# Integrated Stewardship Strategy for the Mackenzie TSA

## Analysis Report

Version 1.3

March 31, 2018

Project 419-35

*Prepared by:*

*Forsite Consultants Ltd.*
*330 – 42nd Street SW*
*PO Box 2079*
*Salmon Arm, BC V1E 4R1*
*250.832.3366*

FORSITE
Forest Management Specialists

*Prepared for:*

*BC Ministry of Forest, Lands and Natural Resource Operations*
*Resource Practices Branch*
*PO Box 9513 Stn Prov Govt*
*Victoria, BC V8W 9C2*

BRITISH COLUMBIA

# Executive Summary


This report summarizes the results for the Integrated Stewardship Strategy (ISS) scenarios conducted to date for the Mackenzie Timber Supply Area. The ISS Base Case scenario included most assumptions used in the latest 2012 Timber Supply Review (TSR) but updated others associated with riparian reserves, caribou management, pine and spruce beetle management, and sensitive watershed management. 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 silviculture scenario explored tactics to enhance timber quantity and quality over the mid- and long-term within a $3M per year budget over the forest 20 years of the planning horizon. The Combined Scenario integrated key elements form all other scenario in order to guide the development, implementation, and monitoring of tactical plans over the first 20 years of the planning horizon.

The long-term timber harvesting land base (THLB) was estimated to be 1,170,013 ha, which is approximately 10% below the TSR Benchmark scenario (which attempted to mimic the latest TSR). The important differences between the TSR and ISS land base definition include assumptions related to: excessive haul distance, wildlife habitat constraints, and riparian reserve areas. These land base differences, plus additional management assumptions, resulted in harvest rate decreases in the ISS Base Case compared to the TSR Benchmark of 18.4% and 4.9% over the short- and mid-terms, respectively. The long-term harvest rate exceeded the TSR Benchmark by 4.3%. These differences are explained by changes in the land base definition and yield assumptions for stands impacted by insects; specifically, Mountain Pine Beetle and Spruce Bark Beetle.

The federal Caribou recovery strategy was also explored in the ISS Base Case scenario. Very significant impacts (30% in short-term, 33.8% in mid-term, and 23% 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 federal and provincial recovery strategies.

Other non-timber objectives in the ISS Base Case scenario did not significantly constrain the harvest rate. New requirements modelled for some sensitive watersheds were not constraining.

Fifteen Access Timing Constraint zones (22,831 ha THLB) were mocked up as wilderness areas and grizzly bear habitat to explore harvest restrictions over 35-year cycles. These had no impact on harvest rates.

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 12,000 ha (<1%) of THLB area was required to meet these requirements. These areas were generally restricted to small assessment units. 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 harvest openings can be grouped into larger sizes without compromising the harvest flow. Turning off the harvest partitions aimed to encourage salvage and limit the volume generated in deciduous and balsam leading stands, increased the harvest rate by 12.3% in the short-term, and 14.5% in the mid- and long-terms.

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 visibly increased the harvest flow by 4.7% while filling-in the mid-term trough. Most of the budget was spent on enhanced basic silviculture and stand rehabilitation despite the higher costs relative to the fertilization tactic. The

silviculture tactics advantages 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 during the planning horizon and fill in the mid-term trough.

The Combined Scenario considered key elements from all other scenarios, including the removal of the Kwadacha First Nation Woodland Licence which, compared to the ISS Base Case, reduced the Crown Forested Land Base by 9.8% and THLB by 10.3%. Consequently the harvest flow was reduced by 6.2% in the short term and 8.5% in the long term, while the mid-term trough of the ISS base Case was matched by the mid-term harvest flow of the Combined Scenario. Here, the harvesting of stands identified with extreme wildfire fire threat was pursued more aggressively, but without impacting the MPB and spruce beetle salvaging. The harvest opening sizes were also controlled more aggressively by reducing to zero openings <1 ha and controlling the sizes 1-20 ha to a maximum of 15% of the harvested THLB during a 5-year period.

# Table of Contents

# List of Tables



# List of Figures

# List of Acronyms

| | |
|---|---|
| AD | Anthropogenic Disturbance |
| ATC | Access Timing Constraints |
| BEC | Biogeoclimatic Ecosystem Classification |
| BEO | Biodiversity Emphasis Option |
| BUF | Buffer (a-anthropogenic, h-harvest, r-road) |
| CFLB | Contributing Forest Land Base |
| ECA | Equivalent Clearcut Area |
| GIS | Geographic Information System |
| IBS | Insect Beetle Spruce (i.e., Spruce Beetle) |
| ISS | Integrated Stewardship Strategy |
| LU | Landscape Units |
| MPB | Mountain Pine Beetle |
| 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 |
| VRI | Vegetation Resource Inventory |
| WHA | Wildlife Habitat Area |

# Document Revision History

| Version | Date | Notes/Revisions |
|---|---|---|
| 1.0 | Sep 2017 | First version distributed to project team for review and comment. Only included results for Base Case and Reserve Scenarios. |
| 1.0 (not changed) | Sep 29, 2017 | Updated section 1 (Introduction), updated section 5 (Harvest Scenario), and added observations/recommendations to section 8 (Discussion). |
| 1.2 | Dec 15, 2017 | Updated section 1 (Introduction), updated section 6 (Silviculture Scenario), and added observations/recommendations to section 8 (Discussion). |
| 1.3 | March 31, 2018 | Updated Executive Summary<br>Changed Integrated Silviculture Strategy to Integrated Stewardship Strategy.<br>Added Section 7 (Combined Scenario) and updated section 8 (Discussion) to include findings from the Combined Scenario.<br>Updated Figure 29 to include correct area for second fertilization application. |

# 1 Introduction

This document summarizes the results for the Integrated Stewardship Strategy (ISS) scenarios conducted for the Mackenzie 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 of the ISS Base Case (Table 1) indicates a long-term Timber Harvesting Land Base (THLB) of 1,170,013 ha, which is approximately 130,543 ha (or 10.0%) below the TSR Benchmark. Major differences between the two land bases are discussed below.

[1] Forsite Consultants Ltd. 2018. Integrated Stewardship Strategy for the Mackenzie TSA – Data Package. Version 1.3. Project 419-35. March 31, 2018. 51 pg.

### *Table 1 Mackenzie ISS Base Case Scenario Land Base Definition*

| Factor | Gross Area (ha) | Effective Area (ha) | % of Total Area | % of CFLB |
|---|---|---|---|---|
| **Total Area** | **6,410,665** | **6,410,665** | **100.0%** | |
| Less: | | | | |
| Non TSA (Private, Woodlots, CFA, Federal/Military/Misc. Reserves) | 41,738 | 41,738 | 0.7% | |
| FN Reserves | 838 | 286 | 0.0% | |
| **Total Timber Supply Area (TSA)** | | **6,368,641** | **99.3%** | |
| Less: | | | | |
| Water | 225,384 | 221,552 | 3.5% | |
| Wetland and Alpine | 1,438,756 | 1,213,071 | 18.9% | |
| BEC Alpine | 1,075,980 | 227,528 | 3.5% | |
| Snow, Ice, Rock | 795,397 | 18,524 | 0.3% | |
| Shrubs, Herbs | 1,176,344 | 591,994 | 9.2% | |
| Glacier, Bedrock | 790,376 | 0 | 0.0% | |
| Exposed Soil | 2,767 | 0 | 0.0% | |
| Low Site Index (<5m) | 2,831,783 | 777,169 | 12.1% | |
| Roads and Utility | 66,744 | 55,708 | 0.9% | |
| Logged Agricultural and Settlement Areas | 535 | 535 | 0.0% | |
| **Crown Forested Land Base (CFLB)** | | **3,262,561** | **50.9%** | **100.0%** |
| Less: | #in CFLB | | | |
| *Inoperable* | | | | |
| Excessive Haul Distance | 280,501 | 280,501 | 4.4% | 8.6% |
| Unstable Terrain (U,V, 5) | 14,953 | 14,953 | 0.2% | 0.5% |
| Slope >=46% and Vol <250m³ | 497,000 | 453,933 | 7.1% | 13.9% |
| Non Commercial Species (W,EP, Z) | 15,962 | 13,459 | 0.2% | 0.4% |
| Slope <=35 and Vol<150m³ (incl PL) | 694,814 | 565,938 | 8.8% | 17.3% |
| Slope 35-46 and Vol<150m³ | 226,383 | 204,769 | 3.2% | 6.3% |
| *Reserves* | | | | |
| Provincial Parks | 375,051 | 124,850 | 1.9% | 3.8% |
| Crown Reserves | 377,637 | 442 | 0.0% | 0.0% |
| Misc. Reserves | 110 | 91 | 0.0% | 0.0% |
| Ungulate Winter Range (UWR) No Harvest | 398,443 | 108,202 | 1.7% | 3.3% |
| Wildlife Habitat Area (WHA) No Harvest | 107,073 | 61,899 | 1.0% | 1.9% |
| Old Growth Management Area (OGMA) | 55,112 | 28,218 | 0.4% | 0.9% |
| Mugaha Marsh Sensitive Area | 0 | 0 | 0.0% | 0.0% |
| Muskwa-Kechika Management Area | 397,811 | 33,894 | 0.5% | 1.0% |
| Weissener Buffer | 473 | 162 | 0.0% | 0.0% |
| Riparian | 248,190 | 106,930 | 1.7% | 3.3% |
| Isolated | 3,469 | 2,450 | 0.0% | 0.1% |
| **Current Timber Harvesting Land Base (THLB)** | | **1,261,869** | **19.7%** | **38.7%** |
| Less: | | | | |
| Agriculture/Settlement areas | | 611 | 0.0% | 0.0% |
| Retention (In-block + MPB Salvage Zones)* | | 66,331 | 1.0% | 2.0% |
| Future Roads (4% of THLB>300m from roads)** | | 24,914 | 0.4% | 0.8% |
| **Long-Term Timber Harvesting Land Base (THLB)** | | **1,170,013** | **18.3%** | **35.9%** |

* Various in-block retention depending on the patch size within MPB Salvage Zone (0% for non-Salvage Zone and 10-30% for Salvage Zones)

** Yield reduction of 1.97% applied to future stands regenerated after clearcut of existing natural stands.

## 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).

***Table 2 Important differences between TSR Benchmark and ISS Base Case***

| Assumption/Factor | TSR Benchmark | ISS Base Case | Harvest impact |
|---|---|---|---|
| Excessive Haul Distance | 293 km away from Mackenzie, spatially explicit layer (estimated for TSR Benchmark) | Forsite developed a haul distance profile based on cycle hours (i.e., haul cycle >5 hours was assumed too far to be harvested). ISS netted out **332,043 ha** (net) less than TSR Benchmark. | ⬆ |
| UWRs (No-Harvest) | u-7-004, u-7-006, u-7-009 (PP-001, PP-002, PP-004), u-7-017 (AP3, AP4, AP5, AP6) | **u-7-001**, u-7-004, u-7-006, u-7-009 (PP-001, PP-002, PP-004), u-7-017 (AP3, AP4, AP5, AP6) , **u-7-025, u-7-028, u-7-029, u-7-030, draft amended (u-9-002, u-9-004)**. ISS netted out **81,104 ha** (net) more than TSR Benchmark | ⬇ |
| UWR (Management) | u-7-001, u-7-005, u-7-007, u-7-008, u-7-009, u-7-017 (AP1, AP2) | u-7-005, u-7o-007, u-7-008, u-7-009, u-7-017 (AP1, AP2) | ● |
| WHAs (No-Harvest) | TAG# 9-001, 9-035, 9-036, 9-037, 9-038, 9-039, 9-040, 9-102, 9-103 | TAG# 9-001, 9-035, 9-036, 9-037, 9-038, 9-039, 9-040, 9-102, 9-103, **proposed (9-146), draft (7-012, 7-013, 7-014, 7-015, 7-016, Bull Trout 5 units, 9-999), and draft Caribou PostRut (7-233, 7-234, 7-237, 7-238, 7-239, 999).** ISS netted out **48,724 ha** (net) more than TSR Benchmark | ⬇ |
| WHAs (Management) | None | Northern Caribou Migration Corridors (Finlay Herd [7-318], Wolverine Herd [7-244-7-248, 7-252], and Chase Herd [7-292-7-295, 7-313]) | ⬇ |
| Riparian | 4.7% aspatial (in-block + riparian). Netted out 65,474 ha | Spatially explicit netted out using FWA except small streams. The small stream sizes were netted out as aspatial retention within the MPB salvage retention strategy. ISS netted out **107,787 ha** (net) more than TSR Benchmark | ⬇ |
| Unstable Terrain | Classes U and V | Classes U, V, **5**. ISS netted out 7,493 ha (net) more than TSR Benchmark | ⬇ |
| Muskwa-Kechika Management Area | Excluded by excessive haul distance | Specifically excluded 397,811 ha (gross) or 33,894 ha (net) | ● |
| Weissener Buffer | Excluded by excessive haul distance | Specifically excluded 473 ha (gross) or 162 ha (net) | ● |
| Fox/Obo River Landscape Unit (LU) Landscape-Level Biodiversity | Not modelled | Seral objectives (Mature + Old, Old) and patch size distribution by NDT | ⬇ |
| Stand-Level Biodiversity | 4.7% in-block retention | Used Chief Forester guidance (2005) for retention levels relative to opening size | Included in Riparian |
| Sensitive Watersheds | Not modelled | Max ECA targets applied. Height-based ECA curves for existing managed stands, MPB-based ECA curves for managed and mature stands impacted by MPB, and IBS-based ECA for managed and mature stands impacted by IBS. There were stands with MPB and IBS impacts. | ● From model results |
| Analysis Units | Did not consider | Complex and detailed algorithm to include BEC, MPB, and | ● |

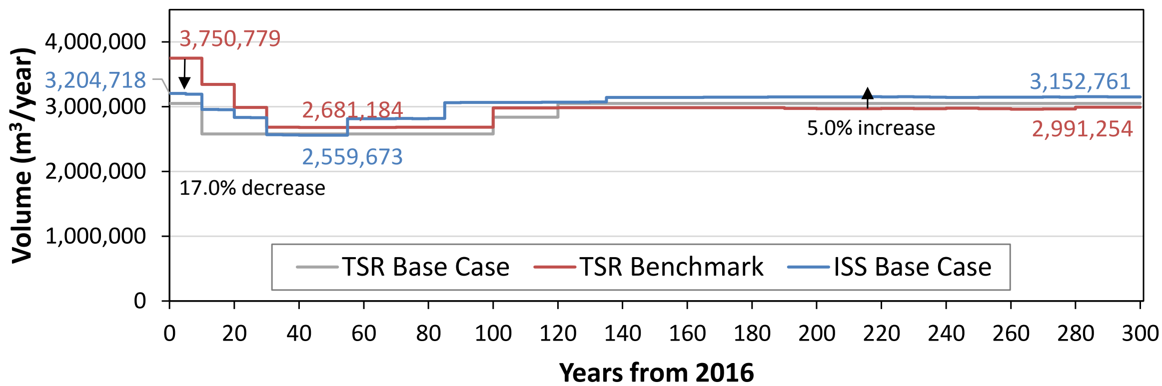
| Assumption/Factor | TSR Benchmark | ISS Base Case | Harvest impact |
|---|---|---|---|
| | Biogeoclimatic Ecosystems Classification (BEC) as a stratification level | IBS as stratification levels | Difficult to estimate |
| MPB Shelf Life | Killed PL volume was maintained for 15 years following MPB attack | Used a 22-year declining shelf life curve | ● Difficult to estimate |
| MPB Attack Year | 3 years of attack (2005,2009, and 2011) | 9 years of attack (2003-2011) | ● Difficult to estimate |
| MPB Mortality (<=60 yrs) | No change | No change | ● |
| MPB Mortality (>60 yrs) | 75% pine component mortality for all mature stands | 9 classes of 10% width for 10-100% stand percentage dead for mature stands where Vegetation Resource Inventory (VRI) indicated stand percentage dead and attack year | ● Difficult to estimate |
| Regeneration Layer Post-MPB | Not modelled | Same natural yield curve (without MPB stratification, used only Spp, BEC, and SI) with 10 year advanced regeneration (i.e., year 10 on regen yield corresponds to attack year) | ↑ |
| IBS Shelf Life | Not modelled | 5 years | ● |
| IBS Attack Year | Not modelled | 2015 (from Forest Health Surveys 2014-2015) | ● |
| IBS Mortality | Not modelled | All stands >10 years, spruce component is killed (based on IBS severity – M-20%, S-40%, VS-60%) in attack year, and maintained for 5 years (no decline curve). After 5 years, the killed spruce component is removed from yield | ↓ minor |
| Regeneration Layer Post-IBS | Not modelled | Same natural yield curve (WITHOUT MPB or IBS STRATIFICATION, used only Spp, BEC, and SI) with 10 year advanced regeneration (i.e., year 10 on regen yield corresponds to attack year). | ↑ |
| Natural Disturbances on Non-THLB | Not modelled | By each BEC/BDT as guided in Biodiversity Guidebook (average of 7,494 ha/year) | ↓ |
| Harvest Partition During MPB Salvage Period | Pine-leading: min 67% | Pine-leading: min 67% | ● |
| | Non-Pine leading: max 905,000 m³/year<br>Spruce-leading: max 850,000 m³/year | Non-pine coniferous leading: max 950,000 m³/year and max 300,000 m³/year from southwest TSA. | ↓ |
| Other Harvest Partitions | Deciduous leading: max 100,000 m³/year | No change | ● |
| | Balsam-leading: even-flow at 92,000 m³/year | No change | ● |

# 3 ISS Base Case Scenario

## 3.1 Timber Objectives

The harvest flows for TSR Benchmark and ISS Base Case are compared in Figure 1, which account for non-recoverable losses (NRL) of 195,000 m³/year. In the short-term, the ISS Base Case harvest flow is approximately 546,000 m³/year (17.0%) lower than the TSR Benchmark. In the mid-term, the difference between the two harvest flows decreases to 4.8%. In the long-term, the ISS Base Case harvest flow is approximately 158,000 m³/year (5.0%) higher than the TSR Benchmark.

The differences between the two flows over the short-term are explained by the difference in THLB area (TSR Benchmark is 10.0% higher than ISS Base Case) and differences in MPB and IBS yield assumptions. The ISS Base Case used a more complex, and arguably more accurate, algorithm to estimate MPB mortalities. IBS mortality was also considered but the impact on growing stock is relatively minor compared to the MPB impact. Consequently, the TSR Benchmark initial THLB growing stock is 11.1% higher than the ISS Base Case, an increase that cannot be solely explained by the 10.0% THLB area difference. The fact that mid-term harvest flows are almost identical suggest that the MPB yields perform better in the ISS Base Case because the same mid-term harvest flow is produced in a 10.0% lower THLB area.



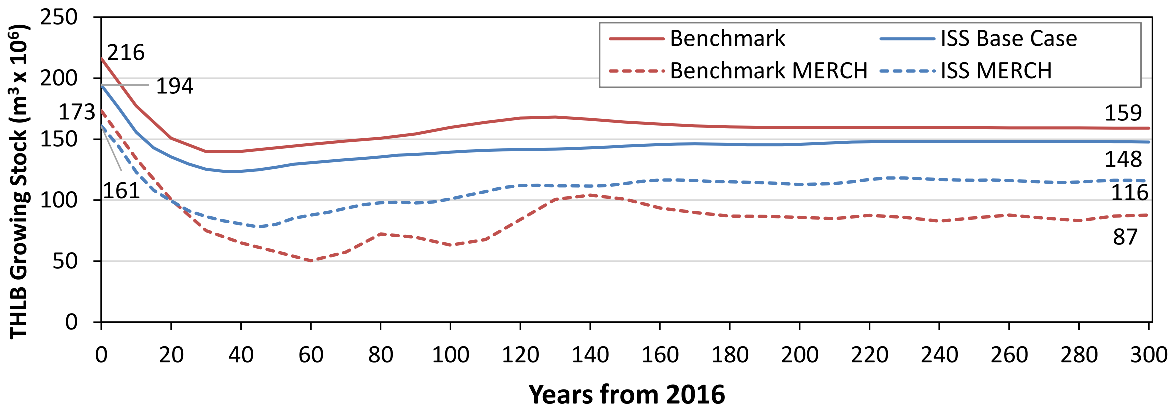




***Figure 1 Comparing Harvest Flows and THLB Growing Stock for TSR and ISS Base Case Scenario***

The long-term differences between the two flows can be solely explained by the MPB yield assumptions and the ripple effects on operability windows. TSR Benchmark assumed that in all mature stands after the MPB shelf-life, the dead volume was removed and the remaining live volume continues to grow with no emergent regeneration layer. In contrast, the ISS Base Case assumed that in mature stands where VRI indicated an attack year and standing dead was ≥10%, a regeneration layer will emerge. Under this assumption, the regeneration layer is proportional to the dead MPB volume removed after the shelf-life which emulates the original yield. The consequence of the differing yield assumptions resulted in more constraining operability windows in the TSR Benchmark, defined by the Minimum Harvest Age (≥151m³/ha on slopes <46% and >250 m³/ha on slopes ≥46%).

Figure 2 shows that compared to the TSR Benchmark, area and THLB growing stock of MPB impacted stands are significantly lower in the ISS Base Case. The initial area and yield of MPB stands are significantly higher in the TSR Benchmark as its MPB assumptions were applied to all mature stands. By the end of the 300-year horizon, only the live volume in the MPB impacted stands is left. However, in both scenarios, some stands will never be harvested, either due to operability window constraints, or because the model chooses to recruit these stands for non-timber purposes. It is noteworthy that at the end of the 300-year planning horizon, the MPB area and THLB growing stock are still significantly higher in the TSR Benchmark, which suggests that TSR Benchmark long-term harvest flow could have been higher.

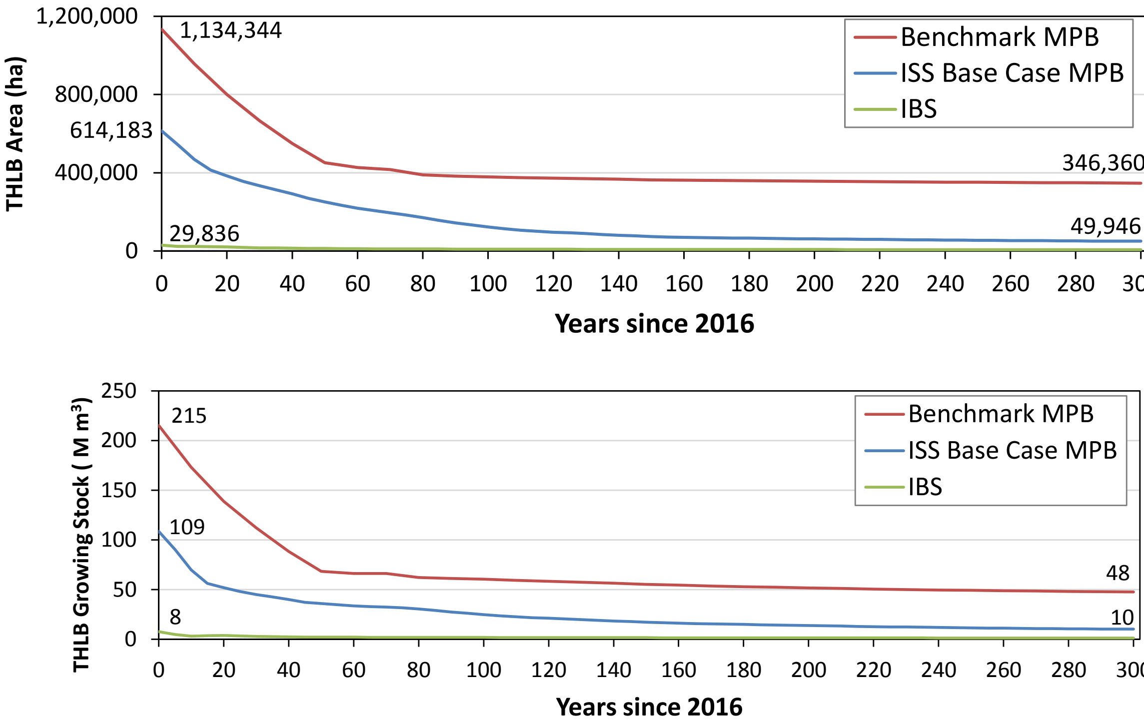



***Figure 2 Comparing THLB Area and Growing Stock of MPB and IBS Impacted Stands***

The initial dead MPB volume is higher for the TSR Benchmark than the ISS Base Case (Table 3). As mentioned above, this difference is explained by the THLB area and MPB yield assumptions differences. The ripple effect of MPB yield assumptions differences is that the MPB NRL are significantly higher in the ISS Base Case compared to the TSR Benchmark. This is explained by the shelf-life curve used by the ISS Base Case compared to no shelf-life curve in the case of the TSR Benchmark. The shelf-life curve used in the ISS Base Case assumed a steady decline of the usable dead volume over a 22-year period following the attack. In contrast, the TSR Benchmark assumed that in year of attack, the affected pine component is killed and the killed volume persists for the 15-year shelf-live. Thus, there was more MPB dead volume available to be harvested in the case of the TSR Benchmark.

***Table 3 MPB Non-Recoverable Losses***

| Variable | TSR Benchmark | ISS Base Case | Difference ($m^3$) |
|---|---|---|---|
| Initial dead MPB volume | 46,666,956 | 33,932,216 | 12,734,740 |
| MPB Dead Volume Harvested by the End of the Shelf-life | 33,245,246 | 12,722,069 | 20,523,177 |
| MPB NRL Dead Volume | 13,421,710 | 21,210,147 | -7,788,437 |

The initial dead IBS volume is 1,764,619 $m^3$, which is in line with the FLNRO estimates[2]. From this dead IBS volume, approximately 873,658 $m^3$ is harvested by the end of the shelf-life. The resulting NRL from IBS impacts over this time are estimated to approximately 891,000 $m^3$.

The harvest partitions in the ISS Base Case were successfully achieved in this analysis (Figure 3). During the first 15 years of the 300-year planning horizon, the model was instructed to generate at least 67% of the volume from the pine-leading stands, and cap the volume generated by non-pine coniferous leading stands (i.e., sub-alpine fir and Spruce) to 950,000 $m^3$/year. In addition, within the southwestern portion of the TSA, the volume generated from non-pine coniferous leading stands was capped to 300,000 $m^3$/year. Finally, the deciduous harvest flow was restricted to maximum 100,000 $m^3$/year and the sub-alpine fir was modelled as an even-flow of 92,000 $m^3$/year. There was no need to activate the cap on spruce leading stands during the MPB salvage period (i.e., maximum 850,000 $m^3$/year) because the 950,000 $m^3$/year cap on non-pine coniferous leading stands was sufficient.

[2] 2016 spruce bark beetle infested THLB area and THLB dead volume estimates provided by Mike McLachlan, RPF, PMP, Project Manager for Omineca Region.

