

TYPE 4 SILVICULTURE STRATEGY IN THE KAMLOOPS TSA

MODELLING AND ANALYSIS REPORT

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1.0 INTRODUCTION

The Kamloops TSA has been selected for a Type 4 Silviculture Strategy project to provide tactical level direction for steering silviculture investment to help mitigate mid-term timber supply impacts created from the mountain pine beetle (MPB) epidemic and provide direction that might improve future conditions. This project will provide general direction for investing in silvicultural activities to address the challenges identified in the Kamloops TSA. Underlying analysis assumptions have been documented in the information package.

1.1 Context

This “modelling and analysis report” document is the third of four documents to make up the Type 4 Silviculture Strategy for the Kamloops TSA:

1. **Situational analysis:** describing the general situation for the TSA;
2. **Information package:** describing the input data, information and assumptions;
3. **Modelling analysis report:** describing the modelling 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 to identify treatment options, targets and benefits.

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

The modelling scenarios and results presented in this report are a small selected portion of the results available from the planning tool developed through this modelling 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 Scenarios

Scenarios (or value positions) are broadly defined perspectives that intend to capture the range of viewpoints held by the stakeholders, public, First Nations and government. These value positions are captured in the modelling environment by assigning indicators, thresholds and weightings. The modelling scenarios that have been defined in this project include:

1. No Activities;
2. TSR-equivalent;
3. Economic;
4. Range;
5. Wildfire;
6. Climate Change;
7. Forest Health;

8. Social;
9. Environmental; and
10. Silviculture Scenario.

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 are 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.

1.3 2016 Update

The initial analysis project was undertaken in 2014/2015 with draft reports completed at that time. In 2016 as part of the continual update, feedback and improvement process, the analysis was updated with:

- Align the netdown with the recently published Kamloops TSR data package (September 2015). Changes were made to the definition of the following netdown items: problem forest type (PFT), operability, non-forest/non-productive, terrain stability and environmentally sensitive areas (ESAs), archaeological sites, permanent sample plots (PSPs) and research installations. This resulted in an increase in assumed THLB from 878,165 ha in 2014 to 953,450 ha in 2016. This is closely aligned with the THLB reported in the September 2015 data package of 931,373 ha. New netdown assumptions are documented in the updated information package.
- Model an additional silviculture treatment 'commercial thinning' consistent with the recent silviculture strategy addendum in the Okanagan TSA. Modeling of commercial thinning is described in the updated information package.
- Update estimates of cost and value for forage supply to be more consistent with the recent silviculture strategy addendum in the Okanagan TSA and the way that forestry costs and value are estimated. Assumptions are documented in the updated information package.
- Model the harvest from offsite species on high risk ecosystems for climate change as described in the updated information package.
- The potential boundaries of 5 potential FNWL within the current Kamloops TSA are included and the AAC coming from each is modeled.

Analysis results from the 2016 update are documented in the silviculture strategy report.

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 land base summaries. In general, analysis scenarios in this project include:

- A netdown as described in the information package, resulting in a THLB of 878,165 ha;
- TSR harvest level of 2.1 million m³/year with increased importance placed on the maximization of the mid-term harvest level;
- Non-declining long term managed growing stock;
- 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 species, age, site index, BGC zone, MPB characteristics, stand density and harvest method;
- Managed stand AUs based on BGC zone, species and productivity;
- MPB modelling using shelf life curves and the 2014 BCMPB model (year 11);
- Resource management zones: community watershed (CWS), integrated resource management (IRM), visually sensitive areas (VQO), mule deer winter range (MDWR) and caribou winter range; and
- Hydrology indicators including equivalent disturbance area (EDA) above and below the H50 line.

The following section describes the outcomes for the base case in four general areas: initial land base summaries, timber quantity and harvesting forecast, timber quality and product profile, and non-timber value outcomes.

2.1 Land Base Summaries

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

- Land base classification: 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 Kamloops TSA is a gross area of 2.77 million ha of which 32% is classified as THLB.

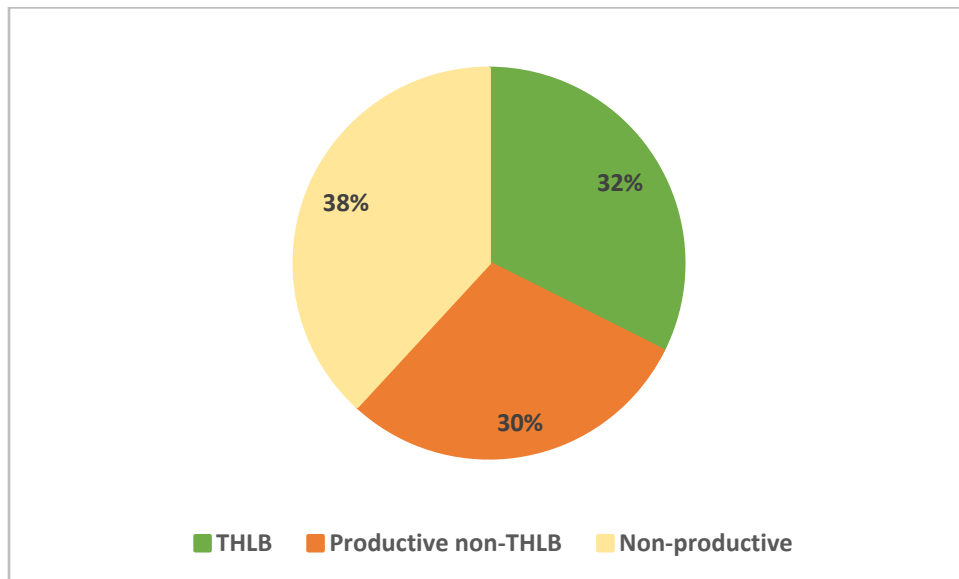


Figure 2.1: Area by Classification

Figure 2.2 shows the area for each BGC zone. The TSA has a variety of ecosystems, however the southern portion is generally dryer and the northern portion is moister. On the THLB, predominate BGC zones are IDFdK (16%), ESSFwc (13%), MSxk (11%) and ICHmw (10%).

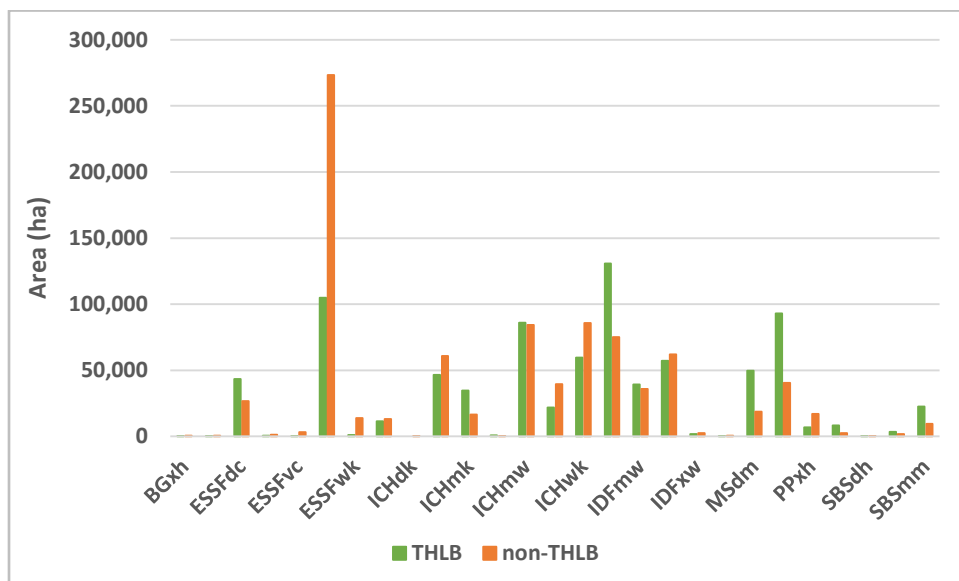


Figure 2.2: BGC Summary

Figure 2.3 shows the area by leading species on the productive land base. The TSA is 37% Douglas-fir leading and 25% Spruce leading.

