Type 4 Silviculture Strategy in the Okanagan TSA

Modeling and Analysis Report

Prepared for:

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TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1.0 INTRODUCTION

1.1 Context

This 'modeling and analysis report' document is the third of four documents to make up the Type 4 Silviculture Strategy for the Okanagan TSA:

1. **Situational analysis:** describing the general situation for the TSA. PowerPoint slides that were presented at the initial meeting are included at the end of the document;
2. **Data package:** describing the input data, information and assumptions;
3. **Modelling and analysis report:** describing the modeling output and rationale; and
4. **Silviculture Strategy:** provides direction for a TSA-level silviculture strategy considering input from stakeholders, various experts and the forest estate modelling.

This report describes and presents results for several selected modeling scenarios that were implemented in this project. The primary focus of this project is to develop a Silviculture Strategy scenario, however is doing this there are many scenarios run to help understand modeling dynamics and the tradeoffs associated with the many values captured in the analysis.

The modeling scenarios and results presented in this report are a small selected portion of the results available from the planning tool developed through this modeling process. For the scenarios presented and many others there are fully spatial and detailed results available through the internet using *Patchwork's* HTML output, customized specifically for this project.

1.2 Description of Scenarios

Scenarios are broadly defined perspectives that intend to capture the range of viewpoints held by stakeholders, public, First Nations and government. These value positions are captured in the modeling environment by assigning indicators, targets and weightings.

The modelling scenarios that have been defined in this project include:

1. **TSR-equivalent**: This scenario implements the TSR harvest level and RMZs that are modeled in TSR. This is an important benchmarking scenario to ensure the model is consistent with TSR and to help understand any differences.

2. **Silviculture scenario:** This main scenario was developed considering the findings from the many scenarios that were run to understand the dynamics of the analysis. The scenario considers the TSR indicators as well as additional indicators that captured landbase values such as EDA and economics. The silviculture scenario allows silviculture activities (planting, fertilization and spacing) to be implemented for 10 years. The model will only select silviculture

activity where the cost and benefits make sense considering all the land base values.

3. **Economic scenario**: Selects a management regime and silviculture program that uses net-revenue (monetary value generated minus cost) as the dominant objective.

4. **Forage supply:** This scenario optimizes the harvest scheduling and silviculture activities to fulfill forage targets by pasture. Range cut-block types 1/2, 3 and 4 can be implemented throughout the planning horizon.

5. **No activities:** This scenario is a benchmark for comparison that has no harvesting or silviculture activities implemented. Over the 250 year planning horizon, natural disturbances are implemented based on the NROV on the entire productive landbase.

In an analysis scenario each indicator has targets and weightings that are set with the intent to appropriately consider each factor. Targets are specific thresholds set for each indicator. Weightings are the cost associated with not meeting a target. When discussing weightings there four qualitative weighting classes used, specifically:

- **Low:** default weighting so the model will consider the indicator;
- **Moderate:** prioritize this indicator;
- **High:** a pseudo rule that must be achieved (can't have many of these); and
- **Tracked:** no weight, but the model will still report on the status.

The activities and results for the main indicators are shown initially for the main scenario- the 'Silviculture scenario' and then comparative reports for the other scenarios are shown.

2.0 Analysis Overview

The analysis assumptions are shown in detail in the information package, however this section provides a brief overview and some general landbase summaries. In general, analysis scenarios in this project include:

- A netdown as described in the information package, resulting in a THLB of 927,000 ha;
- Natural stand yields from VDYP7 and managed stand yields from TIPSYv4.2 using site index tile productivity estimates;
- Near stand-level natural stand analysis units (AU) based on harvest method, MPB characteristics, species, age, productivity, BGC zone and stand density. Managed stand AUs based on wet/dry-belt, species, age and productivity;
- MPB modelling using shelf life curves and the 2012 BCMPB model (year 9);
- Resource management zones: community watershed (CWS), goat habitat, integrated resource management (IRM), lake management zones (LMZ), mule deer winter range (MDWR), moose habitat, visually sensitive areas and wildlife habitat areas (WHA);
- Hydrology indicators including equivalent disturbance area (EDA) above and below the H40 line and the ratio between the two; and
- Non-declining long term managed growing stock.

2.1 Land Base Summaries

This section summarizes the following important forest characteristics on the productive land base:

- THLB vs non-THLB;
- Biogeoclimatic (BGC) Ecosystem Classification (BEC) zone;
- Leading species;
- Site index; and
- Initial age class distribution.

Figure 2.1 summarizes the THLB, non-THLB and non-productive land base. In this analysis, the Okanagan TSA is a gross area of 2.25 million ha of which 44% is classified as THLB.

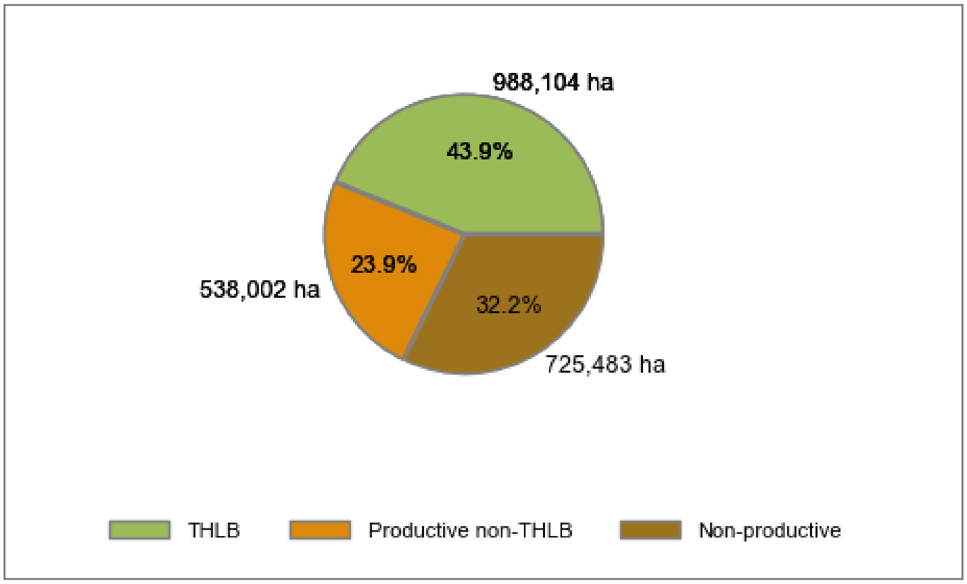


Figure 2.1: Area by Classification

2.1.1 Biogeoclimatic Ecosystem Classification

Figure 2.2 shows the area and percentage for each BGC zone. The TSA has a variety of ecosystems, however the southern portion is generally dryer and the northern portion more moist.

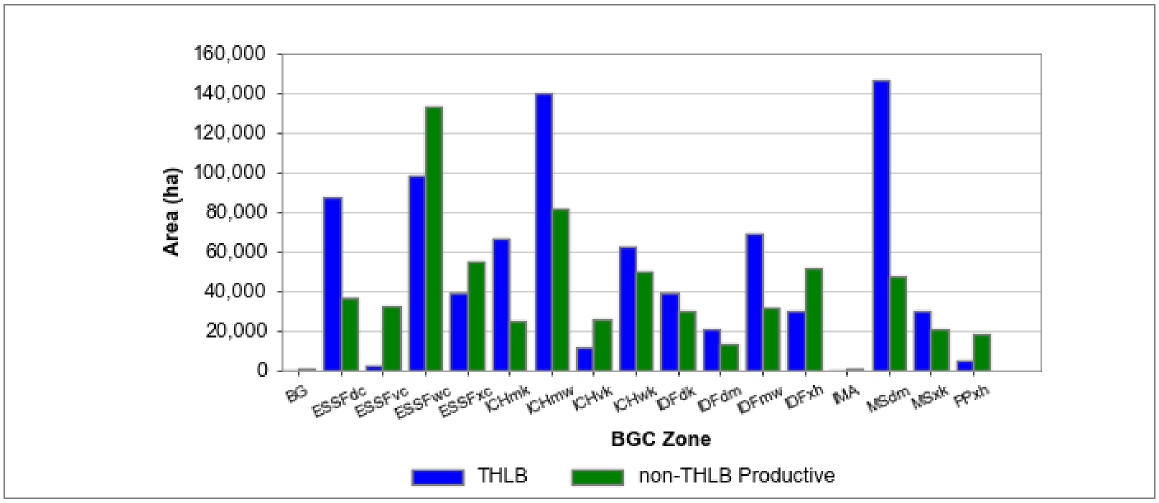


Figure 2.2: BGC Summary

2.1.2 Leading Species

Figure 2.3 shows the area and percentage by leading species on the productive land base. The TSA is 24% Lodgepole pine leading and 23% dry-belt Douglas-fir leading

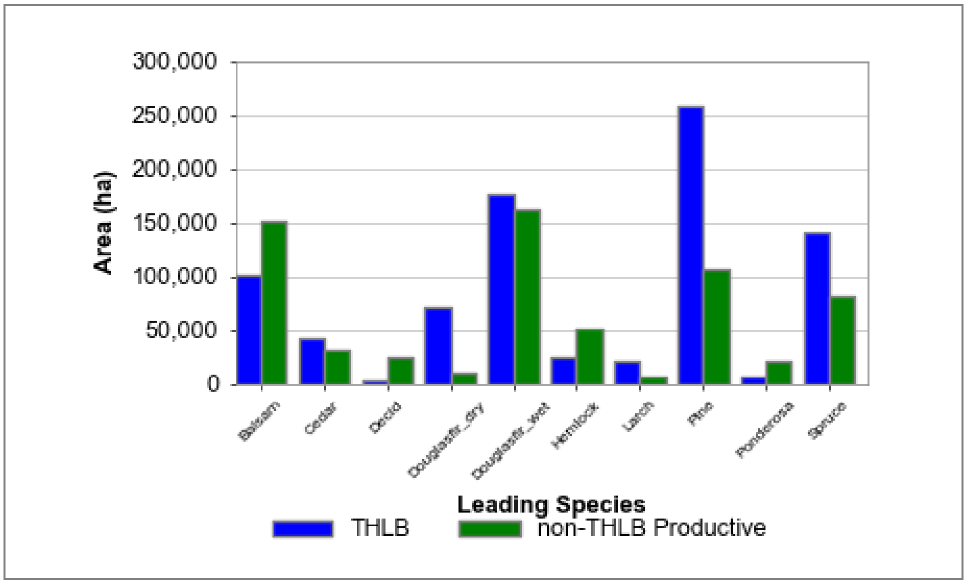


Figure 2.3: Leading Species Summary

2.1.3 Site Index

Figure 2.4 shows the area and percentage by site index class (inventory site index rounded to the nearest 3m). The area-weighted average THLB inventory site index is 15.3.

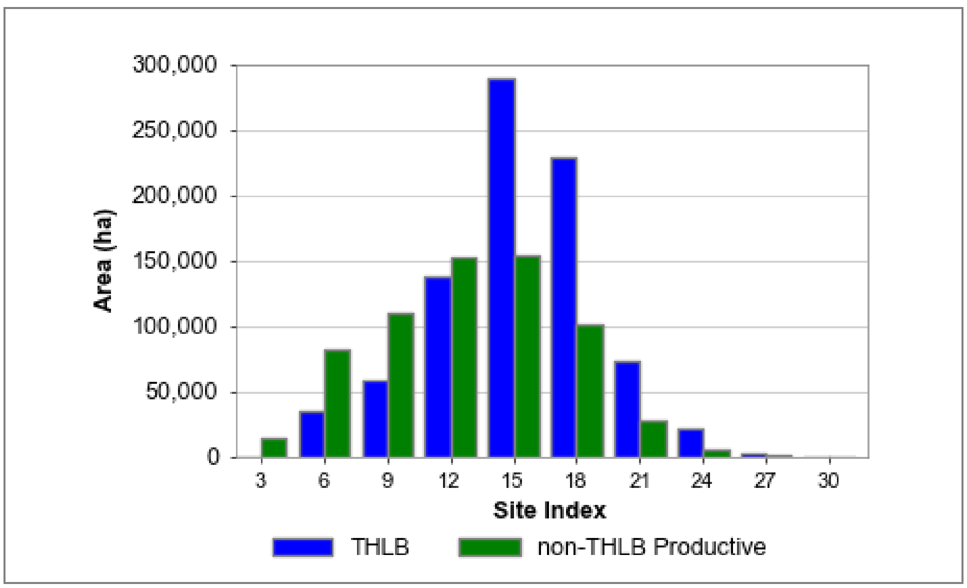


Figure 2.4: Site Index Summary

2.1.4 Initial Age Distribution

Figure 2.5 shows the area and percentage by age class.