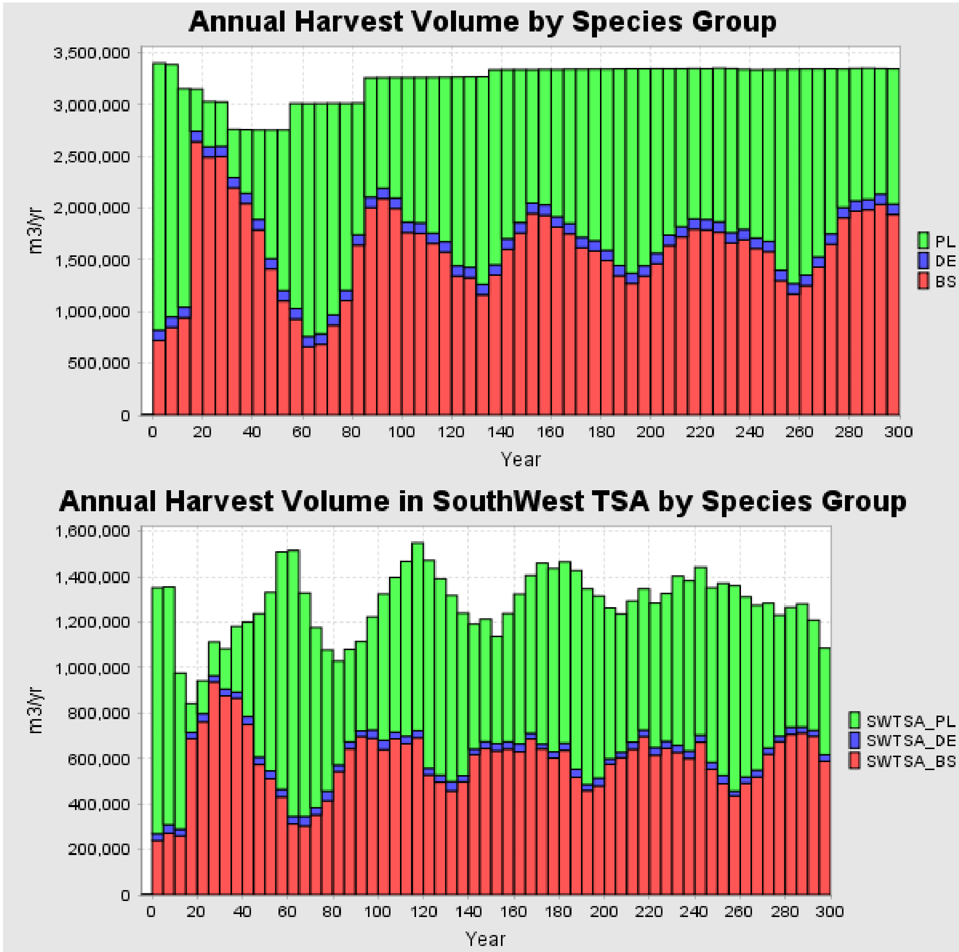
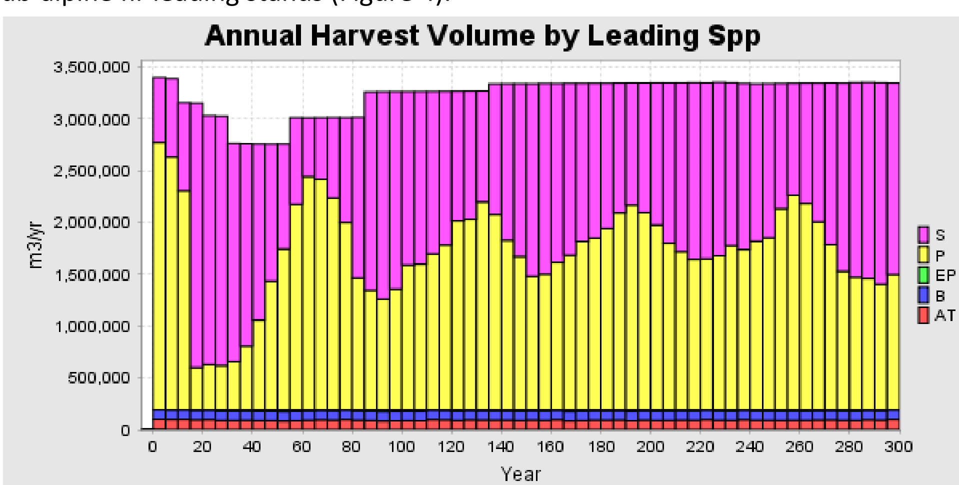



***Figure 3 ISS Base Case Harvest Flow by Species Groups (Total TSA and Southwest TSA)***

The harvest profile by species (leading and individual) indicate that for the next 30-40 years following the MPB/IBS salvage period, most of the volume will be sourced from spruce, deciduous, and sub-alpine fir leading stands (Figure 4).



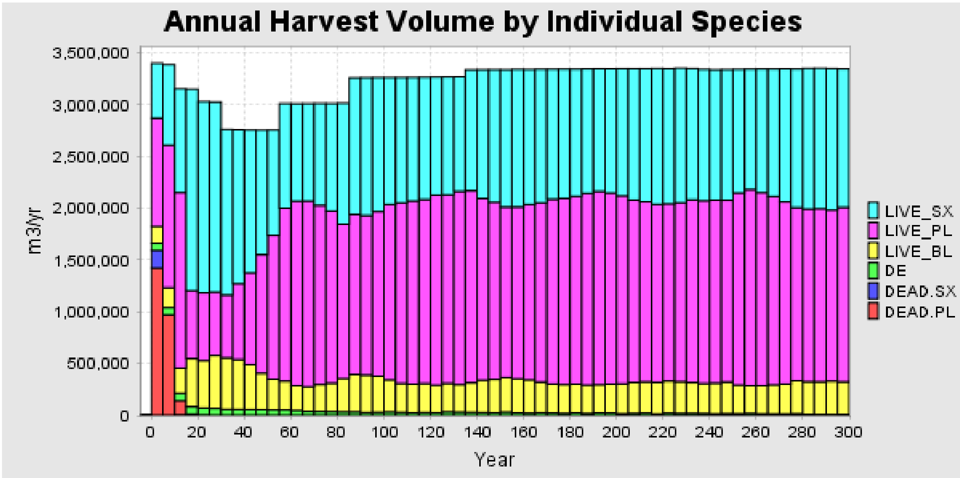



***Figure 4 ISS Base Case Harvest Profile by Leading and Individual Species***

An average unit volume harvest target was imposed to be greater than 200 m³/ha in each period. This seems to have constrained the model only in the beginning of the planning horizon (Figure 5).

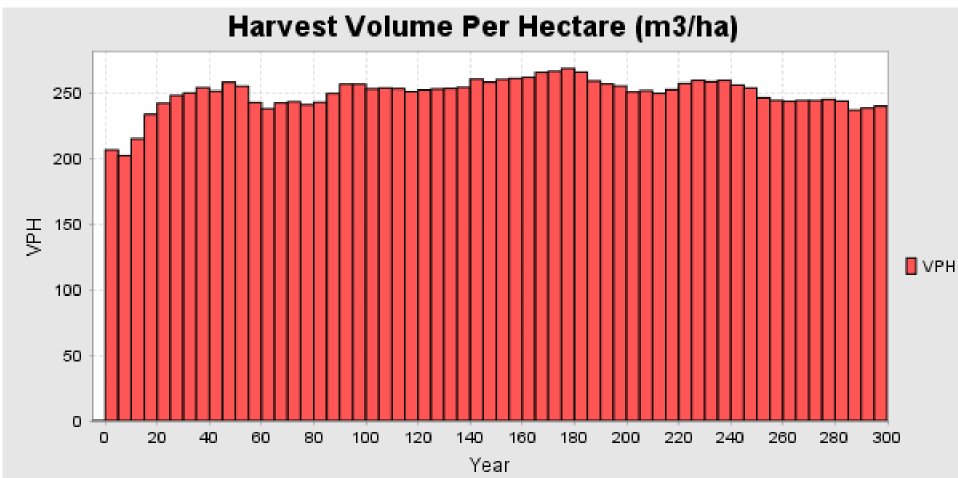



***Figure 5 SS Base Case Harvest Volume per ha (VPH)***

The average age of stands being harvested was between 140 and 160 years during the MPB salvage period, followed by higher harvest ages (up to 190 years) for the next 30-40 years following the MPB salvage period (Figure 6). This, combined with the above results, suggests that the model targeted relatively old pine stands during the salvage period. Following the salvage period, the model targeted relatively old sub-alpine fir and spruce stands. In the long term, the average harvest age stabilizes in approximately 80 years as the model harvests more productive managed stands that reach relatively high volumes per ha at younger ages.

A detailed chart of the harvested volume by age class (Figure 6) shows that harvest of young stands (<60 years) will begin past year 50 of the planning horizon, which is in line with the minimum harvest definition of 150m³/ha, volume that is achieved a younger ages for productive regenerated stands following MPB/IBS salvage (site index higher by 4.2m compared to the existing natural stands). However, the relatively lower quality of wood products sourced from younger, faster-growing stands can pose some economic challenges. Accordingly, the minimum harvest age criteria for future managed stands should be reconsidered in the next ISS iterations.

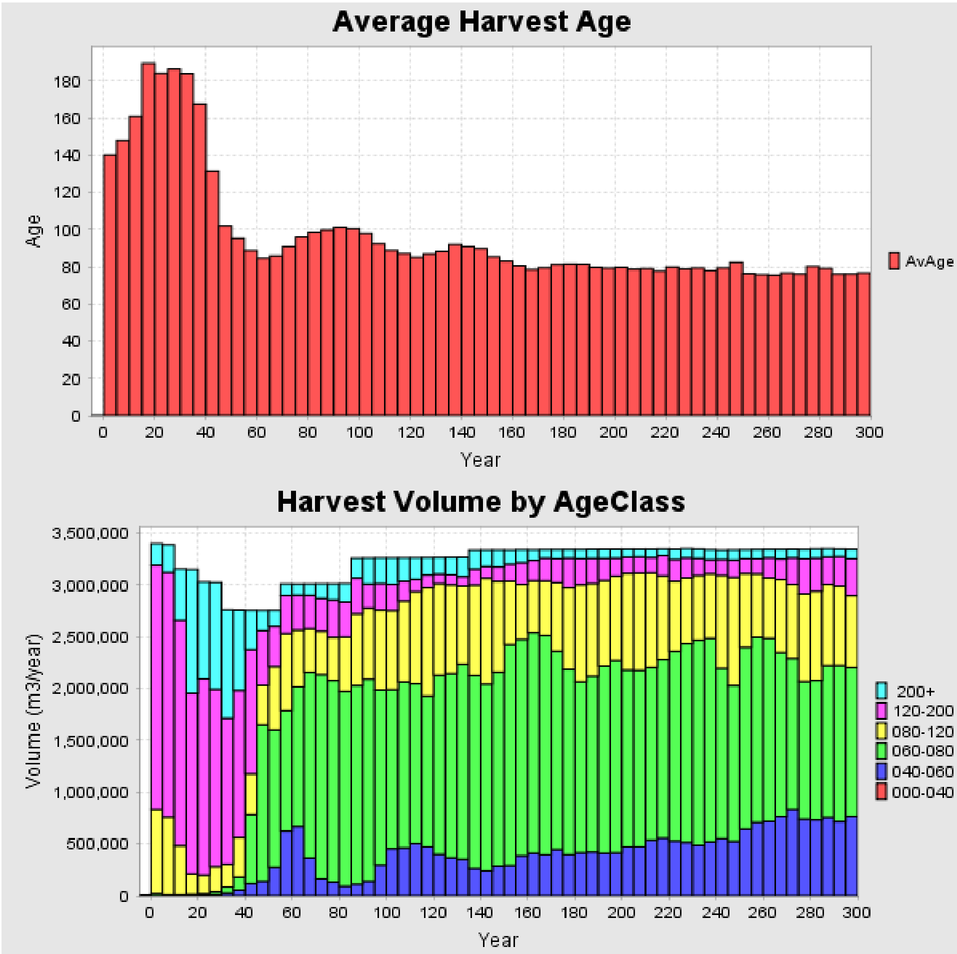



***Figure 6 ISS Base Case Average Harvest Age and Harvest Volume by Age Class***

The age class distribution indicates that the THLB transitions from a relatively mature and old structured forest to a relatively young structured forest (Figure 7). This is in line with the expected changes over time, as the model converts the THLB to a relatively regular forest estate. On the non-THLB, the area disturbed by fires (approximately 7,500 ha/year) cycles through age classes over time, yet, by the end of the 300-year planning horizon, most of the non-THLB area will be older than 240 years.

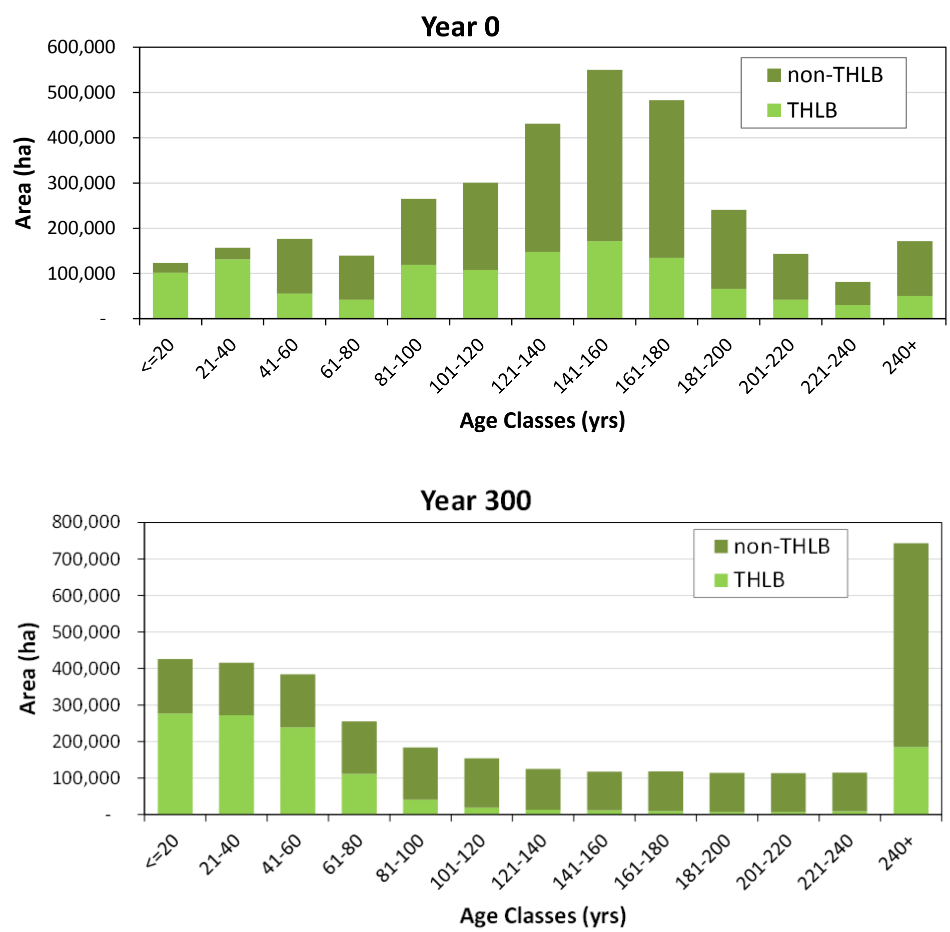



***Figure 7 ISS Base Case Area by Age Classes in Years 0 and 300 of the Planning Horizon***

## 3.2 Non-Timber Objectives

The landscape-level biodiversity objectives require that specific CFLB area percentages are maintained in old condition. These requirements were developed for a combination of LU, BEO, and BEC groups, while the definition of 'old forest' varied depending on the leading species and BEC zone. In addition, the Fox and Obo River LUs had different landscape-level biodiversity requirements which included 'mature + old' and 'old' requirements by BEC and BEO, as well as, patch requirements (opening size resulted from harvesting THLB area).

The results indicated that few landscape-level biodiversity targets constrained the harvest flow. Examples of the most constraining targets are included in Figure 8. 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.

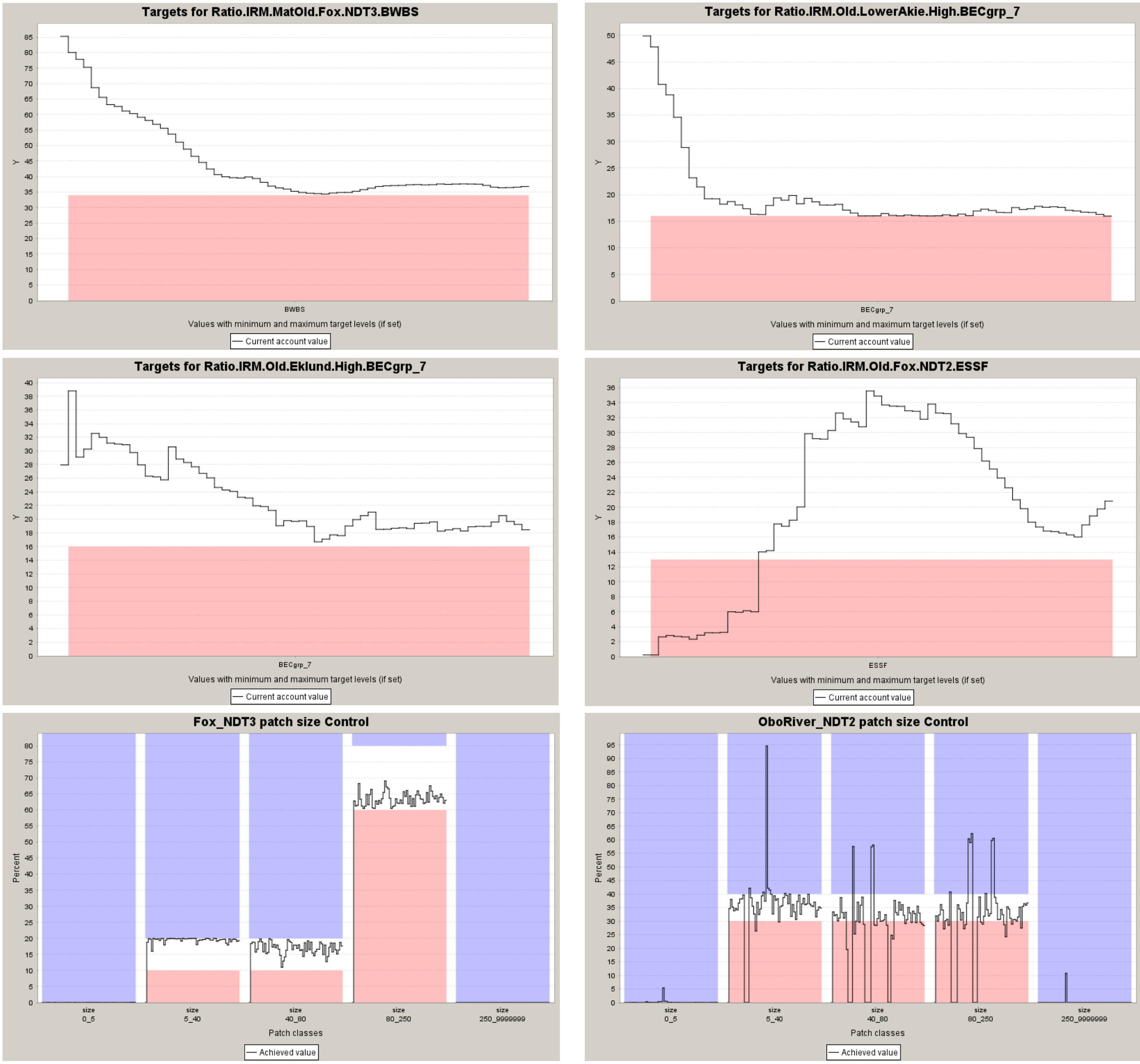



***Figure 8 Examples of landscape-level Biodiversity Targets***

The UWR objectives constrained some of the harvest within the designated UWR areas. Harvest flow was negatively impacted where the harvest disturbance was limited to a maximum disturbance percentage (e.g., u-7-017-max 20% <20 years old and u-7-007 – max 50% <70 years old), or where minimum 40% of the CFLB area needed to be older than 100 years (Figure 9). The rest of the UWR habitat objectives did not seem to impact the harvest flow.

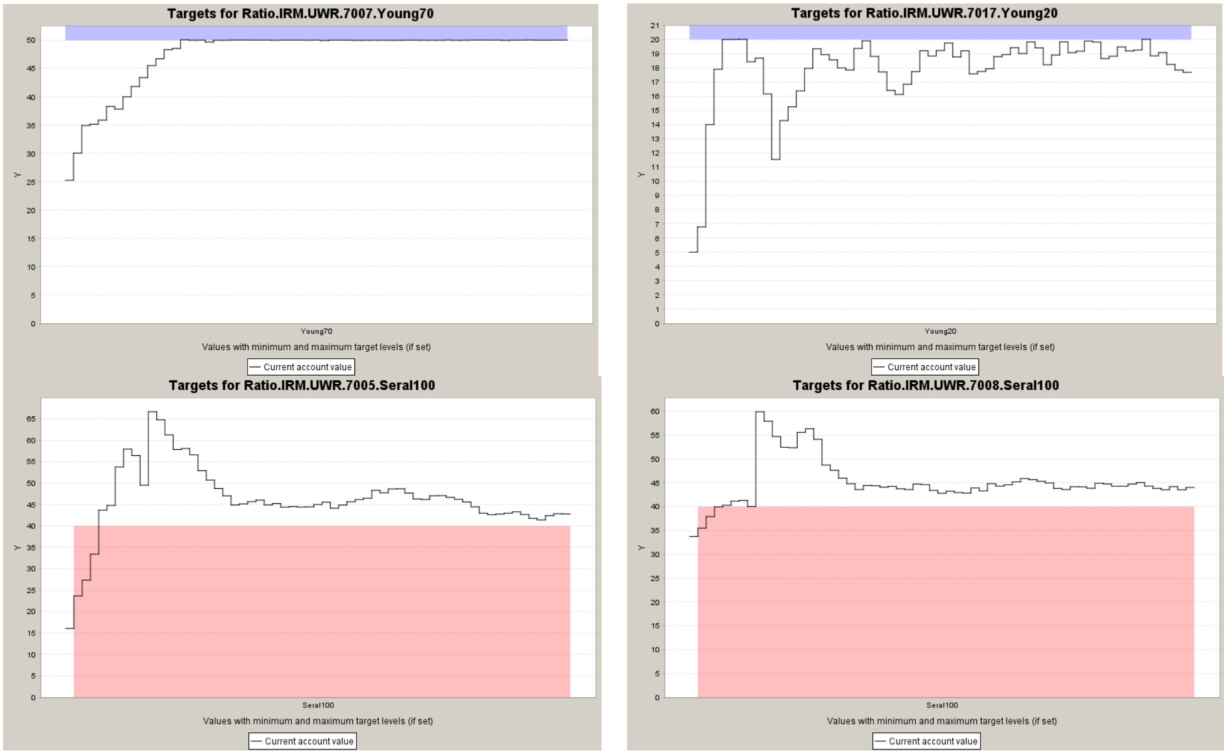



***Figure 9 UWR Management Objectives Constraining the Harvest Flow***

Watershed ECA constraints applied maximum disturbance levels in some sensitive watersheds (i.e., community watersheds, Fish Sensitive Watersheds (FSW), and watersheds identified by the District Manager). Constraints were based on stand height (existing and future managed) and stand percentage dead in MPB/IBS impacted stands. The targeted sensitive watersheds did not impact the harvest flow. The most restrictive ECA targets (Height+MPB+IBS) are included in Figure 10. In some cases, ECA levels were simply monitored without applying targets. The left example in Figure 10 shows the ECA values for the monitored sensitive watershed did not exceed the new maximum ECA 28% (blue bar). ECA values were just reported for the example on the right (no blue bar).

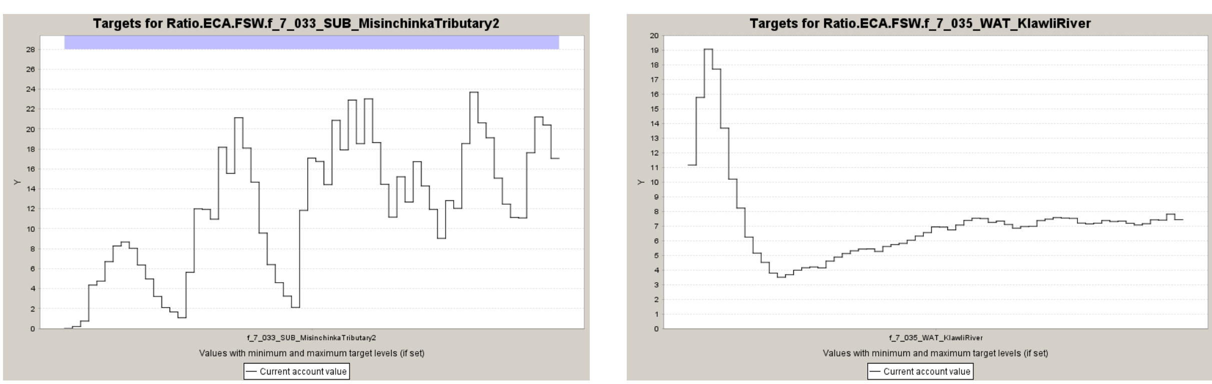



***Figure 10 Example of ECA Targets (Height + MPB+IBS) and ECA Monitored Values***

The spatially-defined Northern Caribou migration corridors for Finlay (WHA# 7-318), Wolverine (WHA# 7-244 to 7-248, and 7-252), and Chase (7-292-7-295, 7-313) herds were restricted from harvesting. A maximum disturbance level of 35% of the CFLB had to be maintained for the entire planning horizon. The area contributing to the disturbance was defined by the areas disturbed by natural events in the last 40 years (where age is <40 years) and areas disturbed by logging events in the last 70 years (where age is <70 years). The results indicated that these objectives were constraining the harvest rates, with a possible negative impact of up to 3%. This is the percentage of the THLB area within the migration corridors (approximately 35,790 ha) of the TSA. The largest CFLB area migration corridor objectives are included in Figure 11.

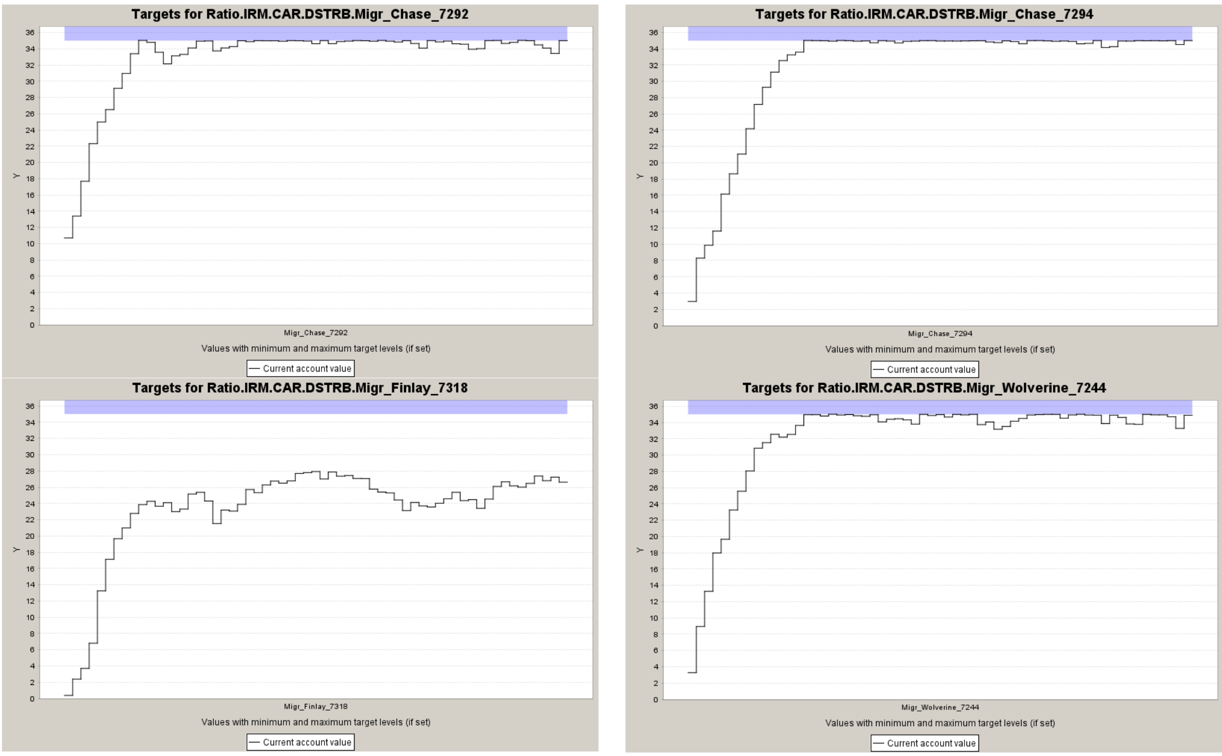



***Figure 11 Examples of Northern Caribou Migration Corridors Objectives***

There are 658 legally established visual polygons that required a range of visual quality objectives (VQO) to be achieved by limiting the amount of disturbance. In the previous TSR analysis it was estimated that the VQOs impact on harvest level would be minor. The VQOs were not model in the ISS analysis.