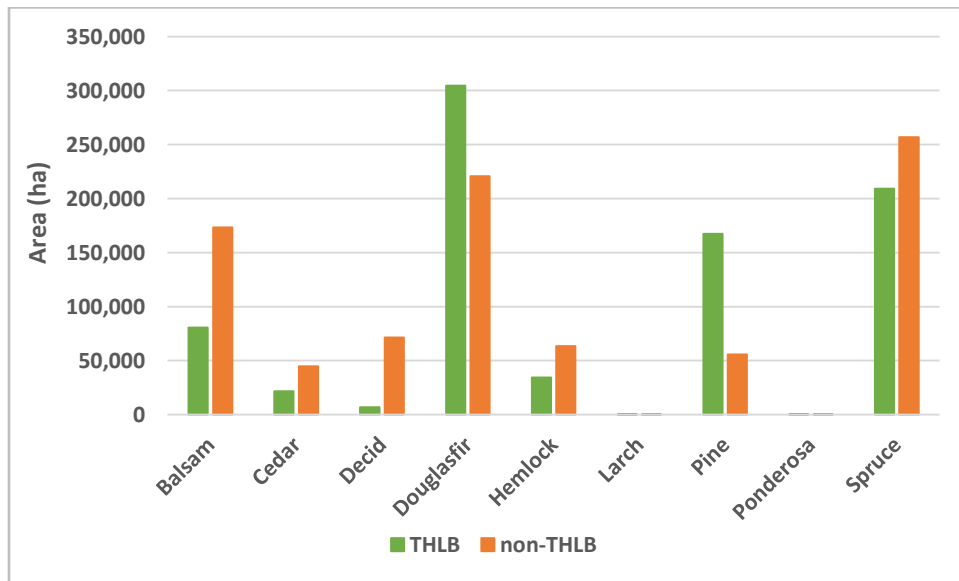


Figure 2.3: Leading Species Summary

Figure 2.4 shows the THLB area by site index class (site index rounded to the nearest 3m) inventory site index and the provincial site index tile layer. Inventory site index is used to estimate the productivity of natural stands whereas the site index tile is used to estimate the site potential for managed stands. The area-weighted average THLB site index is 16m.

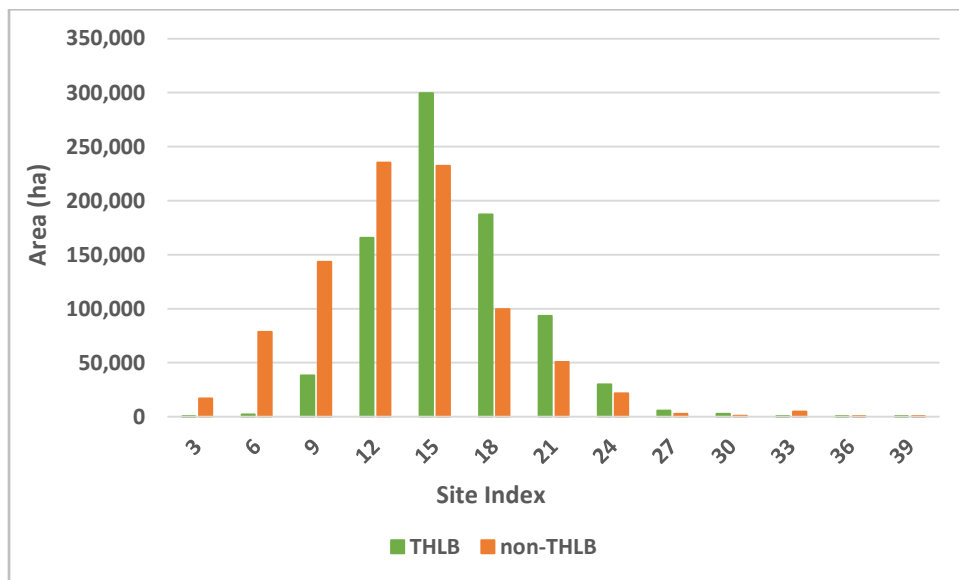


Figure 2.4: Site Index Summary

Figure 2.5 shows the initial area by age class on the THLB and non-THLB productive land base.

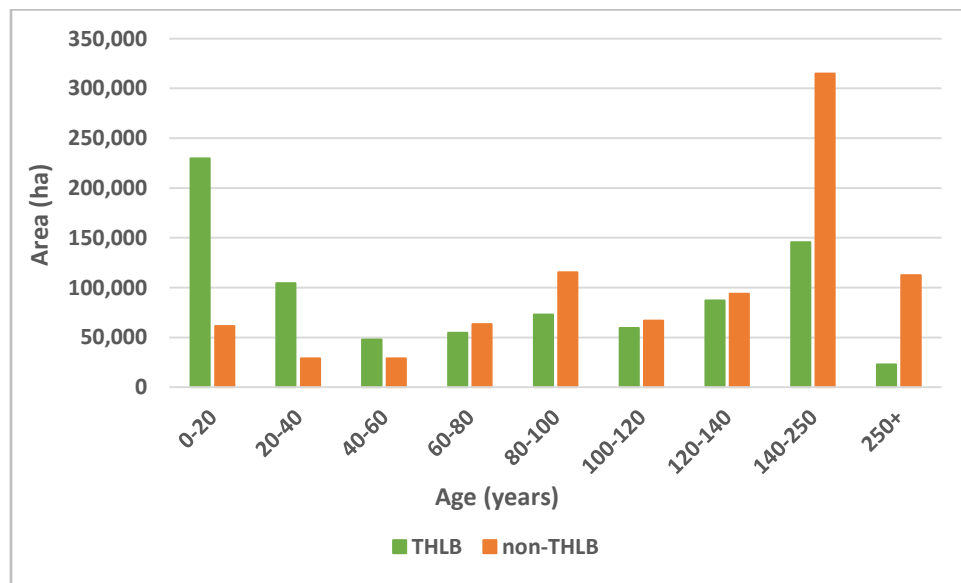


Figure 2.5: Initial Age Class Summary

3.0 SILVICULTURE SCENARIOS

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 land base objectives. Additional to the factors included in the bullets from Section 0 above, the silviculture scenario also incorporates:

- Silviculture activities at \$10 million per year allowed for 20 years, including: fertilization, innovative timber sales license, ecosystem restoration (grass, open forest, and open range), and intermediate utilization stands;
- Positive net-revenue where net-revenue is calculated as the value from harvesting minus cost from harvesting and silviculture;
- Minimization of wildfire hazard in the short-term;
- Targets for ecosystem restoration applied;
- A 30% watershed EDA limit;
- Range targets applied by pasture and AUM; and
- Minimization of forest health hazard for mountain pine beetle (MPB) hazard, Douglas-fir beetle (DFB) hazard, spruce beetle (SB) hazard, and western spruce budworm.

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	Moderate
MPB volume	Maximize mid-term	Moderate
Cedar/ hemlock partition	Yes	Moderate
Non-declining THLB growing stock	Yes	Moderate
TSR RMZs	Yes	High
Silviculture activities	\$10 million limit	Moderate
Net-revenue (value – cost)	Maximum positive – set at \$10 per m ³ harvested	Moderate
Wildfire	Minimize hazard	Low
Hydrology - EDA	30% above/ below H50 limit	Moderate
Range	AUM targets	Low
Forest health	Minimize hazard	Low
High risk IDF PI	Yes	Tracked
Shorter rotation	Yes	Tracked

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 and partial-cut;
- Fertilization;
- Rehabilitation (ITSL and intermediate utilization stands); and
- Ecosystem restoration (ER) (grass, open forest and open range).

3.2 Harvest Level

Figure 3.1 shows the harvest forecast of the Type 4 Silviculture Strategy by region (north and south). The first four periods represent historical harvest data from 1975 to 2014. The Type 4 Silviculture Strategy can achieve a harvest level of 2.3 million m³/year in the short-term, drops to the current AAC of 2.1 million m³/year in the mid-term, then increases to a non-declining long-term harvest level of 2.2 million m³/year. The harvest level in the first period exceeds the TSR harvest level of 2.1 million m³/year in order to immediately reduce wildfire hazard in the identified priority zones (where fire threat rating equaled 4 and 5).

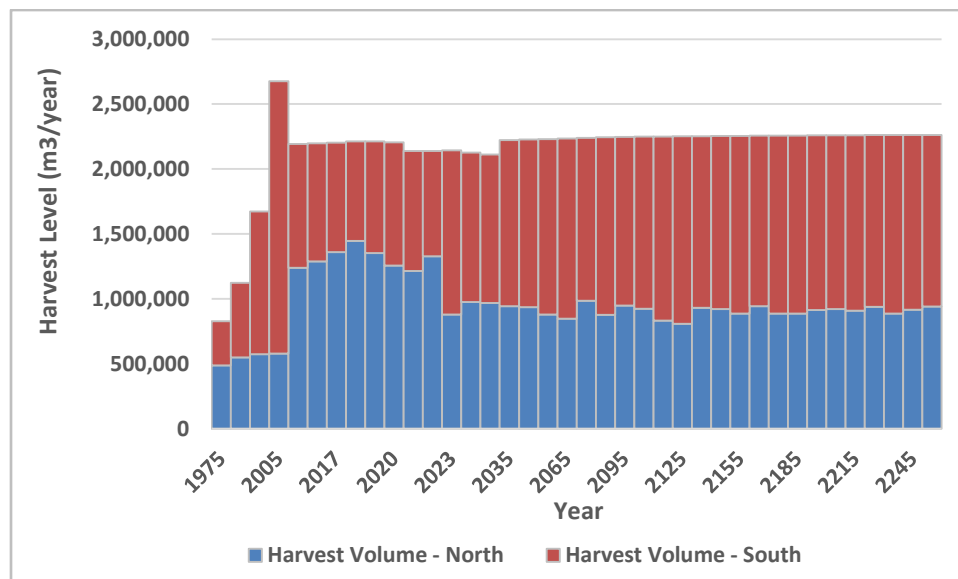


Figure 3.1: Harvest Volume: Silviculture Scenario

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, is implemented spatially so that the stand-level location is known. Figure 3.2 shows an example of this. Detailed maps of silviculture activity at the TSA-level and operational scale 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.

