Integrated Stewardship Strategy for the Stuart TSBs (A, B, C) in the Prince George TSA

Analysis Report

Version 1.1

March 31, 2018

Project 419-37

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Executive Summary

This report summarizes the results for the Integrated Stewardship Strategy (ISS) scenarios conducted to date for the Stuart Timber Supply Blocks (A, B, C) in the Prince George Timber Supply Area. The ISS Base Case scenario included most assumptions used in the latest 2008 Timber Supply Review (TSR) but updated others associated with riparian reserves, wildlife management (white pelican, grizzly bear, and Northern Caribou), tenures (First Nations Woodlot Licences – Nak'azdli, Tanizul, and Yekooche; Quantum Treaty (Yekooche Area of Interest)), fisheries sensitive watershed management, mountain pine beetle management, and patch sizes for mature plus old pine leading stands. The reserve scenario explored tactics aimed to maintain the harvestable area while providing a wide range of values on the land base by overlapping or co-locating these values where possible. The harvest scenario explored tactics to improve harvesting opportunities to alleviate mid-term harvest decline.

The ISS Base Case Scenario identified a long-term timber harvesting land base (THLB) was estimated to be 1,032,728 ha, which is approximately 4.7% below the TSR Benchmark scenario (which attempted to mimic the latest TSR). The important differences between the TSR and ISS land base definition include wildlife habitat areas and new tenures. These land base differences, plus refined yield assumptions for mountain pine beetle infested stands and additional management assumptions, resulted in harvest rate decreases of 23% over the short- and mid-terms and 11% over the long-term.

The non-timber objectives in the ISS Base Case scenario that impacted the harvest the most include ungulate winter range habitat and visual quality objectives. New requirements modelled for fisheries sensitive watersheds and caribou migration corridors were not at all constraining.

Potential impacts from the federal Caribou Recovery Strategy was also explored in the ISS Base Case scenario. Very significant impacts (28% in short- and mid-term, and 20% in long-term) on harvest rate resulted when a maximum disturbance level of 35% was maintained for the Chase and Wolverine herds. Further assessments are needed to refine the impacts of meeting provincial and federal recovery strategies.

Thirteen Access Timing Constraint zones (6,276 ha THLB) were mocked up as wilderness areas and grizzly bear habitat to explore harvest restrictions over 35-year cycles. These had a minor impact on harvest rates (1.2% harvest decrease in the short-term).

The non-timber objectives developed by the Tl'azt'en First Nation on nine fisheries sensitive watersheds had minor impacts on the overall harvest rates (1.4% harvest decrease in the short-term).

The reserve scenario indicated that in most assessment units, the non-harvestable land base already meets old seral and interior old forest requirements. However, approximately 5,000 ha (<1%) of THLB area was required to meet these requirements. Further refinement of this strategy is needed to limit the selection of THLB area and to assess the candidate reserves to ensure they accurately address interior old forest requirements.

The harvest scenario indicated that revised minimum harvest criteria (i.e., minimum 100 m^3/ha on slopes up to 35% and a haul cycle time of up to 3 hours) aimed to salvage mountain pine beetle infested stands increased the harvest flow by approximately 185,000 m^3/year (7.6%) in the short-term (no impacts on mid- and long-term). In the first 20 years of the planning horizon, an average of 118,000 m^3/year were sourced solely from the mountain pine beetle infested stands with relaxed minimum harvest criteria. The harvest scenario also indicated that harvest openings can be grouped into larger sizes without compromising the harvest flow. Turning off the harvest partitions aimed to encourage pine salvage and limit the volume generated from deciduous leading stands did not result in significant harvest gains.

Advantages of the silviculture tactics include higher growing stands, younger minimum harvest ages, and harvest eligibility for rehabilitated stands which otherwise would not have been harvested. These advantages allowed to model to shift harvested stands throughout the planning horizon and address key periods where available volume is low (e.g., mid-term). The silviculture scenario indicated that a budget of $3 million per year could be spent in the first 20 years of the planning horizon to make use of the silviculture tactics advantages and significantly increase the harvest flow by 7% in the short-term and 6% in the long-term. Over the first 20 years, expenditures on fertilization and enhanced basic silviculture treatments increased, while rehabilitation decreased.

The Combined Scenario considered key elements from all other scenarios to develop a desirable harvest flow that reflects the interactions of all the tactics explored. In the short-term, the harvest flow for the Combined Scenario was 7.6% higher than the Base Case Scenario, and 7.5% higher in the long-term. Candidate reserves were locked from harvesting for the first 40 years of the planning horizon and harvest opening sizes were aggressively controlled to reduce the amount of small openings (i.e., <5 hectares). Prioritizing the harvest on stands identified with extreme wildfire fire threat contributed to a 43% reduction in the salvage of MPB impacted stands. Given the current harvest system profile, the Combined Scenario harvest flow relies on approximately 38% of the harvest coming from stands identified as cable ground (≥64% slope).

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

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List of Abbreviations and Acronyms

AAC	Allowable Annual Cut
AD	Anthropogenic Disturbance
AOI	Area of Interest
ATC	Access Timing Constraints
BEC	Biogeoclimatic Ecosystem Classification
BUF	Buffered Areas (road and harvest)
ECA	Equivalent Clearcut Area
FMLB	Forest Management Land Base
FNWL	First Nations Woodlot Licence
FSW	Fisheries Sensitive Watershed
GIS	Geographic Information System
ISS	Integrated Stewardship Strategy
ISS Base Case	ISS Base Case Scenario
LUP	Land Use Plan
MHC	Minimum Harvest Criteria
MPB	Mountain Pine Beetle
NHLB	Non-Harvestable Land Base
NRL	Non-Recoverable Losses
THLB	Timber Harvesting Land Base
TSA	Timber Supply Area
TSB	Timber Supply Block
TSR	Timber Supply Reserve
UWR	Ungulate Winter Range
VQO	Visual Quality Objective
WHP	Wildfire and Harvest Priorities

Document Revision History

Version	Date	Notes/Revisions
1.0	Sep 30, 2017	First version distributed to project team for review and comment.
1.1	Mar 31, 2018	Changed project name from 'Integrated Silviculture Strategy' to 'Integrated Stewardship Strategy'; added Document Revision History; incorporated comments from project team; corrected several spelling errors; added discussion for silviculture and combined scenarios (sections 6 and 7).

1 Introduction

This document summarizes the results for the Integrated Stewardship Strategy (ISS) scenarios conducted for the Stuart Timber Supply Blocks (TSB) (A, B, C) in the Prince George Timber Supply Area (TSA). This includes the following scenarios: Base Case, Reserve, Harvest, and Silviculture.

The ISS Base Case is a two-step process that first develops a model to mimic the assumptions applied in the latest Timber Supply Review (TSR). The TSR Benchmark 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 scenarios introduced new tactics aimed to achieve the following objectives:

- Reserve Scenario - maintain the harvest area while providing a wide range of values on the land base (i.e. co-location).
- Harvest Scenario - improve timber harvesting opportunities.
- Silviculture Scenario - enhance timber quantity and quality over the mid- and long-term, as well as, improve biodiversity, wildlife habitat, and cultural interests.

Assumptions for these forest level modelling exercises are documented in a data package[1].

The Combined Scenario includes 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.

Note that some graphs presented below were copied directly from reports generated by the model and are 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 Land Base Definition

The land base definition for the ISS Base Case (Table 1) shows a long-term Timber Harvesting Land Base (THLB) of 1,032,728 ha, which is approximately 51,448 hectares (4.7%) below the TSR Benchmark. The major differences between the two land bases are discussed below.

[1] Forsite Consultants Ltd. 2018. Integrated Stewardship Strategy for the Stuart TSBs (A, B, C) in the Prince George TSA – Data Package. Version 1.1. Project 419-37. March 31, 2018. 40pg.

Table 1 Stuart ISS Base Case Land Base Definition

Land Base element	Total Area (ha)	Effective Area (ha)*	% Total Area	% FMLB
Total Crown area	**3,178,261**	**3,178,261**		
Less:				
Non-Forest	516,380	516,380	16.2%	
Roads, Rail, Utilities Corridors	18,837	17,039	0.5%	
Low Site Index	535,660	535,660	16.9%	
Fed/Private/Non-TSA	226,825	112,901	3.6%	
First Nations Tenures	102,685	88,235	2.8%	
John Prince Research	13,035	12,132	0.4%	
Forest management land base (FMLB)		**1,895,914**	**59.7%**	
Less:				
Agriculture Development Area	4,229	3,959	0.1%	0.2%
Misc Lease/Protected Area	421	143	0.0%	0.0%
Settlement Reserve Area	1,979	1,835	0.1%	0.1%
Parks and Reserves	185,120	127,172	4.0%	6.7%
Ungulate Winter Range (UWR) approved	387,967	73,801	2.3%	3.9%
Grizzly	2,071	6	0.0%	0.0%
Pelican	498	441	0.0%	0.0%
FSW (No Harvest Zones)	855	699	0.0%	0.0%
Uneconomic -Low Volume Pine	52,546	35,981	1.1%	1.9%
Uneconomic - Low Volume Other	1,489,741	307,876	9.7%	16.2%
Uneconomic -Haul Distance	268,959	34,753	1.1%	1.8%
Uneconomic -Steep Slope	239,883	16,465	0.5%	0.9%
Uneconomic - Elevation	578,320	7,064	0.2%	0.4%
Uneconomic -Problem Forest Type	4,190	1,437	0.0%	0.1%
Riparian Buffers	420,619	90,272	2.8%	4.8%
Uneconomic - Isolated	1,193	1,193	0.0%	0.1%
Spatial THLB		**1,192,816**	**37.5%**	**62.9%**
Less Non spatial Netdowns*:				
Stand Level MPB Conservation Uplift		88,552	2.8%	4.7%
Stand Level Retention (in-block and matrix - 4.5%)		53,677	1.7%	2.8%
Effective THLB		**1,050,588**	**33.1%**	**55.4%**
Less Future Non-Spatial Netdowns**:				
Future permanent roads (1.7%)		17,860	0.6%	0.9%
Effective future THLB		**1,032,728**	**32.5%**	**54.5%**

* Aspatial netdowns are applied in the model but are not reflected in the Geographic Information System (GIS) dataset areas.

** To be applied with a yield table reduction.

2 Important Differences between TSR Benchmark and ISS Base Case

Table 2 summarizes key differences observed between the TSR Benchmark and ISS Base Case. The relative harvest impact is depicted as increasing (green arrow), decreasing (red arrow), or remaining neutral (yellow circle); increasing significance depicted with thicker arrows.

Table 2 Important differences between TSR Benchmark and ISS Base Case

Assumption/Factor	TSR Benchmark	ISS Base Case	Harvest impact on ISS
Riparian Reserves	Included in Aspatial Netdown	Removed from Aspatial Netdown (7.6%) Included spatially 90,272 ha net impact	●
Habitat Areas	Not modelled.	**Removed From THLB:** Draft White Pelican (441 ha net) Draft Grizzly Bear (6ha net) Draft Northern Caribou (33,852 ha net) **Constrained in Model (still in THLB)** Provincial Caribou (Post Rut, Migration, Calving areas)	↓
New Tenures	Not modelled.	Removed 88,235 ha (net Nak'azdli First Nations Woodlot Licences (FNWL; two areas) Tanizul FNWL Yekooche FNWL Quantum Treaty (Yekooche Area of Interest [AOI])	↓
Watershed Equivalent Clearcut Area (ECA)	Not modelled	699 ha net removed from THLB 15 areas with Base ECA targets (176,594 ha) 9 areas with Special Tl'azt'en ECA targets (as sensitivity)	● and ↓ Basic ECA targets are non-constraining
Caribou Habitat	Not modelled	Maintain maximum 65% disturbance within identified habitat boundaries; done as a post-processing assessment.	↓
Pine Beetle Management	Included Decline Curves for MPB	Included regeneration curves as understory for MPB impacted stands	↑
Patch Size for Mature plus Old Pine Leading Stands.	Not modelled.	Modelled for reporting purposes, but not constrained in Base Case. Targets may be implemented as a sensitivity. Model size/memory requirements limited analysis to natural disturbance type resolution, rather than landscape unit/Biogeoclimatic Ecosystem Classification (BEC).	●
Access Timing Constraints (ATC)	Not modeled	Added areas where 30% of the THLB can be harvested on a 35 year pass system.	●

3 ISS Base Case Scenario

3.1 Timber objectives

The harvest flows for TSR Benchmark and ISS Base Case Scenarios are compared in Figure 2, and account for non-recoverable losses (NRL) prorated from the TSR5 for the Prince George TSA relative to the area of Stuart TSBs (Table 3). In the short-term, the ISS Base Case harvest flow is approximately 731,000 m^3/year (23%) lower than the TSR Benchmark. In the long-term, the ISS Base Case harvest flow is approximately 419,000 m^3/year (11%) lower than the TSR Benchmark.

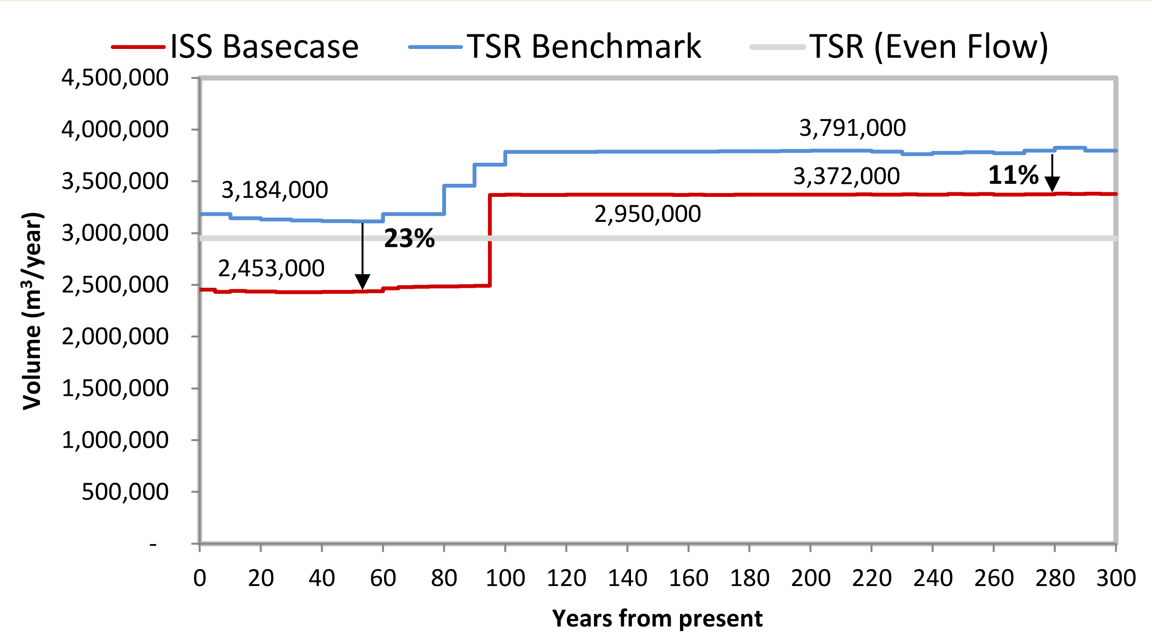


Figure 1 Comparing Harvest Flows for TSR and ISS Base Case Scenario

Table 3 Non-recoverable Losses within the THLB

Variable	Volume (m³/yr)
NRL through midterm (95 years)	147,722
Long-term NRL	159,120

Some of the harvest flow difference is explained by a reduced THLB (the ISS Base Case is 4.7% lower than the TSR Benchmark) and an increase in non-harvest constraints (habitat and FSW). The ISS Base Case used a more complex, and arguably more accurate, algorithm to estimate MPB regeneration. Consequently, the long-term flow was achieved earlier. Furthermore the pine retention uplift persisted throughout the entire planning horizon which increased the in-block retention by 88,000 ha. One factor that dampened the effects of the increased constraints was an analysis of Haul Distance and available roads to further classify the haul distance allowance. This decreased the THLB impact from Haul Distance from 4.75% to 1.1%.

The THLB growing stock in Figure 2 shows a reduction of 21% in the short-term, and virtually no change over the long-term. This can be explained by the increased retention and decreased THLB in the short-term. In the long-term the difference is due to increased constraints within the THLB (which is still considered growing stock, but is unavailable).

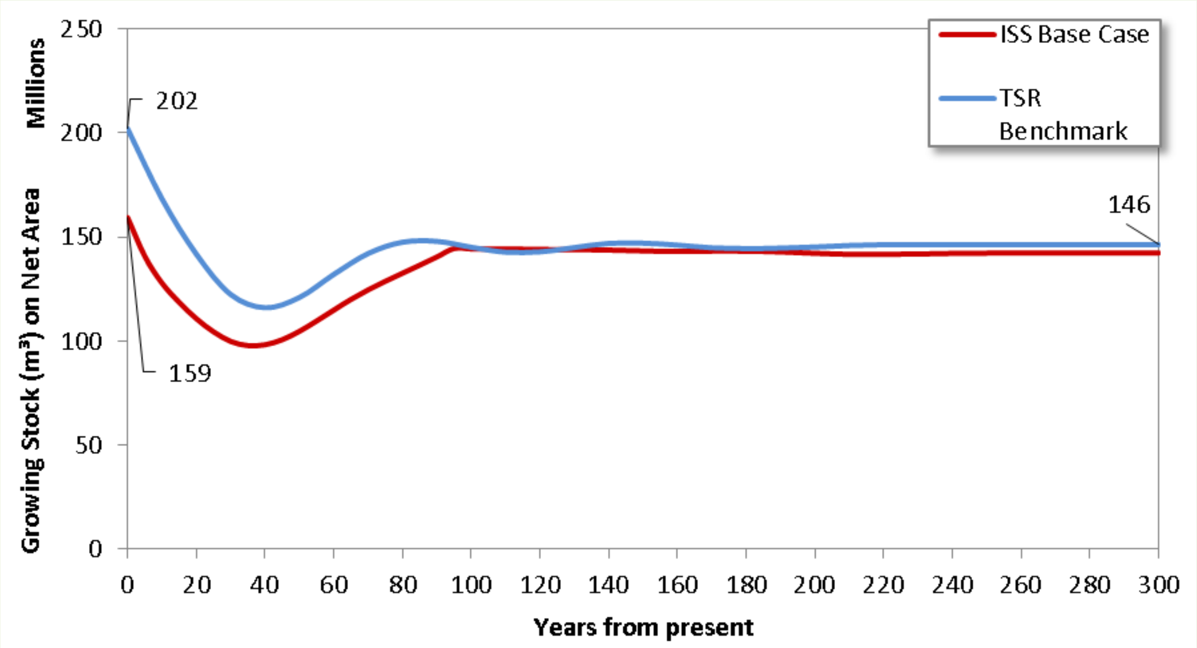


Figure 2 Comparing THLB Growing Stock for TSR and ISS Base Case Scenario

Harvest partitions in the ISS Base Case were successfully controlled in this analysis (Figure 3). During the first 10 years of the 300-year planning horizon, the model was instructed to generate at least 80% of the volume from the pine-leading stands. In addition, the model was limited to approximately 5.6% of the harvest coming from deciduous stands throughout the planning horizon. For the next 20 years following MPB salvage (periods 3 to 6), most of the volume will be sourced from balsam- and spruce-leading stands.