### 3.3 Caribou Habitat Assessment

Caribou assessments were conducted as post-processing Geographic Information System (GIS) exercises for 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., maximum allowed disturbance level). In the case of the federal recovery strategy, the harvest area was capped at 0.5% of the THLB area, in each 5-year period and within Chase and Wolverine herds. Harvesting was not controlled within the Finlay and Scott herd areas.

The results indicated that the overall harvest rate was reduced by 31.4% in the short-term, by 33.9% in the mid-term, and by 23.9% in the long-term (Figure 12). In most cases, the disturbance level within the Chase and Wolverine provincial herd areas was maintained under the 35% threshold when harvesting was controlled, compared to the initial assessment (Figure 13). The THLB area within the provincial caribou recovery area was 220,559 ha (17.47% of total THLB) for Chase and 185,142 ha (14.67% of total THLB) for Wolverine.

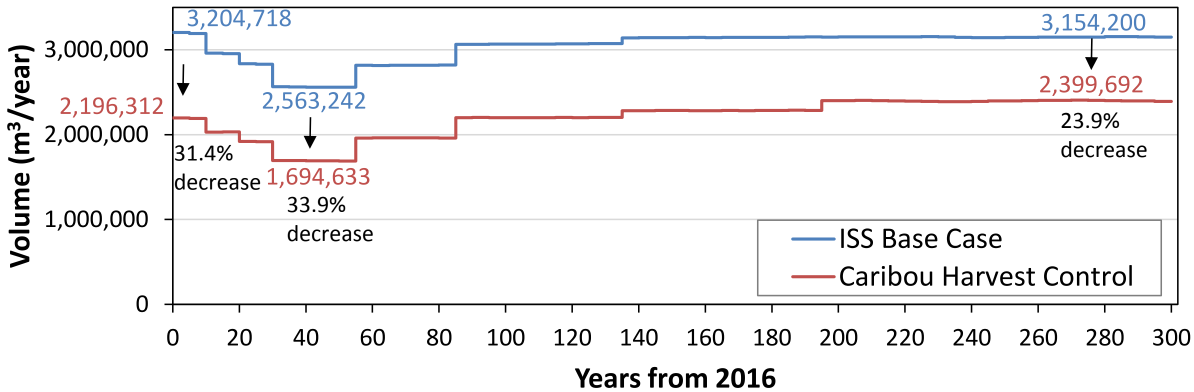
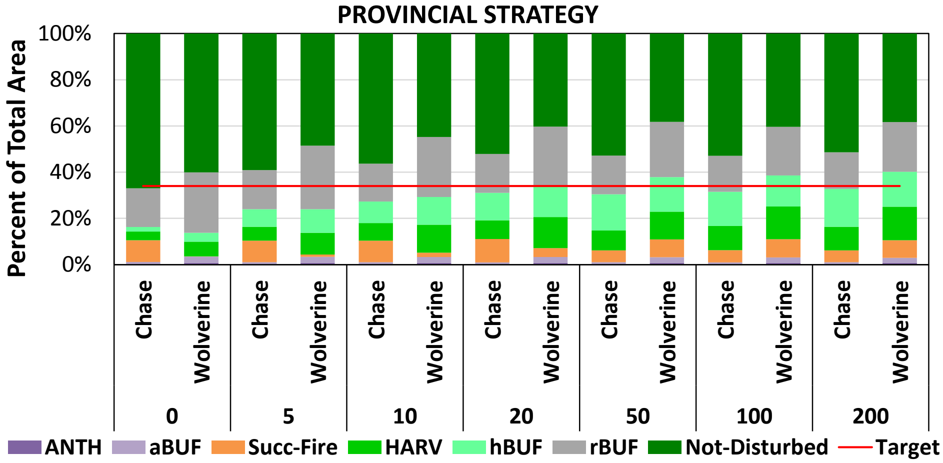



***Figure 12 Comparing harvest rates (m³/5-year period) for the Base Case and Caribou Assessment Iteration***

No Harvest Control




Harvest Control (max 0.5% of THLB harvest/5-year period)

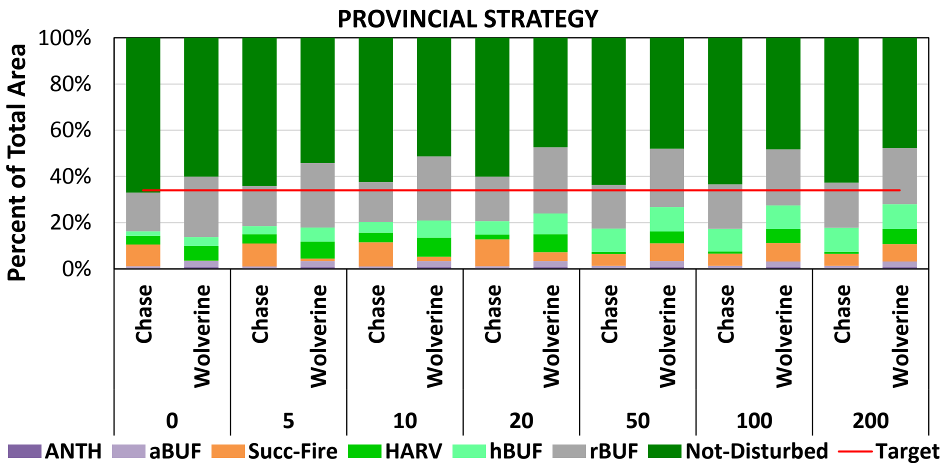



***Figure 13 Disturbance Levels for Chase and Wolverine Provincial Herd Boundaries – with/without Harvesting Control***

Road (rBUF) and harvesting (hBUF) buffers had a significant impact on the disturbance level. An example is shown in Figure 14. Here, more refining of the harvest disturbance (lower harvest level, group harvest into patches, reduce construction of new roads) need to be conducted in order to maintain the disturbance level under 35%.

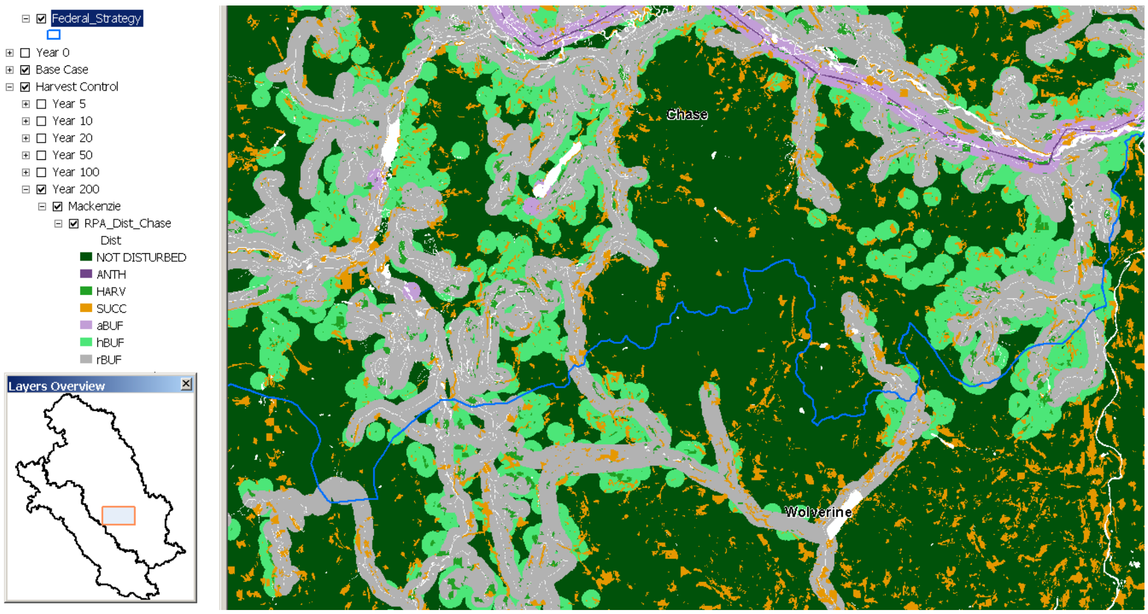



***Figure 14 Example of Disturbance within Caribou Assessment Area in P40 – 200 years when harvest is controlled***

## 3.4 Access Timing Constraints

A sensitivity analysis was conducted to investigate the impact of Access Timing Constraints (ATC) zones on harvest rate. As a 'proof-of-concept', fifteen ATC zones were created via a GIS exercise to prioritize wilderness areas and key grizzly bear habitats. These areas covered a total THLB area of 22,831 ha. The overarching goal was to promote a certain range of values and maximize long-term sustainability in each of the ATC zones. 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 no difference between harvest rates (Figure 15), while the harvest objectives in the ATC zones were not violated (Figure 16).

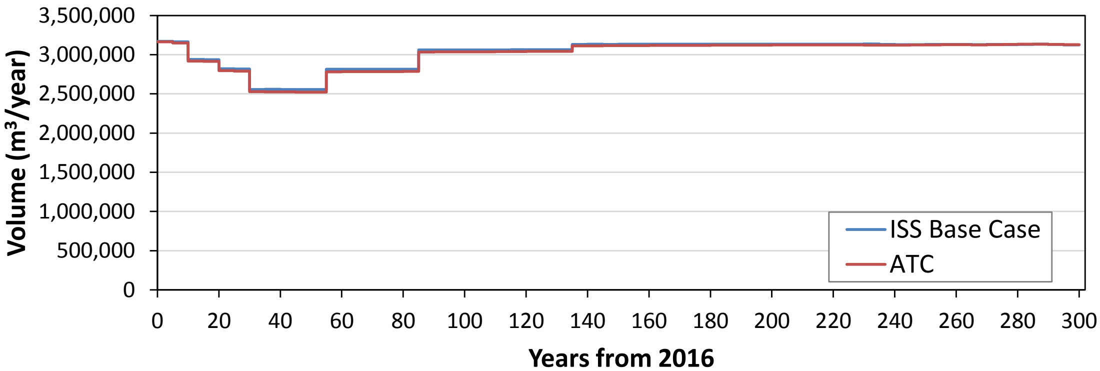



***Figure 15 Comparing Harvest Rates of the Base case and ATC Scenarios***

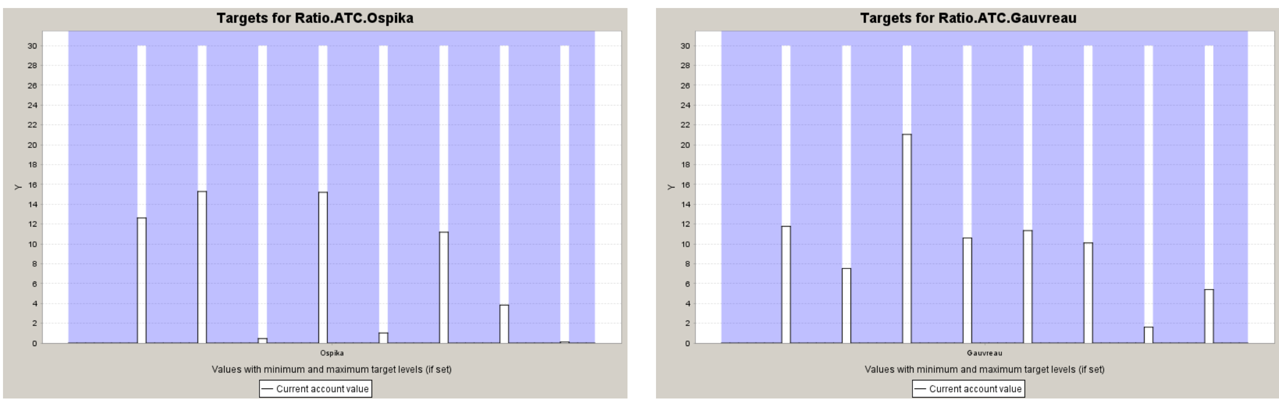



***Figure 16 Examples of Harvest Objectives for ATC Zones***

# 4 Reserve Scenario

## 4.1 Description

The Reserves scenario was designed 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?" Spatial OGMAs were only designated for some LUs throughout the southern section of the Mackenzie TSA, while for the rest of TSA, the landscape level biodiversity objectives were addressed through non-spatial old growth orders. The underlying purpose of this scenario was to explore tactics aimed at maintaining the harvest area while providing a wide range of values on the land base (i.e. co-location).

Initially, it was decided to conduct 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 reserve candidates were assessed on the same units as for the landscape-level biodiversity objectives (BEC group, biodiversity emphasis option (BEO), and LU). Preliminary results displayed scattered reserves so we elected to move the selection of candidate reserves into a modelling environment using Patchworks™. The selection priority in each assessment unit was based on land base category (non-THLB first and THLB second) and current seral stage (oldest first). The model was also encouraged to select the reserves that are currently interior old forest and to group them into relatively large old seral patches over the entire landscape. Finally, the non-THLB anchors (no harvesting) were hard-coded into the model to ensure they will always be selected as reserves.

## 4.2 Results

In most assessment units, there were already large non-THLB areas that met the old seral and interior old forest requirements (some examples are included in Figure 17). In other cases, the model had to select old THLB areas – as well as some mature areas (non-THLB or THLB) – to meet the old seral requirements. Over the entire landscape, 12,000 ha of THLB area was selected as reserves (<1% of the Total THLB). Some examples where the model had to select old THLB area include 2-High-Selwyn, 4-Intermediate-Nation, 4-Low-Philip, 5-Low-Philip, and 6-High-Selwyn. Most of these assessment units (except 4-Low-Philip) are relatively small (<5,000 ha).

There were also assessment units without enough old forest to meet the interior old forest requirement. Again, these assessment units were relatively small; some examples include 2-High-Selwyn CFLB area = 119 ha, CFLB old = 2 ha), 5-High-Nation (CFLB area = 715 ha, CFLB old = 12 ha), and 14 assessment units in BEC group 67.

More refinement of this recruitment strategy is required as the model could be configured to stop selecting reserves where anchors (i.e., no harvesting) have already met the target thresholds. It was expected that once the old seral target was met, the reserve selection process would be stopped.

An example of the spatial distribution of selected reserves is shown in Figure 17, while detailed statistics of the current condition and the selected reserves are included in Appendix 1 and Appendix 2, respectively.

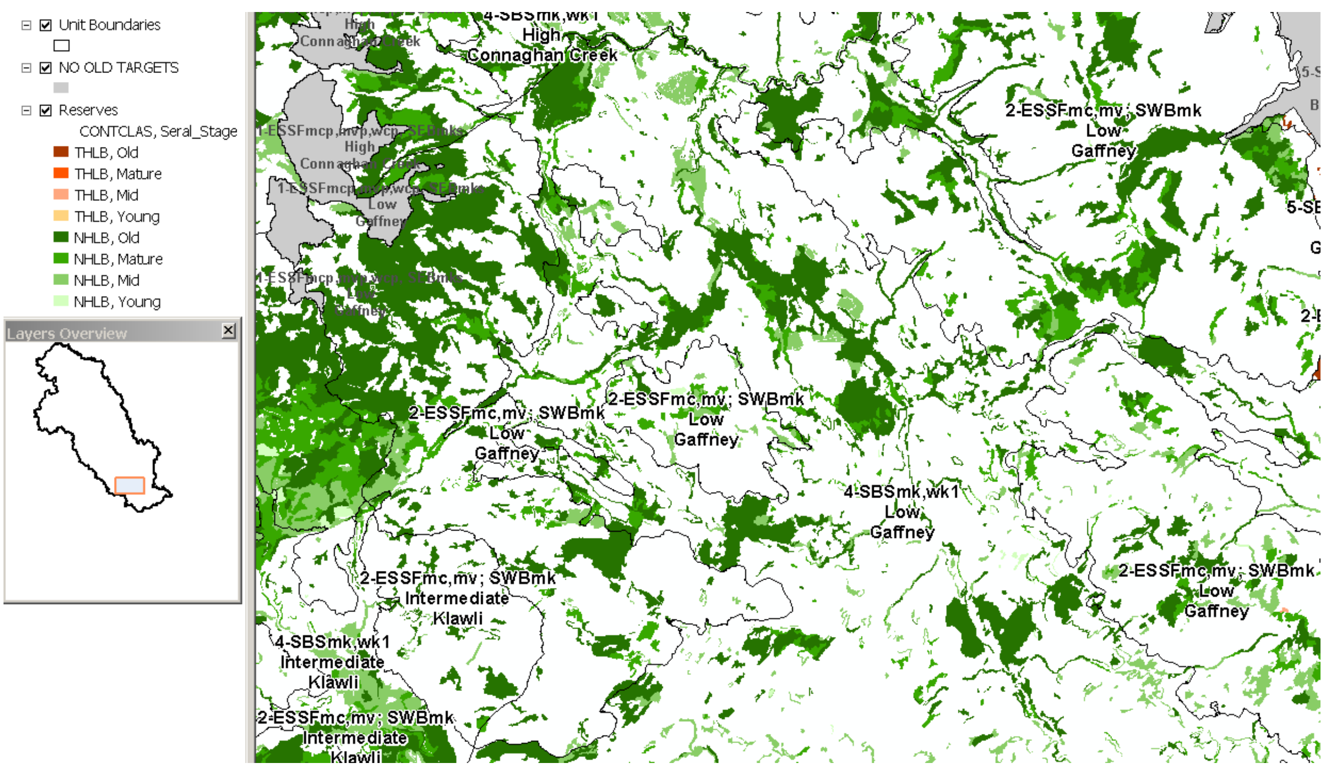



***Figure 17 Example of Spatially Distributed Reserve Selection***

# 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) minimum harvest criteria, 2) wildfire management, and 3) harvest priorities.

For the Mackenzie ISS, the minimum harvest criteria set for the ISS Base Case scenario remained unchanged (i.e., minimum 151 $m^3$/ha conifer on <46% slope; 250$m^3$/ha on slopes ≥46%; dead pine salvage only on slopes <36%; plus minimum average volume limit of 200 $m^3$/ha per period; exclude deciduous from all conifer-leading stands).

The wildfire management included higher harvest priorities for stands that are rated as extreme fire threat according to the 2015 Provincial Strategic Threat Analysis (PSTA) – wildfire threat component dataset for Mackenzie TSA. The extreme fire threat rated stands cover approximately 135,000 ha THLB. No other wildfire management tactics were implemented in this harvest scenario but others may be considered in the silviculture scenario.

The harvest priorities for the ISS Base Case Scenario include 5 partitions: 1) for the first 15 years, min 67% from pine-leading stands, 2) for the first 15 years, max non-pine leading at 905,000 $m^3$/yr, 3) for the first 15 years, max non-pine leading at 300,000 $m^3$/yr from the SW portion of the TSA, 4) for the entire planning horizon, max 100,000 $m^3$/yr deciduous, and 5) for the entire planning horizon, even-flow balsam leading stands at 92,000 $m^3$/yr. Other harvest constraints/priorities included a 5 hour maximum haul time (one-way) to log dump or processing facility and an access timing constraint to harvest up to 30% THLB every 35 yrs over 15 example locations (~23,000 ha). All these priorities/constraints remained unchanged in the Harvest scenario. In addition, harvest opening sizes were controlled in each 5-year period to spatially group harvested blocks into more realistic opening sizes.

## 5.2 Results

There was virtually no difference in harvest flows between the Harvest and the ISS Base Case scenarios (Figure 18). However, minor differences of the dead (MPB and IBS) harvest volumes occurred (Table 4). These very slight differences likely resulted from the higher harvest priority set on THLB areas with extreme fire threat rating and from grouping opening sizes.

***Table 4 Comparing MPB and IBS Non-Recoverable Losses between Base Case and Harvest Scenarios***

| Variable | Base Case ($m^3$) | Harvest ($m^3$) | Difference Salvaged ($m^3$) |
|---|---|---|---|
| Initial dead MPB volume | 33,932,216 | 33,932,216 | 0 |
| MPB Dead Volume Harvested by the end of the shelf-life | 12,722,069 | 12,326,615 | 395,453 |
| **Non-recoverable MPB dead volume** | **21,210,147** | **21,605,601** | **-395,453** |
| Initial dead IBS volume | 1,764,619 | 1,764,619 | 0 |
| IBS Dead Volume Harvested by the end of the shelf-life | 873,658 | 996,547 | -122,888 |
| **Non-recoverable IBS dead volume** | **890,961** | **768,072** | **122,888** |

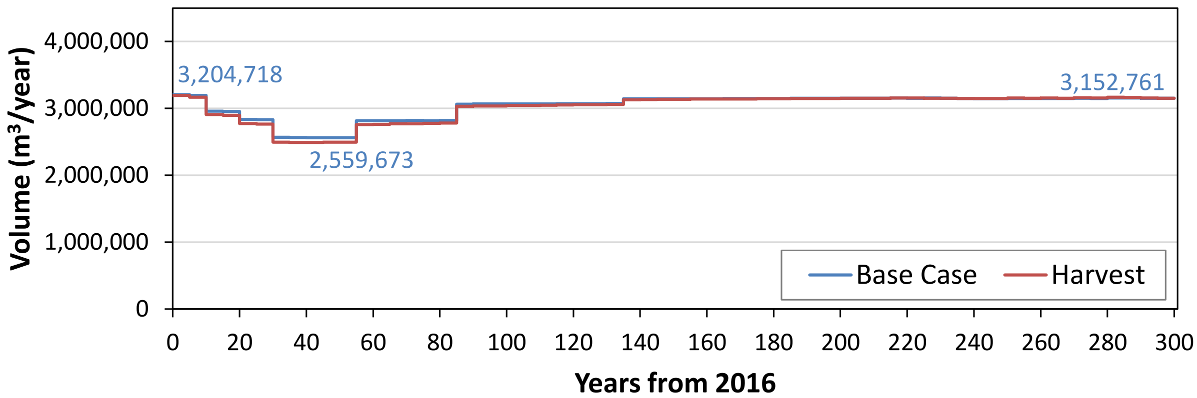



***Figure 18 Comparing Harvest Flows between ISS Base Case and Harvest Scenarios***

One key finding was that a similar harvest flow was possible while controlling the opening sizes in each 5-year period. Figure 19 illustrates the significant change in distribution of opening sizes between the Base Case Scenario (top), where the majority of openings were under 50ha in size, and the Harvest scenario (bottom), where the majority of opening sizes were larger than 50ha. An example of the spatial distribution is shown in year 10 of the planning horizon in Figure 20. This shows many more and unevenly distributed openings under 20 ha (red colour) in the Base Case scenario. In comparison, the Harvest scenario reduces small openings and by groups openings into larger openings.

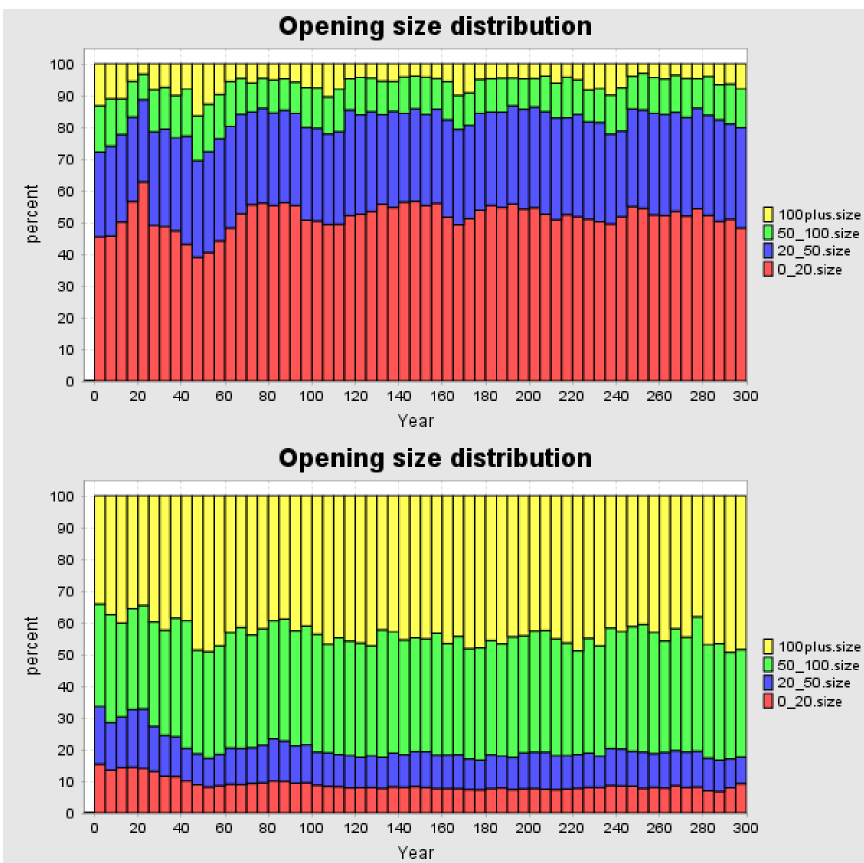



***Figure 19 Comparing Opening Size Distributions between the Base Case (top) and Harvest Scenarios (bottom)***

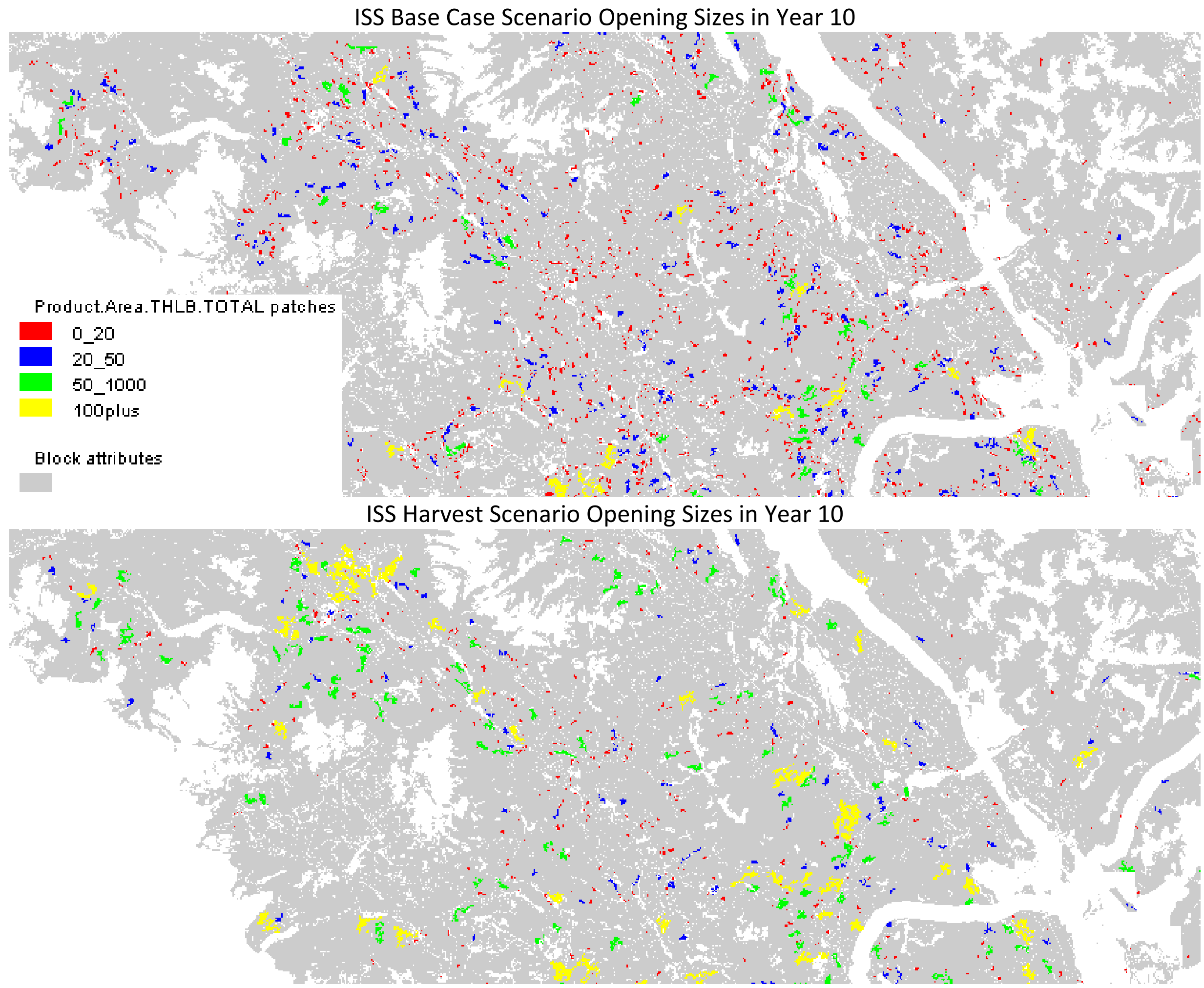



***Figure 20 Comparing Spatial Distribution of Opening Size in Year 10 between the Base Case and Harvest Scenarios***

The spatial harvest sequence generated from the Harvest Scenario model was used to prepare a twenty year plan map (Figure 21). Over this twenty year period, most of the harvest is focused on salvaging MPB- and IBS-attacked stands that are limited to ground-based harvest systems (Table 5).