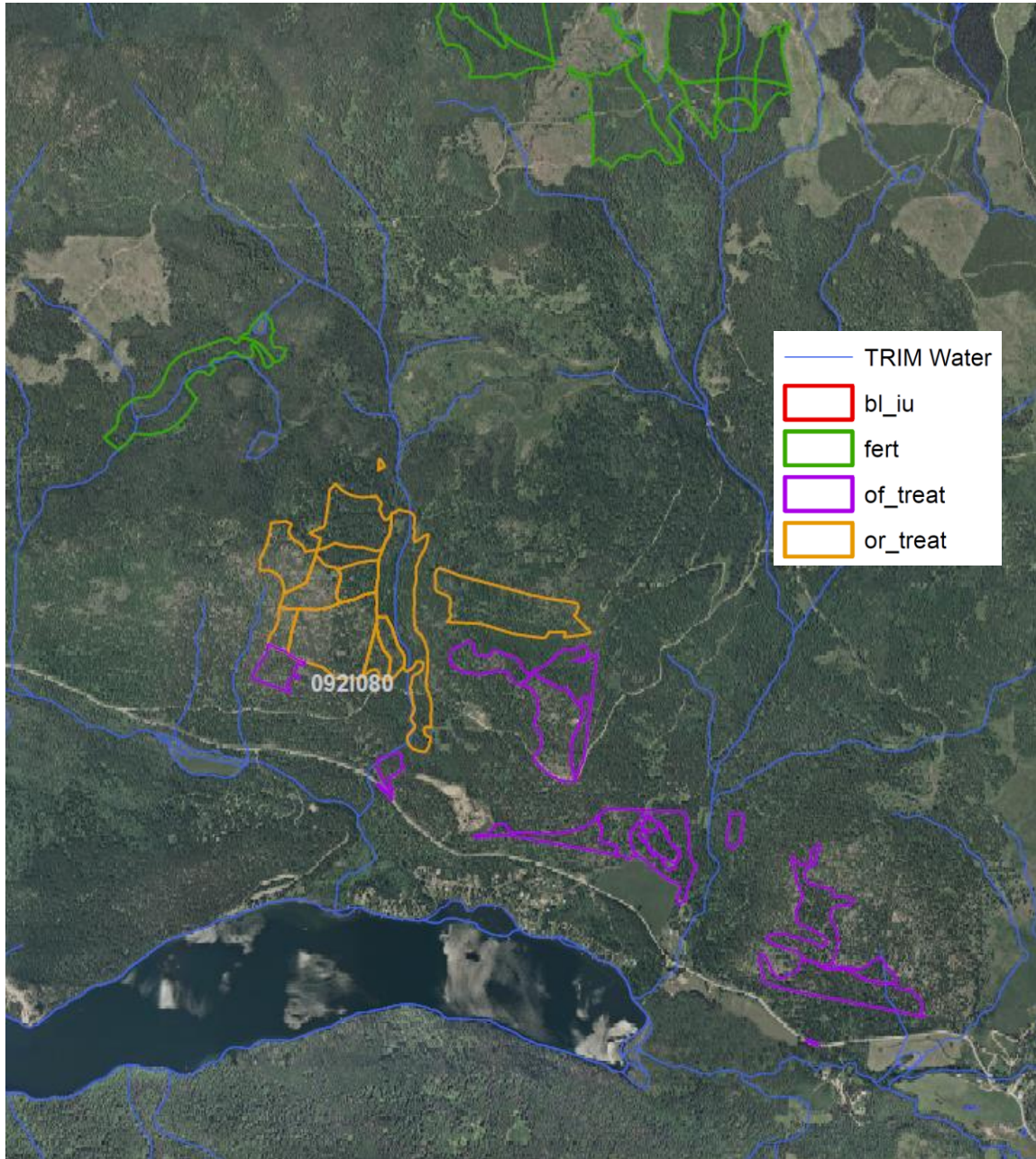


Figure 3.2: Activity and Treatment Location Example

A summary of the area and cost by year for the silviculture program is shown in Table 3.2, which is a total of \$27.7 million over 20 years. With the following labor assumptions¹, 225 jobs per year for 20 years are estimated to be generated by this silviculture program.

Table 3.2: Silviculture Activity – Area and Cost by Year

Year	Areas (ha)						Costs (\$)						
	Balsam IU	Fertilization	ER: Grass	ER: Open Forest	ER: Open Range	ITSL	Balsam IU	Fertilization	ER: Grass	ER: Open Forest	ER: Open Range	ITSL	
1	25	546	25	936	1,221	2	257,807	245,726	41,611	1,539,818	2,009,071	8,349	
2	31	924	6	606	978	0	409,470	415,629	9,718	996,159	1,608,454	0	
3	46	382	13	410	515	11	476,516	171,828	20,941	674,383	847,580	42,310	
4	14	288	2	563	188	8	147,860	129,657	2,841	926,599	308,851	29,864	
5	12	502	2	299	239	0	119,798	225,933	2,906	492,242	393,659	0	
6	35	463	0	457	302	0	361,191	208,332	140	752,438	497,197	0	
7	48	212	0	617	703	0	496,291	95,443	131	1,015,462	1,157,322	926	
8	31	447	12	675	789	0	340,194	201,187	19,804	1,110,741	1,298,442	0	
9	11	490	0	473	567	1	106,720	220,711	0	777,459	933,041	3,837	
10	72	266	5	428	807	21	737,803	119,704	8,505	703,658	1,327,642	84,285	
20	62	346	5	445	491	40	687,282	155,798	7,831	732,222	807,681	159,721	
Total	387	4,866	70	5,909	6,801	83	4,140,933	2,189,949	114,428	9,721,181	11,188,940	329,292	

Table 3.3 shows the area eligible for each modelled 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.

Table 3.3: Silviculture Activity – Eligible versus Treated Areas

	Areas (ha)		
	Eligible	Treated	% Treated
Balsam IU	21,954	387	2%
Fertilization	24,333	4,866	20%
ER: Grass	983	70	7%
ER: Open Forest	41,203	5,909	14%
ER: Open Range	36,040	6,801	19%
ITSL	1,627	83	5%

3.3.1 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:

¹Based 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)

Ecosystem Restoration: 2 person days per ha (from PG Type 4 Data Package)

Fertilization:

- The model chose to fertilize area primarily in the wet belt ecosystems in the northern portion of the TSA;

Ecosystem Restoration:

- The model chooses ecosystem restoration treatments, specifically open forest and open range, in the southern portion of the TSA;

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

- Fertilization: average of 15 m³/ha gained at time of harvesting; and
- Planting (ITSL and Balsam IU):

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;
- Resource management zones (RMZ);
- Equivalent disturbance area (EDA);
- Forest health factors (FHF);
- Wildfire hazard; and
- Forage.

3.4.1 Harvest Characteristics

Figure 3.3 shows the harvest level and both total and merchantable growing stock 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.

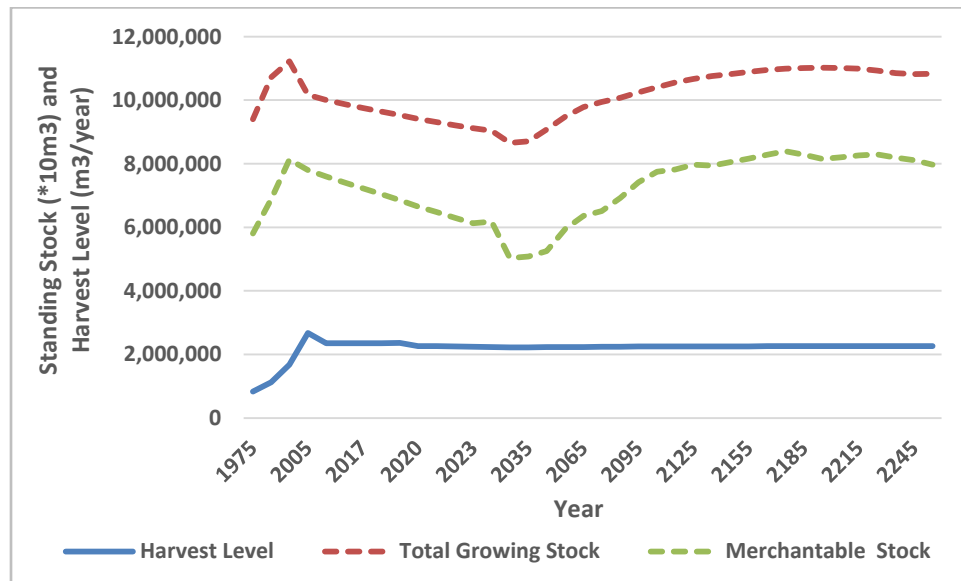


Figure 3.3: Harvest Level, Merchantable Stock and Total Growing Stock

Figure 3.4 shows the THLB area by age class. The area in the older age class remains relatively constant on the THLB. The 15% on the THLB that remains old (> 250 years) in the long-term will be tied up in various land base retention requirements².