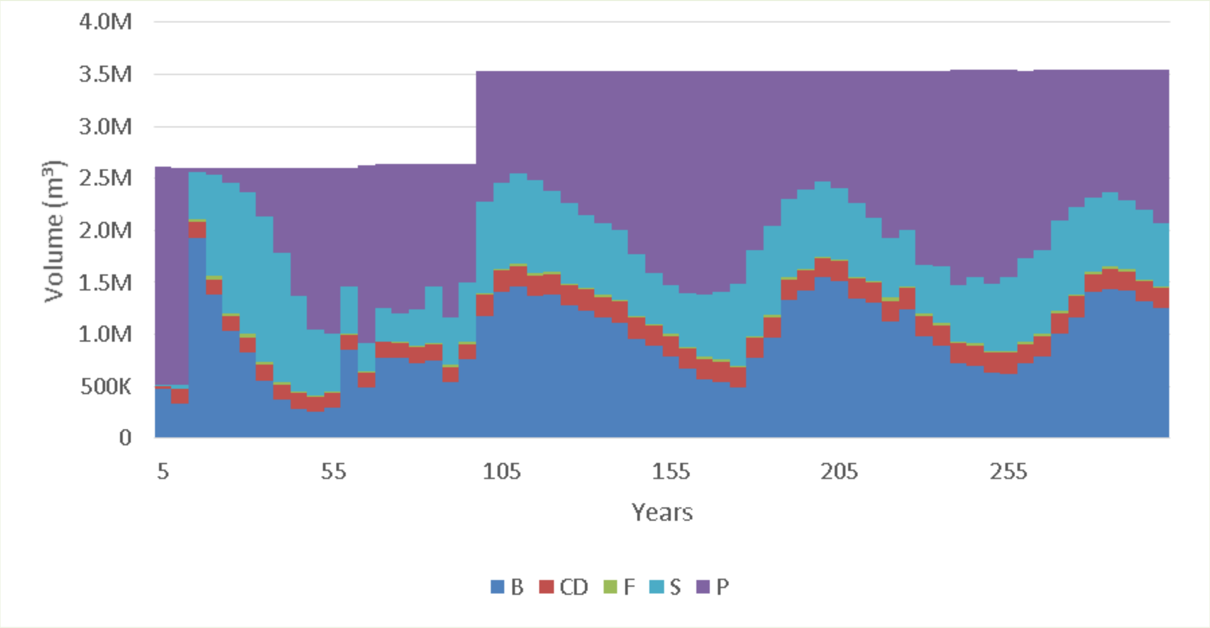


Figure 3 ISS Base Case Annual Harvest Flow by Leading Species

As harvest shifts from natural stands – MPB-impacted stands – to more productive managed stands, the harvest volume per hectare (Figure 4) shows a steady increases over the planning horizon. Over the MPB salvage period, the average age of stands being harvested was between 165 and 170 years (forced as 80% pine harvest in the first 10 years), followed by higher harvest ages (up to 218 years) over the next 30-40 years. These results suggest that the model targeted relatively old pine stands during the salvage period. Post salvage period, the model targeted relatively old subalpine fir and spruce stands. In the long-term, the model harvested more productive managed stands that reached relatively high volumes at younger ages, compared to the natural stands. Therefore, the average harvest age stabilized at 80 years.

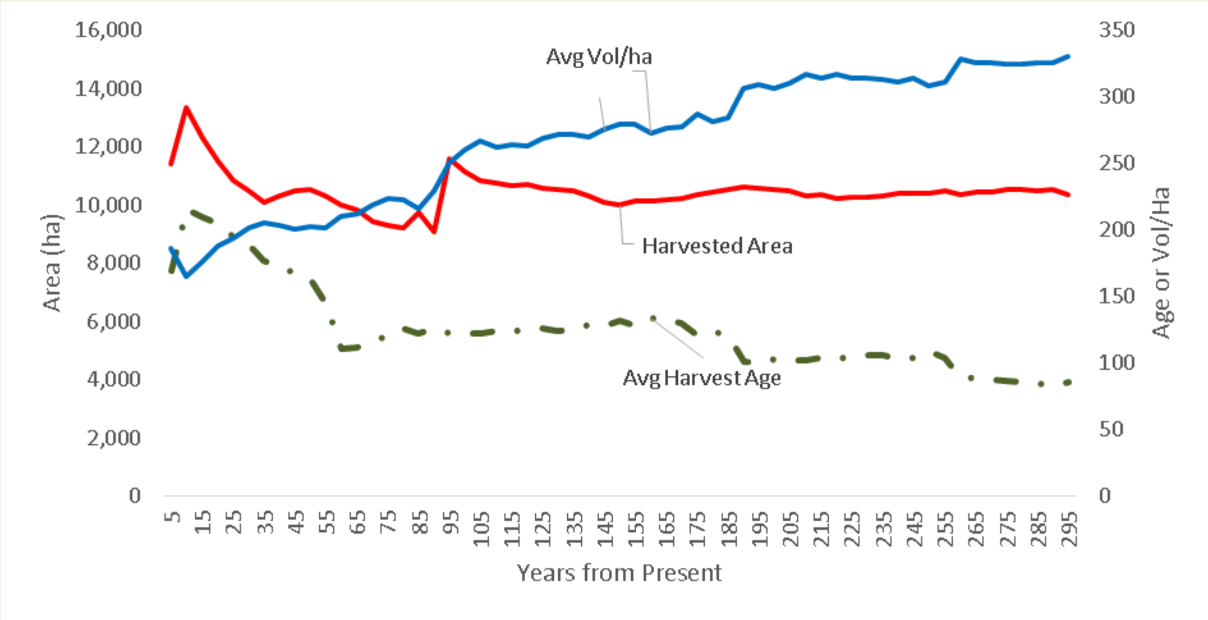


Figure 4 Comparing Harvested Area with Average Harvest Age and Volume

The age class distribution indicates that the THLB transitioned from a relatively mature and old structured forest to a relatively young structured forest (Figure 5). This is in line with the expected changes over time as the model converts most of the THLB to a relatively regular forest estate. Note that there are approximately 144,000 ha THLB that were never harvested because following the MPB, the regenerated stands did not reach the minimum volume requirement (i.e., 140 m³/ha). These are MPB-infested old stands (>250 years) whose yields were not projected long enough into the future to capture the full regeneration. Within the non-harvestable land base (NHLB), the area disturbed cycles through age classes over time, yet most of the NHLB area is older than 240 years.

Figure 5 ISS Base Case Area over Age Classes in Year 0, 50, 100, and 200 of the Planning Horizon

3.2 Non-Timber Objectives

Non-timber objectives modelled in the ISS Base Case scenario included landscape-level biodiversity, equivalent clearcut area (ECA) for fisheries sensitive watersheds (FSW), visual quality objectives (VQOs), and wildlife objectives.

3.2.1 Landscape-level Biodiversity Objectives

The landscape-level biodiversity objectives required certain FMLB area percentages to be maintained in old condition. These requirements were developed for a combination of BEC units called Merged BEC (mBEC). There was also a requirement that a percentage of the old forest be maintained as interior old, and as non-pine leading for five mBEC units.

None of the old seral targets were constraining in the model. Some examples are included in Figure 6 and Figure *7*. Minimum targets are indicated by the red shaded areas and maximum targets are indicated by the blue shaded areas. If a target is not achieved, the black line is either in the red or blue shaded area. Note that the Patchworks modelling system does not have a mechanism to control for interior forest. Thus, a post-processing GIS exercise along with increased patch size targets is recommended.

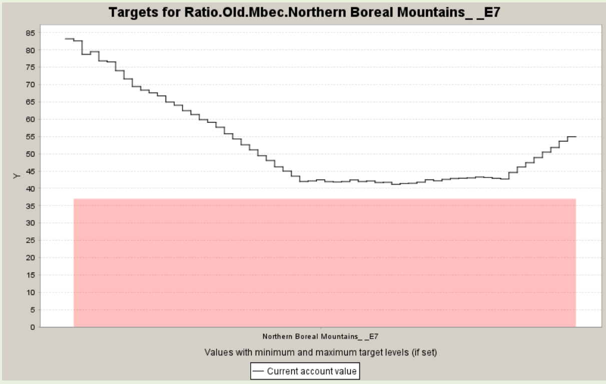


Figure 6mBEC E7 old target and value (%)

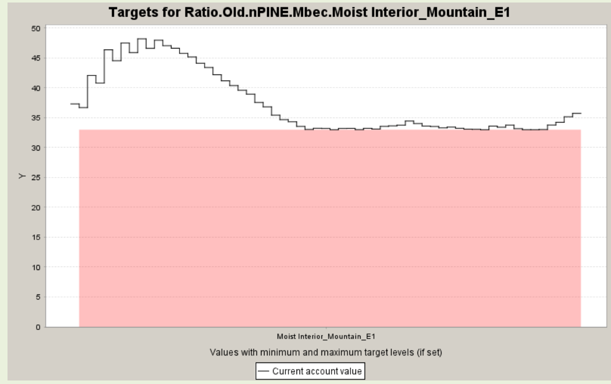


Figure 7mBEC E1 non-pine target & value (%)

3.2.2 Fisheries Sensitive Watersheds

Harvesting within FSWs was limited by ECA constraints based on stand height (existing and future managed stands) and stand percentage dead in MPB impacted stands. The targeted FSWs did not impact the harvest flow. Examples of FSWs that are closer to the maximum allowable ECA level (shaded blue) are shown in Figure 8. Significant areas of NHLB within FSWs allowed the model to schedule the spatially-explicit harvest blocks without exceeding the maximum ECA values or impacting the harvest flow.

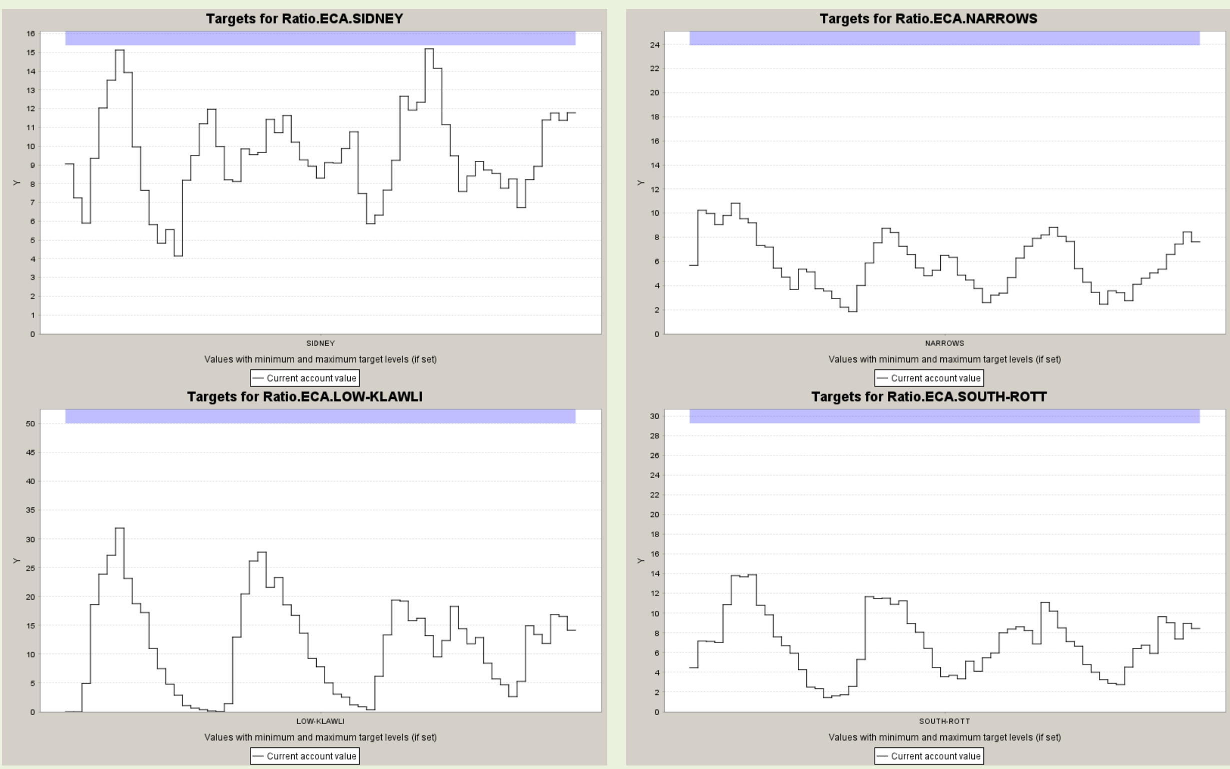


Figure 8 Example of ECA Targets (Height + MPB)

3.2.3 Visual Quality Objectives

VQOs were addressed using plan to perspective ratios and stand height curves based on age. Each VQO polygon was assigned a maximum disturbance target according to its recommended visual quality objective. Natural disturbance caused some polygons to violate their targets and some polygons started the planning period already constrained (Figure 9).

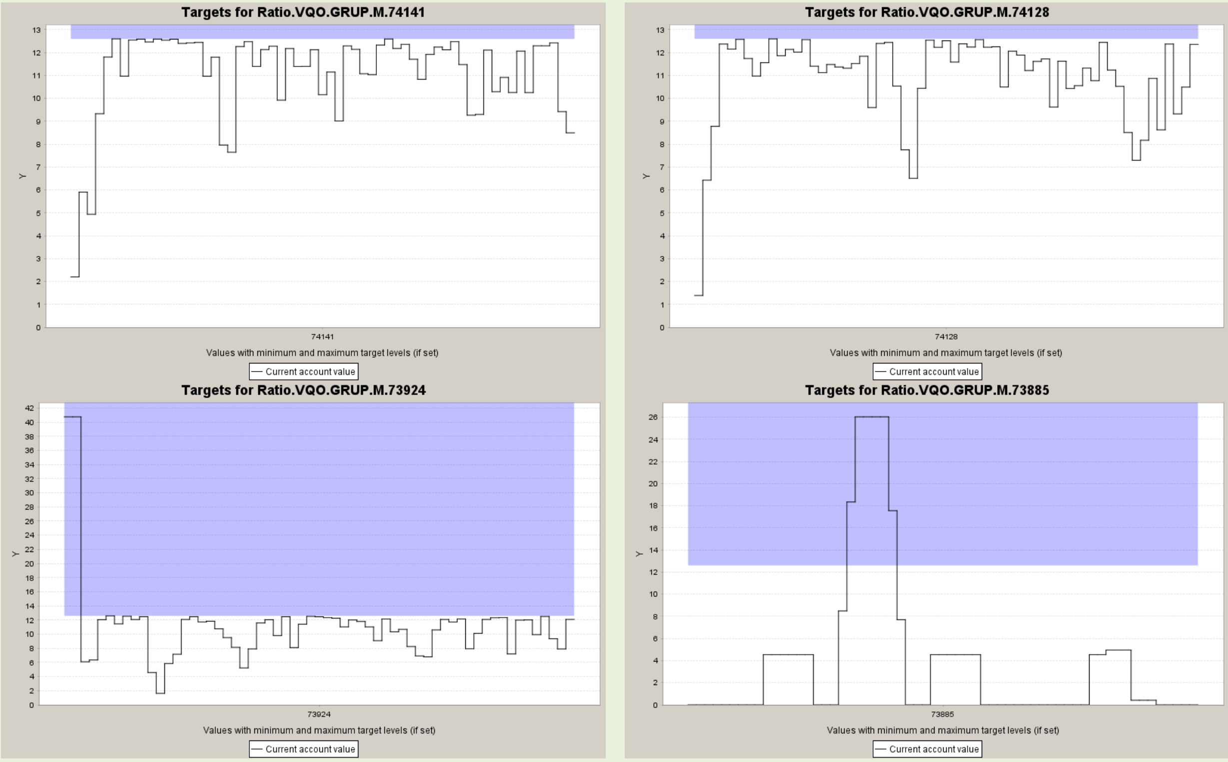


Figure 9 Examples of constraining Visual Quality Targets

3.2.4 Draft Caribou Habitat Areas

Draft caribou habitat areas for calving, migration corridors, and post rut were constrained within the model. No harvest was permitted within the calving and post rut areas but within the migration corridors, a disturbance threshold was applied of less than 35% for stands with 40 years since natural disturbance (fire), and 70 years since harvest. In some cases harvest was constricted, but as the model could choose a different spatial pattern this did not affect the harvest flow (Figure 10).

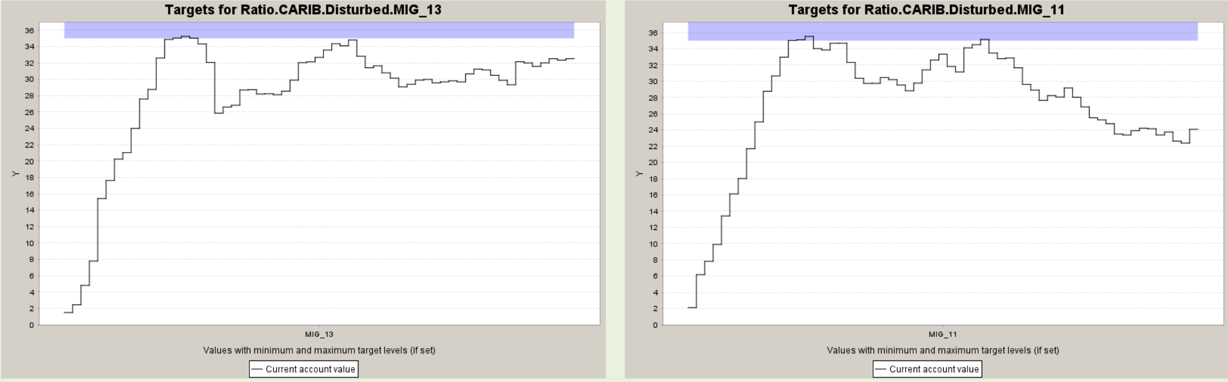


Figure 10 Caribou Migration Corridors

Other UWR habitat objectives constrained some of the harvest to areas older than 100 years, harvest flow was negatively impacted (Figure 11). The top graphs in Figure 11 show constraints on a maximum area less than 80 years. In the graphs below, a minimum area greater than 140 years was constraining.

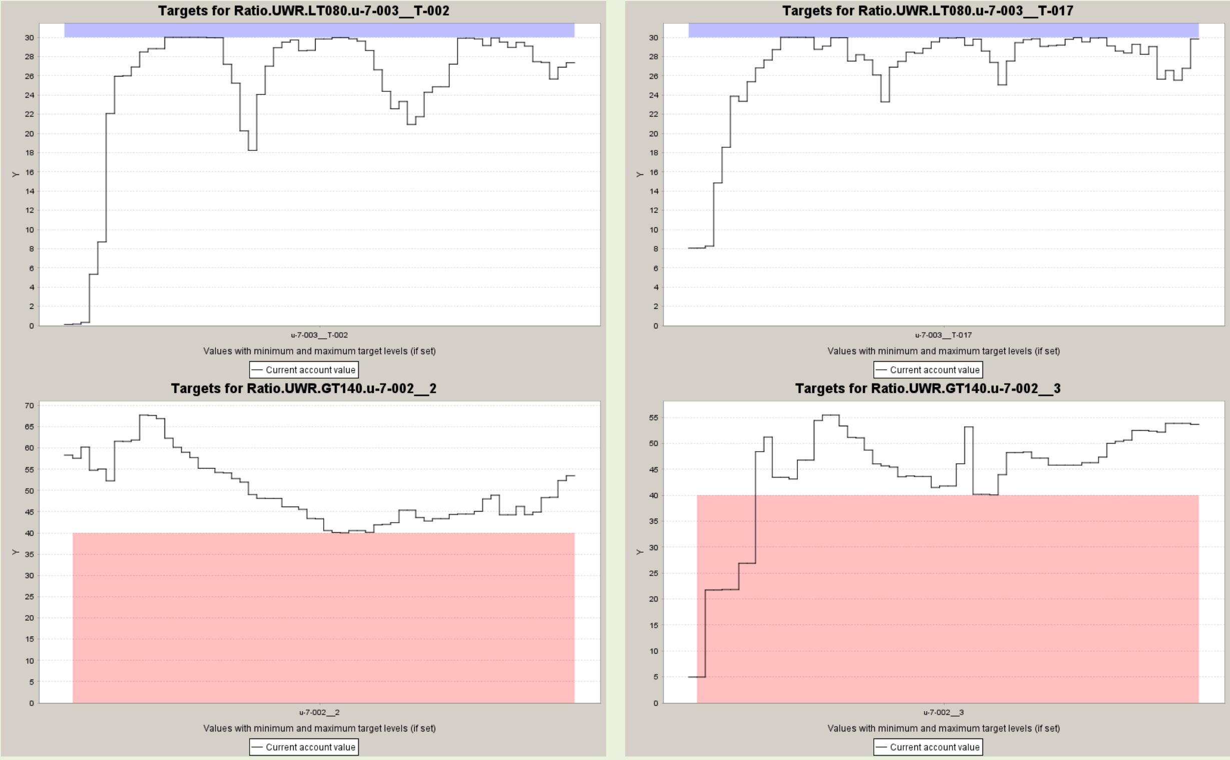


Figure 11 Examples of UWR Management Objectives Constraining the Harvest Flow

3.3 Caribou Habitat Assessment

Caribou habitat assessments were conducted as post-processing Geographic Information System (GIS) exercises that utilized modelled outputs at 7 periods along the 300-year planning horizon (P0 – initial, P1 – 5 years, P2 – 10 years, P4 – 20 years, P10 – 50 years, P20 – 100 years, and P40 – 200 years).