***Table 5 20-Year Plan Summary for the Harvest Scenario - Area by harvest treatment and period***

| | | Area (ha) by Harvest System (min volume and slope criteria) | | |
|---|---|---|---|---|
| Period | Years | Ground (151m³/ha; <35%) | Cable (151m³/ha; ≥35%) | Cable-Steep (250m³/ha; ≥46%) |
| 1 | 1-5 | 15,721 | 351 | 49 |
| 2 | 6-10 | 15,586 | 579 | 50 |
| 3 | 11-15 | 13,289 | 973 | 96 |
| 4 | 16-20 | 10,882 | 1,514 | 398 |

*No pine salvage with cable systems*

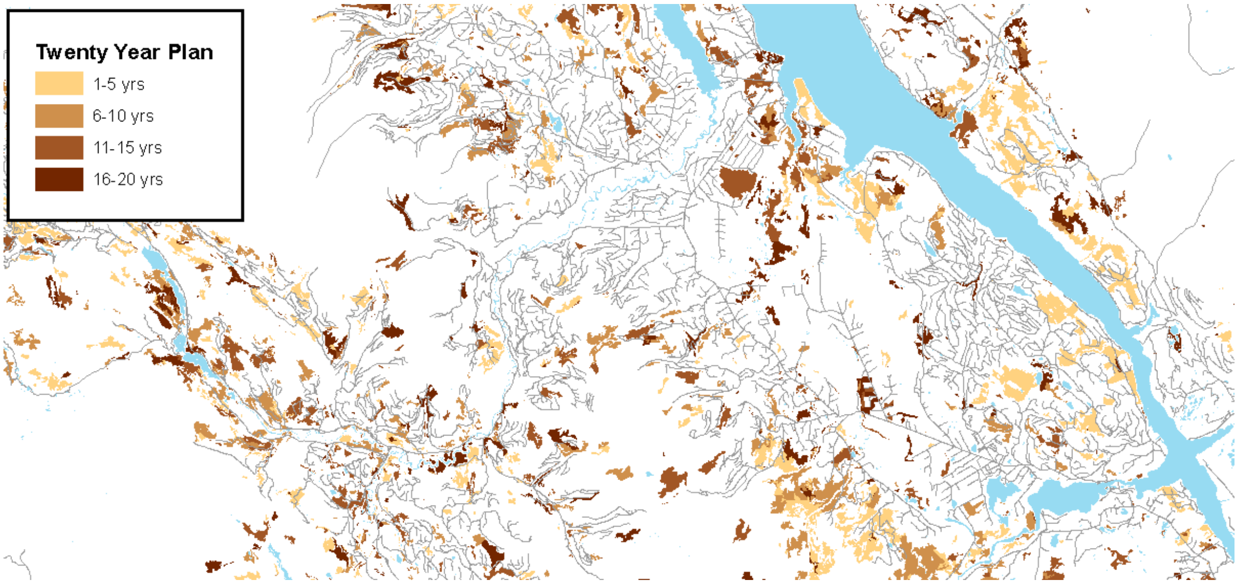



***Figure 21 Sample map showing 20-Year Plan for the Harvest Scenario***

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 22) according to the species and grade distribution by age class (Table 6).

***Table 6 Species and Grade Distribution by Age Class – Mocked Up for Deriving a Harvest Profile***

| | BL | | | DE | PL Live | | | PL Dead | SX Live | | | SX Dead |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **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*

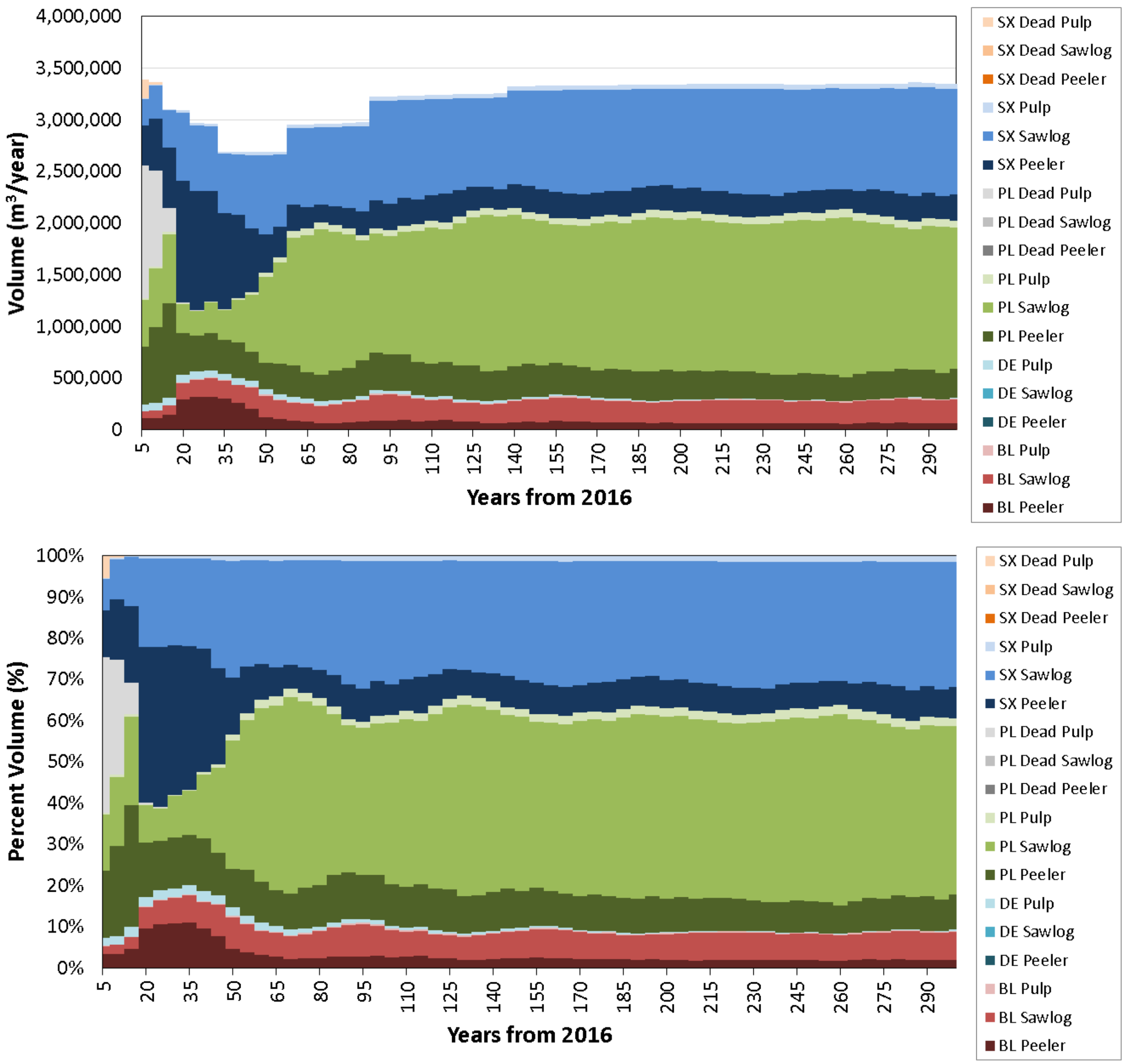
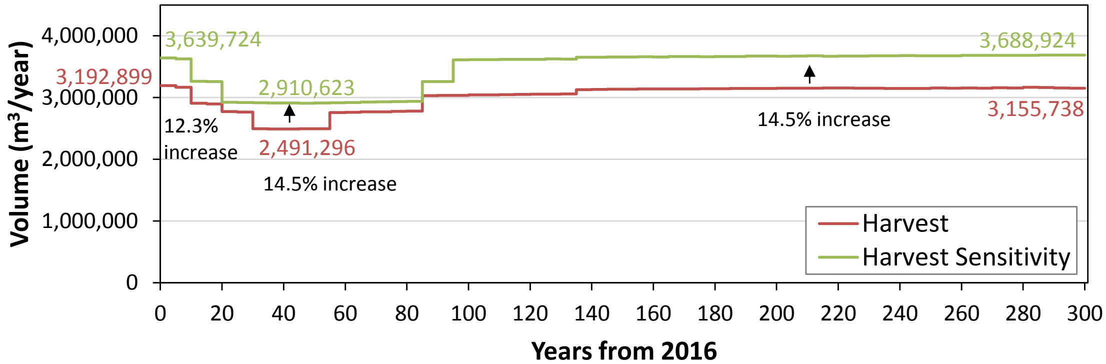



***Figure 22 Species and Grade Profile (Harvest Flow and Percentages)***

## 5.3 Sensitivity – No Partitions

A sensitivity analysis was also run where the 5 harvest partitions were turned off to explore other opportunities to increase the mid-term harvest flow. In addition, without negatively impacting the harvest flow, harvest priorities were set to favour harvesting of stands impacted by MPB/IBS.

Results from this Harvest Sensitivity run indicated that the harvest flow can be significantly increased compared to the Base Case; by 12.3% in the short-term, and 14.5% in the mid- and long-term (Figure 23). The 'no partition' Harvest Sensitivity run was more efficient with utilization of the growing stock – particularly stands dominated by deciduous and subalpine fir – which ends 21 Million m³ below the Harvest Scenario run.



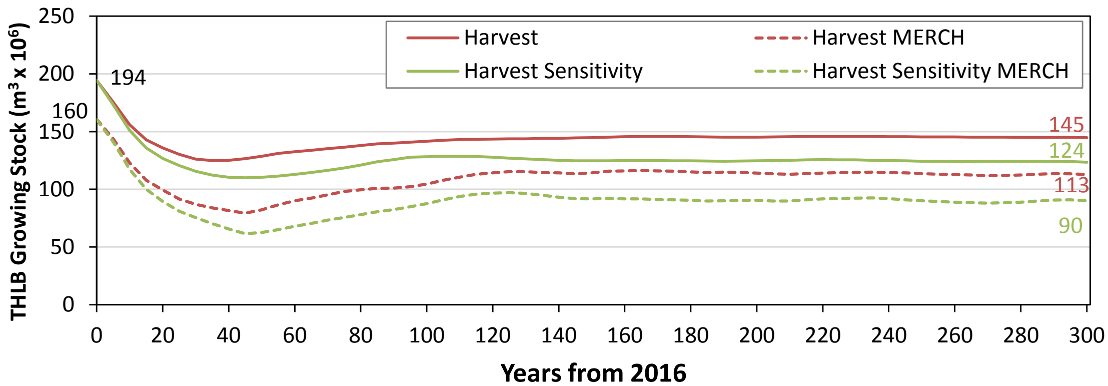




***Figure 23 Comparing Harvest Flows and THLB Growing Stock for the Harvest and Harvest Sensitivity (No Partition) Runs***

The NRLs for the Harvest Sensitivity run indicate a similar trend to the original Harvest scenario (Table 7). The sensitivity run harvested less dead MPB volume and more IBS volume compared to the Harvest scenario. These results suggest that salvaging some MPB stands is not worth pursuing in the first 15-20 years of the planning horizon. It is more advantageous, from a harvest flow perspective, to discontinue salvaging of some MPB-attacked stands, wait for them to regenerate, then schedule them for harvest in the distant future. It is also possible the model never harvests these stands; instead, using them to meet non-timber objectives. Note that the dead MPB stands include the remaining live overstory, and a regenerated understorey that has an identical yield to the undisturbed original stand, proportional to the dead MPB volume loss following the salvage period.

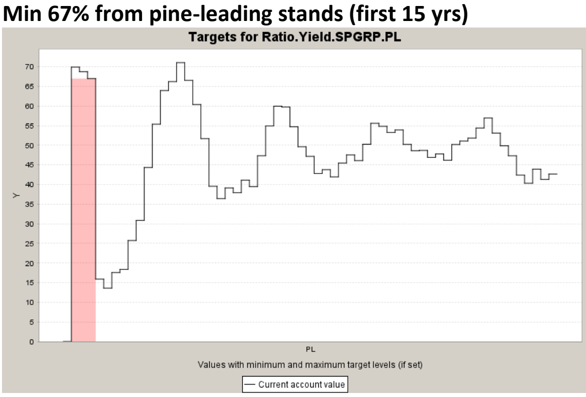
***Table 7 Comparing MPB and IBS Non-Recoverable Losses between Harvest and Harvest Sensitivity Scenarios***

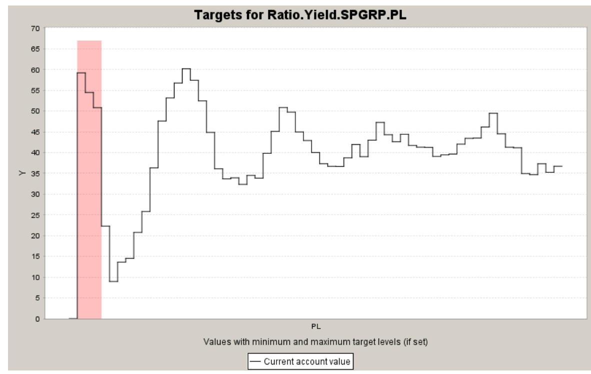
| Variable | Harvest Sensitivity ($m^3$) | Harvest ($m^3$) | Difference ($m^3$) |
|---|---|---|---|
| Initial dead MPB volume | 33,932,216 | 33,932,216 | 0 |
| MPB Dead Volume Harvested by the end of the shelf-life | 2,321,244 | 2,465,323 | -144,079 |
| **Non-recoverable MPB dead volume** | **31,610,972** | **31,466,893** | **144,079** |
| Initial dead IBS volume | 1,764,619 | 1,764,619 | 0 |
| IBS Dead Volume Harvested by the end of the shelf-life | 210,863 | 199,309 | 11,554 |
| **Non-recoverable IBS dead volume** | **1,553,756** | **1,565,310** | **-11,554** |

The improved harvest flow is explained by the influx of volume harvested from the non-pine leading stands; volume that was otherwise constrained by the harvest partitions. To illustrate the differences in harvest partitions, Figure 24 compares the performance of all five partitions. These differences result in significant changes of the harvest profile by species (Figure 25). Specifically, the Harvest Sensitivity run resulted in significantly more balsam and deciduous volume harvested in the short-term than the Harvest Scenario run. Removing the harvest partitions also resulted in the harvested balsam- and deciduous-leading stands being converted to stands with higher pine and spruce proportions. Thus, in the long-term, significantly higher volumes of pine, spruce, and balsam can be harvested. Note that NRLs (i.e., 195,000 m³/year) were not considered in these charts (Figure 24 and Figure 25).

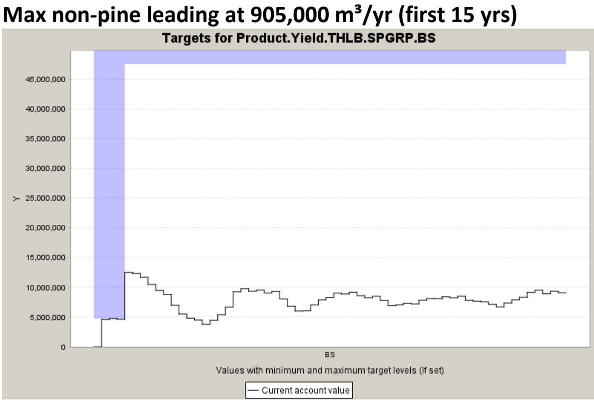
| Harvest Scenario Run (partitions turned ON) | Harvest Sensitivity Run (partitions turned OFF) |
|---|---|

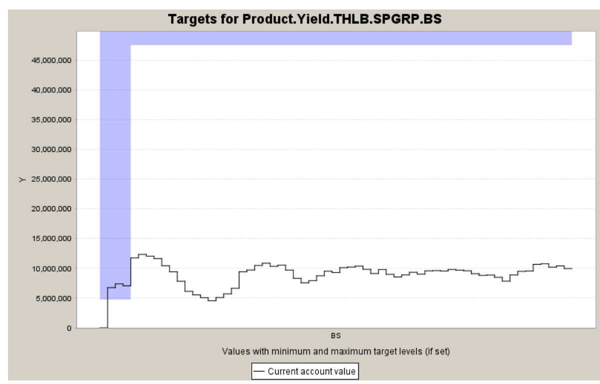
**Min 67% from pine-leading stands (first 15 yrs)**



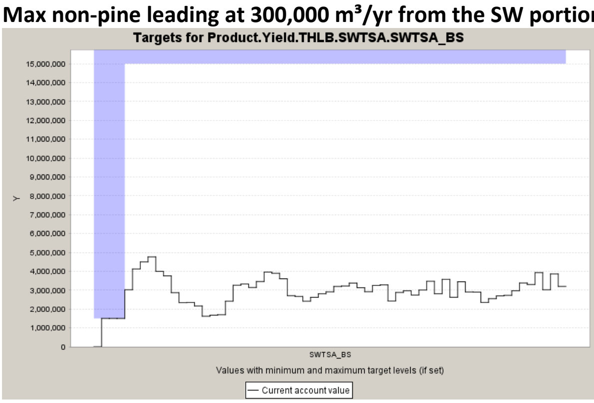



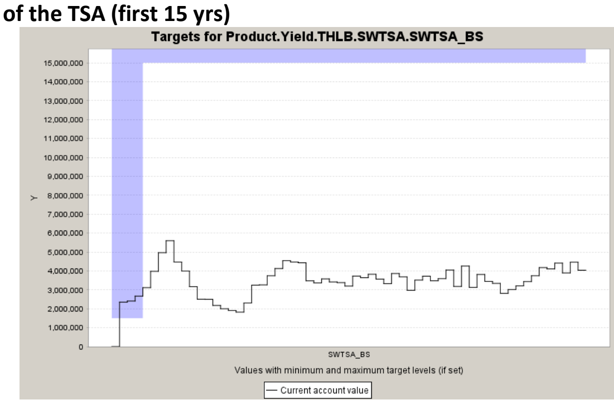

**Max non-pine leading at 905,000 m³/yr (first 15 yrs)**



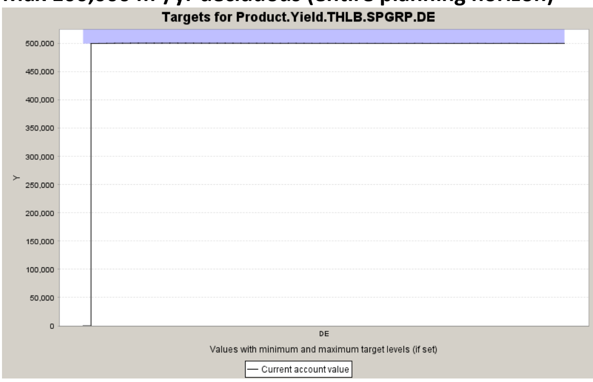

**Max non-pine leading at 300,000 m³/yr from the SW portion of the TSA (first 15 yrs)**

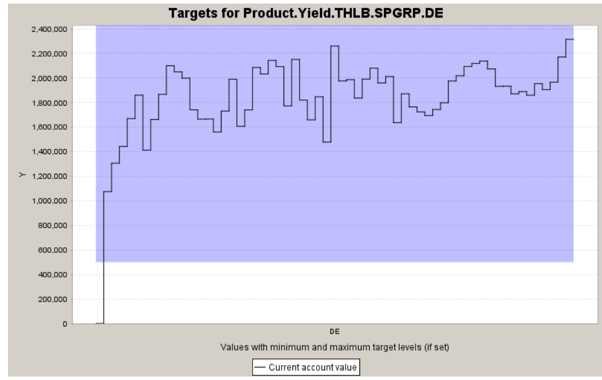


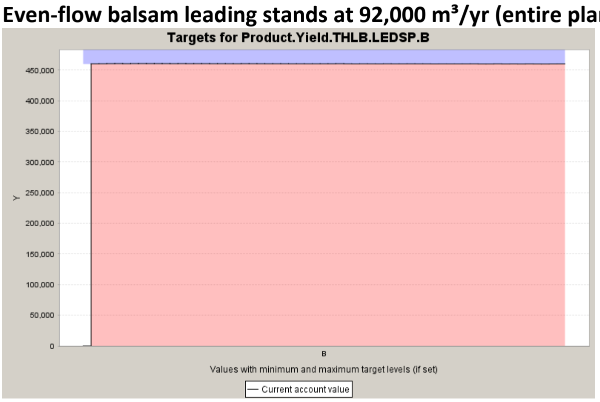
| Harvest Scenario Run (partitions turned ON) | Harvest Sensitivity Run (partitions turned OFF) |
| --- | --- |

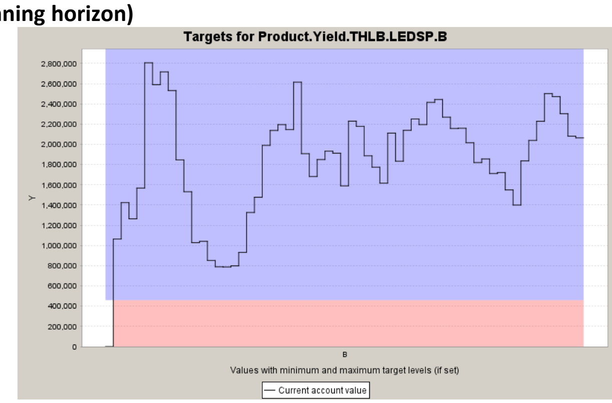
**Max 100,000 m³/yr deciduous (entire planning horizon)**



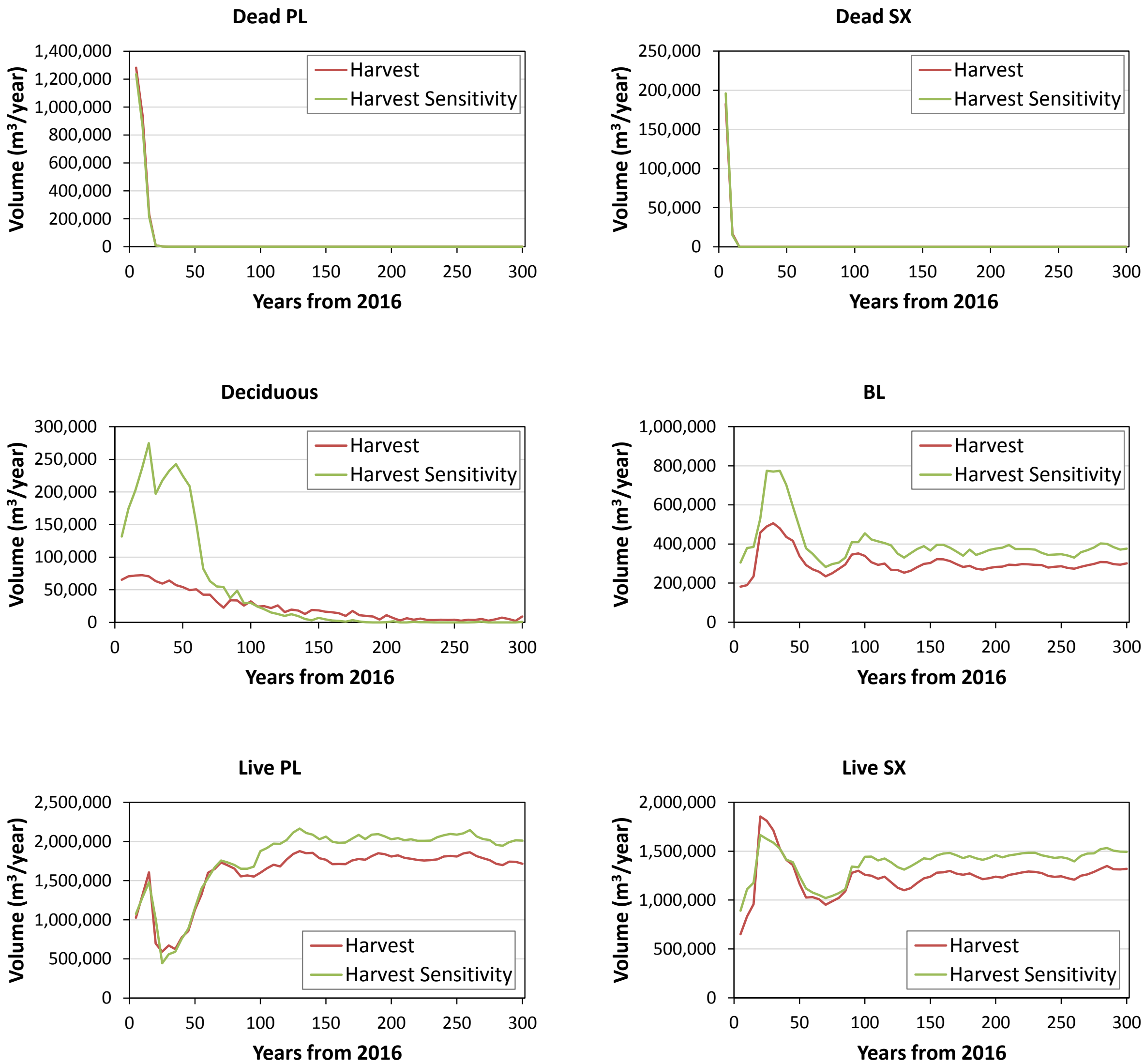

**Even-flow balsam leading stands at 92,000 m³/yr (entire planning horizon)**




*Note: Red and Blue areas indicate minimum and maximum target levels, respectively, and NRLs are not applied here*

***Figure 24 Comparing Harvest Partition Requirements and Performance between Harvest Scenario and Harvest Sensitivity Runs***




*Note: NRLs were not applied here*

***Figure 25 Comparing Individual Species Harvest Flows between the Harvest Scenario and Harvest Sensitivity Runs***

To avoid over-harvesting within the southwest portion of the TSA and to encourage licensees to consider harvesting opportunities in other regions of the TSA during the MPB salvage period, the Chief Forester imposed a harvest partition that limited the non-pine volume to a maximum 300,000 m³/year from southwest portion of the TSA (i.e., 'go north' partition). Figure 26 shows that over the first 15 years of the planning horizon turning off this partition results in approximately 245,000 m³/year or 1,000 ha/year of non-pine volumes harvested from the southwest portion of the TSA. The 'go north' partition clearly reduces the area harvested within the southwest portion of the TSA (i.e., 17% of the annual harvest from this location).