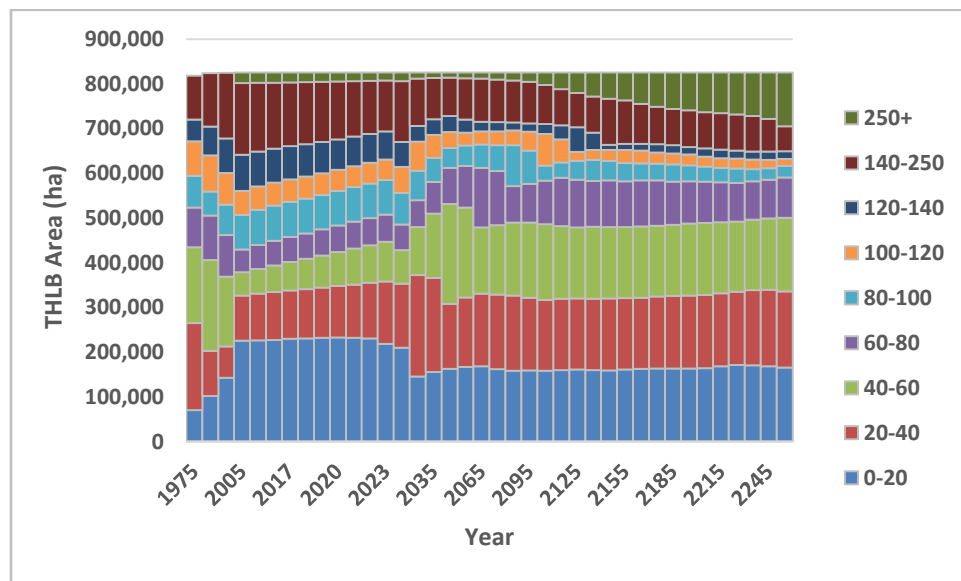


Figure 3.4: Age Class Distribution on the THLB

Figure 3.5 shows the standing volume by leading species on the THLB. Throughout the planning horizon the THLB is primarily Douglas-fir and Spruce leading stands, with Pine leading stands increasing on the land base in the long-term.

² This old % is only on the THLB. When looking at the total productive land base, the area that remains in old and mature (> 140 years) is approximately 40%.

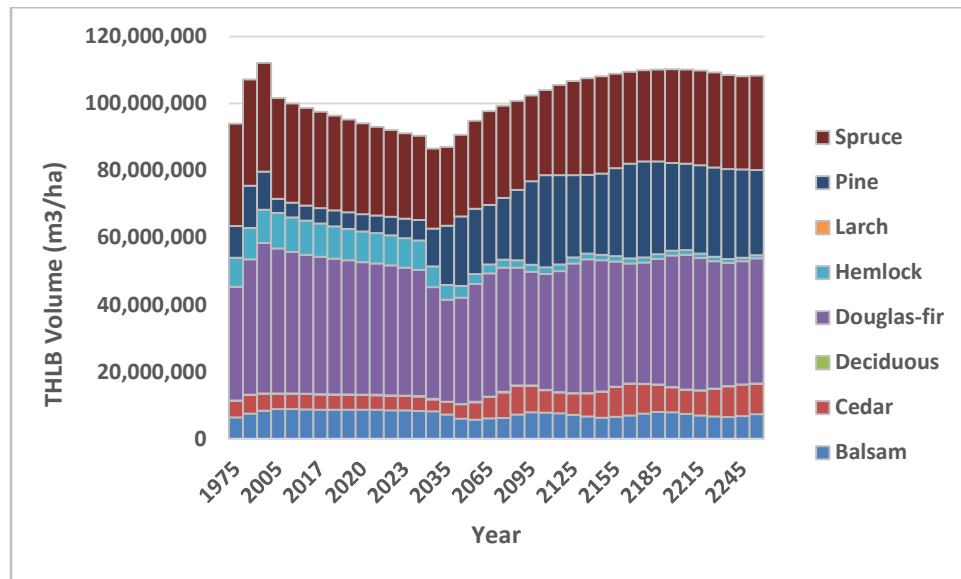


Figure 3.5: Tree Species Composition on the THLB – Volume

Figure 3.6 through Figure 3.9 show the volume harvested across the planning horizon by harvest from visually sensitive stands, harvest type, leading species and age class. Figure 3.6 shows that an average of 7% of the total harvest is sourced from visually sensitive areas in the short-term but increases to 27% in the long-term.

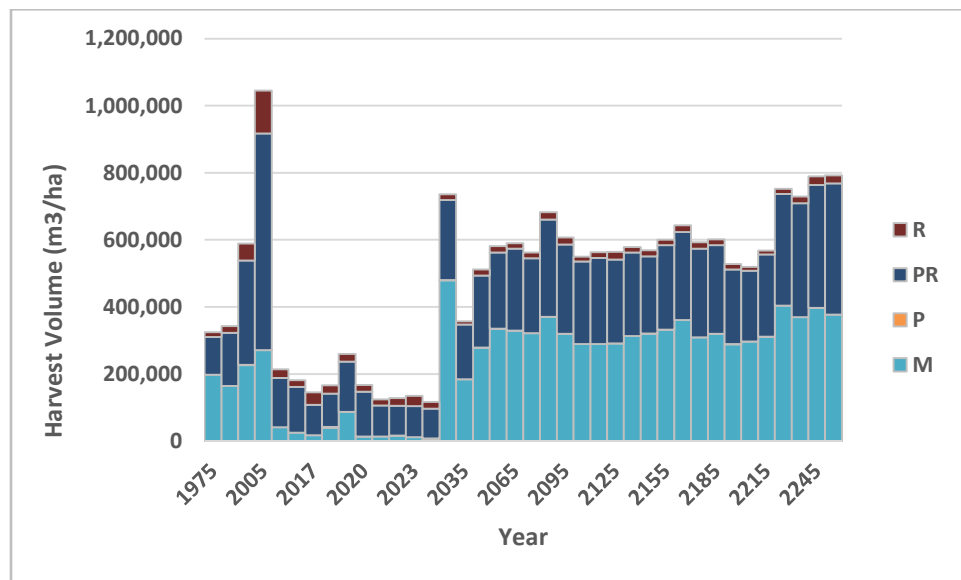


Figure 3.6: Harvest Volume by Visuals

Figure 3.7 shows that the harvest system is almost entirely clear-cut with of average 3% from partial-cut harvesting and 1% from ecosystem restoration activities (open forest and open range).

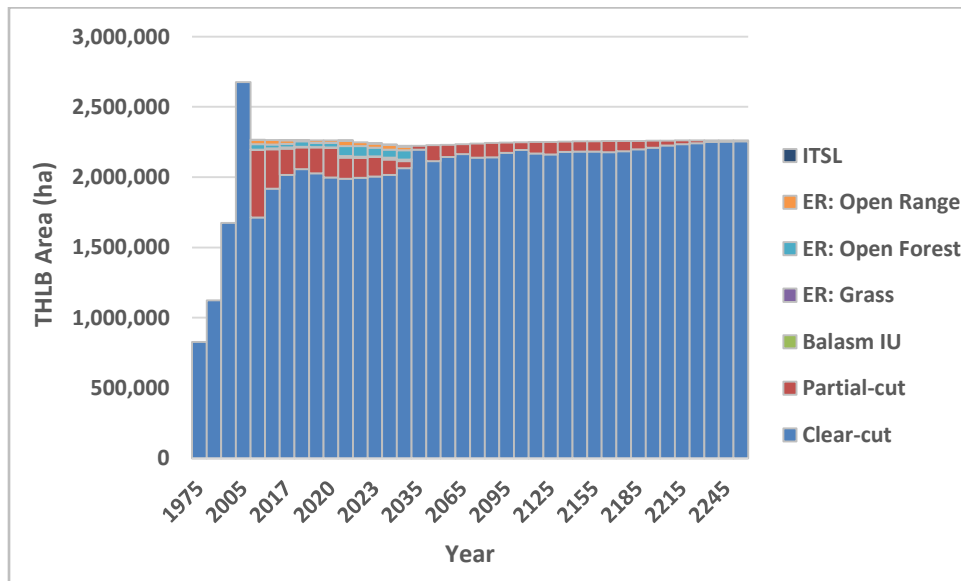


Figure 3.7: Harvest Volume by Type

Figure 3.8 shows that the short- and mid-term harvest species composition is primarily Spruce and Douglas-fir. Hemlock stands are utilized in the mid-term but moves to Pine leading stands in the long-term.