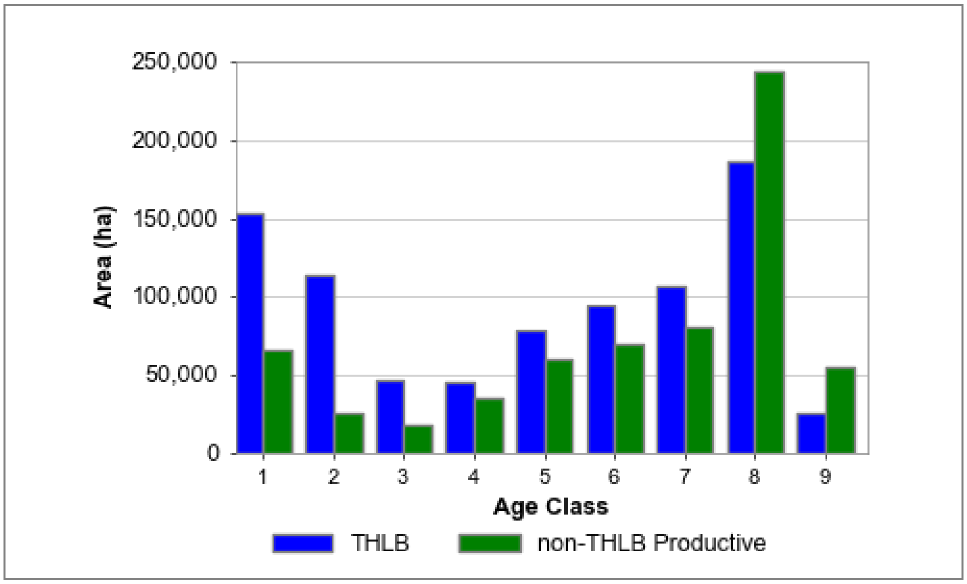


Figure 2.5: Initial Age Class Summary

3.0 SILVICULTURE SCENARIO

3.1 Description of Scenario

The main scenario in this analysis is the optimized "Silviculture scenario", reflecting one of the main project objectives- a fully rationalized and spatial silviculture program that considers a wide range of multiple landbase objectives. Additional to the factors included in the bullets from section 2.0 above, the silviculture scenario also incorporates:

- Silviculture activities allowed for 10 years: rehabilitation (planting), fertilization and spacing;
- Initial harvest level set at the current AAC of 3.1million m^3/year for 10 years before dropping down to a non-declining harvest level. Increased importance is placed on the maximization of the mid-term harvest level; and
- Positive net-revenue where net-revenue is calculated as the value (from harvesting and range) minus cost (harvesting and silviculture).

Table 3.1 shows the targets and weightings for the important indicators in the silviculture scenario.

Table 3.1: Indicators, Targets and Weightings for the Silviculture Scenario

Indicator	Target	Weighting
Harvest Volume	TSR	mod
Mid-term harvest level	Maximize mid-term	high
Net-revenue (value – cost)	Maximum positive	mod
Wildlife RMZs	GAR targets	high
Visuals	TSR retention targets	high
IRM	TSR targets	high
Hydrology - EDA	25% above/below H40	high
Forest Health	Minimize hazard	tracked
Land base carbon	Maximize	tracked
Forage targets	Forage targets by pasture	tracked
Silv. activities	Allowed for 10 years	allowed
Range cut-blocks	Across planning horizon	not allowed

3.1.1 Activities

The key output of the forest estate modelling is the schedule of activities. In the silviculture scenario, the activities being considered are:

- Harvesting- clear-cut or partial-cut.
- Rehabilitation (planting);
- Fertilization; and
- Spacing.

Activities that are not allowed in the silviculture scenario (but are modeled in other scenarios) are the clear-cut harvesting of partial-cut stands to deal with forest health issues and harvesting of range cut-block types 1/2, 3 and 4 (see information package for details of these cut-block types). The silviculture activities are allowed to occur in the first modelling period only.

3.2 Harvest Level

Figure 3.1 shows the harvest forecast of the Type 4 Silviculture Strategy and TSR 4. The Type 4 Silviculture strategy can achieve a harvest level of 3.1million m3/year for 10 years(current AAC) before dropping down to a non-declining mid-term harvest level of 2.7million m3/year. TSR 4 starts at 3.35million m3/year before dropping to 2.35million m3/year through the mid-term.

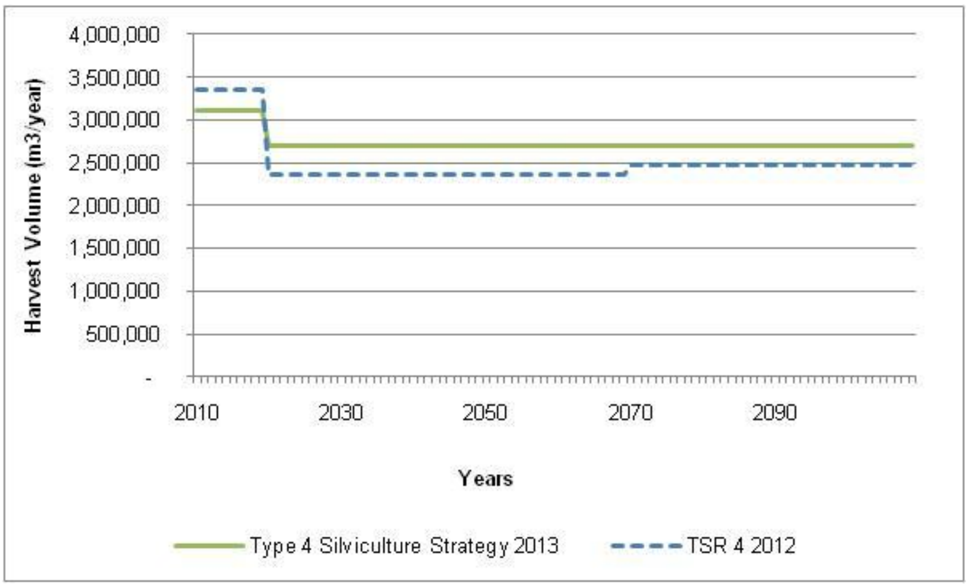


Figure 3.1: Harvest Volume: TSR and Silviculture Scenario

3.3 Silviculture Program

This section outlines the area, cost and characteristics of each of the silviculture options. in the *Patchworks* modelling environment, the silviculture program, as with all activities are implemented spatially- so the stand-level location is know. Figure 3.2 shows an example of this. Detailed maps of silviculture activity at the TSA-level will be provided as an output for the final silviculture scenario.

The model output provides very specific spatial locations for all treatments (harvesting and silviculture activity), however it should be recognized that the input data does not have sufficient accuracy to make the results accurate at this level. For this reason the results are summarized to provide general direction to the types of stands treated and the amount of area selected for treatment, which can be used to direct stands considered for silviculture activity.

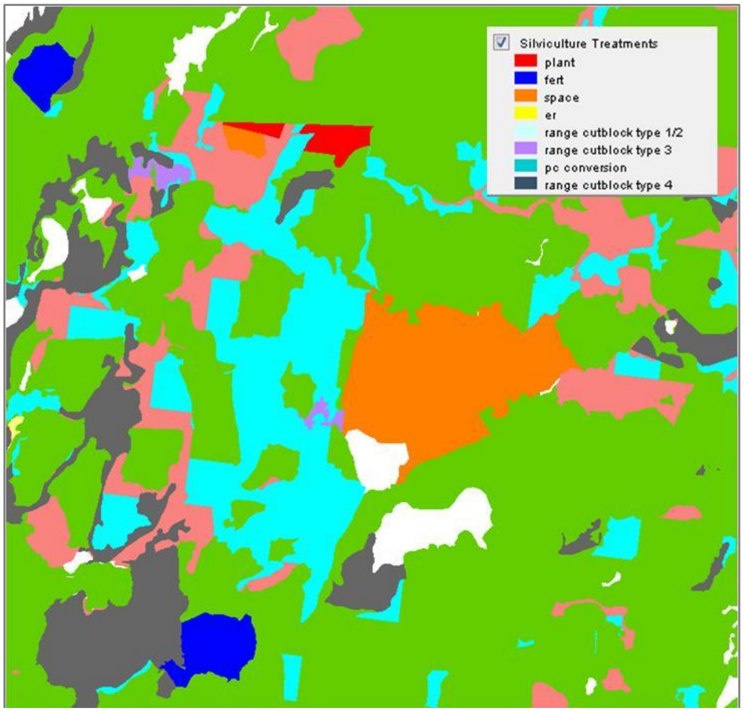


Figure 3.2: Activity and Treatment Location Example

A summary of the area and cost by year for the 5 year silviculture program is shown in Table 3.2, which is a total of $17.9 million over 5 years. With the following labor assumptions[1], 84 jobs per year for 5 years are estimated to be generated by this silviculture program.

Table 3.2: Silviculture Activity - Area and Cost by Year

	Areas (ha)			Costs ($)		
Year	**Rehabilitation**	**Fertilization**	**Spacing**	**Rehabilitation**	**Fertilization**	**Spacing**
1	1,975	1,242	173	5,294,810	559,026	259,532
2	502	3,191	88	1,346,216	1,435,895	132,380
3	443	3,712	157	1,187,823	1,670,524	235,148
4	444	3,943	143	1,190,427	1,774,640	215,088
5	174	4,185	162	467,561	1,883,419	243,519
Total	**3,538**	**16,274**	**724**	**9,486,837**	**7,323,504**	**1,085,667**

Table 3.3 shows the area eligible for each modeled silviculture activity (in accordance with the LBIS MFLNRO 2013/14 to 2017/18 LBIS Silviculture Funding Criteria for FFT) with the areas chosen to be treated in the silviculture strategy scenario.

[1] Based on 120 working days per year :
Planting: 2 person days per ha (from PG Type 4 Data Package)
Fertilization: 0.1 person days per ha (from PG Type 4 Data Package)
Spacing: 2 person days per ha (from PG Type 4 Data Package)

Table 3.3: Silviculture Activity - Eligible versus Treated Areas

	Areas (ha)		
	Eligible	Treated	% Treated
Rehabilitation	8,285	3,538	43%
Fertilization	61,316	16,274	27%
Spacing	4,056	724	18%

General silviculture trends

The area that is treated in the silviculture scenario is a subset of the total area eligible for silviculture activities. Summaries of the total eligible area compared to the areas treated show a few general trends worth mentioning:

Fertilization:

- Leading species: in the analysis, Douglas-fir, spruce and pine leading stands were considered for fertilization. The model chose to fertilize a higher proportion of spruce and less Douglas-fir and pine (see Figure 3.3); and
- Site index: there was no trend regarding fertilization across site index - likely due to a constant growth response input assumption of 12/15 m^3/ha post fertilization;
- Age: although ages from 15years through 80years were eligible for fertilization, the model chose to fertilize heavily (73% of fertilization as shown in Figure 3.4) in the 30 to 50year age range. This is likely to bring stands up to MHA earlier for harvest in the mid-term; and
- Wet belt / dry belt: the model chose to fertilize proportionally more area in wet belt ecosystems.