Disturbances were assessed either as anthropogenic or as natural. Anthropogenic disturbances (AD) were buffered by 500 m and include disturbed blocks <40 yrs old and permanent AD (camps, mines, linear features including existing and future roads). Natural disturbances (fires) were not buffered. After initial assessments, the harvest area was controlled in caribou habitats of each herd so that the disturbance level, including permanent AD and natural disturbances, did not exceed 35% (i.e., the maximum allowed disturbance level). In the case of the federal recovery strategy, the FMLB area under 40 years was capped at 10%, in each five-year period and within Chase and Wolverine herds. The FMLB area was not controlled within the Takla, Finlay, and Scott herd areas.

The results indicated that the overall harvest rate was reduced by 28% in the short-term and by 20% in the long-term (Figure 12). Only the disturbance level within the Chase provincial herd area was maintained under the 35% threshold when FMLB area under 40 years was controlled, compared to the initial assessment (Figure 13). Within the Wolverine provincial herd area, the disturbance control strategy was less successful because of the significantly larger area covered by the 500 m buffers (roads (rBUF) + harvest (hBUF)).

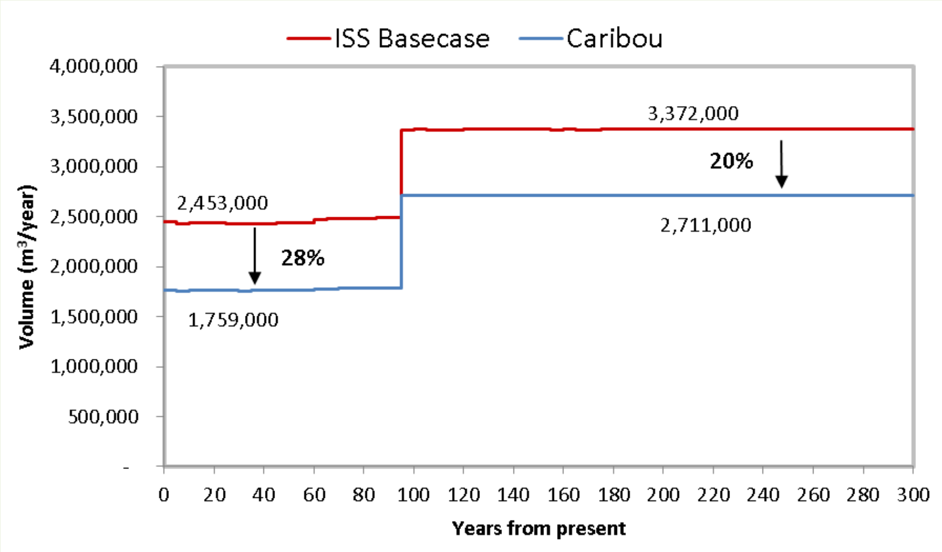
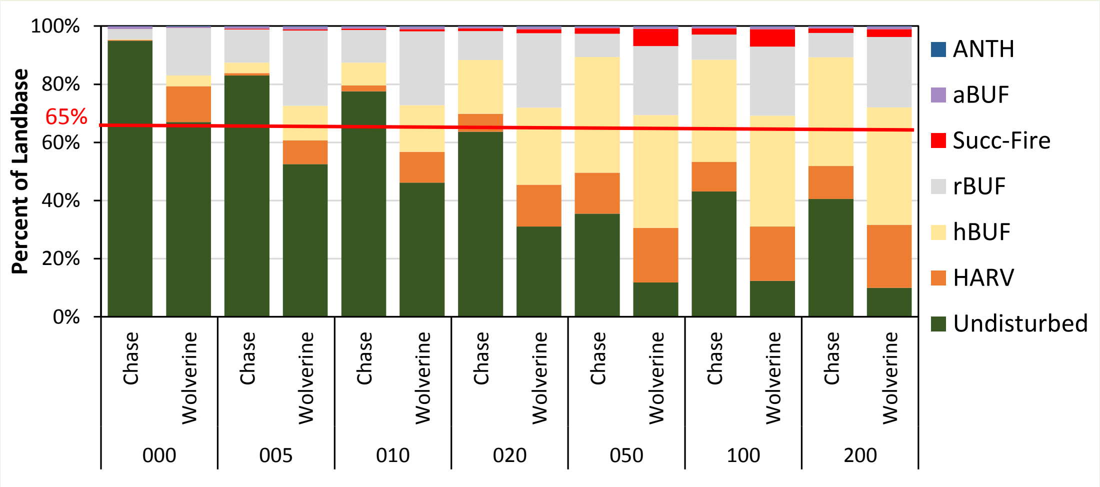


Figure 12 Comparing harvest rates for the Base Case and Caribou Assessment Iteration

No Harvest Control



Harvest Control (max 10% FMLB younger than 40 years)

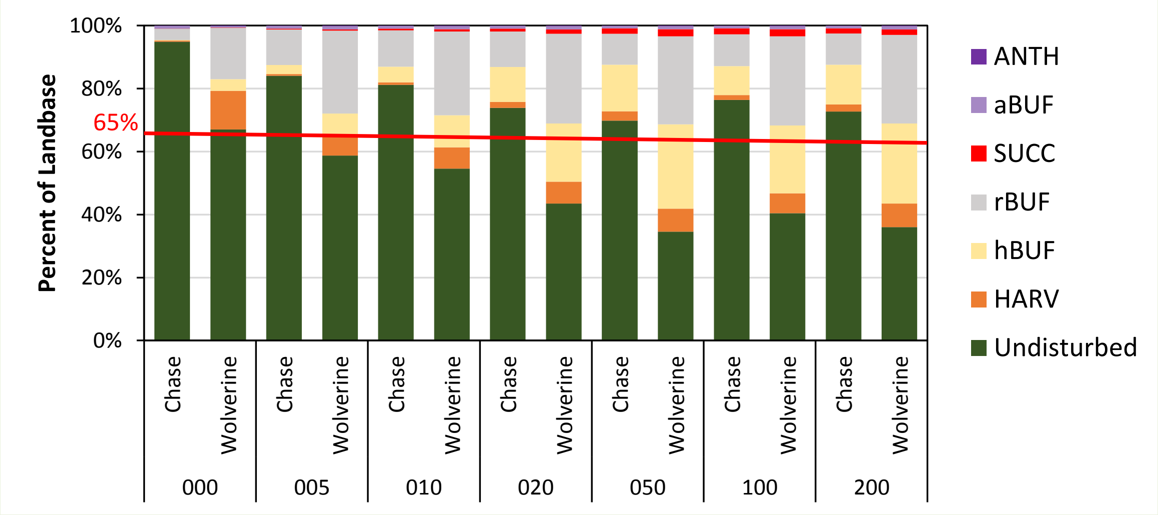


Figure 13 Disturbance Levels for Chase and Wolverine Provincial Herd Boundaries – without and with Harvesting Control

3.4 Access Timing Constraints

A sensitivity analysis was conducted to investigate the impact of access timing constraints (ATC) zones on harvest rate. The overarching goal was to promote a certain range of values and maximize long-term sustainability in each of the ATC zones. In this analysis, thirteen ATC zones were selected, which covered 6,276 ha of THLB. The model was set up such that in each of the ATC zones, harvesting capped at 30% of the THLB was only allowed one 5-year period every 30 years. Initially, the model was run with no ATC constraints to determine the first period where cumulated harvested area was ≥30% of the THLB; this was the first period when harvesting was allowed. Then, the ATC constraints were applied. For example, if the first 5-year period to be disturbed was period 1 (or model year 1-5), the next six 5-year periods (or 30 years) were set to a maximum 0% harvest area. In period 7 (or model years 36-40), a maximum harvested area of 30% of THLB was set again. This cycle was repeated throughout the 300-year (or sixty 5-year periods) planning horizon.

The results indicated a 1.2% harvest decrease in the short-term, and no differences in the long-term (Figure 14) while the harvest objectives in the ATC zones were not violated (Appendix 1).

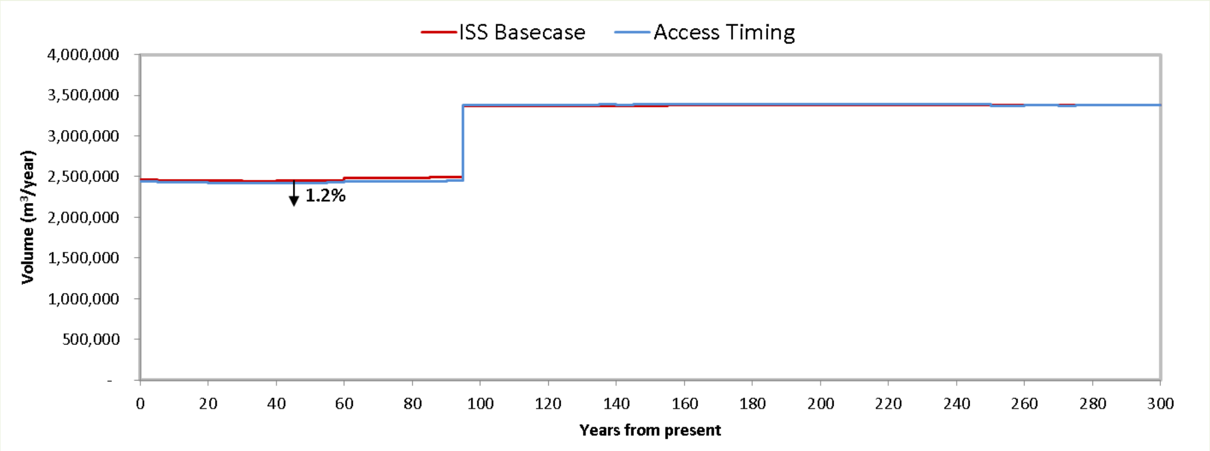


Figure 14 Harvest comparison between Base Case and ATC scenarios

3.5 Tl'azt'en ECA Targets

The Tl'azt'en First Nation prepared a Land Use Plan (LUP) that includes ECA targets using the same FSW boundaries as proposed above. The LUP includes significantly more constraining ECA targets for nine watersheds. When applying the Tl'azt'en ECA targets, the reduction to harvest flow in the short-term is 1.4% and none in the long-term (Figure 15). These targets are initially violated in four watersheds (Figure 16). Previous harvest decisions caused these watersheds to be violated at the beginning of the planning horizon, but they quickly recover and remain below the required thresholds, with the exception of the Sidney watershed. While the original target on the Sidney watershed is 5%, the target decreased to 0.017% after the inclusion of private land and anthropogenic disturbances. No harvesting was scheduled with such a low target but natural succession applied in the model caused Sidney watershed to be in constant violation throughout the planning horizon.

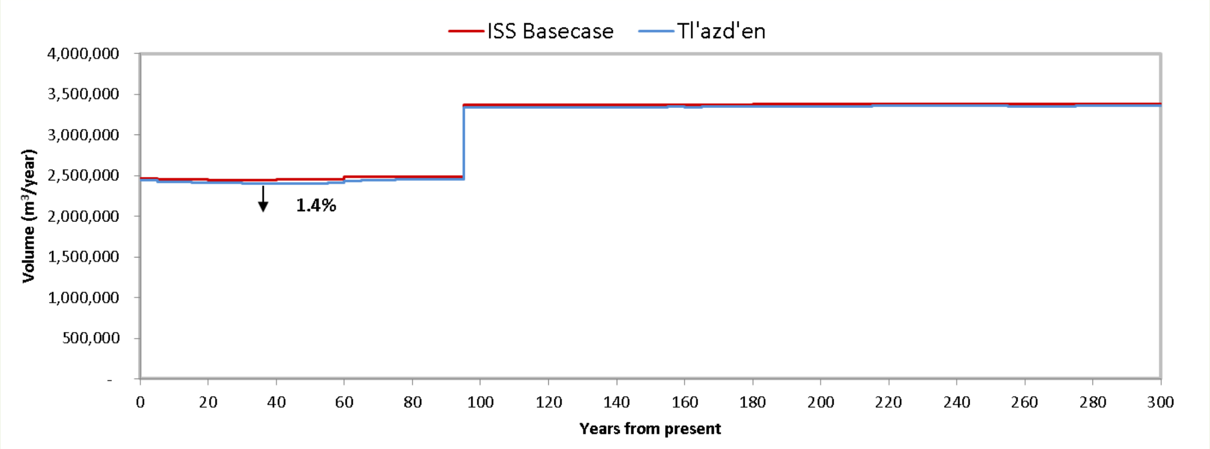


Figure 15 Harvest flow with Tl'azt'en ECA targets imposed

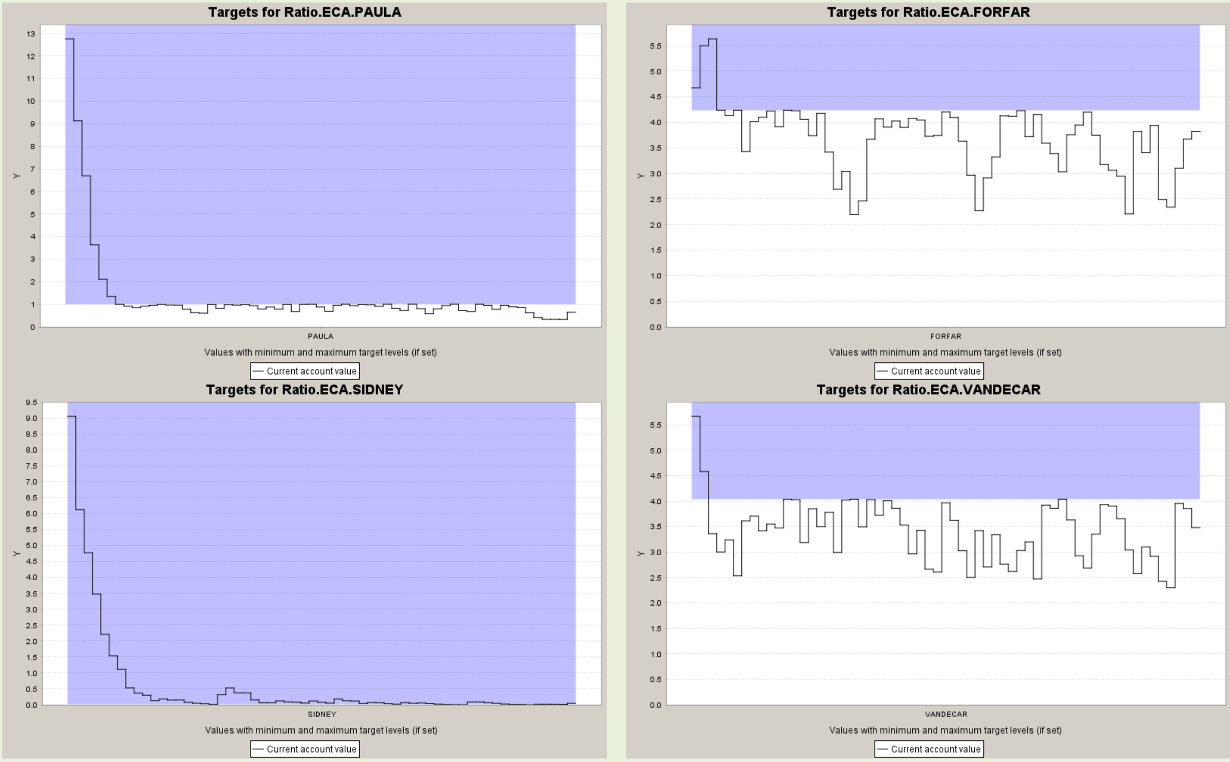


Figure 16 Violated Targets using the Tl'azt'en ECA

4 Reserve Scenario

4.1 Description

The Reserve Scenario aimed to answer the question, “Where and how should we reserve forested stands to address landscape-level biodiversity and non-timber values while minimizing impacts to the working forest?” Since landscape-level biodiversity objectives are addressed through non-spatial old growth orders, the underlying purpose of this scenario was to explore tactics aimed to maintain the harvest area while providing a wide range of values on the land base (i.e., co-location or overlapping requirements).

Initially, the Reserve Scenario was planned as a spatial exercise where the current forest conditions were assessed based on a scoring scheme for existing anchors (no harvest zones), management constraints (conditional harvest), and stand attributes (management state, seral stage, species composition, deadwood abundance, vertical complexity, tree height, rare ecosystems, and interior old forest). The candidate reserves would be assessed for the same units as the landscape-level biodiversity objectives (i.e., mBEC units). Preliminary results provided scattered reserves so a new approach was implemented as a modelling exercise using Patchworks™. The selection priority in each assessment unit was based on land base category (NHLB first and THLB second) and current seral stage (oldest first). NHLB anchors (i.e., no harvesting areas) were hard-coded into the model to ensure they will always be selected as reserves. Finally, the model was also encouraged to select the reserves that are currently interior old forest and group them into relatively large old seral patches over the entire landscape.

4.2 Results

The initial analysis indicated that in most assessment units (i.e., mBEC), there are large NHLB areas that can meet the old seral forest requirements (Figure 17). In order to meet the old seral requirements, the model occasionally had to select old THLB or mature areas (NHLB or THLB) (Figure 18). The THLB area selected as reserves was 5,186 ha (0.5% of total THLB). Note that there are large areas covered by mature stands that are shy of being classified as old stands.