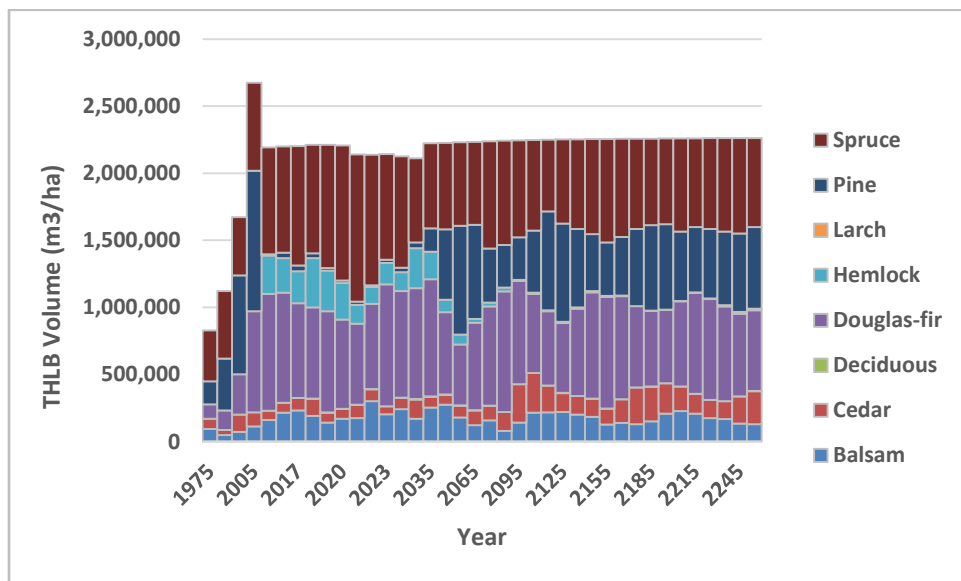


Figure 3.8: Harvest Volume by Species

Figure 3.9 shows the volume by age class throughout the planning horizon. Through the short- and mid-term the majority of stands being selected for harvest are in the age class 140 – 250 years, but drops to 60 – 100 years in the long term.

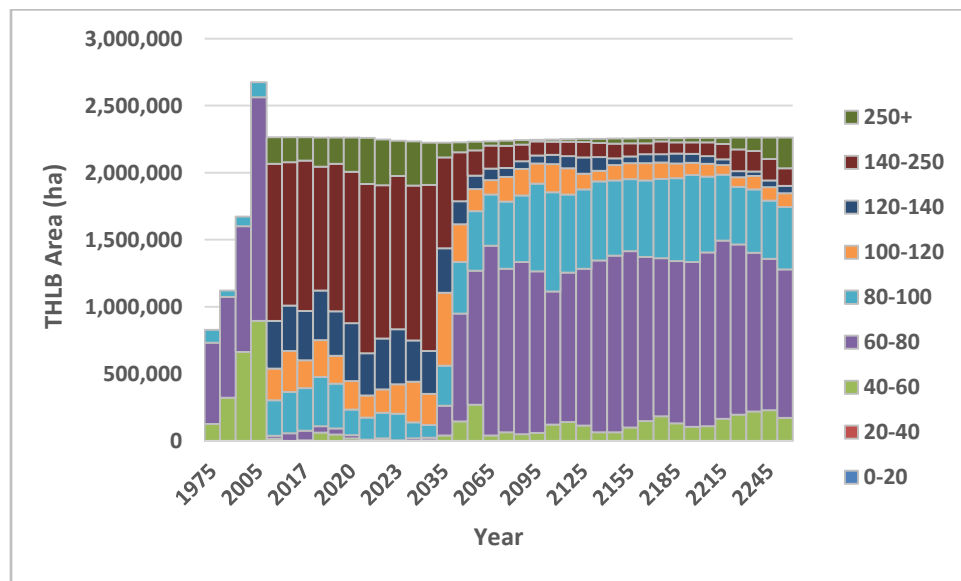


Figure 3.9: Volume by Age Class

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 shown in one graph. This shows general indicator trends, but doesn't capture the areas that are constraint by a specific indicator. To capture specific areas that are approaching or exceeding their targets, the highest penalized zones are identified and reported.

Harvest Profile:

Figure 3.10 shows the volume harvested across the planning horizon by harvest method (cable or conventional/ ground). On average, 39% is sourced from cable stands in the first decade with a maximum of 45% in the third year of the silviculture program. This is reduced and stabilizes to the long-term average of 27%. The mid- and long-term is more dependent on ground harvesting systems.

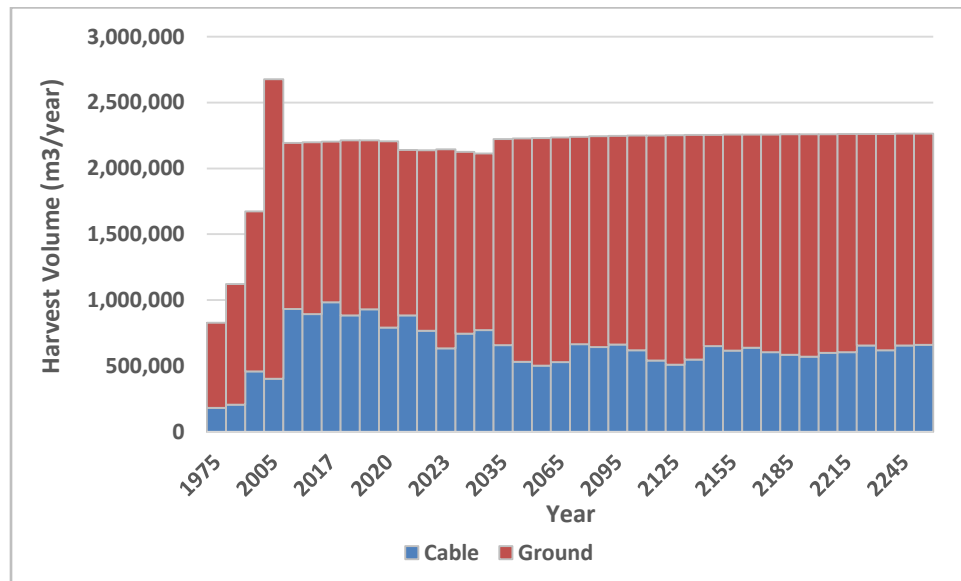


Figure 3.10: Indicators: Harvest Profile

Net Revenue:

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 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 21.50 \$/m³ in the first decade to 28 \$/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.

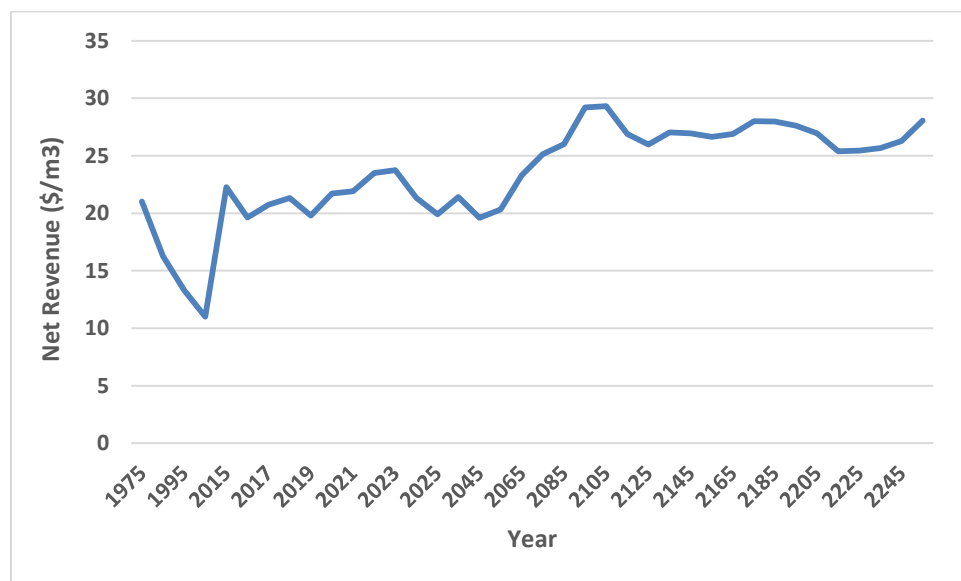


Figure 3.11: Indicators: Net-revenue

Hydrology:

Figure 3.12 shows the EDA for all community watersheds. The actual EDA exceeds the target of 30% in the short-term due to MPB mortality and salvage.