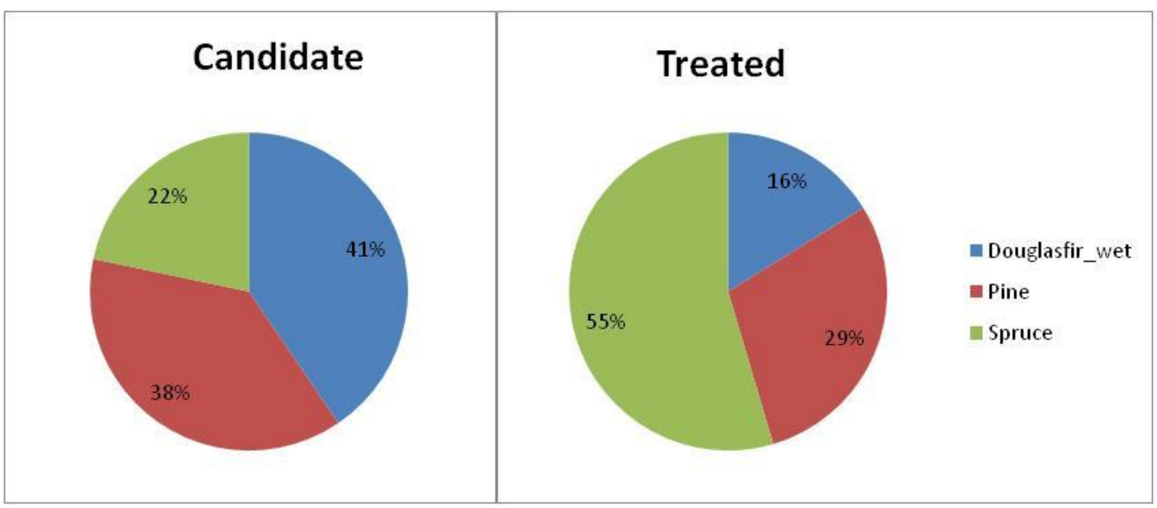


Figure 3.3: Candidate vs Treated for Fertilized Stands - Leading Species

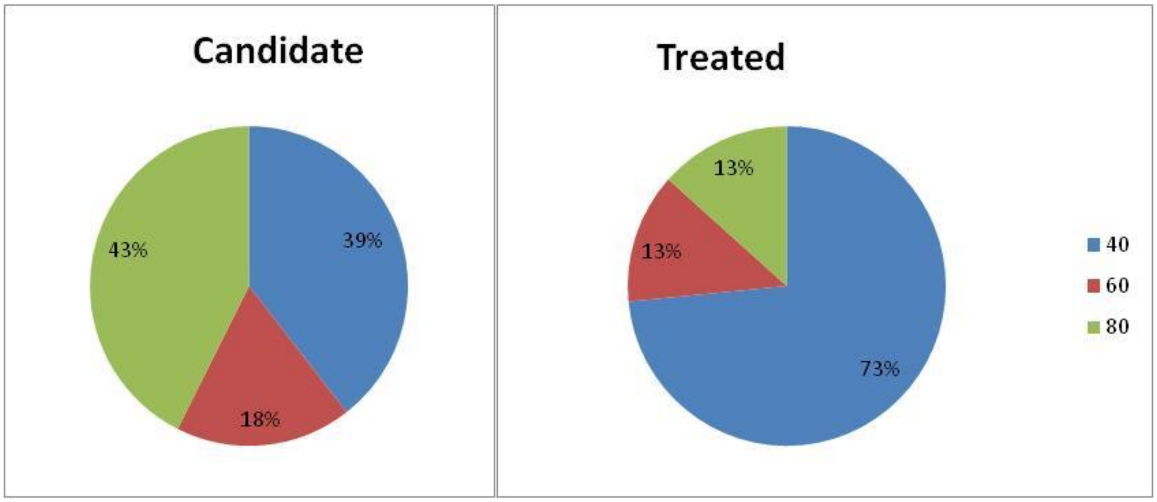


Figure 3.4: Candidate vs Treated for Fertilized Stands - Age

Spacing:
Of the possible 4,056ha considered for spacing only 724ha was selected for treatment, which is the least of any activity. The areas selected for treatment tended to be in lower site indexes.

Planting:
Of the possibly 8,285ha considered for reforestation 3,538ha was selected for treatment (43%), which is the most of any activity. Reforestation occurred across the landbase slightly favoring areas in the dry belt.

MPB affected stands will be harvested preferentially rather than planted because the volume and value of standing volume is utilized. Of the stands eligible and available for planting, most were harvested in the first 10 years. Although harvesting and planting occurred in all types of affected stands, in general harvesting occurred in stands with lower levels of mortality i.e. those with mixed species, and planting occurred proportionally in those with higher mortality.

In addition to understanding direction regarding which type of stand is treated, it is important to know when and how the volume created by the activities is being used. Figure 3.5 shows the decade in which a stand that underwent silviculture treatment was harvested. In general, the increased volume from fertilization was utilized throughout the mid-term. The planted and spaced stands are utilized near the end of the mid-term.

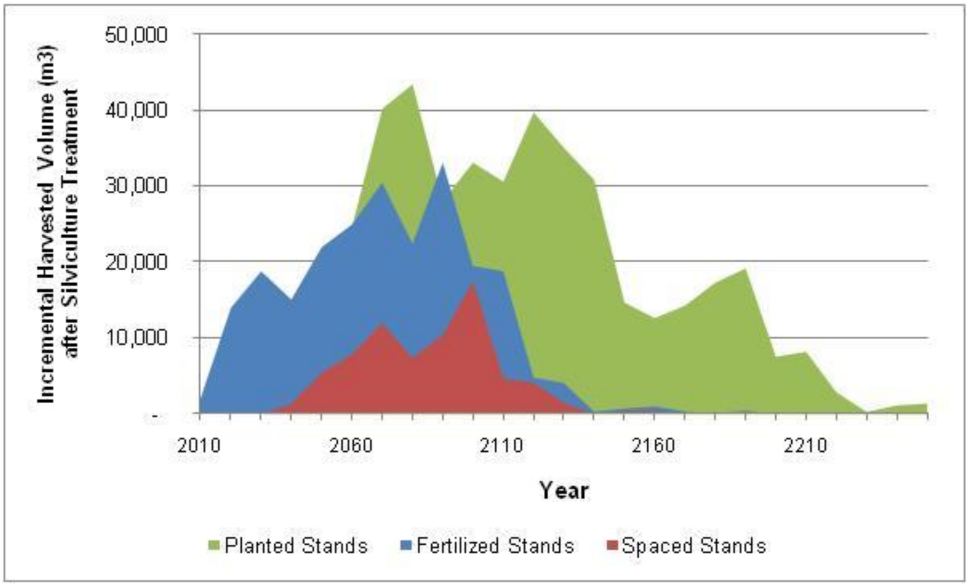


Figure 3.5: Utilization of Previously Treated Stands

Summary of volume gained during the mid-term from silviculture:

- Fertilization: average of 14 m3/ha gained at time of harvesting;
- Planting: average of 120 m3/ha and 95 years off MHA; and
- Spacing: average of 84 m3/ha and 32 years off MHA.

3.4 Output Indicators

Reporting on the indicators modelled in this scenario includes:

- Harvest volume,
- Standing volume,
- Standing age-class;
- Standing species composition;
- Net-revenue;
- RMZs- wildlife, visuals, IRM;
- EDA;
- FHF; and
- Forage.

3.4.1 Harvest Characteristics

Figure 3.6 shows the harvest level, standing merchantable and total volume for the silviculture scenario. The standing volume drives the long term harvest level as the scenario maintains a standing volume similar to the current with a volume reduction through the mid-term.

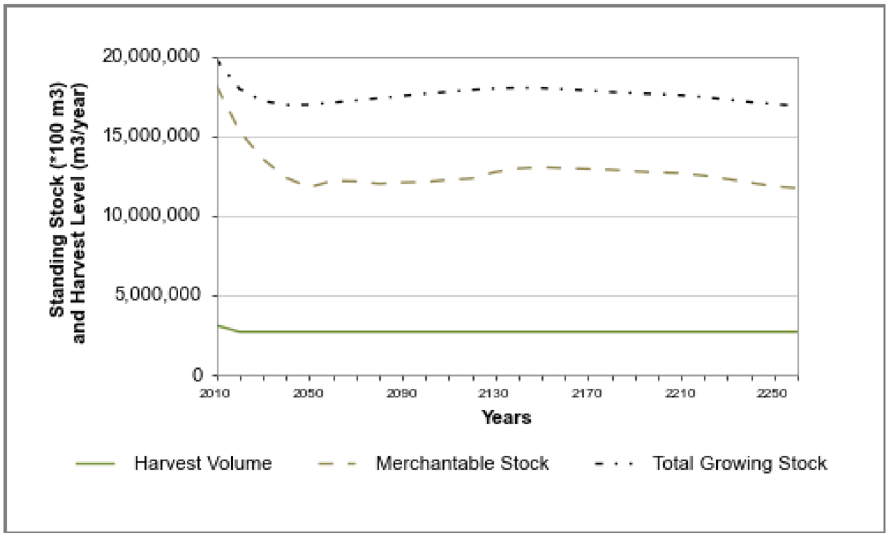


Figure 3.6: Harvest Level, Standing Merchantable and Total Growing Stock

Figure 3.7 shows the THLB area by age class. The area in the older age class is reduced considerably on the THLB. The 8% on the THLB that remains old will be tied up in various land base retention requirements[2].

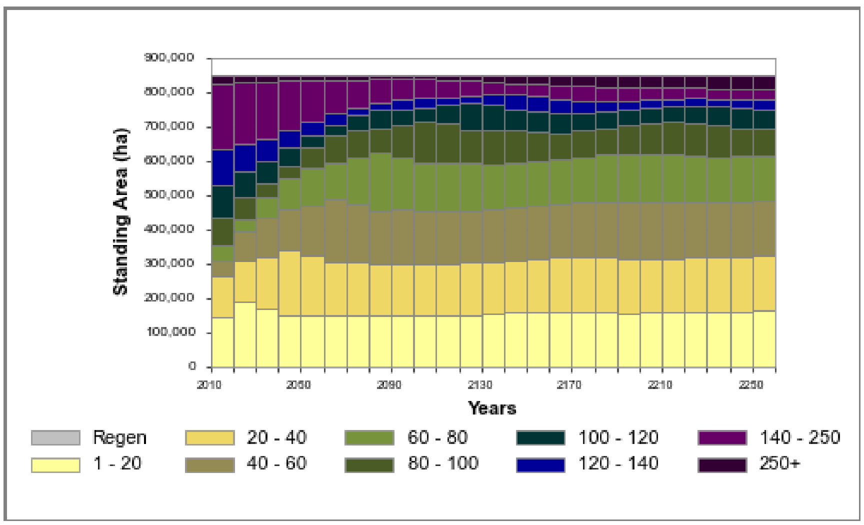


Figure 3.7: Age Class Distribution

Figure 3.8 shows the standing volume by species. The Douglas-fir volume is higher in the short term and is reduced over time in exchange for pine- due to managed stand species assumptions. This trend is a result of aggressive pine harvest in the past decade and little Douglas-fir harvest.

[2] This old % is only on the THLB- when looking at the total productive landbase, the area that remains in old and mature (> 140 years) is approximately 30%.

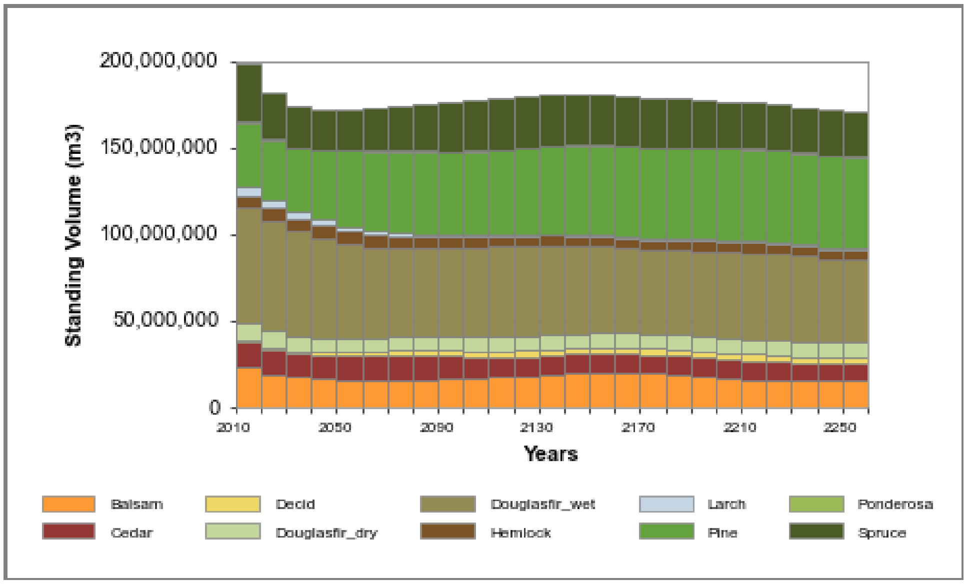


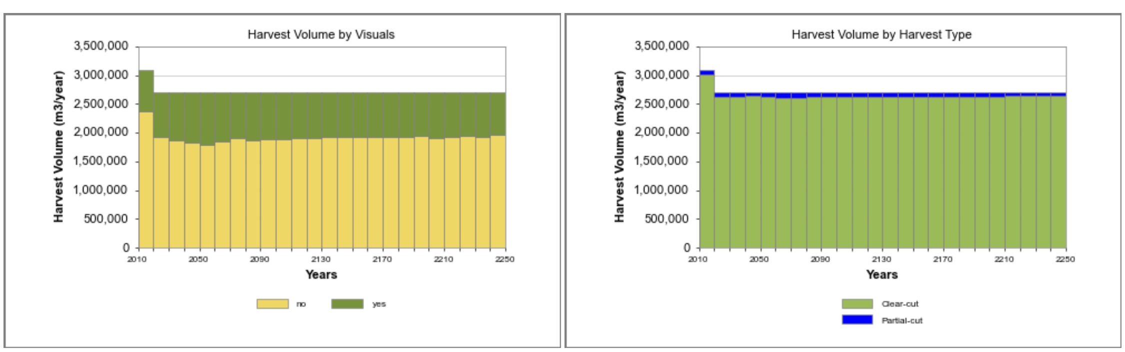
Figure 3.8: Tree Species Composition on the THLB - Volume

Figure 3.9 shows the volume harvested across the planning horizon by harvest from visually sensitive stands, harvest type (clear-cut/partial-cut/conversion/range cut-block type), and leading species (clockwise from top left).

An average of 29% is sourced from visually sensitive areas - a proportion which is quite stable throughout the planning horizon.

The harvest system is almost entirely clear-cut with on average 3% from partial-cut harvesting. Interestingly, if allowed to clear-cut in partial stands, the model chose that option (not allowed in this scenario because it is not a current management regime).

18% of harvest volume in the first decade is sourced from Balsam-leading stands. This is a result of the 10% maximum cable target. The mid-term harvest species composition moves more heavily into spruce and Douglas-fir leading stands.



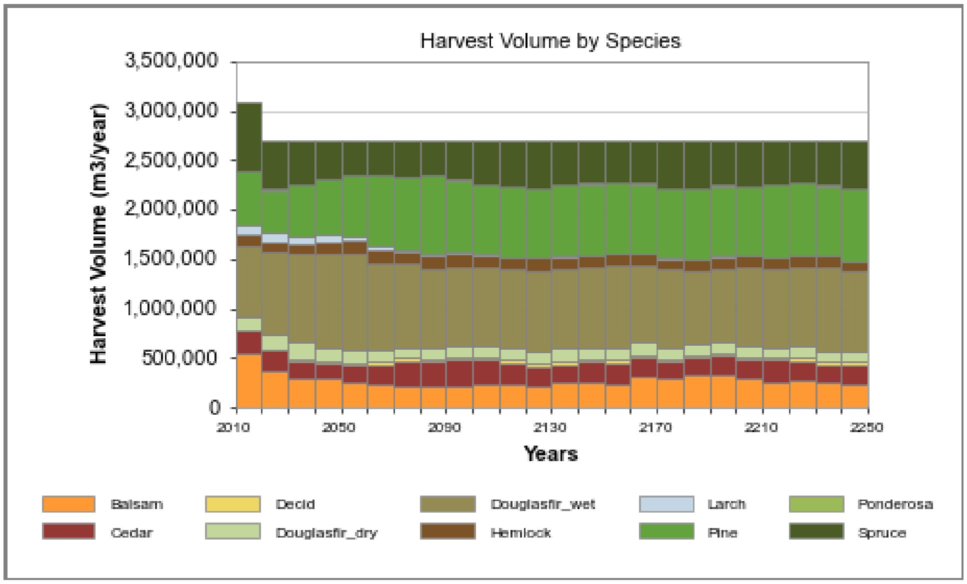
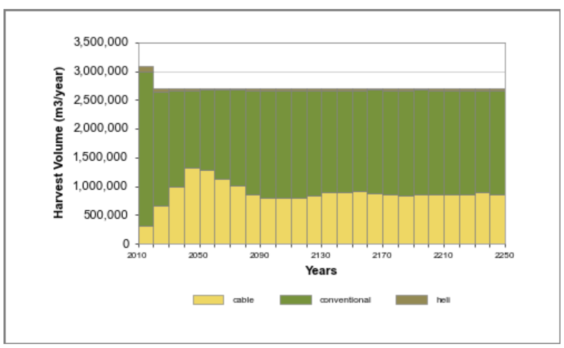


Figure 3.9: Volume by Harvest Type

Figure 3.10 shows the volume harvested across the planning horizon by harvest method (cable/conventional or heli) in the silviculture scenario (left) and if left uncontrolled (right). Harvest by type- cable volume is going to make up a significant portion of the mid-term timber supply. Without controlled step-ups into the mid-term, the model jumps to 54% cable in the second decade as shown in the right figure.

On average, 33% is sourced from cable stands, ranging from 10% in the first decade and stepping up to a maximum of 49% in decade 4 before stabilizing around the average in the long term. The mid-term timber basket is heavily dependent on cable harvest stands.



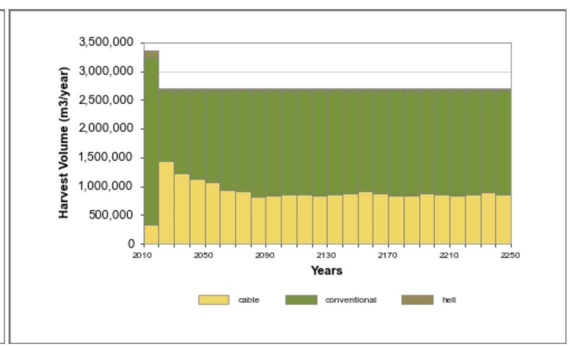


Figure 3.10: Volume by Harvest Method- with/without control

3.4.2 Indicators

Selected indicators have been included in the report to summarize the results of the scenario. For example "visuals" are implemented and tracked for each visual landscape inventory polygon, however in this document the visuals are combined by type and shows in one graph. This shows general indicator trends, but doesn't capture the areas that are constraint by a specific indicator. For example, MDWR as a whole is not constraining, however many specific planning cells are constraining. To capture specific areas that are approaching or exceeding their targets the highest penalized zones are identified and reported.

Figure 3.11 shows the net-revenue generated in the silviculture scenario from harvest activities over the planning horizon. Net-revenue is defined as value (from harvest and range) minus the cost of harvesting, transporting the wood, range activities and silviculture activities. For value and cost estimates, see the information package. The net-revenue varies between an average of 9 $/m3 in the first decade to 16 $/m3 near the end of the planning horizon. The net-revenue is lower in the first decade because this calculation takes account of expenditure in the silviculture program.

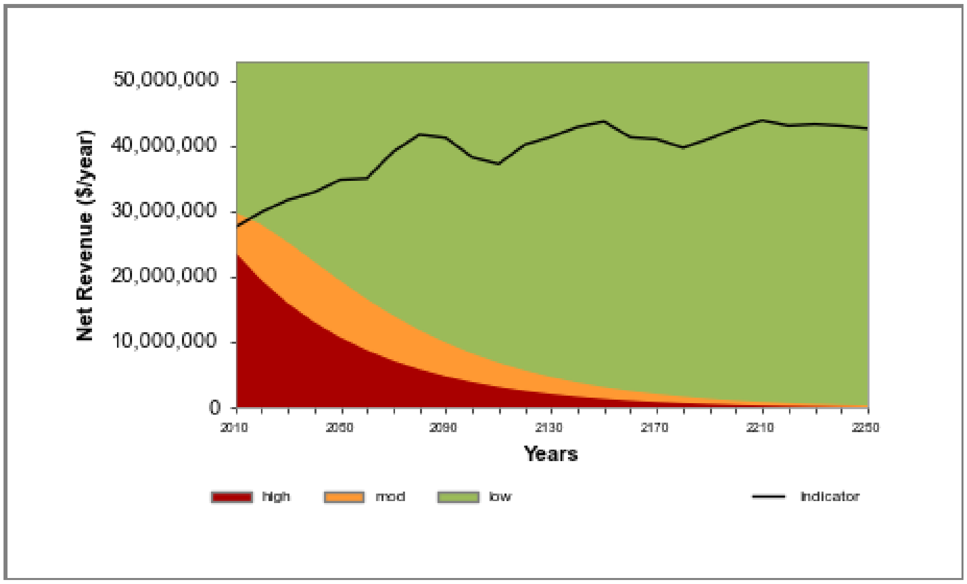


Figure 3.11: Indicators: Net-revenue

Figure 3.12 shows the THLB area by hazard for key forest health factors modeled in this analysis- mountain pine beetle (MPB), Douglas-fir beetle (DFB) and spruce bark beetle (SBB).

MPB, DFB and SXB were modelled at the stand level and summarized at the landscape level. The reporting figures are quite static throughout the planning horizon. The indicators may need to be tweaked to reflect change more readily.

