Lakes TSA – Type 4 Silviculture Strategy

Silviculture Strategy

Version 1.0

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Project 419-24

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Strategy at a Glance

Historical Context	The most recent timber supply review completed in 2011 lowered the uplift harvest level from 3.162M m^3/yr to 2.000M m^3/yr, with 350,000 m^3/yr attributable to non-pine volume. An analysis of the mid-term timber supply was completed in 2012 that showed that without mitigation, this uplift harvest could be maintained until 2020, decline to 500,000 m^3/yr for 50 years.	
Objective	Mitigate impacts from past mountain pine beetle (MPB) and wildfires on mid-term timber supply.	
General Strategy	Attempt to harvest the current AAC and concentrate harvest on salvageable MPB-impacted pine stands. Apply an appropriate mix of silviculture activities aimed to achieve the working targets stated below.	
Working Targets	**Timber Volume Flow Over Time:**	**Short-Term** (1-10yrs): Maximize salvage of dead pine using the current AAC of 2.0 million m^3/yr; salvage - harvest older stands before they deteriorate below minimum merchantability (140 m^3/ha).
		Mid-Term (11-80yrs): Maximize mid-term harvest levels by accepting decreased long-term harvest levels.
		Long-Term (≥81yrs): Maintain the highest stable growing stock over time.
	Timber Quality:	After the salvage period, harvest stands once they achieve minimum merchantability (140 m^3/ha) and maintain a supply of peeler logs (200,000m3/yr of Sx/Fd 8"top, 17'2").
		Short-Term (1-10yrs): Capture economically viable sawlog volumes before stands deteriorate.
		Mid-Term (11-80yrs): Maximize stand values to the extent possible as the main focus is on maximizing recoverable volume.
		Long Term (≥81yrs): Regenerate newly harvested areas with silviculture practices that improve timber quality.
	Habitat Supply:	Throughout the planning period minimize negative impacts to water resource, ecosystems and species by meeting current legal objectives with respect to terrestrial biodiversity, aquatic, and riparian values through both operational and silviculture activities.
Major Silviculture Strategies	**Timber Volume Flow Over Time:**	**<u>Years 2011-2020</u>** (during the salvage period) • Rehabilitate eligible stands that will not likely be salvaged (e.g., younger stands without merchantable volume, including fire-damaged areas). • Focus fertilization on stands closest to harvest eligibility; prioritize by Sx then Pl; apply multiple treatments on Sx where possible. • Pre-commercial thin and fertilize eligible stands where possible (low priority). **<u>Years 2021-2030</u>** (following the salvage period) • Continue rehabilitation levels but shift priority onto stands that optimize various aspects including: merchantable volume, site productivity, haul distance, road access and fire risk. • Increase fertilization levels with same approach. • Eligible stand for PCT and fertilization are expected to be exhausted.
	Timber Quality:	• Continue to monitor timber profiles being harvested with particular attention on minimum merchantability criteria. • Encourage enhanced basic silviculture practices and monitor stand performance to ensure that objectives are being met.
	Habitat Supply:	• Prioritize silviculture treatments to promote old growth attributes within designated habitat areas. • Retain coarse woody debris and wildlife trees where practicable. • Explore opportunities for partial cutting within constrained areas while maintaining the appropriate non-timber values.

Silviculture Program Scenarios

Potential Program

Years 2011-2020

Priority	Treatment	Target Area (ha/yr)	Unit Cost ($/ha)	Target Funding ($M/yr)
1	Rehab	1,850	1,250	2.012
2	Fertilize	500	500	0.656
3	PCT + Fert	256	1,300	0.323

Years 2021-2030

Priority	Treatment	Target Area (ha/yr)	Unit Cost ($/ha)	Target Funding ($M/yr)
1	Rehab	1,492	1,250	1.865
2	Fertilize	2,270	500	1.135
3	PCT + Fert	0	0	0

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Outcomes

Timber Volume Flow Over Time:

Short Term (years 2011-2020)
- No forecasted changes relative to the base case scenario.

Midterm (years 2021-2030)
- Harvest level increase of 28% relative to base case scenario.

Timber Quality:
- Targets were not implemented as the analysis focused on maximizing mid-term volume.

Habitat Supply:
- Assumptions applied to capture stand- and forest-level impacts from MPB and associated wildfire also suggest there are substantial risks to habitat in both the short and mid-term.

Related Plans and Strategies

Climate Change	Enhanced Retention
Tree Species Deployment	Secondary Stand Structure
Land Use Plans	Watershed Management
Landscape Level Biodiversity	Wildlife Habitat
Forest Health	Tree Improvement and Seed Transfer
Wildfire Management	Forest Inventory
Ecosystem Restoration	

Recommendations

Implementing Strategies

1. Develop a process to track and report unsalvageable stands.
2. Track actual treatment costs.
3. Develop an access management plan.
4. Establish a task force to develop guidance on how enhanced basic silviculture can be incorporated in the current appraisal system as a silviculture cost allowance used in the stumpage calculation.

Data Gaps and Information Needs

5. Strengthen the inventory update process to reflect available RESULTS data and where possible, impacts from natural disturbances (e.g., harvesting, fire, insects and disease).
6. Apply adjustments to the VRI to account for MPB impacts for future Type 4 analyses (rather than using the LVI).
7. Improve yield assumptions for post-attack regenerating stands.
8. Confirm estimates of live volume remaining on MPB-impacted stands.
9. Continue monitoring managed stand yields against predicted yields and consider approaches to differentiate the location and productivity of extreme sites.
10. Streamline the process for retrieving information on past incremental silviculture treatments and verify that the data is accurate and complete.
11. Continue supporting the tree improvement program and ensure that genetic gains are closely monitored and applied in future forest-level analyses.
12. Investigate the linkages between desired product profiles, minimum merchantability and harvest ages.
13. Update stream network and classification used to assign riparian areas.
14. Develop a current, classified road network with associated widths.
15. Map and track areas designated for long-term retention.

Modelling

16. Develop a base case sensitivity that examines increased young stand mortality.
17. Develop a base case sensitivity that alters the minimum harvest criteria to reflect actual volumes harvested during the salvage period.
18. Continue to develop appropriate growth responses for Fd and Lw within the TSA and

		run the enhanced basic reforestation strategy. 19. Develop a modified fertilization strategy that includes more eligible stands. 20. Develop a modified fertilization strategy that generates Pl responses directly through TIPSY. 21. Develop a silviculture strategy that examines an appropriate level of partial cutting within constrained areas. 22. Aggregate resultant polygons into spatially-appropriate blocks for modelling and mapping operationally.
	Related Plans and Strategies	23. Develop a consistent, coordinated map base to host the various strategies and multiple values. 24. Periodically check, update and add hyperlinks to information on related plans and strategies. 25. Encourage activities and develop programs that will aid in prioritizing and maintaining road systems adequate throughout the TSA.
	Monitoring	26. Develop a coordinated monitoring program to ensure outputs from the various silviculture treatments employed meet expectations.
References	• Lakes TSA Type 4 Silviculture Strategy – Situational Analysis, Version 1.1. July 2013. • Lakes TSA Type 4 Silviculture Strategy – Data Package, Version 3.0, September 2013. • Lakes TSA Type 4 Silviculture Strategy – Modelling and Analysis Report, Version 1.1, September 2013. • Lakes TSA Type 4 Silviculture Strategy – Silviculture Strategy, Version 1.0, September 2013.	

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1 Introduction

In 2012, the British Columbia Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) initiated a Type 4 Silviculture Strategy for the Lakes (LT4) Timber Supply Area (TSA) to help government and licensees better understand the current and future timber and habitat supply situation in the Lakes TSA, and what can be done to improve it.

1.1 Project Objectives

In support of government objectives to mitigate impacts from past mountain pine beetle (MPB) and wildfires on mid-term timber supply, the project aims to:

1. Provide a realistic, forward-looking assessment of timber and habitat supply under a range of scenarios that will produce a preferred silviculture strategy supported locally and provincially. This strategy will clearly identify the activities that will provide the best return on investment to government.
2. Provide products that will support operational implementation of the strategy (e.g., a tactical plan).
3. Inform licensees and government on the alternative outcomes that could be achieved through different approaches to basic (mandatory) silviculture in the TSA.
4. Provide context information or indicators that would be useful to support future management decisions in the TSA.
5. Where appropriate, illustrate how the recommended treatments link with other landscape-level strategies while considering treatment risk.

1.2 Context

This document is the fourth of four documents that make up a Type 4 Silviculture Strategy:

- Situational Analysis – describes in general terms the current situation for the unit.
- Data Package – describes the information that is material to the analysis including the model used, data inputs and assumptions.
- Modelling and Analysis Report – describes modelling outputs.
- **Silviculture Strategy –**provides a rationale for choosing a preferred scenario and describes treatment options, associated targets, timeframes and benefits.

1.3 Landbase

This section summarizes material from the situational analysis[1], data package report[2] and modelling and analysis report[3] for this project. Details for this summary can be accessed from these sources.

[1] Forsite Consultants Ltd. 2013. *Lakes TSA - Type 4 Silviculture Strategy, Situational Analysis.* Technical Report.

[2] Forsite Consultants Ltd. 2013. *Lakes TSA - Type 4 Silviculture Strategy, Data Package.* Technical Report.

[3] Forsite Consultants Ltd. 2013. *Lakes TSA - Type 4 Silviculture Strategy, Modelling and Analysis Report.* Technical Report.

Excluding Tweedsmuir Park, the TSA covers about 1.12 million ha (Figure 1 and Table 1) of which approximately 0.74 million ha is considered the Crown Forest Land Base (CFLB).

Areas set aside for roads, parks, wildlife habitat, Old growth Management Areas (OGMA), plus other areas considered unavailable for timber harvesting, account for roughly 243,000 ha. The effective Timber Harvesting Land Base (THLB) is approximately 495,000 ha or 44% of the total area in the Lakes TSA.