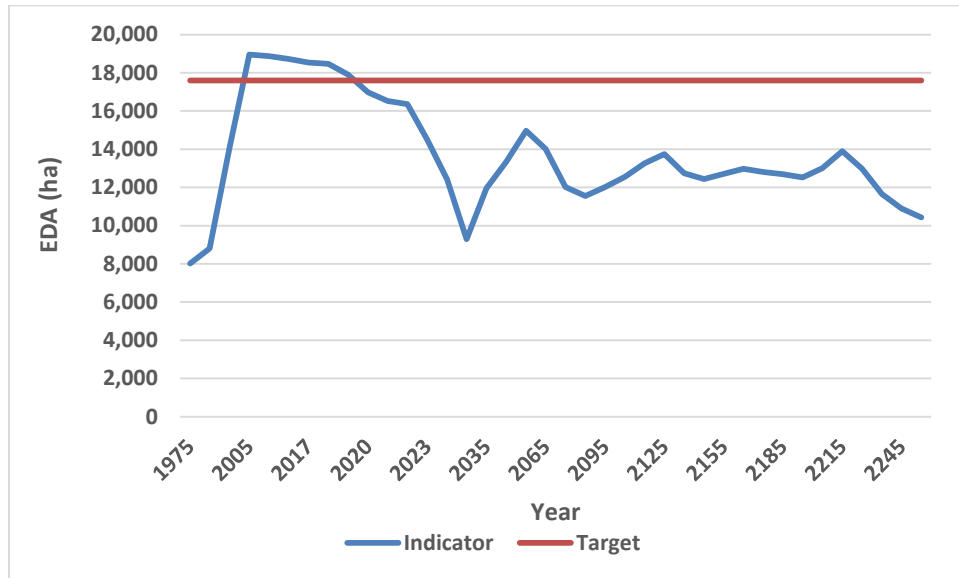


Figure 3.12: Indicators: Community Watershed EDA

A watershed risk analysis was conducted in the Kamloops TSA in 2012. Rankings were developed for both social and environmental (fisheries) factors at risk. The highest ranking units are of importance in this analysis as results suggest these watersheds have a high to very high potential risk. Table 3.4 shows the top 10 watersheds at risk based on environmental scores. The status of all watersheds were tracked throughout the planning horizon in the analysis and reporting for the top 10 at risk is included below.

Table 3.4: Top 10 at Risk Watersheds

Rank	Reporting Unit	Type	Risk Score
1	Barriere River	Large Watershed	10.0
2	North Barriere River	Watershed	9.6
3	Louis Creek	Watershed	8.4
4	Lemeiux Creek	Watershed	8.4
5	Deadman River	Large Watershed	8.3
6	Criss Creek	Watershed	7.6
7	Harper Creek	Basin	7.6
8	Campbell Creek	Watershed	7.2
9	Tunkwa Creek	Basin	7.1
10	Durand Creek	Watershed	7.1

Of the listed at risk watersheds, 5 exceed the maximum EDA target as shown in Figure 3.13: Louis Creek, Lemeiux Creek, Deadman River, Criss Creek, and Campbell Creek. Tunkwa Creek meets the maximum EDA target but does not exceed it. Targets were not achieved from 2005 to 2014 due to MPB mortality and associated salvage operations.

As well, the maximum target EDA was surpassed in the first decade in these watersheds due to these stands being selected for silvicultural treatment.



Figure 3.13: Indicators: At Risk Watersheds EDA

Forest Health:

Figure 3.14 shows the THLB area by hazard for key forest health factors (FHF) modelled at the stand level and summarized at the landscape level: mountain pine beetle (MPB), Douglas-fir beetle (DFB) and spruce bark beetle (SXB).

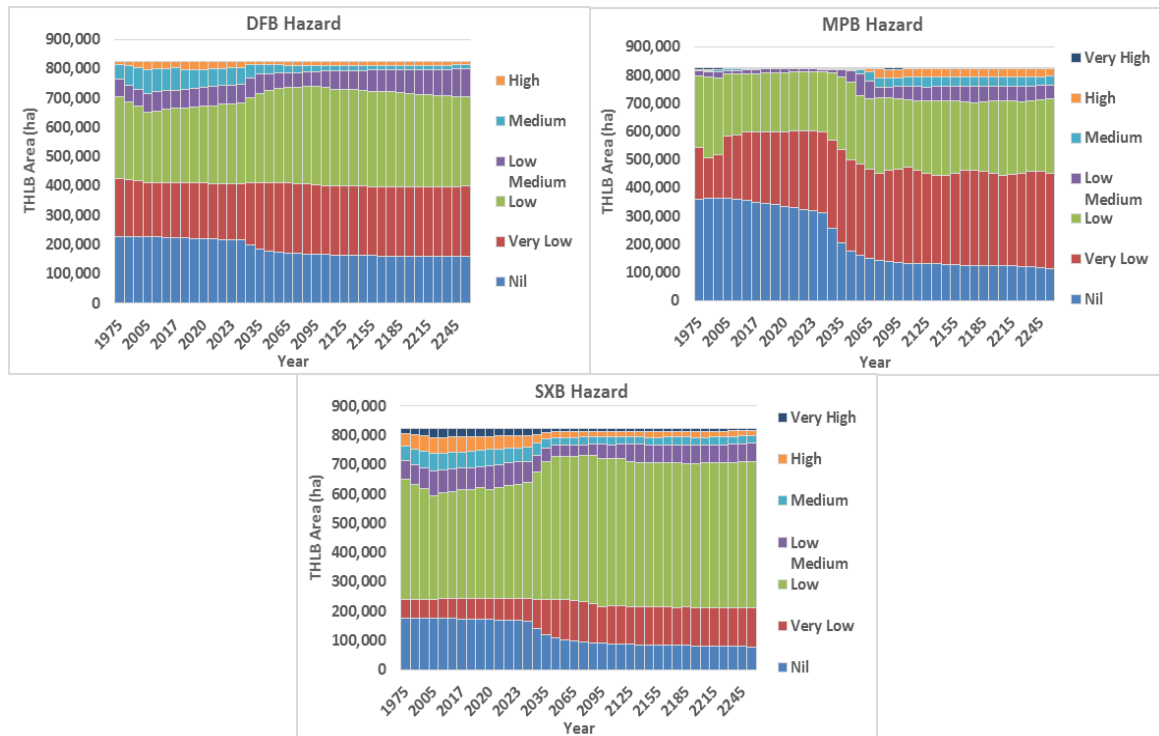


Figure 3.14: Indicators: FHF hazard (MPB, DFB, SXB)

Range:

Figure 3.15 shows forage production for all pastures. The forage targets by pasture are not achieved throughout the planning horizon with the exception of the first historical decade.

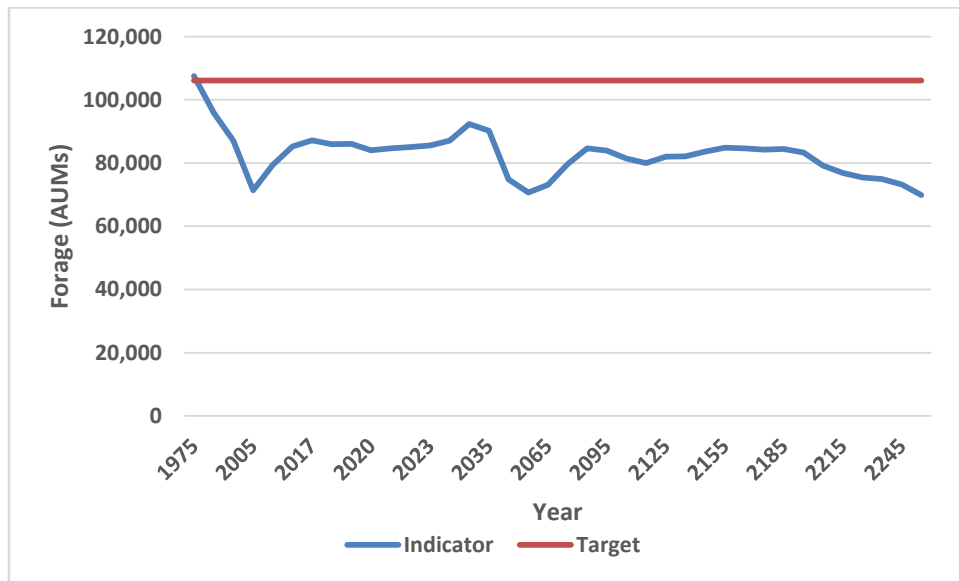


Figure 3.15: Indicators: Forage by Pasture

Wildfire:

Figure 3.16 shows an area summary of wildfire hazard across the planning horizon for two areas: within the crown interface and within the 'high threat' wildfire hazard abatement zone. Wildfire hazard is significantly reduced after the mid-term.