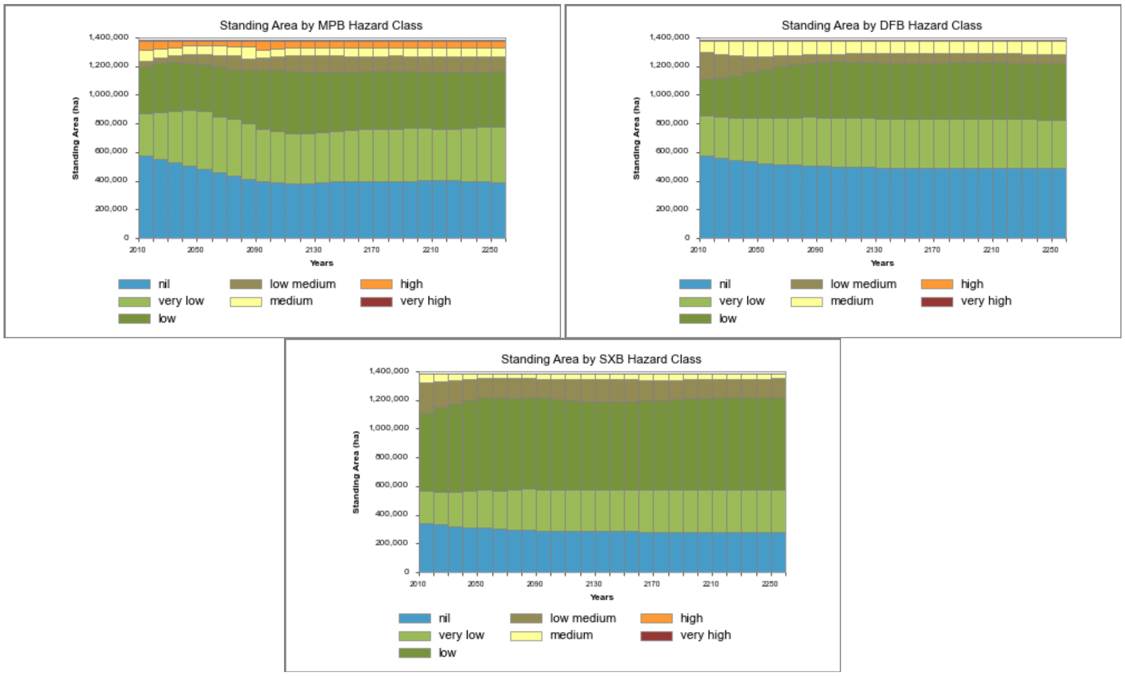


Figure 3.12: Indicators: FHF hazard (MPB, DFB, SXB)

Figure 3.13 shows the EDA above the H40 line for all watershed basins and the ratio (calculated as EDA above H40 over total EDA by basin). Post MPB mortality and salvage, the EDA above H40 increases into moderate risk category. The ratio indicator is usually around 40%, meaning that there is proportionally more harvest below the H40 line than above it.

Compared to TSR, modelling of hydrology has been greatly enhanced through the inclusion of EDA and the H40 line (ratio above/below H40). This indicator shows significant sensitivity to MPB mortality and harvesting patterns and is limiting in some areas.

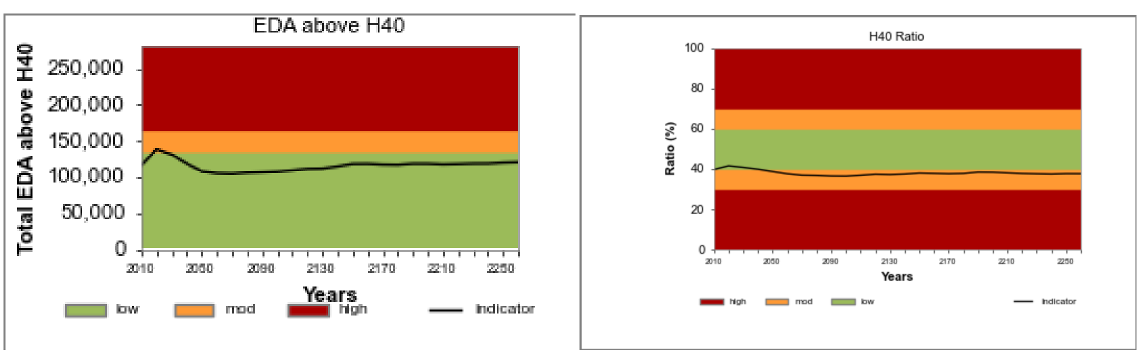


Figure 3.13: Indicators: EDA above H40 and EDA Ratio

Figure 3.14 shows forage production for all pastures. Range cut-blocks were not allowed to occur in this sensitivity as they are not considered current management - the forage volume show in Figure 3.14 is forage after traditional harvest methods throughout. The forage targets by pasture are in the high risk category indicating that under the current management regime the range commitments are not likely to be met. However, scenarios that allow alternative harvest methods can meet the range targets with relative ease.

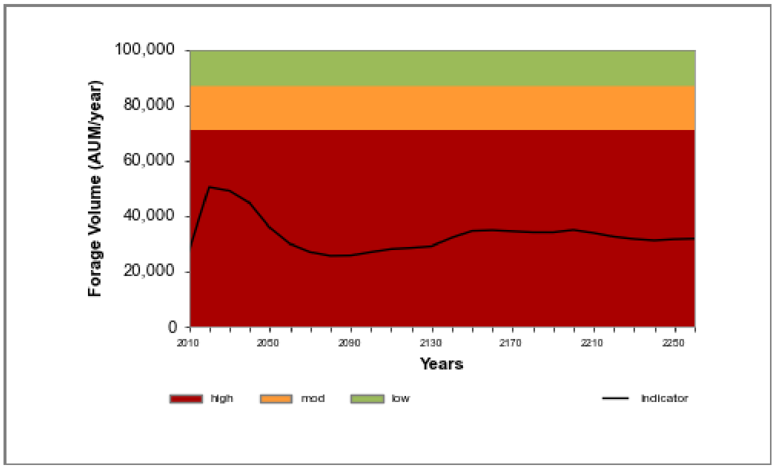


Figure 3.14: Indicators: Forage

The Berger-Parker Index (BPI) is a measure of species diversity and is calculated as the proportion of the most common species at the stand-level and summed using area-weight averaging to the TSA level total on the THLB. Figure 3.15 shows the BPI on the THLB across the planning horizon. The BPI increases slightly from 71% to 76% across the planning horizon. A higher BPI equates to lower diversity (i.e. a higher proportion in one species).

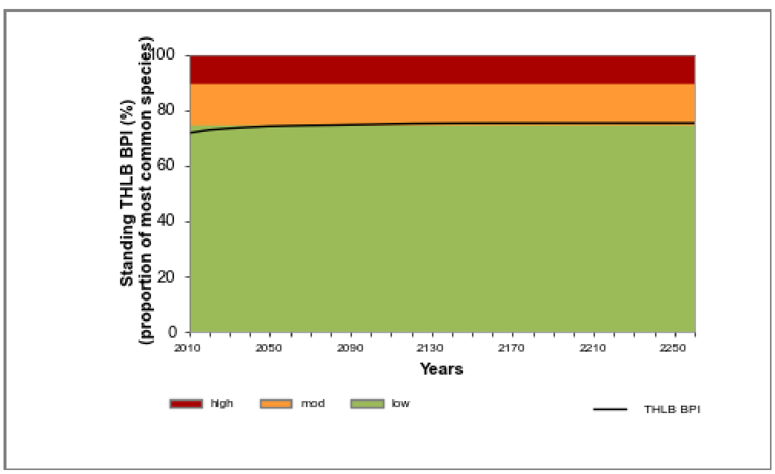
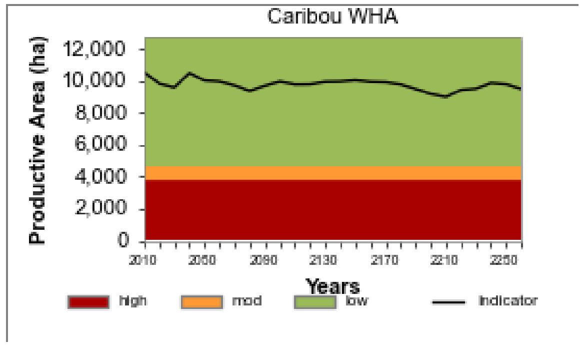


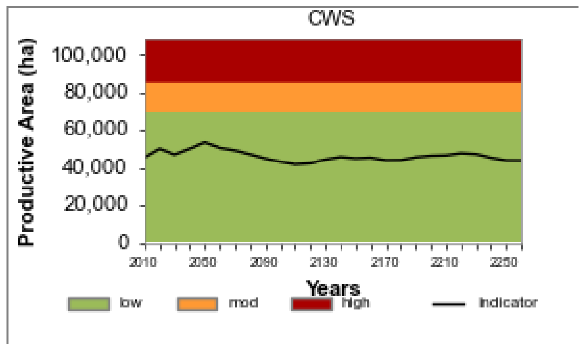
Figure 3.15: Indicators: THLB BPI (%)

The following figures show summary indicator performance against targets in a risk-based back drop for a number of indicators.

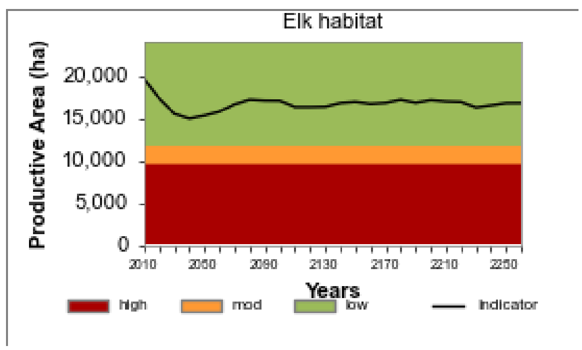
The Mountain Caribou Specified Area WHA #8-233 minimum retention requirement is overall at the TSA- level not very limiting.



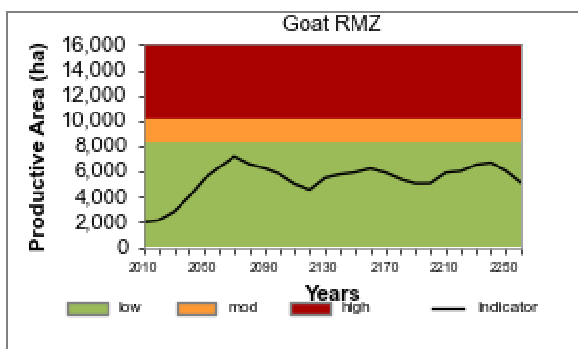
The CWS requirements of a maximum of 30% less than 6m height is not constraining to timber supply at the TSA level.



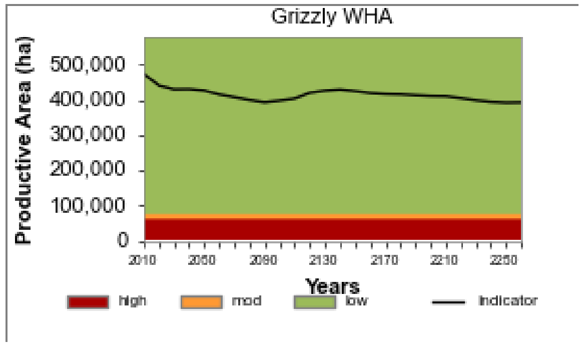
OSLRMP retention requirements for elk habitat become more constrainted in the mid-term, but overall are not highly limiting.



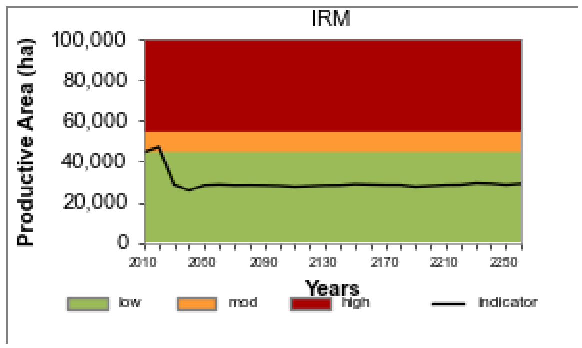
Maximum disturbance limits in OSLRMP goat habitat become more constraining in near the end of the mid-term and into the long-term but are not highly constraining.



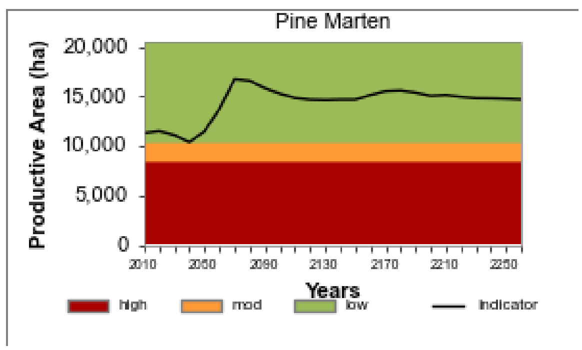
Grizzly Bear Specified Area #8-232 retention requirements are not constraining.



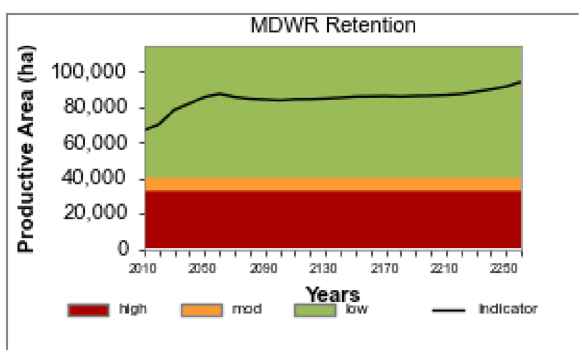
IRM requirements (that a maximum of 30% may be less than 3m height) is very constraining in the first 2 decades of the planning horizon. This is due to the large area in MPB mortality and harvesting.



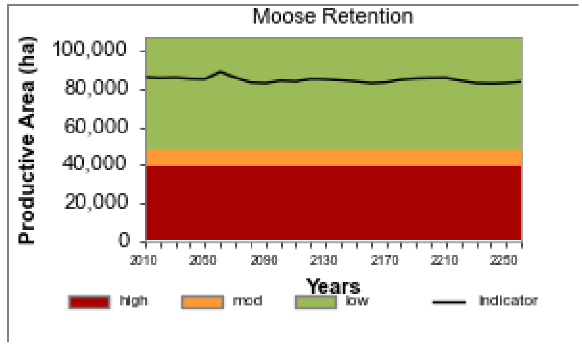
OSLRMP retention targets for pine marten habitat are getting close to constraining for the first 3 decades of the planning horizon. There is a considerable increase in 60 years in the area in pine marten habitat that satisfies the retention requirement of being > 19m height.



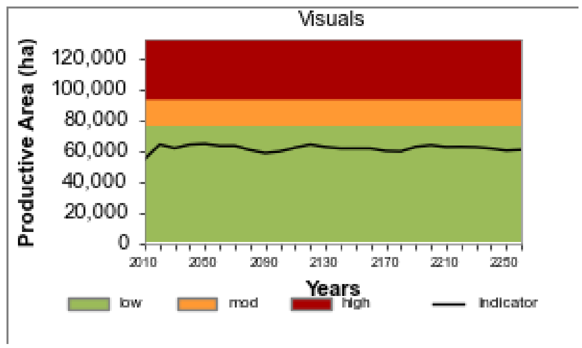
Mule deer winter range retention targets (from GAR UWR #U-8-001) are not constraining.



Moose retention targets (from GAR UWR #U-8-006) are not constraining.



Visually sensitive areas are overall not constraining but several individual zones are.



The traditional RMZs considered in TSR were generally met with relative ease in the silviculture strategy scenario and therefore have little impact on the analysis. Specific zones were constraining and have been provided in a list/map to bring attention to.

The density of active existing roads throughout the planning horizon was tracked in the analysis in *Patchworks* and can be summarized in many different ways. Figure 3.16 shows the road density in km of road per km2 area in two different ways- inside /outside the crown interface (left) and inside / outside the Grizzly bear WHA #8-232 (right).

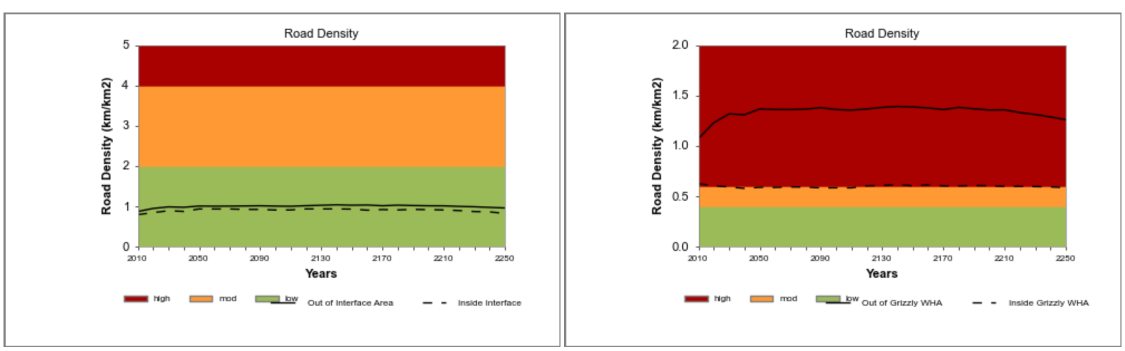


Figure 3.16: Indicators: Road Density in Crown Interface/Grizzly WHA

FPB fuel types were assigned to each stand based on VRI attributes. Figure 3.17 shows a summary of the area in each FPB fuel type across the planning horizon for two areas:

- area within the crown interface; and
- area inside the ‘severe’ wildfire hazard abatement zone.

Inside the crown interface, there is a significant increase in FBP fuel type C5 (mature pine) and corresponding decrease in C7 (Ponderosa pine/ Douglas-fir). All other FBP fuel types are consistent throughout the planning horizon.

This project was able to work out the methodology to characterize the landbase by FBP fuel types- using a decision matrix based on VRI attributes. The hazard ratings can be assigned by fuel type by fuel experts to dynamically determine a wildfire hazard rating for each stand throughout the planning horizon.

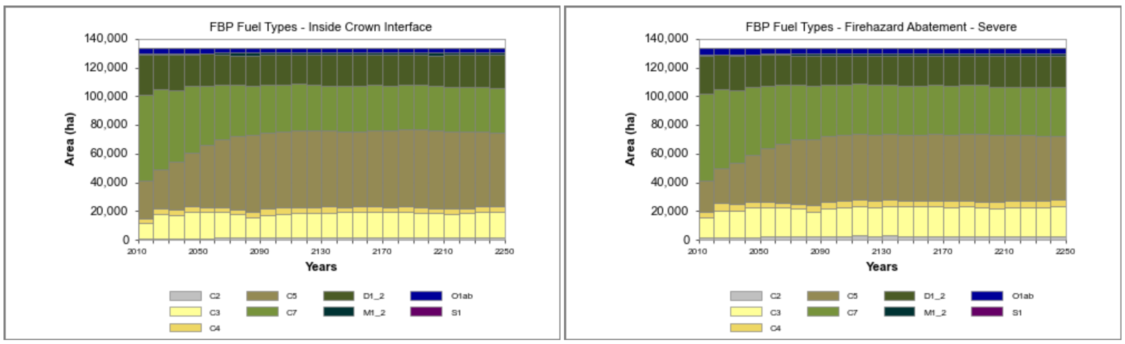


Figure 3.17: Indicators: FBP Fuel Types in Crown Interface and Severe Wildfire Hazard Abatement Zone

Figure 3.18 shows the volume sourced from 3 categories of stands: peeler (>32.5 cm DBH), sawlog (27.5-32.5 DBH) and merchantable (DBH > utilization). Initially and through the mid-term, an average of 33% of volume is sourced from peeler stands. Once the harvest is sourced from managed stands, long-term average is 11% from peelers.

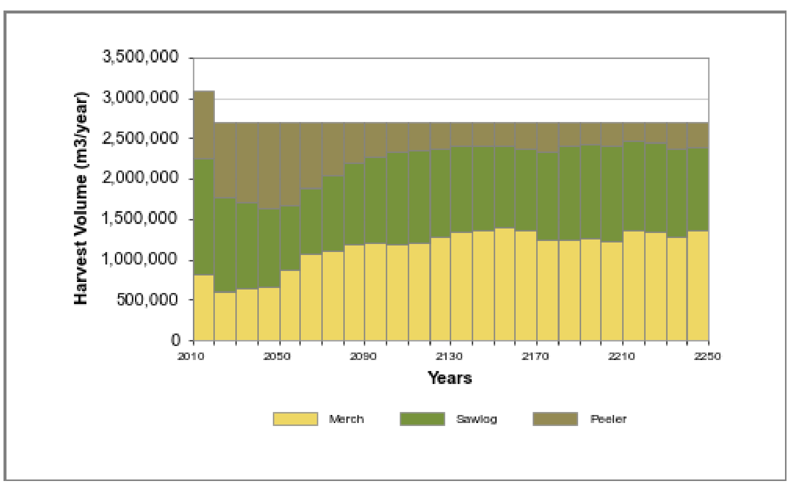


Figure 3.18: Indicators: Timber Quality- Premium Product

3.4.3 Constraining Indicators

Figure 3.19 shows a selection of constraining indicators in period 1 against risk-based back drop. The IRM, EDA and visual zones that are shown are highly affected by the MPB epidemic.

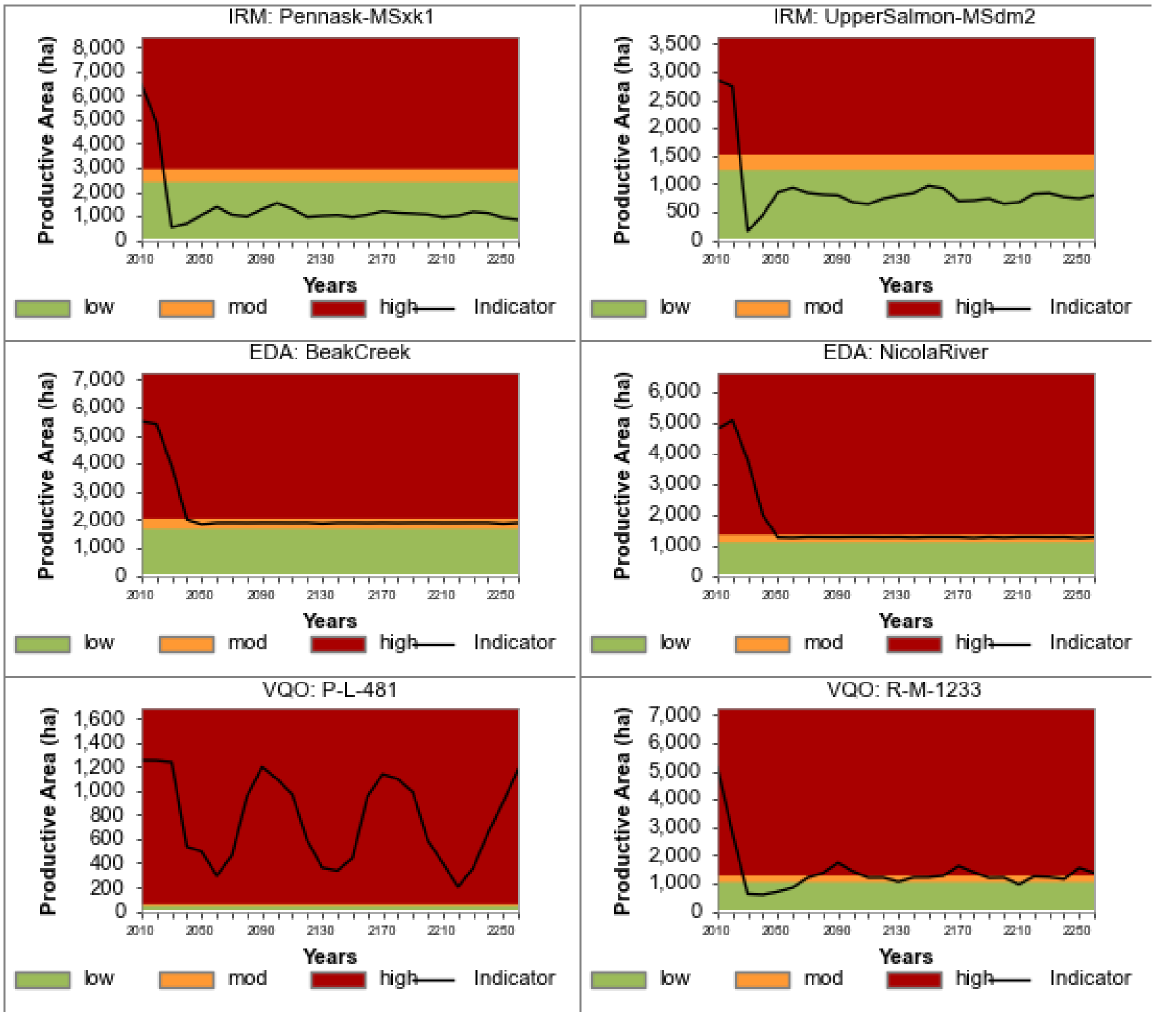


Figure 3.19: Indicators: Selection of Top Constraining RMZs

4.0 OTHER MODELLING SCENARIOS

Other modelling scenarios included:

1. **TSR-equivalent**: This scenario implements the TSR harvest level and RMZs that are modeled in TSR. This is an important benchmarking scenario to ensure the model is consistent with TSR and to help understand any differences.
2. **Silviculture scenario:** This main scenario was developed considering the findings from the many scenarios that were run to understand the dynamics of the analysis. The scenario considers the TSR indicators as well as additional indicators that captured landbase values such as EDA and economics. The silviculture scenario allows silviculture activities (planting, fertilization and spacing) to be implemented for 10 years. The model will only select silviculture activity where the cost and benefits make sense considering all the land base values.
3. **Economic scenario**: Selects a management regime and silviculture program that uses net-revenue (monetary value generated minus cost) as the dominant objective.
4. **Forage supply:** This scenario optimizes the harvest scheduling and silviculture activities to fulfill forage targets by pasture. Range cut-block types 1/2, 3 and 4 can be implemented throughout the planning horizon.
5. **No activities:** This scenario is a benchmark for comparison that has no harvesting or silviculture activities implemented. Over the 250 year planning horizon, natural disturbances are implemented based on the NROV on the entire productive landbase.

Table 4.1 outlines the relative weightings of each indicator by scenario.

Table 4.1: Indicators, Targets and Weightings by Scenario

Indicator	TSR Equivalent	Silviculture scenario	Forage supply	Economic scenario
Harvest Volume	high	mod	tracked	tracked
Mid-term harvest level	high	high	tracked	tracked
Net-revenue	tracked	mod	tracked	high
Wildlife RMZs	high	high	high	mod
Visuals	high	high	high	mod
IRM	high	high	high	mod
EDA	tracked	high	tracked	tracked
FHF	tracked	tracked	tracked	tracked
Landbase carbon	tracked	tracked	tracked	tracked
Forage targets	tracked	tracked	high	tracked
Silv. activities	not allowed	allowed	allowed	allowed
Range cut-blocks	not allowed	not allowed	allowed	allowed

4.1 Comparison of Indicators

A comparison of key indicators is shown in the following sections. Figure 4.1 shows the harvest volume by scenario. The TSR and silviculture scenario both start with the same initial harvest level - set according to last TSR at 3.1 million m3/year. After the first decade both drop down to an MPB-induced mid-term harvest level. The silviculture scenario is able to access more volume in the mid-term.

The economic scenario chooses to harvest aggressively in the first decade with a harvest level of 5.6 million m3/year as the model tries to profit from harvesting as much wood as soon as possible. After this, the harvest level drops to between 1 and 2 million for the rest of the planning horizon.

The scenario that maximizes only forage supply needs an initial harvest level of just over 1 million m3/year to satisfy forage targets.

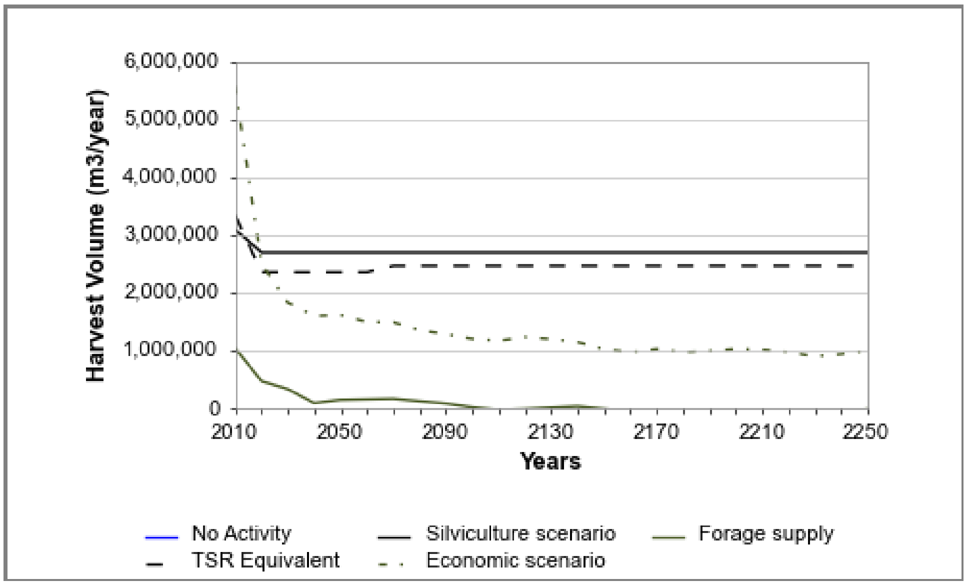


Figure 4.1: Harvest Volume by Scenario

Figure 4.2 shows a comparison of the harvest area for each scenario summarized into regular harvesting (clear-cut and partial-cut) and range-cut block types.

In general, the area harvested for each scenario follows the harvest volume trend. An interesting trend is that in scenarios that considered economics, the average harvest volume per ha was higher- e.g. 313, 340 and 382 m3/ha for the TSR, silviculture and economic scenarios respectively.

The economic scenario also chose to harvest significant amounts of range cut-block types - especially type 4 (conversion to permanent pasture). This is because in order to maximize the revenue derived from range, a large area was converted to range land where it keeps accruing forage value at no additional cost. This may be an extreme outcome for the scenario, but points towards the importance of considering the considerable value of range in management decisions.

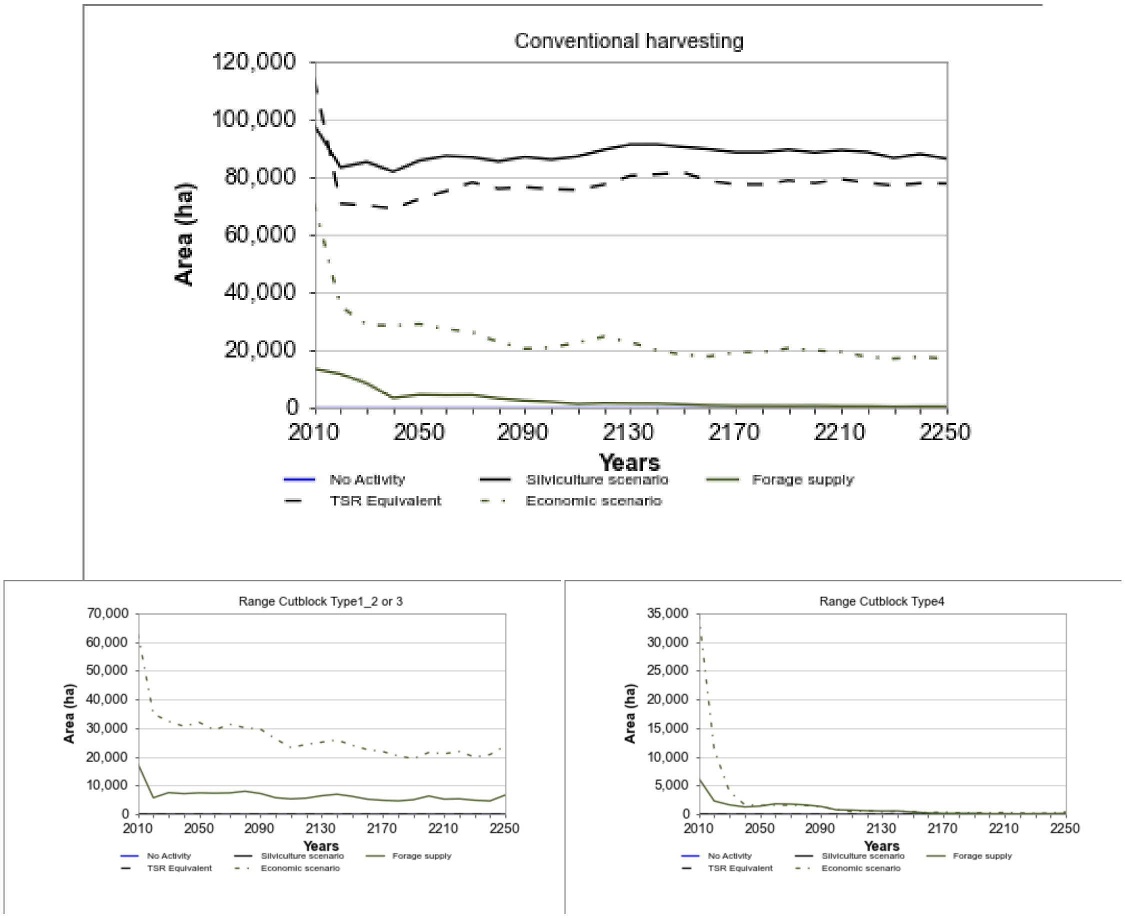


Figure 4.2: Harvest Level by Scenario

Table 4.2 shows silviculture activities by scenario. No silviculture activities were allowed in TSR or forage scenarios. When allowed to consider silviculture activities in the silviculture scenario, it chose to fertilize, plant and space significant areas. When the economic weighting is increased and other indicators not considered, the area treated is reduced- although interestingly there are still significant areas fertilized.

Table 4.2: Silviculture Activities by Scenario

Scenario	Fertilization	Rehabilitation	Spacing
Silviculture scenario	16,274	3,538	724
Economic scenario	3,237	34	0

Figure 4.3 shows the net-revenue comparison by scenario. The economic scenario dramatically increases total net-revenue compared to other scenarios- at the expense of other indicators. The forage scenario has similar net-revenue to the TSR and silviculture scenarios with significantly less area harvested because of the revenue gained from

forage/range. The silviculture scenario net-revenue is higher than TSR in every decade apart from the first, because of expenditure on silviculture.

The economic scenario, when allowed, generated significant value by from range. The model chose to harvest as much as possible- especially in range cut-blocks in order to realize the full ongoing value from range.

Economic assumptions may need to be reviewed and refined - the numbers were more positive than expected.

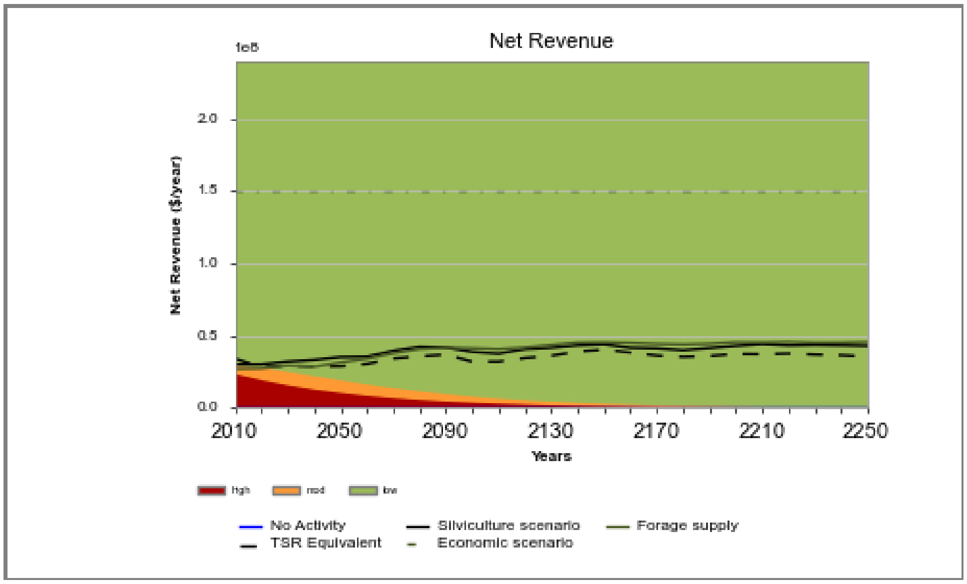


Figure 4.3: Net-revenue by Scenario

Figure 4.4 shows a comparison of selected summary indicators by scenario.