For the rest of the TSA, turning off the 'go north' partition increased the non-pine volumes harvested by approximately 392,000 m³/ha or 1,700 ha/year over the first 15 years. These significant changes in non-pine harvest from both areas (southwest TSA and the rest) suggests that the interaction of balsam, deciduous (i.e., bonus wood) and 'go north' partitions is constraining everywhere.

Turning off these partitions resulted in very little change in pine harvest throughout the TSA. Similar pine volumes were harvested from the southwest TSA, while 428,000 m³ less pine was salvaged from stands beyond the southwest TSA over the first 15 years (28,549 m³/year).

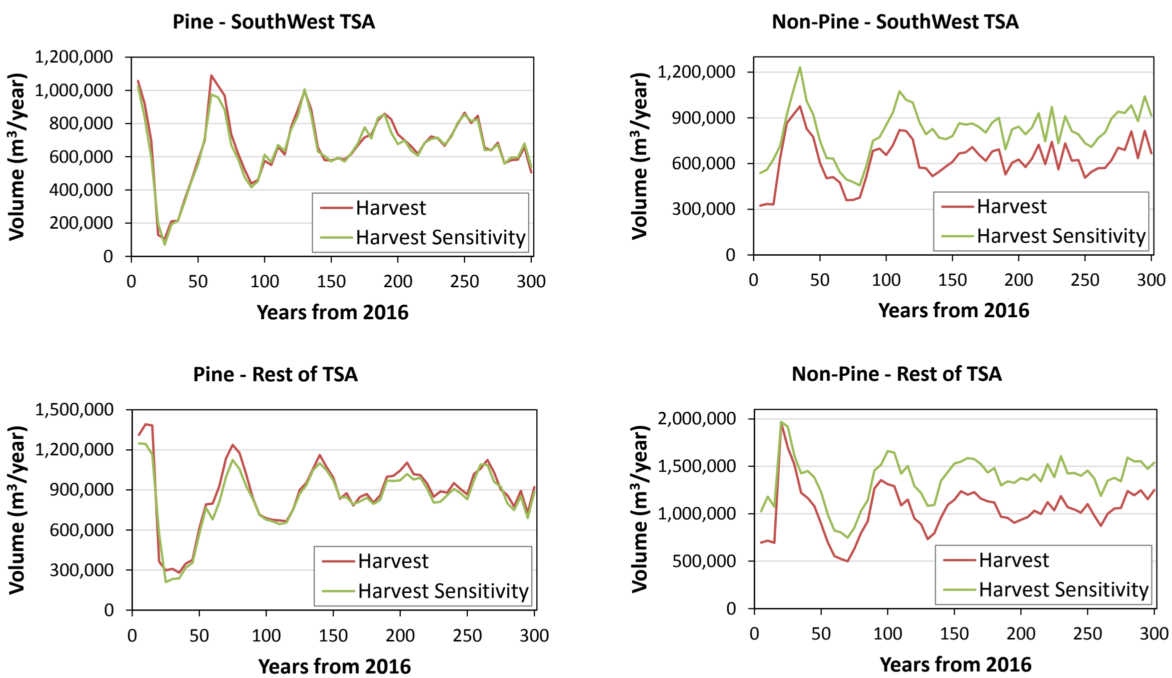



***Figure 26 Comparing Species Groups (Pine and Non-Pine) Harvest Flows between the harvest Scenario and Harvest Sensitivity Runs (NRLs not considered)***

Harvest partitions can also be related to the modelling approaches used in various forest estate models. For example, the same thresholds can easily be controlled in a forest estate model with the ability to track and control a wide range of timber and non-timber objectives. Simpler models may lack these capabilities but are favourable for processing speed and convenience. For these models, harvest partitions provide a useful surrogate when non-timber objectives cannot be tracked and controlled. Harvest partitions applied to forest-level analyses should be revisited in light of using more complex models that can track and control all of the non-timber objectives.

# *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) fertilization, 2) enhanced basic silviculture, and 3) rehabilitating MPB/IBS impacted stands.

Fertilization aims 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 <=45% (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.

Treated 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.

An enhanced basic silviculture treatment was set-up, in addition to the clearcut treatments, to give the model the option to enhance the regeneration of more productive stands along with an additional cost. Enhanced basic silviculture treatments were set-up for all existing natural and managed stands covering 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 $385/ha.

Rehabilitation was modelled for medium /good productivity, mature-conifer-leading existing natural stands 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 m³/ha and $2,000/ha, where the standing live volume was <50 m³/ha. Additional costs were added for blocks that were more than 2 hours away from the dumping sites – $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.

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 (i.e., 4.7% and 5.9% increase over the short- and mid-term, where volume from rehabilitation treatments is excluded and included, respectively) This effectively removed the mid-term trough from the Base Case (nearly 300,000 m³/year – Figure 27). There is also a slight gain of approximately 100,000 m³/yr over the long-term that reflects the ongoing regeneration of enhanced stands. Harvest over the short-term remained unchanged where volume from rehabilitation treatments were excluded but where they are included, the short-term harvest could increase to over 2 million m³ over the first 20 years.

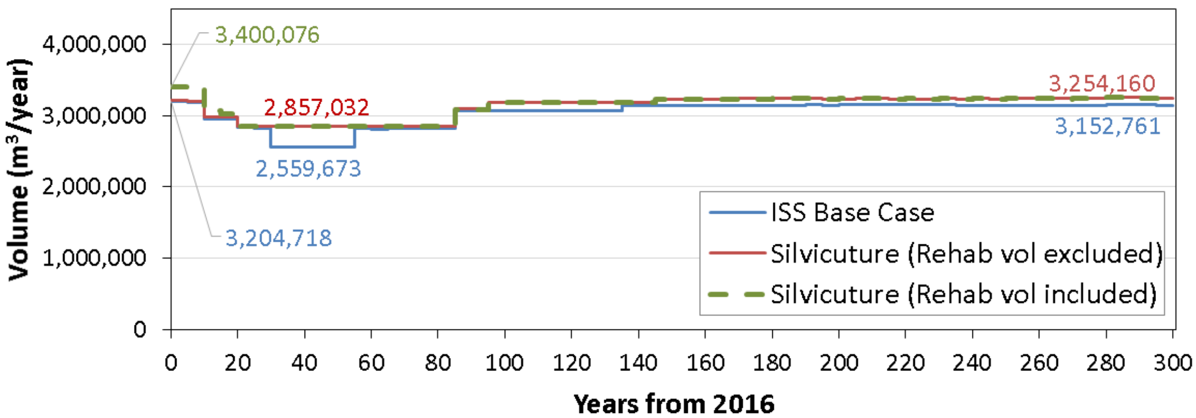



***Figure 27 Comparing Harvest Flows between ISS Base Case and Silviculture Scenario***

The mid-term trough is filled with stands that become available as stands treated over the first 2 decades contribute to the harvest flow either within or following the mid-term period. Figure 28 shows the amount and when specific tactics contribute to the harvest flow. Note the period of the mid-term trough (years 30 to 55) is highlighted yellow. Fertilized stands contribute to the harvest flow towards the end of the mid-term while the contribution of rehabilitated stands, then reforested with enhanced basic silviculture treatments, occurs after the mid-term period. Contributions from these treatments allow other available stands to be harvested earlier, within the mid-term, or later into the planning horizon.

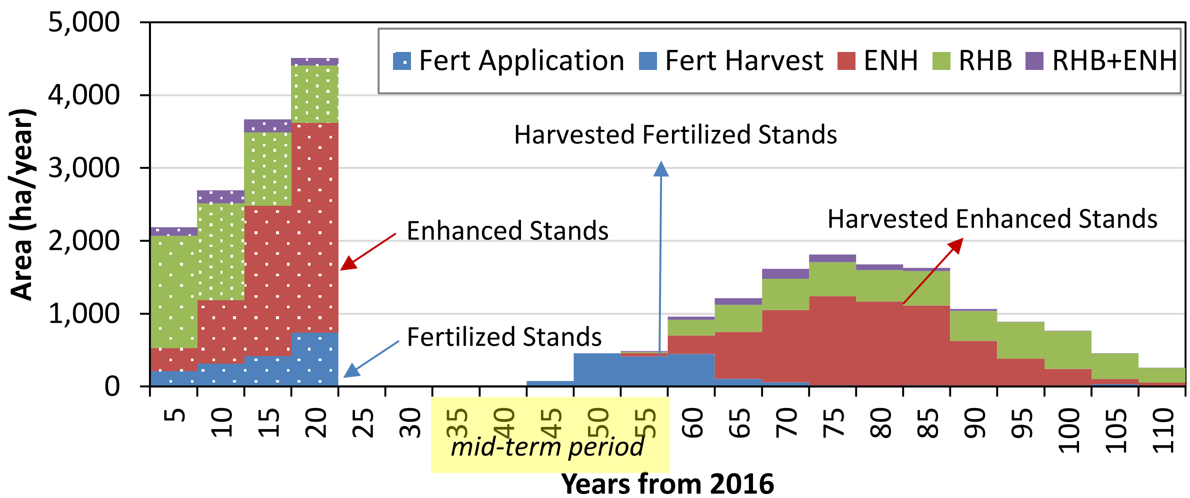



***Figure 28 Harvest by Treatment Type (Rehab volume included)***

Some key aspects of silviculture tactics impacts on harvest flow are noteworthy:

- Rehabilitated stands would have never been harvested in a normal scenario. THLB area available for rehabilitation (Rehab and Rehab+Enhanced) was approximately 136,000 ha, out of which the model treated in the first two decades approximately 26,000 ha. Then, the model clear-cut the rehabilitated stands relatively uniformly between year 55 and 110 of the planning horizon.

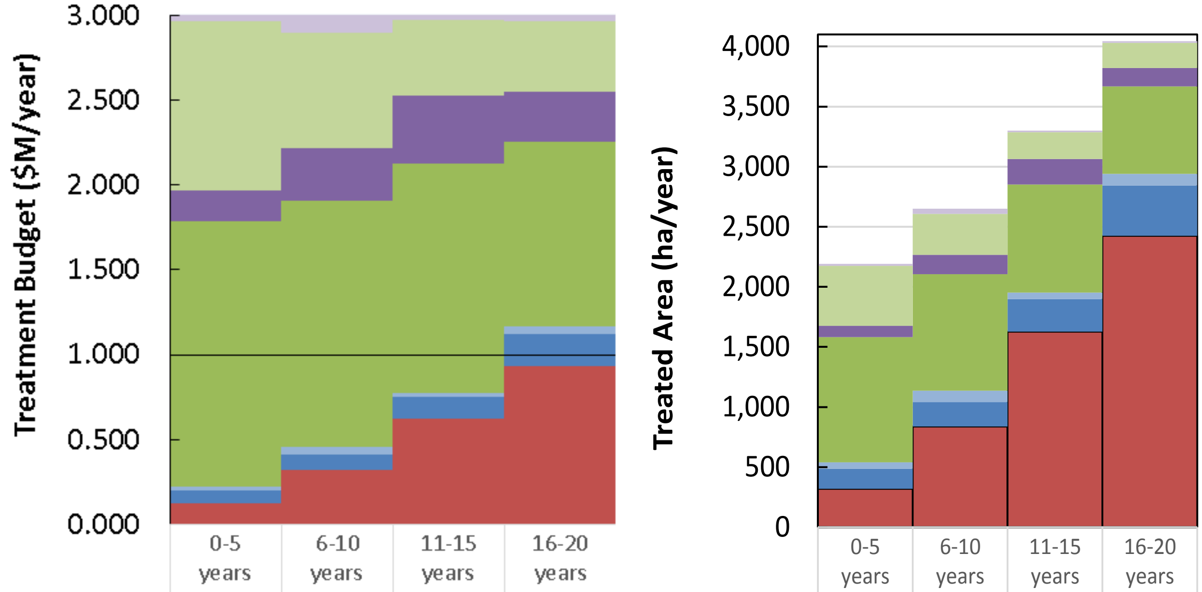
- THLB area available for enhanced tactic was approximately 207,000 ha (does not include overlaps with rehabilitation and fertilization), out of which the model treated in the first two decades approximately 30,000 ha. Then, the model started to clear-cut the enhanced stands in year 55 of the planning horizon with the peak harvest between year 75 and 85 of the planning horizon. The enhanced stands were harvested a significantly younger ages compared to non-enhanced stands and thus, the enhanced stands could have been cycled more often during the planning horizon (e.g., transition a normal stand to enhanced by the end of year 5 and then harvest the same stand by the end of year 55 of the planning horizon).
- THLB area available for fertilization tactic was approximately 99,000 ha (includes overlaps with enhanced tactic, 18,000 ha with no overlaps), out of which the model treated in the first two decades approximately 8,500 ha. Then, the model started to clear-cut the fertilized stands in year 30 of the planning horizon with the peak harvest between year 50 and 60 of the planning horizon.
- To fill in the mid-term trough, the model evaluated the enhanced and rehabilitation as better tactics instead of fertilization, despite the fact that two fertilization applications ($900/ha) are significantly less expensive than enhanced ($1,385/ha) or rehabilitation ($1,500/ha to $2,000/ha). Here, it was more important to harvest sooner the available stands for harvesting compared to a scenario without silviculture tactics (e.g., Base Case).

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 29 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.

Funding was limited to 20 years to identify the specific responses over the land base for treatments over this timeframe, resulting in the following irregularities:

- the model did not fertilize stands with more than two applications because that requires at least 40 years of funding,
- to address the mid-term, all fertilized stands were harvested well after the 10 year delay for harvesting. There may be opportunities to fertilize closer to harvest (i.e., just before and within the mid-term), and
- rehabilitating MPB/IBS impacted stands did not occur over the mid-term where it is typically applied as a tactic that contributes towards the harvest flow.

Allowing the same or adjusted fund level to run for a longer period can be explored in the Combined Scenario.




| | 0-5 years | 6-10 years | 11-15 years | 16-20 years |
|---|---|---|---|---|
| RHB_UN+ENH | 38,514 | 104,219 | 31,701 | 32,345 |
| RHB_UN | 996,663 | 682,168 | 444,450 | 420,567 |
| RHB_ME+ENH | 180,035 | 303,585 | 399,464 | 290,462 |
| RHB_ME | 1,562,979 | 1,452,955 | 1,351,562 | 1,090,184 |
| FERT_4 | 0 | 0 | 0 | 0 |
| FERT_3 | 0 | 0 | 0 | 0 |
| FERT_2 | 23,588 | 42,959 | 23,588 | 42,959 |
| FERT_1 | 74,829 | 91,069 | 122,866 | 189,449 |
| ENH | 123,334 | 323,022 | 626,329 | 933,225 |

| | 0-5 years | 6-10 years | 11-15 years | 16-20 years |
|---|---|---|---|---|
| RHB_UN+ENH | 16 | 44 | 13 | 14 |
| RHB_UN | 498 | 341 | 222 | 210 |
| RHB_ME+ENH | 96 | 161 | 212 | 154 |
| RHB_ME | 1,042 | 968 | 901 | 727 |
| FERT_4 | 0 | 0 | 0 | 0 |
| FERT_3 | 0 | 0 | 0 | 0 |
| FERT_2 | 52 | 95 | 52 | 95 |
| FERT_1 | 166 | 202 | 273 | 421 |
| ENH | 320 | 839 | 1,627 | 2,424 |

***Figure 29 Treatment Budget and Area over first 20 years (Rehab volume included)***

# 7 Combined Scenario

## 7.1 Description

The goal of the Combined Scenario was to guide the development, implementation, and monitoring of tactical plans over the first 20 years of the planning horizon. In this first iteration of the ISS process, the following key elements were included from all four scenarios– Base Case, Reserves, Harvest, and Silviculture:

- Base Case assumptions unchanged except:
  - Removal of Kwadacha FNWL from the CFLB
  - Inclusion of IBS impact estimates to year 2017
  - Exclude MPB salvage around Williston Reservoir (No Salvage Zone)
  - No Caribou Habitat Assessment
  - No Access Timing Constraints
- Harvest assumptions include:
  - Harvest priority for the first 10 years on extreme PSTA rated stands

  - Harvest opening class sizes adjusted to avoid sliver opening under 1ha and control the openings 1 to 5 ha and 5 to 20 ha in size. A harvest reduction of up to 5% was accepted in order to produce a more realistic and spatially-explicit tactical plan.
- Reserve – lock from harvesting the THLB candidate reserves for the first 40 years
- Silviculture assumptions unchanged except the volume produced from stand rehabilitation is not considered in controlling the harvest flow in the model.

## 7.2 Results

### 7.2.1 Timber Harvesting Land Base

The removal of Kwadacha FNWL reduced the CFLB by 9.8% (to 2,942,866 ha) and THLB by 10.3% (to 1,131,743 ha) compared to the Base Case (Table 8).

***Table 8 Mackenzie ISS Combined Scenario Land Base Definition***

| Factor | | Gross Area (ha) | Effective Area (ha) | % of Total Area | % of CFLB |
|---|---|---|---|---|---|
| **Total Area** | | **6,410,665** | **6,410,665** | **100.0%** | |
| Less: | | | | | |
| | Non TSA (Private, Woodlots, CFA, Federal/Military/Misc. Reserves) | 41,738 | 41,738 | 0.7% | |
| | FN Reserves | 838 | 286 | 0.0% | |
| | Kwadacha Proposed FNWL | 522,972 | 522,003 | | |
| **Total TSA** | | | **5,846,638** | **91.2%** | |
| Less: | | | | | |
| | Water | 225,384 | 216,330 | 3.4% | |
| | Wetland and Alpine | 1,438,756 | 1,171,282 | 18.3% | |
| | BEC Alpine | 1,075,980 | 195,868 | 3.1% | |
| | Snow, Ice, Rock | 795,397 | 18,017 | 0.3% | |
| | Shrubs, Herbs | 1,176,344 | 554,776 | 8.7% | |
| | Glacier, Bedrock | 790,376 | 0 | 0.0% | |
| | Exposed Soil | 2,767 | 0 | 0.0% | |
| | Low Site Index (<5m) | 2,831,783 | 693,104 | 10.8% | |
| | Roads and Utility | 66,744 | 53,860 | 0.8% | |
| | Logged Agricultural and Settlement Areas | 535 | 535 | 0.0% | |
| **Crown Forest Land Base (CFLB)** | | | **2,942,866** | **45.9%** | **100.0%** |
| Less: | | #in CFLB | | | |
| | ***Inoperable*** | | | | |
| | Excessive Haul Distance | 280,501 | 280,501 | 4.4% | 9.5% |
| | Unstable Terrain (U,V, 5) | 13,360 | 13,360 | 0.2% | 0.5% |
| | Slope >=46% and Vol <250m³ | 427,250 | 384,983 | 6.0% | 13.1% |
| | Non Commercial Species (W,EP, Z) | 12,864 | 10,764 | 0.2% | 0.4% |
| | Slope <=35 and Vol<150m³ (incl PL) | 626,058 | 497,441 | 7.8% | 16.9% |
| | Slope 35-46 and Vol<150m³ | 199,625 | 178,221 | 2.8% | 6.1% |
| | ***Reserves*** | | | | |
| | Provincial Parks | 372,814 | 123,952 | 1.9% | 4.2% |
| | Crown Reserves | 375,400 | 442 | 0.0% | 0.0% |
| | Misc. Reserves | 110 | 91 | 0.0% | 0.0% |
| | UWR No Harvest | 352,229 | 101,719 | 1.6% | 3.5% |
| | WHA No Harvest | 107,073 | 61,899 | 1.0% | 2.1% |
| | OGMA | 55,112 | 28,218 | 0.4% | 1.0% |
| | Mugaha Marsh Sensitive Area | 0 | 0 | 0.0% | 0.0% |
| | Muskwa-Kechika Management Area | 397,560 | 33,817 | 0.5% | 1.1% |
| | Weissener Buffer | 0 | 0 | 0.0% | 0.0% |
| | Riparian | 221,479 | 93,660 | 1.5% | 3.2% |

| Factor | Gross Area (ha) | Effective Area (ha) | % of Total Area | % of CFLB |
|---|---|---|---|---|
| Isolated | 2,978 | 2,055 | 0.0% | 0.1% |
| **Current THLB** | | **1,131,743** | **17.7%** | **38.5%** |
| Less: | | | | |
| Agriculture/Settlement areas | | 611 | 0.0% | 0.0% |
| Retention (In-block + MPB Salvage Zones) | | 55,429 | 0.9% | 1.9% |
| Future Roads (4% of THLB>300m from roads) | | 21,276 | 0.3% | 0.7% |
| **Long Term THLB** | | **1,054,427** | **16.4%** | **35.8%** |

### 7.2.2 Harvest Forecast and Growing Stock

With this change in land base, the initial growing stock was reduced by 10.0% while the harvest flow was over the first 10-years was reduced by 6.3%, compared to the Base Case (Figure 30). Note that the harvest flow shown for the Combined Scenario does not include the volume produced from stand rehabilitation. Over the mid- and long-terms, the harvest flow difference was maintained to approximately 10%, except the mid-term trough (lowest level) matched the Base Case. Here, the model took full advantage of silviculture tactics like rehabilitation (i.e., harvest stands that otherwise would have not been harvested and transition to a higher productivity yield with younger MHA), fertilization (i.e., growth increase), and stand growth enhancement (i.e., transition to a higher productivity yield with younger MHA).

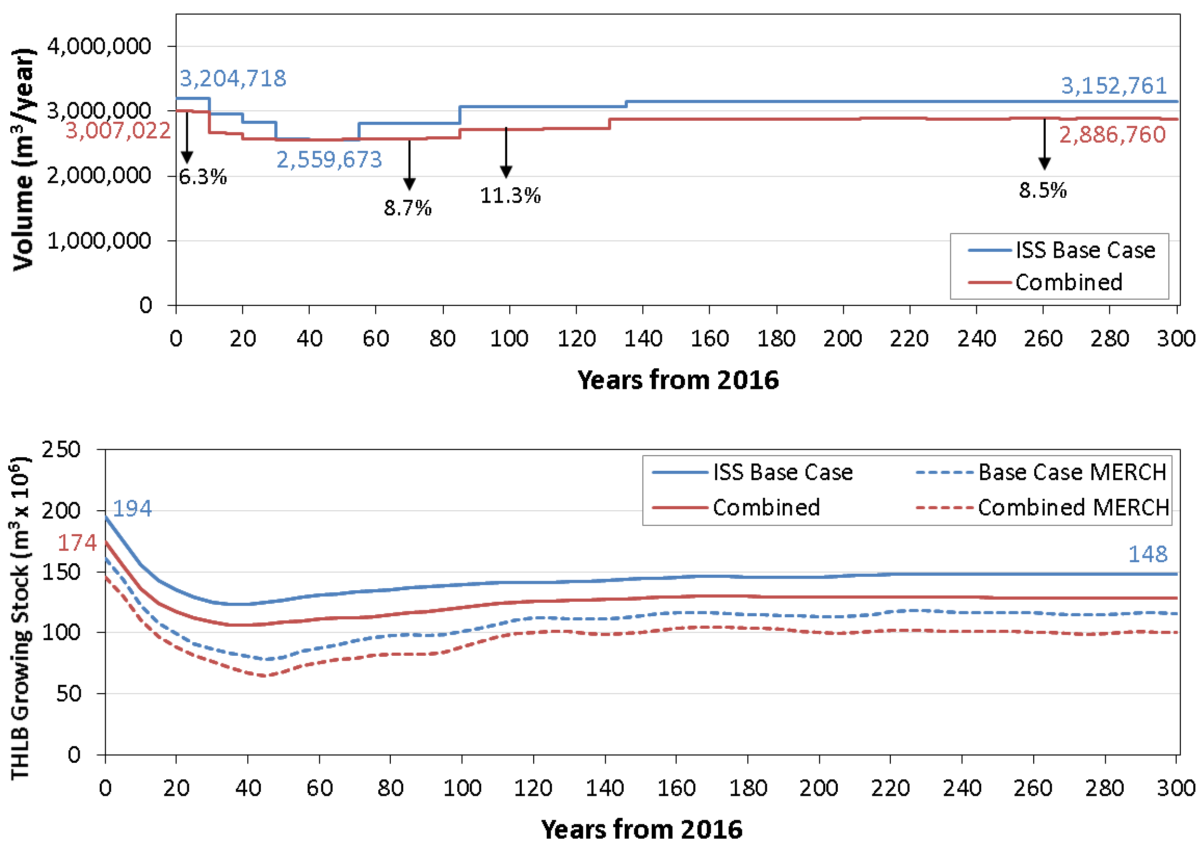



***Figure 30 Comparing Harvested Volume and Growing Stock between ISS Base Case and Combined Scenarios***

### 7.2.3 Silviculture Tactics

Similar to the Silviculture Scenario, the model applied gains from the silviculture tactics by transitioning stands onto higher productivity yields, which cycled more often over the 300-year planning horizon. Some stands could be also harvested sooner to maintain the mid-term trough (Figure 31). Overall, these tactics contributed to lessen the impact of the 10% reduction in land base (i.e., 8.5% over the long-term).