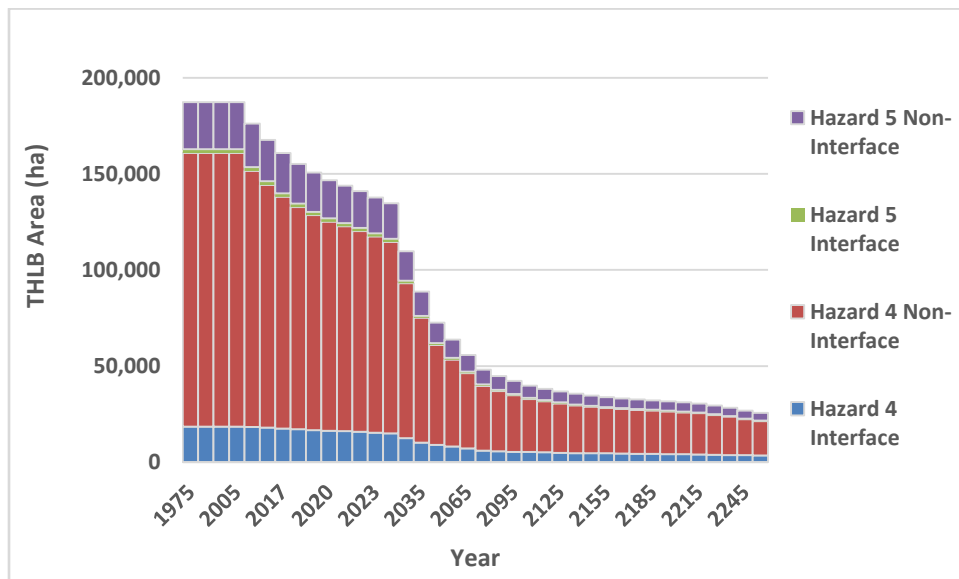


Figure 3.16: Indicators: Wildfire Hazard in Crown Interface and High Threat Zone

4.0 OTHER MODELLING SCENARIOS

Other modelling scenarios defined in this project include:

1. **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 land base.
2. **TSR-equivalent:** This scenario implements the TSR harvest level and RMZs that are modelled in TSR. It does not include silviculture activities and does not consider other land base indicators such as EDA.
3. **Economic:** Selects a management regime and silviculture program that uses net-revenue (monetary value generated minus cost) as the dominant objective. The general concept is that if funding is limited, this scenario will identify where the best return on investment could be.
4. **Range:** This scenario optimizes the harvest scheduling and silviculture activities to fulfill forage targets by pasture.
5. **Wildfire:** Harvest scheduling is optimized with the primary focus of reducing risk in identified high wildfire threat areas. Ecosystem restoration activities are allowed in this scenario to assist treating highest risk locations while achieving multiple objectives.
6. **Forest Health:** This scenario selects a management regime directed at reducing forest health risk based on current status. Ecosystem restoration activities are also allowed to occur to reduce risk while achieving multiple objectives.
7. **Social:** This scenario considers wildfire hazard, forage targets, a higher EDA weighting for watershed management, and ecosystem restoration activities to achieve a higher harvest level while maintaining the silviculture investment.
8. **Environmental:** This scenario balances the objectives for EDA, ecosystem restoration, and climate change while maintaining TSR harvest level, maximizing net revenue, and allowing flexibility for the cedar hemlock partition and non-declining growing stock.
9. **Climate Change:** Selects the harvest scheduling based on future potential climate envelopes. Identifies high risk BEC-species combinations to prioritize for treatment, and includes shorter rotations to facilitate increasing species diversity to create resilient future forests.
10. **Silviculture Strategy:** This main scenario considers TSR indicators as well as additional indicators such as EDA and economics. Silviculture activities (planting, fertilization and ecosystem restoration) can be implemented for the first 20 years. The model will only select silviculture activity where the cost and benefits make sense considering all the land base values.

Table 4.1 outlines the relative weightings of each indicator by scenario. The climate change scenario is currently excluded from the analysis as modelling assumptions are being refined by the working group.

Table 4.1: Indicators, Targets and Weightings by Scenario

Indicator	TSR	Economic	Range	Wildfire	Forest Health	Social	Enviro.	Silv.
Harvest volume	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
MPB volume	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Cedar/ hemlock partition	Moderate	Tracked	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Non-declining THLB growing stock	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
TSR RMZs	High	High	High	High	High	High	High	High
Silviculture activities	Not allowed	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Net-revenue	Tracked	Moderate	Tracked	Tracked	Tracked	Tracked	Tracked	Moderate
Wildfire	Tracked	Tracked	Tracked	Moderate	Tracked	Low	Low	Low
Hydrology - EDA	Tracked	Tracked	Tracked	Tracked	Tracked	Moderate	Moderate	Moderate
Range	Tracked	Moderate	Moderate	Tracked	Tracked	Moderate	Tracked	Low
Forest health	Tracked	Tracked	Tracked	Tracked	Moderate	Tracked	Low	Low
High risk IDF PI	Tracked	Tracked	Tracked	Tracked	Tracked	Tracked	Tracked	Tracked
Shorter rotations	Tracked	Tracked	Tracked	Tracked	Tracked	Tracked	Tracked	Tracked

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. Harvest level was set to higher than TSR for the forest health, social, economic and silviculture scenarios, however the model only selected a higher harvest volume in the economic and forest health scenarios.

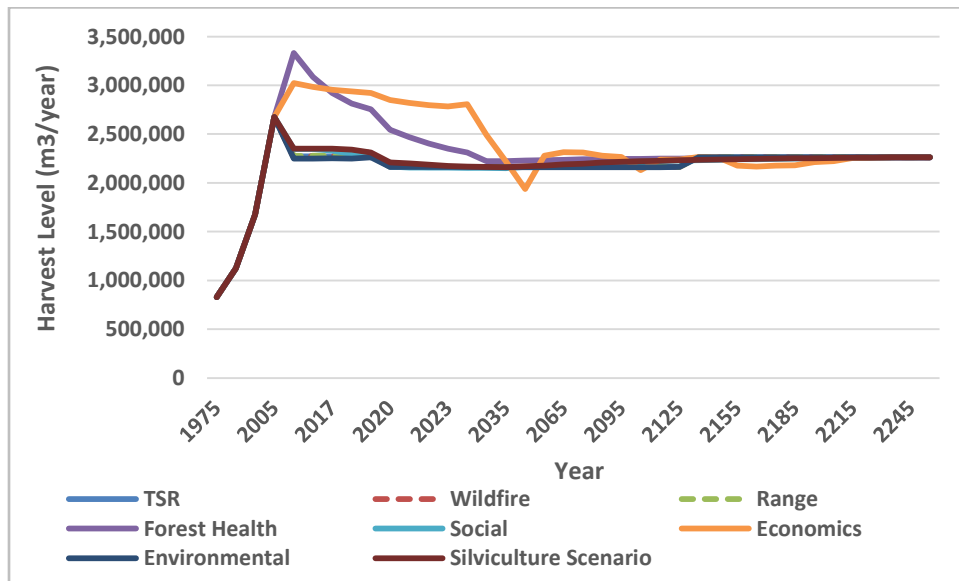


Figure 4.1: Harvest Volume by Scenario

Table 4.2 shows silviculture activities by scenario. No silviculture activities were applied in TSR scenario. Ecosystem restoration activities were the highest silviculture expenditure for every scenario with an average of 75% of the total budget being spent on open forest and open range treatment.

Table 4.2: Silviculture Activity Cost by Scenario

Scenario	Cost (\$)						Percent of Expenditure (%)					
	Balsam IU	Fertilization	ER: Grass	ER: Open Forest	ER: Open Range	ITSL	Balsam IU	Fertilization	ER: Grass	ER: Open Forest	ER: Open Range	ITSL
Wildfire	681,156	221,757	18,991	1,163,395	1,498,944	1,199,962	19%	6%	1%	32%	41%	2%
Range	295,363	346,684	6,984	783,511	1,137,933	842,735	11%	13%	0%	29%	43%	3%
Forest Health	394,090	395,846	59,421	2,414,977	2,822,537	2,437,728	6%	6%	1%	39%	46%	1%
Social	548,545	355,526	3,421	380,433	541,226	39,574	29%	19%	0%	20%	29%	2%
Economic	460	3,436	31,559	3,833,592	2,879,366	358,445	0%	0%	0%	54%	41%	5%
Environmental	466,473	209,008	21,789	966,284	1,137,820	76,748	16%	7%	1%	34%	40%	3%
Silviculture	376,448	199,086	10,403	883,744	1,017,176	29,935	15%	8%	0%	35%	40%	1%

Figure 4.2 shows the net-revenue comparison by scenario. The economics scenario produces the highest net revenue as expected because this target is given a high weighting of importance.