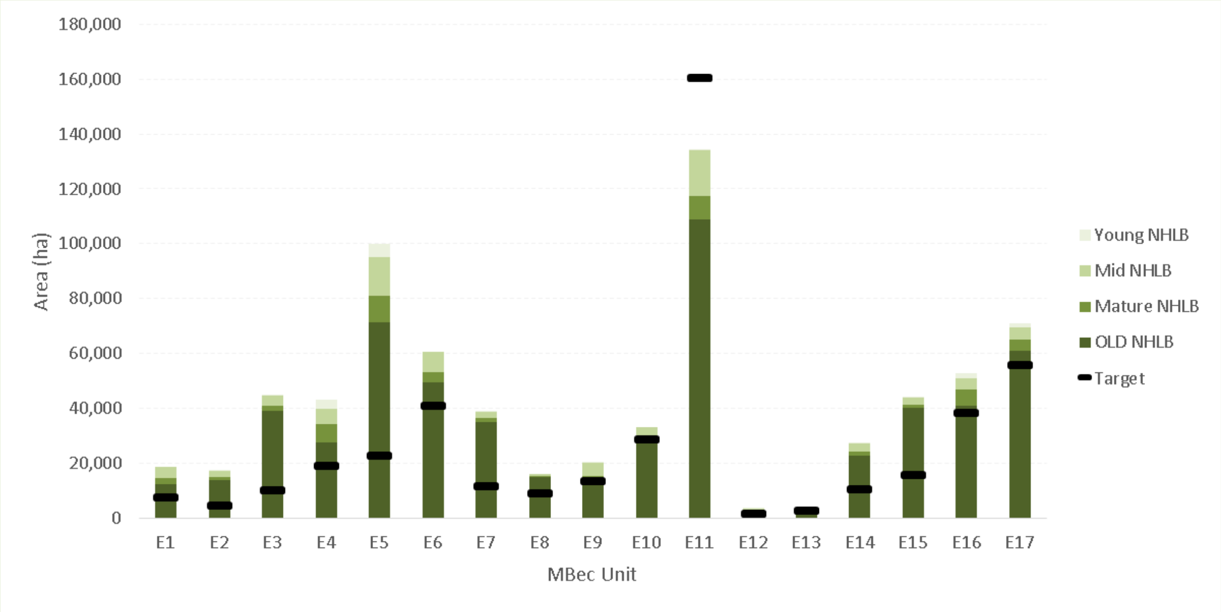
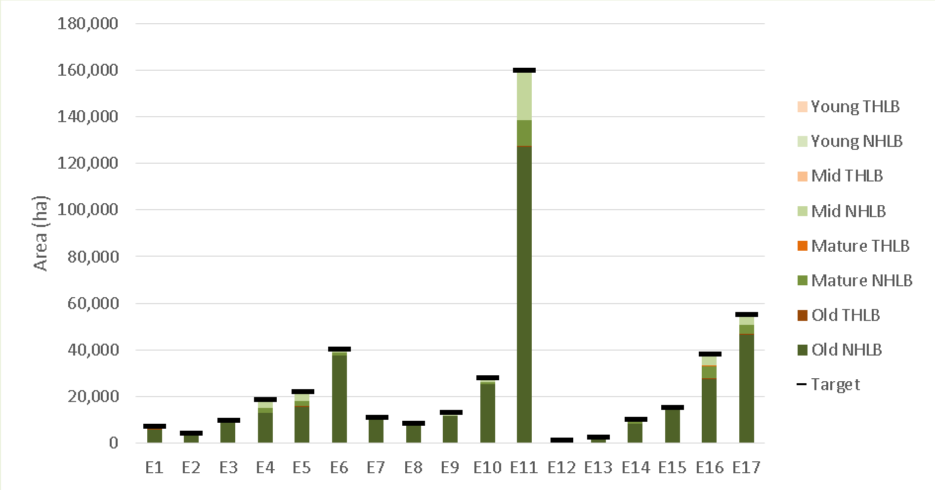
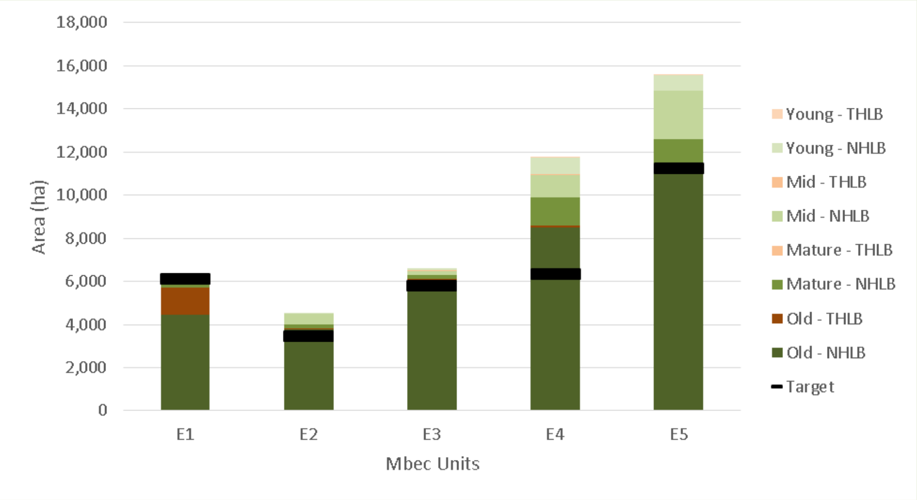


Figure 17 Distribution of the NHLB Area within Anchors (no harvest) Over the mBEC Units

Old Seral



Old from non-pine leading stands



Old Interior

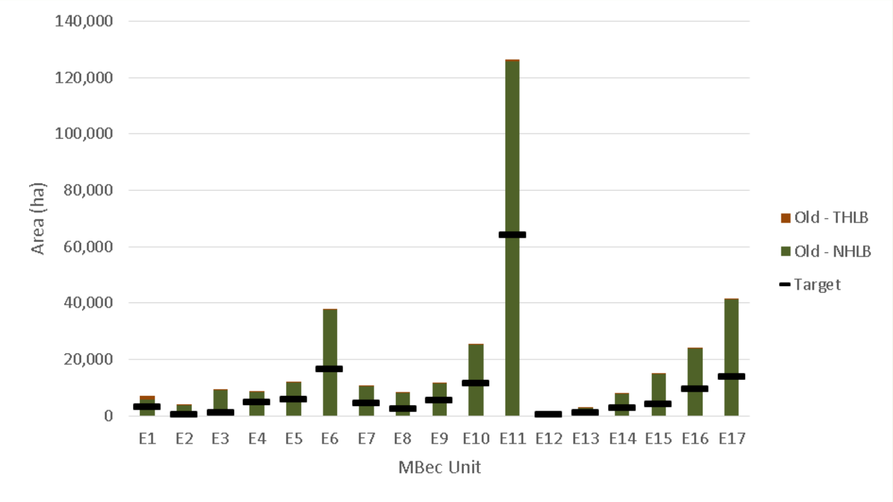


Figure 18 Reserve Scenario – Comparing the Area Selected as Reserves against the Landscape-level Objectives (Target)

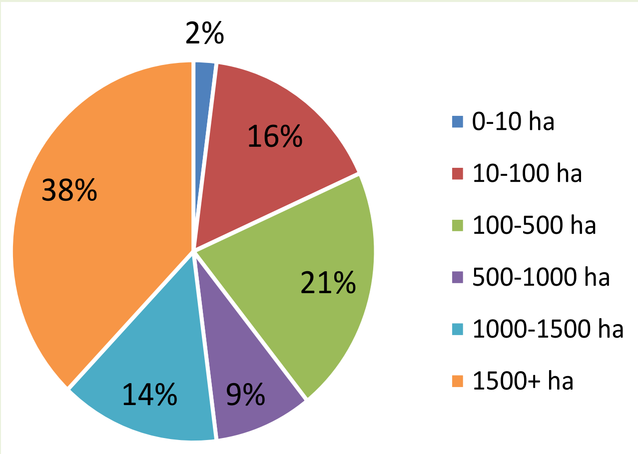


Figure 19 Area Distribution of Patch Sizes

Targets for larger patch sizes were also included in the model (Figure 19). There was downward pressure on stands 0-100 ha and upward pressure on stands 1,000+ ha in size. There were also targets set on the 'roundness' on the patches to attempt to increase the interior old area. This upward pressure caused some over-selection of reserves, and some non-old and THLB to be selected to fill in and create larger patches. In the end, this selection process identified areas with overlapping values to help and spatialize the non-spatial old seral targets. The results can now be used as a springboard for planners to create final old growth reserves by integrating local and on the ground knowledge.

5 Harvest Scenario

5.1 Description

The Harvest Scenario aimed to answer the question "Which stands should be prioritized for harvest/salvage in the short-term (and what are the mid/long-term consequences of not following this strategy)?" Besides salvage, the Harvest Scenario could also be used to illustrate differences in species profile that may occur if harvest is not distributed well (i.e., volume looks alright in the future, but economics become much more challenging). The underlying purpose of the Harvest Scenario was to explore tactics aimed to improve timber harvesting opportunities. Three tactics were explored: 1) modify minimum harvest criteria, 2) implement wildfire management methods, and 3) assign harvest priorities. Two models were built, one to explore the minimum harvest criteria and another to explore harvest priorities with wildfire management.

The minimum harvest criteria (MHC) set for the ISS Base Case scenario limited harvesting by slope (maximum 62%) and by volume (minimum 140 m^3/ha in pine leading stands and minimum 182 m^3/ha in non-pine-leading stands). In addition, the MHC tactics examined an opportunity for low volume salvage treatment of MPB-attacked stands (i.e., FLNRORD had identified 750k m^3/yr potential AAC for 20–year bioenergy tenures within the Fort St. James/Stuart district[2]). In this model run, the MHC criteria were reduced to a minimum of 100 m^3/ha on maximum 35% slope and the haul cycle time was set to maximum of 3 hours.

The wildfire management tactic aimed to incorporate stand- and landscape-level wildfire management strategies to mitigate wildfire risk. Harvest was prioritized for stands rated as 'extreme' risk through the 2015 Provincial Strategic Threat Analysis. These stands cover approximately 88,000 ha THLB. In addition, the fire loss mitigation through identified fuel breaks landscape-level strategy was addressed by prioritizing harvesting in coniferous-leading stands covering the identified fuel breaks. The coniferous-leading stands within identified fuel breaks cover approximately 101,000 ha THLB.

[2] https://www.for.gov.bc.ca/hth/timber-tenures/bioenergy/potential-tenure.htm

The harvest priority tactic aimed to influence the model to prioritize or limit harvesting under certain conditions. The wildfire and harvest priority (WHP) criteria turned off the pine and deciduous harvest partitions set for the ISS Base Case scenario (i.e., pine harvest had been set to minimum 80% during the first 10 years for the Base Case and deciduous harvest had been set to maximum 5.598% of the harvest volume for entire planning horizon). In addition, harvest opening sizes were controlled in each 5-year period without adversely impacting harvest flow.

5.2 Results

5.2.1 MHC Harvest Scenario

The MHC Harvest Scenario showed an increase of 185,269 m³/year (7.6%) in short-term harvest rate, with no significant change in the mid- and long-term harvest flow (Figure 20). The revised MHC did not add new stands to the THLB rather, the new criteria simply makes more stands available in the short-term. This added approximately 2.37 million m³ (average of 118,606 m³/year) to the harvest flow over the first 20 years of the planning horizon, denoted by treatment 'SALV' in Figure 21 (note that NRLs are not considered here). It is also noteworthy that the average harvest age did not change significantly despite a more relaxed MHC for the MPB stands (Figure 22).

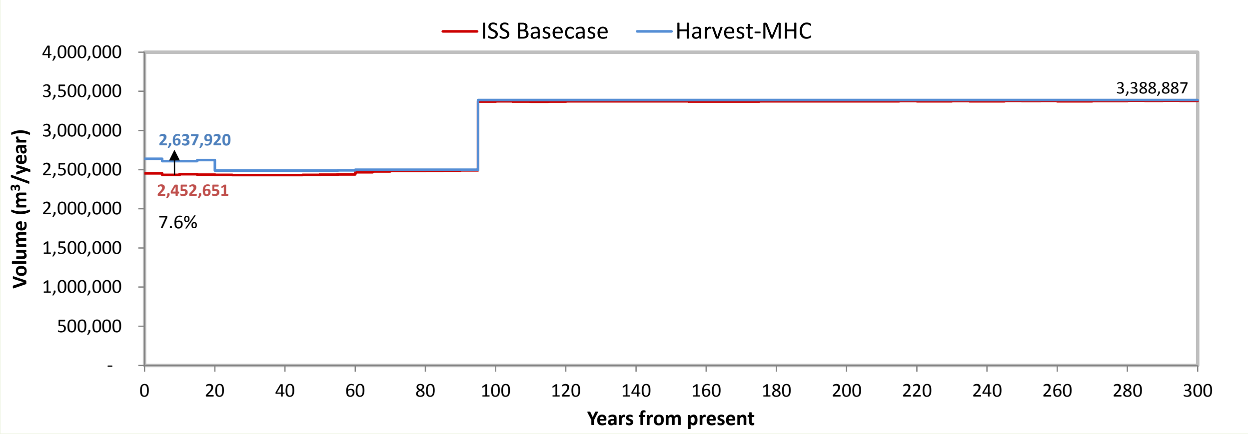


Figure 20 Comparing Harvest Flows between ISS Base Case and MHC Harvest Scenarios

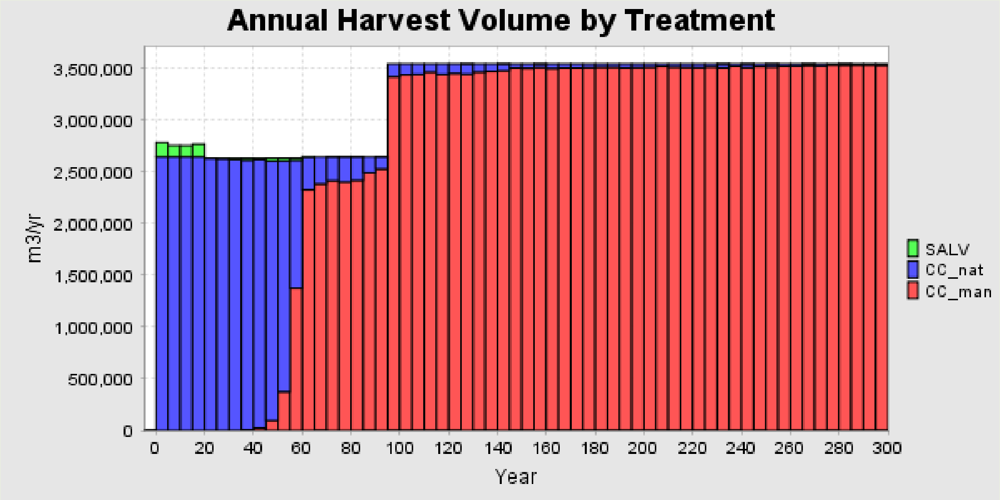


Figure 21 MHC Harvest Scenario - Annual Harvest Volume by Treatment

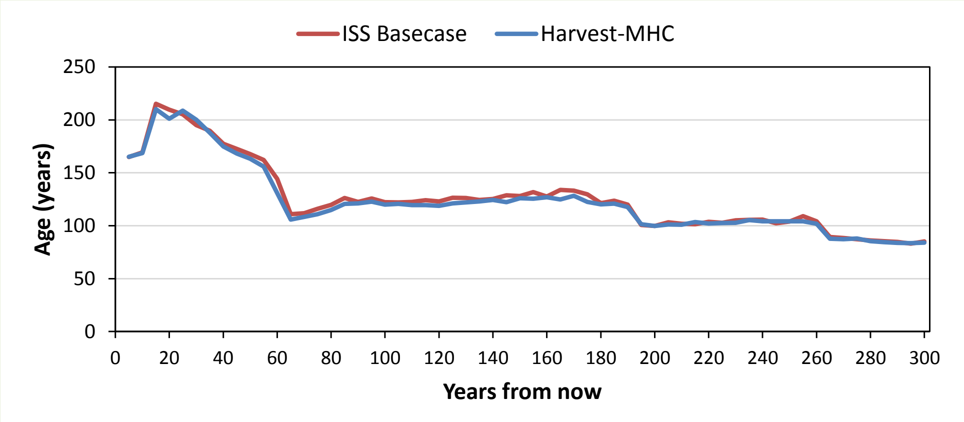


Figure 22 Comparing Average Harvest Age between ISS Base Case and MHC Harvest Scenarios

5.2.2 WHP Harvest Scenario

There was virtually no difference in harvest flows between the ISS Base Case and the WHP Harvest Scenarios (Figure 23) – NRLs are not considered here. Very slight differences likely resulted from the higher harvest priority set stands with extreme fire risk and grouping of harvest openings.

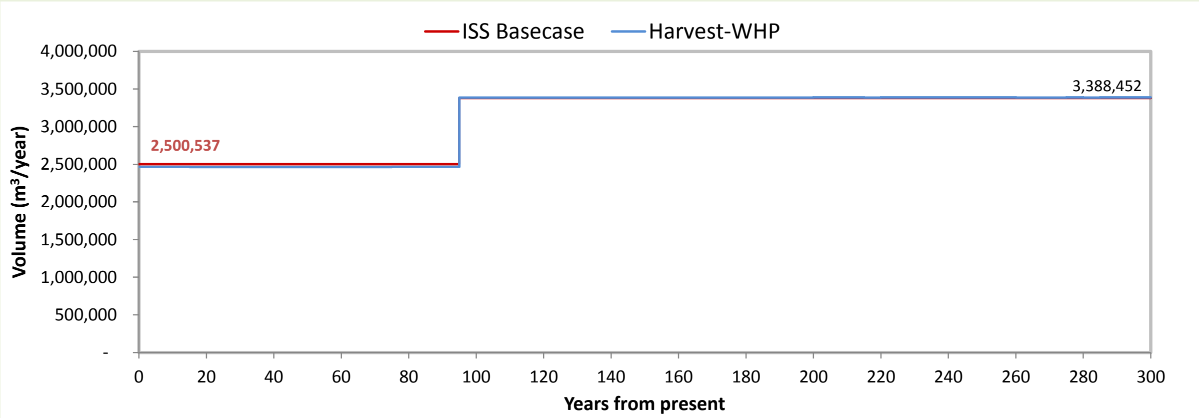
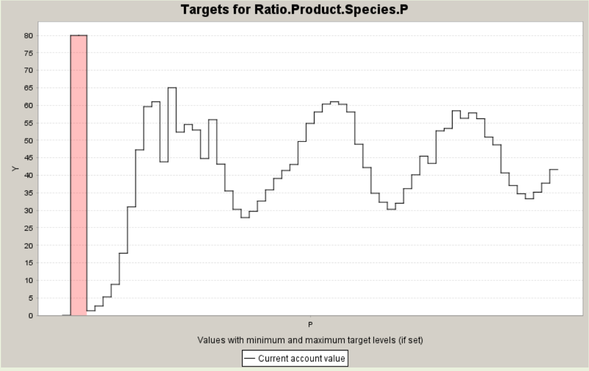


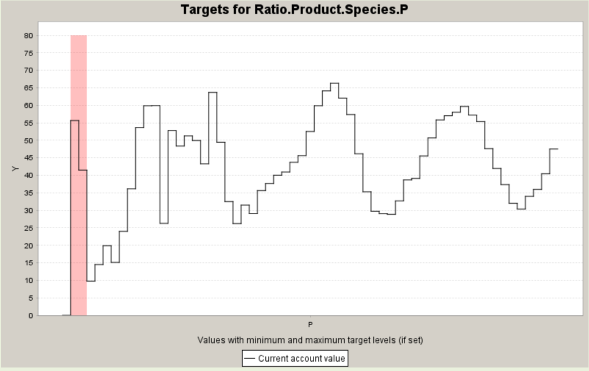
Figure 23 Comparing Harvest Flows between ISS Base Case and WHP Harvest Scenarios

Figure 24 shows the performance of the harvest partitions as they were on for the Base Case Scenario (left) and off for the WHP Harvest Scenario (right) –NRLs are not considered here. The significant drop in pine harvest (~30%) shown in the top two graphs suggests that there may be better options available to maximize mid- and long-term harvest levels than forcing salvage of MPB. But this salvage program does help to recover timber value that would otherwise be lost. The bottom to graphs show that turning off the partition for deciduous-leading results in a more erratic harvest flow, while the average harvest rate for this this profile is similar to the Base Case Scenario.