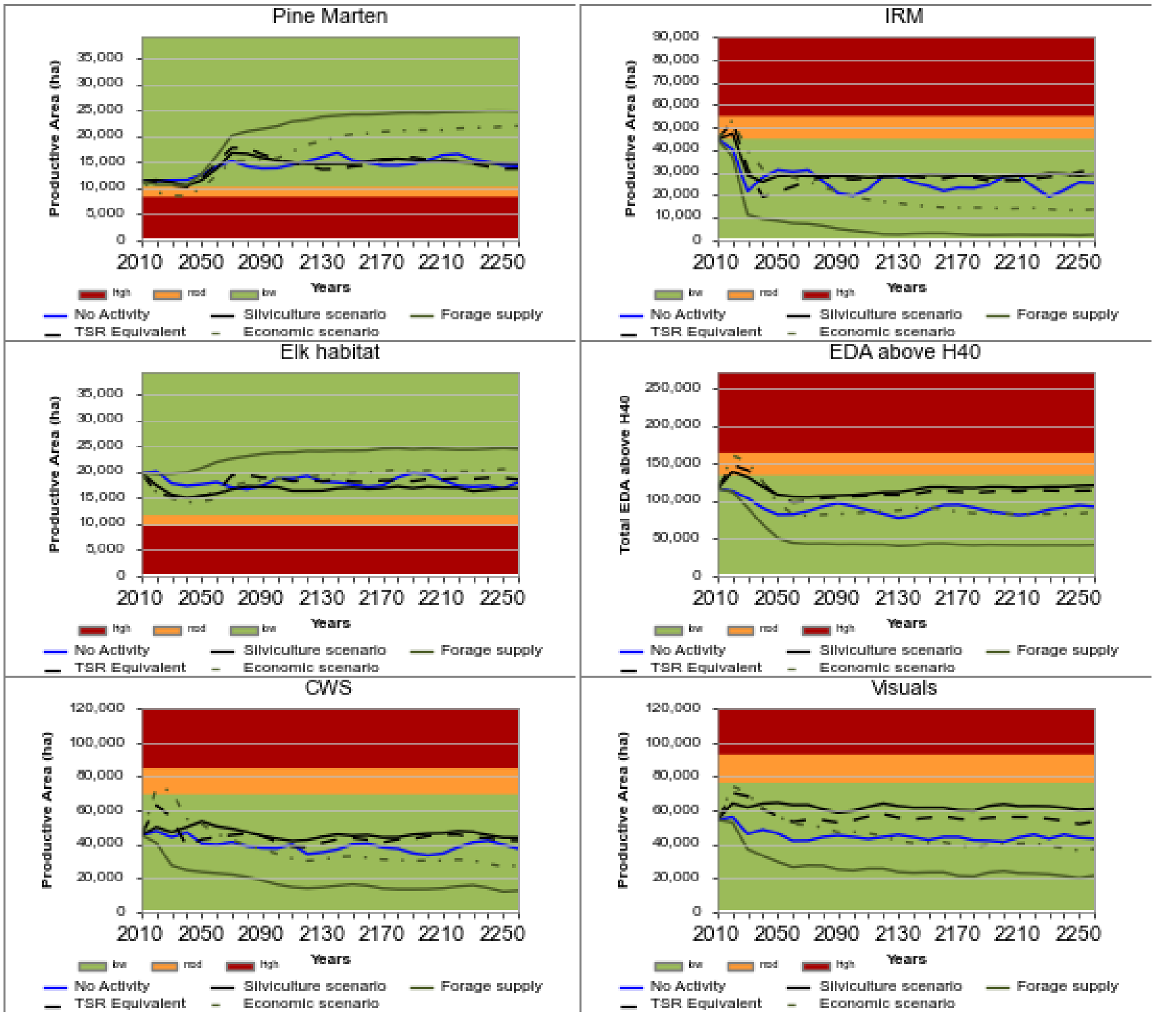


Figure 4.4: RMZs Comparison

Figure 4.5 shows comparison of forage by scenario.

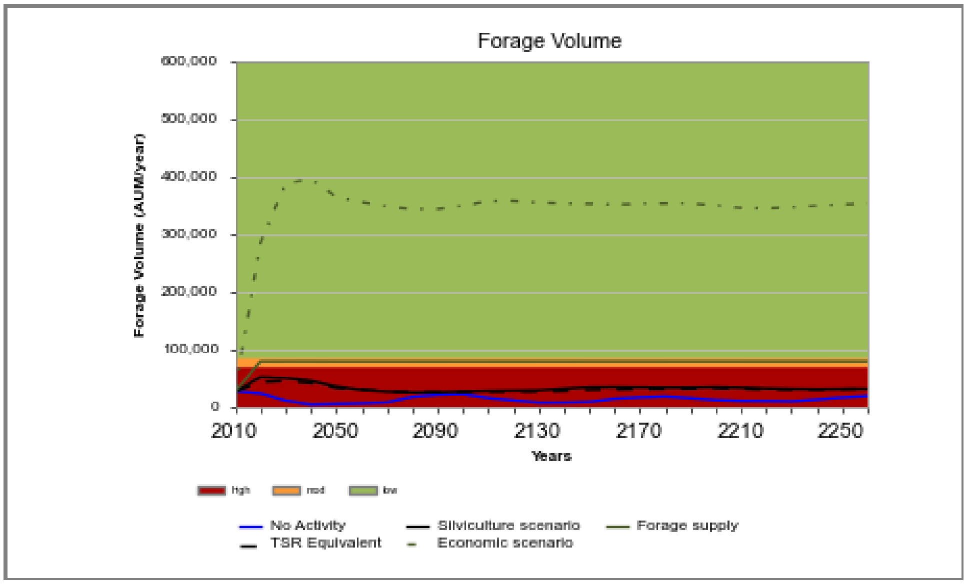


Figure 4.5: Forage Comparison

In scenarios where no range cut-blocks were allowed- e.g. TSR scenario and silviculture scenario, forage production fell well below the AUM target. Table 4.3 shows the levels of range cut-blocks for various scenarios. In the silviculture with forage supply scenario, only a small change in management (cut-block types) is needed to fulfill forage targets.

Table 4.3: Range Cut-block by Scenario

Scenario	Conventional Harvest (cc/pc)	Range cut-block type 1/2	Range cut-block type 3	Range cut-block type 4
Silviculture scenario	10,545	0	0	0
Silviculture with forage supply	9,298	521	108	426
Forage supply	1,342	1,028	721	623

5.0 DISCUSSION

On the outset of the Okanagan Type 4 Silviculture analysis there were two future points in time where the amount of timber available for harvest (and available for meeting other landbase objectives) are most limited, specifically 2025 and 2060 (Figure 5.1).

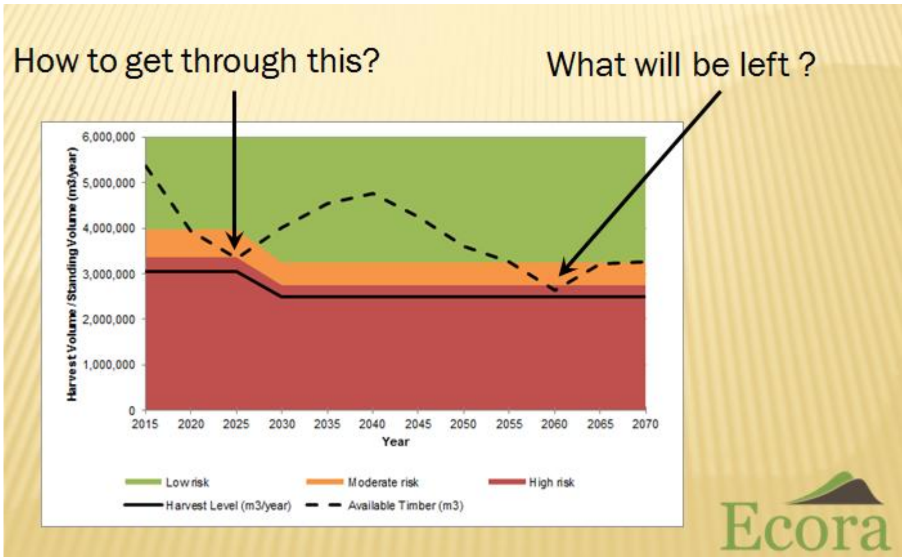


Figure 5.1: Timber Availability (from Situational Analysis)

The silviculture activities scheduled in the analysis quite effectively target these 'pinch points', by using fertilization to mitigate the shortage around 2025 and a series of activities to mitigate the mid-term shortage (Figure 5.2).

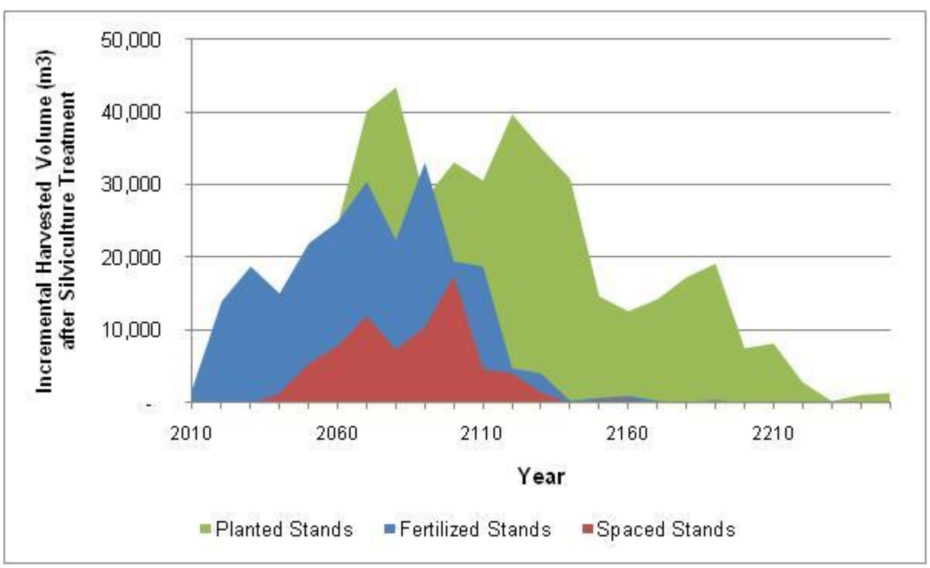


Figure 5.2: Harvest of Treated Stands

Key findings in this analysis include:

1. The silviculture program selected by the model is $3.6million/year for 5 years. Most interesting is that this was the result of the 'optimized' solution that included no encouragement to implement silviculture activity[3]
2. The model was aggressive with the reforestation of MPB affected stands, which provides clear direction to make sure that stands are either reforested or are tracking to be naturally regenerated at rates similar to managed stands;
3. The fertilization program was reasonably aggressive and had a clear preference for fertilizing younger (~40 years old) spruce stands;
4. If allowed, the model would clear-cut harvest all partially harvested stands to capture benefits associated with forest health, wildfire hazard, volume, and regeneration growth rates. This suggests that stands currently identified for partial harvest that have forest health issues should be considered for clear-cut harvesting; and
5. Dry slower growing forests were immediately converted to range if allowed. The model found the range value/revenue far exceeded the timber value for these stands.

[3] Often silviculture budgets are implemented to force the model to implement silviculture activity. In this case the silviculture activity was selected entirely due to other landbase objectives such as volume and value.