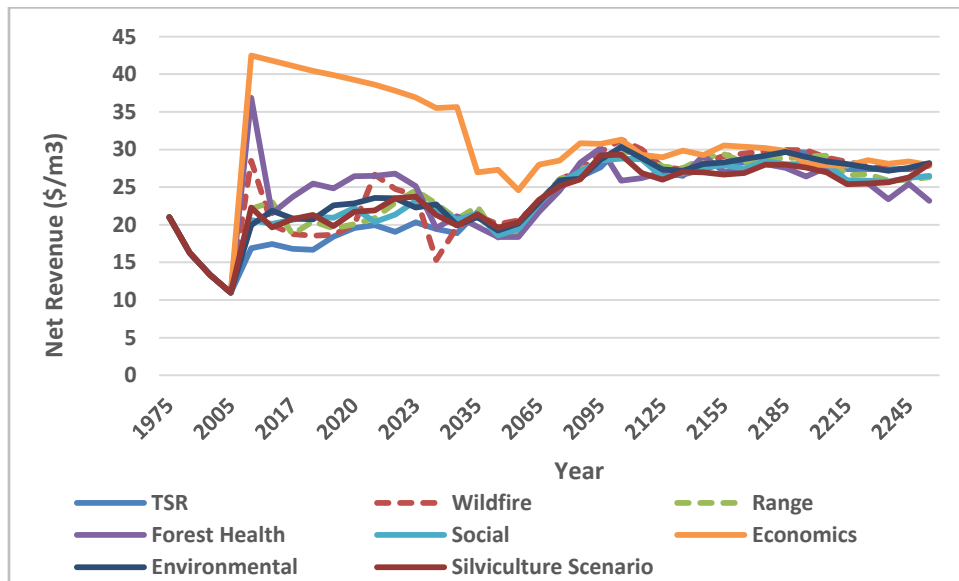


Figure 4.2: Net-revenue by Scenario

Forest health hazard for DFB and SXB was consistent between scenarios, it declined in the short-term and stabilized in the mid-term for the remainder of the planning horizon. However, total MPB hazard increased in the short-term and was variable between scenarios for the mid- and long-term as shown in Figure 4.3. The forest health scenario reduced MPB hazard the greatest and TSR reduced it the least, which was expected given the scenario assumptions.

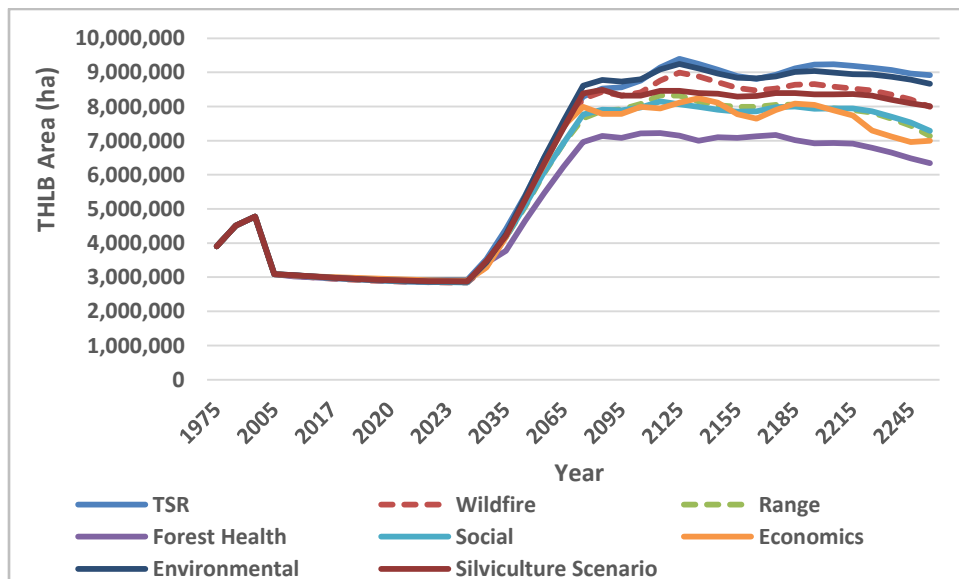


Figure 4.3: MPB Hazard by Scenario

5.0 DISCUSSION

5.1 Key Findings

A reoccurring theme in many scenarios is the large amount of area is being selected for partial cutting and ecosystem restoration, mainly open forest and open range treatments. This is most likely due to the many overlapping reasons to do it immediately. Partial cutting and ecosystem restoration treatments meets the objectives for wildfire hazard, forest health hazard, range targets, while considering social objectives and maintaining positive economic net revenue.

Consistent among all scenarios is the significant increase in MPB hazard in the long-term. This is indicative of the high pine percentage assumed to be planted in managed analysis units. This result shows the level of risk associated with the current species composition being planted. To reduce forest health risk it is recommended to diversify species composition.

5.2 Silviculture Scenario

Key findings in this analysis include:

- The silviculture program selected by the model is \$2.5 million per year for 20 years. The majority is being spent on open forest and open range treatments (75%), followed by balsam IU (15%) and fertilization (8%).
- Partial cutting is being selected at a consistent level throughout the planning horizon, similarly to TSR.
- A good amount of volume is also being harvested from open forest and open range treatments through the first 20 years.
- Wildfire hazard is significantly reduced.
- On average, 24 ha/year of high fire threat stands are being selected for fertilization. This is occurring because these stands contribute to the 10 ha minimum patch size requirement for fertilization, where one stand has a higher fire threat than the remaining stands in that patch and therefore the patch is still being selected for treatment.
- Forage AUM targets are not being completely met.
- Harvest moves slightly north over the planning horizon and into a bit more cable operations.
- Take home message: partial cutting is being selected now but transitions to significant open forest and open range treatments in order to achieve the many overlapping benefits (range, wildfire, forest health) while still achieving volume targets and not impacting EDA and RMZs as much as only selecting clear-cutting. The main message is that these treatments can be applied to achieve the overlapping objectives while still accomplishing good net revenue.

5.3 Other Scenarios

Key findings for each additional scenario includes:

TSR

- No silviculture activities allowed in this scenario.
- MPB hazard increases significantly in the long-term. This is indicative of the high pine percentage assumed to be planted in managed analysis units.
- Take home message: to reduce forest health risk it is recommended to diversify species composition.

Wildfire

- Compared to TSR, wildfire hazard is reduced significantly.
- More area is being selected for partial cutting compared to TSR, which results in very negative net revenue values.
- Spending \$3.6 million per year on silviculture, 73% of which coming from ecosystem restoration activities (open forest and open range) and 19% from utilization of balsam stands.
- Ecosystem restoration activities are being selected in addition to partial cutting to reduce wildfire hazard while achieving additional values on the land base.
- Take home message: the model is selecting lots of area of partial cutting, open forest and open range activities to immediately reduce wildfire hazard.

Range

- In contrast to TSR, this scenario is able to achieve AUM targets.
- Similarly to the wildfire scenario, there is an increase in area being selected for partial cutting.
- Spending \$2.6 million per year on silviculture, 72% of which is coming from open forest and open range activities.
- Take home message: similar treatment outcome as the wildfire scenario, therefore management for these two values has many synergies.

Forest Health

- Forest health hazard for MPB, DFB and SXB is reduced compared to TSR and other scenarios, however this is not as significant as expected. In order to further reduce forest health hazards, the model selects an increased harvest level of 3 million m³/year for the first decade before stabilizing in the long-term to the TSR harvest level of 2.1 million m³/year.
- Again, lots of area is being selected for partial cutting which reduces forest health hazards, especially for MPB which is mostly located in the south.
- However, forest health hazards look similar when forecasted over the planning horizon and compared to other scenarios with the exception of MPB.
- Large amounts of ecosystem restoration treatments (open forest and open range) and less balsam IU being selected than other scenarios.
- Spending \$6.1 million per year on silviculture
- Take home message: to best reduce forest health hazard, partial cutting and ecosystem restoration treatments should be selected. This is the same outcome for the wildfire and range scenarios.

Social

- Less area being selected for partial cutting. Instead, there is a better balance between silviculture activities than the previous scenarios.

- Forage AUM targets are close to being achieved throughout the planning horizon.
- Spending \$1.8 million per year on silviculture, approximately 25% for each of the following treatments: balsam IU stands, fertilization, open forest and open range.
- Take home message: Similar trends as the wildfire, range and forest health scenarios but with a better balance between selected treatments.

Economic

- Substantial increase in average and total short-term net revenue with an average of 40 m³/ha compared to 20 m³/ha for TSR.
- Harvest level is increased in the short-term to 3 million m³/year before dropping to the long-term sustainable yield of 2.2 million m³/year. Interestingly, harvest level is more variable when managing for economics. The model is choosing to wait and harvest at maximum net revenue rather than harvesting at maximum volume.
- Some partial cutting occurring in the first few periods but not as much as other scenarios. This is because economic factors are lowering the need to harvest lots of partial cut candidate stands. Area is still being selected for partial cutting, however the modelling is not solely selecting partial cutting.
- Forage AUM targets are not quite met but achievable.
- Visually sensitive areas are much more limiting in this scenario than others. A higher harvest level could be achieved if this constraint was relaxed on the land base.
- Currently, net revenue does not consider the value achieved from range activities (i.e. the value realized from cattle). This was chosen so that the model does not place a higher significance on forage activities due to economic reasons opposed to considering all resource values.
- Spending \$7 million per year on silviculture, almost entirely on open forest and open range treatments. The cost of silviculture spending was balanced out by the increased harvest level in the short-term.
- Take home message:

Environmental

- A consistent amount of area is being selected for partial cutting, similar to TSR levels.
- Harvest occurs slightly more than proportional in the north in the short-term.
- Wildfire hazard decreases more than TSR but not as much as the wildfire specific scenario.
- Spending \$2.8 million per year on silviculture, the majority of which is spent on open forest and open range treatments (73%), then balsam IU (16%) and fertilization (7%).
- Take home message: