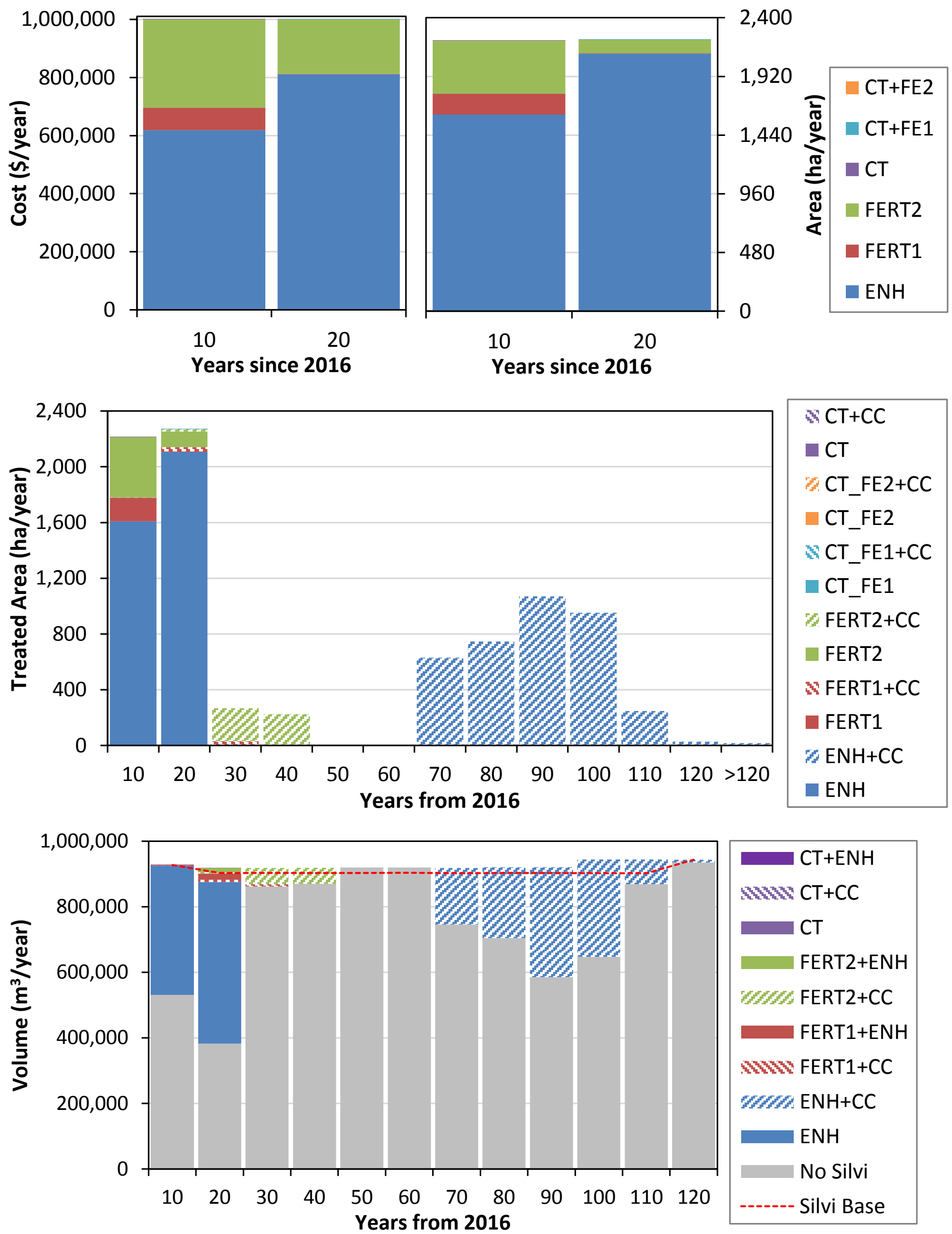
Increasing the funding level to $1 million per year over the first 20 years of the planning horizon led to an increase in the mid-term harvest rate by an additional 0.1% compared to the 021_Silvi_03M run shown in Figure 25, and a total increase of up to 2.0% compared to the ISS Base Case. The increased funding did not result in further shortening of the mid-term period. The higher funding level did not correlate with a similar increase in harvest rate because the land base was relatively constrained over the short- and mid-term and harvest rates were already maximized with the lower funding level.

In developing a harvest rate for this run, the analyst increased weights set on volume targets to encourage the model to produce a higher harvest rate. As a result, the slightly higher harvest rate caused targets for some non-timber objectives to be violated, especially the VQOs. The discussion in section 3.2 described that VQOs were among the most constraining of the non-timber objectives.

The long-term growing stock on the THLB was 1.0 million m³ higher than the 021_Silvi_03M run. This suggests that the additional funding level was used by the model to increase the long-term growing stock rather than improving the mid-term harvest rate. This observation also supports the fact that the land base was relatively constrained and opportunities to increase the mid-term harvest rate are limited. The primary outcome of providing a higher funding level was an increase to the growing stock.

The model allocated the entire $1.0 million/year budget over the first 20 years (i.e., $20 million). On average, most of the funding was spent on ENH (~$714,000/year), while much less was spent on FERT (~$284,000/year) and very little on CT (~$211/year). Accordingly, the model treated approximately 1,857 ha/year for ENH and approximately 360 ha/year to FERT, while <1ha was treated with CT (Figure 28).

Again, the ENH tactic had the highest impact in improving the harvest rate. To achieve the increased harvest rates described above, the model treated a relatively small fraction of the eligible stands for the three tactics (i.e., 28% of eligible ENH, 25% of eligible FERT, and virtually 0% of eligible CT).



(Note: hatched symbology depicts the timber harvest for each tactic)

Figure 28 Silviculture Scenario – Results, $1 million/year for 20 years

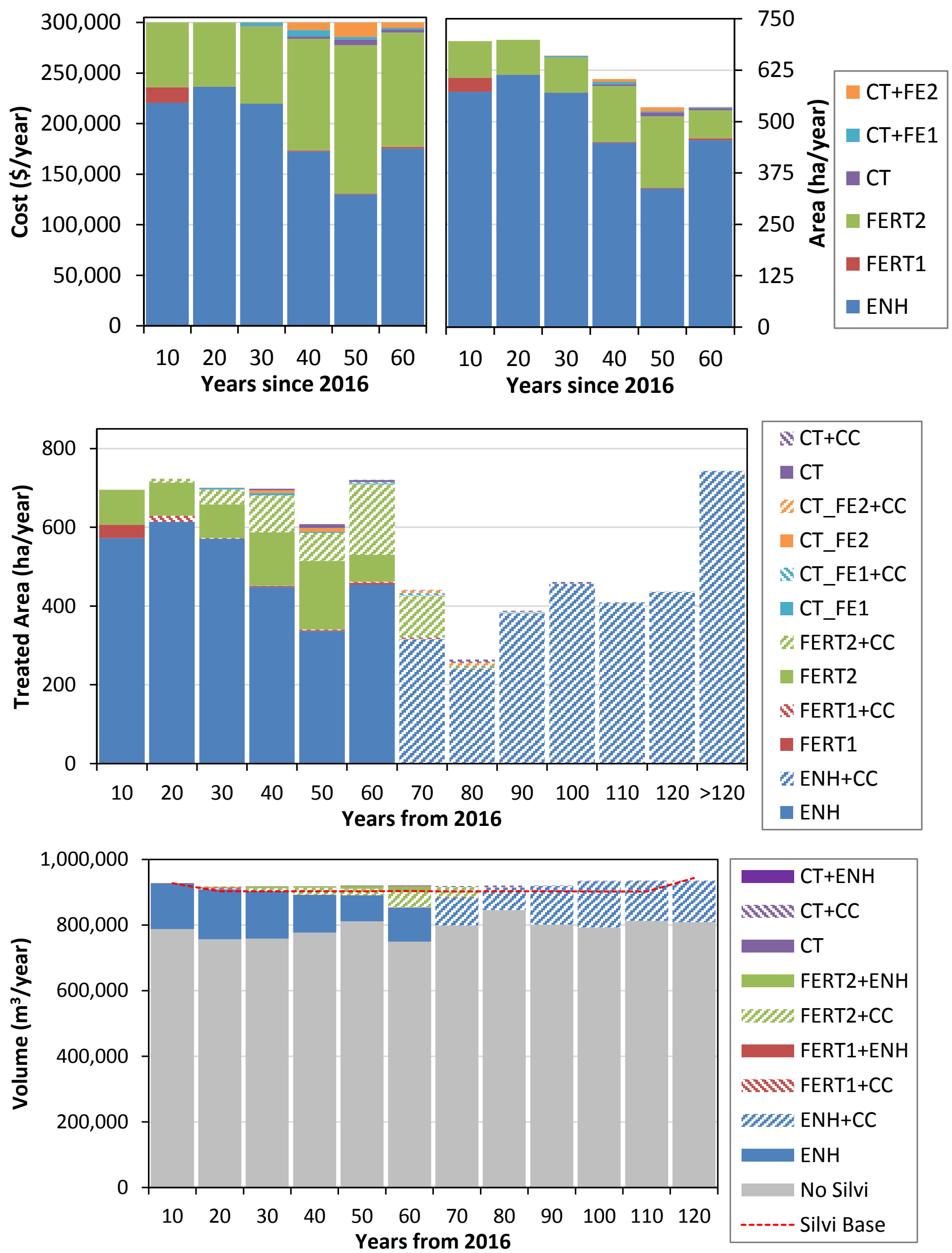
4.3.3 Funding Extended to 60 Years

Extending the funding level of $0.3 million per year from 20 to 60 years provided more treatment opportunities for ENH, FERT and CT. Yet, the harvest rate remained similar to the 021_Silvi_03M run shown in Figure 25. The harvest rate increased by an additional 0.1% (total increase of 2.1% compared to the ISS Base Case). The harvest flow remained slightly higher (-0.1%) over the long-term, while the growing stock on the THLB was even higher at 1.7 million m³. This suggests that applying higher target levels might increase the harvest level in the long term and the extended funding period did not exclusively improve the mid-term harvest rate.

The model allocated the entire $0.3 million per year budget over the first 60 years ($18 million). On average, it spent most of the funding on ENH (~$192,000/year), less on FERT (~$102,000/year) and even less on CT (~$5,000/year). Accordingly, the model treated approximately 500 ha/year for ENH, approximately 116 ha/year for FERT, and approximately 6 ha/year for CT (Figure 29). Compared to 020_Silvi_0.3M run, the model treated a slightly higher proportion of eligible stands for the three tactics (15% of eligible ENH, 9% of eligible FERT, and 4% of eligible CT).

Over the mid-term period (years 20-90), the FERT and CT tactics had a more significant impact on harvest rate than previous runs, particularly during periods when timber availability was lowest. It was more efficient for the model to trade long-term volume losses from thinned stands with the immediate benefit from CT (i.e., relatively small amounts of harvested volume that was immediately available). The model recovered some, if not all, of the CT losses in the long-term by the additional volume generated from ENH stands.

The area harvested under the ENH tactic increased approximately 2.4 times (~329 ha/year) and the area harvested under the FERT tactic increased approximately 4.7 times (~63 ha/year). Between the 7th and 10th decades, the total area harvested under the CT tactic (final entry) increased to ~170 ha (~4 ha/year).



(Note: hatched symbology depicts the timber harvest for each tactic)

Figure 29 Silviculture Scenario – Results, $0.3 million/year for 60 years

4.3.4 Additional Observations

The silviculture tactics explored here also provided improved flexibility to address forest cover requirements (e.g., biodiversity, wildlife habitat, watershed, and cultural interests). This analysis was not set-up with specific metrics to track stand structure related to biodiversity, wildlife habitat, and cultural interests. However, one might apply CT and some uneven-aged silvicultural systems to more stands, especially those within relatively constrained areas such as visually sensitive areas, UWR habitat, and watersheds. Such tactics could deliver similar volumes spread over cutting cycles while not altering stand age. Recall, the non-timber objectives that constrain the THLB are age-related indices where typically, an older age relates to a lower penalty. Moreover, one might apply silviculture tactics such as FERT or ENH to overcome potential volume gaps incurred by the CT or uneven-aged silvicultural system.

The proportion of eligible stands where the silviculture tactics were applied was relatively modest. This occurred because: (1) the landbase was relatively constrained, (2) relative cost tactics were different; favouring the ENH tactic, and (3) timing windows for the FERT and CT tactics or the combination of the two were relatively narrow.

An extensive quality check of the silviculture scenario identified that the harvest rate increases described above were achieved by considering each silviculture tactic on its own. In addition, the budget used to achieve similar harvest rate increases using one tactic at a time could be less. For example, applying only the CT or FERT tactic for the first 60 years of the planning horizon achieved similar harvest rate increases at a fraction of the allocated budget of $0.3 million per year (i.e., higher use of the budget for FERT tactic compared to CT). These observations support at least two alternative approaches to the silviculture tactics explored in this analysis: (1) expand the CT tactic to the areas covered by non-timber objectives such as VQOs, UWR, ECA, and (2) control the budget allocated for each tactic rather than applying one budget for all tactics, as implemented in current analysis.

4.3.5 Exploratory Runs

Besides the model runs described above, we conducted several exploratory runs to examine questions that arose from our preliminary analysis (i.e., Series 1). Changes were made to subsequent models so not all runs can be compared appropriately, but key observations are briefly summarized below.

Commercial Thinning

The model rarely applied CT treatments where funding was available for only 20 years (sections 4.3.1 and 4.3.2). This was appropriate since, for this TSA, the CT tactic benefits the harvest flow by capturing additional thinning volume during periods when the available volume is particularly low – in this case between the third and seventh decades (Figure 25). To explore this further, we modeled two runs that made CT available over these critical periods, while applying various treatment costs to test the sensitivity of this particular assumption:

- $0.3 M/year for 60 years and set CT cost @ $600/ha (same; half of total)
- $0.3 M/year for 60 years and set CT cost @ $0/ha (break-even)

For these exploratory runs, we also had to develop new yields and analysis units as we identified additional eligible stands for CT over the first 60 years. These were limited to existing natural and managed stands (not future).

Extending CT throughout the mid-term significantly increased the area treated. These results led to the sensitivity discussed in section 4.3.3. In contrast, decreasing treatment cost did not significantly affect the area treated.

Separate Tactics

To understand the combined impact of the silviculture tactics, we explored each tactic separately using the same budget allocation of $0.3 million/year for 60 years. Results showed that independently, each tactic achieved similar harvest flow increases.

Table 4 shows results for runs with each individual tactic compared to a silviculture base (Run 000) where tactics were effectively turned off. In this comparison, CT was clearly the most cost-effective silviculture tactic when considering the increased harvest rates between the 2nd and 4th decades relative to the budget spent. However, the CT lone tactic also produced lower harvest rates over the long-term. Combining CT with the ENH tactic would likely recover the loss in harvest observed over the long-term.

Table 4 Silviculture Scenario – Summary of Results for Individual Tactics compared to Silv Base (no tactics prior to addressing issue with analysis units)

Tactic	Total Budget Spent *	Change in Harvest Rates Compared to the 000 Silv Base Run		
		2nd to 4th Decade	5th Decade	≥6th Decade
024 ENH	$18.0 M	1.8%	1.1%	0.1%
025 FERT	$18.0 M	0.7%	0.1%	-0.1%
026 CT	$2.0 M	0.2%	-0.2%	-0.2%

**M = million ($0.3 million budget over 60 years = $18 million max)*

Analysis Units

In the ISS Base Case, we grouped stands into analysis units using the same criteria as TSR but in most cases, these criteria did not match those used to identify eligible stands for various silviculture tactics. Our initial approach to create analysis units for silviculture treatments involved splitting the Base Case analysis units according to the parameters defined for each silviculture tactic. Ultimately, this led to inconsistent impacts on yields and modelled results. Therefore, we revised our method by first identifying eligible stands then, rather than developing new yields, kept the averaged Base Case yields and adjusted these according to relative changes associated with each tactic. We tested this new Silviculture Base model by effectively turning off the silviculture tactics and demonstrating very similar results as the ISS Base Case (i.e., Run 020). This prompted a new series of model runs (i.e., Series 2) presented above in sections 4.3.1, 4.3.2, and 4.3.3.

5 Wildlife Scenario

The Wildlife Scenario was designed to assess habitat quality and quantity for a range of wildlife species while continuing to meet all other timber and non-timber objectives. In this ISS iteration, the Project Team elected to explore three tactics: wildlife habitat, species at risk, and access. Due to time and budget constraints, the Project Team decided not to proceed with the access tactic.

5.1 Wildlife Habitat Tactic

5.1.1 Description

The wildlife habitat tactic explored effects of future forest harvest on wildlife habitat. Without specific thresholds, we configured the model to maintain the current area identified as wildlife habitat in classes 1, 2, and 3 for 14 habitat types (i.e., combination of 7 wildlife species and their life requisites). A curve was developed for each of the 14 habitat types to portray the habitat class rating – 1 (highest) to 6 (Nil) – by structural stage. Madrone developed information on these curves in 2016 to model wildlife habitat for DIN and DCB TSAs. Linkages between structural stage and age were developed for each PEM unit, slope/aspect, and stand composition (broadleaf, mixed, conifer) combination. Thus, habitat classes could be assigned based on stand age (or structural stage) for each habitat type and each PEM unit, slope/aspect, and stand composition combination. Finally, the habitat class for each habitat type was translated into a binary curve (0 or 1) and used to build area accounts in Patchworks (up to 168 area accounts (84 managed, 84 unmanaged); 14 habitat types x 6 habitat classes x 2 land types). For each of the managed accounts, the total area in the top three habitat classes at time zero was set as the wildlife habitat target over the planning horizon.

Three model runs were developed:

- [031] – Maintain ISS Base Case harvest flow (accept max 1% change in harvest level) and apply lower weights to encourage the model wildlife habitat targets; not necessarily maintain them. To accommodate PEM units, it was necessary to replicate the Base Case, since new blocking was required (i.e., one PEM unit per block; each fragment was assigned the dominant PEM unit).
- [032] – Apply habitat targets (i.e., maintain current distribution of 'at least habitat class 3' (i.e., combine class 1, 2, and 3) and apply a MINDY harvest flow (Maximum Initial Non-Declining Yield).
- [033] – Apply habitat targets (i.e., maintain current distribution of 'at least habitat class 3' (i.e., combine class 1, 2, and 3) without harvest targets. Model determines the harvest necessary to achieve appropriate foraging habitat (or habitat needing young ages).

Note applying that the 2016 wildlife habitat rating curves highlighted several interesting trends:

- Some PEM units did not correspond with the wildlife habitat models.
- Non-FMLB areas (CONTCLAS = 'X') were stripped from non-TSA lands (e.g., private lands); where there was no age, the habitat class for age zero was applied.
- Some habitat classes did not develop continuously with age. Foraging habitat types, for example, show that class 2 habitat occurs between ages 0-40 and then again at ages 80+, while a different habitat class was assigned between ages 40 and 80. This is in line with species account description from the 2016 work.
- The area summary tables in the 2016 report did not match well with outputs from the wildlife habitat model. Our investigation of the issue did not produce a clear solution so we continued to use the consolidated model outputs CSV files (as opposed to the data that produced the 2016 reports), as the consolidated outputs matched with the individual models run for each habitat type.

5.1.2 Results

The model was configured to replicate the 2016 reports (Muhly, et al. 2016) prepared using the latest TSR5. Patchworks produced wildlife habitat rating charts (Figure 30) for each of the 14 habitat types. In most cases, these results were similar to those developed in the latest TSR5 (Figure 31). In other cases, it appeared that the errors were introduced in the process used in the latest TSR5.

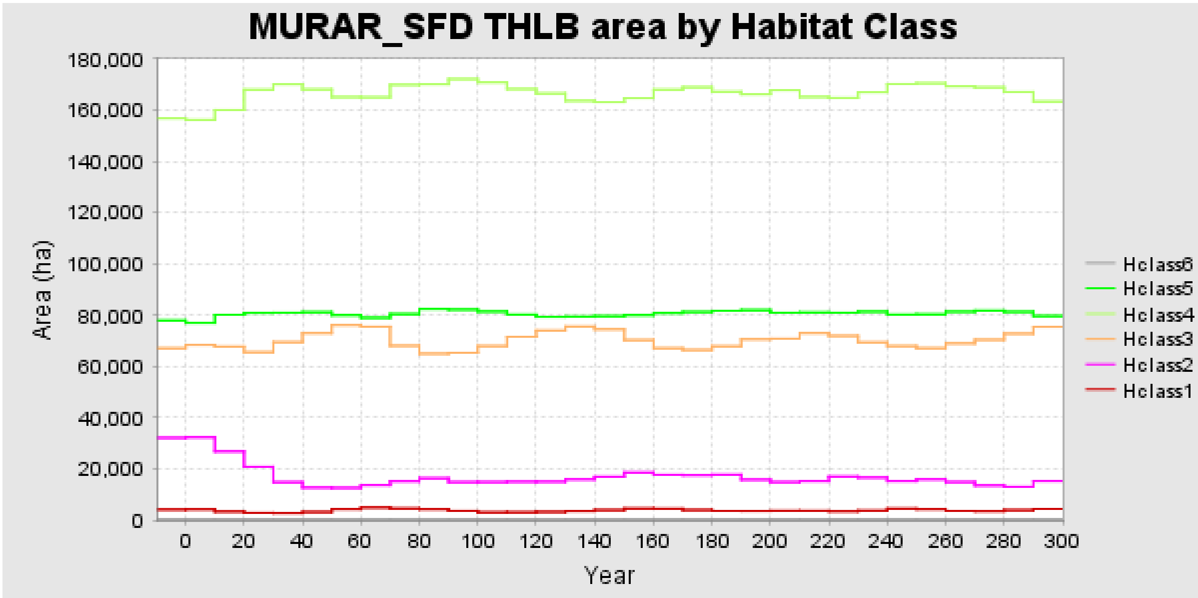


Figure 30 Distribution of grizzly bear habitat class (summer forage) over time (run 031)

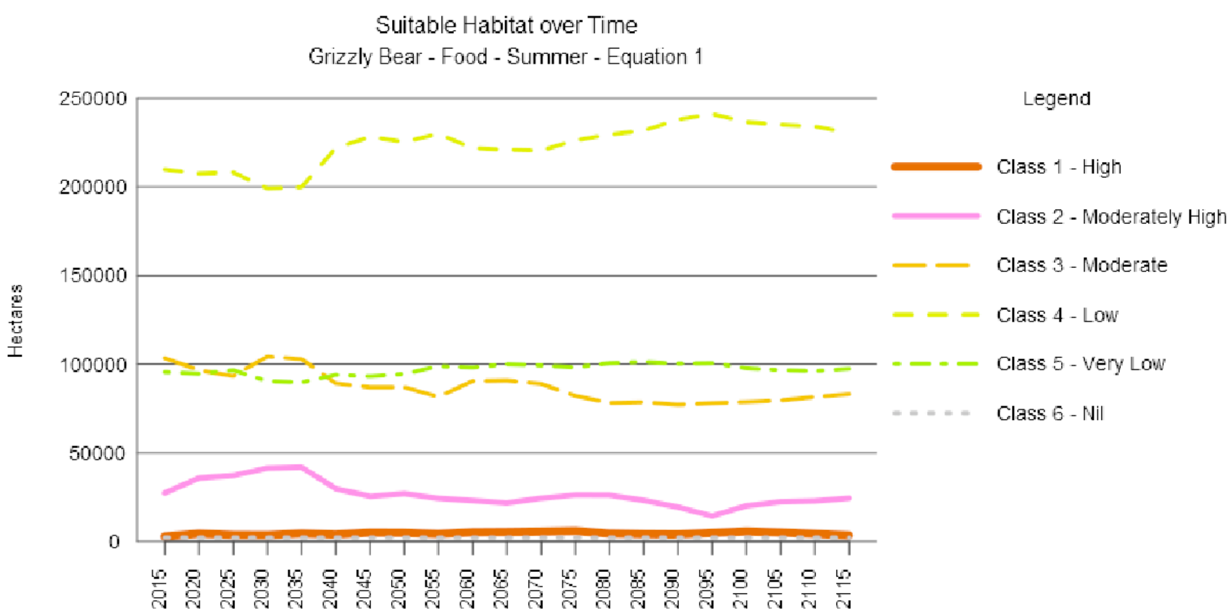


Figure 31 Matching example using the latest TSR5 (Muhly, et al. 2016): Distribution of grizzly bear habitat class (summer forage) over time (simulated timber harvest)

Figure 32 shows an example of the maps produced by the model. These maps illustrate the spatial distribution of habitat classes across the landbase at a specific year along the planning horizon (i.e., years 0, 20, 50, and 100). NHLB darker and THLB lighter shades for the different colours assigned to each habitat class. Similar maps were replicated in ArcMap to include non-FMLB areas (CONTCLAS = ‘X’).

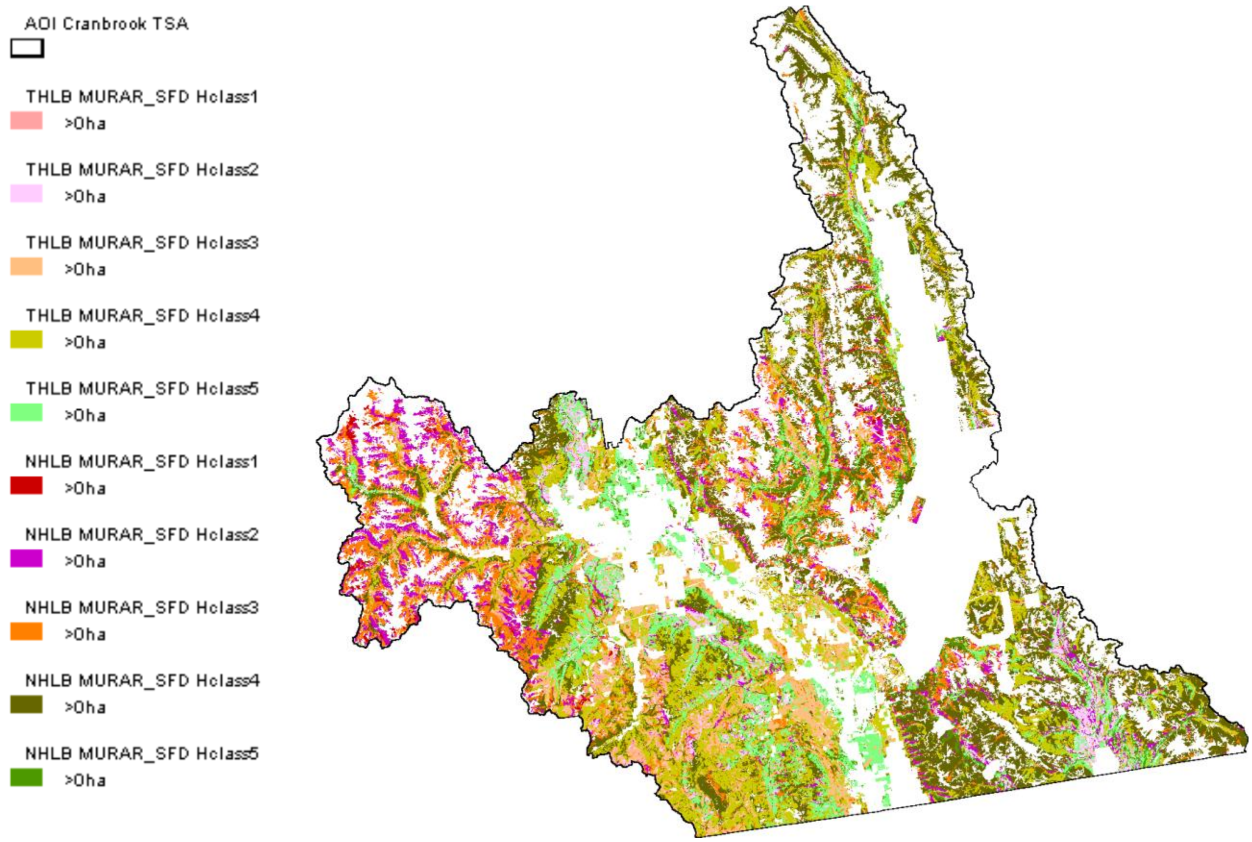


Figure 32 Spatial distribution of grizzly bear habitat classes (1 to 6) at year 0

We observed that, in some cases, the habitat classes did not appear to flow appropriately across TSA boundaries (Figure 33). This was likely resulted from different slope/aspect, Eco section, or PEM unit attributes.

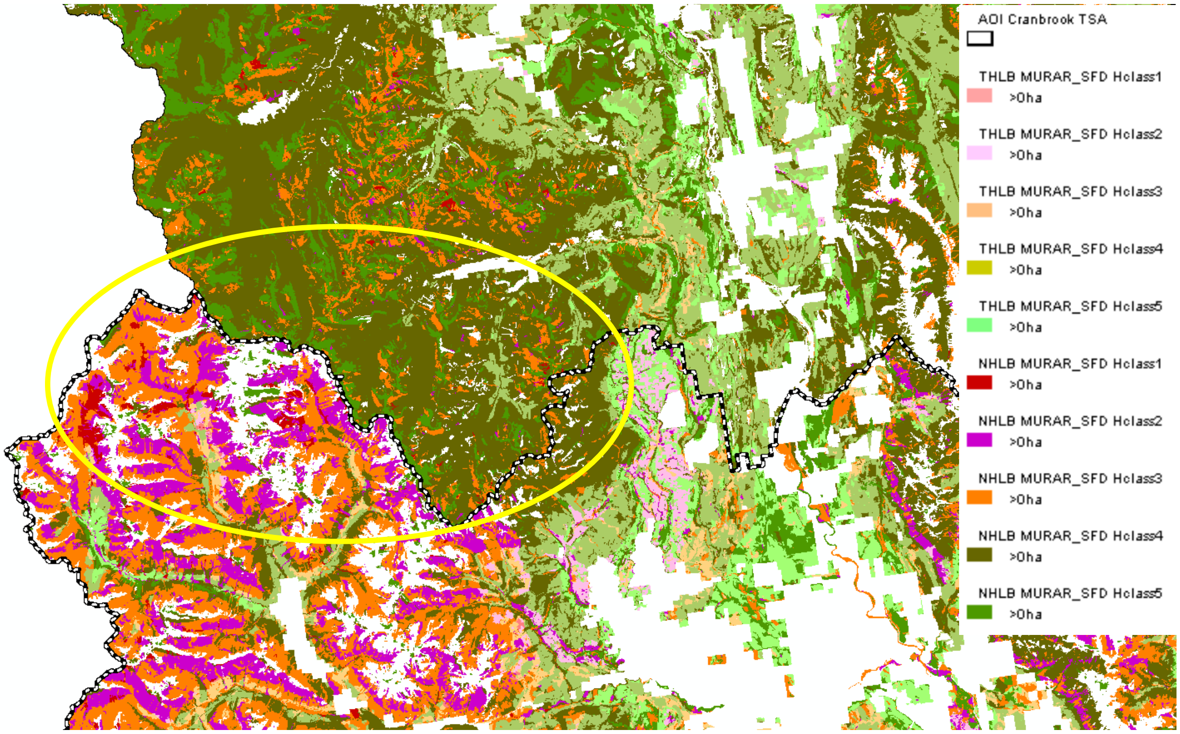


Figure 33 Example of inconsistent habitat classes assigned across TSAs (grizzly bear summer food habitat classes at year 0)

The following observations were made from the harvest flows (Figure 34) and growing stock (Figure 35) charts for the four model runs:

- [031] - Despite an increase in 'blocks' (~50% more) required to accommodate the PEM units, the harvest flow and growing stock for the Wildlife Base Case was almost identical to those developed for the ISS Base Case (Figure 4).
- [032] – Applying targets for combined habitat classes 1,2,3 (i.e., current level) resulted in a 33% reduction in harvest rate over the entire planning horizon. Accordingly, the decreased harvest led to significant increases in growing stock (65% total and 242% merchantable).
- [033] – Applying targets for combined habitat classes 1,2,3 (i.e., current level) without imposing a desired harvest flow resulted in an even lower (37%) harvest rate over the entire planning horizon. Accordingly, the decreased harvest led to significant increases in growing stock (79% total and 296% merchantable).

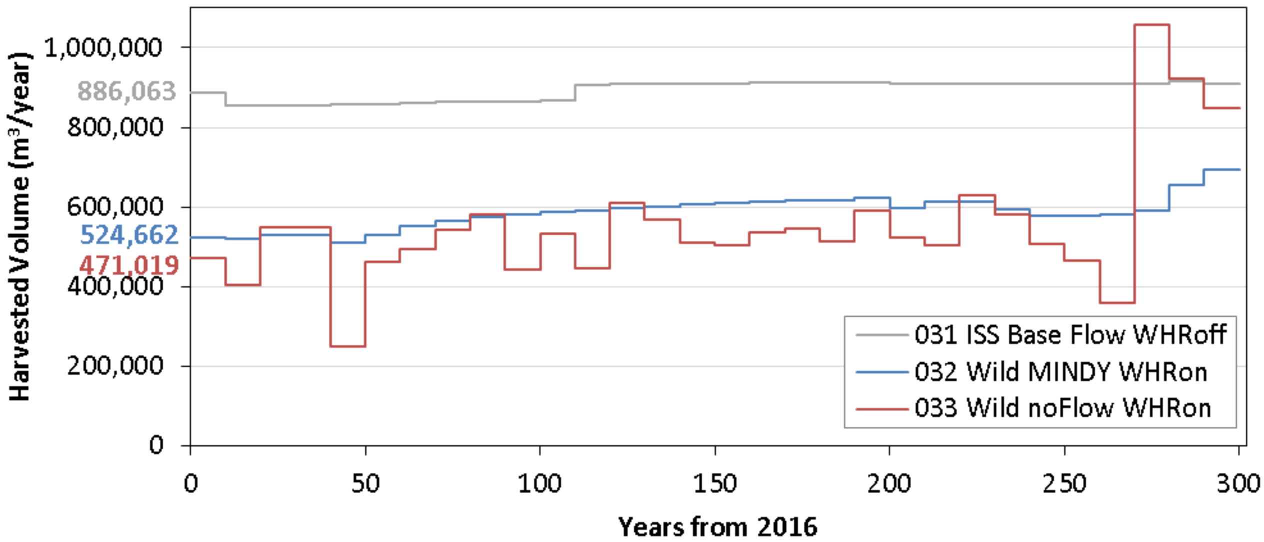


Figure 34 Harvest flows for the model runs

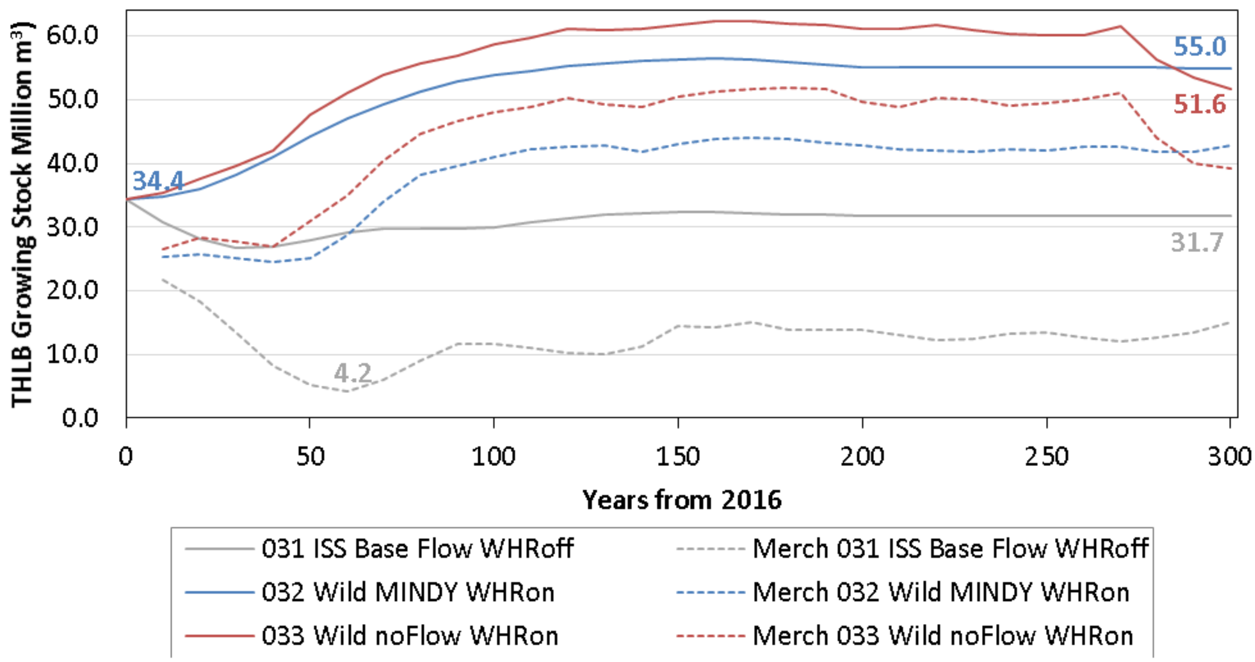


Figure 35 Growing stock on the THLB

5.2 Species At Risk Tactic – Caribou Habitat

5.2.1 Description

This tactic examines potential impacts on timber harvest from implementing the federal caribou recovery strategy for the Purcells South herd area and combines the results across both, Cranbrook and

Invermere TSAs. The federal caribou recovery strategy aims to reduce the disturbance levels within High/Low Elevation Range and Matrix Range in the context of recovery plan thresholds (65% undisturbed). Anthropogenic disturbances include permanent (e.g., hydro transmission lines, camps, mines, roads etc.) and temporarily (i.e., <40 years old harvests and temporary roads) disturbed areas, including their associated 500 m buffer. Areas disturbed naturally (i.e., wildfire) were also considered temporary disturbances for 40 years following the event but no buffers were applied.

Three model runs were developed:

- [040] – No harvest throughout the entire TSA.
- [041] – Apply the harvest schedule from the ISS Base Case scenario and assess disturbance levels within the Purcells South herd area.
- [042] – Reduce the disturbance levels within the Purcells South herd area by controlling the area under 40 years (for each range – Low/High Elevation and Matrix) and grouping harvest openings within each range and for the rest of the TSA (i.e., 3 sets of harvest opening control).

5.2.2 Results

The assessment of critical Caribou habitat under the federal recovery strategy (CH 638) indicates that disturbance within the High or Low Elevation range (Figure 36) is currently below the maximum allowed of 35%. Disturbance remained fairly steady at approximately 35% over the first 20 years of the 300-year planning horizon and decreased after 50 years as the 500m buffers of the temporary roads were only accounted if they were used for hauling over the previous 40 years. In addition, most of the High or Low Elevation range overlapped with the UWR orders for Caribou (#U-4-013 and U-4-014) which had a 'No Harvest' constraint (i.e., excluded from THLB). While the area of random fires (SUCC) within the NHLB appears to have been increased after year 50, it actually reflects road buffers being accounted for prior to fires on the NHLB. Many of the NHLB fires were located within the temporary road buffers over the first 50 years of the planning horizon.

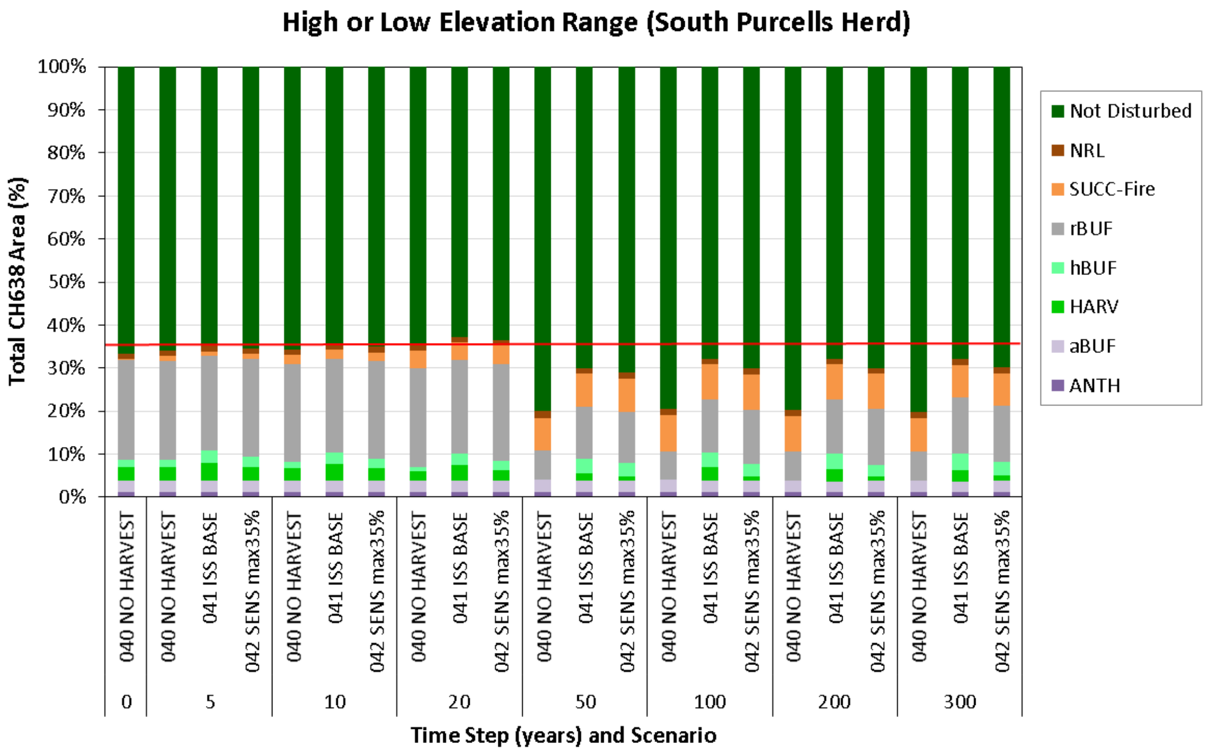


Figure 36 Disturbance categories over time within High/Low Elevation Range for the 3 scenarios

Due primarily to the extensive road network and permanent anthropogenic features, disturbance within the Matrix range (Figure 37) exceeded the maximum threshold of 35% (applied as a surrogate for low predation risk) across the entire planning horizon for all three modelling scenarios – including the [040] No Harvest run.

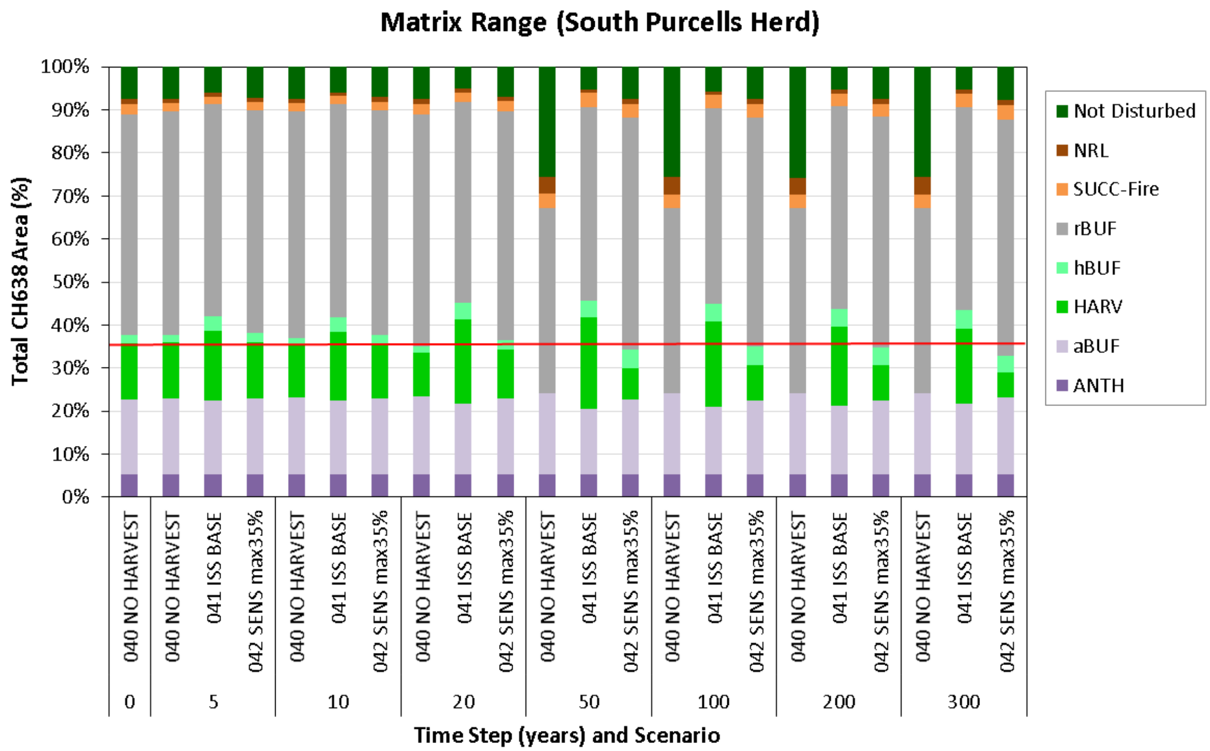


Figure 37 Disturbance categories over time within Matrix Range for the 3 model runs

Model run [042] attempted to decrease disturbance over time by applying a forest cover requirement and controlling harvest opening size distributions. Since the Base Case results already maintained the maximum threshold for disturbed habitat for High or Low Elevation Range (Figure 36), this tactic resulted in only slight improvements to maintain undisturbed habitat while it decreased the harvest rate (Figure 38) by 19.7% in the first decade, 21.5% over the mid-term, and 10 to 14.3% over the long-term.

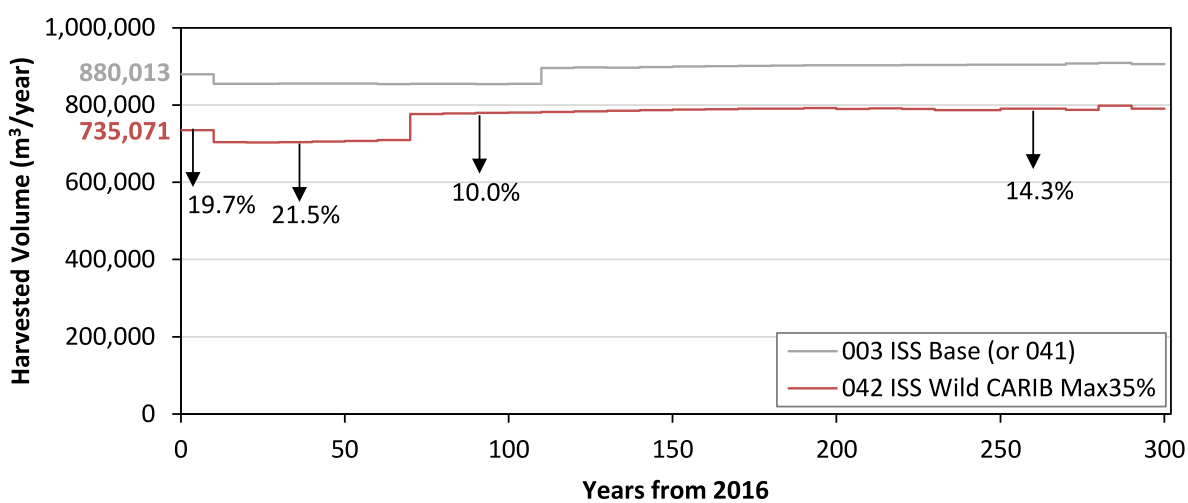


Figure 38 Harvest rate comparison for the Base Case and Caribou habitat control runs (Cranbrook TSA)

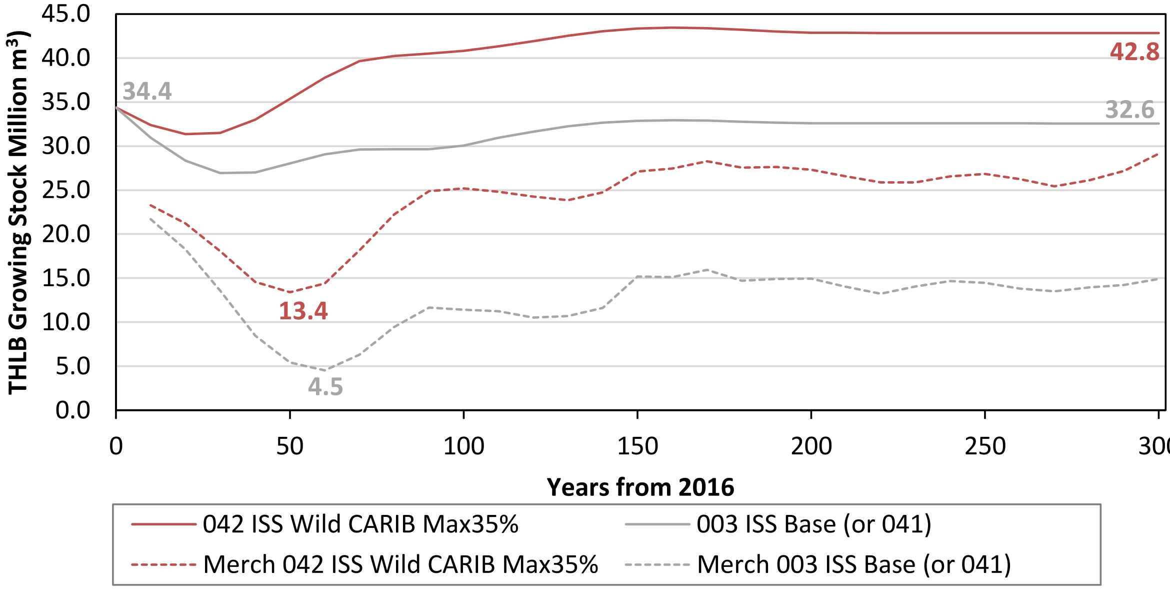


Figure 39 Growing stock comparison for the Base Case and Caribou habitat control runs (Cranbrook TSA)

6 Reserve Scenario

6.1 Description

The reserve scenario aimed to identify where and how we should reserve forested stands to address landscape-level biodiversity and where possible, non-timber values, while minimizing impacts to the working forest. While it considers strategies already in place (e.g., spatial OGMAs and MMAs), this scenario incorporates operational factors to identify alternative areas to maintain for non-timber values.

The Reserve Scenario focused on meeting the biodiversity targets and involved three general steps: 1) assign relative scores to each stand; 2) run two modelling stages (old then mature-plus-old) to select candidate stands that meet landscape-level thresholds; and 3) undertake a post-processing exercise to assess how the Candidate Reserves address targets for old interior forest.

We prepared and incrementally ran several models to explore the various controls designed to influence the selection of Candidate Reserves (Table 5). However, the results presented below incorporated all of these controls.

Table 5 Controls Applied in the Reserve Scenario

Sequence	Objective/Lever	Description	Weight
1	Old & Mature-Plus-Old Seral	o minimum and maximum targets set on each LU/BECvar o only a subset of LU/BECvar for mature-plus-old (per KBLUP)	Hard
2	Score	o minimum target set on combined score/ha o no target set on total combined score (track only)	Moderately Hard
3	THLB	o maximum target set on THLB (entire TSA)	Moderate
4	Old Interior	o minimum target set on areas identified as Old Interior + Edges (total area)	Moderate
5	Reserve Size Distribution	o minimum or maximum targets set on NDT/Reserve Size class	Moderately Hard

6.2 Results

Candidate Reserves were prepared as a spatial layer to display on maps and compare against existing OGMA/MMAs (Figure 40). Statistics for old forest, mature-plus-old forest, reserve size distribution, interior old forest, and resource management areas were summarized from reports created in Patchworks™.

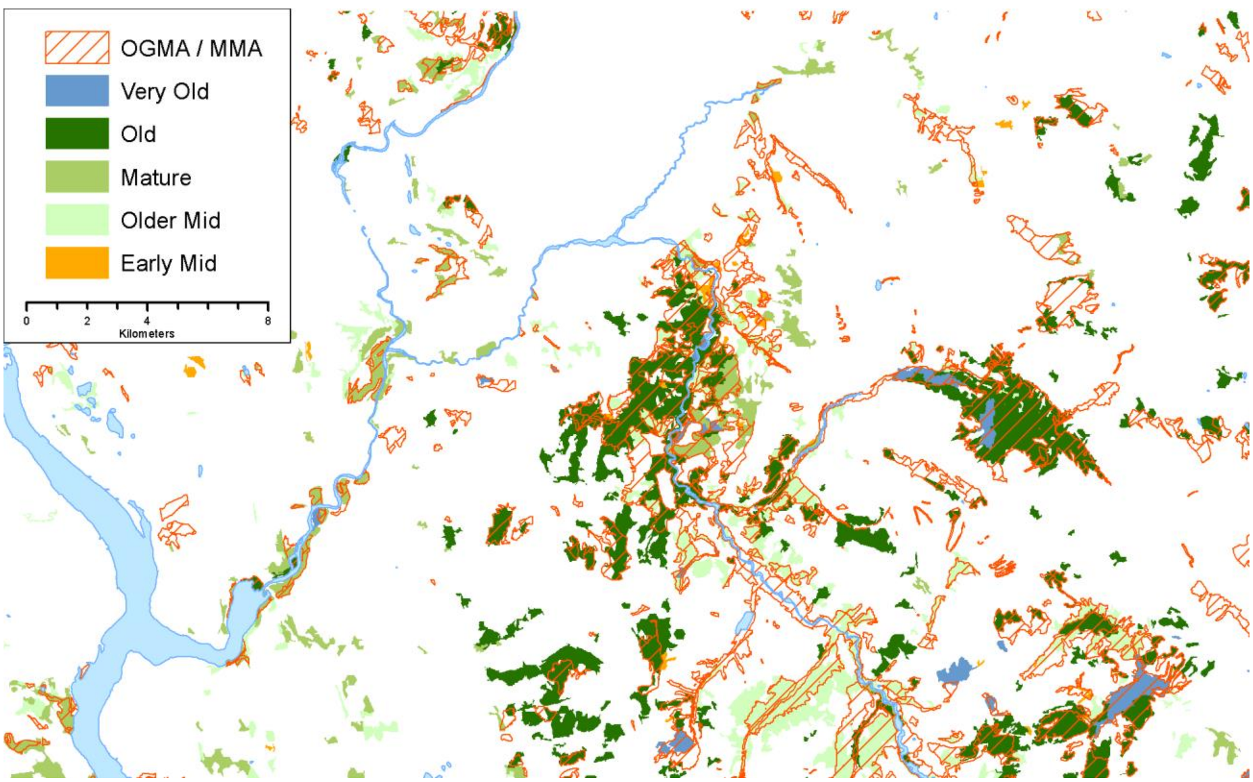


Figure 40 Example of Candidate Reserves selected by the model

The FMLB selected as Candidate Reserves totalled 144,187 ha (16.7%); 39,076 ha more area than the current OGMA/MMA. The ISS Base Case THLB selected as Candidate Reserves was 14,165 ha (4.2%). After considering the current OGMA/MMAs that do not overlap with the Candidate Reserves, are not otherwise constrained, and are now available for timber harvesting, these Candidate Reserves resulted in a net loss in THLB of 12,222 ha or 3.6%.

The average score per hectare of 39.6 for the Candidate Reserves was 80% higher than the average score (22.0) across the entire FMLB. While these figures are not absolute or field-verified, this suggests that the Candidate Reserves provide higher relative value as old and mature-plus-old forests.

An accompanying Excel file (Cranbrook_ISS_Resv_Resultsv4.xls) provides detailed statistics for the Candidate Reserves selected by the model, while the subsections below summarize the results.

6.2.1 Old Forest Retention

Overall, the landscape-level biodiversity objectives are currently below the minimum target levels for old seral by 40,293 ha (32%) in 127 of the 210 reporting units.

The Candidate Reserves addressed the targets for old forest retention on all but one of the reporting units (i.e., Cranbrook Watershed, Intermediate BEO, NDT2, ESSFwm4 with only 5 ha of FMLB), by selecting the better old seral stands or younger stands for future recruitment as old seral forest. Note that to incorporate more operational flexibility in this analysis, we applied the full target rather than the 2/3 drawdown for old seral in LUs with low BEO. In order to meet the additional criteria described in the subsections below, a total of approximately 17,617 ha selected from 41 reporting units exceeded the minimum old forest requirement.

6.2.2 Mature-Plus-Old Forest Retention

Overall, the landscape-level biodiversity objectives are currently below the minimum target levels for mature-plus-old seral by 8,728 ha (21%) in 9 of the 18 reporting units.

The Candidate Reserves addressed the targets for mature-plus-old forest retention on all reporting units by selecting the better old seral stands or younger stands for future recruitment as mature-plus-old seral forest. Note that mature-plus-old targets only apply to specific LU/BEC Variant combinations; not all of them. In order to meet the additional criteria described in the subsections below, a total of approximately 3 ha selected from 2 reporting units exceeded the minimum mature-plus-old forest requirement.

6.2.3 Reserve Size Distribution

One of the goals of the Reserves Scenario was to develop relatively large, contiguous areas of mature and old forest to maximize the area of the interior forest habitat. In the absence of established criteria, we influenced the model to combine reserves according to reserve size distributions shown by the white regions in Figure 41, with blue and red regions respectively showing maximum and minimum targets. The bars in the chart depict the current size distribution for the Candidate Reserves. These reserve size distribution targets were adapted from Habitat Branch document – Guidance for OGMA Implementation. Note that these patch criteria were developed for reserves and differ from patches for cutblocks in the Biodiversity Guidebook.

Clearly, the Candidate Reserves do not meet all of the target reserve sizes – particularly for large classes. While further refinement of this indicator may be required, it did have considerable influence on the selection of Candidate Reserves. The reserve size distribution across the TSA appears to be fairly well balanced (Figure 42).

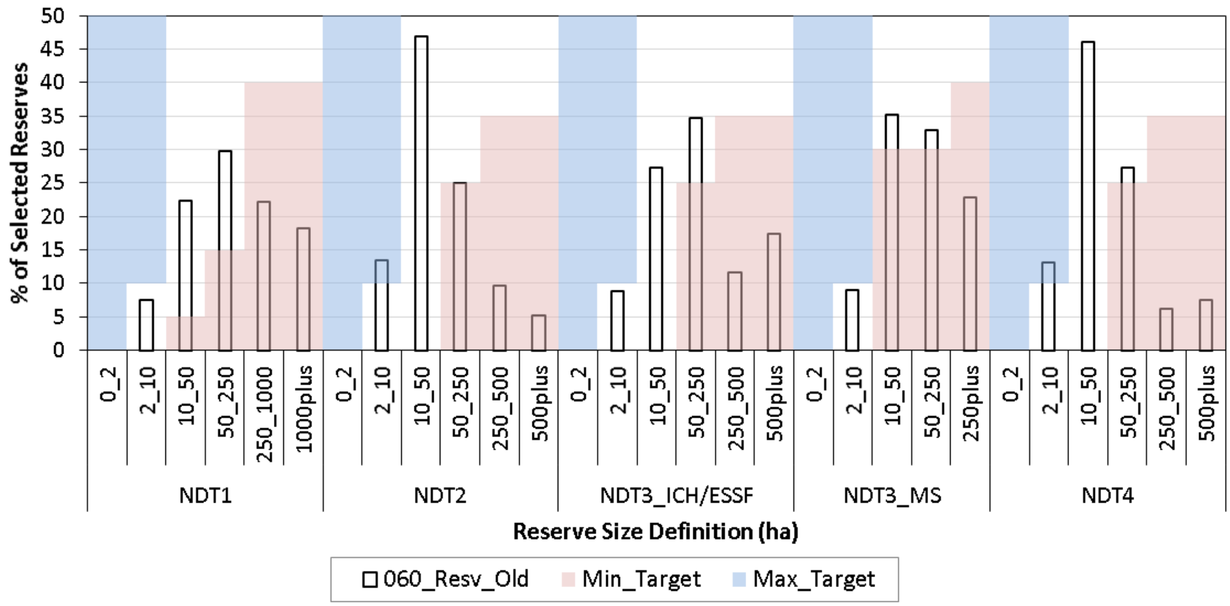


Figure 41 Reserve Size Distribution by Natural Disturbance Type

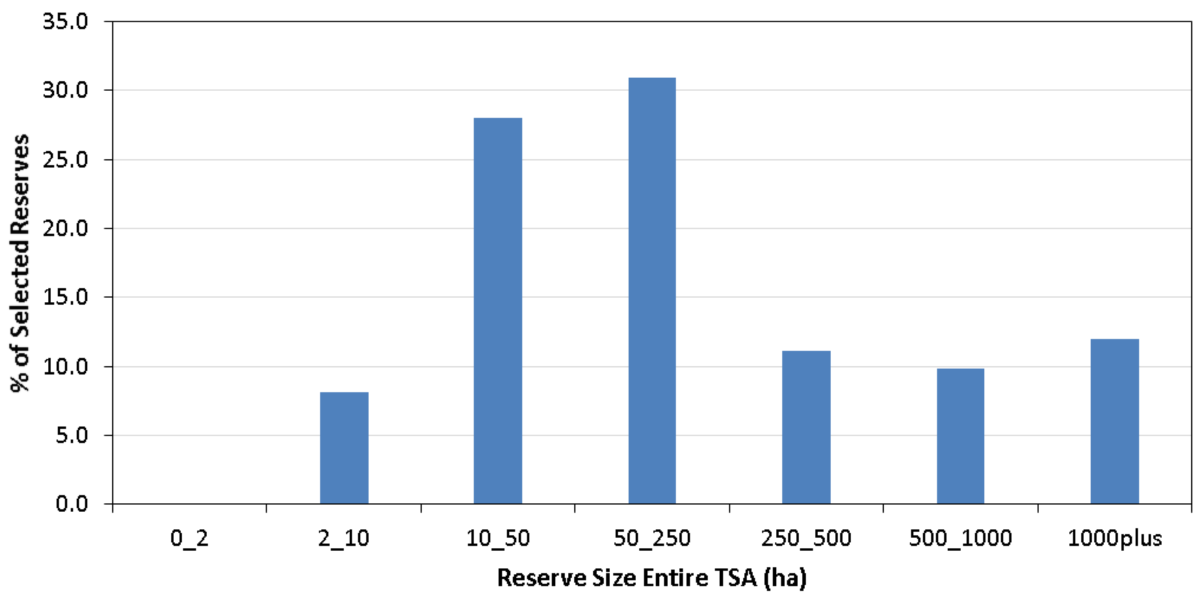


Figure 42 Reserve Size Distribution across the Cranbrook TSA

6.2.4 Interior Old Forest

Specific criteria for interior old forest were not established for the Cranbrook TSA. For this analysis, interior old forest was identified as the area of 'old seral' forest or natural forest area that is uninfluenced by the microclimate of biotic edge effects (i.e., 100m buffer from adjacent stands less than 60 years or any permanent anthropogenic disturbance). We implemented controls to influence the selection of stands identified as interior old forest along with a minimum size criteria of 20 ha.

Candidate Reserves selected by the model included a total of 53,929 ha (62.3%) identified as interior old forest.

6.2.5 Resource Management Areas as Candidate Reserves

Together with stand feature scoring, we incorporated resource management areas into the overall stand-level scoring used to influence the selection of Candidate Reserves. Resource management areas include areas that restrict harvesting completely (i.e., anchors) or partially (i.e., constraints). Table 6 provides a breakdown of resource management areas selected as Candidate Reserves. Note that this is not a netdown table, as overlaps may exist between various factors.

Table 6 Summary of Resource Management Areas as Candidate Reserves

Resource Management Area	Area (ha)	% of Candidate Reserve*
PARKS	10,057	7%
FSC_HCVF	17,397	12%
FSC_RARE	4,085	3%
WHAa	14,182	10%
WHAp	913	1%
RIPARIAN	9,046	6%
WTRA	1,632	1%
CORRIDORS	86,666	60%
UWR_CARIBOU	19,687	14%
UWR_MULE DEER	35,322	24%
CWS	8,432	6%
DWS	13,236	9%
VQO_R	2,286	2%
VQO_PR	15,823	11%
VQO_M	3,257	2%
WUI	0	0%
FUEL_BREAKS	0	0%
INOP_PHYS	101,806	71%
ISOLATED	28	0%
INOP_ECON	45,069	31%
NON_MERCH	30,613	21%
THLB	14,165	10%

** Candidate Reserves Total 144,187 ha*

6.2.6 Comparing Candidate Reserves with Current OGMA/MMAs

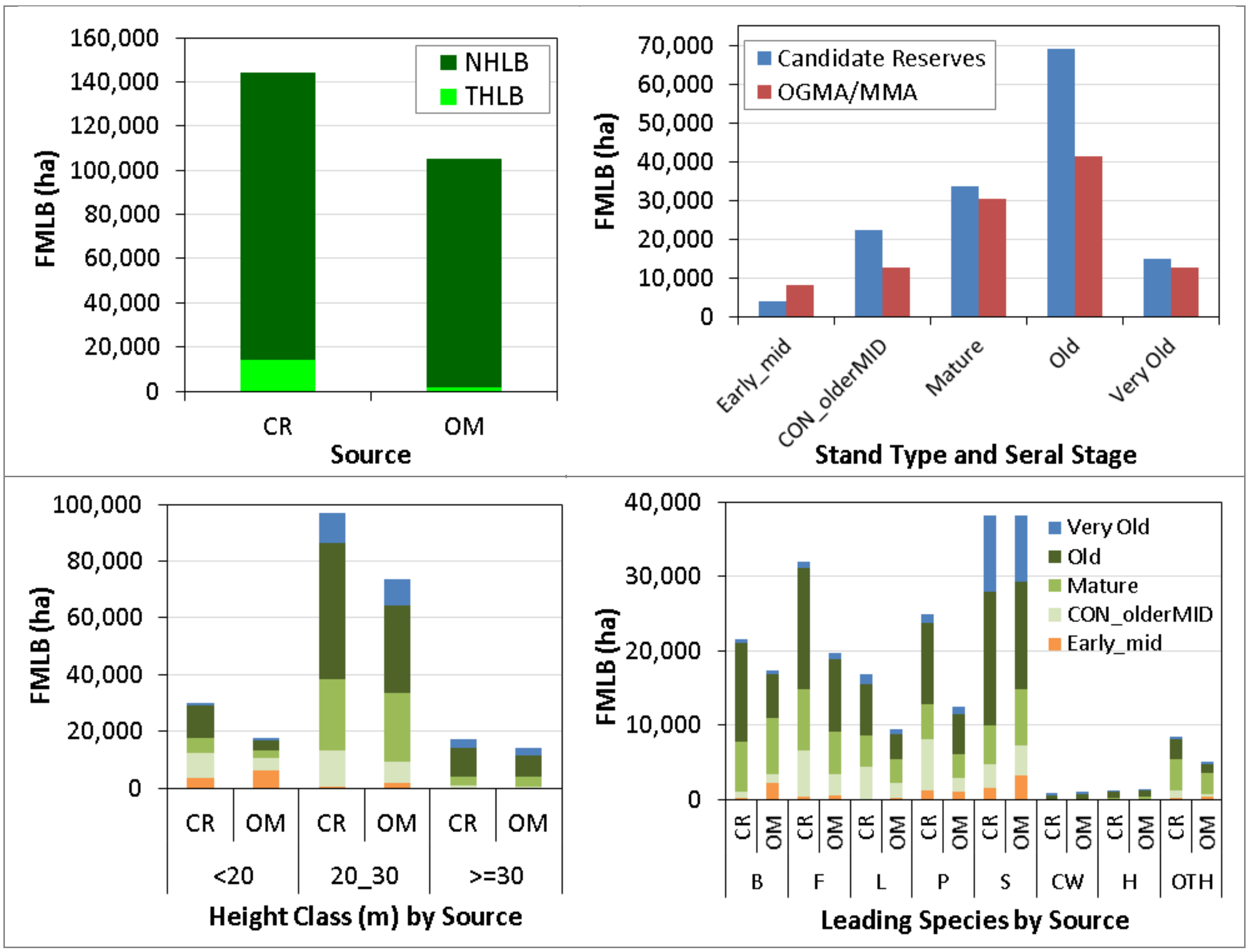
The non-legal, spatial OGMA/MMAs currently managed within the Cranbrook TSA were developed through a similar, systematic process involving forest licenses and government. Initially completed in 2003, then further refined in 2004, this process implemented detailed local planning and inventory work, and applied a cursory examination of the script-driven OGMA/MMAs to refine selections within a limited scope. In contrast, this Reserve Scenario applied a modelled approach of several objectives with a priority on achieving landscape-level biodiversity thresholds. It is not surprising, then, that these disparate approaches produced significantly different results. This section provides a brief comparison of the non-legal, spatial OGMA/MMAs and the Candidate Reserves selected through this Reserve Scenario.

As mentioned above, with an example shown in Figure 40, Candidate Reserves selected through this analysis identified 39,076 ha more area than the existing OGMA/MMAs, including an overlap of 65%.

Applying the full target rather than the 2/3 drawdown for old seral in LUs with low BEO likely contributed to this difference in area selected.

Figure 43 shows results for several indicators that describe the overall quality of reserves selected from both approaches. Compared to the OGMA/MMAs (OM), Candidate Reserves (CR) exhibited the following trends:

- 14% increase in the average score per hectare
- significantly more area with old seral forest and slightly less area with early-mid seral forest (Stand Type)
- more area with taller stands (Height Class)
- more area with pine, Douglas-fir and balsam (Leading Species)
- more area within the ESSF and MS (BEC Zone)
- more area with stands in both lower and higher productivity classes (Site Index Class)



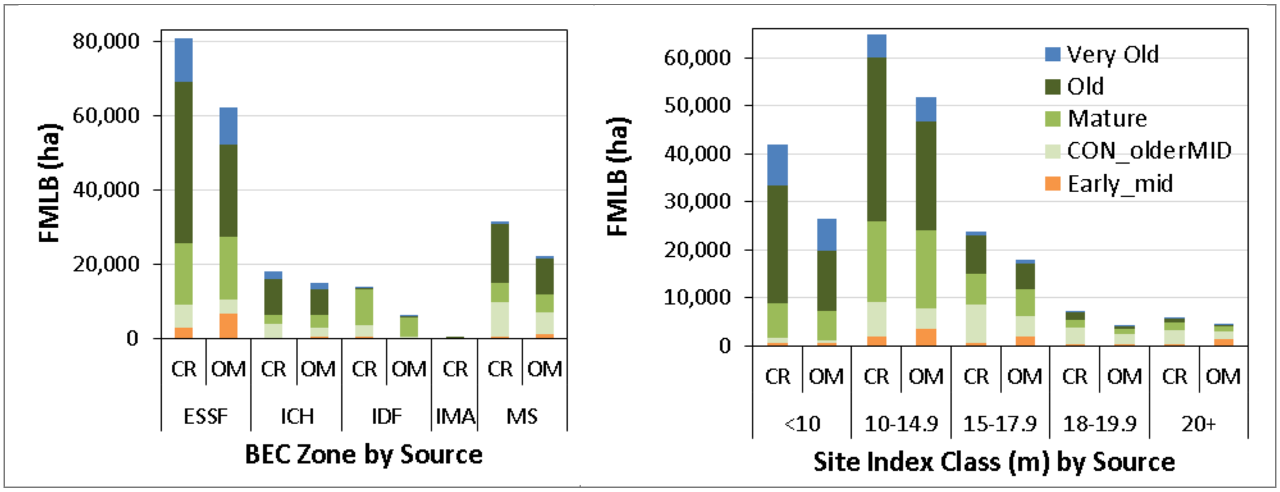


Figure 43 Indicators Comparing Candidate Reserves (CR) and current OGMA/MMAs (OM)

7 Combined Scenario

7.1 Description

The Combined Scenario aimed to guide development, implementation, and monitoring of tactical plans over the first 20 years of the planning horizon. Key tactics from the three scenarios (ISS Base Case, Silviculture, and Reserve) were included to provide an integrated strategy to this first iteration of the ISS process. The project team omitted potential tactics from the Wildlife Scenario, as it was not yet complete.

Table 7 summarizes the six different model runs completed for the Combined Scenario. We then developed a seventh, Run 080 – Comb_AAC, as the most appropriate harvest forecast to describe in detail (section 7) and to use for the ISS Tactical Plan.

Table 7 Criteria Applied in the Combined Scenario Runs

Scenario	Criteria
Run 070 – CR20 MINDY	○ utilized the spatially defined candidate reserves developed through the reserve scenario (i.e., full old seral target in LUs with low BEO). ○ locked the reserves from being harvested over the first 20 years and applied aspatial seral targets afterwards (i.e., included 2/3 drawdown). ○ developed a MINDY harvest profile as described in section 3.1.2.
Run 071 – CR20 AAC	○ utilized the spatially defined candidate reserves developed through the reserve scenario (i.e., full old seral target in LUs with low BEO). ○ locked the reserves from being harvested over the first 20 years and applied aspatial seral targets afterwards (i.e., included 2/3 drawdown). ○ set the harvest level for the first period at the current AAC and developed a NDY harvest profile beyond the first period.
Run 072 – OGMA20 MINDY	○ utilized the current spatially defined OGMA/MMA areas (i.e., included 2/3 drawdown). ○ locked the reserves from being harvested over the first 20 years and applied aspatial seral targets afterwards (i.e., included 2/3 drawdown). ○ developed a MINDY harvest profile as described in section 3.1.2.

Scenario	Criteria
Run 073 – OGMA20 AAC	o utilized the current spatially defined OGMA/MMA areas (i.e., included 2/3 drawdown). o locked the reserves from being harvested over the first 20 years and applied aspatial seral targets afterwards (i.e., included 2/3 drawdown). o set the harvest level for the first period at the current AAC and developed a NDY harvest profile beyond the first period.
Run 074 – CR300 AAC	o utilized the spatially defined candidate reserves developed through the reserve scenario (i.e., full old seral target in LUs with low BEO). o locked the reserves from being harvested over the entire planning horizon and applied aspatial seral targets (i.e., included 2/3 drawdown). o set the harvest level for the first period at the current AAC and developed a NDY harvest profile beyond the first period.
Run 075 – OGMA300 AAC	o utilized the current spatially defined OGMA/MMA areas (i.e., included 2/3 drawdown). o locked the reserves from being harvested over the entire planning horizon and applied aspatial seral targets (i.e., included 2/3 drawdown). o set the harvest level for the first period at the current AAC and developed a NDY harvest profile beyond the first period.
Run 080 – Comb_AAC	o utilized the spatially defined candidate reserves developed through the reserve scenario (i.e., full old seral target in LUs with low BEO). o removed these reserves from the THLB. o set the harvest level for the first period at the current AAC and developed a NDY harvest profile beyond the first period.
Run 081 – Comb_SilviOFF	o made silviculture treatments unavailable to the model by dropping the silviculture budget to zero dollars. o set the harvest level for the first period at the current AAC and developed a NDY harvest profile beyond the first period.
Run 083 – Comb_BAU	o aimed to demonstrate timber and non-timber impacts if the tactical plan were ignored (i.e., Business As Usual). o made silviculture treatments unavailable to the model by dropping the silviculture budget to zero dollars. o adjusted the harvest profile for cable harvest system at 9.0%, to reflect performance over the last 10 years. We disregarded other harvest profiles that would not have no effect. o deactivated haul time and patch size distribution targets. o targeted higher volume stands over the first 20 years. o set the harvest level for the first period at the current AAC and developed a NDY harvest profile beyond the first period.

The key tactics from each of the Base Case, Silviculture and Reserve Scenarios are briefly summarized in Table 8.

Table 8 Key Tactics Applied in the Combined Scenario Runs

Scenario	Key Tactics
ISS Base Case	o Updated spatial delineation for BECv11, OGMA/MMA, FSC HCVF, proposed WHAs, 2018 wildfires, and recent harvest depletions. o Included 2/3 drawdown on old seral targets for LUs with low BEO and applied mature-plus-old seral targets only to reporting units designated in the KBLUP. o Applied the current harvest profiles for harvest system (ground/cable/partial) and haul distance over the first 40 years, plus harvest opening size criteria to reduce the amount of small (<5 ha) openings.
Silviculture	o Implemented ENH and FERT treatments over the first 20 years but extended CT to 60 years. o Limited the area treated for ENH and CT to 10% and 5%, respectively, of the treated area over each period. Also limited the budget for all treatments to $300,000 per year.
Reserve Scenario	o Prepared one model that utilized the spatially defined candidate reserves developed through the reserve scenario and a second model that utilized the current spatially defined OGMA/MMAs (Table 7).

7.2 Land Base Definition

The land base definition for the Combined Scenario (Table 9) shows the Forest Management land Base (FMLB) is 863,548 ha; ~2,117 ha (0.2%) less than the ISS Base Case Scenario. The current effective Timber Harvesting Land Base (THLB) of 333,053 ha is ~5,290 ha or 1.6% less than the ISS Base Case Scenario, while the long-term effective THLB is 314,048 ha; ~4,674 ha (or 1.5%) less than the ISS Base Case Scenario.

Table 9 Land Base Definition for the Combined Scenario – Cranbrook TSA

Factor		Total Area (ha)	Effective Area (ha)	% of Total Area	% of FMLB
Total Area		**1,484,998**	**1,484,998**	**100.0%**	
Less	Community Forests	20,163	20,163	1.4%	
	Private	223,370	223,370	15.0%	
	Christmas Trees Permit	5,510	5,510	0.4%	
	Indian Reserves	20,266	20,266	1.4%	
	Woodlots	8,475	8,475	0.6%	
	Misc leases	73	73	0.0%	
	Special Permit	215	139	0.0%	
	Mines	18,689	8,233	0.6%	
	Not typed	84,392	2,822	0.2%	
	Non-vegetated	284,646	261,168	17.6%	
	Non-treed	108,830	70,352	4.7%	
	Vegetated, non CFLB	152	152	0.0%	
	Factored Roads		725	0.0%	
Total Forest Management land Base (FMLB)		***(in FMLB)***	**863,548**	**58.2%**	**100.0%**
Less:	Parks	28,644	28,644	1.9%	3.3%
	Inoperable	347,972	322,161	21.7%	37.3%
	Steep Slopes (>70%)	48,875	2,224	0.1%	0.3%
	Terrain Class V in CWS	1,359	49	0.0%	0.0%
	ESA	93,299	8,202	0.6%	0.9%
	Non Merchantable	84,965	11,644	0.8%	1.3%
	Low Sites	150,187	5,378	0.4%	0.6%
	Misc Reserves	234	156	0.0%	0.0%
	Crown UREP	662	526	0.0%	0.1%
	UWR Caribou	72,613	11,472	0.8%	1.3%
	WHA	3,259	2,580	0.2%	0.3%
	WHA Proposed	2,084	1,392		
	FSC Endangered Forests	44,610	1,747	0.1%	0.2%
	FSC Rare and Uncommon Ecosystems	6,132	3,656	0.2%	0.4%
	Existing WTRAs	10,061	6,580	0.4%	0.8%
	100% InBlock Retention	852	852	0.1%	0.1%
Gross Timber Harvesting Land Base (THLB)			**456,284**	**30.7%**	**52.8%**
Less Partial Removals	Slopes 40-70% (50%)	248,145	39,872	2.7%	4.6%
	Terrain Class V outside CWS (95%)	13,364	1,359	0.1%	0.2%
	Terrain Class IV outside CWS (5%)	102,080	1,792	0.1%	0.2%
	Terrain Class IV in CWS (95%)	6,257	355	0.0%	0.0%
	PFT Pine >80yrs (29%)	60,254	5,625	0.4%	0.7%
	PFT Pine 61-80yrs (18%)	38,903	2,509	0.2%	0.3%
	PFT Pine 41-60yrs (35%)	3,208	584	0.0%	0.1%
	PFT Pine <40yrs (80%)	9,171	970	0.1%	0.1%
	Isolated	234	234	0.0%	0.0%
	In-Block Retention*		38,287	2.6%	4.4%
	Candidate Reserves	31,643	31,643	2.1%	3.7%
Current Effective THLB			**333,053**	**22.4%**	**38.6%**
Less Future Reductions	Open Range Conversion	12,292	9,212	0.6%	1.1%
	Future Roads (3.8%)		9,793	0.7%	1.1%
Long-term Effective THLB			**314,048**	**21.1%**	**36.4%**

** In-Block Retentions include FSC Rare Ecosystems, (50%), WTRA (6% for existing natural stands and 3.5% for existing managed stands), and Riparian (% determined spatially for each polygon).*

7.3 Results

For the Combine Scenario we selected the Run 080 – Comb_AAC as the most appropriate harvest forecast to describe in detail and to develop the ISS Tactical Plan for the Cranbrook TSA. The following points outline our rationale for this selection:

- While the Candidate Reserves require further review, they reflect a systematic process that identifies the most appropriate areas that meet the landscape-level biodiversity objectives.
- The Candidate Reserves reflect full old seral targets, while the current OGMA/MMAs incorporated a 2/3 drawdown of old seral targets in LUs with low BEO (~half of the TSAs). While this approach is more conservative, it helps to ensure that biodiversity objectives can be maintained over the planning horizon.
- Locking Candidate Reserves from being harvest in the model demonstrates that similar areas can be maintained over the entire planning horizon. In reality, these reserves may be adjusted provided the same or better quality OGMA/MMAs are maintained.
- This model run results in retaining more merchantable volume on the landbase as a greater cushion for addressing catastrophic events (e.g., wildfire, forest health).
- The harvest flows are quite similar to those that include the current OGMA/MMAs rather than the Candidate Reserves. Other than the potential loss of field-confirmed OGMA/MMAs, there does not appear to be any significant advantage to maintaining the existing OGMA/MMAs.

7.3.1 Non-Timber Values

7.3.1.1 Seral Stage

The seral stage distribution (Figure 44) shows that after transitioning from harvesting natural to managed stands over the first century, seral stage distributions are stable over the rest of the planning period. Approximately half of the NHLB is in old seral stage and the rest is well distributed in early, mid, and mature seral stages.

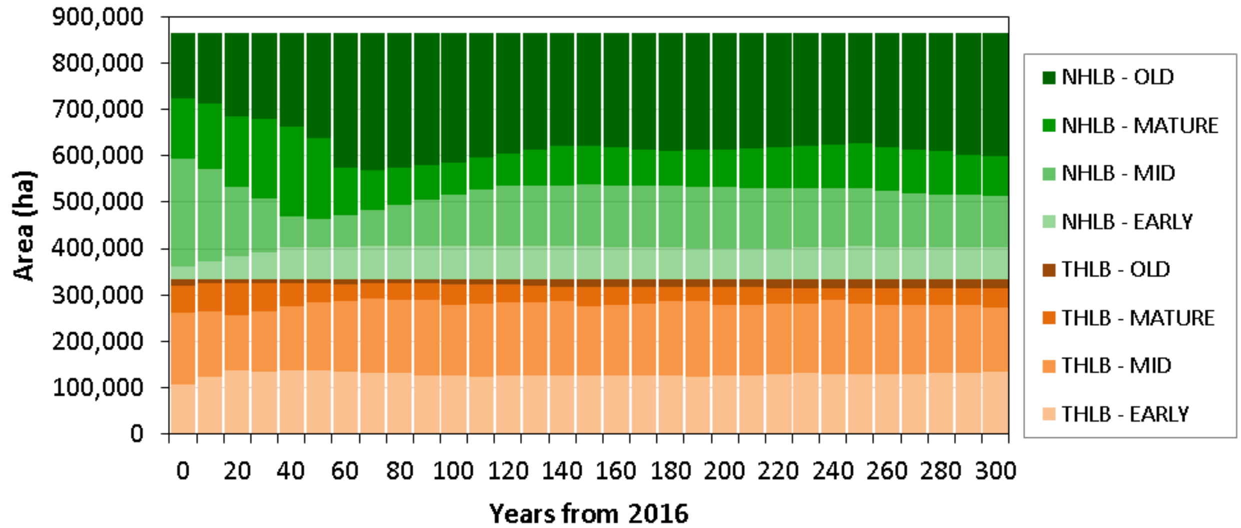


Figure 44 Combined Scenario – Seral Stages by Landbase Type

Summarizing old seral target status across all reporting units (Figure 45) shows a couple of interesting trends. Most importantly, incorporating the candidate reserves and implementing old seral targets in the model reduced the area (left axis) and most of the units (right axis) under the minimum target to nearly zero over the first 6 decades. Secondly, the amount of old seral area ranges between 65% and 192% more than the minimum target levels across the planning period.

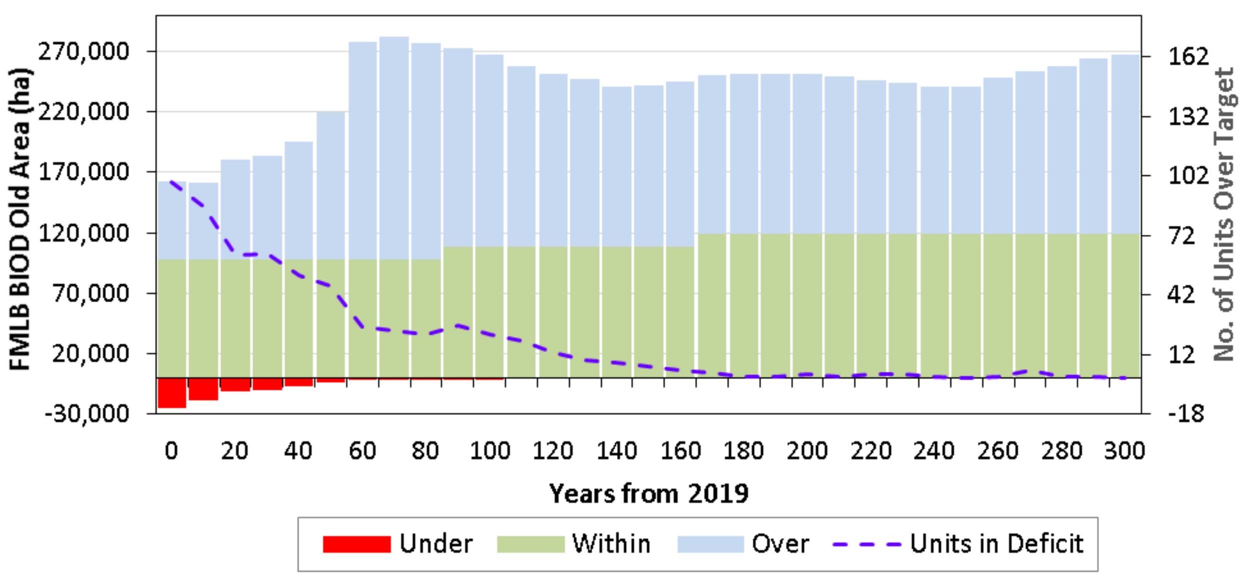


Figure 45 Combined Scenario – Old Seral Target Status Across All Reporting Units

Summarizing mature-plus-old seral target status across all reporting units (Figure 46) shows similar trends as the old seral. Incorporating the candidate reserves and implementing mature-plus-old seral targets on appropriate LU/BEC variant units reduced the area (left axis) and most of the units (right axis) under the minimum target to nearly zero over the first 4 decades. In addition, the amount of mature-plus-old seral area ranges between 27% and 79% more than the minimum target levels across the planning period.

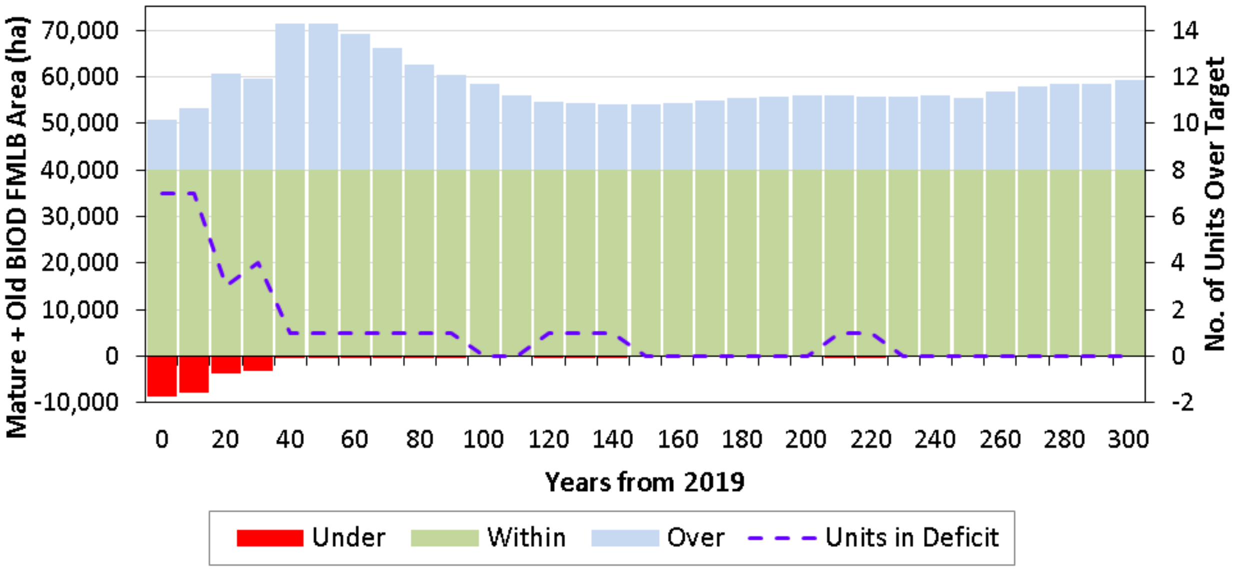


Figure 46 Combined Scenario – Mature-Plus-Old Seral Target Status Across All Reporting Units

Examples for some units are shown in Figure 47, where the black line represents the percentage of THLB area of old and mature-plus-old seral forest within the reporting unit in each period. The model aimed to remain above the red-shaded zone (i.e., minimum target level). Note that targets for old seral within LUs designated with low BEO included draw-downs over established periods (top left).

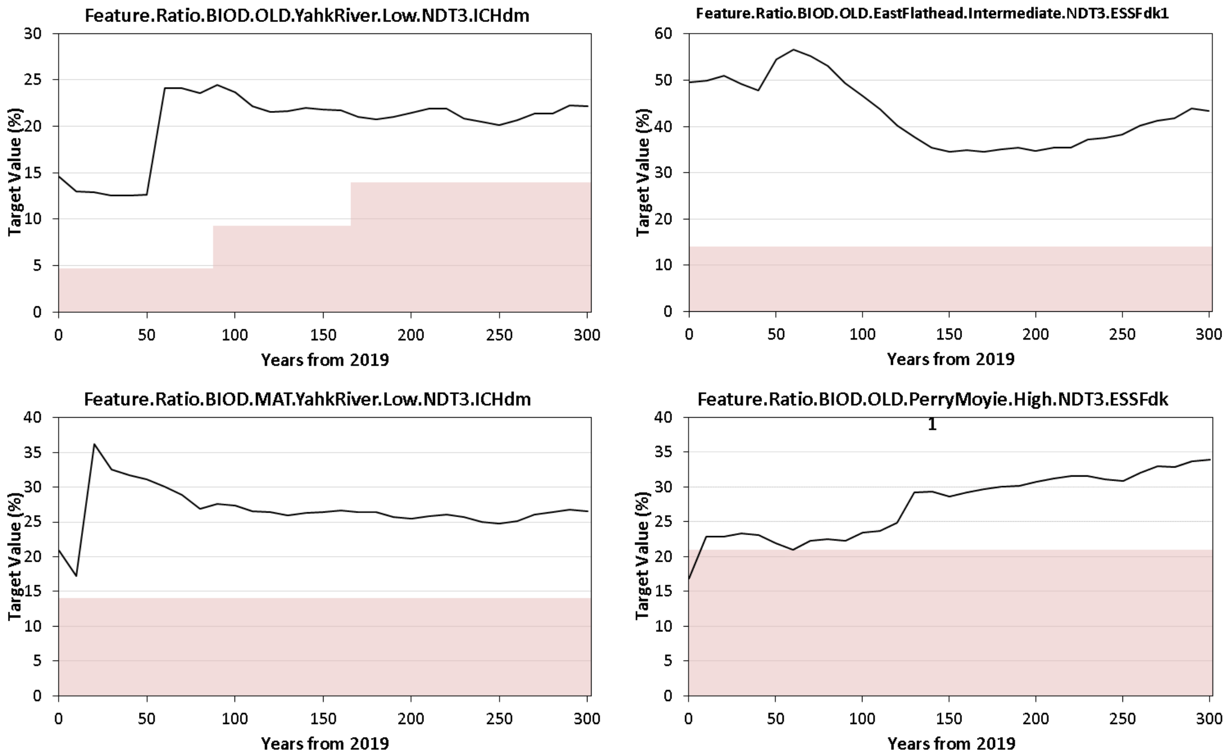


Figure 47 Combined Scenario – Old and Mature-Plus-Old Seral Objectives (examples)

7.3.1.2 Interior Old Forest

Criteria for interior old forest were not directly applied in the model but post-processed spatial summaries were prepared at four periods (i.e., years 0, 20, 100, and 300) (Figure 48). This aimed to support the process developed for the Reserve Scenario (section 6.2.4), without implementing targets. Interior old forest varies on the THLB from harvesting and on the NHLB from natural disturbance events scheduled in the model. The total amount of interior old forest fluctuated between ~109,000 and ~129,000 ha, with 1.2% to 3.6% within the THLB, and remained well distributed within each of the size classes.

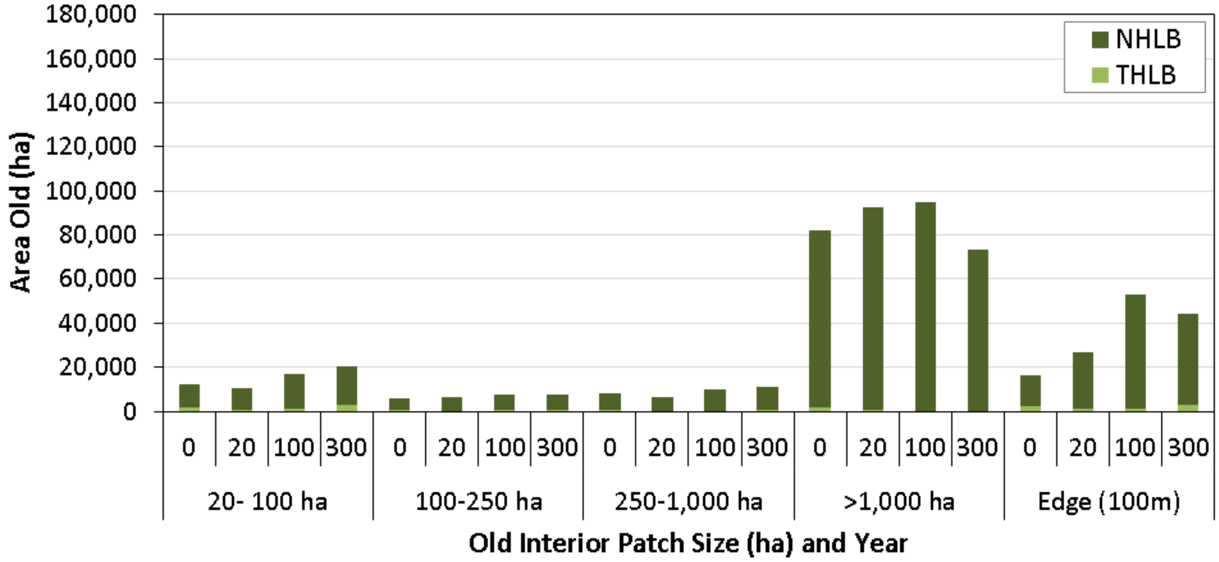


Figure 48 Combined Scenario –Interior Old Forest Size Classes at Years 0, 20, 100, and 300

7.3.1.3 Patch Size Distribution (Very Early Seral)

The patch size distribution summarized for very early seral and all reporting units (Figure 49) shows the average and range for each patch size category relative to the targets, while comparing results from the ISS Base Case (003 – targets not applied) with results from the Combined Scenario (074 – targets applied). Results for the Combined Scenario trend much closer towards the target distributions (white space between blue/maximum and red/minimum targets). Patch size requirements certainly influenced the harvest schedule and significantly impacted the harvest flow.

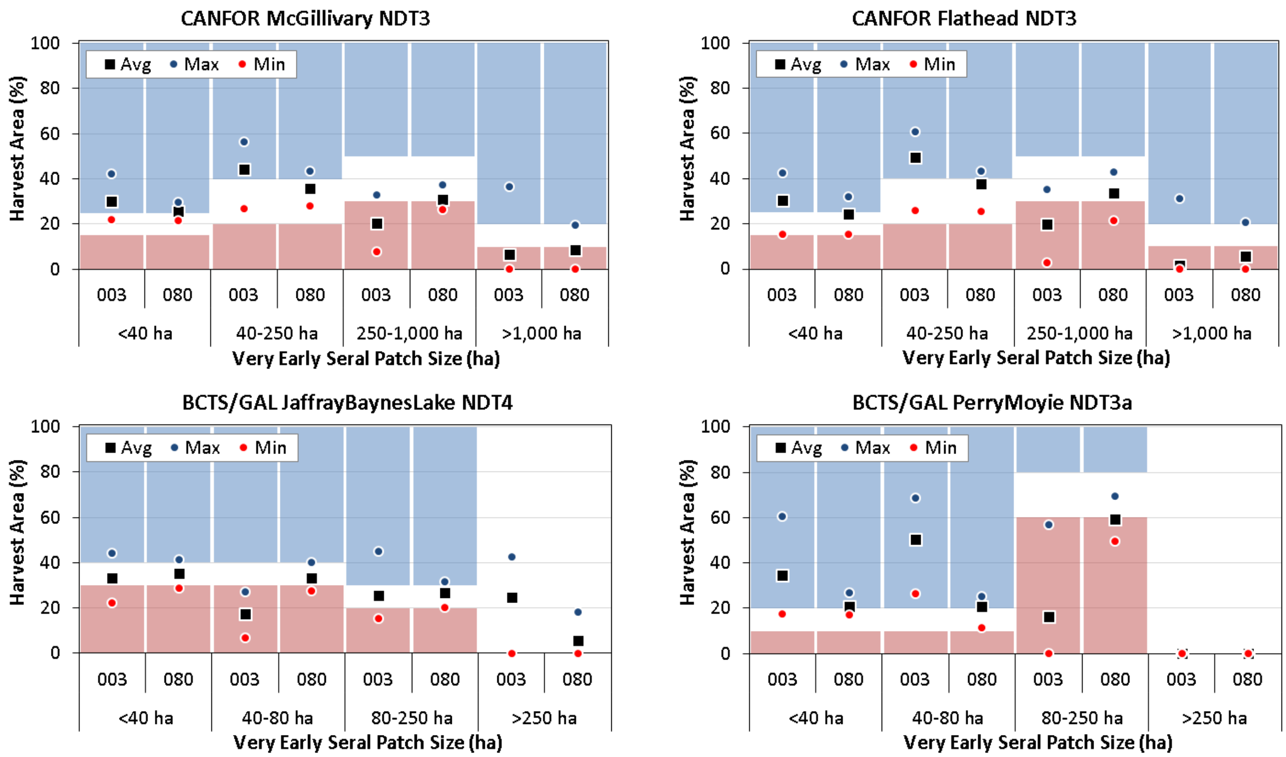


Figure 49 Combined Scenario – Very Early Seral Patch Objectives (examples)

7.3.1.4 Green-up

Maximum target levels for green-up were not constraining in the Combined Scenario. Cumulative results across all reporting units (Figure 50) show that implementing green-up requirements reduced the area (left axis) and the number of units (right axis) over the maximum target to zero after the first decade. Examples for some units are shown in Figure 51 (largest reporting units in each combination category), where the black line represents the percentage of THLB area disturbed within the reporting unit in each period. The model aimed to remain below the blue-shaded zone (i.e., maximum target level).

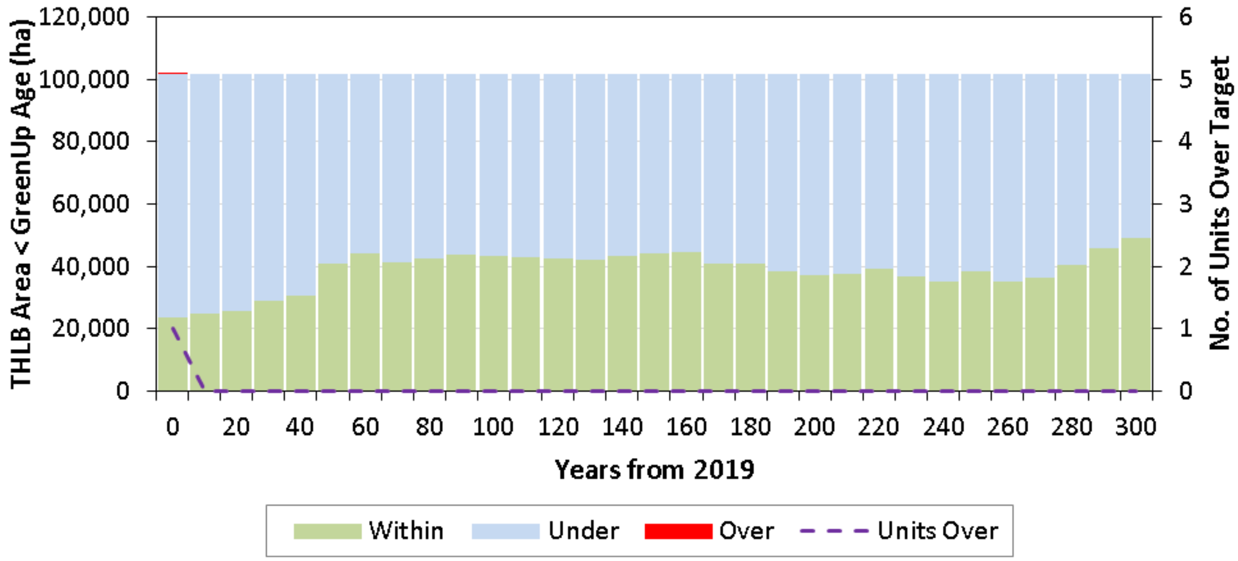


Figure 50 Combined Scenario – Cumulative Target Status for Green-Up

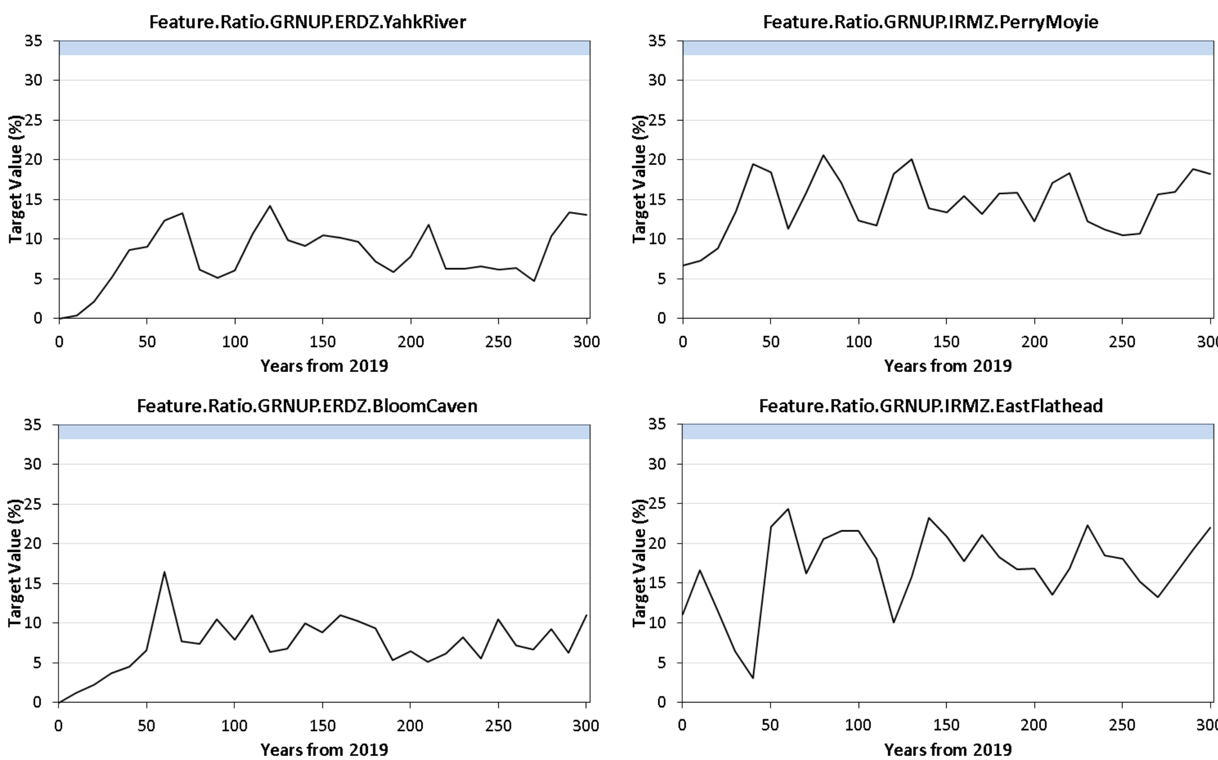


Figure 51 Combined Scenario – Green-Up Targets (examples)

7.3.1.5 Ungulate Winter Range

Minimum target levels for snow interception and mature forest cover requirements within UWRs were moderately constraining in the Combined Scenario. Cumulative results across all reporting units (Figure 52) show that implementing the forest cover requirements significantly reduced the FMLB area (left axis) and the number of units (right axis) under the minimum target after the first 2 decades (i.e., 71 ha to9 ha under). Given the small size of some reporting units, minor amounts of area were occasionally violated throughout the 300 year planning period. Examples for some units are shown in Figure 53 (largest reporting units in each combination category), where the black line represents the percentage of FMLB area that meet the forest cover requirements within the reporting unit in each period. The model aimed to remain above the red-shaded zone (i.e., minimum target level).

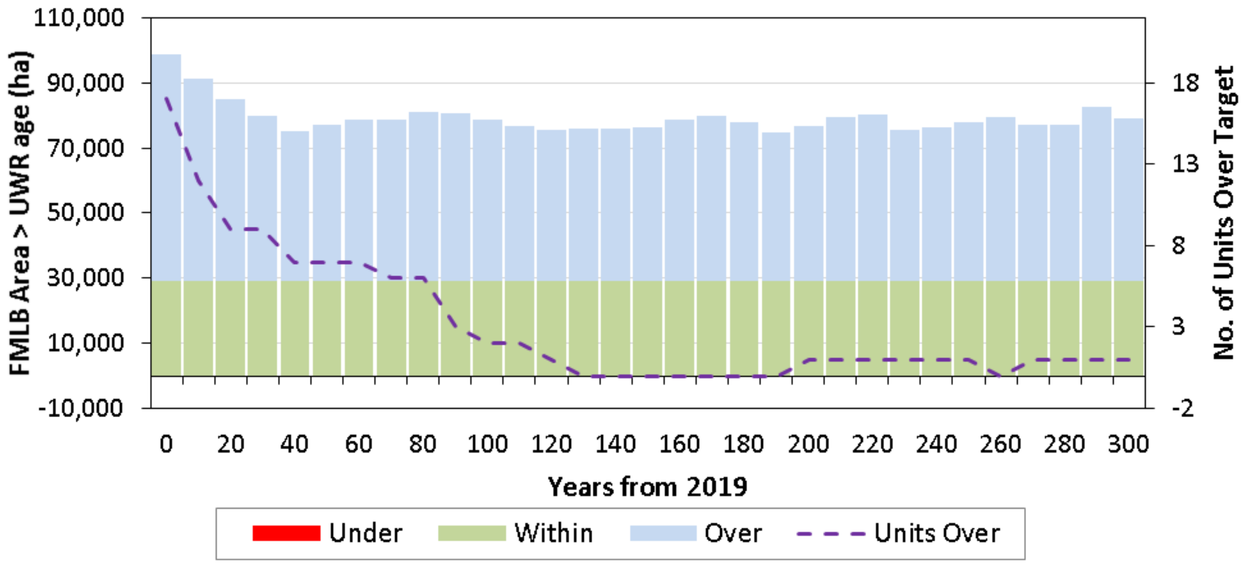


Figure 52 Combined Scenario – Cumulative Target Status for UWR (Cover Requirements)

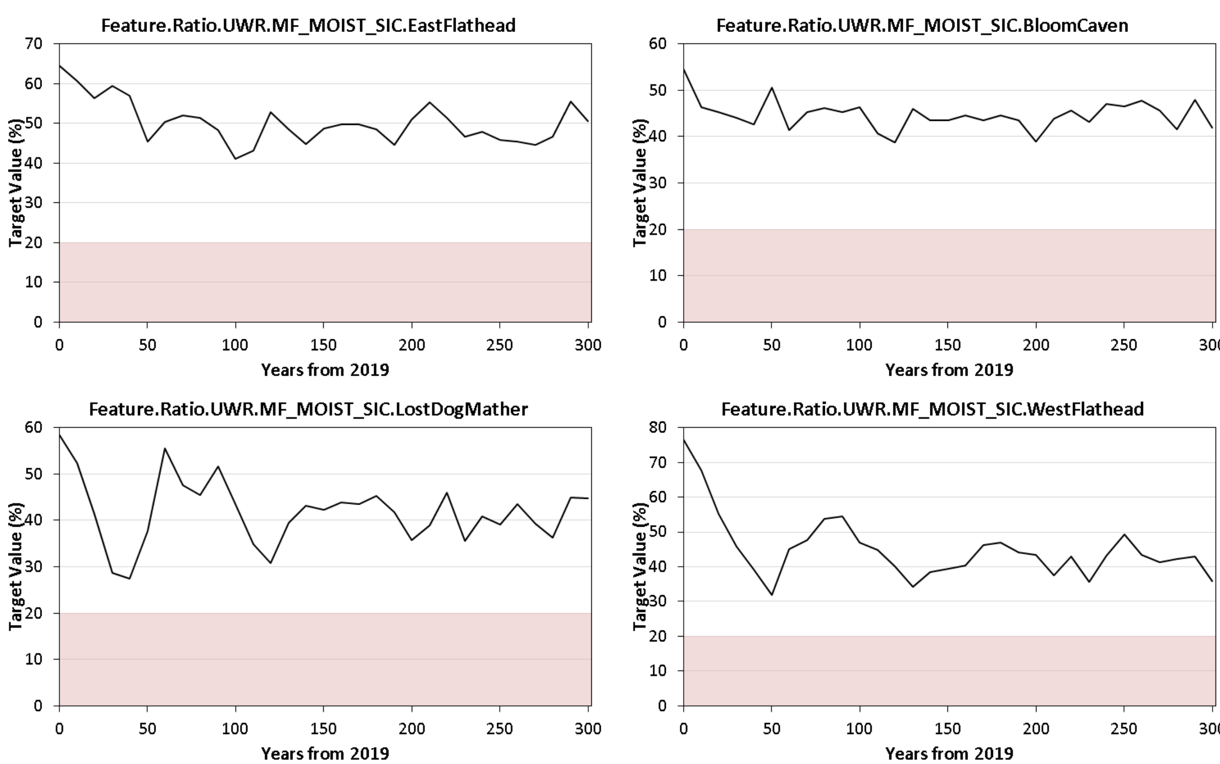


Figure 53 Combined Scenario – UWR Snow Interception and Mature Cover Requirements (examples)

Maximum target levels for very early seral cover requirements within UWRs were not constraining in the Combined Scenario. Cumulative results across all reporting units (Figure 54) show that implementing the forest cover requirements significantly reduced the FMLB area (left axis) and the number of units (right axis) over the maximum target after the first 2 decades. Given the small size of some reporting units, minor amounts of area were occasionally violated throughout the 300 year planning period. Examples for some units are shown in Figure 55 (largest reporting units in each combination category), where the black line represents the percentage of FMLB area that meet the very early seral cover requirements within LU/UWRs in each period. The model aimed to remain below the blue-shaded zone (i.e., maximum target level).

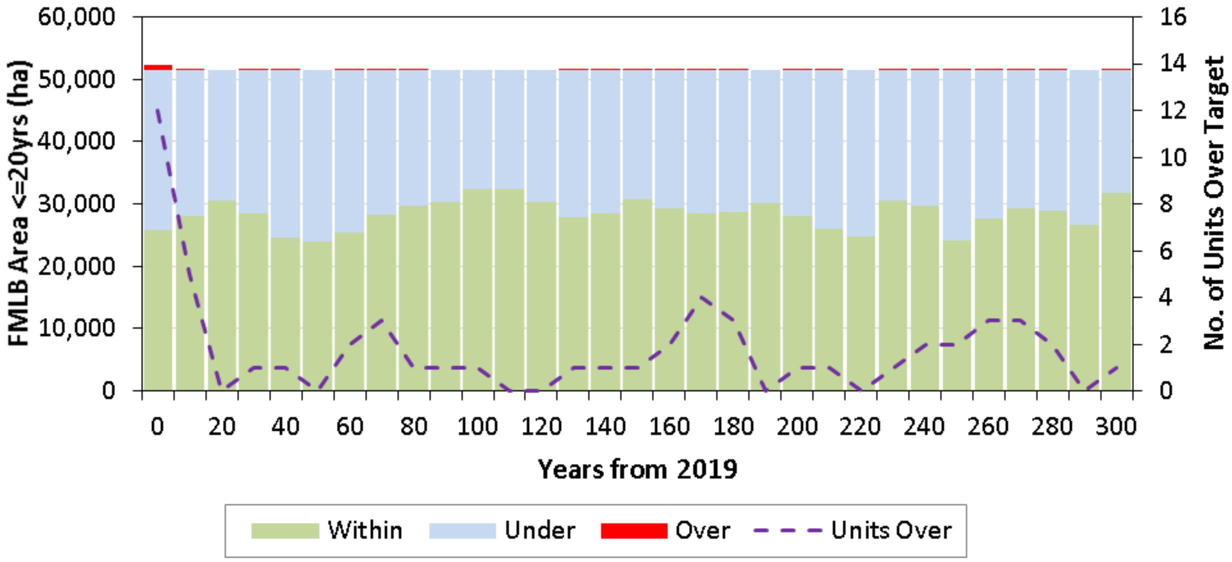


Figure 54 Combined Scenario – Cumulative Target Status for UWR (Very Early Seral)

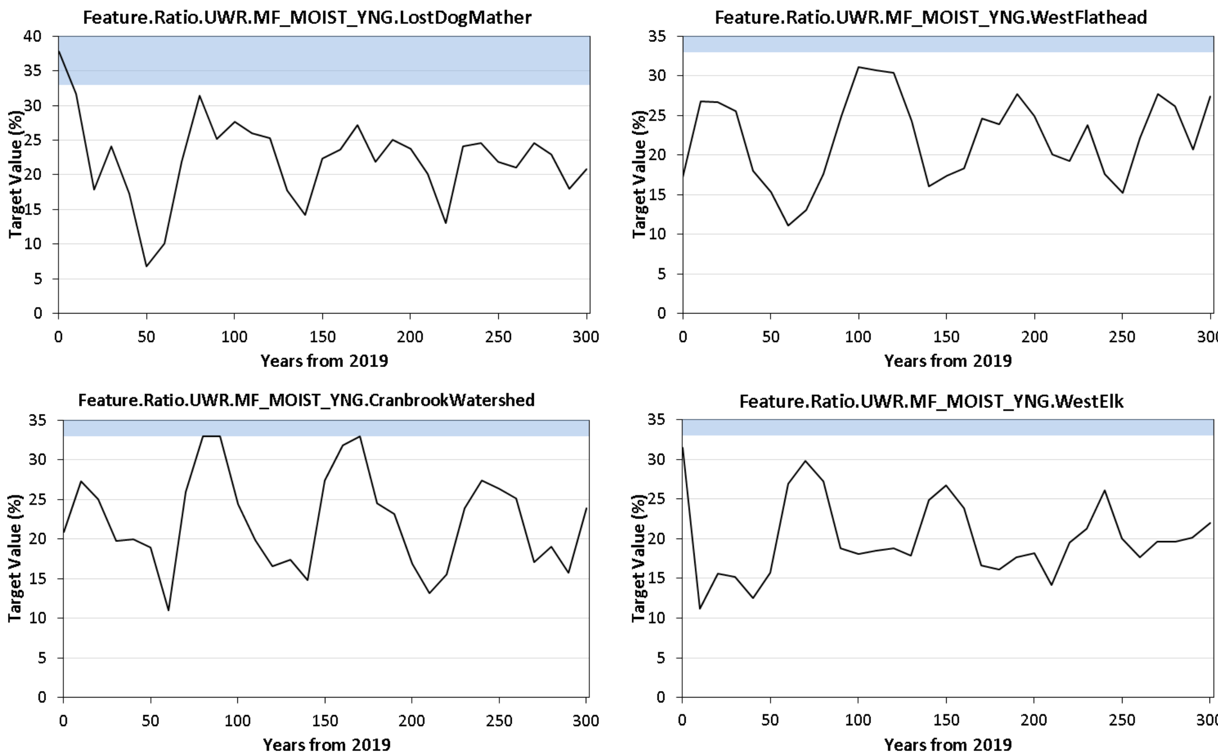


Figure 55 Combined Scenario – UWR Young Seral Cover Objectives (examples)

7.3.1.6 Community and Domestic Watersheds

Maximum target levels for ECA requirements were significantly constraining for some community and domestic watersheds in the Combined Scenario. Cumulative results across all reporting units (Figure 56) show that implementing the ECA requirements significantly reduced the FMLB area (left axis) over the maximum target after the first 2 decades. While the number of units (right axis) over the maximum target remained constant over the rest of the 300 year planning period the associated area was minor. Examples for some units are shown in Figure 57 for Community Watersheds and Figure 58 Domestic Watersheds (largest reporting units in each combination category), where the black line represents the percentage of FMLB area that meet the ECA requirements within watersheds in each period. The model aimed to remain below the blue-shaded zone (i.e., maximum target level).

Note that the THLB for some of the relatively large watersheds prevented harvesting because the prorated ECA target – after removing non-FMLB area – was zero (e.g., Norbury Creek). Natural disturbance modelled within the NHLB also exacerbated these constraints by reducing the FMLB area that could be disturbed.

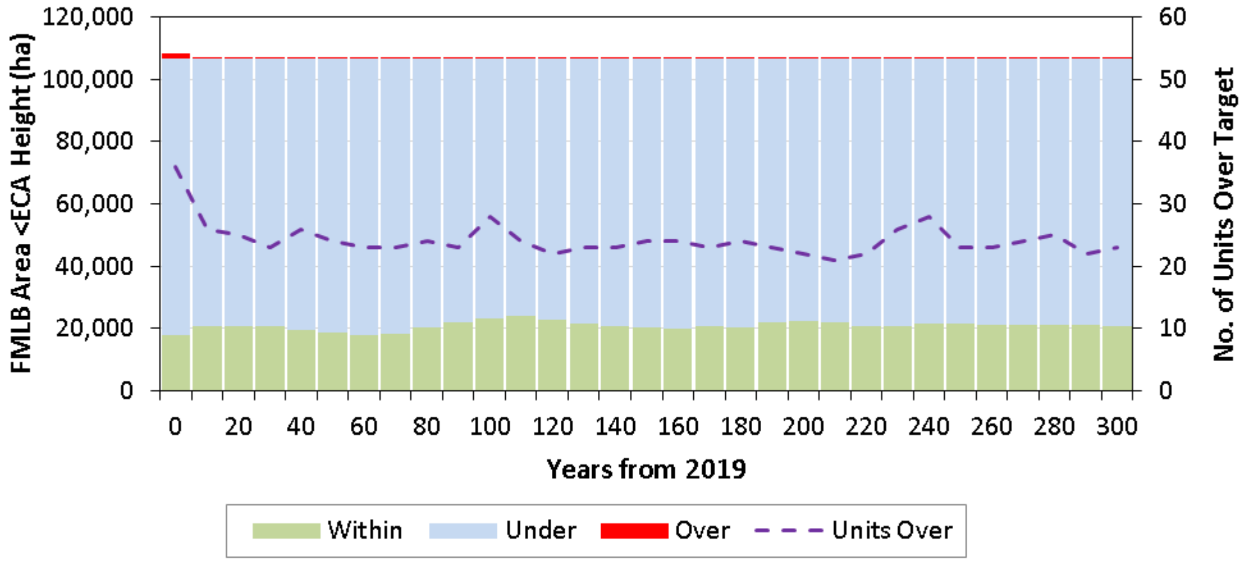


Figure 56 Combined Scenario – Cumulative Target Status for Watersheds

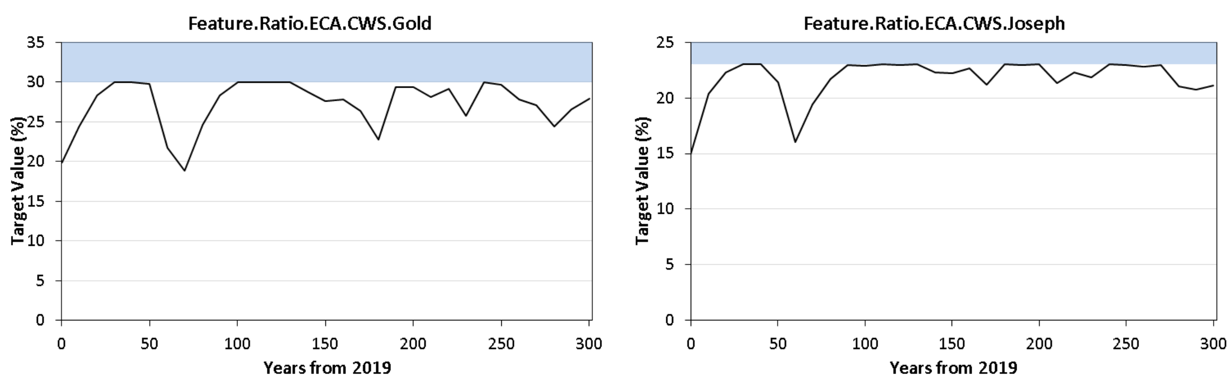


Figure 57 Combined Scenario – Community Watershed Targets (examples)

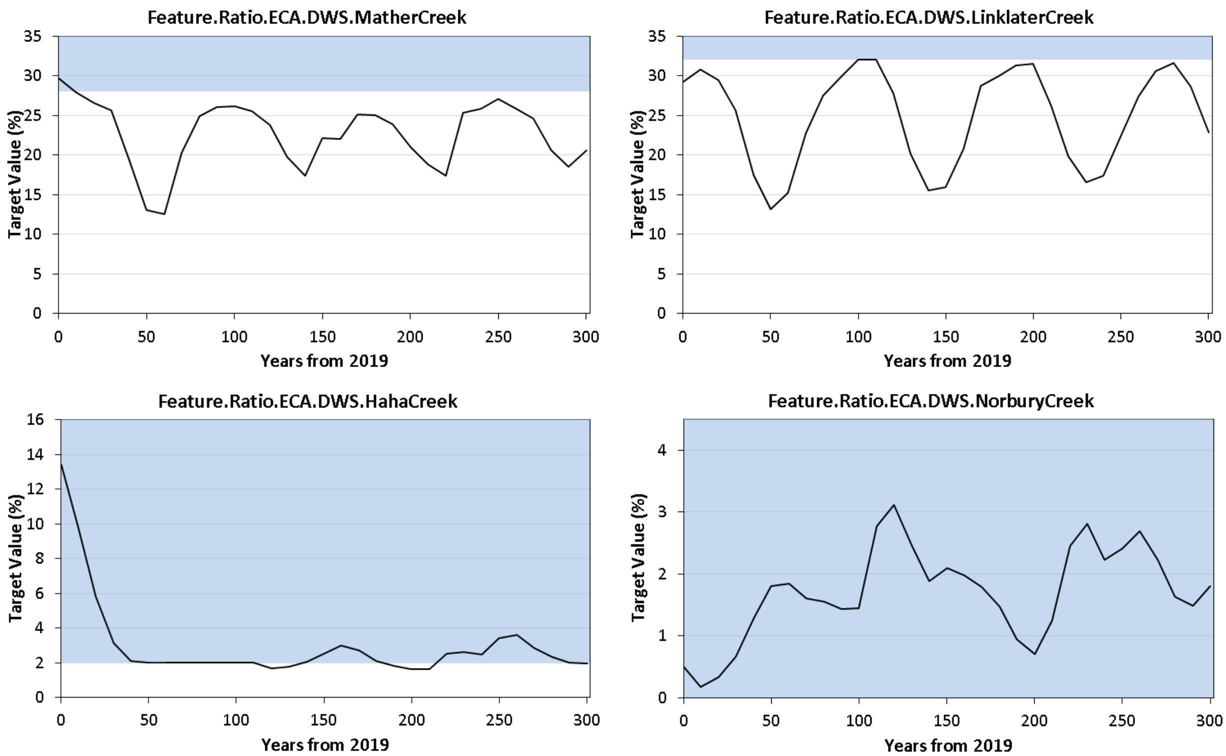


Figure 58 Combined Scenario – Domestic Watershed Targets (examples)

7.3.1.7 Visual Quality Objectives

The Combined Scenario applied a visually-effective green-up (VEG) height to each analysis unit within VLI polygons rather than applying an average VEG height for the VLI polygon. Maximum disturbance levels applied for visual were constraining for some visual polygons throughout the planning horizon. Cumulative results across all reporting units (Figure 59) show that implementing visual requirements significantly reduced the area (left axis) and the number of units (right axis) over the maximum disturbance targets after the second decade. Examples for some units are shown in Figure 60 (largest reporting units in each combination category), where the black line represents the percentage of FMLB area disturbed by period within the visual polygon. The model aimed to remain below the blue-shaded zone (i.e., maximum target level) and adjusted harvest patterns to avoid violating these targets.

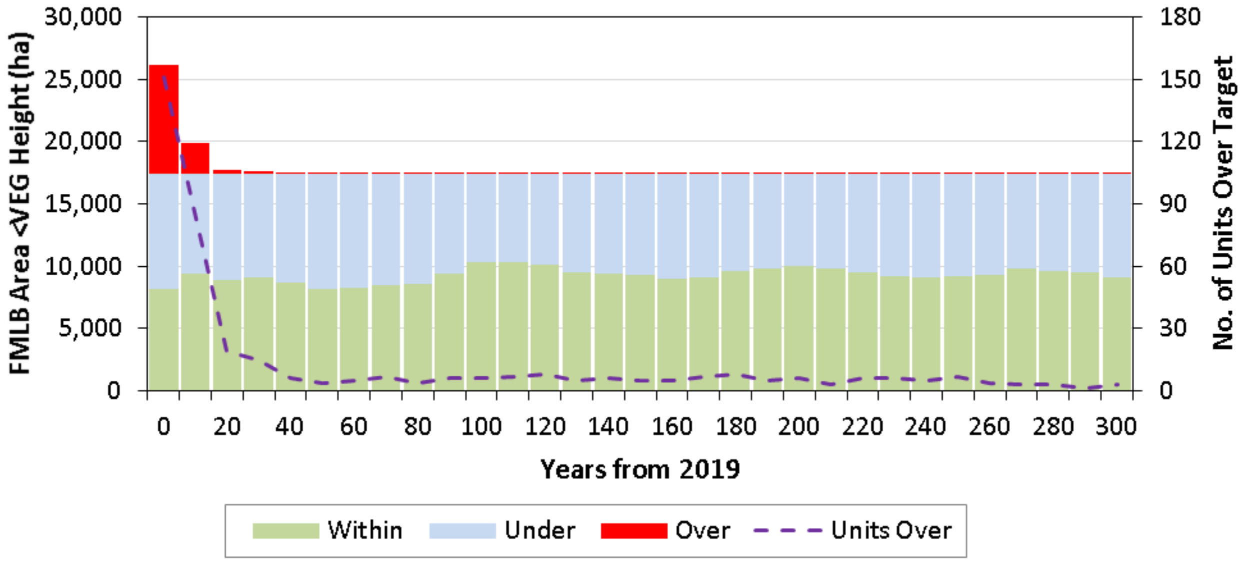


Figure 59 Combined Scenario – Cumulative Target Status for Visual Quality

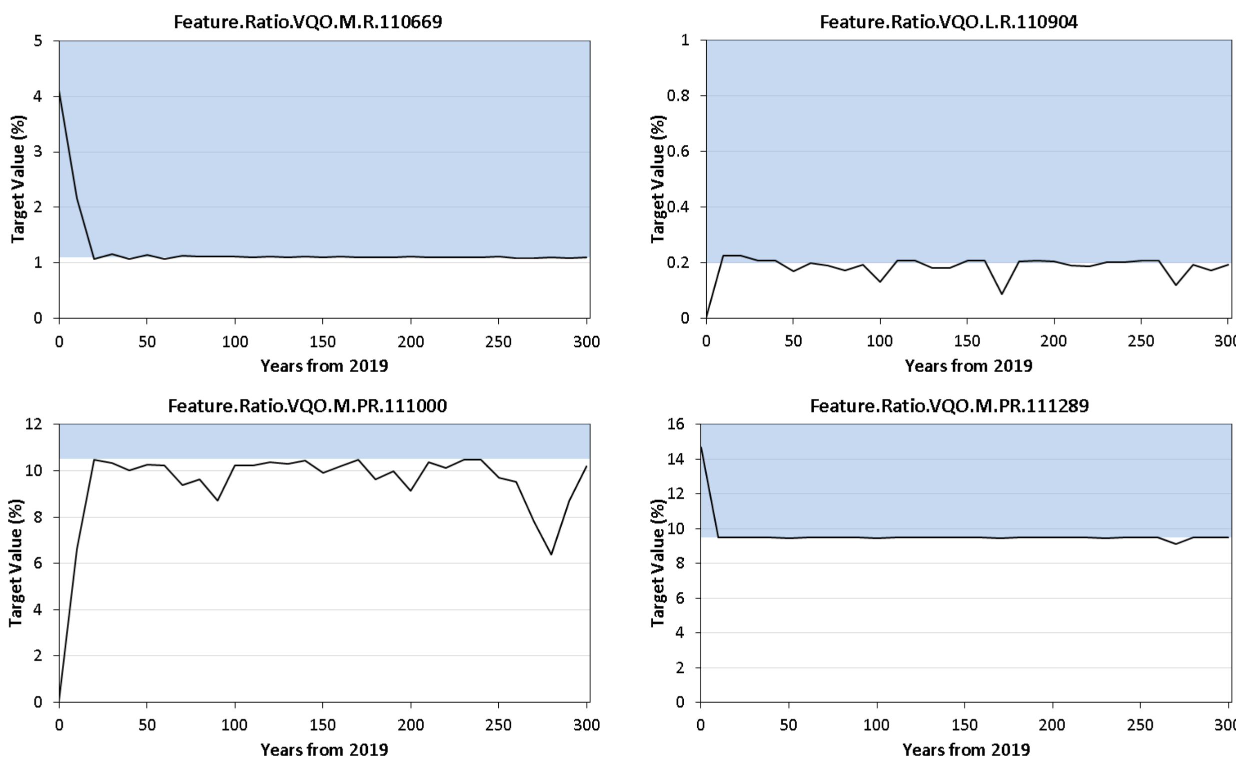


Figure 60 Combined Scenario – VQO Objectives (examples)

7.3.2 Timber Values

7.3.2.1 Harvest Forecast

Compared to the ISS Base Case (MINDY), the Combined Scenario (080-Comb_AAC) harvest profile was 8.2% less in the first decade (i.e., current AAC), 5.4% less over a shorter mid-term, and 2.7% less over the long-term (Figure 61).

Setting the initial harvest rate at the current AAC nearly supported a non-declining harvest profile afterwards, with only a slight decrease of 1.0% in the second decade and a jump of 8.5% to the long-term harvest level in the ninth decade. This jump occurs three periods sooner than the ISS Base Case.

The decrease in the long-term harvest level was attributed to the decrease in the THLB (i.e., ~5,290 ha or 1.6%) plus the sustained growing stock constraint described in the next section 7.3.2.2. Otherwise, improved yields associated with the enhanced basic silviculture tactic supported a higher long-term rate.

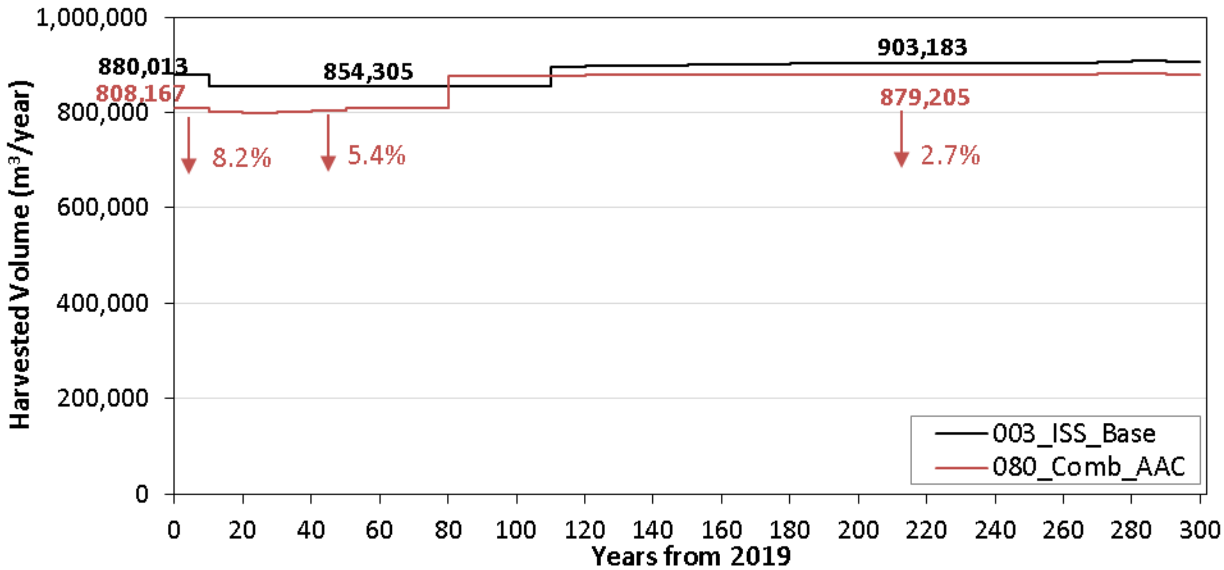


Figure 61 Combined Scenario – Harvest Forecast

7.3.2.2 Growing Stock

To demonstrate a sustained harvest flow we implemented a key criterion that forced the model to maintain a non-declining total growing stock over the last 100 years of the planning horizon (Figure 62). This constraint had been applied on the merchantable growing stock in all of the other sensitivity analyses but changed back to total growing stock to be consistent with the ISS Base Case.

Both the total and merchantable growing stock followed similar patterns but were higher in the Combined Scenario compared to the ISS Base Case. This reflected the implementation of seral and patch size requirements, that provides a larger merchantable volume cushion of 10.1 million m³, or over 12 years of AAC, at the start of the sixth period – the 'pinch point' or lowest level of merchantable timber, which is a significant increase compared to the ISS Base Case.

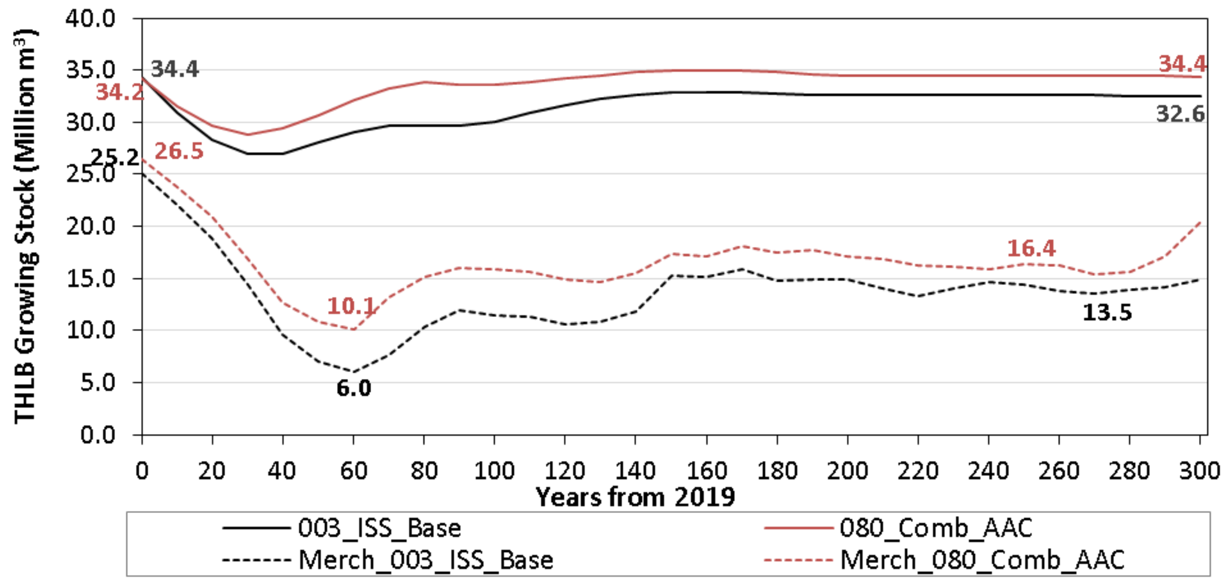


Figure 62 Combined Scenario –THLB Growing Stock

7.3.2.3 Management State

The harvest profile reported by management state (Figure 63) shows that for the first 40 years, the volume was harvested almost exclusively from existing natural (EN) stands. Existing managed (EM) stands begin to contribute significantly to the harvest rate in the fifth decade. By the ninth decade most of the volume harvested is from future managed stands (FM). Stands impacted by wildfires in 2017 and 2018 contributed to the harvest mostly between decades 7 and 10.

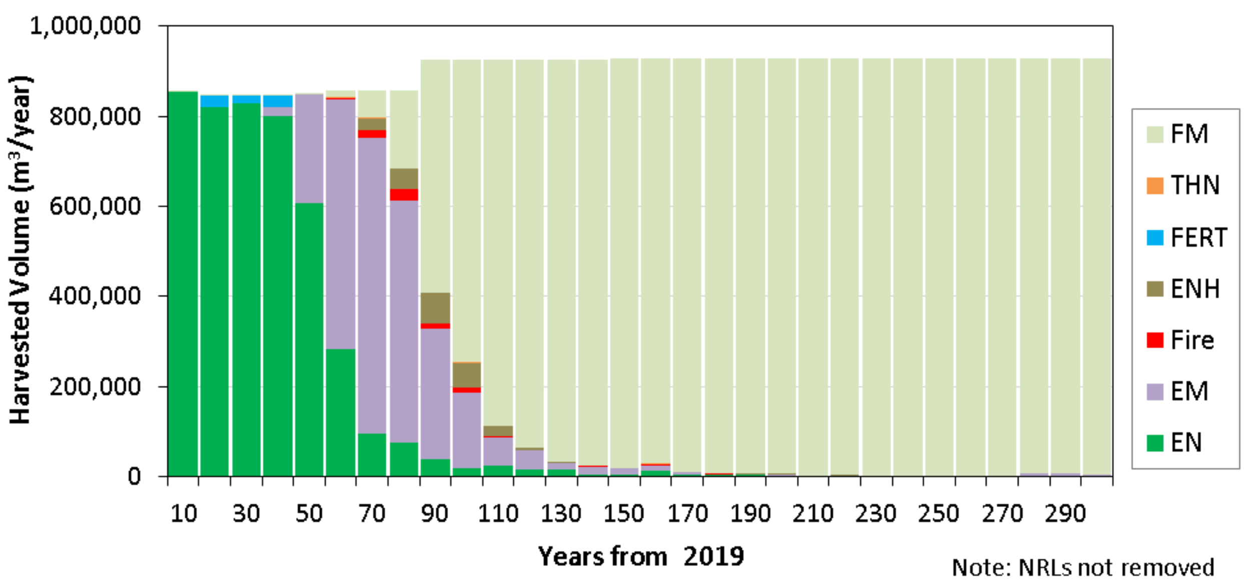


Figure 63 Combined Scenario – Harvest Volume by Management State

7.3.2.4 Age Class Distribution

The age class distribution over time (Figure 64) shows that the THLB is already reasonably distributed across all age classes. A normalized forest is achieved and maintained over the long-term (>100 years). By the end of the planning period over ~17,400 ha of THLB are older than 240 years. Most of these areas were retained to meet ECA requirements on community and domestic watersheds. Meanwhile, disturbance throughout the NHLB (approximately 1,750 ha/year) cycled through age classes over time and by the end of the 300-year planning horizon, 75% of the NHLB is evenly distributed in age classes under 240 years. Exceptions include in-block retention (THLB_ret @ ~38,400 ha), which was never affected by either harvesting or natural disturbance.

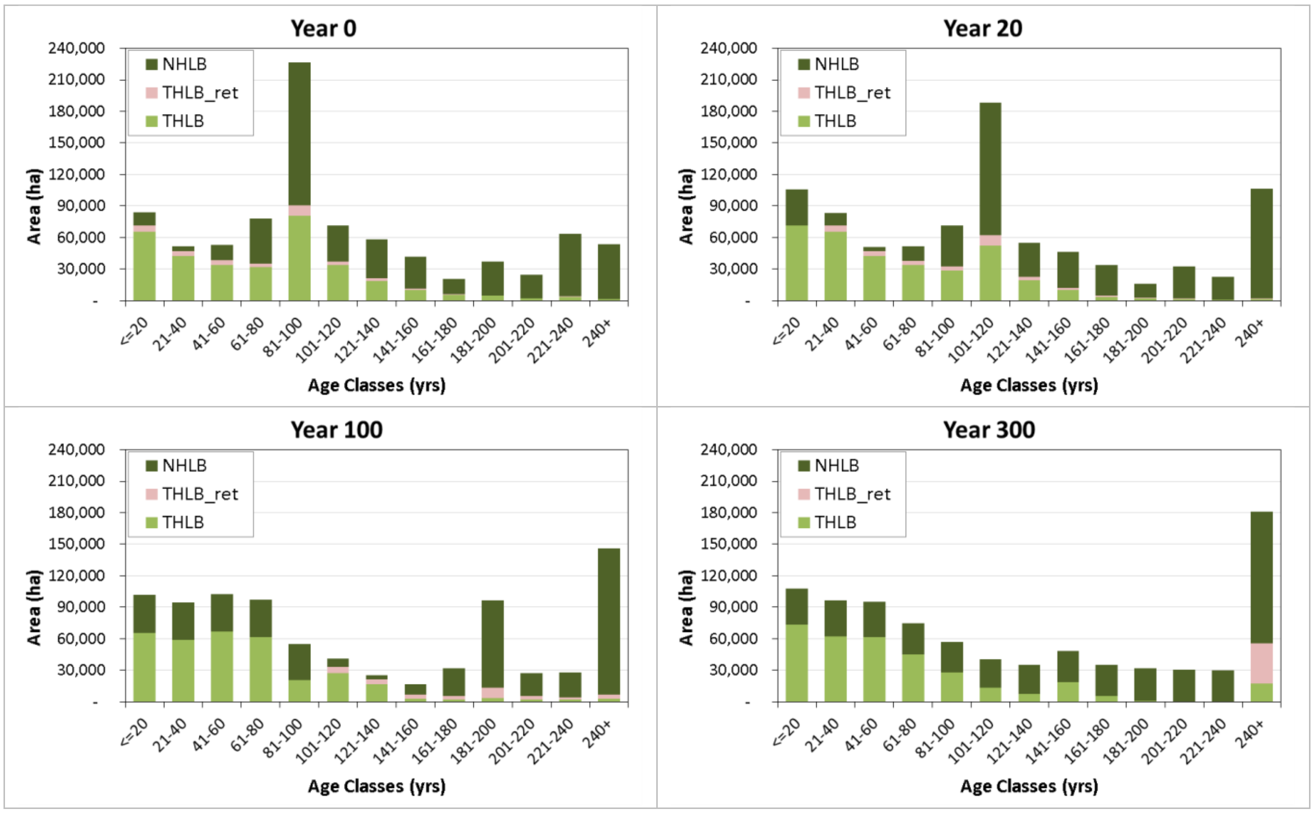


Figure 64 Combined Scenario – Age Class Distribution at Years 0, 20, 100, and 300

7.3.2.5 Age Class

The harvest profile reported by age class (Figure 65) shows that after the first decade most of volume is harvested from mature stands (60 to 120 years), which is earlier than results observed in Figure 62 by the observed 'pinch-point' (sixth decade) and Figure 63 by the introduction of harvesting EM stands (fifth decade). The volume harvested from stands aged >200 years averaged 7.5% over the first period and less than 1% thereafter.

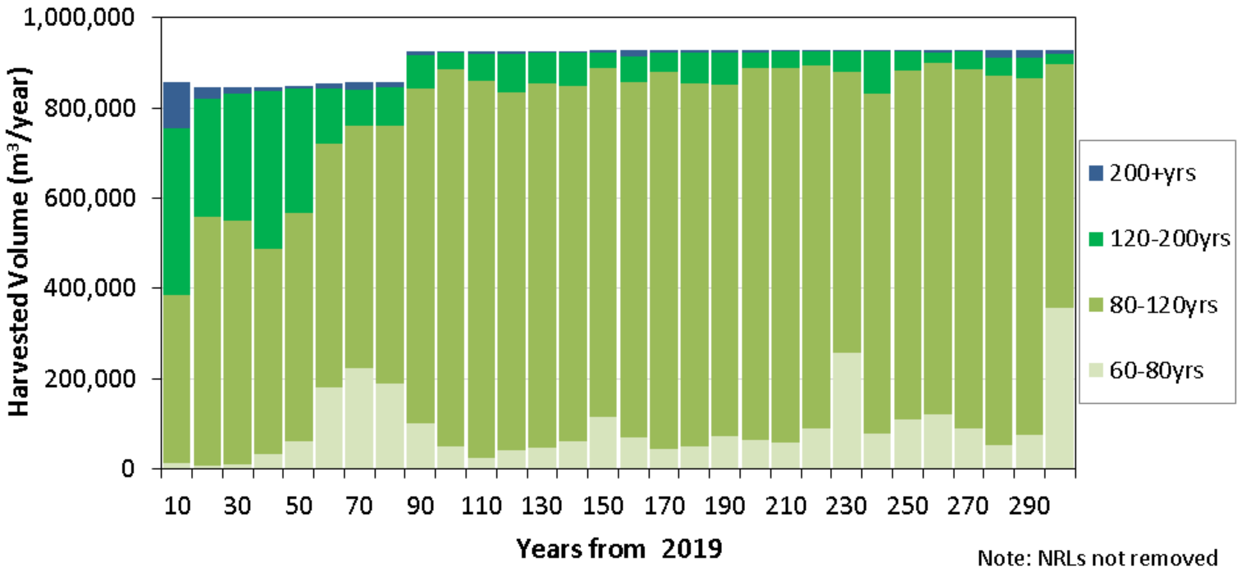


Figure 65 Combined Scenario – Harvest Volume by Age Class

7.3.2.6 Volume Class

The harvest profile reported by volume class (Figure 66) shows that the FM yields that support long-term harvest levels are projected to produce a higher proportion of stands with larger volume classes (i.e., 300-450 m³/ha). Only small fractions of the volume is harvested from the highest volume class (>450 m³/ha). The volume harvested at less than 150 m³/ha results from partial cut stands and commercial thinning.

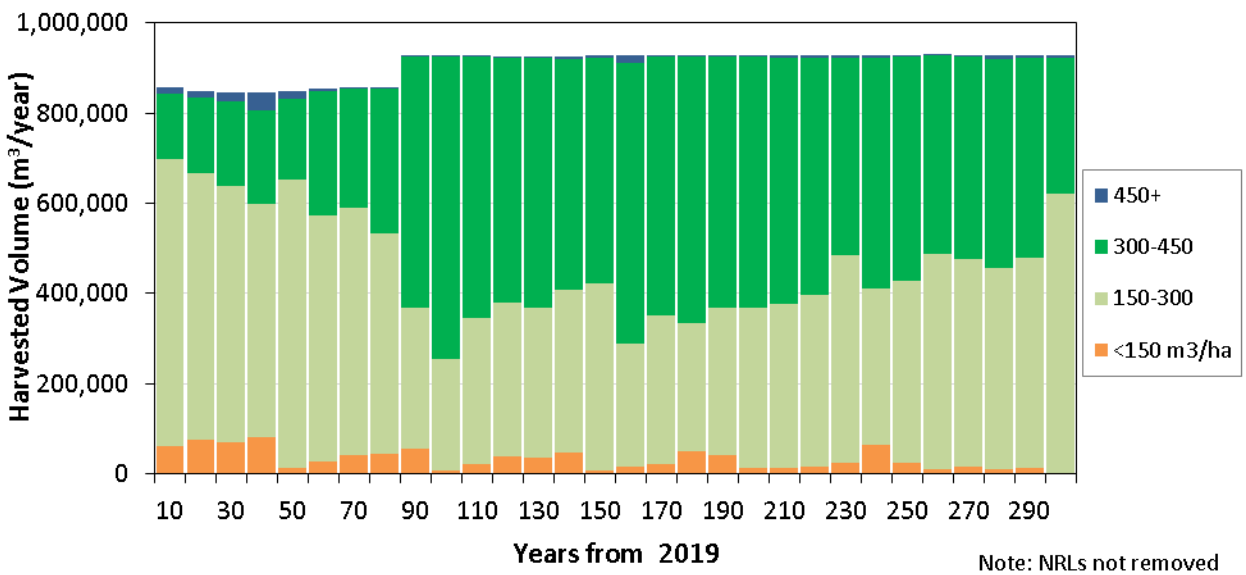


Figure 66 Combined Scenario – Harvest Volume by Volume Class

7.3.2.7 Average Harvest Volume, Age, and Area

The average age of harvested stands (dotted black line and left axis in Figure 67), starts at 134 years and declines to 96 years after 10 decades, as the harvest transitioned from existing to future stands (i.e., post-harvest regenerated stands). For the rest of the 300-year planning horizon, the average age at harvest stabilized at around 98 years.

The average volume at harvest (solid black line and left axis in Figure 67), fluctuated between 202 m³/ha and 299 m³/ha and averaged 251 m³/ha over the 300-year planning horizon. Note that these values are considerably higher than the minimum harvest volume criterion set between 100 m³/ha and 200 m³/ha based on slope and leading species.

The average area harvested each year (solid red line and right axes in Figure 67), fluctuated between ~3,300 ha/year and ~4,500 ha/year and averaged ~3,800 ha/year over the 300-year planning horizon. The inverse relationship between average volume and average area harvested is particularly evident in this example.

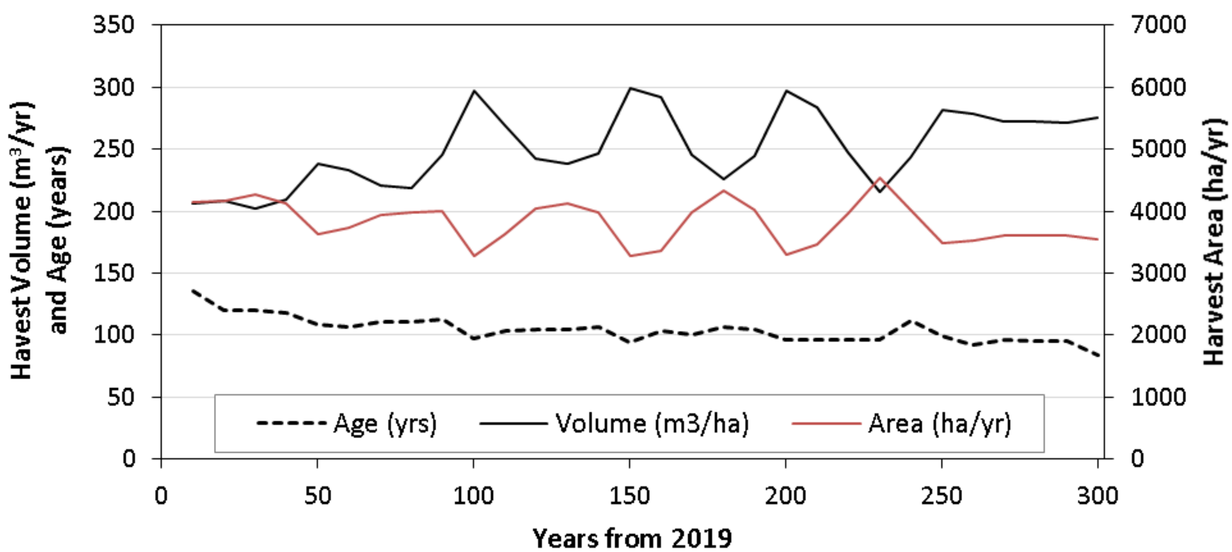


Figure 67 Combined Scenario – Average Age and Volume at Harvest

7.3.2.8 Species Groups

The harvest profile reported by species group (Figure 68) shows that most of the harvested volume is white wood from spruce and lodgepole pine, followed by red wood from Douglas-fir and larch, and white wood from balsam/subalpine fir and hemlock. There are minor contributions of red wood volume from yellow pine and cedar.

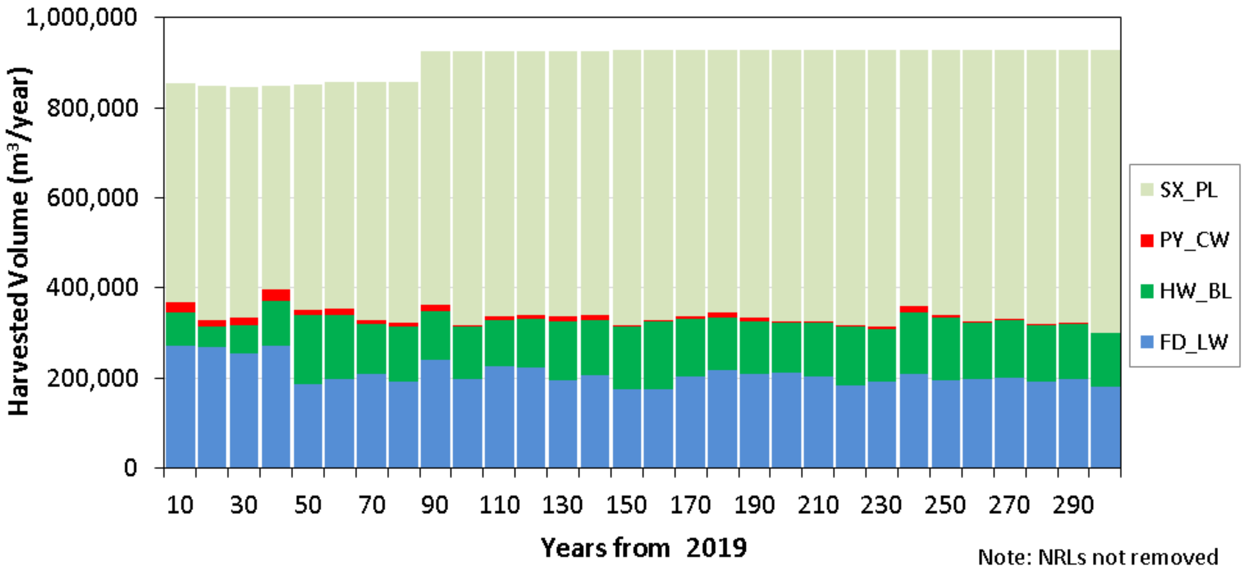


Figure 68 Combined Scenario – Harvest Volume by Species Groups

7.3.2.9 Individual Tree Species

The harvest profile reported by individual species (Figure 69), shows that most of the harvested volume was comprised of lodgepole pine and spruce, with important contributions from Douglas-fir, subalpine fir, and western larch.

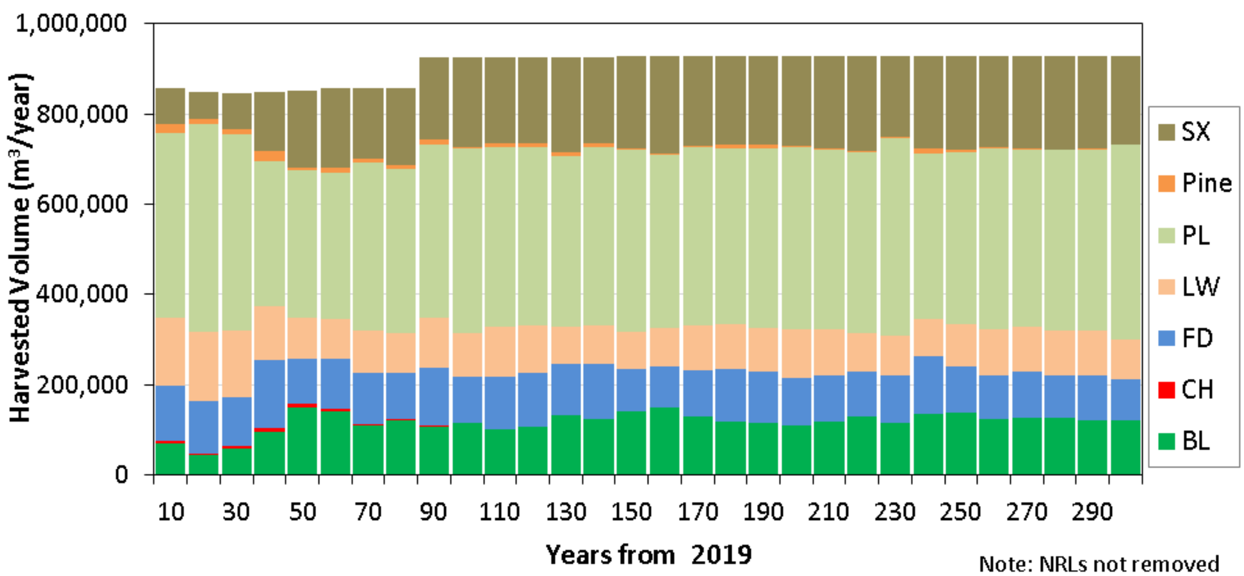


Figure 69 Combined Scenario – Harvest Volume by Individual Species

7.3.2.10 Haul Time

The harvest profile reported by one-way haul time (Figure 70) shows that most of the harvested volume came from stands less than one-hour (green + blue) away from the closest processing facility. Over the first 40 years, minimum targets were applied according to the current THLB profile (i.e., <0.5 hours @

57% and 0.5-1.0 hours @ 32%). While this requirement influenced the harvest schedule, it had little impact on harvest flow.

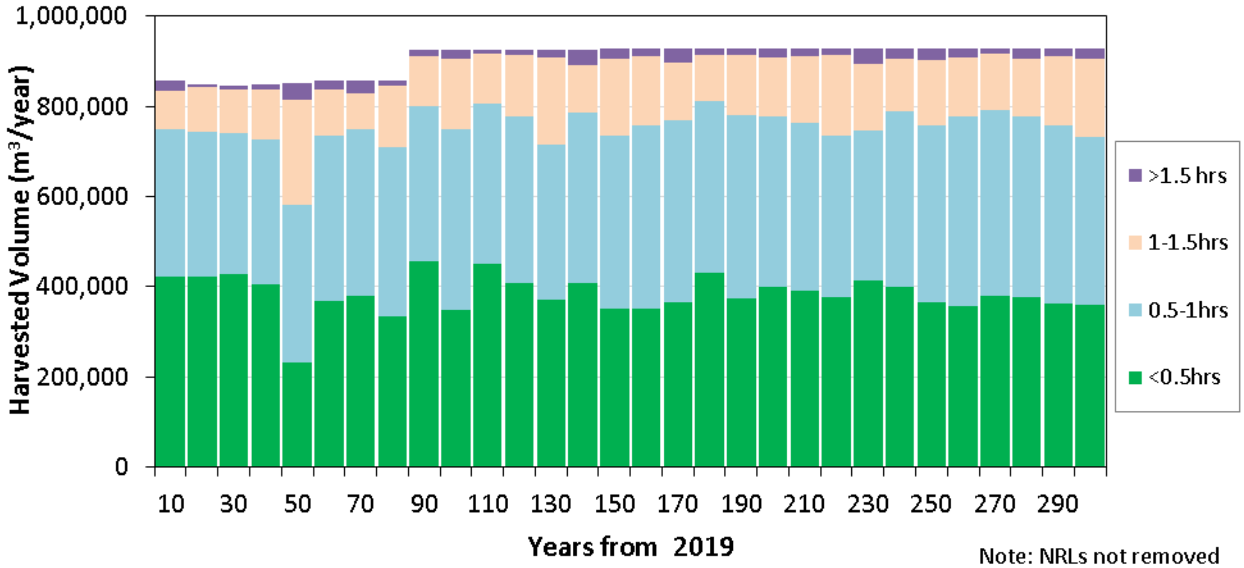


Figure 70 Combined Scenario – Harvest Volume by Haul Time (one-way)

7.3.2.11 Harvest System

The harvest profile reported by harvesting system (Figure 71) shows that most of the volume was harvested from ground-based harvest systems where slopes are ≤40%. Over the first 40 years, a minimum target was applied according to the THLB profile (i.e., ≤40% slope @ 90%). This requirement certainly influenced the harvest schedule but had little impact on harvest flow.

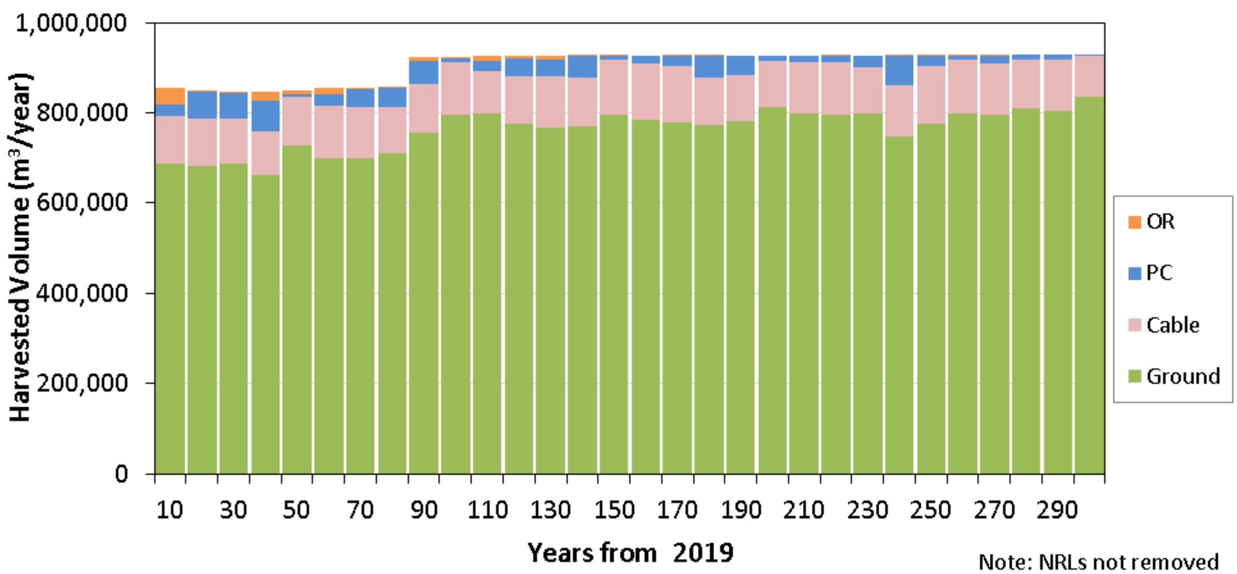


Figure 71 Combined Scenario – Harvest Volume by Harvest System

7.3.2.12 Harvest Opening Size

The harvest profile reported by harvesting opening size (Figure 72), shows that the applied targets successfully restricted the harvest proportion from small blocks. Over the entire planning period, maximum targets were applied to restrict the harvest of small blocks (i.e., 1-5 ha @ 5% and <1 ha @ 0%). This requirement certainly influenced the harvest schedule and moderately impacted the harvest flow.

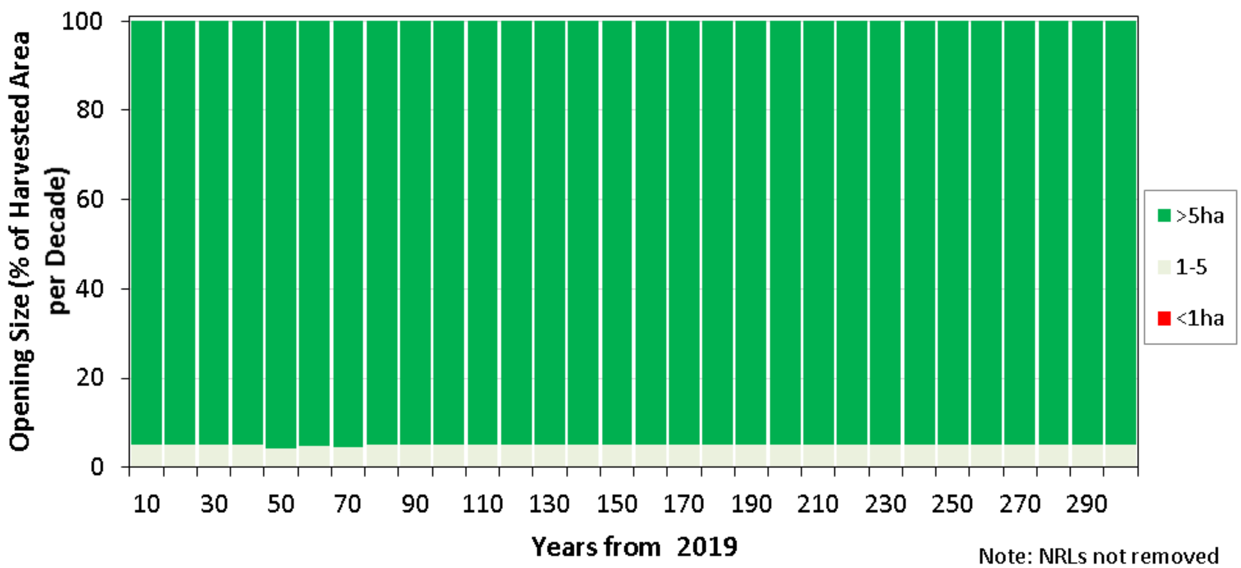
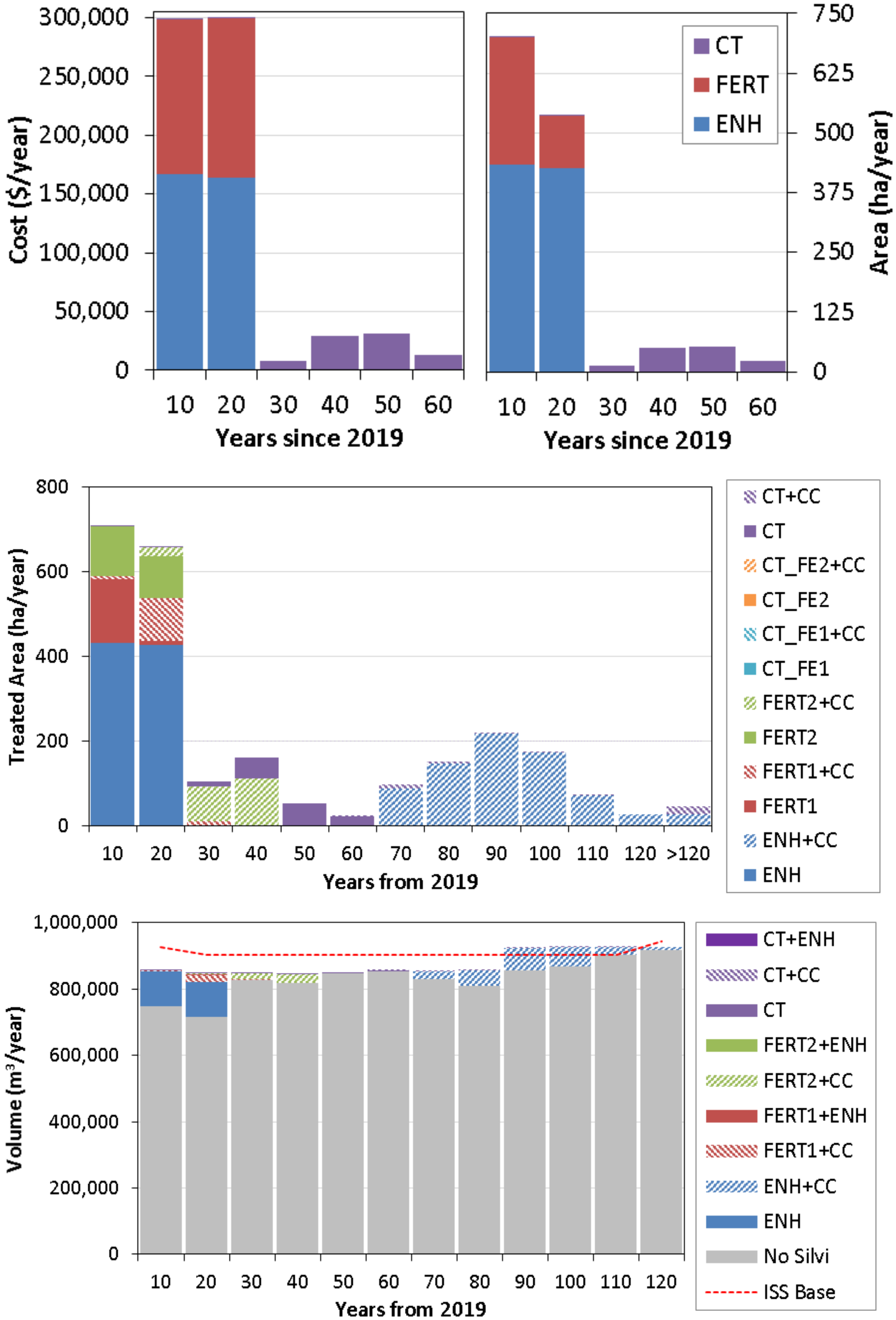


Figure 72 Combined Scenario – Percent of Harvest Area by Opening Size

7.3.3 Silviculture Treatments

The model allocated all of the $0.3 million per year budget over the first 20 years (i.e., $6 million total - Figure 73). Unlike the ISS Base Case that favoured ENH, the model directed funding more evenly between ENH (~$165,000/year treating ~430 ha/year) and FERT (~$133,700/year treating ~188 ha/year). Where stands were eligible for two fertilizer applications, the model tended to select two applications over one. The budget was extended over the first 60 years for CT (~$13,900/year treating ~23ha/year). Fertilized stands contributed directly to the mid-term as they were harvested between the 2nd and 4th decades, while harvesting of ENH stands started to get harvested in the 7th decade (i.e., rise from the mid- to long-term).



(Note: hatched symbology depicts the timber harvest for each tactic)

Figure 73 Combined Scenario - Silviculture Treatments

7.3.4 Sensitivity Analyses

Six runs were modelled in the Combined Scenario (Table 10) to explore the following adjustments:

1) Spatially defined areas to meet old seral requirements (i.e., OGMA/MMAs versus Candidate Reserves),
2) Number of periods to restrict these spatially defined areas from being harvested (i.e., first 20 years versus entire planning period), and
3) Harvest profiles (i.e., MINDY versus AAC+NDY).

Table 10 Combined Scenario – Summary of Sensitivity Analyses

Run	Description	THLB		Harvest rate (m³/year)			Harvest rate % from 003		
		(ha)	%from 003	First decade	Mid-term	Long-term	First decade	Mid-term	Long-term
000a	TSR4 Even Flow	351,773	4.0%	824,700	824,700	824,700	-6.3%	-3.5%	-9.0%
001	TSR Benchmark (Even Flow)	358,076	5.9%	851,895	851,895	851,895	-3.2%	-0.3%	-5.7%
003	**ISS Base Case (MINDY)**	**338,224**	**0.0%**	**880,013**	**854,305**	**903,183**	**0.0%**	**0.0%**	**0.0%**
070	ISS Comb CR20 MINDY	359,306	6.2%	872,197	853,027	980,257	-0.9%	-0.1%	8.5%
071	ISS Comb CR20 AAC	359,306	6.2%	808,104	878,731	975,999	-8.2%	2.9%	8.1%
072	ISS Comb OGMA20 MINDY	359,306	6.2%	922,310	885,090	997,945	4.8%	3.6%	10.5%
073	ISS Comb OGMA20 AAC	359,306	6.2%	808,201	914,689	994,822	-8.2%	7.1%	10.1%
074	ISS Comb CR300 AAC	359,306	6.2%	808,232	822,845	932,084	-8.2%	-3.7%	3.2%
075	ISS Comb OGMA300 AAC	359,306	6.2%	808,094	836,660	938,674	-8.2%	-2.1%	3.9%
080	080_ISS_Comb_AAC	332,934	-1.6%	808,167	808,169	879,205	-8.2%	-5.4%	-2.7%
081	ISS Comb AAC SilviOFF	332,934	-1.6%	808,483	767,408	885,303	-8.1%	-10.2%	-2.0%
083	ISS Comb AAC BAU	332,934	-1.6%	808,058	787,638	882,032	-8.2%	-7.8%	-2.3%

The sensitivity analyses produced the following outcomes:

<u>Locking reserves over the first 20 years (071_CR20_AAC & 073_OGMA20_AAC)</u>

- Compared to the ISS Base Case, the harvest volume increased substantially over the mid- (especially) and long-terms with both Candidate Reserves and OGMA/MMAs. When the harvest timing constraint are removed, the model generally seeks to harvest stands with the most volume and growth capacity over time. As a result, we expect that the model will eventually meet seral objectives with the worst stands from both a harvesting and biodiversity perspective, which does not align with the biodiversity objectives.
- By the end of the planning horizon, less than 2% (only ~500 ha) of the current OGMA/MMAs or Candidate Reserves remained unharvested. While it is generally accepted that these spatial reserves can and should move across the landbase to respond to natural disturbances, this turnover may not be appropriate from a biodiversity perspective (i.e., not the 'best old growth').

<u>Locking reserves over the entire planning horizon (074_CR300_AAC & 075_OGMA300_AAC)</u>

- We set up the model such that these runs show erroneously high levels of merchantable growing stock on the THLB because these volumes include OGMA/MMAs and Candidate Reserves that are not actually available for harvest.

Turning off silviculture tactics (081_Comb_SilviOFF)

- Turning off the silviculture tactics reduced mid-term harvest level by 5.0%, which accounted for approximately 2.6 million m^3 at a cost of $2.64/$m^3$ (not discounted).

Business as usual (083_Comb_BAU)

- The business as usual sensitivity reduced the mid-term harvest level by 2.5%.
- Maintaining patch size distribution targets would have resulted in a greater reduction. Deactivating this objective caused patch sizes to trend away from their target distribution.

8 Discussion

8.1 Differences from TSR

Compared to the TSR Benchmark Scenario harvest flow, the ISS Base Case was 4.2% lower in the first decade, the same during the mid-term, and 14.5% lower over the long-term.

Major differences between the TSR Benchmark and ISS Base Case scenarios (section 2) involved elements of the land base definition (e.g., non-forest and non-productive, depletions, FSC, partial netdowns), non-timber objectives (e.g., UWR, landscape-level biodiversity, ECA), growth and yield models (e.g., newer TIPSY version (4.4)), non-THLB disturbance, and NRL estimates. The THLB for the ISS Base Case was 5.5% less than the TSR Benchmark Scenario, but the NHLB was significantly larger (24.6%).

8.2 Key Observations

These ISS analyses generated numerous reports and spatial outputs associated with the modelling of various resource management tactics. The key observations for completed scenarios are briefly summarized in Table 11 based on discussions from the sections above.

Table 11 Summary of Key Observations

Topic	Key Observations
Harvest rate strategy	○ The MINDY harvest profile is a better approach for comparing results and analyzing a range of assumptions.
Non-timber Objectives	○ VQOs and ECAs (domestic watersheds) were most constraining for some THLB areas.
NRL	○ Higher NRLs in the ISS Base Case had a direct impact that lowered the even-flow harvest level relative to the TSR Benchmark Scenario.
NHLB	○ The significantly larger NHLB (24.6%) in the ISS Base Case alleviated constraints applied over the smaller THLB (-5.5%).
NHLB disturbance	○ Including disturbance on the NHLB resulted in disproportional impacts to highly constrained reporting units dominated by NHLB. Here, harvest opportunities over some significant THLB areas were reduced. Still, NHLB disturbance eventually produced a relatively even area distribution of early, mid, and mature stands for half of the NHLB, while the other half remained undisturbed.
2017 wildfires	○ Wildfires that occurred in 2017 throughout the TSA had little impact on harvest rates.
Minimum Harvest Age	○ Average volume at harvest was significantly higher than the minimum harvest criteria implemented in the model.

Topic	Key Observations
Visual Quality	o While VQOs generally constrained the harvest flow, we can implement proper visual landscape design and partial cut harvest systems to alleviate these constraints. We did not model specific tactics to mitigate visual quality constraints.
ECA	o Overall, the ECA thresholds applied to domestic watersheds had a negative impact on the harvest rate. o Current management can support a more constraining ECA (i.e., 30% to 25%).
OGMA+MMA	o OGMAs and MMAs were relatively successful in meeting the landscape-level biodiversity constraints since implementing seral requirements, in addition to these spatial reserves, did not have a significant impact on harvest rate. However, removing OGMAs and MMAs, while maintaining landscape-level biodiversity requirements (seral and spatial early seral patches), increased the THLB and in turn, increased harvest levels.
Unharvested THLB	o Some stands in the THLB are retained from being harvested because they are needed to address forest cover requirements (Figure 1). An artefact of this particular model is that stands retained may be relatively poor, and least likely to contribute to the harvest flow.
Very Early Seral Patch Sizes	o While implementing patch size targets for very early seral forests (THLB only) improved the patch size distribution over time, it significantly reduced harvest rates over the short- and mid-terms. o Whether or not targets were implemented, smaller reporting units were unable to develop larger patches for the simple fact that they are too small (i.e., difficult to create 250 ha patches within a 500 hectare reporting unit).
Old seral Patch sizes	o Implementing patch size targets for very early seral forests (THLB only) did not influence old seral patch size distributions. This is because most of the old seral patches exist within the NHLB that is the same whether or not patch targets are implemented.
FSC	o Removing FSC criteria while maintaining FPPR requirements increased the THLB by 3.1%, which increased harvest levels by nearly as much.
LU Grouping	o Grouping LUs to provide more flexibility to address non-timber objectives had very little impact on the harvest profile over time.
Silviculture Tactics	o Implementing silviculture tactics (FERT, CT, ENH) with a funding level set at $0.3 million per year for the first 20 years of the planning horizon (Figure 25) combined to improve the transition from harvesting natural to managed stands by shortening the mid-term period by 20 years. Meanwhile, the harvest rate increased over the short-term by 2.8 to 3.4%. o Increasing the available funding over the short-term did not correlate with a similar increase in harvest level because the land base was relatively constrained over the short- and mid-term and the harvest rates were already maximized at the lower funding level. o The ENH tactic provided the most significant improvements to the harvest flow. The additional volume generated by the enhanced stands harvested after year 110 allowed the model to shift the harvest of some stands earlier in the planning horizon. o The primary opportunity with the CT tactic is providing the model an option to harvest a portion of the stand, while it is still growing well, to address periods when available volume is low. The rest of the stand is then harvested later, when much more merchantable volume is available across the landscape. Extending funding well into mid-term provided more options for the model to leverage the CT tactic. o The model tended to treat stands eligible for two fertilizer applications over one. This suggests that increased volume on existing stands is a primary driver for this tactic. o Both CT and FERT treatments were configured with relatively narrow opportunity windows making eligibility highly dependent on age. o These silviculture tactics provided the model with more flexibility to address forest cover requirements like biodiversity, wildlife habitat, watershed, and cultural interests.
	Generally, the silviculture tactics demonstrated the anticipated benefits when planning them: o FERT provided incremental volume over the mid-term. o CT provided incremental volume later in the mid-term over periods when available harvest volume was lowest, but at some cost later on when the remaining stands were harvested at lower volume. o ENH provided incremental volume early in the long-term, which replaced merchantable stands that could then be harvested earlier (late mid-term).
Wildlife Habitat	o In most cases, results were similar to those developed in the latest TSR5. In other cases, it appeared that errors were introduced in the process used in the latest TSR5. o In some cases, the habitat classes did not appear to flow appropriately across TSA boundaries. This likely resulted from different slope/aspect, Eco section, or PEM unit attributes. o The project team was unable to validate the wildlife habitat modelling in time to incorporate any aspects into the Combined Scenario.

Topic	Key Observations
Caribou Habitat	○ While this proof-of-concept analysis provided appropriate summaries of critical caribou habitat over time, the project team did not feel that the current linework from the federal caribou recovery strategy was appropriate to incorporate into the Combined Scenario.
Reserve Tactics	○ The model process can easily manage further refinement of the Candidate Reserves, such as additional information/inventories, new values, revised stand-level scoring, or different reserve size classes/thresholds. ○ Preparing the resultant file used in the Reserve Scenario (i.e., combination of splitting larger polygons and 'blocking' stands together) produced a much more appropriate baseline for the model to improve the selection of Candidate Reserves. ○ Splitting the selection of candidate reserves into two separate stages (old forest first; then mature-plus-old and other criteria) aligned with the KBLUP intent to retain the best stands for old growth management. ○ Incrementally exploring each control in the model allowed the analyst to develop appropriate weights on targets. ○ Setting targets on score/ha rather than total score, removed an inappropriate influence of stand area. ○ Where it is available, additional detail on the quality of existing OGMA/MMAs (e.g., field assessment) could be incorporated into the reserve selection process.
Key Observations with Combined Scenario	
20-Year Lock on Candidate Reserves	○ Locking the candidate reserves for 20 years did not produce the desired results using stand age as the only criterion for managing old seral. Once the 20-year lock was removed, the model generally sought to harvest stands with the most volume and growth capacity over time. We expect that eventually, the seral objectives will be met with the worst stands from both a harvesting and biodiversity perspective – not at all aligned with the biodiversity objectives. ○ By the end of the planning horizon, less than 2% (only ~500 ha) of the current OGMA/MMAs or Candidate Reserves remained unharvested. Besides increasing timber harvesting opportunities, this may be beneficial from a wildfire management perspective but may not be appropriate from a biodiversity perspective (i.e., not the 'best old growth').
Spatial Constraints	○ As observed above, implementing spatial criteria (i.e., patch size distribution (section 7.3.1.3), harvest opening size (section 7.3.2.12), harvest system profile (section 7.3.2.11), and haul time profile (section7.3.2.10)) significantly reduced harvest rates over the short- and mid-terms. Removing these non-legal criteria would nearly eliminate the mid-term trough; to 1.6% of the ISS Base Case Scenario mid-term.
Harvest Forecast	○ The significant drop over the short- and mid-terms reflected two key modelling assumptions: setting the initial period at the current AAC (8.2% lower than the ISS Base Case Scenario) and implementing the spatial criteria as described directly above.
Visuals	○ After modelling was complete, we discovered that the updated visual assessment applied the wrong values for maximum alteration in perspective view that significantly relaxed target levels (e.g., increased maximum disturbance levels from 1.1% to 4.8%). We corrected this in the Combined Scenario run.
Silviculture Tactics	○ Turning off the silviculture tactics reduced mid-term harvest level by 5.0%, which accounted for approximately 2.6 million m³ at a cost of $2.64/m³ (not discounted).
Business As Usual	○ The business as usual sensitivity reduced the mid-term harvest level by 2.5%. ○ Maintaining patch size distribution targets would have resulted in a greater reduction. Deactivating this objective caused patch sizes to trend away from their target distribution.

8.3 Recommendations

Opportunities to improve future analyses or explore new tactics were identified through these analyses. Specific recommendations are briefly summarized in Table 12.

Table 12 Summary of Recommendations

Topic	Recommendation
Minimum Harvest Age	○ Refine the minimum harvest criteria for managed stands by including a criterion based on mean annual increment. While this new criterion may constrain harvest levels, it should improve harvest profiles (e.g., age and products).
Disturbance in the NHLB	○ Refine the approach for disturbing the NHLB to mimic areas and spatial patterns disturbed naturally.
OGMA+MMA	○ Apply these spatial reserves for a limited time only (e.g., 40-60 years) and then allow the model to explore alternative ways to meet landscape-level biodiversity objectives, while maintaining or enhancing reserve.
FSC Criteria	○ Continue to assess impacts and trade-offs associated with implementing FSC standards.
Early Seral Patches	○ Continue to assess impacts and trade-offs associated with implementing early seral patches. This might include merging reporting units across the TSA, application of target weights within an acceptable impact to harvest levels.
Harvest opening size	○ Assess impacts and trade-offs associated with creating operationally feasible harvest opening sizes. This could be done to ensure that harvested blocks are more operationally feasible.
Harvest Profiles	○ Haul Time and Harvest System targets were based on preferred classes, current profiles across the THLB, set as minimum targets, and applied over the first 40 years. Recommend revising these to maximum targets over the first 20 years.
Non-timber objectives	○ Continue to explore modelling approaches to address highly constraining non-timber objectives (e.g., VQOs and ECAs).
Commercial Thinning	○ Increase the timing window for CT as the timing window set for CT was relatively narrow to capture the stands potential to recover volume. More opportunities should present when the CT option is available for older managed stands. ○ Increase the eligibility of CT to apply to future managed stands. The analyses done so far considered only existing managed stands for this treatment but some future managed stands will be available over the next 60 years.
Partial harvest in Constrained Areas	○ In addition to providing available volume during the most constraining periods, the CT treatment can provide other benefits to improve stand structure within UWRs and to lower fire risk. Future silviculture scenarios could explore CT and/or partial-cut silviculture systems to treat stands within constrained areas (e.g., UWRs, Visuals, ECAs, Seral, Wildland Urban Interfaces, etc.) provided these treatments can maintain or improve the structural characteristics, or reduce forest health risks, right away or shortly after the treatment.
Silviculture Treatments	○ Consider evaluating treatments based on net present value rather than cost alone. For example, the net cost for CT and ENH tactics were $600/ha and $385/ha, respectively, while the Net Present Value for the same tactics would be +$221/ha and -$231/ha. This new account would likely influence the model to select different tactics at different times.
Wildlife Habitat	○ Complete validation for the wildlife habitat modelling and explore appropriate recommendations. ○ Develop appropriate thresholds to maintain over time (e.g., maintain current level of habitat classes 1 to 3). ○ Continue to work towards developing spatial criteria to apply in the model (e.g., area and shape required for specific habitat types).
Caribou Habitat	○ Revisit the caribou habitat analysis once the new linework from the joint provincial and federal caribou recovery strategy is available.

Topic	Recommendation
Reserve Tactics	○ Conduct a post-processing GIS analysis to identify edges and determine – more precisely – the amount of interior old forest for each assessment unit. We did not re-assess interior old forest with the Candidate Reserves within the Reserve Scenario as it was planned within the Combined Scenario. ○ Utilize the Candidate Reserves to provide context and a draft set of polygons for further analysis (i.e., Combined Scenario). ○ Assess Candidate Reserves at tactical- and eventually, operational-levels; involving stakeholders to verify values are addressed appropriately for each LU. ○ Develop age dependent scoring curves for each stand and include them into the Combine Scenario. Here, as opposed to static locked reserves for the entire planning horizon, the model will assess on the fly the "reserve value" of each stand and set aside candidate reserves as needed. These reserves will be dynamically changing overtime, in line with OGMA/MMAs policy.
Outstanding Tactics	○ Continue work on scenarios and tactics identified but not examined in this iteration. This includes additional wildlife tactics (spatial criteria for specific habitat types and revised caribou strategy), Forest Health (fire and climate change), Carbon (carbon stocks), and Range (forage production). ○ Examine changes in results from incorporating a vegetation inventory with LiDAR-derived attributes.

Appendix 1 Very Early Seral Patch Results

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Unit	NDT	Patch Size (ha)	Target		003 MINDY (Patch not controlled)				009 Patch Controlled			
			Min (%)	Max (%)	THLB (ha)	Min (%)	Max (%)	Avr (%)	THLB (ha)	Min (%)	Max (%)	Avr (%)
Cranbrook	NDT3b	0_40	20	30	3,191	17	63	35	3,192	21	30	26
		40_80	25	40	3,191	0	36	12	3,192	25	39	31
		80_250	30	50	3,191	0	63	31	3,192	33	50	43
		250plus	0	100	3,191	0	67	21	3,192	0	0	0
	NDT4	0_40	30	40	7,193	34	78	53	7,466	34	40	39
		40_80	30	40	7,193	5	36	18	7,466	30	39	34
		80_250	20	30	7,193	0	41	25	7,466	22	30	27
		250plus	0	100	7,193	0	20	3	7,466	0	0	0
Cranbrook Watershed	NDT3a	0_40	10	20	6,827	19	67	36	7,480	14	20	19
		40_250	10	20	6,827	18	74	50	7,480	10	20	18
		250_1000	60	80	6,827	0	51	13	7,480	60	76	63
		1000plus	0	100	6,827	0	0	0	7,480	0	0	0
	NDT3b	0_40	20	30	5,212	14	85	37	5,786	20	30	26
		40_80	25	40	5,212	5	38	16	5,786	25	40	31
		80_250	30	50	5,212	0	59	26	5,786	30	50	41
		250plus	0	100	5,212	0	63	20	5,786	0	25	2
East Flathead	NDT3a	0_40	10	20	1,462	15	100	40	1,494	19	51	46
		40_250	10	20	1,462	0	85	54	1,494	11	50	45
		250_1000	60	80	1,462	0	50	6	1,494	0	69	9
		1000plus	0	100	1,462	0	0	0	1,494	0	0	0
	NDT3b	0_40	20	30	1,623	10	100	50	2,491	20	30	26
		40_80	25	40	1,623	0	63	19	2,491	25	40	34
		80_250	30	50	1,623	0	62	24	2,491	30	50	40
		250plus	0	100	1,623	0	52	6	2,491	0	0	0
Galbraith Dibble	NDT2	0_40	30	40	3,263	29	72	52	3,293	29	50	39
		40_80	30	40	3,263	0	39	20	3,293	29	50	36
		80_250	20	30	3,263	0	58	28	3,293	0	31	24
		250plus	0	100	3,263	0	0	0	3,293	0	23	1
	NDT3b	0_40	20	30	7,286	28	74	43	8,141	19	30	28
		40_80	25	40	7,286	7	31	16	8,141	23	39	29
		80_250	30	50	7,286	6	47	28	8,141	27	49	38
		250plus	0	100	7,286	0	46	12	8,141	0	30	6
Galton Range	NDT3a	0_40	10	20	876	35	100	80	897	42	100	52
		40_250	10	20	876	0	65	20	897	0	58	48
		250_1000	60	80	876	0	0	0	897	0	0	0
		1000plus	0	100	876	0	0	0	897	0	0	0
	NDT3b	0_40	20	30	1,004	36	100	77	1,023	30	46	43
		40_80	25	40	1,004	0	64	21	1,023	0	56	48
		80_250	30	50	1,004	0	55	2	1,023	0	60	9
		250plus	0	100	1,004	0	0	0	1,023	0	0	0
	NDT4	0_40	30	40	944	72	100	99	947	50	100	80
		40_80	30	40	944	0	28	1	947	0	50	20
		80_250	20	30	944	0	0	0	947	0	0	0
		250plus	0	100	944	0	0	0	947	0	0	0
Iron Sulphur	NDT2	0_40	30	40	1,731	21	100	48	1,812	26	50	40
		40_80	30	40	1,731	0	55	20	1,812	20	50	37
		80_250	20	30	1,731	0	51	14	1,812	0	31	19
		250plus	0	100	1,731	0	79	17	1,812	0	39	4
	NDT3b	0_40	20	30	4,637	27	75	44	5,170	20	30	26

Unit	NDT	Patch Size (ha)	Target		003 MINDY (Patch not controlled)				009 Patch Controlled			
			Min (%)	Max (%)	THLB (ha)	Min (%)	Max (%)	Avr (%)	THLB (ha)	Min (%)	Max (%)	Avr (%)
		40_80	25	40	4,637	3	46	21	5,170	25	39	30
		80_250	30	50	4,637	0	50	28	5,170	30	50	41
		250plus	0	100	4,637	0	43	7	5,170	0	23	3
Jaffray Baynes Lake	NDT4	0_40	30	40	14,333	22	44	33	14,847	30	38	32
		40_80	30	40	14,333	7	27	17	14,847	30	37	31
		80_250	20	30	14,333	15	44	25	14,847	20	30	26
		250plus	0	100	14,333	0	42	24	14,847	0	20	11
Kimberley Watershed	NDT3a	0_40	10	20	2,999	17	100	45	3,498	15	50	33
		40_250	10	20	2,999	0	83	40	3,498	14	50	33
		250_1000	60	80	2,999	0	55	16	3,498	0	68	33
		1000plus	0	100	2,999	0	0	0	3,498	0	0	0
	NDT3b	0_40	20	30	1,126	23	100	64	1,240	20	40	29
		40_80	25	40	1,126	0	71	24	1,240	0	40	29
		80_250	30	50	1,126	0	64	13	1,240	30	60	43
		250plus	0	100	1,126	0	0	0	1,240	0	0	0
Lamb Creek	NDT2	0_40	30	40	3,283	6	50	27	3,748	0	52	35
		40_80	30	40	3,283	0	58	24	3,748	0	48	34
		80_250	20	30	3,283	0	70	42	3,748	0	46	24
		250plus	0	100	3,283	0	52	8	3,748	0	25	1
	NDT3b	0_40	20	30	4,612	8	80	37	5,120	18	45	26
		40_80	25	40	4,612	0	40	15	5,120	12	55	32
		80_250	30	50	4,612	0	67	21	5,120	0	50	35
		250plus	0	100	4,612	0	78	27	5,120	0	70	7
Linklater Englishman	NDT4	0_40	30	40	1,500	29	100	53	1,708	31	50	38
		40_80	30	40	1,500	0	50	23	1,708	23	50	33
		80_250	20	30	1,500	0	63	24	1,708	0	36	29
		250plus	0	100	1,500	0	0	0	1,708	0	0	0
Lost Dog Mather	NDT3b	0_40	20	30	4,787	13	45	29	4,865	18	30	25
		40_80	25	40	4,787	0	36	19	4,865	23	39	29
		80_250	30	50	4,787	0	48	26	4,865	27	49	42
		250plus	0	100	4,787	0	57	26	4,865	0	32	4
	NDT4	0_40	30	40	2,059	10	68	34	2,098	32	50	39
		40_80	30	40	2,059	0	60	22	2,098	28	50	35
		80_250	20	30	2,059	0	67	35	2,098	0	32	27
		250plus	0	100	2,059	0	55	9	2,098	0	0	0
Mayook Wardner	NDT3a	0_40	10	20	1,125	28	100	66	1,211	50	52	50
		40_250	10	20	1,125	0	72	34	1,211	48	50	50
		250_1000	60	80	1,125	0	0	0	1,211	0	0	0
		1000plus	0	100	1,125	0	0	0	1,211	0	0	0
	NDT3b	0_40	20	30	4,256	33	92	58	4,840	20	30	28
		40_80	25	40	4,256	7	42	22	4,840	25	40	33
		80_250	30	50	4,256	0	44	20	4,840	30	49	39
		250plus	0	100	4,256	0	0	0	4,840	0	0	0
	NDT4	0_40	30	40	4,465	25	83	54	5,034	32	40	38
		40_80	30	40	4,465	0	56	27	5,034	30	40	35
		80_250	20	30	4,465	0	54	18	5,034	20	30	26
		250plus	0	100	4,465	0	27	1	5,034	0	0	0
Perry Moyie	NDT2	0_40	30	40	3,572	6	71	25	3,843	30	50	36
		40_80	30	40	3,572	4	93	26	3,843	30	50	38
		80_250	20	30	3,572	0	59	24	3,843	0	30	26
		250plus	0	100	3,572	0	68	25	3,843	0	21	1
	NDT3a	0_40	10	20	7,979	17	60	34	8,907	13	52	21
		40_250	10	20	7,979	26	68	50	8,907	11	48	21

Unit	NDT	Patch Size (ha)	Target		003 MINDY (Patch not controlled)				009 Patch Controlled			
			Min (%)	Max (%)	THLB (ha)	Min (%)	Max (%)	Avr (%)	THLB (ha)	Min (%)	Max (%)	Avr (%)
		250_1000	60	80	7,979	0	56	16	8,907	0	77	59
		1000plus	0	100	7,979	0	0	0	8,907	0	0	0
	NDT3b	0_40	20	30	8,361	20	52	30	8,425	20	30	23
		40_80	25	40	8,361	7	37	16	8,425	25	34	28
		80_250	30	50	8,361	12	67	36	8,425	30	50	40
		250plus	0	100	8,361	0	54	18	8,425	0	22	9
	NDT4	0_40	30	40	504	3	100	27	528	26	51	48
		40_80	30	40	504	0	97	38	528	28	52	48
		80_250	20	30	504	0	94	35	528	0	45	4
		250plus	0	100	504	0	0	0	528	0	0	0
Sand Creek	NDT3b	0_40	20	30	1,158	32	100	64	1,305	22	45	30
		40_80	25	40	1,158	0	68	22	1,305	25	55	32
		80_250	30	50	1,158	0	50	14	1,305	0	50	38
		250plus	0	100	1,158	0	0	0	1,305	0	0	0
St Marys Prairie	NDT4	0_40	30	40	3,341	11	100	55	3,465	29	54	41
		40_80	30	40	3,341	0	49	23	3,465	26	50	37
		80_250	20	30	3,341	0	80	17	3,465	0	45	21
		250plus	0	100	3,341	0	80	5	3,465	0	0	0
Teepee Creek	NDT3a	0_40	10	20	2,680	22	91	59	2,682	18	50	36
		40_250	10	20	2,680	9	70	37	2,682	10	50	35
		250_1000	60	80	2,680	0	62	4	2,682	0	70	30
		1000plus	0	100	2,680	0	0	0	2,682	0	0	0
	NDT3b	0_40	20	30	6,875	11	37	24	7,142	20	30	23
		40_80	25	40	6,875	4	24	13	7,142	25	34	28
		80_250	30	50	6,875	5	58	32	7,142	30	50	37
		250plus	0	100	6,875	0	65	31	7,142	0	24	11
	NDT4	0_40	30	40	595	9	100	51	598	49	53	50
		40_80	30	40	595	0	91	23	598	47	51	50
		80_250	20	30	595	0	85	26	598	0	0	0
		250plus	0	100	595	0	0	0	598	0	0	0
Tobacco Plains	NDT4	0_40	30	40	6,340	3	100	13	6,414	30	39	31
		40_80	30	40	6,340	0	30	2	6,414	30	40	32
		80_250	20	30	6,340	0	66	18	6,414	20	28	26
		250plus	0	100	6,340	0	91	67	6,414	0	21	12
Upper Bull	NDT2	0_40	30	40	823	31	100	63	872	33	100	48
		40_80	30	40	823	0	60	24	872	0	52	43
		80_250	20	30	823	0	69	13	872	0	37	9
		250plus	0	100	823	0	0	0	872	0	0	0
	NDT3a	0_40	10	20	1,492	24	100	59	1,565	18	51	44
		40_250	10	20	1,492	0	76	41	1,565	11	52	43
		250_1000	60	80	1,492	0	0	0	1,565	0	69	13
		1000plus	0	100	1,492	0	0	0	1,565	0	0	0
	NDT3b	0_40	20	30	4,303	19	52	32	4,590	20	30	25
		40_80	25	40	4,303	7	50	23	4,590	25	40	31
		80_250	30	50	4,303	0	66	37	4,590	30	50	41
		250plus	0	100	4,303	0	36	8	4,590	0	24	3
Wasa Picture Valley	NDT4	0_40	30	40	4,706	33	100	42	5,143	32	40	34
		40_80	30	40	4,706	0	62	22	5,143	31	40	37
		80_250	20	30	4,706	0	52	35	5,143	27	30	28
		250plus	0	100	4,706	0	0	0	5,143	0	0	0
West Elk	NDT3b	0_40	20	30	1,750	19	100	60	1,907	22	45	30
		40_80	25	40	1,750	0	49	17	1,907	25	55	34
		80_250	30	50	1,750	0	69	18	1,907	0	49	35

Unit	NDT	Patch Size (ha)	Target Min (%)	Target Max (%)	003 MINDY (Patch not controlled) THLB (ha)	003 Min (%)	003 Max (%)	003 Avr (%)	009 Patch Controlled THLB (ha)	009 Min (%)	009 Max (%)	009 Avr (%)
		250plus	0	100	1,750	0	60	5	1,907	0	0	0
West Flathead	NDT3a	0_40	10	20	1,091	4	100	32	1,092	10	51	41
		40_250	10	20	1,091	0	94	48	1,092	0	51	38
		250_1000	60	80	1,091	0	96	20	1,092	0	80	21
		1000plus	0	100	1,091	0	0	0	1,092	0	0	0
	NDT3b	0_40	20	30	2,854	4	87	32	2,946	20	30	26
		40_80	25	40	2,854	0	46	18	2,946	25	38	31
		80_250	30	50	2,854	0	70	28	2,946	34	50	43
		250plus	0	100	2,854	0	86	23	2,946	0	0	0
White Creek	NDT3b	0_40	20	30	1,197	10	100	50	1,208	0	45	30
		40_80	25	40	1,197	0	65	25	1,208	0	55	35
		80_250	30	50	1,197	0	70	20	1,208	0	50	32
		250plus	0	100	1,197	0	45	4	1,208	0	0	0
Wigwam River	NDT3a	0_40	10	20	440	29	100	79	665	0	50	47
		40_250	10	20	440	0	71	21	665	0	50	47
		250_1000	60	80	440	0	0	0	665	0	82	3
		1000plus	0	100	440	0	0	0	665	0	0	0
	NDT3b	0_40	20	30	374	7	100	45	628	19	45	32
		40_80	25	40	374	0	88	12	628	0	56	22
		80_250	30	50	374	0	93	43	628	0	63	46
		250plus	0	100	374	0	0	0	628	0	0	0

Yellow highlights identify records with no early seral patch area within the reporting unit and patch size class.

Licensee: Canfor

Unit	NDT	Patch Size (ha)	Target Min (%)	Target Max (%)	003 MINDY (Patch not controlled) THLB (ha)	003 Min (%)	003 Max (%)	003 Avr (%)	009 Patch Controlled THLB (ha)	009 Min (%)	009 Max (%)	009 Avr (%)
EK Trench South	NDT3	0_40	15	25	5,867	17	64	37	5,994	16	43	24
		40_250	20	40	5,867	20	72	45	5,994	29	57	38
		250_1000	30	50	5,867	0	39	18	5,994	0	49	38
		1000plus	10	20	5,867	0	0	0	5,994	0	0	0
	NDT4	0_40	30	40	26,080	27	55	37	27,120	30	40	34
		40_80	30	40	26,080	4	21	14	27,120	30	36	31
		80_250	20	30	26,080	14	46	28	27,120	20	30	25
		250plus	5	15	26,080	0	35	21	27,120	0	15	10
Eastern Purcell South	NDT2	0_40	30	40	1,541	26	100	54	1,576	30	50	39
		40_80	30	40	1,541	0	69	33	1,576	30	50	36
		80_250	20	40	1,541	0	48	13	1,576	0	40	25
		250plus	0	5	1,541	0	0	0	1,576	0	0	0
	NDT3	0_40	15	25	7,731	19	75	51	8,233	19	43	25
		40_250	20	40	7,731	25	59	43	8,233	26	57	38
		250_1000	30	50	7,731	0	39	6	8,233	0	49	36
		1000plus	10	20	7,731	0	0	0	8,233	0	0	0
	NDT4	0_40	30	40	640	1	100	47	694	30	53	49
		40_80	30	40	640	0	68	20	694	21	54	49
		80_250	20	30	640	0	99	33	694	0	43	3
		250plus	5	15	640	0	0	0	694	0	0	0
Flathead	NDT2	0_40	30	40	542	5	100	60	542	30	100	54
		40_80	30	40	542	0	72	23	542	0	57	45
		80_250	20	40	542	0	77	17	542	0	39	1
		250plus	0	5	542	0	0	0	542	0	0	0
	NDT3	0_40	15	25	38,130	15	42	30	42,443	15	23	20

Unit	NDT	Patch Size (ha)	Target		003 MINDY (Patch not controlled)				009 Patch Controlled			
			Min (%)	Max (%)	THLB (ha)	Min (%)	Max (%)	Avr (%)	THLB (ha)	Min (%)	Max (%)	Avr (%)
		40_250	20	40	38,130	26	60	49	42,443	24	39	34
		250_1000	30	50	38,130	3	35	19	42,443	30	43	35
		1000plus	10	20	38,130	0	31	2	42,443	0	19	11
McGillivary	NDT2	0_40	30	40	12,970	22	53	36	14,225	30	40	33
		40_80	30	40	12,970	10	36	21	14,225	30	40	32
		80_250	20	40	12,970	9	48	31	14,225	23	40	35
		250plus	0	5	12,970	0	37	12	14,225	0	0	0
	NDT3	0_40	15	25	68,961	22	42	30	71,142	19	25	22
		40_250	20	40	68,961	27	56	44	71,142	26	40	33
		250_1000	30	50	68,961	8	33	20	71,142	30	36	32
		1000plus	10	20	68,961	0	36	7	71,142	10	20	13
	NDT4	0_40	30	40	8,676	29	79	46	9,004	30	40	35
		40_80	30	40	8,676	7	30	20	9,004	30	40	33
		80_250	20	30	8,676	11	44	30	9,004	20	30	24
		250plus	5	15	8,676	0	28	4	9,004	0	15	8
Mid Elk	NDT3	0_40	15	25	3,510	49	100	72	3,935	25	43	41
		40_250	20	40	3,510	0	51	27	3,935	25	58	55
		250_1000	30	50	3,510	0	23	1	3,935	0	50	4
		1000plus	10	20	3,510	0	0	0	3,935	0	0	0
South Park South	NDT3	0_40	15	25	8,897	23	57	42	9,229	21	43	26
		40_250	20	40	8,897	19	67	47	9,229	27	58	38
		250_1000	30	50	8,897	0	56	11	9,229	0	48	36
		1000plus	10	20	8,897	0	0	0	9,229	0	0	0
	NDT4	0_40	30	40	545	3	100	31	546	40	100	52
		40_80	30	40	545	0	96	51	546	0	55	45
		80_250	20	30	545	0	96	18	546	0	32	3
		250plus	5	15	545	0	0	0	546	0	0	0
Southern Purcell Cranbrook	NDT1	0_40	30	40	797	77	100	95	805	50	100	55
		40_80	30	40	797	0	23	5	805	0	50	45
		80_250	20	30	797	0	0	0	805	0	0	0
		250plus	0	100	797	0	0	0	805	0	0	0
	NDT2	0_40	30	40	6,643	25	78	52	6,822	31	40	37
		40_80	30	40	6,643	5	38	19	6,822	30	36	32
		80_250	20	40	6,643	0	42	23	6,822	25	39	31
		250plus	0	5	6,643	0	24	6	6,822	0	0	0
	NDT3	0_40	15	25	9,647	24	76	48	10,130	21	25	25
		40_250	20	40	9,647	24	69	48	10,130	27	41	37
		250_1000	30	50	9,647	0	16	4	10,130	34	48	39
		1000plus	10	20	9,647	0	0	0	10,130	0	0	0
	NDT4	0_40	30	40	543	16	100	67	556	45	100	51
		40_80	30	40	543	0	84	24	556	0	55	49
		80_250	20	30	543	0	58	9	556	0	0	0
		250plus	5	15	543	0	0	0	556	0	0	0
Upper Elk	NDT3	0_40	15	25	20,668	23	55	37	23,268	19	25	24
		40_250	20	40	20,668	35	67	47	23,268	20	40	32
		250_1000	30	50	20,668	0	38	15	23,268	30	42	34
		1000plus	10	20	20,668	0	26	1	23,268	0	20	10

Yellow highlights identify records with no early seral patch area within the reporting unit and patch size class.

Appendix 2 Old Seral Patch Results

Licensee: BCTS/Galloway

Unit	NDT	Patch Size (ha)	Target		003 MINDY (Early Patch not controlled)						009 Early Patch Controlled					
			Min (%)	Max (%)	FMLB (ha)	THLB (ha)	Min (%)	Max (%)	Avr (%)	Last (%)	FMLB (ha)	THLB (ha)	Min (%)	Max (%)	Avr (%)	Last (%)
		0_40	20	30	3,792	3,191	1	65	13	4	3,792	3,192	1	77	14	4
		40_80	25	40	3,792	3,191	0	60	15	6	3,792	3,192	0	58	12	6
		80_250	30	50	3,792	3,191	0	24	11	15	3,792	3,192	0	27	13	12
	NDT3b	250plus	0	100	3,792	3,191	0	81	62	76	3,792	3,192	0	78	61	78
		0_40	30	40	8,885	7,162	0	100	47	46	8,885	7,436	0	100	48	35
		40_80	30	40	8,885	7,162	0	31	16	26	8,885	7,436	0	42	19	41
		80_250	20	30	8,885	7,162	0	53	20	5	8,885	7,436	0	60	17	0
Cranbrook	NDT4	250plus	0	100	8,885	7,162	0	34	13	23	8,885	7,436	0	30	13	24
		0_40	10	20	10,458	6,827	1	27	5	2	10,458	7,480	2	24	6	3
		40_250	10	20	10,458	6,827	0	63	16	10	10,458	7,480	0	33	10	11
		250_1000	60	80	10,458	6,827	0	49	12	0	10,458	7,480	0	53	19	0
	NDT3a	1000plus	0	100	10,458	6,827	0	88	67	88	10,458	7,480	0	91	65	86
		0_40	20	30	6,482	5,201	3	49	10	3	6,482	5,775	1	46	7	2
		40_80	25	40	6,482	5,201	0	26	7	5	6,482	5,775	0	19	5	3
Cranbrook		80_250	30	50	6,482	5,201	0	63	12	0	6,482	5,775	0	73	17	17
Watershed	NDT3b	250plus	0	100	6,482	5,201	0	95	71	92	6,482	5,775	0	96	72	78
		0_40	10	20	12,232	1,462	5	30	19	15	12,232	1,494	5	29	19	19
		40_250	10	20	12,232	1,462	9	64	29	24	12,232	1,494	9	37	22	23
		250_1000	60	80	12,232	1,462	9	60	37	29	12,232	1,494	19	59	44	58
	NDT3a	1000plus	0	100	12,232	1,462	0	60	15	32	12,232	1,494	0	59	16	0
		0_40	20	30	3,780	1,623	10	37	19	18	3,780	2,491	12	39	25	14
		40_80	25	40	3,780	1,623	0	21	10	17	3,780	2,491	0	33	12	16
		80_250	30	50	3,780	1,623	8	46	26	16	3,780	2,491	17	79	52	70
East Flathead	NDT3b	250plus	0	100	3,780	1,623	0	77	45	49	3,780	2,491	0	35	11	0
		0_40	30	40	10,558	3,263	42	72	58	59	10,558	3,293	43	70	57	58
		40_80	30	40	10,558	3,263	7	41	24	16	10,558	3,293	9	46	21	14
		80_250	20	30	10,558	3,263	0	39	18	24	10,558	3,293	0	33	21	28
	NDT2	250plus	0	100	10,558	3,263	0	0	0	0	10,558	3,293	0	11	1	0
		0_40	20	30	15,656	7,286	9	58	19	9	15,656	8,141	9	64	20	12
		40_80	25	40	15,656	7,286	1	27	8	4	15,656	8,141	2	36	7	3
Galbraith		80_250	30	50	15,656	7,286	2	44	11	14	15,656	8,141	0	38	8	6
Dibble	NDT3b	250plus	0	100	15,656	7,286	0	79	62	73	15,656	8,141	0	80	65	79
		0_40	10	20	7,646	876	5	26	16	9	7,646	897	9	33	18	11
		40_250	10	20	7,646	876	0	58	25	18	7,646	897	9	70	28	26
		250_1000	60	80	7,646	876	0	89	40	30	7,646	897	0	73	32	35
	NDT3a	1000plus	0	100	7,646	876	0	80	20	43	7,646	897	0	63	22	28
		0_40	20	30	4,370	1,004	5	35	16	10	4,370	1,023	3	29	12	10
		40_80	25	40	4,370	1,004	0	25	10	9	4,370	1,023	2	28	11	5
		80_250	30	50	4,370	1,004	10	70	38	23	4,370	1,023	13	46	29	35
	NDT3b	250plus	0	100	4,370	1,004	0	57	35	57	4,370	1,023	21	67	48	50
		0_40	30	40	1,888	944	25	100	50	37	1,888	947	32	100	53	55
		40_80	30	40	1,888	944	0	49	19	9	1,888	947	0	56	25	21
		80_250	20	30	1,888	944	0	69	31	54	1,888	947	0	58	22	24
Galton Range	NDT4	250plus	0	100	1,888	944	0	0	0	0	1,888	947	0	0	0	0
		0_40	30	40	10,151	1,731	27	70	60	63	10,151	1,812	30	68	59	65
		40_80	30	40	10,151	1,731	4	28	19	19	10,151	1,812	9	33	21	16
		80_250	20	30	10,151	1,731	12	45	21	18	10,151	1,812	7	44	18	19
	NDT2	250plus	0	100	10,151	1,731	0	0	0	0	10,151	1,812	0	13	1	0
Iron Sulphur	NDT3b	0_40	20	30	13,823	4,635	8	55	21	15	13,823	5,168	8	51	20	15

Unit	NDT	Patch Size (ha)	Target Min (%)	Target Max (%)	003 MINDY (Early Patch not controlled) FMLB (ha)	THLB (ha)	Min (%)	Max (%)	Avr (%)	Last (%)	009 Early Patch Controlled FMLB (ha)	THLB (ha)	Min (%)	Max (%)	Avr (%)	Last (%)
		40_80	25	40	13,823	4,635	1	25	7	4	13,823	5,168	1	25	7	7
		80_250	30	50	13,823	4,635	8	38	17	17	13,823	5,168	0	28	16	12
		250plus	0	100	13,823	4,635	0	81	55	64	13,823	5,168	22	79	57	66
		0_40	30	40	16,375	14,254	0	100	55	23	16,375	14,768	0	100	59	25
		40_80	30	40	16,375	14,254	0	24	6	10	16,375	14,768	0	23	8	8
		80_250	20	30	16,375	14,254	0	48	18	31	16,375	14,768	0	39	15	38
Jaffray Baynes Lake	NDT4	250plus	0	100	16,375	14,254	0	49	14	36	16,375	14,768	0	32	11	29
		0_40	10	20	6,986	2,999	3	22	11	6	6,986	3,498	1	35	11	7
		40_250	10	20	6,986	2,999	0	31	14	2	6,986	3,498	3	30	11	17
		250_1000	60	80	6,986	2,999	0	94	43	13	6,986	3,498	0	87	49	76
	NDT3a	1000plus	0	100	6,986	2,999	0	94	31	78	6,986	3,498	0	94	28	0
		0_40	20	30	1,463	1,126	0	59	10	0	1,463	1,240	7	100	20	8
		40_80	25	40	1,463	1,126	0	48	6	0	1,463	1,240	0	54	8	0
		80_250	30	50	1,463	1,126	0	31	12	0	1,463	1,240	0	80	13	0
Kimberley Watershed	NDT3b	250plus	0	100	1,463	1,126	0	100	72	100	1,463	1,240	0	93	59	92
		0_40	30	40	4,768	3,283	10	100	52	19	4,768	3,748	11	100	44	19
		40_80	30	40	4,768	3,283	0	56	27	0	4,768	3,748	0	54	20	0
		80_250	20	30	4,768	3,283	0	81	21	81	4,768	3,748	0	52	21	38
	NDT2	250plus	0	100	4,768	3,283	0	0	0	0	4,768	3,748	0	81	15	44
		0_40	20	30	6,233	4,612	2	50	15	3	6,233	5,120	1	39	13	2
		40_80	25	40	6,233	4,612	0	64	11	0	6,233	5,120	0	22	4	0
		80_250	30	50	6,233	4,612	0	47	7	0	6,233	5,120	0	55	10	0
Lamb Creek	NDT3b	250plus	0	100	6,233	4,612	0	98	66	97	6,233	5,120	0	99	73	98
		0_40	30	40	1,924	1,500	0	100	39	10	1,924	1,708	0	100	52	19
		40_80	30	40	1,924	1,500	0	60	16	0	1,924	1,708	0	34	5	0
		80_250	20	30	1,924	1,500	0	90	25	90	1,924	1,708	0	64	4	0
Linklater Englishman	NDT4	250plus	0	100	1,924	1,500	0	71	13	0	1,924	1,708	0	82	32	81
		0_40	20	30	5,669	4,787	1	100	20	1	5,669	4,865	1	100	18	2
		40_80	25	40	5,669	4,787	0	14	0	0	5,669	4,865	0	42	4	0
		80_250	30	50	5,669	4,787	0	29	3	0	5,669	4,865	0	47	10	0
	NDT3b	250plus	0	100	5,669	4,787	0	99	77	99	5,669	4,865	0	99	69	98
		0_40	30	40	2,400	2,059	0	100	52	8	2,400	2,098	0	100	44	4
		40_80	30	40	2,400	2,059	0	47	3	0	2,400	2,098	0	21	3	0
		80_250	20	30	2,400	2,059	0	92	30	92	2,400	2,098	0	73	20	0
Lost Dog Mather	NDT4	250plus	0	100	2,400	2,059	0	92	9	0	2,400	2,098	0	96	25	96
		0_40	10	20	2,087	1,125	4	39	10	4	2,087	1,211	0	30	8	7
		40_250	10	20	2,087	1,125	11	95	54	21	2,087	1,211	20	97	54	53
		250_1000	60	80	2,087	1,125	0	82	36	75	2,087	1,211	0	74	38	40
	NDT3a	1000plus	0	100	2,087	1,125	0	0	0	0	2,087	1,211	0	0	0	0
		0_40	20	30	6,416	4,256	0	31	5	0	6,416	4,840	1	46	7	2
		40_80	25	40	6,416	4,256	0	41	6	0	6,416	4,840	0	37	4	0
		80_250	30	50	6,416	4,256	0	45	10	0	6,416	4,840	0	45	15	4
	NDT3b	250plus	0	100	6,416	4,256	0	100	79	100	6,416	4,840	0	99	75	94
		0_40	30	40	5,460	4,450	0	100	39	17	5,460	5,019	0	100	35	16
		40_80	30	40	5,460	4,450	0	47	13	10	5,460	5,019	0	70	13	9
		80_250	20	30	5,460	4,450	0	57	15	21	5,460	5,019	0	49	25	35
Mayook Wardner	NDT4	250plus	0	100	5,460	4,450	0	63	27	53	5,460	5,019	0	50	21	41
		0_40	30	40	8,290	3,566	20	42	28	24	8,290	3,837	14	70	35	23
		40_80	30	40	8,290	3,566	0	20	9	4	8,290	3,837	0	41	18	4
		80_250	20	30	8,290	3,566	0	79	42	24	8,290	3,837	0	83	30	24
	NDT2	250plus	0	100	8,290	3,566	0	59	20	47	8,290	3,837	0	61	17	49
		0_40	10	20	13,727	7,978	4	21	11	5	13,727	8,906	7	20	11	7
Perry Moyie	NDT3a	40_250	10	20	13,727	7,978	0	22	7	2	13,727	8,906	1	39	11	6

Unit	NDT	Patch Size (ha)	Target		003 MINDY (Early Patch not controlled)						009 Early Patch Controlled					
			Min (%)	Max (%)	FMLB (ha)	THLB (ha)	Min (%)	Max (%)	Avr (%)	Last (%)	FMLB (ha)	THLB (ha)	Min (%)	Max (%)	Avr (%)	Last (%)
		250_1000	60	80	13,727	7,978	0	91	45	0	13,727	8,906	15	65	44	57
		1000plus	0	100	13,727	7,978	0	94	37	93	13,727	8,906	0	63	34	30
		0_40	20	30	10,456	8,349	3	41	12	4	10,456	8,413	4	40	13	6
		40_80	25	40	10,456	8,349	0	33	7	3	10,456	8,413	0	26	6	0
		80_250	30	50	10,456	8,349	0	50	19	11	10,456	8,413	5	71	20	15
	NDT3b	250plus	0	100	10,456	8,349	0	89	62	83	10,456	8,413	0	89	61	79
		0_40	30	40	706	504	41	100	96	41	706	527	41	100	81	64
		40_80	30	40	706	504	0	59	4	59	706	527	0	59	19	36
		80_250	20	30	706	504	0	0	0	0	706	527	0	0	0	0
	NDT4	250plus	0	100	706	504	0	0	0	0	706	527	0	0	0	0
		0_40	20	30	5,307	1,158	19	35	27	32	5,307	1,305	18	33	24	22
		40_80	25	40	5,307	1,158	3	18	10	10	5,307	1,305	2	14	9	8
		80_250	30	50	5,307	1,158	0	25	12	13	5,307	1,305	0	26	12	4
Sand Creek	NDT3b	250plus	0	100	5,307	1,158	38	67	52	46	5,307	1,305	38	69	55	66
		0_40	30	40	4,119	3,324	0	77	36	30	4,119	3,448	0	87	52	29
		40_80	30	40	4,119	3,324	0	90	42	38	4,119	3,448	0	90	24	0
St Marys		80_250	20	30	4,119	3,324	0	56	15	32	4,119	3,448	0	71	17	71
Prairie	NDT4	250plus	0	100	4,119	3,324	0	0	0	0	4,119	3,448	0	0	0	0
		0_40	10	20	3,843	2,680	6	41	18	13	3,843	2,682	2	29	13	2
		40_250	10	20	3,843	2,680	8	82	40	10	3,843	2,682	10	81	32	16
		250_1000	60	80	3,843	2,680	0	77	43	76	3,843	2,682	0	83	56	83
	NDT3a	1000plus	0	100	3,843	2,680	0	0	0	0	3,843	2,682	0	0	0	0
		0_40	20	30	8,673	6,845	1	52	10	3	8,673	7,112	2	43	12	2
		40_80	25	40	8,673	6,845	0	15	2	0	8,673	7,112	0	40	4	0
		80_250	30	50	8,673	6,845	0	73	11	0	8,673	7,112	0	51	8	0
	NDT3b	250plus	0	100	8,673	6,845	0	99	77	97	8,673	7,112	0	98	76	98
		0_40	30	40	764	579	0	100	66	39	764	582	0	100	61	3
		40_80	30	40	764	579	0	61	8	61	764	582	0	34	8	27
		80_250	20	30	764	579	0	96	19	0	764	582	0	71	24	70
Teepee Creek	NDT4	250plus	0	100	764	579	0	0	0	0	764	582	0	0	0	0
		0_40	30	40	6,857	6,340	20	100	76	53	6,857	6,414	23	100	53	23
		40_80	30	40	6,857	6,340	0	80	24	47	6,857	6,414	0	63	28	23
Tobacco		80_250	20	30	6,857	6,340	0	0	0	0	6,857	6,414	0	43	14	34
Plains	NDT4	250plus	0	100	6,857	6,340	0	0	0	0	6,857	6,414	0	24	5	20
		0_40	30	40	3,192	823	44	80	65	80	3,192	872	48	80	66	60
		40_80	30	40	3,192	823	0	39	22	0	3,192	872	8	47	23	8
		80_250	20	30	3,192	823	0	39	13	20	3,192	872	0	33	11	32
	NDT2	250plus	0	100	3,192	823	0	0	0	0	3,192	872	0	0	0	0
		0_40	10	20	8,515	1,492	37	69	52	43	8,515	1,565	34	68	48	34
		40_250	10	20	8,515	1,492	25	49	38	28	8,515	1,565	20	56	37	42
		250_1000	60	80	8,515	1,492	0	29	11	29	8,515	1,565	0	33	15	24
	NDT3a	1000plus	0	100	8,515	1,492	0	0	0	0	8,515	1,565	0	0	0	0
		0_40	20	30	8,501	4,303	11	100	29	12	8,501	4,590	9	100	27	10
		40_80	25	40	8,501	4,303	0	15	4	2	8,501	4,590	0	23	5	5
		80_250	30	50	8,501	4,303	0	24	8	6	8,501	4,590	0	22	11	11
Upper Bull	NDT3b	250plus	0	100	8,501	4,303	0	82	59	80	8,501	4,590	0	77	57	74
		0_40	30	40	7,191	4,699	42	100	59	53	7,191	5,135	49	100	76	49
		40_80	30	40	7,191	4,699	0	24	9	13	7,191	5,135	0	8	2	8
Wasa Picture		80_250	20	30	7,191	4,699	0	45	20	12	7,191	5,135	0	33	8	15
Valley	NDT4	250plus	0	100	7,191	4,699	0	24	12	22	7,191	5,135	0	29	14	28
		0_40	20	30	2,616	1,734	5	84	22	19	2,616	1,891	7	100	25	17
		40_80	25	40	2,616	1,734	0	44	14	0	2,616	1,891	0	15	4	0
West Elk	NDT3b	80_250	30	50	2,616	1,734	0	81	35	0	2,616	1,891	0	78	33	45

Unit	NDT	Patch Size (ha)	Target		003 MINDY (Early Patch not controlled)						009 Early Patch Controlled					
			Min (%)	Max (%)	FMLB (ha)	THLB (ha)	Min (%)	Max (%)	Avr (%)	Last (%)	FMLB (ha)	THLB (ha)	Min (%)	Max (%)	Avr (%)	Last (%)
		250plus	0	100	2,616	1,734	0	81	29	81	2,616	1,891	0	88	38	38
		0_40	10	20	2,422	1,091	10	100	30	22	2,422	1,092	6	100	30	9
		40_250	10	20	2,422	1,091	0	88	43	33	2,422	1,092	0	93	53	33
		250_1000	60	80	2,422	1,091	0	52	27	45	2,422	1,092	0	59	17	58
	NDT3a	1000plus	0	100	2,422	1,091	0	0	0	0	2,422	1,092	0	0	0	0
		0_40	20	30	3,541	2,854	1	100	19	2	3,541	2,946	1	100	18	2
		40_80	25	40	3,541	2,854	0	0	0	0	3,541	2,946	0	11	1	0
		80_250	30	50	3,541	2,854	0	37	4	37	3,541	2,946	0	43	24	0
West Flathead	NDT3b	250plus	0	100	3,541	2,854	0	99	77	61	3,541	2,946	0	98	57	98
		0_40	20	30	3,232	1,197	10	45	19	17	3,232	1,208	8	49	19	8
		40_80	25	40	3,232	1,197	0	25	7	0	3,232	1,208	0	36	7	0
		80_250	30	50	3,232	1,197	0	58	22	9	3,232	1,208	0	59	22	9
White Creek	NDT3b	250plus	0	100	3,232	1,197	0	79	52	74	3,232	1,208	0	82	52	82
		0_40	10	20	1,898	440	4	25	12	8	1,898	665	7	28	15	13
		40_250	10	20	1,898	440	0	89	26	11	1,898	665	0	53	14	15
		250_1000	60	80	1,898	440	0	92	62	81	1,898	665	33	88	71	72
	NDT3a	1000plus	0	100	1,898	440	0	0	0	0	1,898	665	0	0	0	0
		0_40	20	30	826	374	14	100	37	18	826	628	10	100	35	24
		40_80	25	40	826	374	0	68	18	0	826	628	0	79	5	0
		80_250	30	50	826	374	0	82	37	82	826	628	0	90	60	76
Wigwam River	NDT3b	250plus	0	100	826	374	0	86	9	0	826	628	0	0	0	0

Yellow highlights identify records with no early seral patch area within the reporting unit and patch size class.

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Unit	NDT	Patch Size (ha)	Target		003 MINDY (Early Patch not controlled)						009 Early Patch Controlled					
			Min (%)	Max (%)	FMLB (ha)	THLB (ha)	Min (%)	Max (%)	Avr (%)	Last (%)	FMLB (ha)	THLB (ha)	Min (%)	Max (%)	Avr (%)	Last (%)
EK Trench South	NDT3	0_40	15	25	8,805	5,867	3	20	9	4	8,805	5,994	5	23	9	6
		40_250	20	40	8,805	5,867	9	27	15	15	8,805	5,994	6	30	19	6
		250_1000	30	50	8,805	5,867	0	67	8	0	8,805	5,994	0	64	8	11
		1000plus	10	20	8,805	5,867	0	82	67	80	8,805	5,994	0	79	64	76
	NDT4	0_40	30	40	32,835	26,046	31	100	49	38	32,835	27,086	32	100	54	38
		40_80	30	40	32,835	26,046	0	44	18	11	32,835	27,086	0	40	16	14
		80_250	20	30	32,835	26,046	0	32	16	13	32,835	27,086	0	35	13	8
		250plus	5	15	32,835	26,046	0	42	18	37	32,835	27,086	0	39	17	39
Eastern Purcell South	NDT2	0_40	30	40	6,389	1,541	11	61	40	43	6,389	1,576	11	49	34	39
		40_80	30	40	6,389	1,541	2	68	16	16	6,389	1,576	0	43	16	34
		80_250	20	40	6,389	1,541	0	49	30	21	6,389	1,576	13	89	39	27
		250plus	0	5	6,389	1,541	0	62	15	21	6,389	1,576	0	49	10	0
	NDT3	0_40	15	25	15,118	7,731	4	23	10	4	15,118	8,233	4	29	10	5
		40_250	20	40	15,118	7,731	2	23	12	2	15,118	8,233	5	27	14	5
		250_1000	30	50	15,118	7,731	0	57	6	6	15,118	8,233	0	54	3	0
		1000plus	10	20	15,118	7,731	0	89	72	88	15,118	8,233	0	90	72	90
	NDT4	0_40	30	40	843	639	0	100	43	15	843	693	0	100	34	29
		40_80	30	40	843	639	0	45	2	0	843	693	0	75	7	0
		80_250	20	30	843	639	0	91	42	85	843	693	0	86	46	71
		250plus	5	15	843	639	0	0	0	0	843	693	0	0	0	0
Flathead	NDT2	0_40	30	40	3,062	542	37	100	61	83	3,062	542	41	100	66	72
		40_80	30	40	3,062	542	0	33	17	17	3,062	542	0	37	20	8
		80_250	20	40	3,062	542	0	45	22	0	3,062	542	0	46	14	20
		250plus	0	5	3,062	542	0	0	0	0	3,062	542	0	0	0	0
	NDT3	0_40	15	25	116,451	38,130	13	26	17	13	116,451	42,443	13	27	17	13

Unit	NDT	Patch Size (ha)	Target		003 MINDY (Early Patch not controlled)						009 Early Patch Controlled					
			Min (%)	Max (%)	FMLB (ha)	THLB (ha)	Min (%)	Max (%)	Avr (%)	Last (%)	FMLB (ha)	THLB (ha)	Min (%)	Max (%)	Avr (%)	Last (%)
		40_250	20	40	116,451	38,130	14	36	19	14	116,451	42,443	16	34	21	16
		250_1000	30	50	116,451	38,130	10	30	19	11	116,451	42,443	13	36	22	18
		1000plus	10	20	116,451	38,130	14	63	45	63	116,451	42,443	5	55	40	53
McGillivary	NDT2	0_40	30	40	20,562	12,961	14	100	36	14	20,562	14,215	15	100	33	17
		40_80	30	40	20,562	12,961	0	34	15	14	20,562	14,215	0	23	10	11
		80_250	20	40	20,562	12,961	0	57	35	30	20,562	14,215	0	54	27	5
		250plus	0	5	20,562	12,961	0	52	15	41	20,562	14,215	0	70	30	68
	NDT3	0_40	15	25	99,697	68,904	2	30	8	2	99,697	71,084	3	28	8	4
		40_250	20	40	99,697	68,904	3	38	9	4	99,697	71,084	3	33	9	4
		250_1000	30	50	99,697	68,904	4	34	14	7	99,697	71,084	7	33	15	7
		1000plus	10	20	99,697	68,904	7	88	69	88	99,697	71,084	15	86	68	85
	NDT4	0_40	30	40	11,229	8,661	11	100	41	13	11,229	8,989	12	100	39	14
		40_80	30	40	11,229	8,661	0	40	14	2	11,229	8,989	0	34	12	5
		80_250	20	30	11,229	8,661	0	45	21	32	11,229	8,989	0	55	27	38
		250plus	5	15	11,229	8,661	0	58	24	53	11,229	8,989	0	53	23	44
Mid Elk	NDT3	0_40	15	25	14,865	3,505	14	31	24	21	14,865	3,929	12	30	22	19
		40_250	20	40	14,865	3,505	29	50	40	37	14,865	3,929	25	47	36	43
		250_1000	30	50	14,865	3,505	12	53	34	42	14,865	3,929	15	58	35	38
		1000plus	10	20	14,865	3,505	0	22	2	0	14,865	3,929	0	24	6	0
South Park South	NDT3	0_40	15	25	28,170	8,897	19	27	23	20	28,170	9,229	19	29	25	24
		40_250	20	40	28,170	8,897	11	45	22	20	28,170	9,229	11	39	20	16
		250_1000	30	50	28,170	8,897	3	40	15	3	28,170	9,229	0	43	20	17
		1000plus	10	20	28,170	8,897	0	58	39	57	28,170	9,229	0	54	35	43
	NDT4	0_40	30	40	1,178	545	0	100	56	42	1,178	546	0	100	63	43
		40_80	30	40	1,178	545	0	55	35	15	1,178	546	0	59	34	57
		80_250	20	30	1,178	545	0	43	6	43	1,178	546	0	0	0	0
		250plus	5	15	1,178	545	0	0	0	0	1,178	546	0	0	0	0
Southern Purcell Cranbrook	NDT1	0_40	30	40	40,720	797	10	29	23	26	40,720	805	10	30	23	30
		40_80	30	40	40,720	797	4	15	12	14	40,720	805	5	18	13	18
		80_250	20	30	40,720	797	19	41	31	36	40,720	805	19	35	29	27
		250plus	0	100	40,720	797	18	64	35	24	40,720	805	19	66	36	25
	NDT2	0_40	30	40	31,439	6,642	24	54	41	45	31,439	6,821	25	52	42	49
		40_80	30	40	31,439	6,642	8	22	14	15	31,439	6,821	8	20	14	11
		80_250	20	40	31,439	6,642	17	41	24	23	31,439	6,821	12	41	22	19
		250plus	0	5	31,439	6,642	9	39	21	17	31,439	6,821	13	33	22	21
	NDT3	0_40	15	25	21,087	9,619	11	33	18	11	21,087	10,101	12	33	19	13
		40_250	20	40	21,087	9,619	18	67	36	29	21,087	10,101	17	58	33	34
		250_1000	30	50	21,087	9,619	7	66	39	43	21,087	10,101	13	58	38	30
		1000plus	10	20	21,087	9,619	0	19	7	17	21,087	10,101	0	23	10	22
	NDT4	0_40	30	40	675	534	0	100	32	2	675	548	0	100	45	3
		40_80	30	40	675	534	0	29	13	26	675	548	0	42	15	29
		80_250	20	30	675	534	0	74	35	72	675	548	0	69	33	68
		250plus	5	15	675	534	0	0	0	0	675	548	0	0	0	0
Upper Elk	NDT3	0_40	15	25	82,498	20,613	17	30	24	20	82,498	23,204	19	29	24	21
		40_250	20	40	82,498	20,613	20	35	26	20	82,498	23,204	21	41	28	21
		250_1000	30	50	82,498	20,613	16	39	27	19	82,498	23,204	20	35	25	22
		1000plus	10	20	82,498	20,613	4	41	23	41	82,498	23,204	0	36	22	35

Yellow highlights identify records with no early seral patch area within the reporting unit and patch size class.

Appendix 3 Landscape Unit Grouping Sensitivity Analyses Results

Two sensitivity analyses were conducted to explore the impact on the timber harvest levels from an adjustment intended to provide the model with more flexibility to address non-timber objectives:

- (011) Group LUs and implement ONLY mature and old seral objectives (including 2/3 draw-down) accordingly. Other non-timber objectives (green-up adjacency and UWR) were still modelled at the LU level.
- (012) Group LUs and implement all non-timber objectives accordingly (i.e., mature and old seral - including 2/3 draw-down, green-up/adjacency, and UWR objectives).

Results were compared relative to sensitivity 008 (i.e., OGMAs and MMAs turned off, with targets applied for mature and old (including 2/3 draw-down), UWR, and green-up, for Individual LUs). Recall that the ISS Base Case 003 (maximum initial, non-declining yield - MINDY) included spatially-explicit OGMAs and MMAs to meet mature and old seral objectives. Thus, comparing impacts from Grouped LUs to the ISS Base Case (003) is less relevant.

Harvest Profiles

Compared to the sensitivity 008, grouping LUs had very little impact on the harvest profile over time.

Sensitivity ID	Description	THLB		Harvest rate (m³/year)			Harvest rate % from 008		
		(ha)*	%from 008	First decade	Mid-term	Long-term	First decade	Mid-term	Long-term
008	Targets applied to Individual LUs; OGMA/MMA off, BIOD mat/old	363,385	0.0%	910,813	892,467	964,240	0.0%	0.0%	0.0%
011	Targets applied to Grouped LUs ; OGMA/MMA off, BIOD mat/old; all other non-timber objectives with LUs	363,385	0.0%	911,211	894,973	973,573	0.0%	0.3%	1.0%
012	Targets applied to Grouped LUs for all related non-timber objectives	363,385	0.0%	909,388	893,995	977,207	-0.2%	0.2%	1.3%

Non-timber Objectives

Three non-timber objectives were examined for reporting units involving Individual LUs (008) and Grouped LUs (011/012): mature and old seral forest, UWR, and green-up. As expected, the average size of reporting units was significantly larger with Grouped LUs. However, the proportion of NHLB within these reporting units was slightly greater with Grouped LUs: 1% for mature and old seral and 4% higher for UWR. Green-up was considered only on the THLB.

No-Timber Objective	Reporting Units as Individual LUs				Reporting Units as Grouped LUs			
	#	FMLB Average (ha)	THLB (%)	NHLB (%)	#	FMLB Average (ha)	THLB (%)	NHLB (%)
Mature and old seral	228	3,755	55%	45%	115	7,445	54%	46%
UWR	131	1,201	87%	13%	64	2,457	83%	17%
Green-up	76	4,372	100%	0%	36	9,492	100%	0%

The slightly higher proportion of NHLB with Grouped LUs meant that more area was available to meet non-timber requirements. This appeared to align well with the harvest rate increases:

- long-term harvest level increase was 1.0% with only mature and old seral objectives applied (011);
- long-term harvest level increase was 1.3% with all non-timber objectives applied (012).

This was not the case with UWR objectives. Recall that these included both minimum targets (10-30% @ >60-100 years) and maximum targets (33% @ <21 years) for the FMLB area within each reporting unit (i.e., habitat type within Individual LUs (008) or Grouped LUs (011-012)). The slight increase in proportion of NHLB (i.e., and less THLB) was not very helpful for meeting maximum targets while increasing the harvest rate. In fact, results indicated that the UWR maximum targets were somewhat constrained (i.e., a cyclical pattern where, in some periods of the planning horizon, the objective value was very close (within 99%) to the maximum target, while in others, the objective value was well below the maximum target).

The following sections describe observations made for each of these non-timber objectives.

Mature and Old Seral

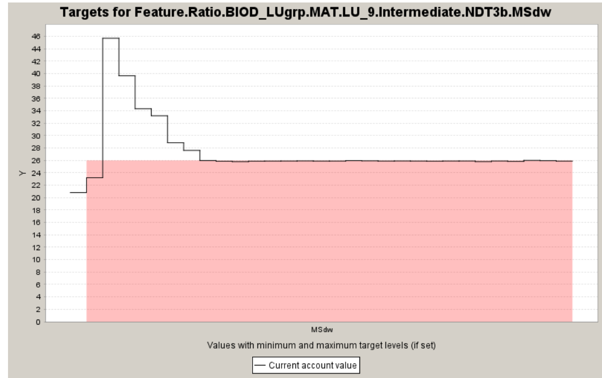
The following observations were made by comparatively investigating the mature and old seral objectives (see Figure A, below):

- The old seral objective (minimum) within the largest Grouped LU (011/012) unit (top right) was not constrained. Similarly, the old seral objective for the largest corresponding Individual LU (008) unit (bottom left) was not constrained.
- Some of the largest reporting units with Grouped LUs were constrained for mature seral objectives in scenario 011/012. While the largest corresponding Individual LUs (008) were also constrained, thresholds were not violated as with the Grouped LUs (011/012). The example shown in Figure A shows the two largest Individual LUs (East and West Flathead) were constrained while the third reporting (Upper Flathead) was not. In comparison, the minimum mature target applied to Grouped LU #9 (top right) was significantly constrained.

The 1% NHLB increase with Grouped LUs appeared sufficient to support modest harvest rate increases in the long-term. It was difficult to observe visible differences relative to Individual LUs (008) (i.e., OGMAs and MMAs turned off, with targets applied for mature and old (including 2/3 draw-down), UWR, and green-up).

Targets Applied to Individual LUs (008)
(not grouped)

Targets Applied to Grouped LUs (011)



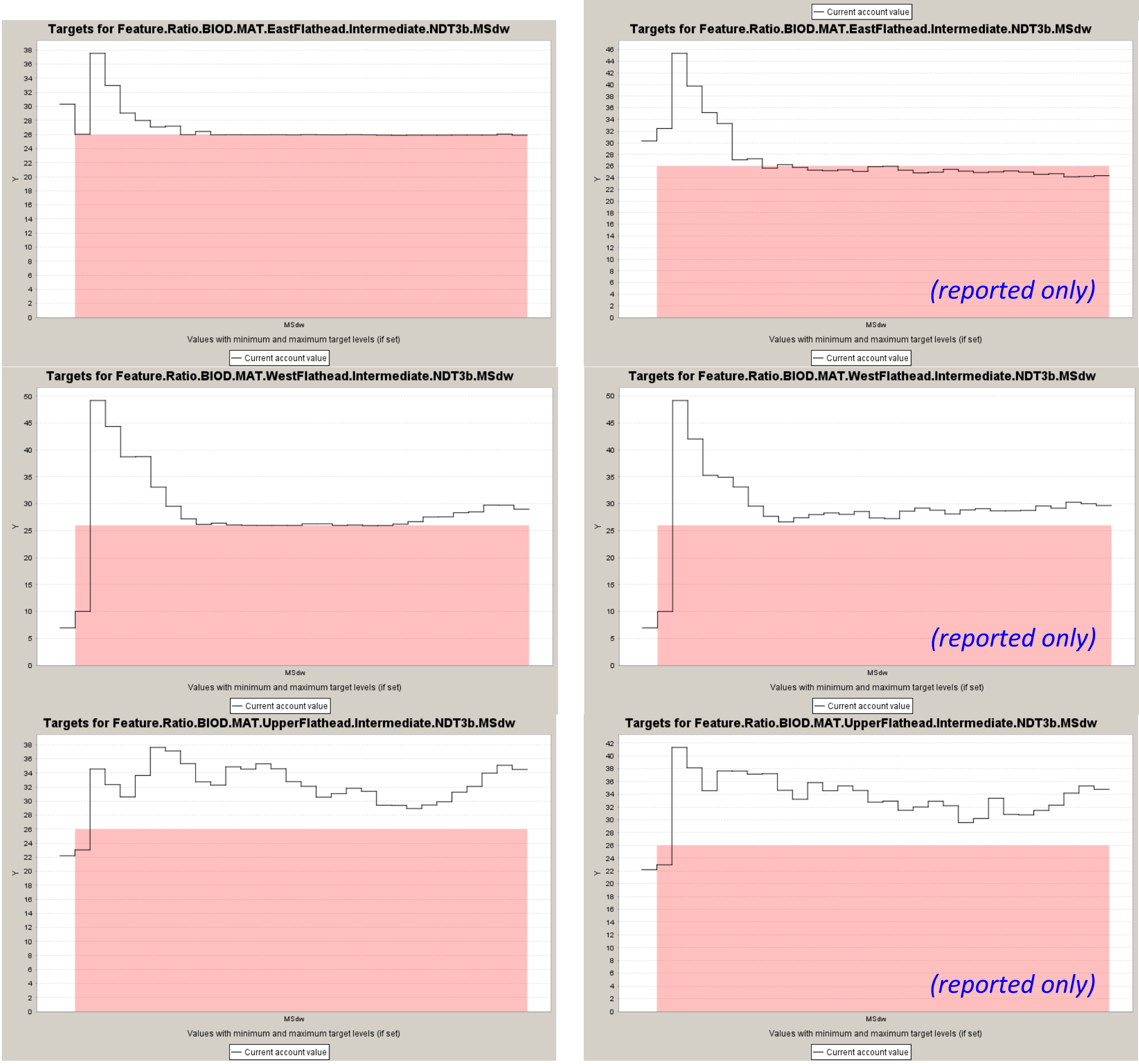


Figure A ***Comparison of disturbance ratios over time relative to minimum mature and old seral targets applied to Individual LUs (008, left) (East Flathead – 19,008 ha; Upper Flathead – 1,148 ha; West Flathead – 12,075 ha) and to Grouped LUs (011, top right) (NDT 3b, MSdw; FMLB = 32,230 ha)***

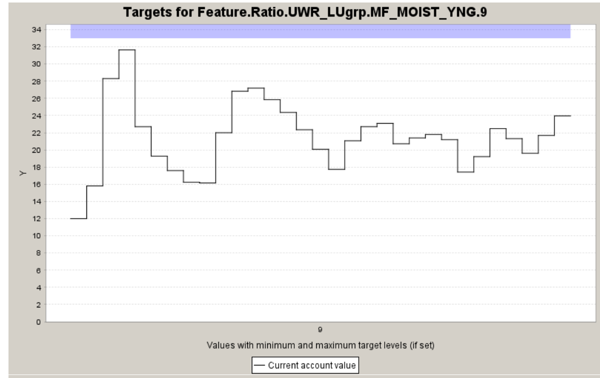
UWRs

The following observations were made by comparatively investigating the UWR objectives (see examples in the figures directly below):

- Overall, minimum UWR targets (10-30% @ >60-100 years) did not appear to constrain harvest flows over time for either the largest Grouped LU units (011/012) or their corresponding Individual LUs (008).
- The example in Figure B, below, shows that maximum UWR targets (33% @ <21 years) were very constraining over some periods when assessed as Individual LUs (008, left) but not so when assessed as Grouped LU#9 (012; top right). While Grouping LUs appeared to have a positive effect (i.e., less constraining), this approach did not translate to gains in harvest levels. This was likely due to constraints from other non-timber objectives like ECAs and VQOs.
- Conversely, the example in Figure C, below, shows that maximum UWR targets (33% @ <21 years) were somewhat constraining over some periods when assessed by Individual LUs (008, left) but more so when assessed as Grouped LU#4 (012; top right). Note that the largest LU (i.e., West Elk) was constrained in both scenarios. Here, Grouping LUs did not have a positive impact constraints or harvest flow.

Targets Applied to Individual LUs (008)
(not grouped)

Targets Applied to Grouped LUs (012)



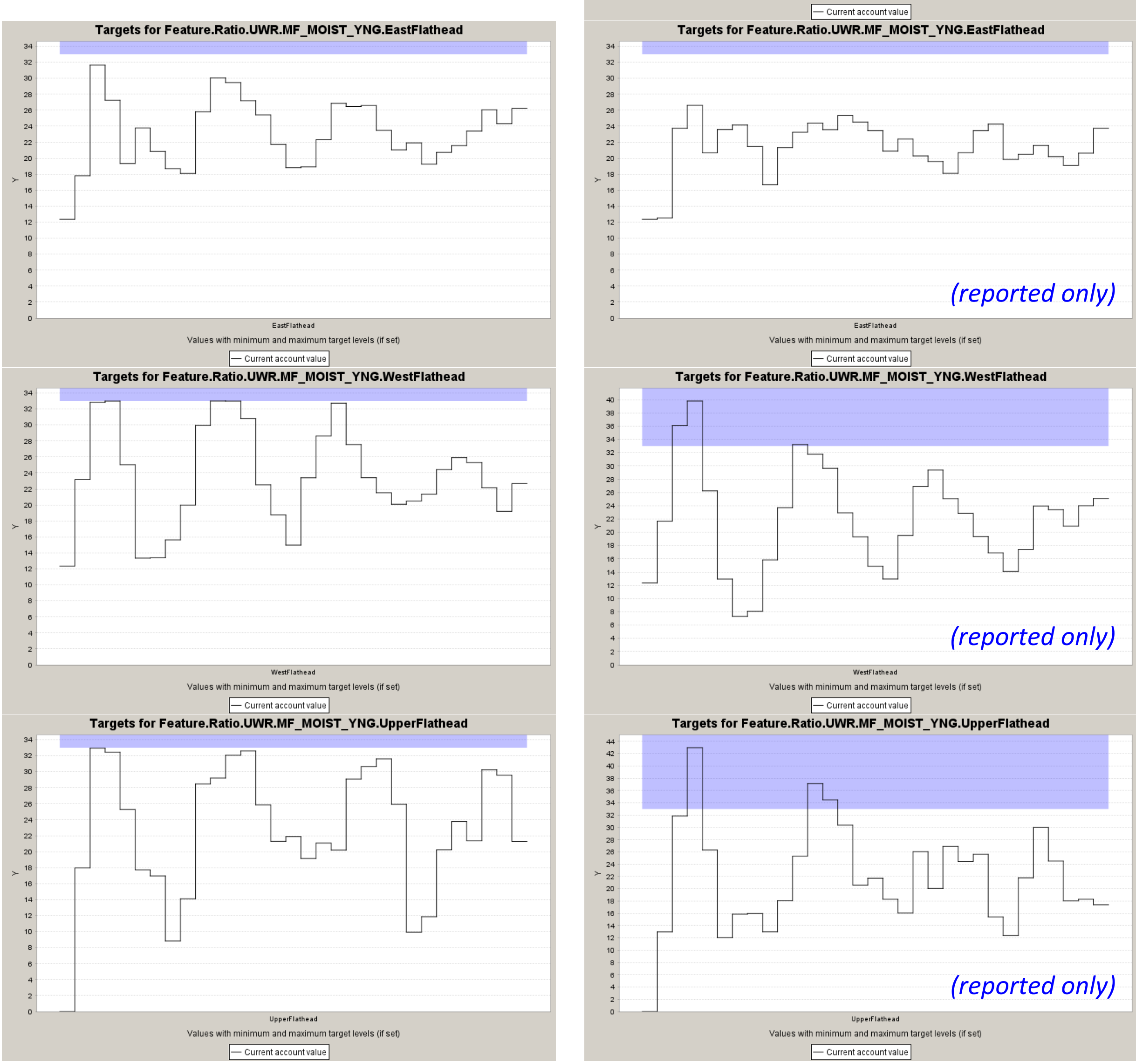


Figure B ***Comparison of disturbance ratios over time relative to maximum UWR targets applied to Individual LUs (008, left) (East Flathead FMLB = 13,291 ha, Upper Flathead FMLB = 420 ha, and West Flathead FMLB = 8,151 ha) and to Grouped LU #9 (012, top right) (UWR Managed Forest Moist; FMLB = 21,862 ha)***

Targets Applied to Individual LUs (008)
(not grouped)

Targets Applied to Grouped LUs (012)

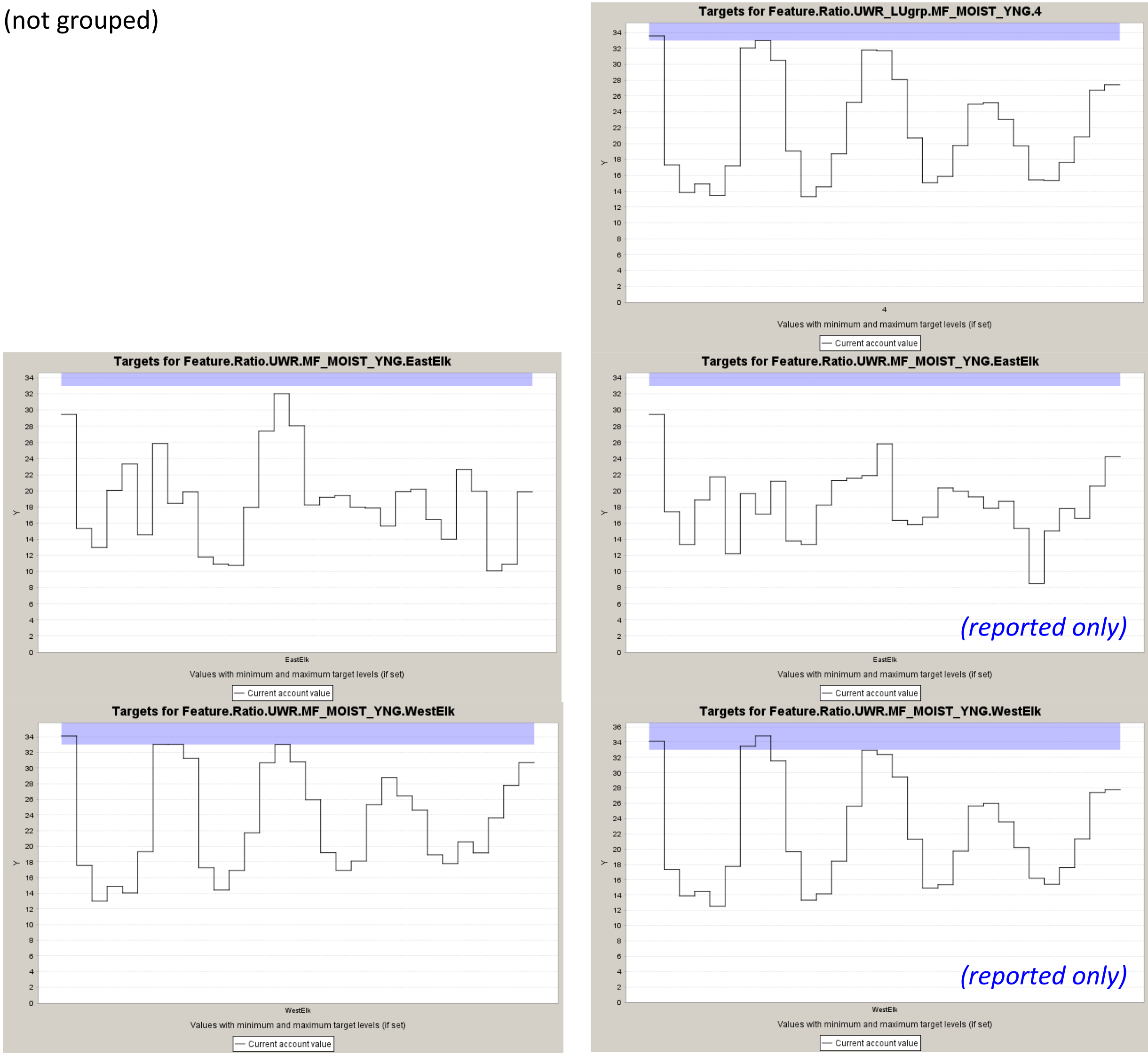


Figure C ***Comparison of disturbance ratios over time relative to maximum UWR targets applied to Individual LUs (008, left) (East Elk FMLB = 767 ha, West Elk FMLB =6,800 ha) and to Grouped LU #4 (012, top right) (UWR Managed Forest Moist; FMLB = 7,567 ha)***

Green-up

No obvious trends were observed for the green-up objectives. This was most likely because overall, these non-timber objectives were not constraining. Other forest cover requirements, like the seral and UWR objectives, were sufficient to address the green-up objectives for a MINDY harvest request.

Amount, Quality, and Spatial Distribution of THLB Area Retained as Old Seral

Both the THLB area retained as old seral and the corresponding standing volume (see Figure D, below) were visibly lower (12% average, 1-17% range) with Grouped LUs (011/012) reporting units compared to those with Individual LUs (008). No trends were observed for the quality of the THLB area retained as old seral, measured as a function of managed site index and volume per ha. Note the uniformity of the old seral THLB selected by the model as the site index varied by less than 0.10 m, and less than 13 m³/ha. These results suggest that the model retained less THLB area as old seral to meet non-timber objectives which aligns with the expectations for increasing the size of reporting units. However, the model retained THLB area as old seral relatively similar in terms of quality, despite the size of the reporting unit.

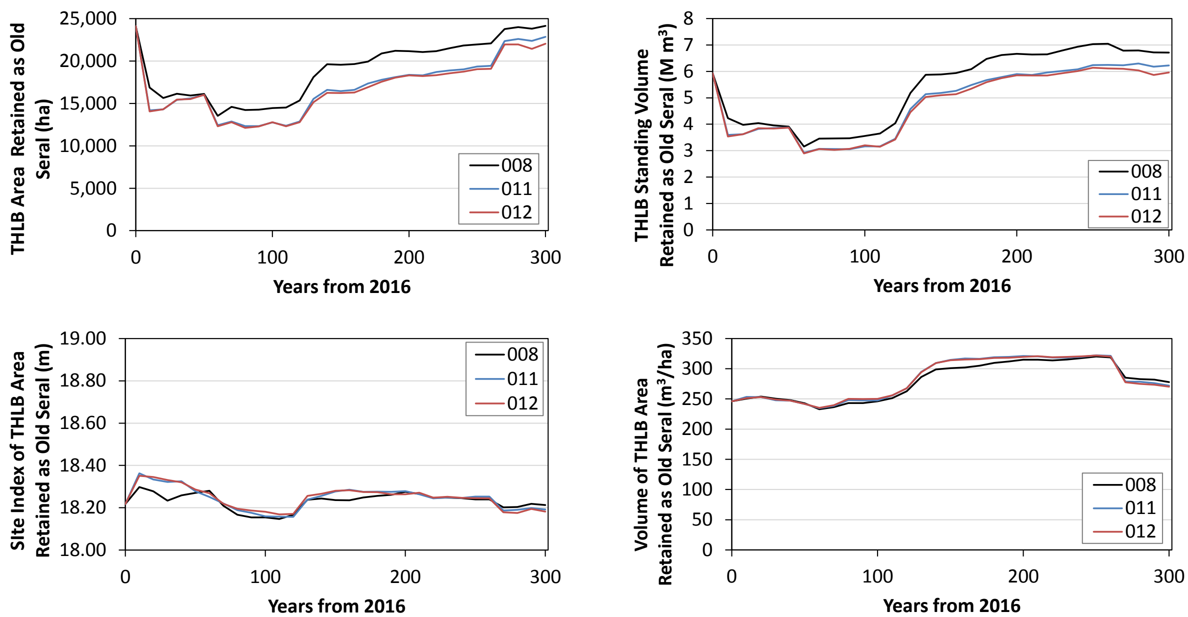
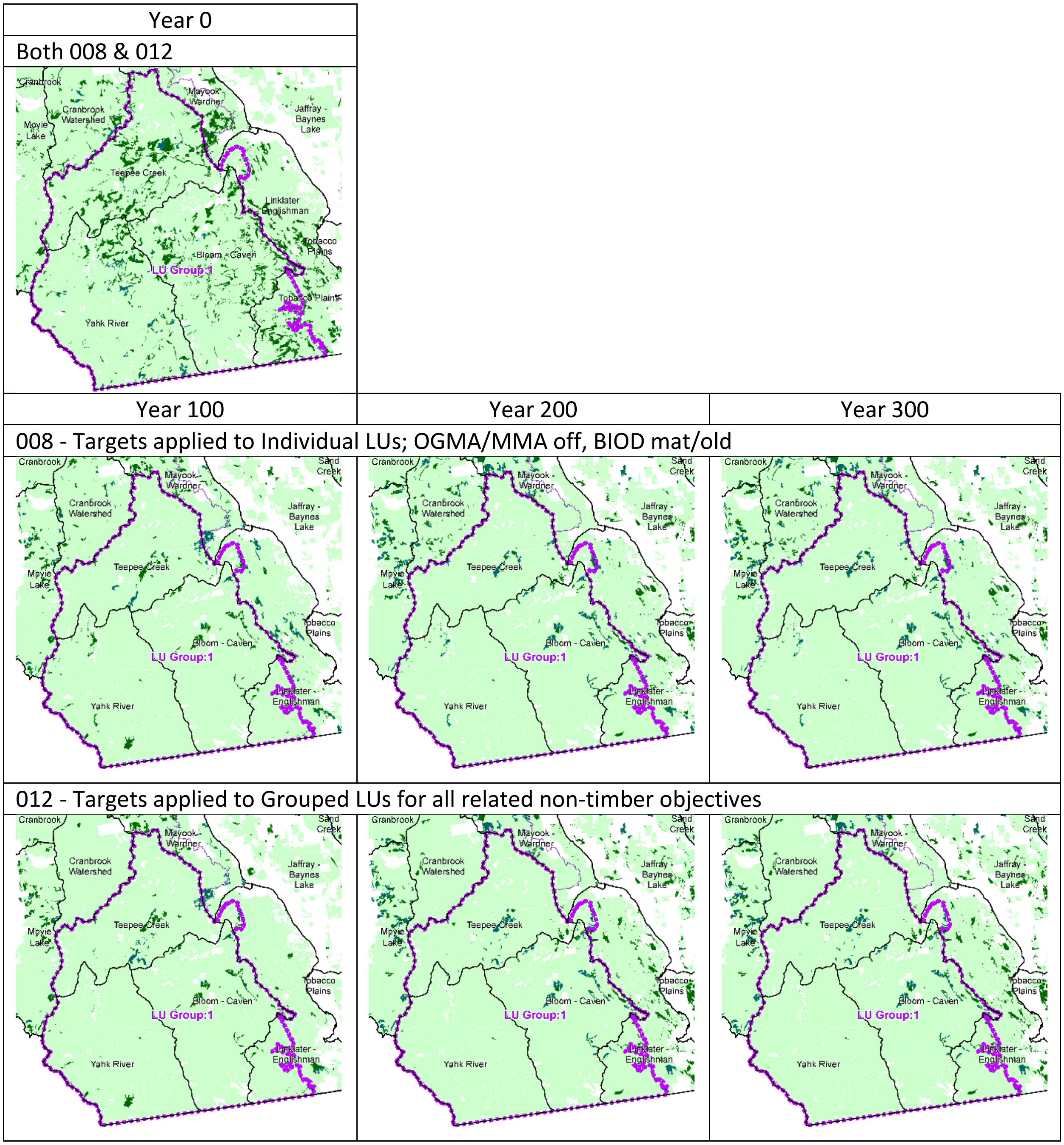


Figure D ***Comparison of THLB indicators (i.e., area retained as old forest, standing volume, site index, and average unit volume retained over time) where targets are applied as Individual LUs (008) and as Grouped LU #4 (011/012)***

The uniformity of the THLB area retained as old seral was also observed spatially (see Figure E, below). In the example below (LU group 1; FMLB = 104,935 ha), there were only minor changes with Individual LUs (008) and Grouped LUs (012) at various periods over the planning horizon. It could be argued that, in the absence of early seral patch objectives, the model was able to group THLB areas retained as old seral slightly better with Individual LUs (008) than with Grouped LUs (012) because: (i) the THLB area retained as old seral was larger with Individual LUs (008), and (ii) the reporting unit sizes were smaller (i.e., fewer options for the model in scenario 008).



Note: solid black lines = individual LUs; dashed purple lines = grouped LUs (#1); dark green polygons = old seral retained in THLB; light green polygons = remaining FMLB.

Figure E Comparison of the spatial distribution of old seral forest forecasted at time 0 and years 100, 200, and 300, with minimum old seral targets applied to Individual LUs (008) and Grouped LUs (012)

It is important to note that, regardless of the LU grouping, the heuristic nature of the model used in this analysis retained similar THLB as old seral forest, in terms of quality and spatial location, to meet non-timber objectives. Most of the old seral THLB was selected by the model fairly early (i.e., by year 100 of the planning horizon) and maintained these as old THLB for the rest of the planning horizon. This is another indication of the uniformity THLB area retained as old seral by the model.

Discussion

Increasing the reporting unit area used to assess forest-level requirements does not always produce the expected result of providing more flexibility to the model that translates to an increase in harvest flow. Depending on the land base, there can be many factors involved with modelling multiple, overlapping forest-level requirements. In this case, Grouping LUs relieved constraints for some units, but not enough to overcome those for other overlapping requirements, like ECAs and VQOs. Moreover, pre-established factors like the current spatial distribution of age classes across the landbase and the distribution of natural disturbance applied within the NHLB, impacted the model's ability to redistribute harvested areas that increase harvest levels over time, while respecting all of the other non-timber objectives applied.