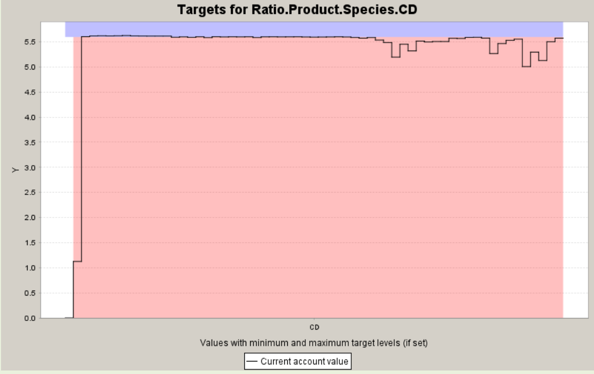
Base Case Scenario Run (partitions turned ON)	WHP Harvest Scenario (partitions turned OFF)

Min 80% from pine-leading stands (first 10 yrs)





Max 5.598% deciduous volume (entire planning horizon)



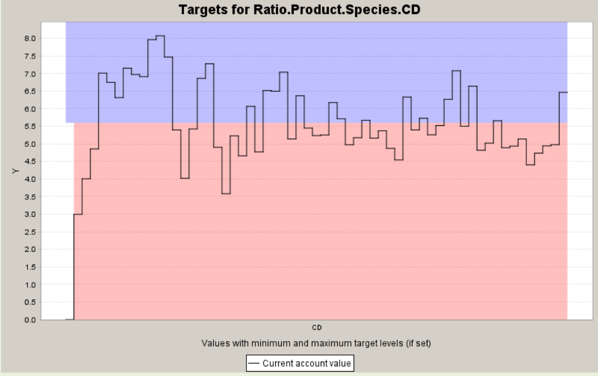


Figure 24 Comparing Harvest Partition Requirements and Performance between Base Case and WHP Harvest Scenarios (Note: Red and Blue areas indicate minimum and maximum target levels, respectively)

Harvest priorities were applied to stands with ‘extreme’ fire risk (~88,000 ha THLB) and conifer-leading stands within landscape-level fuel breaks (~101,000 ha THLB). Figure 25 illustrates how the forest analyst achieved this without setting a specific target over the first 20 years, specifically by maintaining the target (red area) just above the actual harvest without impacting the harvest flow. However, these harvest priorities likely contributed to minor reduction in salvaging dead volume and a reduction in average harvest age.

Harvest-WHP Scenario - Harvest Priority on Stands with 'extreme' fire risk

Harvest-WHP Scenario - Harvest Priority on Conifer-leading stands within fuel breaks

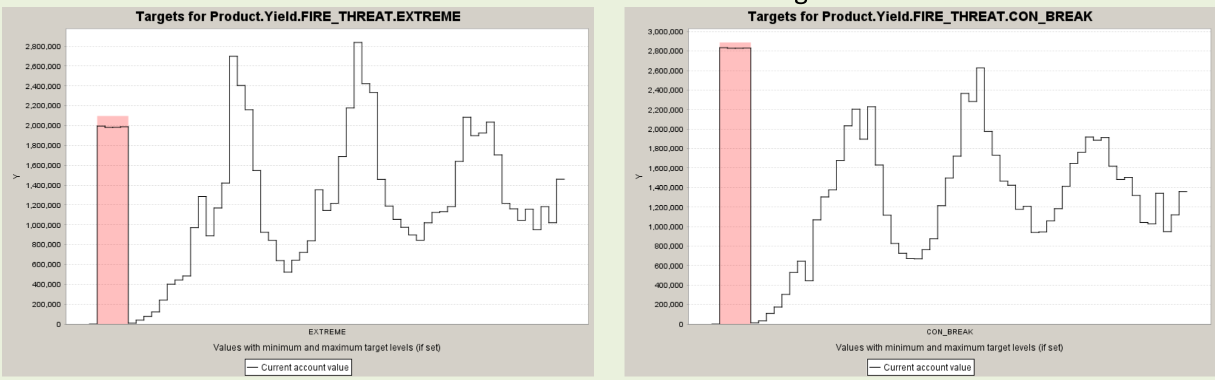


Figure 25 Harvest priories applied to address wildfire risk WHP Harvest Scenarios (Note: Red areas indicate minimum target levels)

One key finding was that a similar harvest flow was possible while grouping harvest openings in each 5-year period. Figure 26 illustrates the significant change in opening size distribution between the Base Case Scenario (top), where the majority of openings were less than 50 ha, and the Harvest Scenario (bottom), where the majority of openings were larger than 50 ha. Figure 27 shows an example of the spatial distribution is shown in year 10, where the Base Case scenario resulted in many more, and unevenly distributed, openings under 20 ha (yellow colour). In comparison, the WHP Harvest Scenario grouped openings into larger ones.

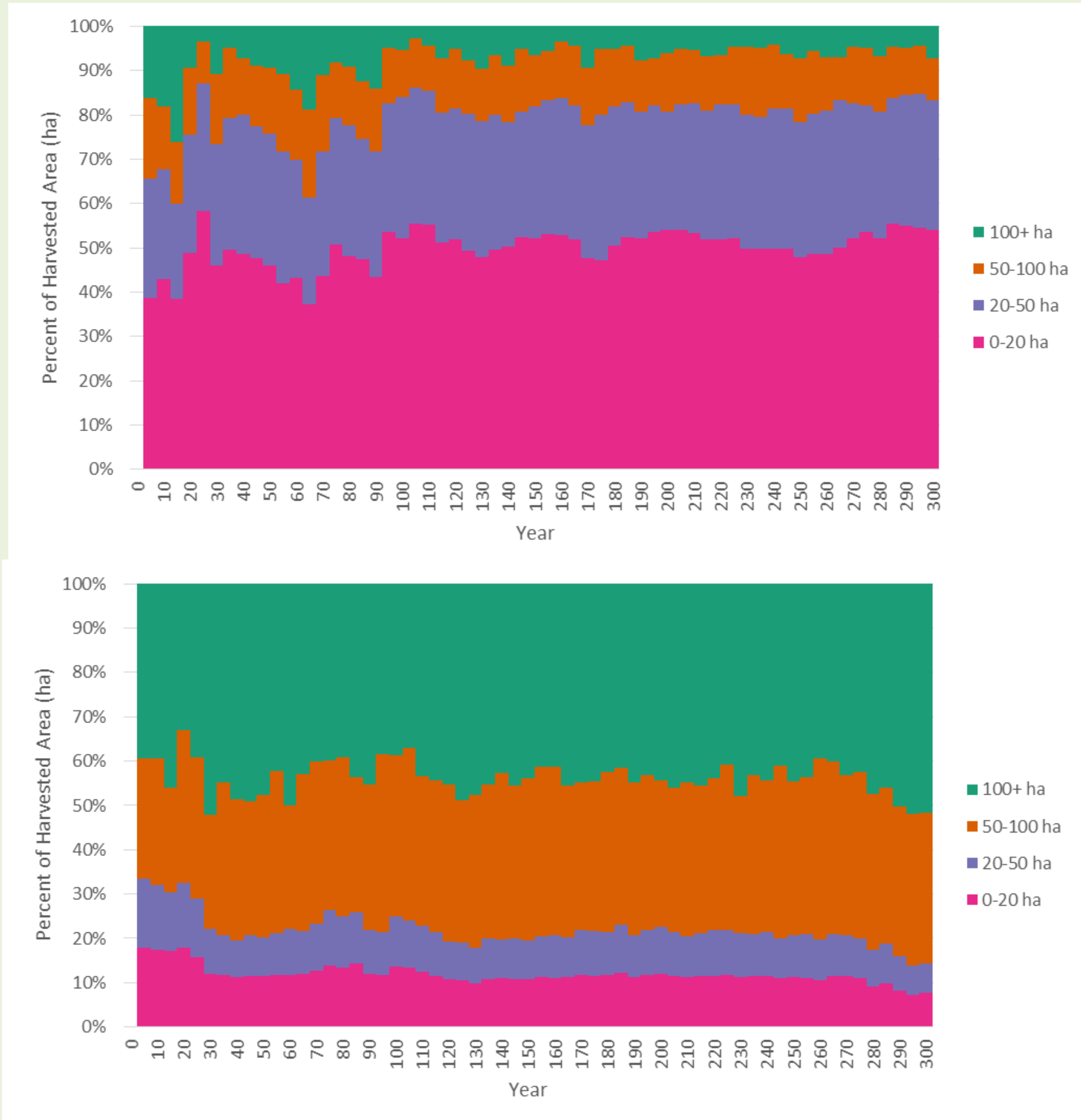
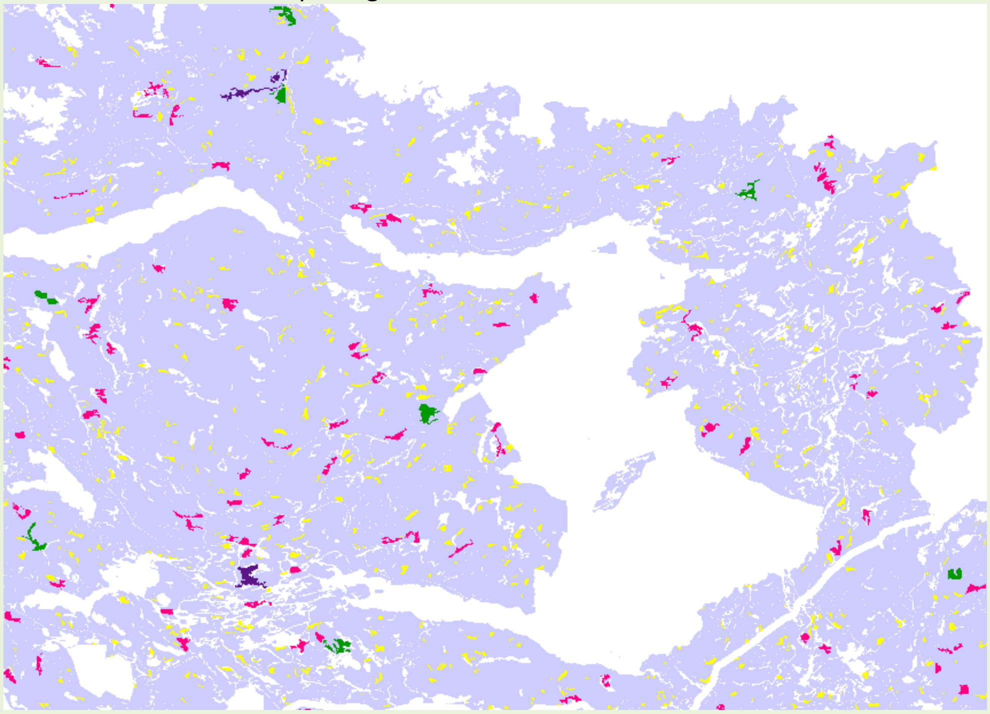


Figure 26 Comparing Opening Size Distributions between the Base Case (top) and WHP Harvest Scenarios (bottom)

ISS Base Case Scenario Opening Sizes in Year 10



ISS WHP Harvest Scenario Opening Sizes in Year 10

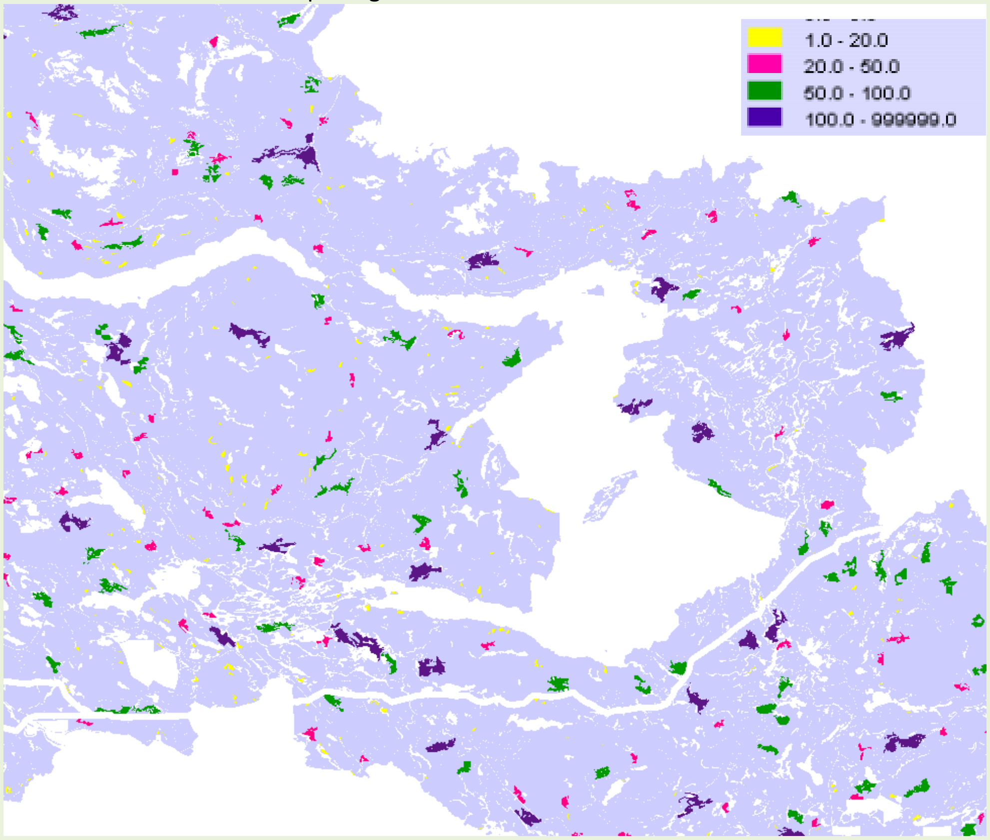


Figure 27 Comparing Spatial Distribution of Opening Size in Year 10 between the Base Case and Harvest Scenarios

The spatial harvest sequence generated from the Harvest Scenario model was used to prepare a twenty year plan map (Figure 28) – as a precursor to tactical plan that will be developed from the Combined Scenario results. Over this twenty year period, most of the harvest is focused on salvaging MPB-attacked stands that are focused on ground-based harvest systems (Table 4).

Table 4 20-Year Plan Summary for the Harvest Scenario – Annual Volume by System and Period

		Annual Harvest Volume (m^3/year) by System	
Period	**Years**	**Ground (<35% slope)**	**Cable (≥35% slope)**
1	1-5	2,323,816	143,192
2	6-10	2,337,538	127,693
3	11-15	2,289,769	175,169
4	16-20	2,300,407	162,392

Minimum harvest criteria: 141m^3/ha for pine-leading; 182 m^3/ha for non-pine-leading

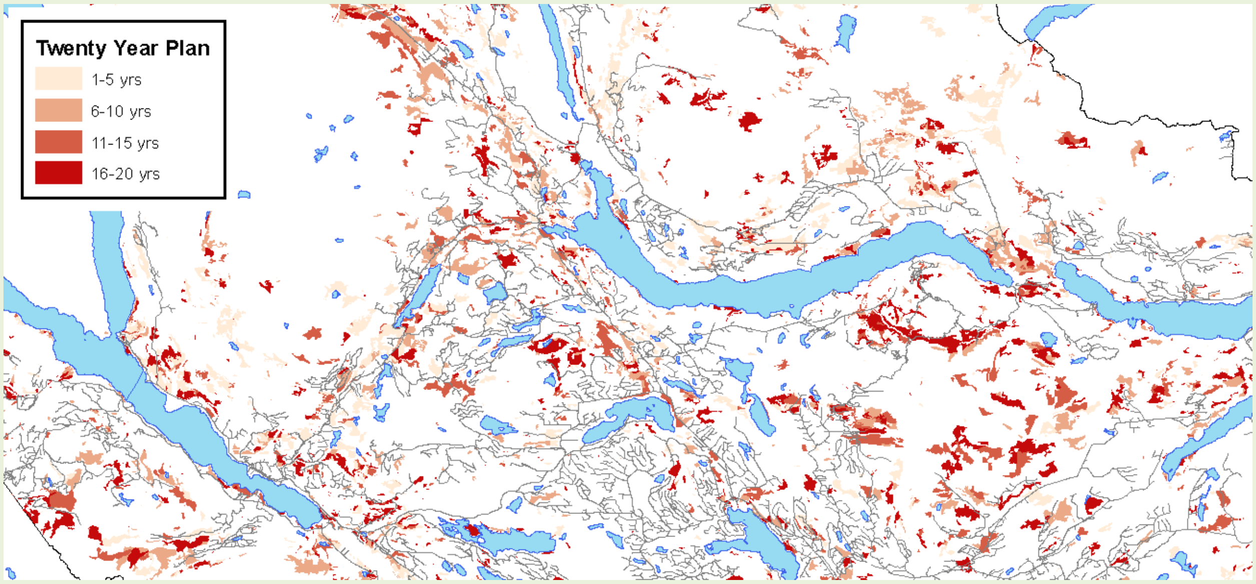


Figure 28 Sample map showing 20-Year Plan for the Harvest Scenario

This analysis was also configured to produce a set of reports that summarize the harvest flow by species group and age classes. A simple spreadsheet was subsequently built to illustrate a species and grade profile (Figure 29) according to the species and grade distribution by age class (Table 5).

Table 5 Species and Grade Distribution by Age Class – Mocked Up for Deriving a Harvest Profile

	BL			DE	PL Live			PL Dead	SX, SB, SE,F			Others
Age Class	**Peeler**	**Saw**	**Pulp**	**Pulp**	**Peeler**	**Saw**	**Pulp**	**Pulp**	**Peeler**	**Saw**	**Pulp**	**Pulp**
0 to <40			100%	100%			100%	100%			100%	100%
40 to <60		93%	7%	100%		93%	7%	100%		93%	7%	100%
60 to <80	7%	89%	4%	100%	7%	89%	4%	100%	7%	89%	4%	100%
80 to <120	35%	63%	2%	100%	35%	63%	2%	100%	35%	63%	2%	100%
120 to <200	62%	37%	1%	100%	62%	37%	1%	100%	62%	37%	1%	100%
200+	69%	30%	1%	100%	69%	30%	1%	100%	69%	30%	1%	100%

Note: These distributions are mocked up but can easily be adjusted to produce species and grade profiles over time

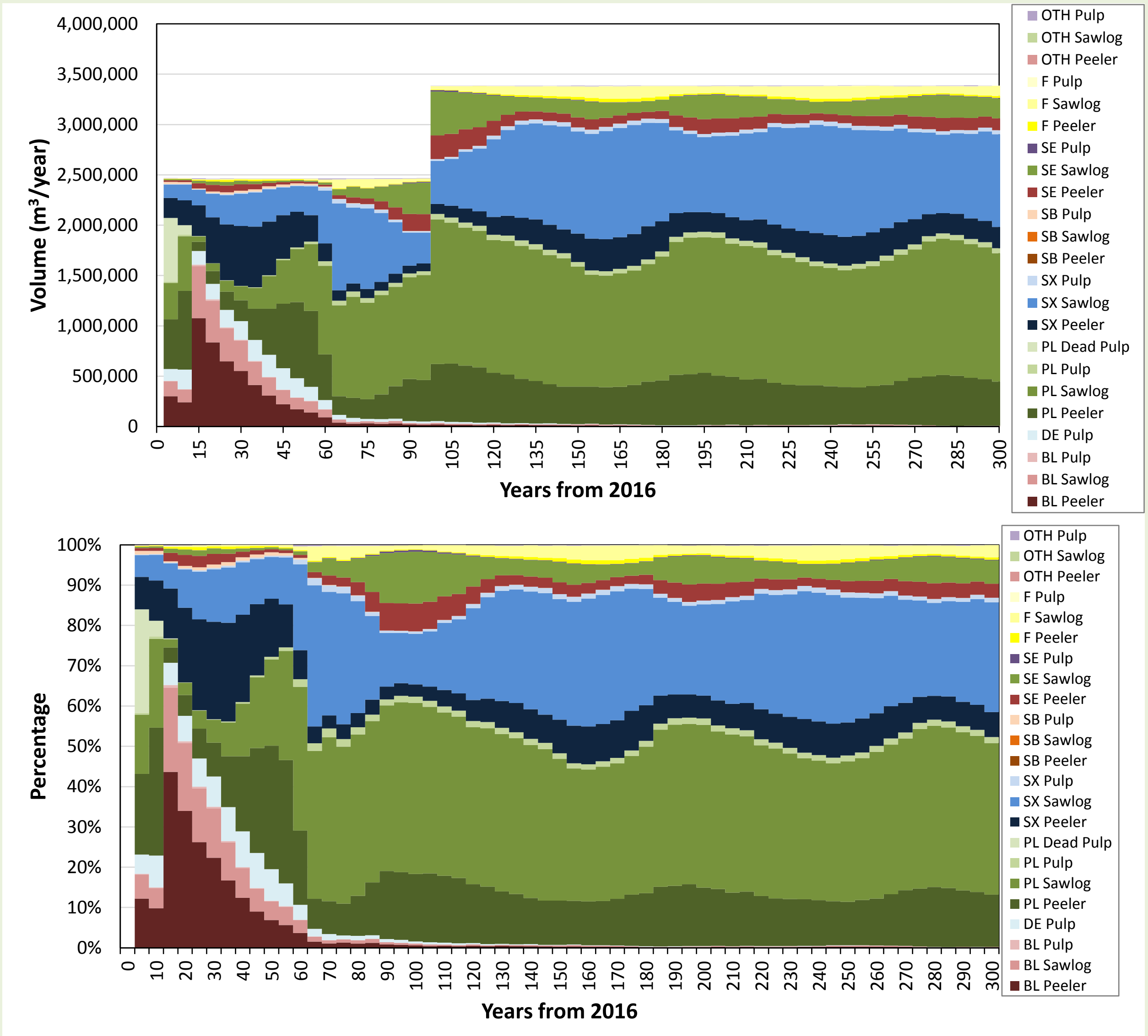


Figure 29 Species and Grade Profile (Harvest Flow and Percentages)

6 Silviculture Scenario

6.1 Description

The goal of the Silviculture scenario was to explore tactics aimed to enhance timber quantity and quality over the mid- and long-term, as well as, improve biodiversity, wildlife habitat, and cultural interests. In doing so, the Silviculture scenario examined silviculture investments that would best serve the TSA's future harvest; given an expected funding level of $3 million per year over the first 20 years of the planning horizon. In this ISS iteration, the Project Team identified 3 tactics to be explored: 1) enhanced basic silviculture, 2) rehabilitating MPB/IBS impacted stands, and 3) fertilization.

In addition to the clearcut treatments, enhanced basic silviculture treatments were configured in the model to provide the option to enhance the regeneration of more productive stands along with an additional cost. Enhanced basic silviculture treatments were set-up to reflect increased planting densities for existing natural and managed stands within SBS and BWBS BEC zones, with Sx-leading and site index >=14, or with Pl-leading and site index >=17. The enhanced basic silviculture cost was assumed to be $285/ha.

Rehabilitation was modelled for mature, conifer-leading existing natural stands with medium to good productivity, on slopes ≤45% that were heavily impacted by MPB/IBS. The rehabilitation costs were separated according to economic feasibility: $1,500/ha, where the standing live volume was >=50 m^3/ha and $2,000/ha, where the standing live volume was <50 m^3/ha. Additional costs were added for blocks that were more than 2 hours away from Fort St. James – $50/ha for each 2 extra hours (one way). The rehabilitated stands could be regenerated either according to assumptions in the Base Case, or with enhanced basic silviculture criteria, subject to the eligibility criteria for enhanced basic silviculture described above.

Fertilization applications aim to increase the stand volume available at time of harvesting. Up to 4 applications were modelled for existing natural and managed stands not impacted by the IBS/MPB stands provided they met the following criteria:

- Slope <=35% (i.e., ground harvesting system),
- Existing natural stands between 26 to 60 years (inventory SI >=14), or existing managed stands <=25 years (managed SI >=14),
- The sum of Pl and Sx components >=80%, and
- SBS and ESSF BEC zones.

Fertilized stands were made unavailable to harvest for the next 10 years after the final application. The fertilization cost of each application was assumed to be $450/ha, with an additional cost of $25/ha for each 2 hour (1 way) distance from Fort St. James.

The Silviculture Scenario involved two model runs: one that included live, merchantable volume harvested from rehabilitation treatment and one that excluded this volume from contributing to the harvest flow. This approach confines the results to reflect the uncertainty associated with operational logistics and quality of these logs.

6.2 Results

Within the allocated budget, the three silviculture tactics provided a significant contribution to the harvest flow. With Rehab volume included, a 12% increase was realized in the short-term, and an 8% gain was realized in the long-term. When the rehab volume was excluded from the target (but still occurred in the background), the increase was 7% in the short-term and 6% in the long-term (Figure 30).

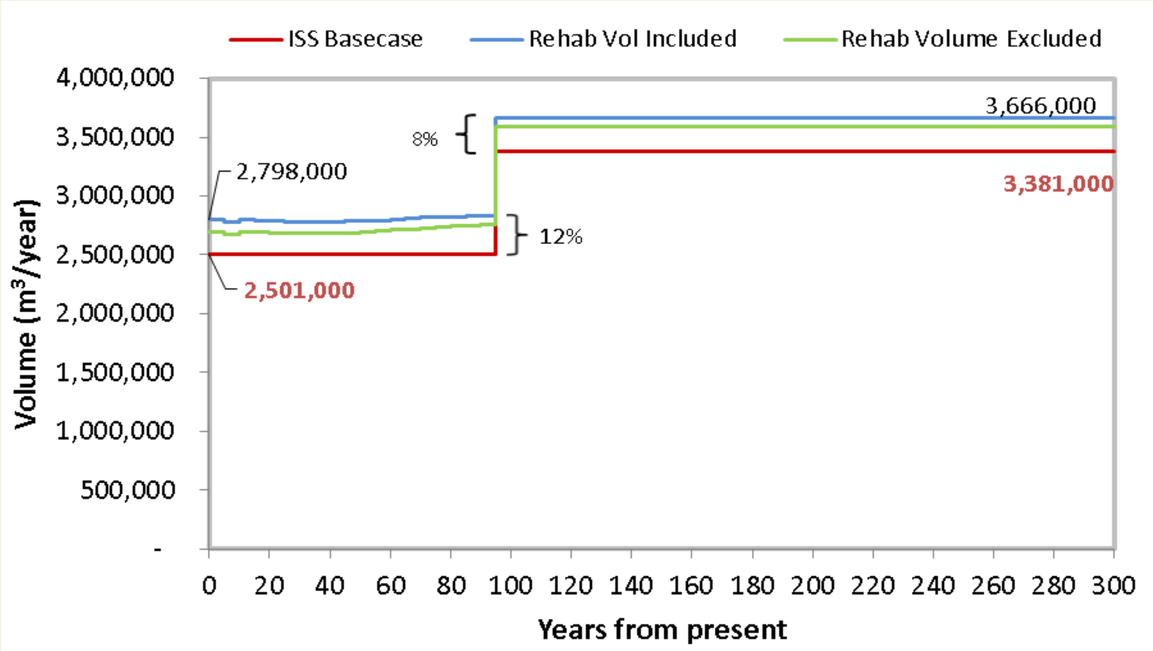


Figure 30 Comparing harvest flows between ISS Base Case and Silviculture Scenarios

Figure 31 demonstrates how the silviculture tactics are applied in the first 20 years, as well as, how each tactic impacts future harvest. Most of the area treated undergoes either one or two fertilization treatments. Fertilized stands are harvested throughout the midterm; specifically 40-80 years into the planning horizon. Most rehabilitated stands also contributed to the harvest over the mid-term while stands treated with enhanced basic silviculture, contributed to harvest more in the long-term allowing for more volume to be harvested while still maintaining a flat growing stock. More rehabilitation may have been available in periods 2 to 4 since stand eligibility was classified based solely on yield status in 2016, as described in the data package, which was not adjusted as yields decreased or increased beyond the eligibility thresholds.

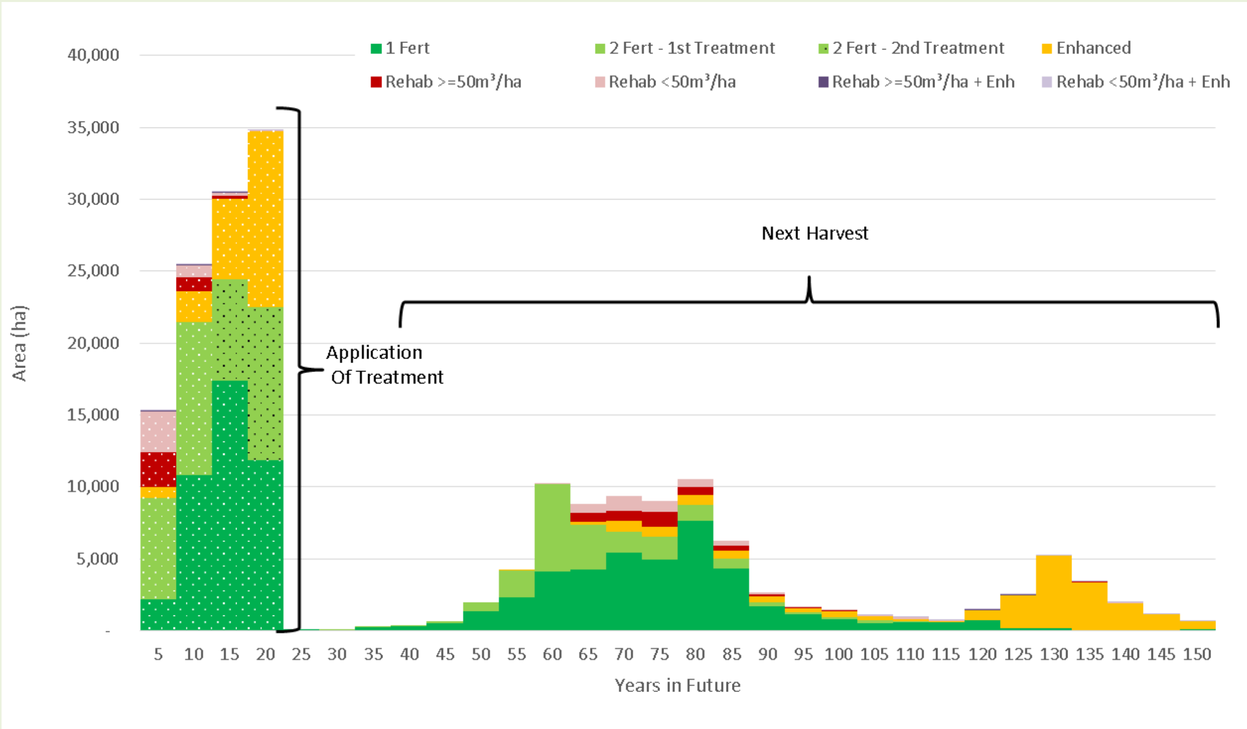
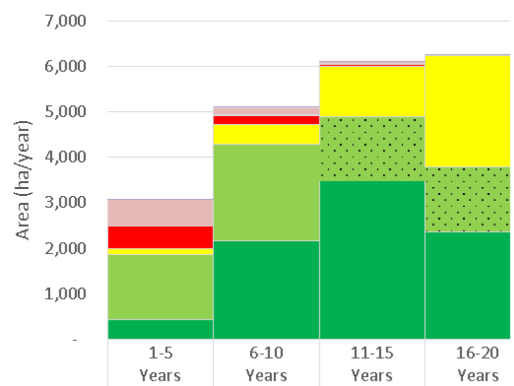
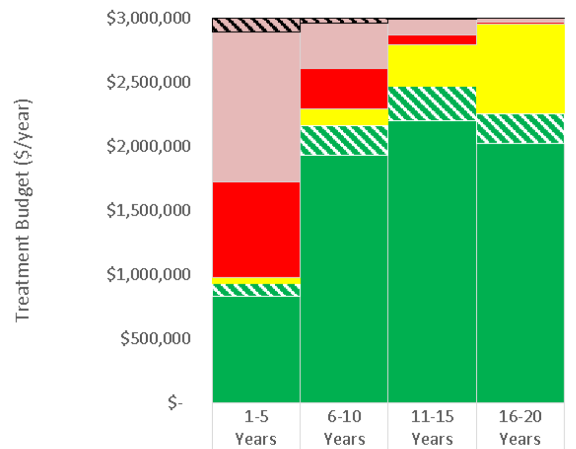


Figure 31 Areas Treated and Harvested by Silviculture Tactic for the Silviculture Scenario

Areas treated in the model depend on the availability of eligible stands for each treatment over the first 20 years. Over this time, the model applied the full annual budget of $3 million per year. Figure 32 shows that expenditures on fertilization and enhanced basic silviculture treatments increased over the 4 periods, while rehabilitation decreased. Note that the financial risk associated with enhanced basic silviculture treatments is higher than fertilization as the treatment cost must be carried over a longer duration. The striped bars in the cost graph below show the incremental cost associated with treating stands further away from Fort St. James. Distance costs for fertilization increases while rehabilitation decreases over the 20 year treatment period.



	1-5 Years	6-10 Years	11-15 Years	16-20 Years
Rehab <50m³/ha + Enh	17	10	16	8
Rehab <50m³/ha	569	165	43	6
Rehab >=50m³/ha + Enh	14	12	8	3
Rehab >=50m³/ha	483	200	42	8
Enhanced	148	433	1,115	2,448
2 Fert - 2nd Treatment			1,416	1,416
2 Fert - 1st Treatment	1,416	2,128	-	-
1 Fert	435	2,158	3,475	2,369



	1-5 Years	6-10 Years	11-15 Years	16-20 Years
Distance Rehab	$105,581	$41,074	$12,244	$2,754
Rehab <50m³/ha	$1,171,952	$350,133	$119,691	$26,235
Rehab >=50m³/ha	$745,179	$318,345	$75,050	$16,132
Enhanced	$50,805	$129,724	$324,808	$700,635
Distance - Fertilization	$93,866	$232,289	$267,624	$230,581
Fertilization	$832,580	$1,928,427	$2,200,579	$2,023,659

Figure 32 Treatment Budget and area for the first 20 years (Rehab Included)

7 Combined Scenario

7.1 Description

The combined scenario aimed to utilize features and assumptions (Table 6) from the Base Case, reserve scenario, harvest scenario, and silviculture scenario, to develop a desirable harvest flow that reflects the interactions with all of these features.

Table 6 Summary of Elements included in the Combined Scenario

Scenario	Elements Included in the Combined Scenario
Base Case	○ Spatial delineation of Community Forests and FNWLs
	○ Spatial delineation of approved, proposed and draft habitat areas
	○ Spatial delineation of riparian reserves
	○ Tl'azt'en ECA requirements
	○ Adjust stand yields to account for pine beetle impacts and shelf life
Reserve	○ For the first 40 years, prevent harvesting of stands identified as candidate reserves
Harvest	○ Drop the pine harvest partition
	○ Add a partition of 1.5 million m³/yr from TSBs A & B (combined)
	○ Apply more strict targets for harvest opening size (accept a 5% drop in harvest level)
Silviculture	○ Apply an annual budget of $3 million over the first 20 years
	○ Do not include rehab volume in harvest flow

7.2 Results

7.2.1 Harvest Forecast and Growing Stock

In the short-term, the harvest flow for the Combined Scenario was 7.6% higher than the Base Case Scenario, and 7.5% higher in the long-term (Figure 33). These increases are less than those demonstrated in the Silviculture Scenario (Figure 30), likely due to the increased pressure placed to reduce small harvest opening sizes.

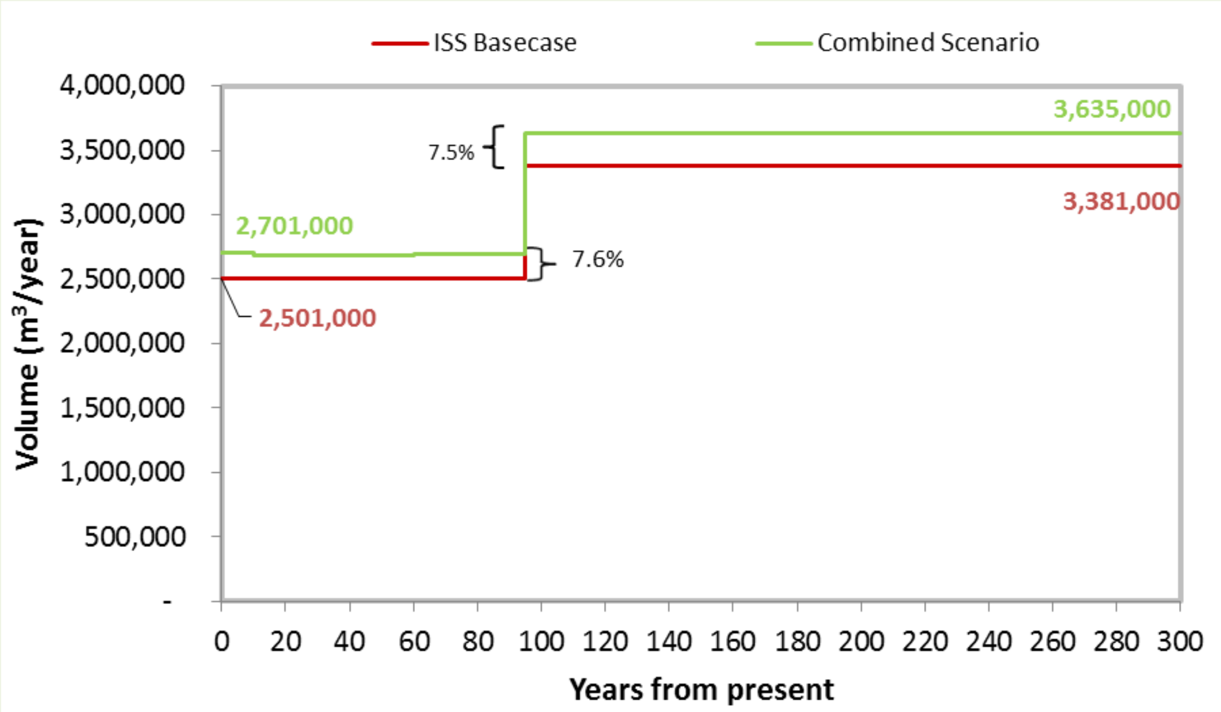


Figure 33 Harvest flow for the combined scenario in comparison to the Base case.

The initial growing stock (160 million m³) is very similar to the Base Case Scenario (Figure 34), but dips lower in year 30 as volume is harvested from rehabilitated stands then recovers to managed curves; resulting in a higher long-term growing stock.

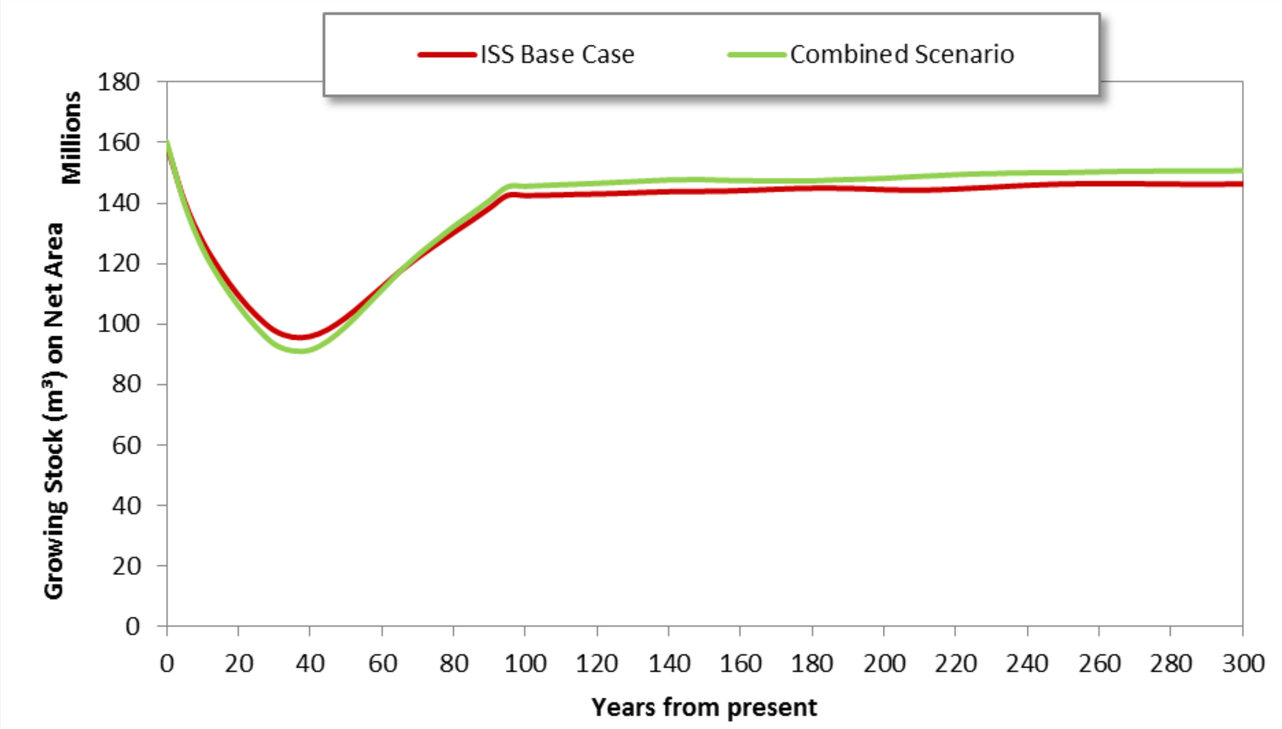


Figure 34 Growing stock on the net landbase

7.2.2 Silviculture Tactics

Similar to the results described in Silviculture Scenario (section 6.2), Figure 35 shows the silviculture tactics applied in the first 20 years, as well as, how each tactic impacts future harvest. Again, due to how the rehabilitation criteria were applied, more stands eligible for rehabilitation may have been available in periods 2 to 4 (see data package).

Compared to the Silviculture Scenario (Figure 31), the distribution of silviculture tactics are drastically different than the Combined Scenario (Figure 35). Over the first 20 years, the Combined Scenario favoured much more rehabilitation and much less enhanced basic silviculture treatments, while areas fertilized were fairly similar. Moreover, the timing that tactics were applied differed as the Combined Scenario applied rehabilitation mostly over the first two periods and postponed fertilization and enhanced basic silviculture over the last three periods.

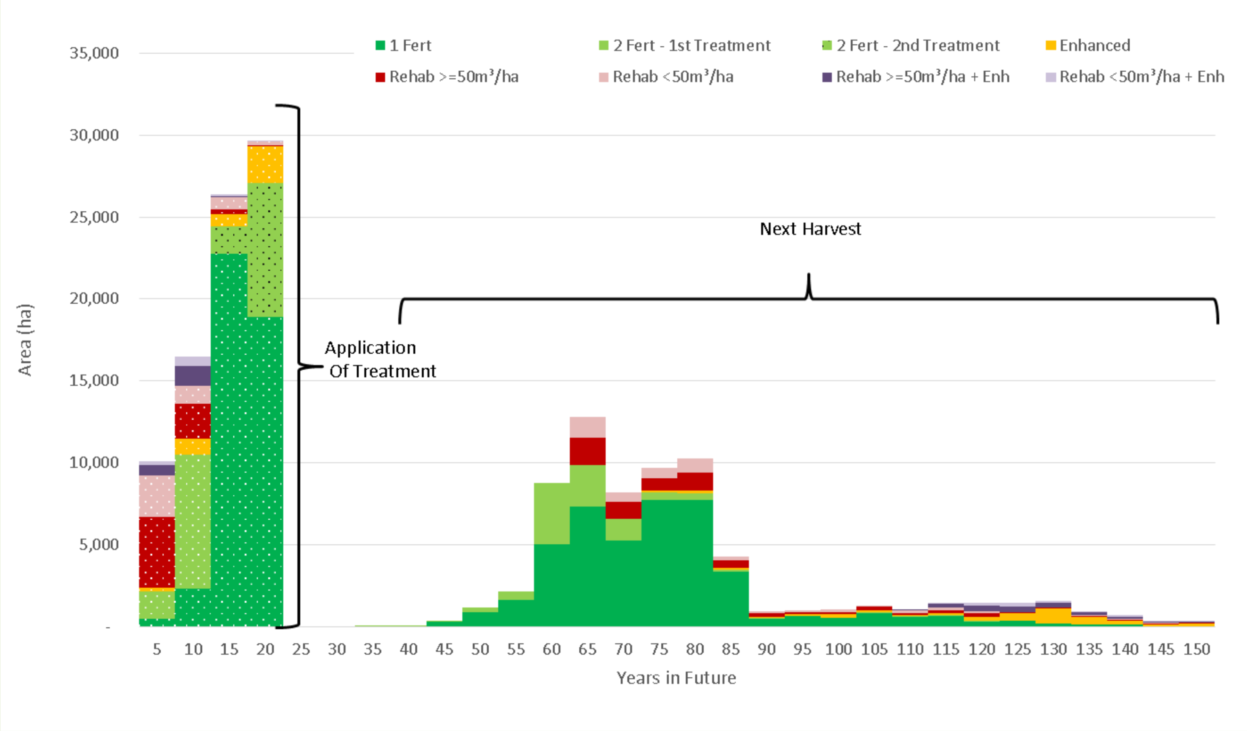
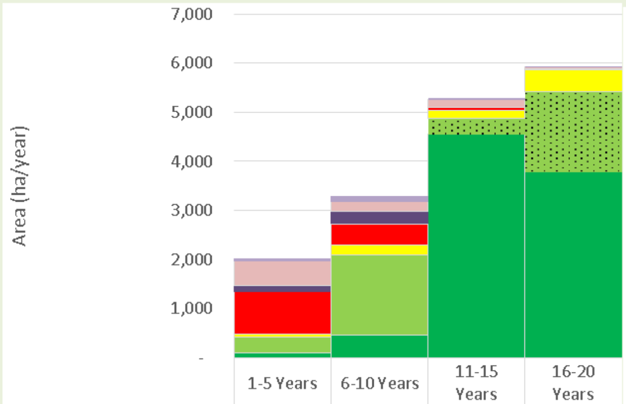
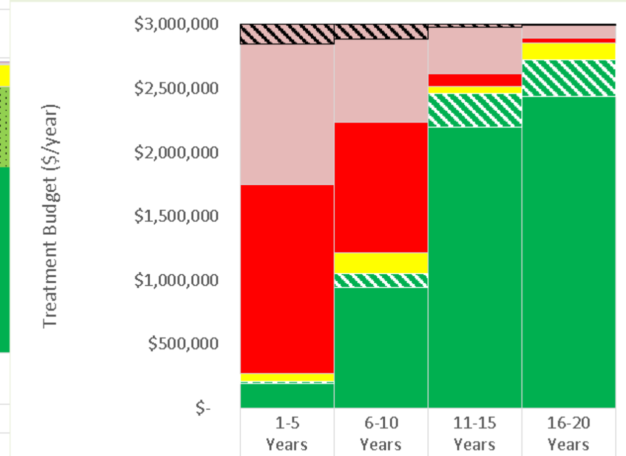


Figure 35 Areas Treated and Harvested by Silviculture Tactic for the Combined Scenario

Over the first 20 years the model utilized the full annual budget of $3 million. In addition to this budget and improvements in the harvest flow overall, areas treated in the model partly depend on the availability of eligible stands for each treatment. Figure 36 shows that expenditures on fertilization treatments increased after the first period. A significant proportion of two treatment fertilizations first occurs in the second period then again in the fourth period.



	1-5 Years	6-10 Years	11-15 Years	16-20 Years
Rehab <50m³/ha + Enh	41	119	28	10
Rehab <50m³/ha	511	209	155	41
Rehab >=50m³/ha + Enh	124	247	11	2
Rehab >=50m³/ha	859	430	53	20
Enhanced	53	199	150	448
2 Fert - 2nd Treatment	-	-	333	1,627
2 Fert - 1st Treatment	333	1,627	-	-
1 Fert	93	470	4,553	3,785



	1-5 Years	6-10 Years	11-15 Years	16-20 Years
Distance Rehab	$148,529	$109,784	$22,623	$7,646
Rehab <50m³/ha	$1,103,026	$656,110	$365,187	$101,006
Rehab >=50m³/ha	$1,473,338	$1,016,393	$95,395	$34,139
Enhanced	$62,124	$161,242	$53,805	$131,025
Distance - Fertilization	$20,621	$112,406	$264,319	$290,566
Fertilization	$191,817	$943,675	$2,198,543	$2,435,525

Figure 36 Areas and costs associated with silviculture treatments in the combined scenario[3]

7.2.3 Harvest Profile

Based on slope criteria, two harvest systems were identified within this TSA: ground (0 to 35%) and cable (35% to 64% slope). A third category was identified as steep cable, which included previously harvested stands greater than 64% slope. Over the planning horizon, the harvest from cable ground averaged 38%; ranging from 33% to 44% of the total harvest (Figure 37).This result suggests that short-term harvesting must prioritize stands from cable ground.

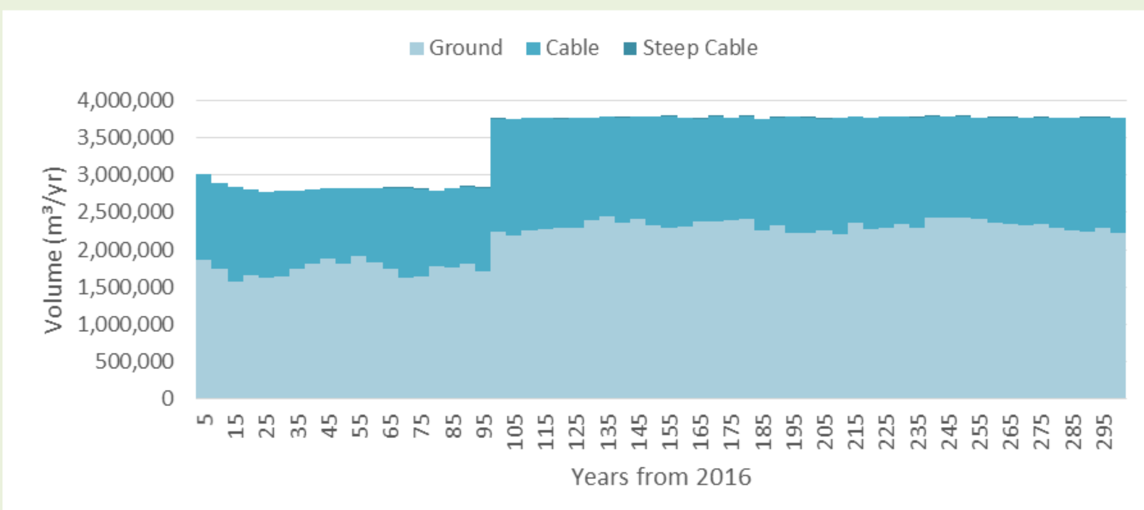


Figure 37 Combined Scenario - Annual Harvest Area by Harvest System

[3] Note that the areas in this chart are net of in-block retention. The numbers in the tables below, will be larger, as they are gross area.

A comparison of the area harvested within a younger age class (40 to 60 years) shows visibly more area harvested over mid-term period (i.e., years 55 to 80) in the Combined Scenario, with less area harvested in the long-term (Figure 38). This observation supports the result that the model harvested stands that transition to yields with higher productivity, while shuffling older stands for harvest earlier in the planning horizon to help fill the mid-term trough.

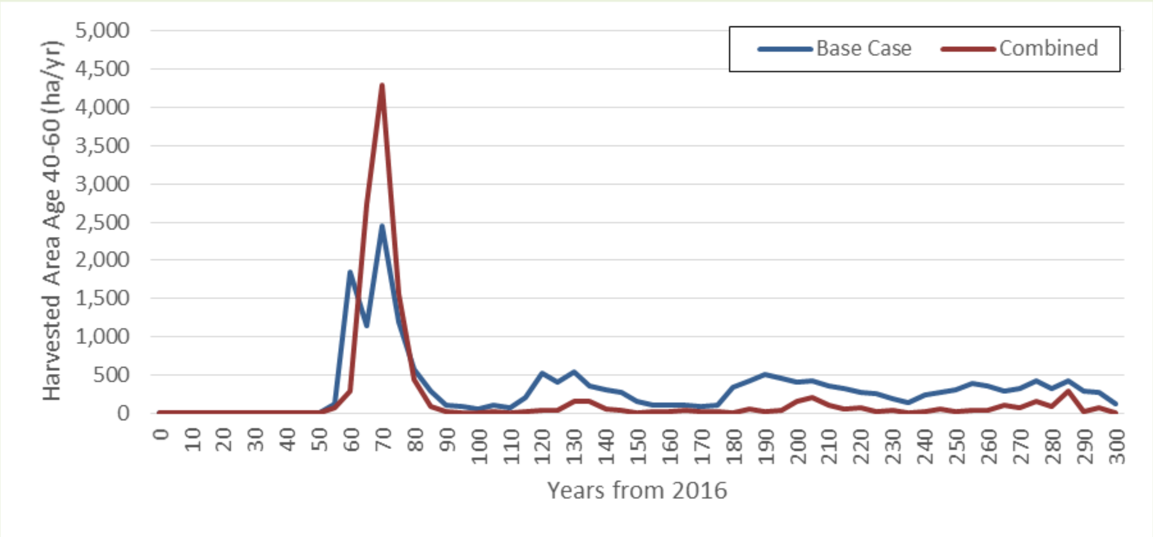


Figure 38 Comparison of Harvested Area Age 40-60 between Base Case and Combined Scenarios

7.2.4 Harvest Partitions

The Base Case Scenario included two harvest partitions: minimum 80% harvest from pine-leading stands in the first 10 years and maximum 5.56% from deciduous-leading stands over the entire planning horizon. The pine partition was removed in the combined scenario, and as Figure 39 illustrates, when the model is not forced, the pine-leading contribution reduces to 58% in period one, and 18% in period two. These percentages include the volume attributed to rehabilitated stands.

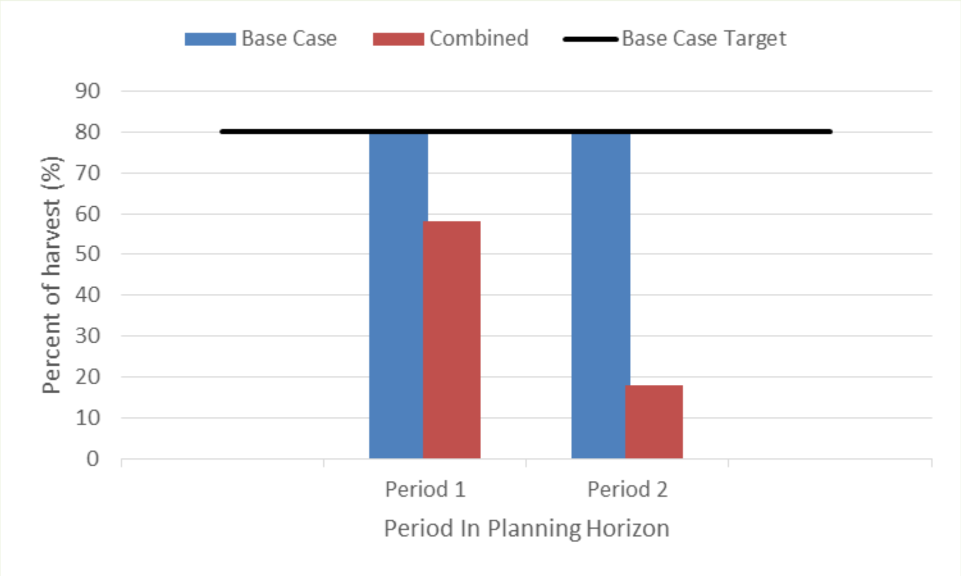


Figure 39 Pine Partition in the base case, and combined scenario

The combined scenario was first attempted without the deciduous partition but this greatly affected the harvest flow, so the partition was reapplied. Figure 40 shows the contribution of deciduous-leading stands across the planning horizon. For both scenarios, the deciduous contribution was around 1% in the first period but by the third period, this contribution remained restricted by the 5.6% target for the most of the planning horizon.

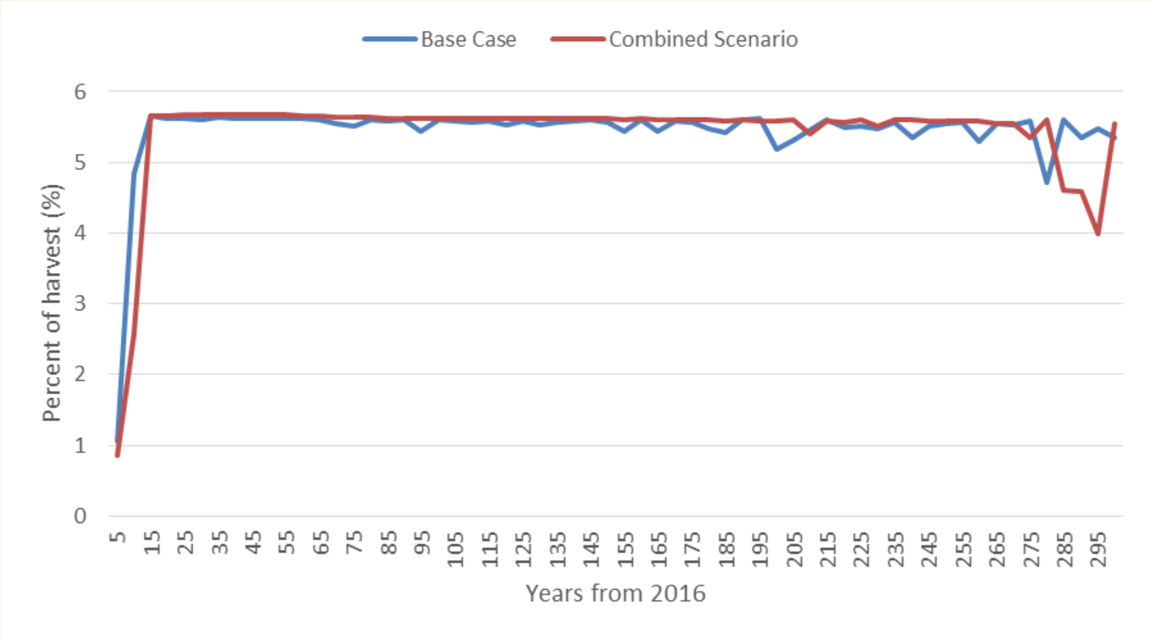


Figure 40 Deciduous partition in the base case and combined scenario

7.2.5 Salvaged Volumes

Compared to the Base Case Scenario, 43% less dead MPB volume was salvaged in the Combined Scenario, which increased the non-recoverable MPB dead volume overall by 14% (Table 7).

Setting higher priorities on harvesting stands with extreme fire threat significantly reduced the salvage of MPB impacted stands.

Table 7 Comparison of MPB and IBS Non-Recoverable Losses

Variable	Base Case (m^3)	Combined (m^3)	Difference (m^3)	Difference %
Initial dead MPB volume	13,444,102	13,444,102	0	0.00%
MPB Dead Volume Harvested by the end of the shelf-life	3,403,099	2,626,784	1,455,366	42.77%
Non-recoverable MPB dead volume	**10,041,003**	**10,817,318**	**1,455,366**	**14.49%**

7.2.6 Wildfire Threat

The 2015 Provincial Strategic Threat Analysis (PSTA) identified stands with extreme wildfire threat ratings which were prioritized for harvesting over the first 10 years of the planning horizon. The THLB area with extreme PSTA ratings was estimated at 44,000 ha (4% of the total THLB). Note that the THLB area identified as both extreme and high threat was estimated at 820,000 ha (69% of the total THLB). The model harvested approximately 16,000 ha of extreme PSTA rated stands in the first 10 years (Figure

41). As discussed in section 7.2.5, prioritizing harvest of stands with extreme wildfire threat significantly reduced the salvage of MPB impacted stands.

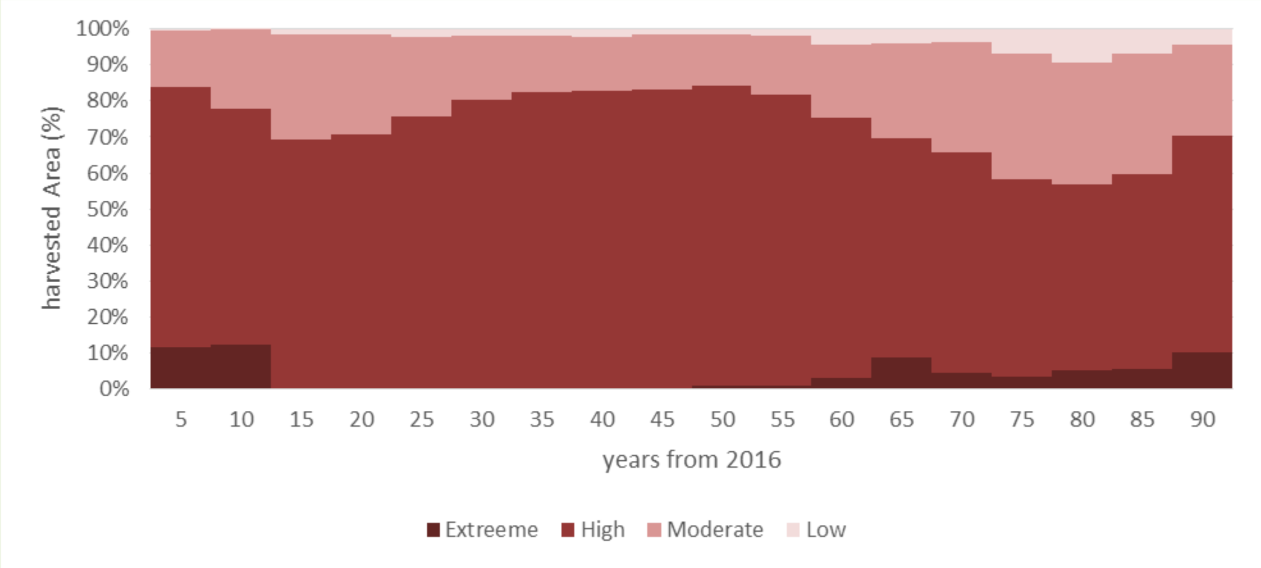


Figure 41 Harvested Area by PSTA Wildfire Rating

7.2.7 Opening Size

The Combined Scenario differed from the Harvest Scenario by creating two harvest opening size target classes: 0-1 ha and 1-5 ha. The goal was to have no openings smaller than one hectare while allowing up to 5% of the area harvested in each period to include openings between 1 and 5 hectares. This target was restrictive in the model.

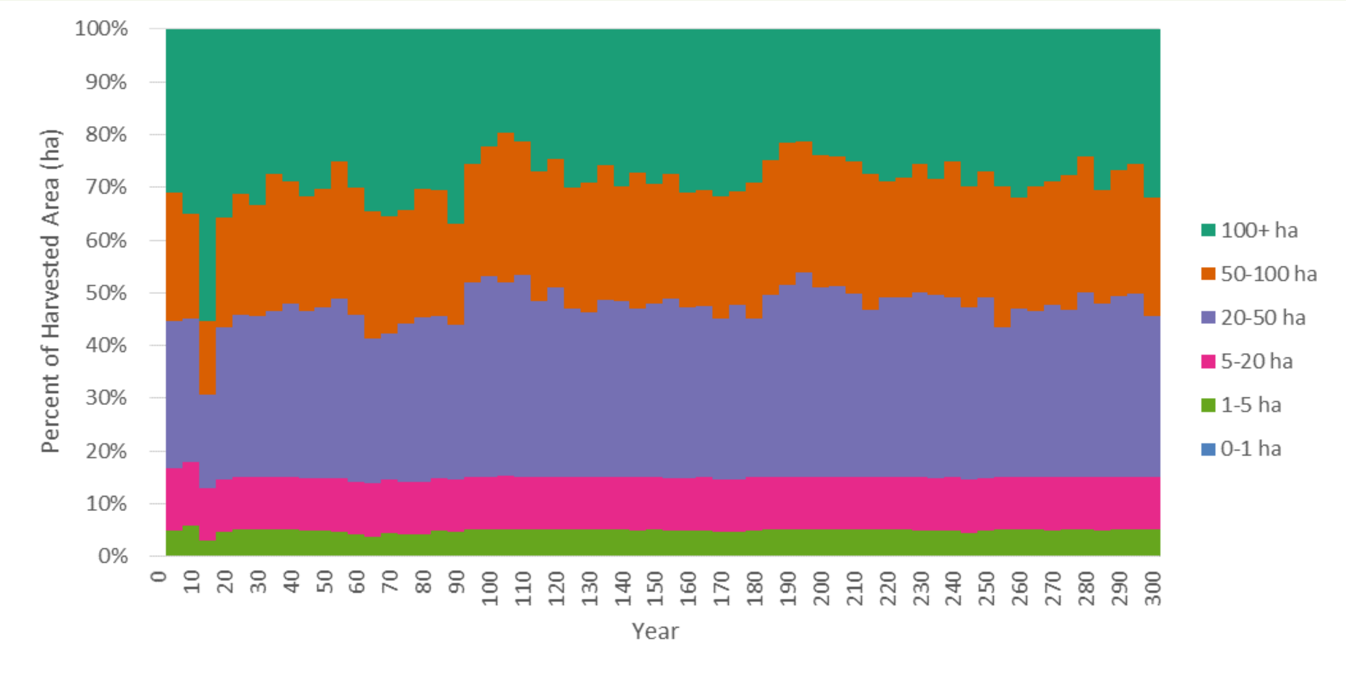


Figure 42 Opening size distribution in the combined scenario.

7.2.8 Candidate Reserves

From the Reserve Scenario (section 4), candidate reserves identified within THLB were locked from harvesting for the first 40 years of the planning horizon. This amounted to approximately 8,500 ha (<1% of the THLB) and had no significant impact on the harvest flow. Note that in addition to these candidate reserves, old seral requirements established under the Non-Spatial Landscape Biodiversity Objectives were applied over the entire planning horizon.

8 Discussion

8.1 Differences from TSR

The major differences between the TSR Benchmark and ISS Base Case scenarios include land base definition, MPB yield assumptions, and non-timber objectives. The ISS Base Case THLB is 4.7% smaller than the TSR Benchmark because the ISS Base Case excludes from harvest significantly more area for wildlife habitat no-harvest zones, riparian reserves, and new tenure boundaries. The MPB yield assumptions were simplified in the TSR Benchmark, whereas the ISS Base Case included many details (including emergence of a regeneration layer) to portray more accurately, in time and space, the reality on the ground. Some of the new tenures and targets overlapped as well (i.e., grizzly habitat and new First Nation tenures), which lessened the impact on the THLB. Overall the new caribou migration corridors and ECA targets are not constraining in the model, as the harvest scheduling and distribution is able to work around these constraints. The most constraining non-timber objectives include ungulate winter range habitat and visual quality objectives, which were unchanged from the TSR Benchmark.

8.2 Key Observations

These ISS analyses generated numerous reports and spatial outputs associated with the modelling tactics implemented. The key observations for all scenarios completed so far (i.e., ISS Base Case, Reserve, and Harvest) are briefly summarized in Table 8.

Table 8 Summary of Key Observations

Topic	Key Observations
Riparian Reserves	The ISS Base Case Scenario significantly increased the riparian area reserved. This analysis spatially retained riparian reserves areas for large and medium sized streams. This reduced the THLB by approximately 90,272 ha.
In-Block Retention	TSR Benchmark used 12.1% in-block retention to account for wildlife tree retention and riparian reserves. ISS Base Case scenario used spatially defined riparian reserves and determined the average wildlife tree retention percentage as 12.1% - 7.6% = 4.5%, where the 7.6% represents the spatially determined riparian reserves (90,272 ha). For the MPB salvage zones, a conservation uplift retention factor was applied instead of the base in-block retention, based on opening sizes (10-30% retention). Consequently, the in-block retention area increased by approximately 88,000 ha, compared to the TSR Benchmark.
Habitat Areas	The ISS Base Case Scenario significantly increased the protection of critical habitat areas. This analysis included spatial delineation of approved, proposed, and draft habitat areas which led to no-harvest habitat areas of approximately 348,864 ha (UWR) and 2,565 ha (WHA) in addition to the TSR Benchmark.
New Tenures	The ISS Base Case Scenario considered spatial delineation of any revised Community Forests, First Nation Woodland Licenses, and First Nations Areas of Interest This removed an additional 88,235 ha from the FMLB.

Topic	Key Observations
Watershed ECA	The ISS Base Case Scenario was configured to monitor and/or implement ECAs within identified watersheds (draft/proposed FSWs and LRMP). In this case, full ECA requirements were typically far from being compromised so the overall harvest flow was not impacted since alternative harvest patterns were available. In addition to ECA targets, there were 699 ha of additional no harvest areas due to no harvest FSW constraints.
Caribou Recovery	The Caribou habitat assessment showed that the ISS Base Case scenario does not maintain the disturbance level below the 35% threshold set in federal caribou recovery strategy over the provincial herd boundaries. When the disturbance in the caribou areas was restricted (i.e., maximum 10% of the FMLB <40years within Chase and Wolverine herd boundaries), harvest decreased by 28% in the short- and mid-term, and 20% in the long-term.
Pine Beetle Management	The ISS Base Case Scenario refined the spatial depiction of MPB impacts and adjusted yields accordingly (i.e., 22-year declining shelf life curve, 9 years of attack (2003-2011), grouped stands according to dead classes (10%), included post-MPB regeneration, and harvest partition on MPB stands). In addition, in-block retention was adjusted based on opening size by implementing patch groups adjusted relative to the current distribution. This led to a significant area reduction (~88,000 ha); contributing to 1.5 times more area retained for WTR and Riparian Reserves than the 12.1% aspatial reduction used in the TSR Benchmark.
Access Timing	The mocked-up access timing constraint zones designed to prioritize wilderness areas and key grizzly bear habitat did not significantly impact the harvest rate compared to the ISS Base Case.
Non-Timber Objectives	The non-timber objectives that were additional to the TSR Benchmark (ECA targets for FSWs, harvest constraints for Northern Caribou migration corridors) did not seem to have significantly constrained the harvest flow of the ISS Base Case.
Candidate Reserves	The Reserves Scenario selected candidate reserves based on a scoring system to prioritize stands in meeting landscape-level thresholds for old seral forest and interior old forest. To meet the required targets, approximately 8,500 ha of the current THLB was identified as candidate reserves.
Minimum Harvest Criteria	Relaxed minimum harvest criteria for MPB stands (i.e., minimum 100 m^3/ha on maximum 35% slope and maximum 3 hours haul cycle) increased the first 20 year harvest flow by 7.6%. The volume sourced exclusively from the stands with relaxed minimum harvest criteria averaged to 118,000 m^3/year (total of 2.37 million m^3 over the first 20 years).
Cable Harvest	The forecasted harvest that comes from cable harvest systems averages out at 38% of the harvest profile. This high percentage should be noted by planners.
Wildfire Management	Including higher harvest priorities for stands that are rated as extreme fire threat (88,000 ha) or within identified fire fuel breaks (101,000 THLB) did not impact harvest flows. However, these harvest priorities significantly reduced the salvage of MPB impacted stands and a reduction in average harvest age.
Harvest Opening Sizes	Implementing opening size criteria resulted in a significant reduction in small openings. Grouping blocks into larger harvest openings was possible without impacting the harvest flow. These criteria were revised in the Combined Scenario where harvesting of small cutblocks (under 20 ha in size) was controlled more aggressively, still with no visible impact on harvest flow.
Harvest Partitions	Turning off the pine and deciduous harvest partitions did not have a significant impact on harvest flows. However, it was observed that there may be better options available to maximize mid- and long-term harvest levels than forcing salvage of MPB.
Silviculture Tactics	Enhanced basic silviculture treatments are likely selected over fertilization and rehabilitation because of the opportunity to meet minimum harvest criteria sooner (incremental volume) which also allowed shifting the harvest of older stands sooner during the planning horizon. Considering economic criteria at both, the stand- and forest –level, can improve our understanding of the ramifications of selecting one treatment over another.
Large Datasets	This analysis created extremely large datasets as a result of the relatively large area involved. In addition, many modelling details and complex approaches were addressed as accurately as possible (e.g., MPB yields and the full range of non-timber objectives). Consequently, these forest estate models grew exponentially resulting in much longer times needed to develop, build, run, and report results. These considerations are important when planning analyses of this magnitude.

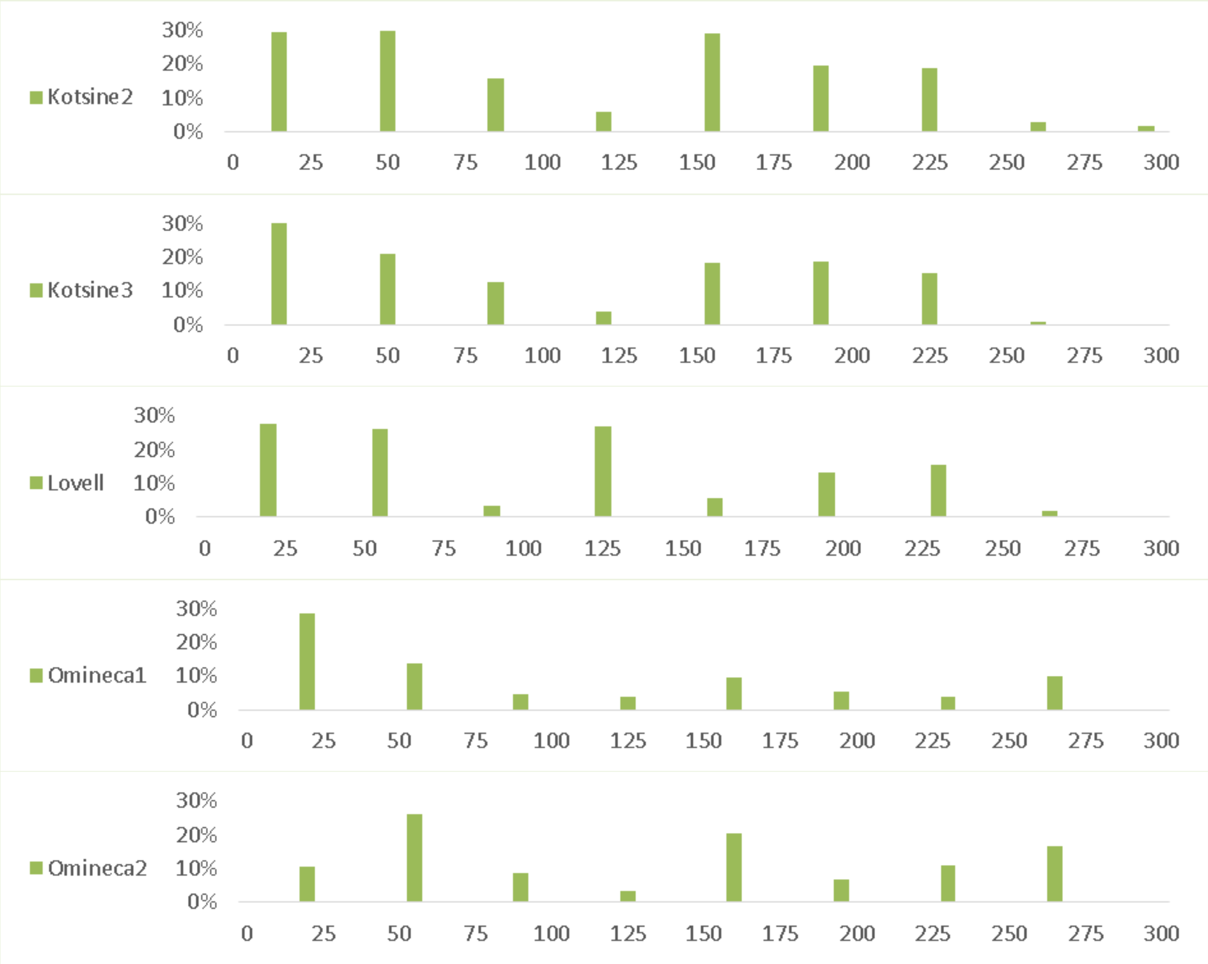
9 Recommendations

Opportunities to improve future analyses or explore new tactics were also identified through these analyses. Specific recommendations are briefly summarized in Table 9.

Table 9 Summary of Recommendations

Topic	Recommendation
Low Productivity	Exclude lower productivity stands that do not meet minimum harvest criteria from the THLB. This will allow a more accurate modelling of standing volume and minimize impacts on harvest flow in the long-term. As a general rule for sustainable forest management, growth rate over the long-term should at least equal the harvest rate. Since growth and harvest rate are very sensitive to the THLB area, it is important to have a robust THLB definition.
Caribou Recovery	Refine the caribou assessment to more accurately determine the impact on harvest rate when maintaining the maximum 35% disturbance threshold. In this analysis, the disturbance level was controlled only within the federal recovery areas and only the Chase and Wolverine herds.
	Include patch targets for harvest and fire disturbances within Caribou assessment areas to reduce road construction and group blocks with different operability requirements.
	Examine alternative disturbance criteria. Road and harvest buffers contributed significantly to the anthropogenic disturbance level.
	Implement patch size criteria within the non-harvestable land base. The natural disturbance schedule imposed on the non-harvestable land base was not spatially realistic as the 'fire' blocks were not grouped into larger patches to more closely mimic reality. Ultimately, this should not affect other modelling results.
	Refine anthropogenic disturbance layer to consider permanent features that have no impact on caribou habitat (e.g., wind tenures, cabins) or are planned for construction in the near future. The available AD data was not clearly defined. As such, some AD features that can potentially cover large forested areas are considered disturbed for the purpose of Caribou habitat assessment.
	Upgrade and expand the road network to access the entire THLB. This will help to reflect AD associated with road buffers.
Excessive Haul Distance	Refine the haul cycle distance to reflect available road systems and other operational realities. This may be further explored as sensitivity analyses.
Candidate Reserves	Refine the reserve scenario by influencing the model to stop selecting more candidate reserves where area in anchors (i.e., no-harvest zones - NHLB) already meet targets.
	Conduct a post-processing GIS analysis to identify edges and determine – more precisely – the amount of interior old forest for each assessment unit. While it was considered, no post-processing GIS analysis was conducted in this analysis as it was planned within the Preferred Scenario.
	Utilize the candidate reserves to provide context and draft set of polygons for further analysis and review at tactical- and eventually, operational-levels; involving stakeholders that work together – for each LU – to verify values are addressed appropriately.
Harvest Openings	Configure the model to develop larger openings without impacting the harvest flow. So far, little emphasis was placed on modelling harvest openings or seral patches but in this TSA, controlling opening size may be achieved to produce appropriate spatially-explicit blocks without penalizing harvest flow. In addition, explore controlling the seral patches to meet interior old forest targets.
Silviculture Tactics	Consider adding more criteria to identify eligible stands for fertilization (e.g., haul distance, low density threshold).
	Determine the most cost-effective treatment schedule to achieve most of the potential harvest gains. This might be done by calculating and comparing the net present value for the incremental volume realized over the planning horizon and under increasingly higher funding levels (i.e., multiple runs).

Appendix 1 Access Timing Constraints Results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Kotsine3
Lovell
Omineca1
Omineca2
30%
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