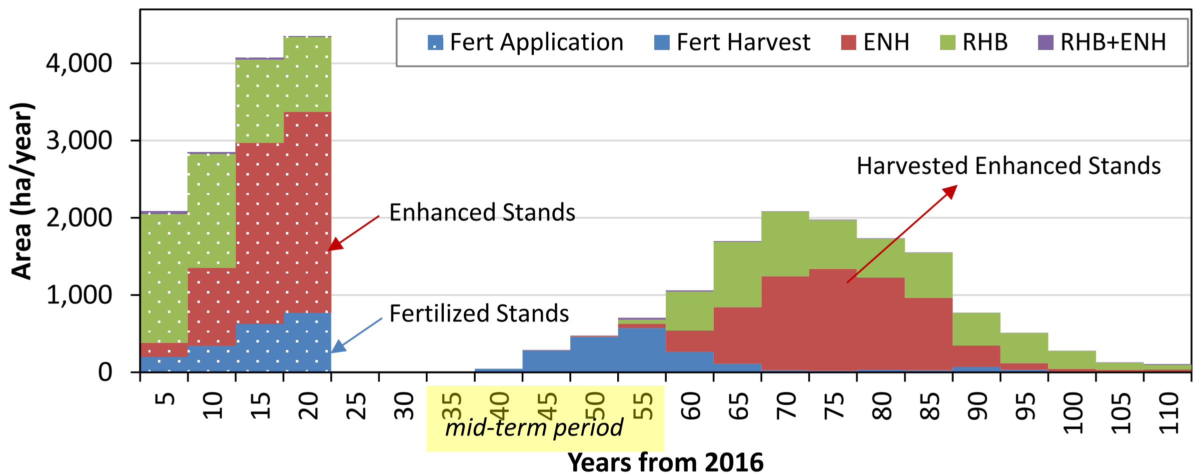
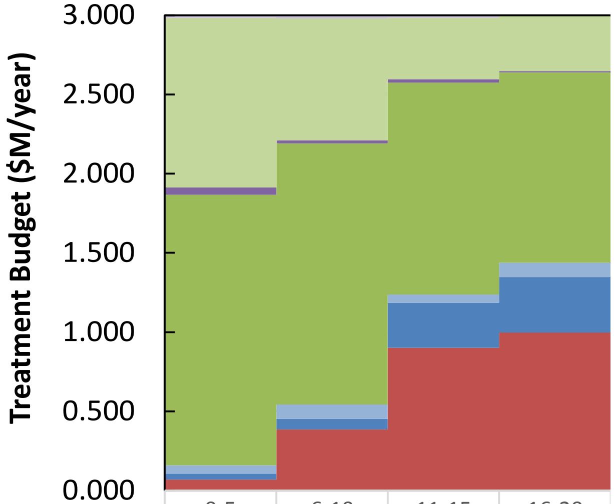
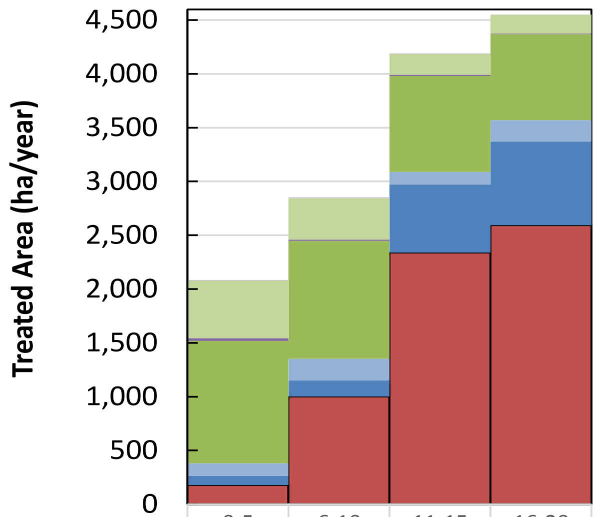



***Figure 31 Harvest Area by Treatment Type***

Like the Silviculture Scenario, the $3 million budget was spent mostly on enhanced and rehabilitation tactics (Figure 32). However, it was observed that compared to the Silviculture Scenario, the model allocated a higher budget for fertilization (especially in the second decade) and less on enhancing rehabilitated stands (i.e., RHB+ENH). While the former is difficult to explain given the change of the land base definition, the latter can be explained by prioritizing rehabilitation within the No Salvage Zone (Table 10). Note that FERT_2 treatment includes 2 fertilization applications that are 10-year apart. Thus, the FERT_2 area in decade 1 (year 1-10) is treated again in decade 2 (year 11-20).




| | 0-5 years | 6-10 years | 11-15 years | 16-20 years |
|---|---|---|---|---|
| RHB_UN+ENH | 17,031 | 19,583 | 16,674 | 1,757 |
| RHB_UN | 1,069,871 | 768,977 | 386,114 | 351,658 |
| RHB_ME+ENH | 46,653 | 20,617 | 22,014 | 8,125 |
| RHB_ME | 1,706,575 | 1,647,960 | 1,336,759 | 1,200,323 |
| FERT_2 | 53,170 | 90,064 | 53,170 | 90,064 |
| FERT_1 | 37,842 | 67,470 | 284,042 | 349,872 |
| ENH | 68,815 | 385,329 | 900,906 | 998,175 |




| | 0-5 years | 6-10 years | 11-15 years | 16-20 years |
|---|---|---|---|---|
| RHB_UN+ENH | 7 | 8 | 7 | 1 |
| RHB_UN | 535 | 384 | 193 | 176 |
| RHB_ME+ENH | 25 | 11 | 12 | 4 |
| RHB_ME | 1,138 | 1,099 | 891 | 800 |
| FERT_2 | 118 | 200 | 118 | 200 |
| FERT_1 | 84 | 150 | 631 | 777 |
| ENH | 179 | 1,001 | 2,340 | 2,592 |

***Figure 32 Combined Scenario – Treatment Budget and Area over first 20 years***

### 7.2.4 Harvest Profile

Based on minimum volume and slope criteria, three harvest systems were identified within this TSA: Ground (151m³/ha; <35%), Cable, (151m³/ha; ≥35%), and Cable-Steep (250m³/ha; ≥46%). In the first 20 years, the harvest was focused on ground systems to salvage MPB and IBS stands, whereas more area was harvested in steeper terrain (up to 17% of total harvest) over the mid-term (Figure 33). This result suggests that, in addition to the silviculture tactics advantages, the mid-term trough is filled in by harvested stands on steeper terrain (i.e., year 35 to 55 of the planning horizon).

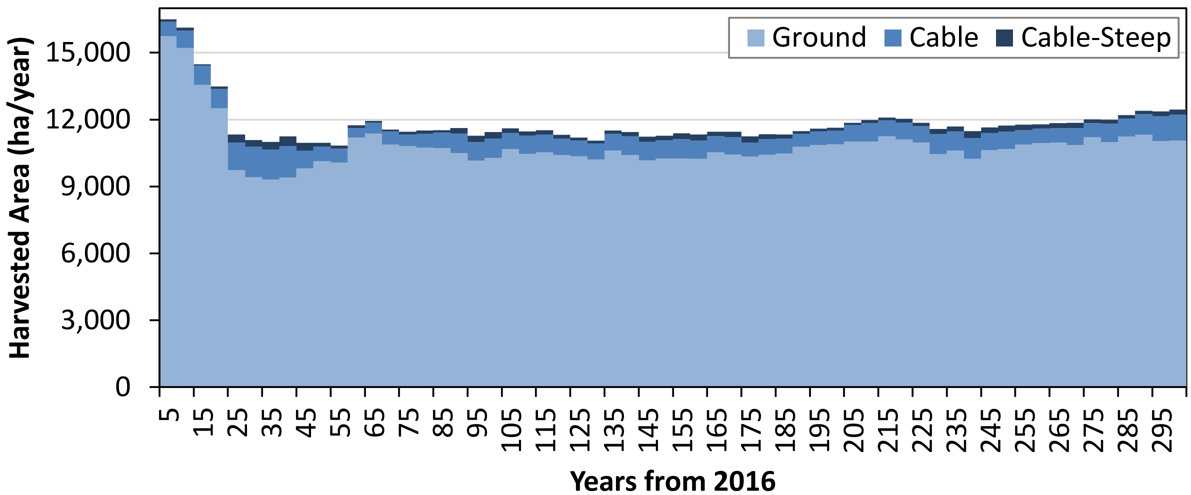



***Figure 33 Combined Scenario - Annual Harvest Area by Harvest System***

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 75) in the Combined Scenario, with less area harvested in the long-term (Figure 34). This observation supports the result that the model harvested stands that transition to yields with higher productivity, while shuffling older stands to be harvested earlier in the planning horizon to help fill the mid-term trough.

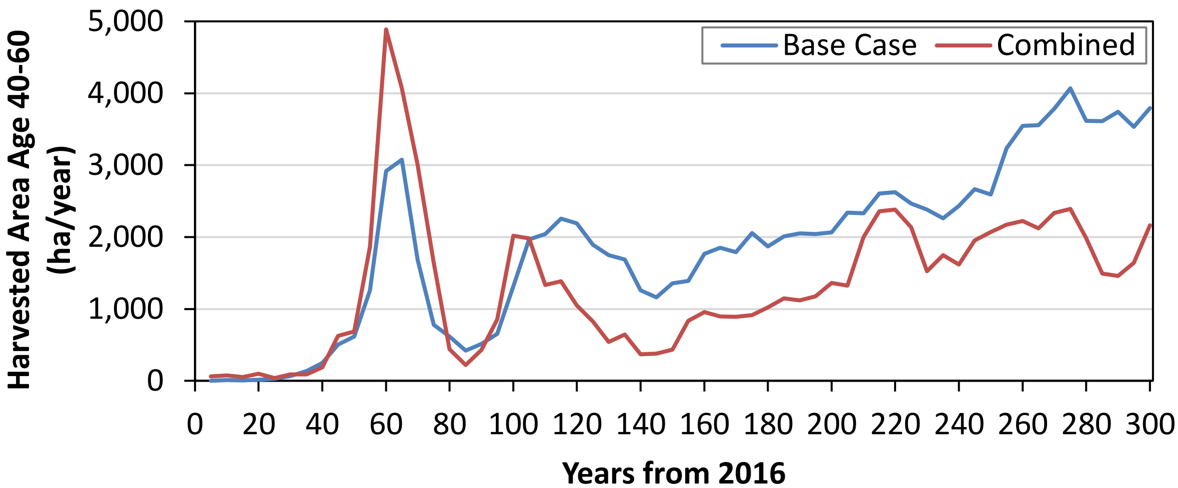



***Figure 34 Comparison of Harvested Area Age 40-60 between Base Case and Combined Scenarios***

### 7.2.5 Salvaged Volumes

Because of the reduced THLB discussed above (Table 8), the MPB dead volume initial was initially 4.19 million $m^3$ (12%) lower than the Base Case. In addition, yield curves re-developed for the Combined Scenario more accurately portrayed the new land base definition. Compared to the Base Case, the salvaged dead MPB volume for the Combined Scenario (Table 9) was 1.46 million $m^3$ (11%) lower, which then resulted in a decrease in non-recoverable MPB dead volume (2.74 million $m^3$ or 13% lower).

The initial dead IBS volume was 290,000 m³ higher because the Combined Scenario updated the IBS disturbed area and severity codes to include the 2017 Aerial Overview Survey data. However, the initial dead IBS volume estimated for the Combined Scenario was approximately 500,000 m³ (18%) lower than the FLNRO[3] estimate of dead IBS volume. Reasons for the difference may include the dead percentages assumptions for each severity class and spatially-explicit THLB area differences. In this analysis, a consistent dead percentage for each severity class was applied in all scenarios used.

It was observed that setting higher priorities on extreme fire threat rated stands significantly reduced the salvage of MPB- and IBS-impacted stands. The harvest partitions set on non-pine leading stands also significantly reduced the IBS salvage potential. To properly influence the model to prioritize salvage over harvesting extreme fire threat rated stands, higher weights were placed on the MPB partition (i.e., at least 67% of the volume harvested from pine leading, MPB-impacted stands over the first 15 years and from IBS impacted stands over the first 5 years.

***Table 9 Comparison of MPB and IBS Non-Recoverable Losses***

| Variable | Base Case (m³) | Combined (m³) | Difference (m³) | Difference % |
|---|---|---|---|---|
| Initial dead MPB volume | 33,932,216 | 29,741,362 | 4,190,854 | 12.4% |
| MPB Dead Volume Harvested by the end of the shelf-life | 12,722,069 | 11,266,702 | 1,455,366 | 11.4% |
| **Non-recoverable MPB dead volume** | **21,210,147** | **18,474,660** | **2,735,488** | 12.9% |
| Initial dead IBS volume | 1,764,619 | 2,055,302 | -290,683 | -16.5% |
| IBS Dead Volume Harvested by the end of the shelf-life | 873,658 | 1,148,695 | -275,036 | -31.5% |
| **Non-recoverable IBS dead volume** | **890,961** | **906,607** | **-15,647** | -1.8% |

The FLNRORD and licensees identified an area adjacent to the Williston Reservoir where MPB salvage operations have ceased so attempts were made to prioritize rehabilitation within this No Salvage Zone, over the first 20 years. These attempts were explored without significant impacts on the harvest flow. Out of the 22,000 ha eligible for rehabilitation within the No Salvage Zone, the model rehabilitated approximately 9,000 ha (Table 10). A higher weight to prioritize rehabilitation within the No Salvage Zone would have influenced the model even more but this would have altered the application of other silviculture tactics included in this analysis. This adjustment was, therefore, not explored here.

***Table 10 Rehabilitated Area (ha) within No Salvage Zone in the First 20 Years***

| | |
|---|---|
| Total Rehabilitated area (all THLB) | 26,451 |
| Rehabilitated area within No Salvage Zone | 9,098 |
| Eligible rehabilitation area within No Salvage Zone | 22,078 |

### 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 120,000 ha (10.6% of the total THLB). Note that the THLB area with high and extreme PSTA ratings was estimated to 1,075,251 ha (95% of the total THLB). The model harvested approximately 62,000 ha of extreme PSTA rated stands in the first 10 years (Figure

[3] 2018 spruce bark beetle infested THLB area and THLB dead volume estimates provided by Mike McLachlan, RPF, PMP, Project Manager for Omineca Region.

35) which impacted harvest flow by up to 1.6%; observed while adjusting harvest priorities. It was also observed that prioritizing harvest of stands with extreme wildfire threat conflicted with the harvest partitions and prioritizing salvaging of IBS stands. Hence, target weights were adjusted so the model would prioritize the harvest partitions and salvaging of IBS stands over the extreme PSTA rated stands.

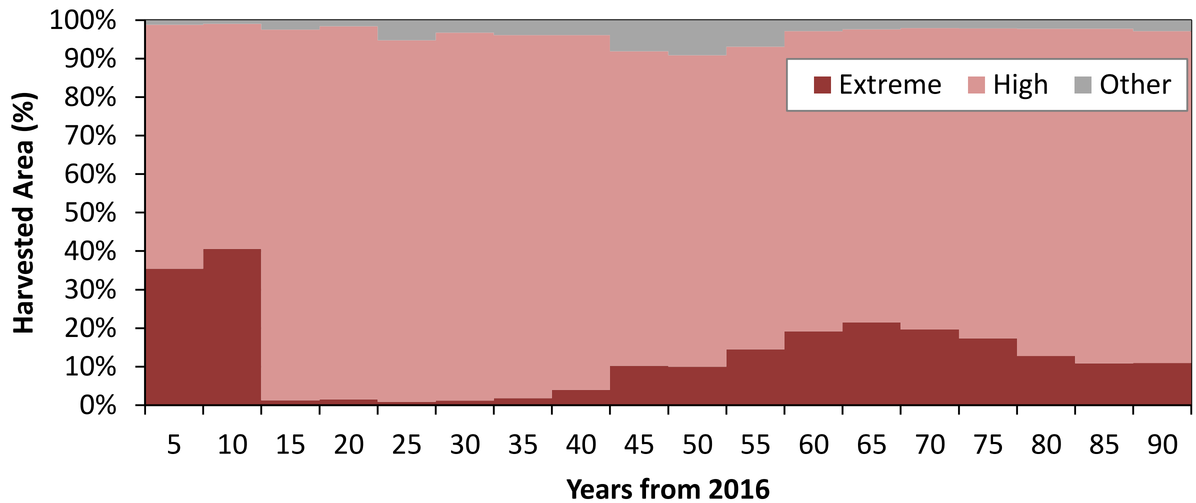



***Figure 35 Harvested Area by PSTA Wildfire Rating***

### 7.2.7 Opening Size

Harvest opening sizes were controlled in the Combined Scenario such that sliver cutblocks would be minimized. By adjusting harvest opening targets and weights while limiting harvest impacts to less than 1%, the model developed a more appropriate spatial harvest pattern. In each 5-year period, virtually no cutblocks harvested were less than 1 ha (Figure 36), while less than 15% of the cutblock area was less than 20 ha.

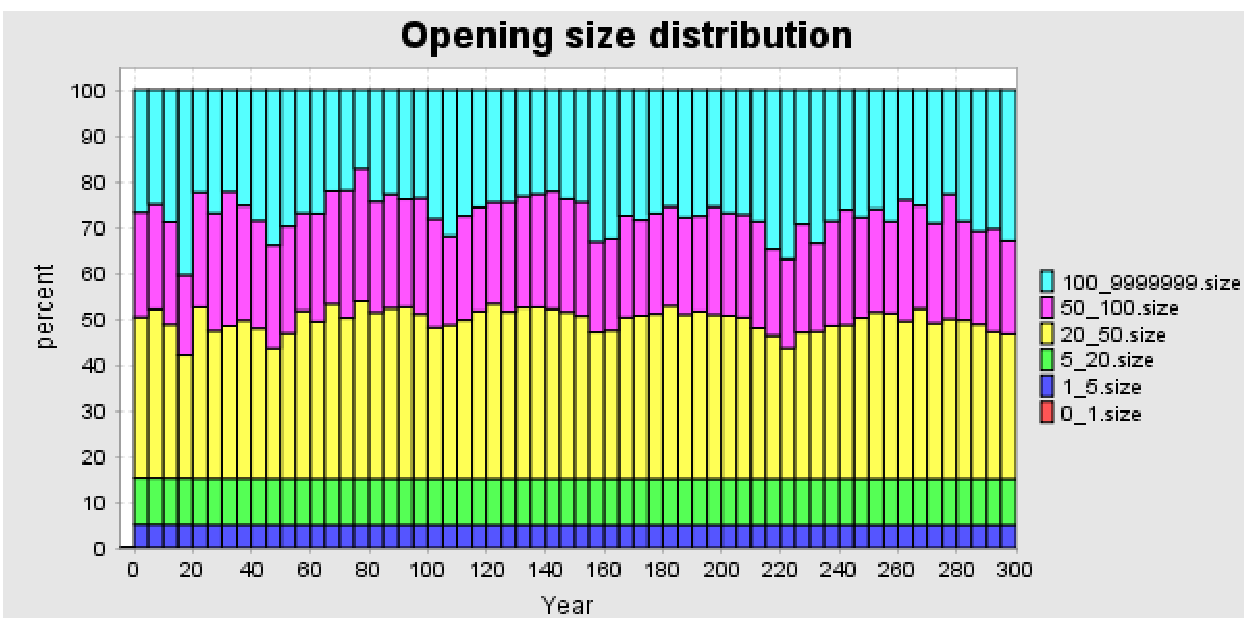



***Figure 36 Combined Scenario – Harvest Opening Size Distribution***

#### 7.2.8 Candidate Reserves

From the Reserve Scenario, candidate reserves identified within THLB were locked from harvesting for the first 40 years of the planning horizon. This amounted to approximately 10,000 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 included land base definition, MPB yield assumptions, and non-THLB disturbance. The ISS Base Case THLB is 10.0% smaller than the TSR Benchmark because the ISS Base Case excludes significantly more area from harvest for WHA/UWRs no-harvest zones and riparian, while TSR Benchmark netted out significantly more area due to excessive haul distance. The MPB yield assumptions were simplified in the TSR Benchmark, whereas the ISS Base Case included many details (including emergence of a regen layer) to portray more accurately, in time and space, the reality on the ground. The ISS Base Case also included IBS yield assumptions. The non-THLB was only disturbed in the ISS Base Case.

These differences had a ripple effect on the timber supply results. Over the first 3 decades the TSR Benchmark harvest flow was higher than the ISS Base Case, during the mid-term, the two harvest flows were identical, and in the long-term, the ISS Base Case harvest flow was higher than the TSR Benchmark. Moreover, the MPB NRL volume was higher in the case of the ISS Base Case.

## 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, Harvest, and Silviculture) are briefly summarized in Table 11.

***Table 11 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 107,000 ha; contributing to 2.5 times more area retained for WTR and Riparian Reserves than the 4.7% aspatial reduction used in 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 108,000 ha (UWR) and 63,000 ha (WHA); 4.2 times more than TSR Benchmark. |
| New Tenures | The ISS Scenarios considered spatial delineation of any revised Community Forests, First Nation Woodland Licenses (FNWL) and First Nations Areas of Interest. Only the Combined Scenario considered the Kwadacha FNWL. |
| Watershed ECA | The ISS Base Case, Harvest, Silviculture, and Combined Scenarios were configured to monitor and/or implement ECAs within identified watersheds (proposed FSWs, LRMP, and Reserve). 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. |

| Topic | Key Observations |
|---|---|
| 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. By controlling the harvest in a sensitivity run (i.e., harvest maximum 0.5% THLB per 5-year period within Chase and Wolverine herds), the disturbance level was maintained at 35% with an overall harvest rate impact of 30% in the short-term, 33% in the mid-term, and 23% 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 implemented harvest partitions). These revisions contributed to an initial growing stock that is 22 million m³ less than TSR Benchmark.<br><br>In addition, wildlife tree retention was adjusted based on opening size by implementing patch groups adjusted relative to the current distribution. This led to a significant area reduction (~66,000 ha); contributing to 2.5 times more area retained for WTR and Riparian Reserves than the 4.7% aspatial reduction used in the TSR Benchmark.<br><br>It was observed that favouring PSTA extreme fire threat rated stands to be harvested in the first 10 years of the planning horizon could have a visible negative impact on dead volume salvaged from MPB and IBS infested stands. The salvaging of MPB and IBS infested stands was favoured over harvesting extreme fire threat rated stands. |
| Spruce Beetle Management | The ISS Base Case Scenario considered estimated IBS mortality (approximately 1.8 million m³) and adjusted yields accordingly. This contributed 8 million m³ to an initial growing stock of that was 22 million m³ less than TSR Benchmark. The ISS Combined Scenario updated the IBS mortality to match the 2017 impact estimates (approximately 2.05 million m³). At this time, no assumptions were made for IBS spread over time.<br><br>It was observed that in addition to the PSTA fire threat stands impact on IBS salvage described above, harvest partitions set to prioritize MPB salvaging visibly reduced the salvaged volume from IBS stands. |
| 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. |
| Site Index | A significant portion of young stands (<60yrs old) was forecasted to be harvested over the mid- and long-term (Figure 6). This is because the MHA criteria (150 m³/ha on slopes <46% and 250 m³/ha on slopes above 46%) significantly lowered the MHA for the more productive future stands. Future managed stands are predicted to be growing on sites that are 3.6m ($SI_{50}$) higher than the existing natural stands. |
| Non-Timber Objectives | The non-timber objectives that were additional to the TSR Benchmark (landscape-level biodiversity for Fox and Obo River LUs, ECA targets for sensitive watersheds, and 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 12,000 ha (<1%) of the current THLB was identified as candidate reserves. When assessing results, it is important to consider the size of the assessment unit since some units are very small and consequently difficult to meet these requirements. The THLB candidate reserves covering <1% of the THLB were locked from harvesting for the first 40 years in the Combined Scenario with no visible impact on harvest flow. |
| Wildfire Management | The Harvest Scenario included higher harvest weights for 2015 PSTA extreme fire threat rated stands (approximately 135,000 ha THLB). While this did not impact harvest flows, it likely contributed to minor reduction in salvaging dead volume from MPB and IBS. In the Combined Scenario a more aggressive approach was undertaken which resulted in a harvest flow impact of up to 2.1%. It was also learned that the harvest partitions might have had a negative impact on prioritizing the extreme rated stands in the first 10 years. |
| Excessive Haul Distance | The ISS Base Case Scenario included revised distance criteria based on haul cycle times and average road speeds. (i.e., harvest cycle >5 hours was assumed too far to be harvested). Compared to the TSR Benchmark approach (removed blocks beyond 293 km from Mackenzie), this approach added 332,043 ha (net) to the THLB. |
| Harvest Opening Sizes | The Harvest Scenario showed that grouping blocks into larger harvest openings was possible without impacting the harvest flow. This tactic was improved in the Combined Scenario where harvesting of small cutblocks (under 20ha in size) was controlled more aggressively, still with no visible impact on harvest flow. |

| Topic | Key Observations |
|---|---|
| Harvest Partitions | In a sensitivity to the Harvest Scenario, turning off the harvest partitions resulted in a 12.3% harvest increase in the short-term, and 14.5% increase in the mid- and long-term. In addition, more deciduous and balsam leading stands were converted to future managed stands that include significant proportions of pine and spruce, which in turn resulted in more pine and spruce volume being harvested in the long-term. |
| | The 'go north' partition clearly reduces the area harvested within the southwest portion of the TSA (i.e., 17% of the annual harvest from this location), which aligns with the objective to avoid over-harvesting within this location. |
| | It was observed in the Combined Scenario that the harvest partitions conflicted with prioritizing harvesting in the first 10 years of PSTA extreme fire threat rated stands. Harvest partitions were favoured over harvesting PSTA extreme fire threat rated stands. |
| Cable Harvest | In 25 years, the forecasted harvest that comes from cable harvest systems increases from 3% to 15% (17% in the Combined Scenario). This is paramount to maintaining the mid-term harvest level – particularly the front end. |
| Minimum Harvest Criteria | The minimum harvest criteria from TSR is based only on minimum volume thresholds. There may be a concern that some of the future harvest relies on smaller timber – particularly stands reforested under enhanced basic silviculture regimes. A recommendation to explore these parameters is provided below. |
| 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. These opportunities contributed significantly to alleviate the mid-term shortage. 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 model grew exponentially that caused much longer times needed to develop, build, run, and report modelling results. These considerations are important when planning analyses of this magnitude. |

## 8.3 Recommendations

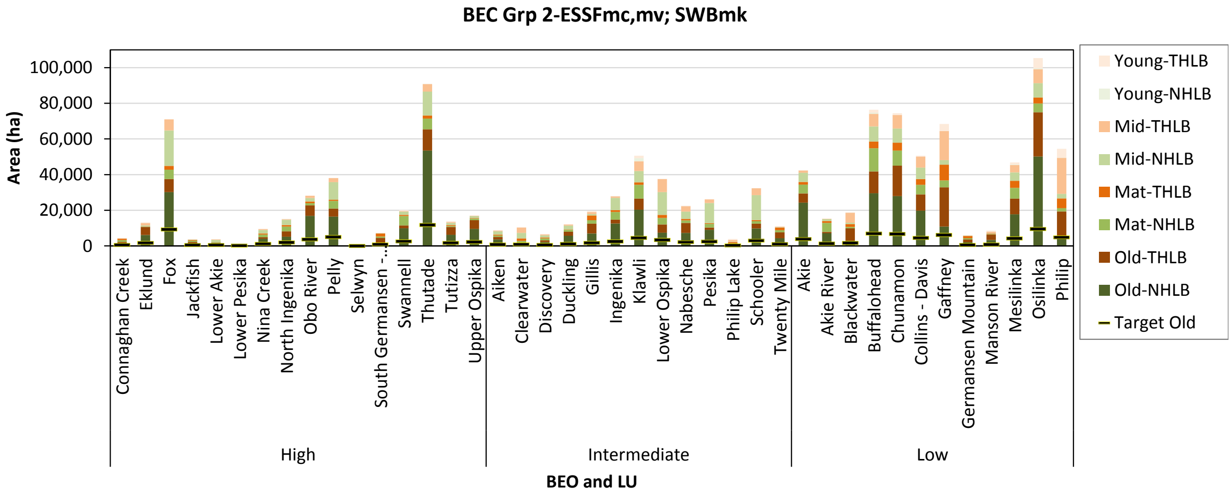
Opportunities to improve future analyses or explore new tactics were identified through these analyses. Specific recommendations are briefly summarized in Table 12.

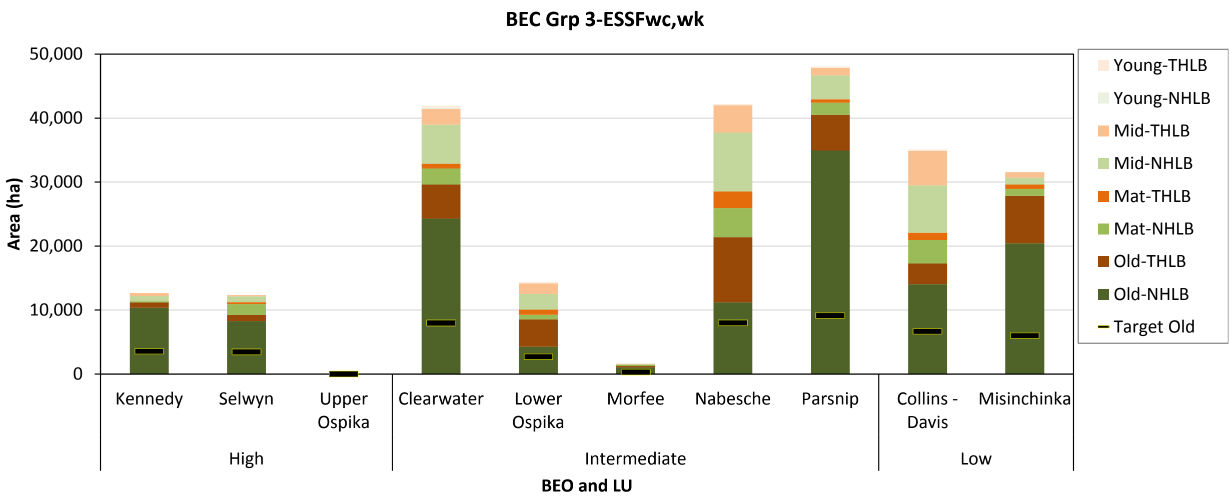
***Table 12 Summary of Recommendations***

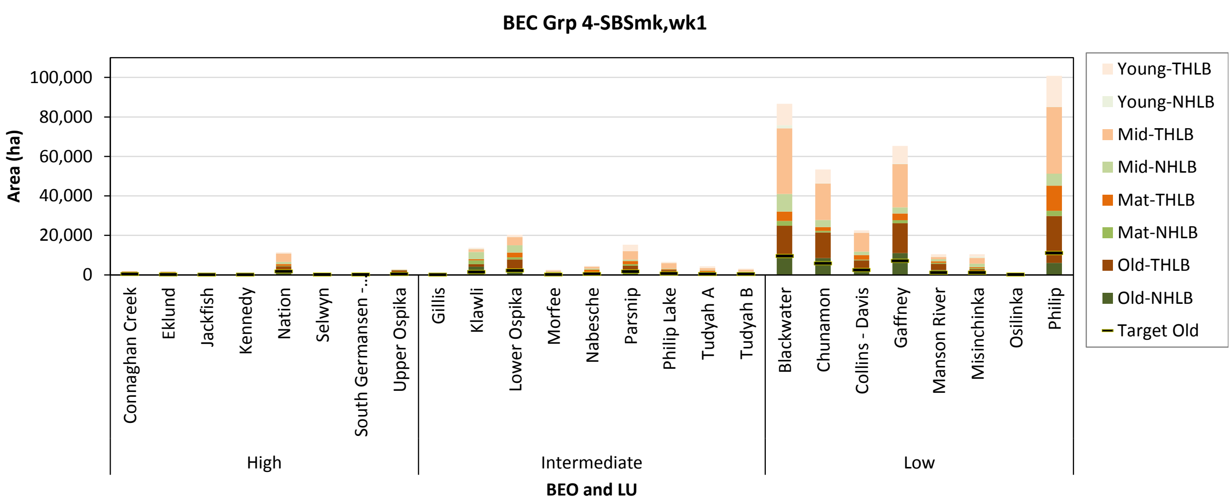
| Topic | Recommendation |
|---|---|
| Low Productivity | Exclude lower productivity stands that do not meet minimum harvest criteria from the THLB. This will allow a more accurate modelling of standing volume and minimize impacts on harvest flow in the long-term. As a general rule for sustainable forest 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. |
| Minimum Harvest Criteria | Refine the minimum harvest age criteria. Future stands, which are potentially more productive, can meet the minimum harvest criteria at ages under 60 years. However, wood products sourced from younger stands can pose potential economic challenges. Consider incorporating different minimum harvest criteria for natural and managed stands, especially when including silviculture tactics to aid the mid-term shortage. |
| 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. |

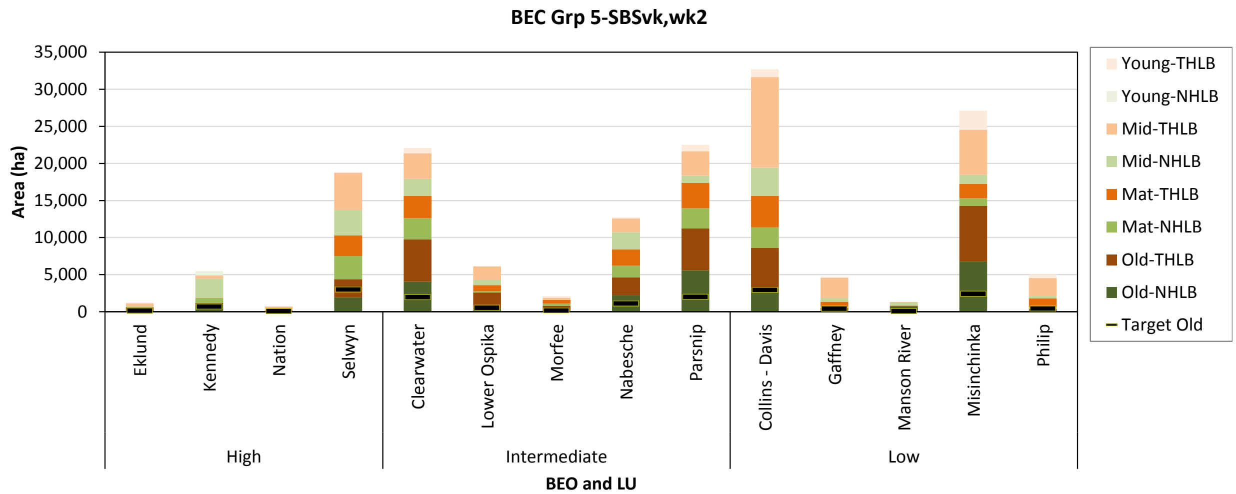
| Topic | Recommendation |
| --- | --- |
| | Implement patch size criteria within the non-harvestable land base. The natural disturbance schedule imposed on the NHLB was not spatially realistic as the 'fire' blocks were not grouped into larger patches to more closely mimic reality. Ultimately, this should 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 anthropogenic disturbance data was not clearly defined. As such, some anthropogenic disturbance features that can potentially cover large forested areas are considered disturbed for the purpose of Caribou habitat assessment. |
| | Rehabilitate roads that are no longer in use and seek input from habitat biologists for planning these activities. |
| | Upgrade and expand the road network to access the entire THLB. This will help to reflect anthropogenic disturbance associated with road buffers. |
| Scenic Areas | This ISS iteration adopted the TSR assumptions that the constraining scenic areas represent a small portion of the THLB with an estimated impact on harvest flow below 1%. This assumption needs to be tested and perhaps scenic areas objectives properly model in future iterations for a more accurate spatial representation. |
| Excessive Haul Distance | Refine the haul cycle distance to reflect available road systems, barging opportunities, 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. |
| Harvest Partitions | Reconsider harvest partitions to reduce the mid-term impact on harvest flows. While current harvest partitions are intended to encourage MPB salvage and limit harvesting of non-pine stands, they have a dramatic negative impact on harvest flow, by limiting the harvest of deciduous and balsam volumes. Without the harvest partitions, the heuristic approach resulted in a higher harvest flow, while salvaging similar MPB volumes to the ISS Base Case, and achieving all other non-timber objectives. In addition, the 5 harvest partitions modelled here were conflicting to each other as they were targeting overlapping areas (e.g., Bl-leading and non-pine stands, deciduous leading and non-pine stands) and once the MPB salvage period was over, large amounts of volume form balsam stands were harvested. |
| | Harvest partitions applied to forest-level analyses should be revisited in light of using more complex models that can track and control all of the non-timber objectives. |
| 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). |

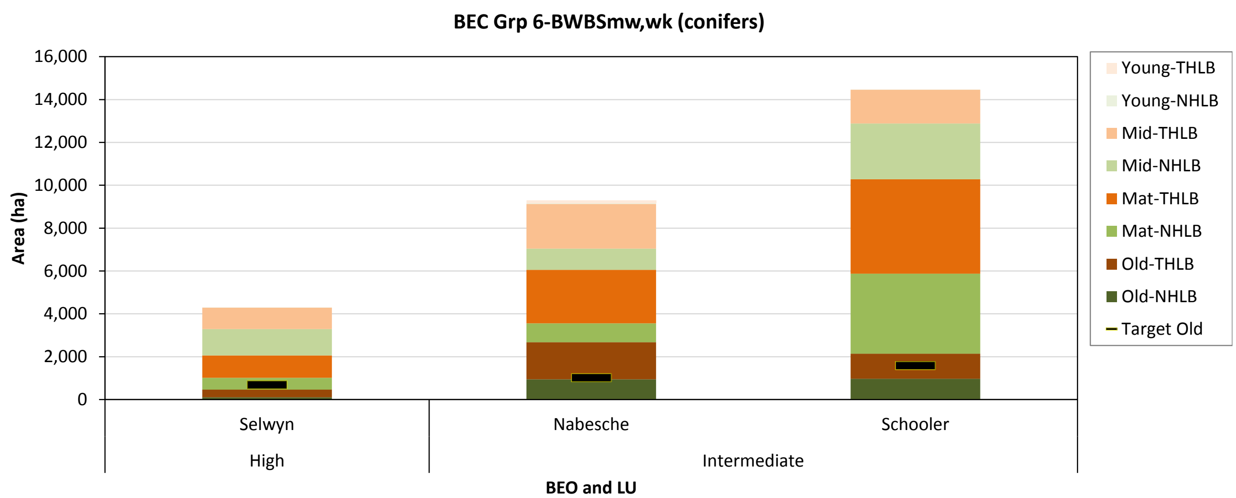
# Appendix 1 Reserves Current Status

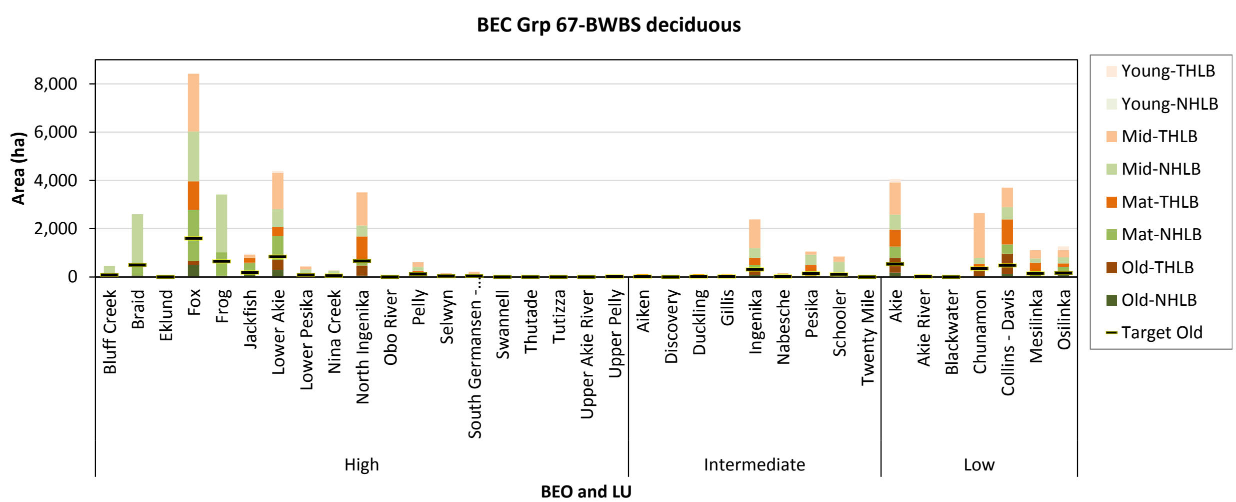


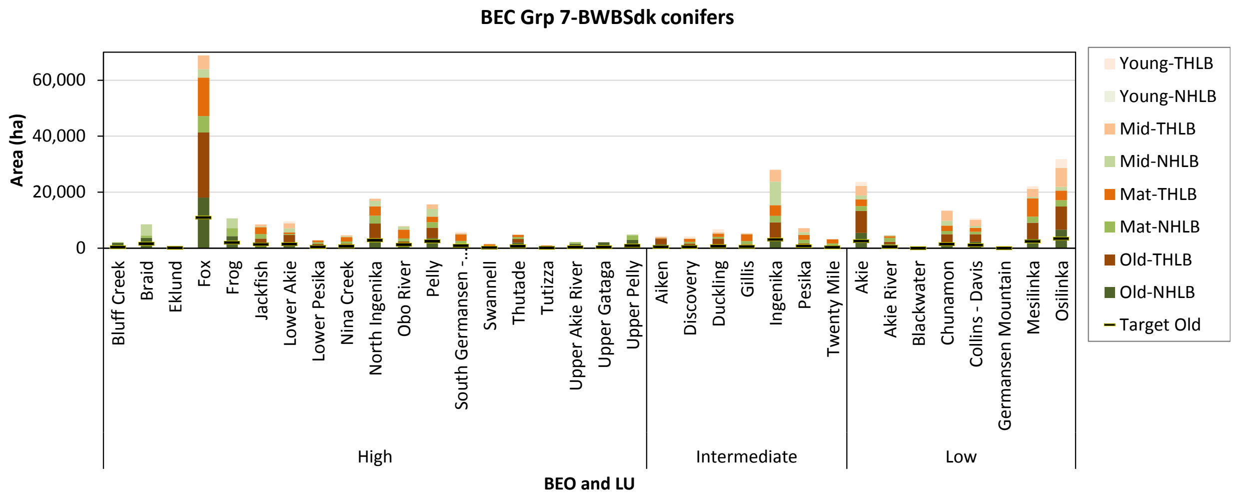



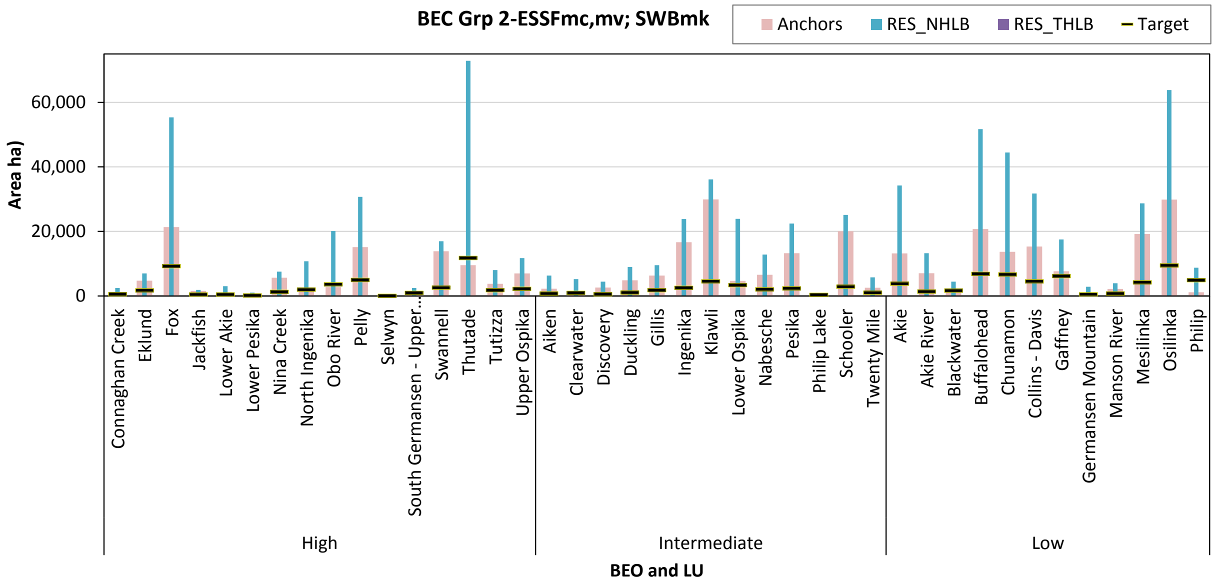

BEC Grp 5-SBSvk,wk2
Area (ha)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Eklund
Kennedy
Nation
Selwyn
Clearwater
Lower Ospika
Morfee
Nabesche
Parsnip
Collins - Davis
Gaffney
Manson River
Misinchinka
Philip
High
Intermediate
Low
BEO and LU
Young-THLB
Young-NHLB
Mid-THLB
Mid-NHLB
Mat-THLB
Mat-NHLB
Old-THLB
Old-NHLB
Target Old

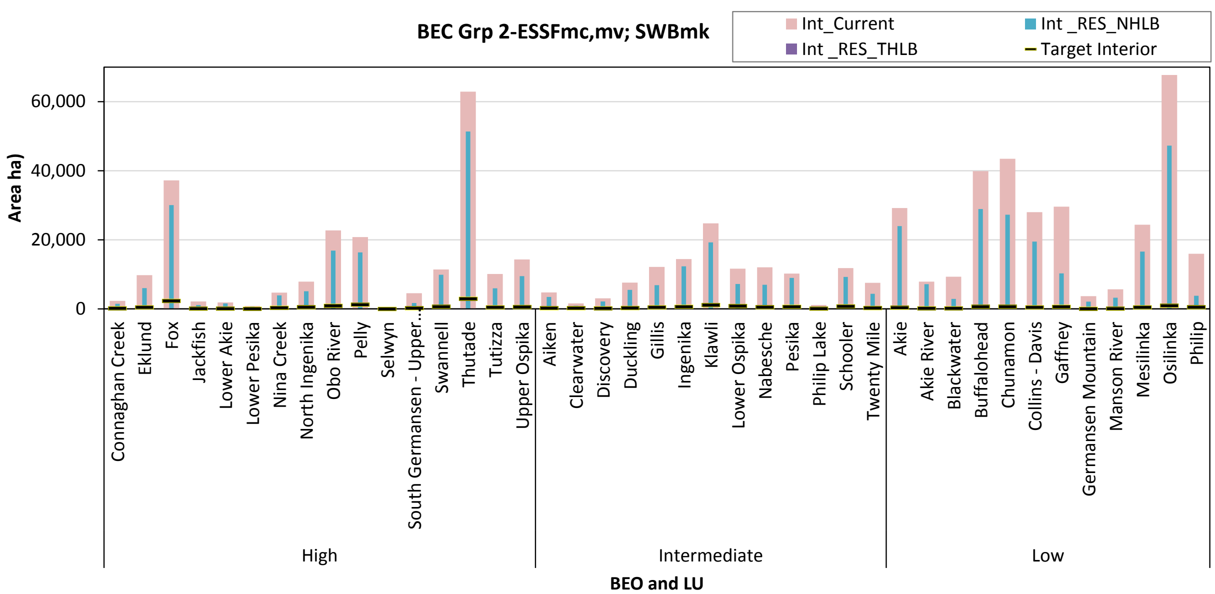

BEC Grp 6-BWBSmw,wk (conifers)
Area (ha)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Selwyn
Nabesche
Schooler
High
Intermediate
BEO and LU
Young-THLB
Young-NHLB
Mid-THLB
Mid-NHLB
Mat-THLB
Mat-NHLB
Old-THLB
Old-NHLB
Target Old

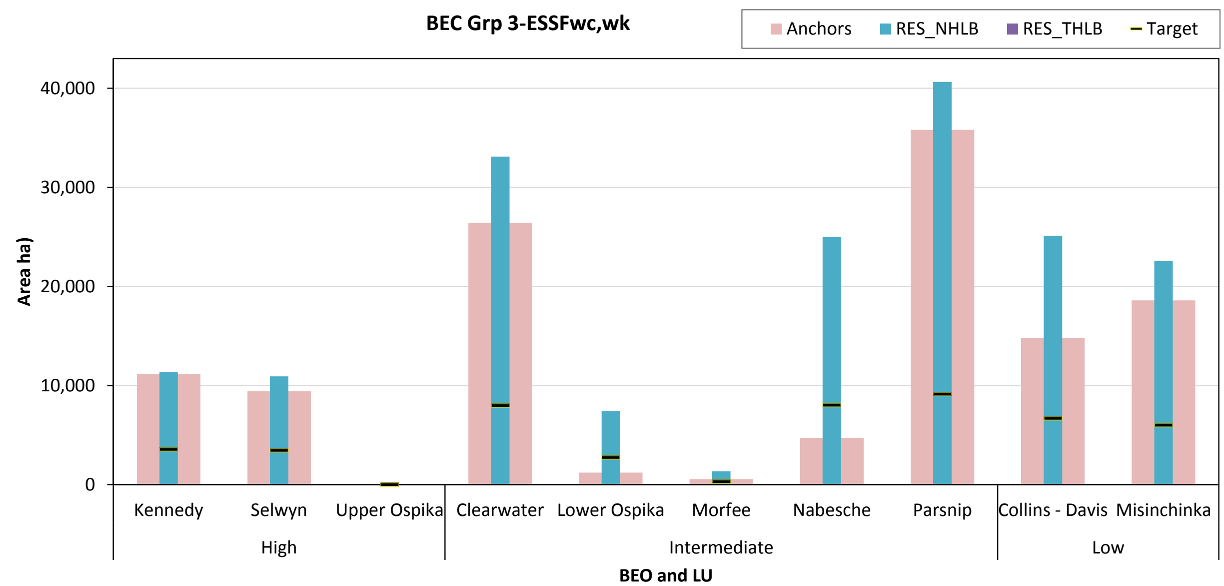

BEC Grp 67-BWBS deciduous
Area (ha)
8,000
6,000
4,000
2,000
0
Bluff Creek
Braid
Eklund
Fox
Frog
Jackfish
Lower Akie
Lower Pesika
Nina Creek
North Ingenika
Obo River
Pelly
Selwyn
South Germansen -...
Swannell
Thutade
Tutizza
Upper Akie River
Upper Pelly
Aiken
Discovery
Duckling
Gillis
Ingenika
Nabesche
Pesika
Schooler
Twenty Mile
Akie
Akie River
Blackwater
Chunamon
Collins - Davis
Mesilinka
Osilinka
High
Intermediate
Low
BEO and LU
Young-THLB
Young-NHLB
Mid-THLB
Mid-NHLB
Mat-THLB
Mat-NHLB
Old-THLB
Old-NHLB
Target Old

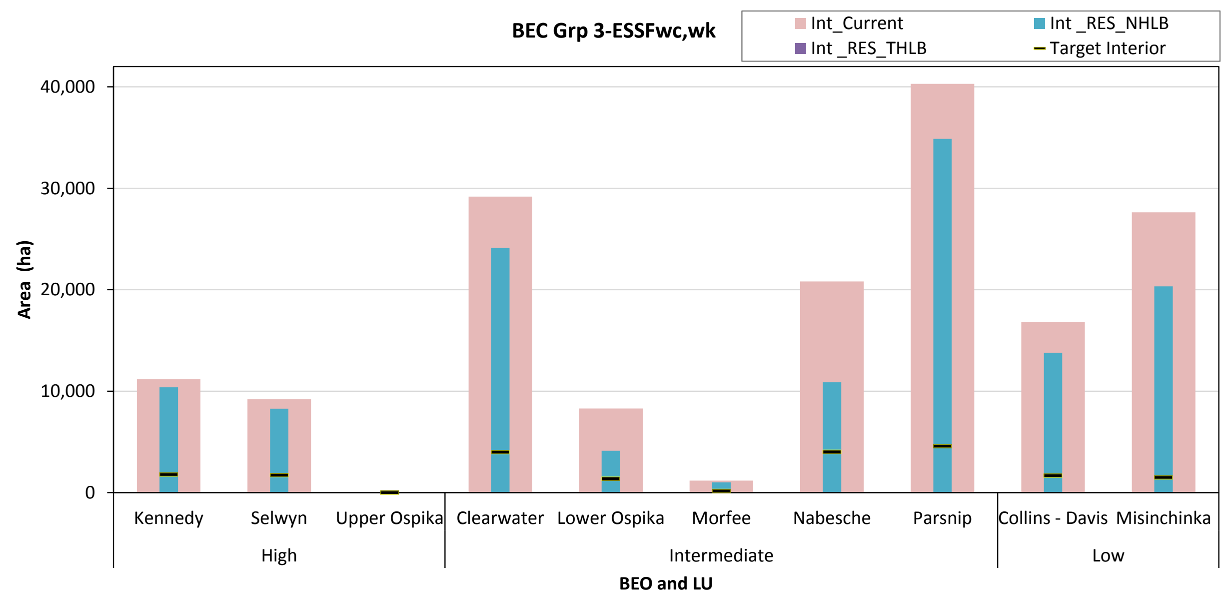

BEC Grp 7-BWBSdk conifers
Area (ha)
60,000
40,000
20,000
0
Bluff Creek
Braid
Eklund
Fox
Frog
Jackfish
Lower Akie
Lower Pesika
Nina Creek
North Ingenika
Obo River
Pelly
South Germansen -...
Swannell
Thutade
Tutizza
Upper Akie River
Upper Gataga
Upper Pelly
Aiken
Discovery
Duckling
Gillis
Ingenika
Pesika
Twenty Mile
Akie
Akie River
Blackwater
Chunamon
Collins - Davis
Germansen Mountain
Mesilinka
Osilinka
High
Intermediate
Low
BEO and LU
Young-THLB
Young-NHLB
Mid-THLB
Mid-NHLB
Mat-THLB
Mat-NHLB
Old-THLB
Old-NHLB
Target Old

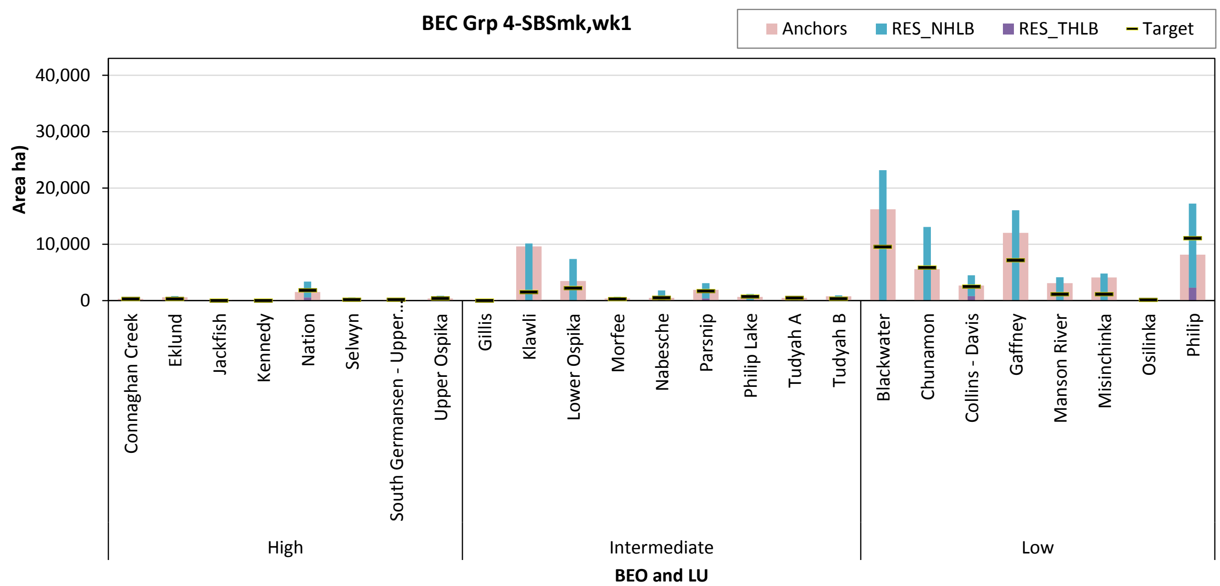
# Appendix 2 Reserves Scenario Results

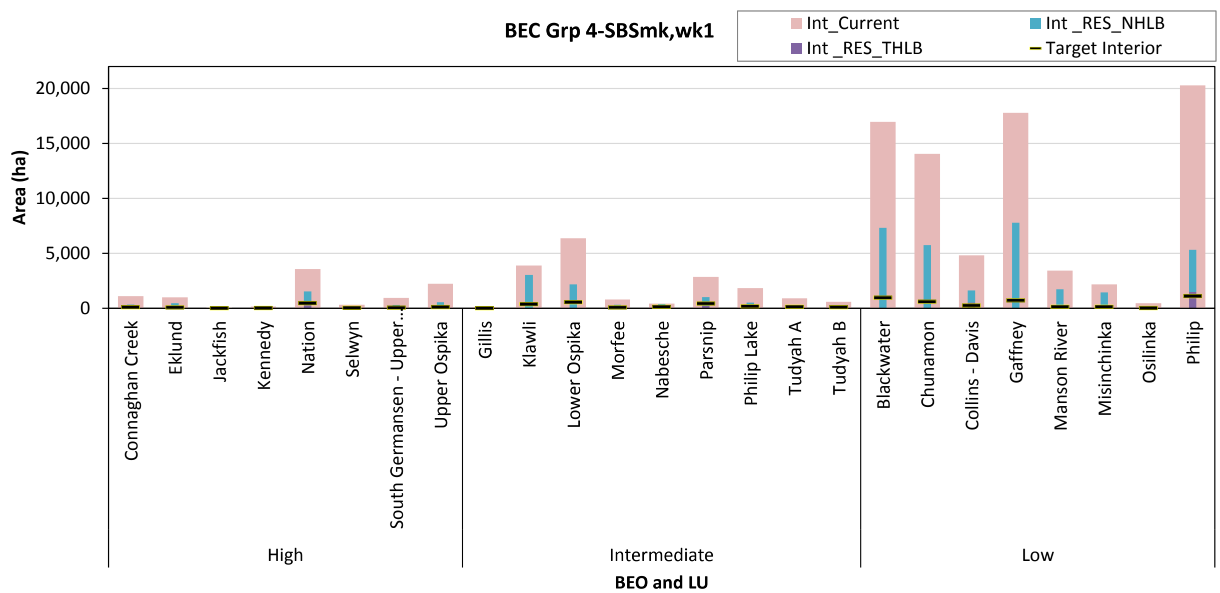


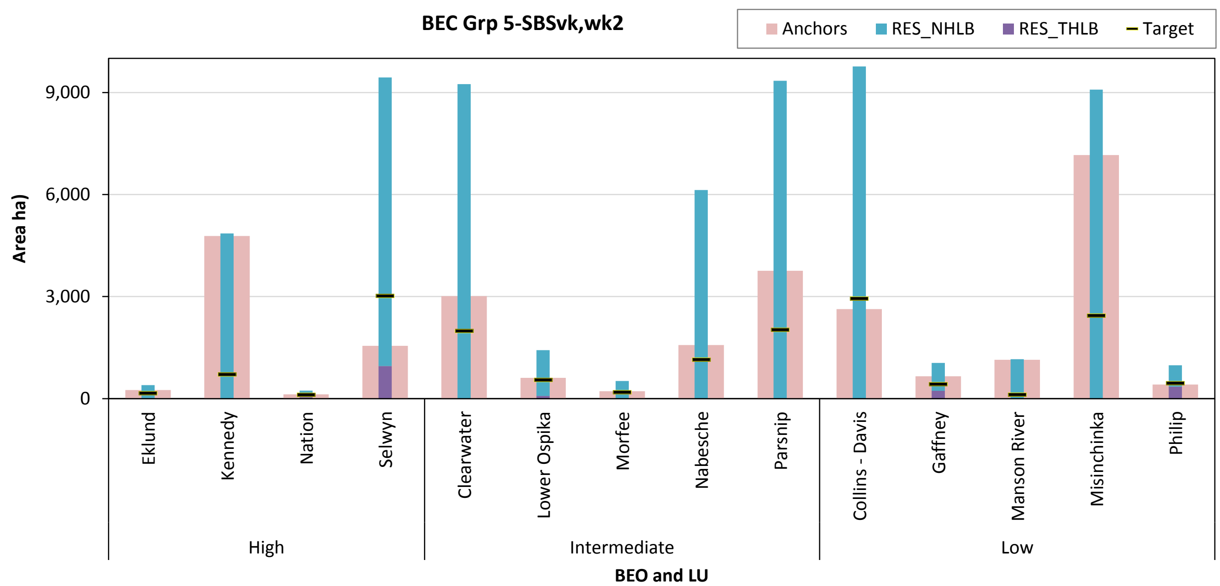



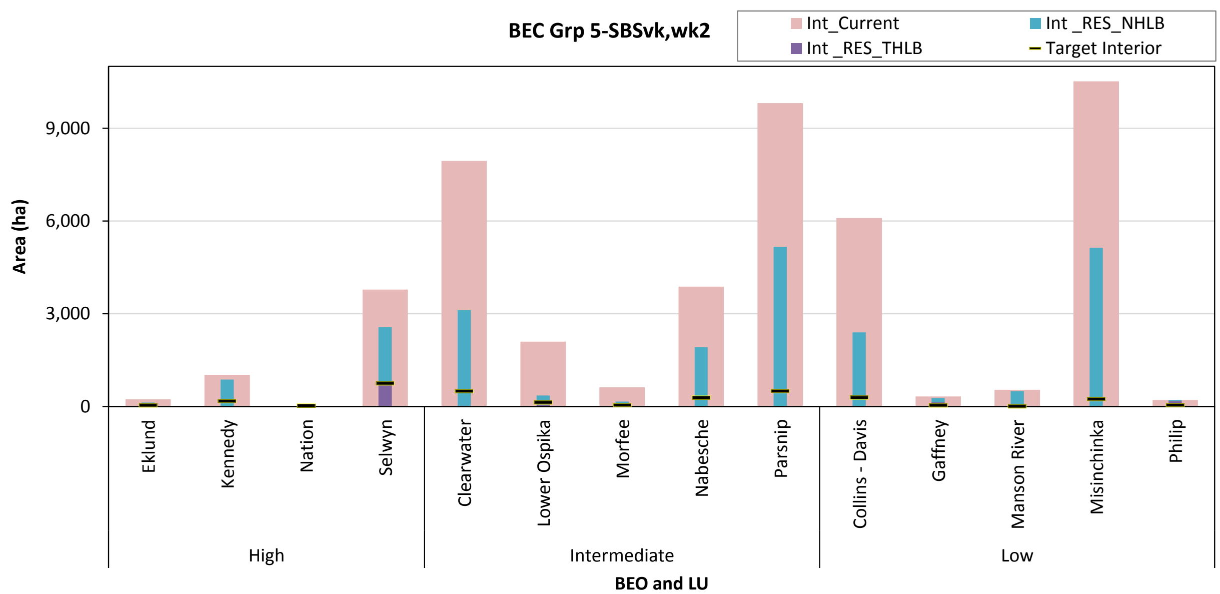

BEC Grp 3-ESSFwc,wk
Anchors
RES_NHLB
RES_THLB
Target
Area ha)
40,000
30,000
20,000
10,000
0
Kennedy
Selwyn
Upper Ospika
Clearwater
Lower Ospika
Morfee
Nabesche
Parsnip
Collins - Davis
Misinchinka
High
Intermediate
Low
BEO and LU

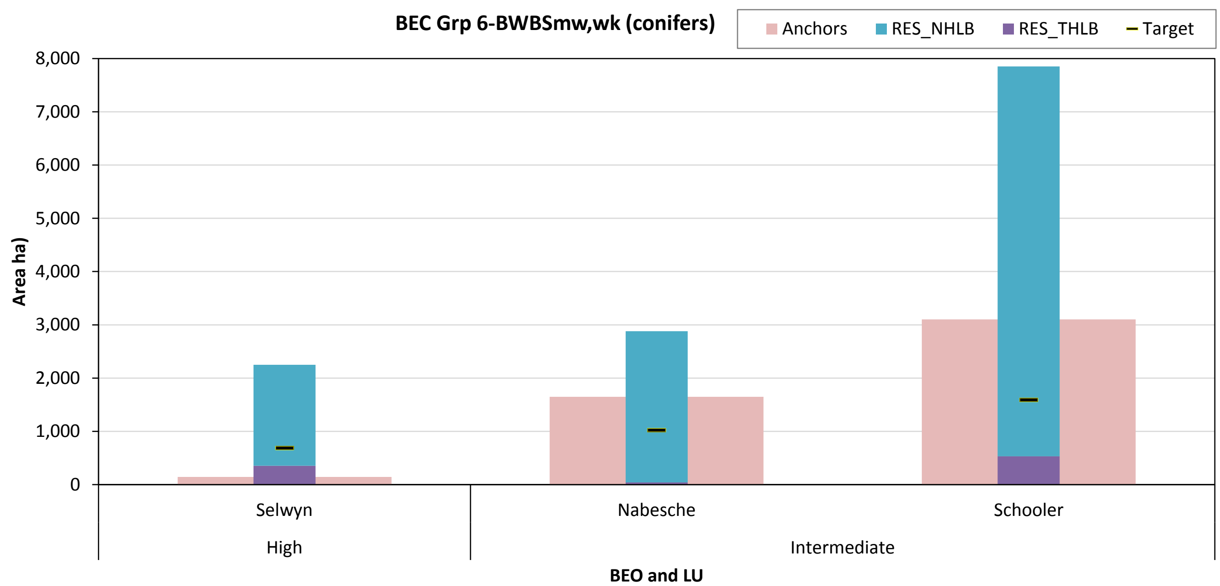

BEC Grp 3-ESSFwc,wk
Int_Current
Int _RES_NHLB
Int _RES_THLB
Target Interior
Area (ha)
40,000
30,000
20,000
10,000
0
Kennedy
Selwyn
Upper Ospika
Clearwater
Lower Ospika
Morfee
Nabesche
Parsnip
Collins - Davis
Misinchinka
High
Intermediate
Low
BEO and LU

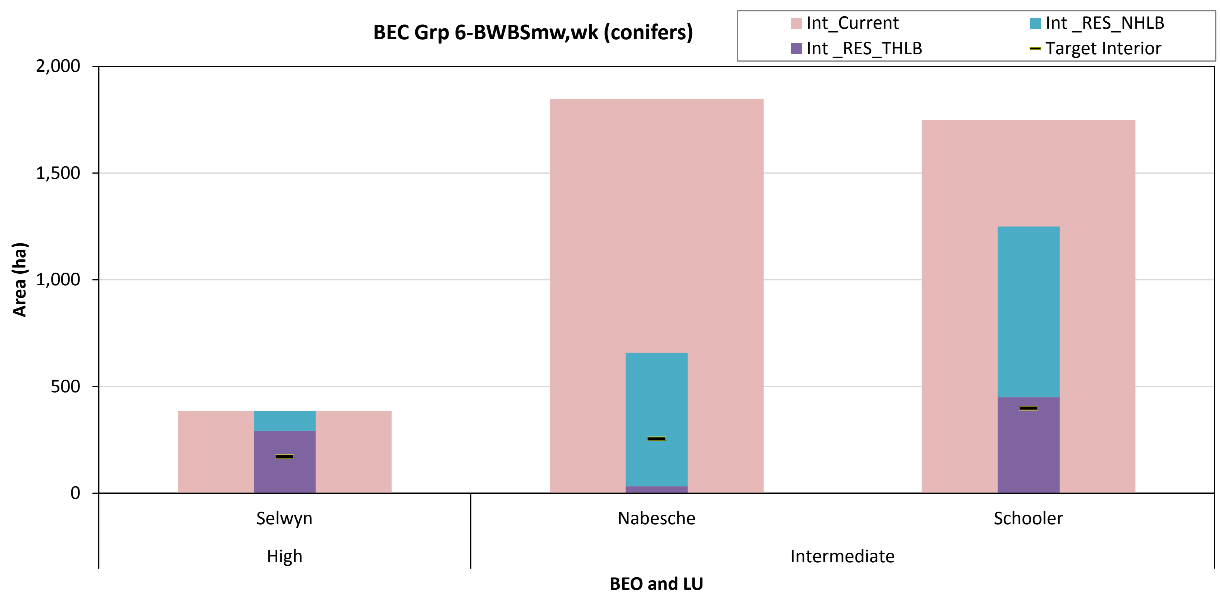

BEC Grp 4-SBSmk,wk1
Anchors
RES_NHLB
RES_THLB
Target
Area ha)
40,000
30,000
20,000
10,000
0
Connaghan Creek
Eklund
Jackfish
Kennedy
Nation
Selwyn
South Germansen - Upper...
Upper Ospika
Gillis
Klawli
Lower Ospika
Morfee
Nabesche
Parsnip
Philip Lake
Tudyah A
Tudyah B
Blackwater
Chunamon
Collins - Davis
Gaffney
Manson River
Misinchinka
Osilinka
Philip
High
Intermediate
Low
BEO and LU

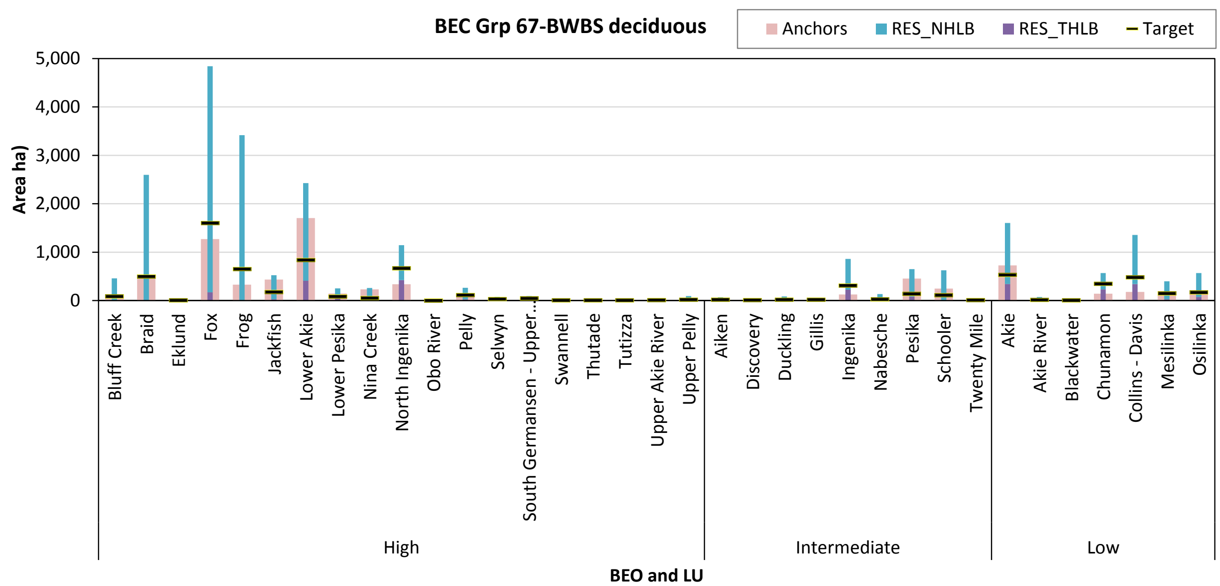

BEC Grp 4-SBSmk,wk1
Int_Current
Int _RES_NHLB
Int _RES_THLB
Target Interior
Area (ha)
20,000
15,000
10,000
5,000
0
Connaghan Creek
Eklund
Jackfish
Kennedy
Nation
Selwyn
South Germansen - Upper...
Upper Ospika
Gillis
Klawli
Lower Ospika
Morfee
Nabesche
Parsnip
Philip Lake
Tudyah A
Tudyah B
Blackwater
Chunamon
Collins - Davis
Gaffney
Manson River
Misinchinka
Osilinka
Philip
High
Intermediate
Low
BEO and LU


BEC Grp 5-SBSvk,wk2
Anchors
RES_NHLB
RES_THLB
Target
Area ha)
9,000
6,000
3,000
0
Eklund
Kennedy
Nation
Selwyn
Clearwater
Lower Ospika
Morfee
Nabesche
Parsnip
Collins - Davis
Gaffney
Manson River
Misinchinka
Philip
High
Intermediate
Low
BEO and LU

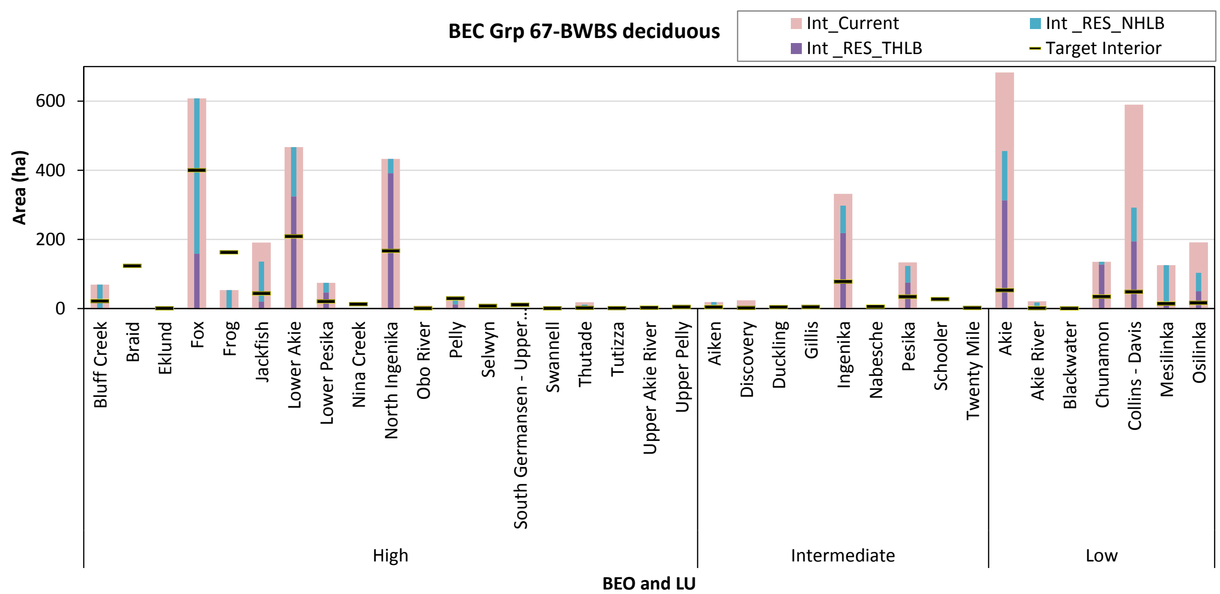

BEC Grp 5-SBSvk,wk2
Int_Current
Int _RES_NHLB
Int _RES_THLB
Target Interior
Area (ha)
9,000
6,000
3,000
0
Eklund
Kennedy
Nation
Selwyn
Clearwater
Lower Ospika
Morfee
Nabesche
Parsnip
Collins - Davis
Gaffney
Manson River
Misinchinka
Philip
High
Intermediate
Low
BEO and LU


BEC Grp 6-BWBSmw,wk (conifers)
Anchors
RES_NHLB
RES_THLB
Target
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Area ha)
Selwyn
Nabesche
Schooler
High
Intermediate
BEO and LU

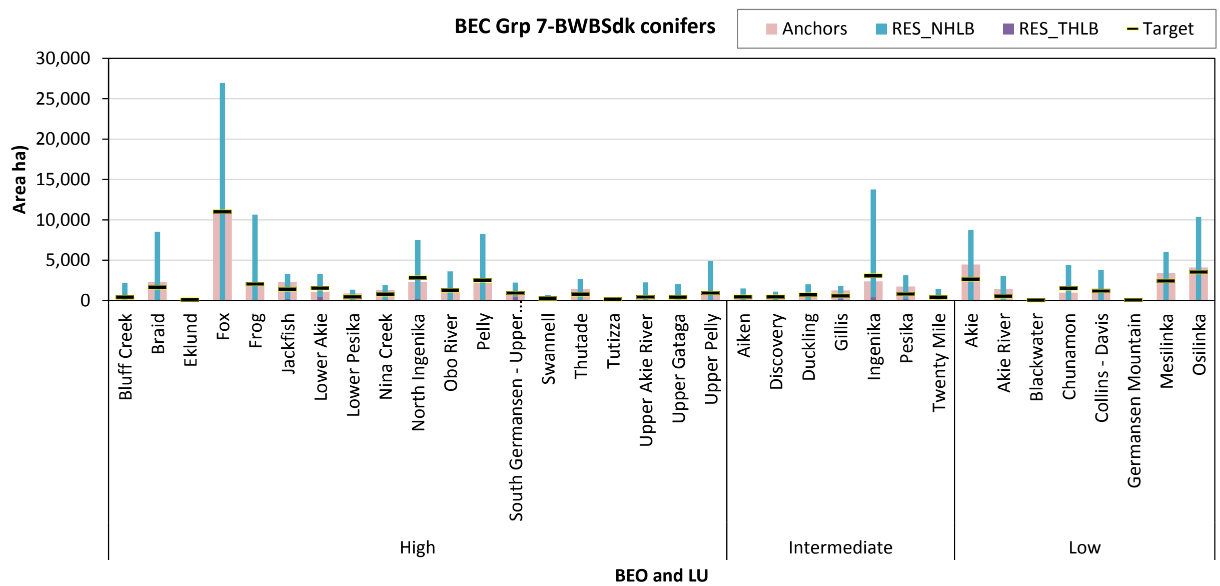

BEC Grp 6-BWBSmw,wk (conifers)
Int_Current
Int _RES_NHLB
Int _RES_THLB
Target Interior
2,000
1,500
1,000
500
0
Area (ha)
Selwyn
Nabesche
Schooler
High
Intermediate
BEO and LU



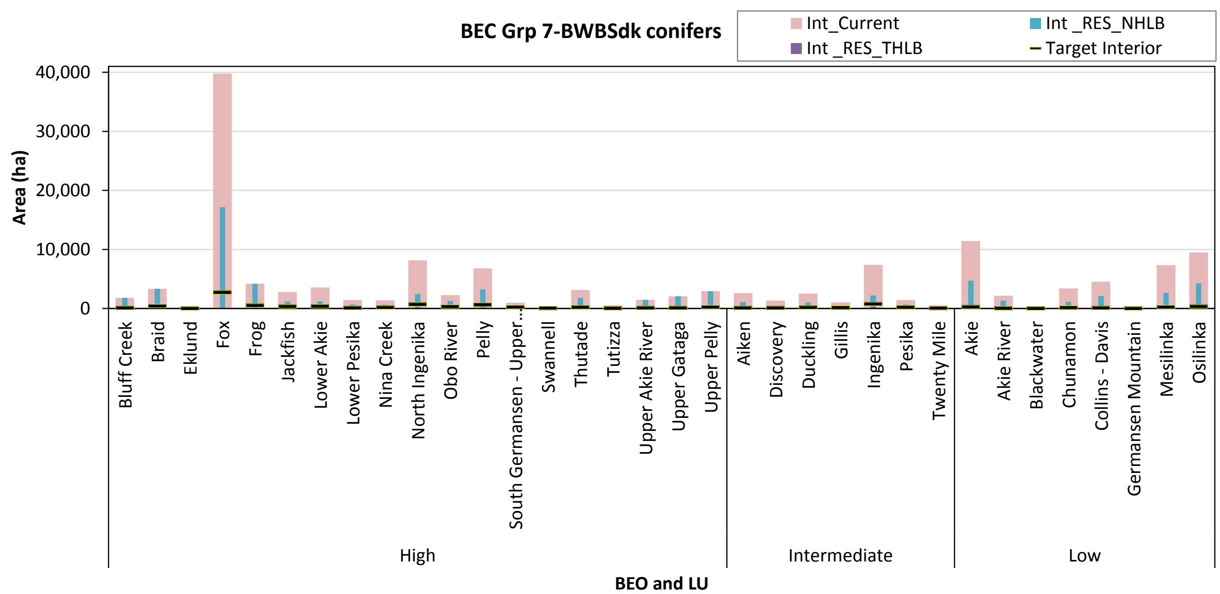
BEC Grp 67-BWBS deciduous
Anchors
RES_NHLB
RES_THLB
Target
Area ha)
5,000
4,000
3,000
2,000
1,000
0
Bluff Creek
Braid
Eklund
Fox
Frog
Jackfish
Lower Akie
Lower Pesika
Nina Creek
North Ingenika
Obo River
Pelly
Selwyn
South Germansen - Upper...
Swannell
Thutade
Tutizza
Upper Akie River
Upper Pelly
Aiken
Discovery
Duckling
Gillis
Ingenika
Nabesche
Pesika
Schooler
Twenty Mile
Akie
Akie River
Blackwater
Chunamon
Collins - Davis
Mesilinka
Osilinka
High
Intermediate
Low
BEO and LU

BEC Grp 67-BWBS deciduous
Int_Current
Int _RES_NHLB
Int _RES_THLB
Target Interior
Area (ha)
600
400
200
0
Bluff Creek
Braid
Eklund
Fox
Frog
Jackfish
Lower Akie
Lower Pesika
Nina Creek
North Ingenika
Obo River
Pelly
Selwyn
South Germansen - Upper...
Swannell
Thutade
Tutizza
Upper Akie River
Upper Pelly
Aiken
Discovery
Duckling
Gillis
Ingenika
Nabesche
Pesika
Schooler
Twenty Mile
Akie
Akie River
Blackwater
Chunamon
Collins - Davis
Mesilinka
Osilinka
High
Intermediate
Low
BEO and LU



BEC Grp 7-BWBSdk conifers
Anchors
RES_NHLB
RES_THLB
Target
Area ha)
30,000
25,000
20,000
15,000
10,000
5,000
0
Bluff Creek
Braid
Eklund
Fox
Frog
Jackfish
Lower Akie
Lower Pesika
Nina Creek
North Ingenika
Obo River
Pelly
South Germansen - Upper...
Swannell
Thutade
Tutizza
Upper Akie River
Upper Gataga
Upper Pelly
Aiken
Discovery
Duckling
Gillis
Ingenika
Pesika
Twenty Mile
Akie
Akie River
Blackwater
Chunamon
Collins - Davis
Germansen Mountain
Mesilinka
Osilinka
High
Intermediate
Low
BEO and LU

BEC Grp 7-BWBSdk conifers
Int_Current
Int _RES_NHLB
Int _RES_THLB
Target Interior
Area (ha)
40,000
30,000
20,000
10,000
0
Bluff Creek
Braid
Eklund
Fox
Frog
Jackfish
Lower Akie
Lower Pesika
Nina Creek
North Ingenika
Obo River
Pelly
South Germansen - Upper...
Swannell
Thutade
Tutizza
Upper Akie River
Upper Gataga
Upper Pelly
Aiken
Discovery
Duckling
Gillis
Ingenika
Pesika
Twenty Mile
Akie
Akie River
Blackwater
Chunamon
Collins - Davis
Germansen Mountain
Mesilinka
Osilinka
High
Intermediate
Low
BEO and LU