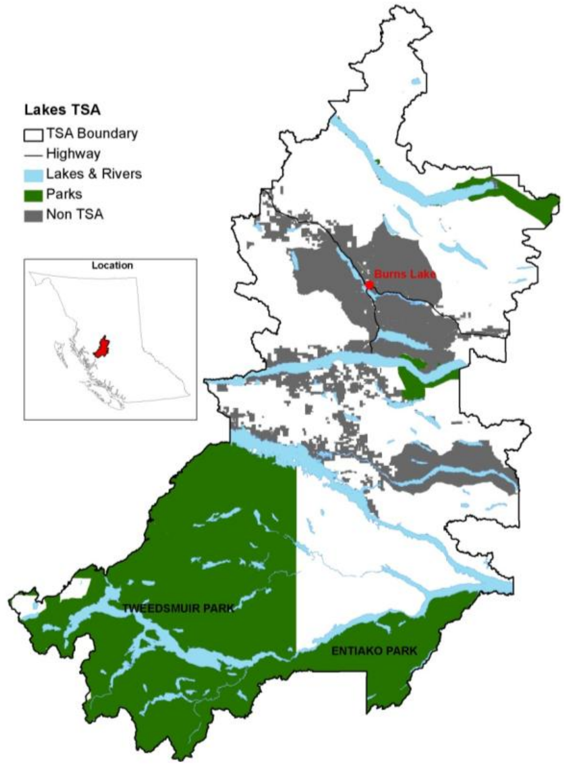


Figure 1 Overview map

Table 1 Lakes TSA land base area summary

	Total Area (Ha)	Effective Area (Ha)	Percent of Total Area	Percent of CFLB
Total Area (less Tweedsmuir Park)	1,121,638	1,121,638	100%	
less:				
Non-TSA (Private, Reserves, Community Forests and Woodlots)	240,710	233,285	20.8%	
Non-Forest / Non-Productive	408,263	150,905	13.5%	
Crown Forest Land Base		737,449	65.7%	100%
less:				
Existing Roads, Trails, and Landings	13,384	9,263	0.8%	1.3%
Parks and Protected Areas	96,960	86,687	7.7%	11.8%
Wildlife Areas	857	205	0.0%	0.0%
OGMA	90,108	63,990	5.7%	8.7%
Low Productivity	97,801	6,064	0.5%	0.8%
Deciduous-Leading	74,351	28,066	2.5%	3.8%
Problem Forest Types (Old Balsam-Leading Stands)	69,365	1,801	0.2%	0.2%
Riparian Reserve Zones	29,302	8,349	0.7%	1.1%
Timber Harvesting Land Base		533,022	47.5%	72.2%
Less aspatial netdowns:				
Future Roads, Trails, and Landings (@2.2%)		* *11,726*	1.0%	1.6%
Wildlife Tree Retention (@5.1%)		* *26,586*	2.4%	3.6%
Effective Timber Harvesting Land Base		494,710	44.1%	67.1%

** Aspatial netdowns are applied in the model but are not reflected in the GIS dataset areas.*

1.3.1 Age Class Distribution

After adjusting ages of stands dying from MPB attack[4], the age class structure for both the NHLB and THLB (Figure 2) shows a significant age class imbalance throughout most of the age classes; indicating potential challenges with the future timber supply.

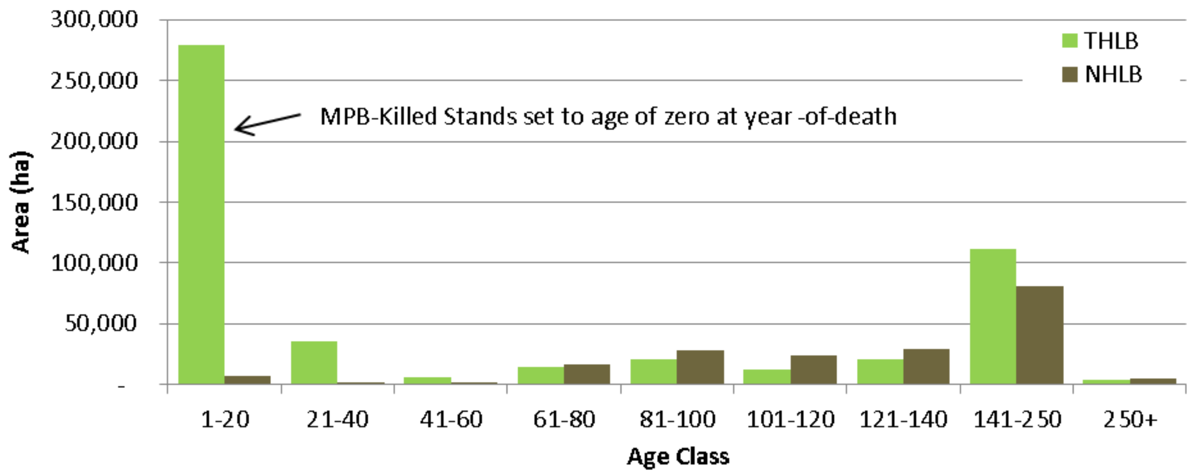
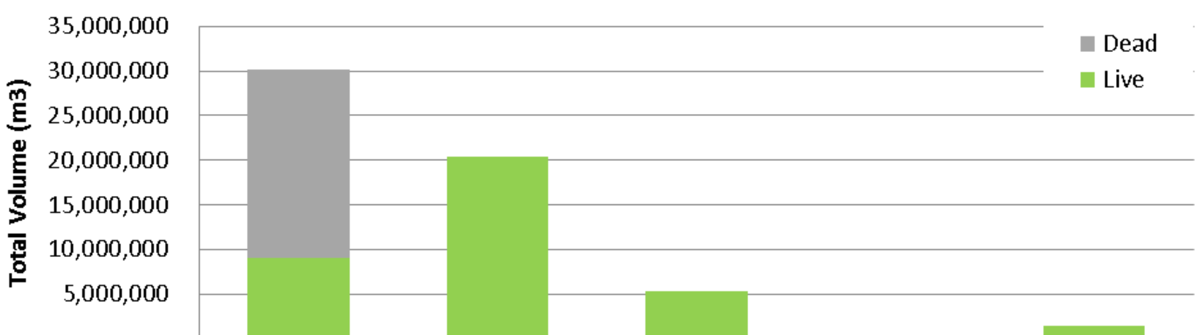


Figure 2 Age class distribution

1.3.2 Growing Stock and Species Profile

The total and merchantable growing stock is currently 57 million m³ of which approximately 69% (28 million m³) is considered merchantable for harvest (i.e., ≥140 m^3/ha merchantable volume). The current distribution of total growing stock by species on the THLB (Figure 3) shows that pine and spruce comprise the majority of the volume on the land base but nearly 70% of the pine volume is dead.



	Pine	Spruce	Balsam	Douglas-fir	Deciduous
Dead	20,981,982				
Live	9,116,235	20,402,256	5,384,323	63,153	1,509,388

Figure 3 Total growing stock on the timber harvesting land base by individual species

1.3.3 Site Productivity Profile

The site productivity of post-harvest regenerated (managed) stands is higher by 3.3 m[5] than natural stands (Figure 4), but the range of variability us considerably narrow: between SI 14 and SI 20. This

[4] Unsalvaged stands with ≥60% MPB mortality had their ages set to zero in the year of maximum infestation (typically 2006).

suggests that stands grown under current management regimes can produce more volume, faster than past forests.

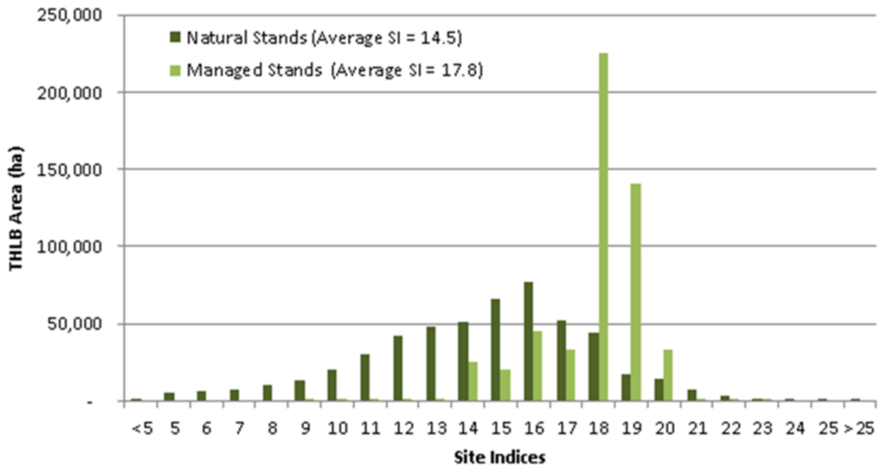


Figure 4 Site productivity distributions on the timber harvesting landbase

1.4 Key Issues and Considerations

This section summarizes material from the situational analysis[6] for this project. Details for this summary can be accessed from this source.

1.4.1 Harvest Levels

The AAC for the TSA (Table 2) has been fairly stable for many years with increases in 2001 and 2004 that reflected the growing mountain pine beetle epidemic. The current AAC of 2 million m^3/yr includes a the condition that a maximum of 350,000 m^3/yr can be attributable to non-pine coniferous tree species volume as indicated in the Harvest Billing System (HBS).

Table 2 Historical and current AAC

	1982	1987	1996	2001	2004	2011
AAC (000,000 m^3)	1.5	1.5	1.5	2.96	3.16	2.0

Harvesting for the past decade (from 2010 - Figure 5[7]) was typically less than the AAC (averaged ~1.7 million m^3/yr), but it has been largely focused on pine.

[5] Site productivity is measured using average site index (height of dominant and co-dominant trees at age 50)

[6] Forsite Consultants Ltd. 2013. *Lakes TSA - Type 4 Silviculture Strategy, Situational Analysis.* Technical Report.

[7] BC Ministry of Forests, Lands and Natural Resource Operations. 2012. *Monitoring Harvest Activity Across 28 Mountain Pine Beetle impacted Management Units.*

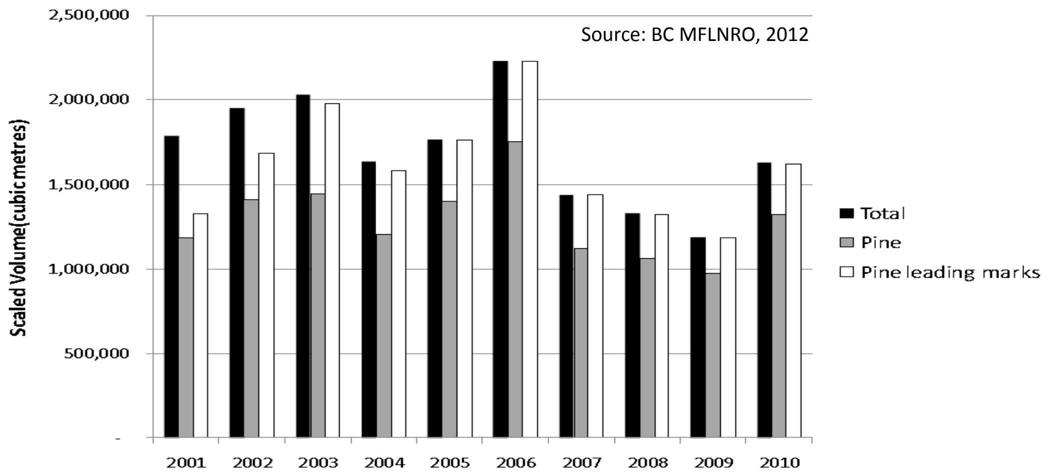


Figure 5 Total harvest, pine harvest and harvest from pine-leading marks

1.4.2 Timber Supply

The prevalence of pine-leading stands on the TSA (64% of the forested landbase), and very high mortality rates (76%) in mature Pl result in severe implications on timber supply. Figure 6 shows projections of the cumulative pine volume killed by the MPB assuming no management intervention[8].

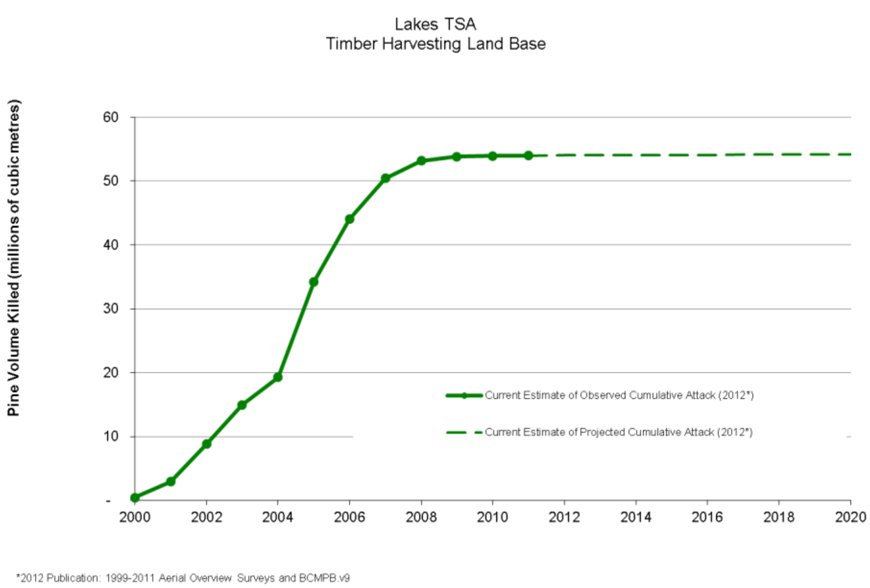


Figure 6 Data and projections of cumulative volume killed by the MPB.

Key timber supply issues that arise as a result of the severe MPB outbreak include:

- While the current harvest is focused on severely attacked stands in the TSA, it is likely that a large number of stands will die and remain unsalvaged. This will lead to a period of high fire

[8] BC Ministry of Forests, Lands and Natural Resource Operations. 2013. *Provincial-Level Projection of the Current Mountain Pine Beetle Outbreak: Update of the infestation projection based on the Provincial Aerial Overview Surveys of Forest Health conducted from 1999 through 2012 and the BCMPB model (year 10).*

hazard due to the high incidence of standing dead timber and/or impaired regeneration. The MPB fuel hazard will continue to be an issue for up to 50 or 60 years depending on the site characteristics.

- As a result of growing stock losses from MPB, the forecasted harvest flow exhibits a significant mid-term trough for 40-60 yrs. How fast managed stands can be brought online directly affects the size and depth of this trough.
- Shelf life refers to the time period over which dead Pl stands degrade until they are no longer economically viable. While varying throughout the landbase, dead Pl tends to retain at least a portion of its value for sawlogs for 14 years after attack.
- It is probable that many immature Pl stands impacted by the MPB have little or poor natural regeneration and will require some form of rehabilitation to remove existing stems, prepare the site and reforest.
- Some unsalvaged MPB-attacked stands contain sufficient understory advanced regeneration and non-pine trees as secondary stand structure to contribute to the mid-term timber supply. Section 43.1 of the FPPR requires protection of this secondary stand structure.
- Given the magnitude of area affected by MPB across many age classes there will be a significant shift of stands into a narrow range of age classes leading to increased fuel continuity across the landbase which can result in more severe wildfires. In turn, these stands, unless impacted by wildfire, will all become available for harvest again at the same time period in the future and, once again, become susceptible to a future MPB infestation.

1.4.3 Timber Quality

Key timber quality issues that arise as a result of the severe MPB outbreak and subsequent dead pine salvage include:

- Dead standing pine trees will gradually decay and eventually fall down or burn up. Shelf life assumptions are used to estimate the average rate of this process.
- The salvage period for MPB-killed pine is generally expected to yield low harvest volumes with small piece sizes mixed with incidental harvest of live trees.
- After the salvage period, as the harvesting enters the mid-term period, green stands will become available and timber quality is expected to improve.
- Near the end of the mid-term (approximately 30 years from now), the harvest is expected to again consist of young, low volume, small piece sizes from stands that are 40 to 60 years old.
- Minimum merchantability criteria reflect the smallest average piece size or stand volume acceptable for harvesting. Reducing the minimum timber quality expectations can support a higher mid-term harvest level. Typically, this becomes critical towards the end of the mid-term period as harvesting transitions from existing natural stands to managed stands. The desired quality of available timber during this critical period is therefore associated with these minimum merchantability criteria and shorter rotation ages that lead to decreasing piece sizes.

1.4.4 Habitat Supply

Key habitat supply issues that arise as a result of the severe MPB outbreak include:

- Lands currently reserved to protect sensitive species, riparian habitat, wildlife tree patches, designated wildlife habitat areas and old growth management areas are affected both directly and indirectly.
- In the mid-term, when timber availability is at its lowest, harvesting will be forced into non-pine stands that are also important for their non-timber values.
- In many cases, the pattern of pine mortality has reduced the structure and value associated with existing plans for landscape connectivity.
- Some wildlife species will be negatively affected by the increased relative road density required to salvage dead pine.
- Cattle use within riparian areas and newly planted areas will continue to be a concern for managing both habitat and timber supply.

1.4.5 Landscape and Watershed

Key landscape and watershed issues that arise as a result of the severe MPB outbreak include:

- The loss of mature and old pine will likely increase risks of higher peak flow and impacts to aquatic species/ecosystems and supply of domestic water.
- Accelerated harvest rates for salvaging dead pine stands increases road densities and overstory removal that can alter water quality and quantity aspects within watersheds.
- Development and monitoring of a landscape retention strategy on retaining forest structure in large-scale salvage operations was identified as means to maintain non-timber values that contributes towards increasing mid-term harvest levels.
- Land use plans may no longer be synchronized with the current status of the productive forest. Updating these plans could significantly impact the availability of short- and mid-term volumes.
- Increased wildfire activity coupled with harvesting impacts will result in less standing timber and vertical structure for the range of ecosystem services it provides.

1.4.6 Climate Change

Rapid change in climate is an overarching pressure on the forests; affecting both timber and environmental values. The exact timing, location and magnitude of future climate change and the unavoidable impacts associated with increased climate variability and extreme events are uncertain – but we expect them to occur. Examples of how climate change is affecting forests and forest ecosystems include:

- Some tree species are increasingly vulnerable to damage and mortality on specific sites:
  - Spruce in the SBS from drought stress and forest health;
  - Pine in the IDF and SBPS from Elytroderma needle cast and drought stress;
  - Douglas-fir in grassland-forest interfaces from drier conditions; and
  - Whitebark pine in the ESSF from blister rust and MPB.
- Some ecosystems are becoming increasingly vulnerable to damage:
  - Salmon streams from low flow, warmer temperatures and little opportunity to shift to better habitat;

  - High elevation forests trapped between unproductive alpine areas and the upward shift of lower elevation forests;
  - Spruce in wetter subzones of the SBS from decreased precipitation;
  - Forested wetlands turning to productive forest from dropping water tables
- Weather is the main influencing factor on:
  - Fire starts with lightening as a major cause;
  - Fire spread, as many major fires are the result of a combination of extended drought drying fuels, and wind that pushes fire spread;
- Weather is quite unpredictable from year-to-year (e.g., 2009 and 2010 were record extreme fire years, while 2011 was a record for being a non-forest fire year);
- Future conditions as a result of climate change remain somewhat uncertain and depend upon numerous factors, one of which is which global emission scenario plays out. Even with optimistic carbon reduction projections, significant impacts are predicted for the southern interior of BC.
- Haughian, S. et al (2012) predicts an increase of 4^0C by 2080 will:
  - increase fire size (doubling from an average of 7,961 ha to 19,076 ha);
  - increase fire severity (by 40% in spring, 95% in summer and 30% in fall);
  - increase fire season length and fire frequency (by 30%);
  - increase crown fire ignition and severe fire behaviour (by 4% to 7%) and,
  - decrease the extent of fire free areas (by -39%).
- Haughian, S. et al (2012) also predicts the annual area burned in the boreal ecozones will increase by 50% to 300% in the next 100 years. This estimation is supported by research done in the US National Research Council that shows an increase in median area burned for a 1^0C increase in global average temperature from 241% for northern rocky mountain forest to 428% for cascade mixed forest – both forest types that extend into the southern portion of British Columbia (National Research Council, 2011).

Long-term adaptation strategies for climate change must complement short- and medium-term strategies for mitigating impending timber supply and environmental challenges resulting from the MPB epidemic.

2 Silviculture Strategy

2.1 Working Targets

Provincial Timber Management Goals and Objectives (under development) will provide context and direction for the Lakes TSA. Local timber goals and objectives rationalize the provincial priorities and goals in the context of local conditions, needs and local values. These objectives will be linked to a set of management targets. Provincial timber management targets (e.g., for timber volume flow over time, timber quality, tree species compositions and productivity and growing stock, inherent site capacity) derived from the TSR or similar processes must be achieved at the management unit level unless there is a rationale for not doing so.

Working targets were created and used to influence modelling decisions and in-turn, outcomes for all of the modelled scenarios in this project. Not all targets are achievable because of limited budgets or conflicts between targets, but they are still presented in Table 3 to frame the high level objectives of the Lakes TSA:

Table 3 Working Targets

Indicator	Working Targets
Timber Volume Flow Over Time:	**Short-Term** (1-10yrs): Maximize salvage of dead pine using the current AAC of 2.0 million m³/yr; salvage - harvest older stands before they deteriorate below minimum merchantability (140 m³/ha). **Mid-Term** (11-80yrs): Maximize mid-term harvest levels by accepting decreased long-term harvest levels. **Long-Term** (≥81yrs): Maintain the highest stable growing stock over time.
Timber Quality:	After the salvage period, harvest stands once they achieve minimum merchantability (140 m³/ha) and maintain a supply of peeler logs (200,000m3/yr of Sx/Fd 8”top, 17’2”).
	Short-Term (1-10yrs): Capture economically viable sawlog volumes before stands deteriorate. **Mid-Term** (11-80yrs): Maximize stand values to the extent possible as the main focus is on maximizing recoverable volume. **Long-Term** (≥81yrs): Regenerate newly harvested areas with silviculture practices that improve timber quality.
Habitat Supply:	Throughout the planning period minimize negative impacts to water resource, ecosystems and species by meeting current legal objectives with respect to terrestrial biodiversity, aquatic, and riparian values through both operational and silviculture activities.

2.2 Overview of Scenarios

A base case scenario was developed and compared against five base case sensitivities and eight silviculture scenarios (see Table 4). Each silviculture strategy was assigned a maximum annual budget for implementing treatments ($3 M/yr). Input assumption and outputs for each scenario or silviculture activity are presented in the Data Package and/or Modelling and Analysis Report for this project.

Table 4 Scenario Overview

Scenario Type	Scenario	Scenario Description / Objective
Base Case	Base Case	Models current practice using best available information.
Base Case Sensitivities	Harvest Sequencing	Effect on short- and mid-term harvest levels from an immediate reduction in the current AAC uplift: (1) establishing the highest flat-line harvest level throughout the short- and mid-term, (2) steadily increasing only the first term harvest level while accepting some loss in harvest level throughout the mid-term.
	Cycle Times	Examined how physical limitations with log hauling can impact the harvest flow by restricting harvesting from areas designated within the maximum hauling criteria of two or more trips per day.
	Hydrology	Impact of constraining harvests within proposed fisheries sensitive watersheds (FSW) by considering proposed Hydrologically Equivalent Disturbed Area (HEDA) thresholds and additional riparian retention for S4, S5 and S6 streams.
Silviculture Scenarios	Single Fertilization	Impact to harvest flows from applying fertilizer one time throughout the rotation of pine and spruce stands.
	Multiple Fertilization	Impact to harvest flows from applying fertilizer multiple times throughout the rotation of pine (every 10 years) and spruce stands (every 5 years).
	PCT & Fertilization	Impact on harvest flow from reducing the density of over-stocked stands (typically 5,000-20,000 sph) to increase opportunities for subsequent fertilization treatment(s).

Scenario Type	Scenario	Scenario Description / Objective
	Rehabilitation	Impact to harvest flows from rehabilitating MPB impacted stands with little or no salvage opportunity. Rehabilitation provides extra merchantable (green) volume at the time of treatment (that would not have otherwise entered the marketplace) and increases the long-term harvest level as managed stand performance is significantly improved.
	Composite Mix - $3M/yr Composite Mix - $7M/yr	Impact to harvest flows from including assumptions for all silviculture strategies so that the model can select the timing and range of treatments that produces the most appropriate outcome using budget constraints of: a) $3 M/year and b) $7 M/year

Table 5 provides a summary of the relative impacts to various indicators resulting from the silviculture strategies, relative to the base case. The Modelling and Analysis Report provides more quantitative details.

Table 5 Summary of impacts to indicator categories for each silviculture strategy

	Timber Supply			Timber	Old + Mat	Landscape		Wildlife
Scenario	**Short**	**Mid**	**Long**	**Quality**	**Seral**	**Corridors**	**Visuals**	**Habitat**
Single Fertilization	Nil	(↑)	Nil	Nil	↓	↓	(↑)	(↑)
Multiple Fertilization	(↑)	↑	(↑)	(↓)	↓	↓	(↑)	(↑)
PCT & Fertilization	Nil	Nil	Nil	(↓)	↓	↓	(↑)	(↑)
Rehabilitation	Nil	↑↑↑	↑↑	↑	↓↓	↓↓	↑↑	↓↓
Composite @ $3M/yr	Nil	↑↑↑	↑↑	↑	↓	↓	↑	↓
Composite @ $7M/yr	Nil	↑↑↑	↑↑	↑↑	↓	↓	↑	↓

Note: arrows indicate increases or decreases (↑ or ↓); multiple arrows indicate greater relative impacts

The following points summarize some of the key trends learned from this exercise:

- The Lakes TSA will begin to experience a severe <u>shortage of available volume</u> in 20 years (12.2 M m³; ~31% of current) lasting 3 decades.
- The approach applied in this analysis was to first develop a base case scenario that reflects a realistic harvest forecast. We learned from this, and other analyses[9], that the <u>harvest flow is very sensitive</u> to assumptions involving salvage effort, shelf-life, and minimum harvest criteria.
- The vast majority of the mid-term harvest is from existing natural stands metred out until existing managed stands become merchantable to contribute to the harvest. Because minimum harvest criteria are less than the biological maximum, filling the mid-term typically involves <u>robbing from potential long-term</u> harvest levels.
- Aiming to maximize the mid-term harvest level also maximizes the harvest flow during the rise to the long-term. Ultimately, this affects which stands are available for specific treatment and dampens any ACE that one might otherwise expect to improve the mid-term. In fact, nearly all of the harvest throughout the short- and mid-term comes from natural stands. So, while there are many opportunities to improve forest conditions in the long-term, there are <u>few silviculture treatments that can increase the mid-term harvest level</u>.

[9] Forsite Consultants Ltd. (2013). Quesnel TSA - Type IV Silviculture Strategy, Modelling and Analysis Report. Technical Report.

Forsite Consultants Ltd. (2013). Williams Lakes TSA - Type IV Silviculture Strategy, Modelling and Analysis Report. Technical Report.

- Reducing salvage immediately leaves more green timber on the landbase that can be harvested throughout the mid-term. However, this benefit comes at the cost of increased loss of dead Pl (less salvage) and the economic loss of a reduced short-term harvest level.
- Waiting longer to harvest managed stands (i.e., applying minimum harvest ages based on culmination of MAI versus the minimum stand volume criteria of ≥140 m³/ha) significantly lowers and prolongs the projected mid-term but improves the long-term harvest level, product profile, and harvest costs (also reduces hectares harvested per year and improves age classes distribution).
- Fertilization is an important strategy but not as time-sensitive as others. There are several decades before any of the managed stands will be harvested so there's plenty of time to treat them. First, the model selected treatments that offer more immediate and/or larger gains; then fertilization increased as treatment windows closed.
- Despite the number of times stands can be fertilized, there are limited opportunities for fertilization in the short-term (next 20 years). This is due, in part, to the current lack of stands in suitable age classes (25-80 year old stands). Fertilization opportunities increase 15 years from now.
- Single-fertilization treatments are best carried out closer to harvest to maximize the NPV and minimize risk – but this approach should be used to fully utilize available budgets to ensure the benefit is captured. While there may be more opportunities for multiple-fertilization treatments sooner, risk of investment loss are increased as costs are carried longer.
- Cumulative gains from multiple-fertilization of spruce stands make this treatment the most favourable approach. Still, fertilization of pine stands should not be overlooked given the relative abundance of these stands.
- Given some uncertainty with regenerated stand densities, there are limited opportunities for pre-commercial thinning and fertilization in the short-term (next 20 years). Although this treatment provides very little benefit to timber supply, it can contribute by improving timber quality.
- Rehabilitation provides the largest opportunity to improve harvest flows and warrants significant investment. This treatment accesses wood throughout the mid-term from MPB-impacted stands that are otherwise assumed to be ineligible for harvesting. It also adds to the long-term harvest by putting these stands back into production.
- The area eligible for rehabilitation is largely dependent on access, market prices for fibre and innovative funding mechanisms to promote rehabilitation. This treatment should initially focus on treating younger or burned stands and those with lower merchantability while deferring stands with live volumes that can rehabilitated in the mid-term.
- Regardless of the budget allocated to alleviate the mid-term timber supply shortage, a combination of scheduled activities produces the highest overall gains in timber supply and return on investment.

2.3 Preferred Silviculture Strategy

The forest estate model used in this analysis applied a goal-seeking approach that scheduled numerous activities across time and space to arrive at the best solution given defined targets. Consequently, for any given funding level, the composite mix of silviculture strategies should produce a preferred silviculture strategy.

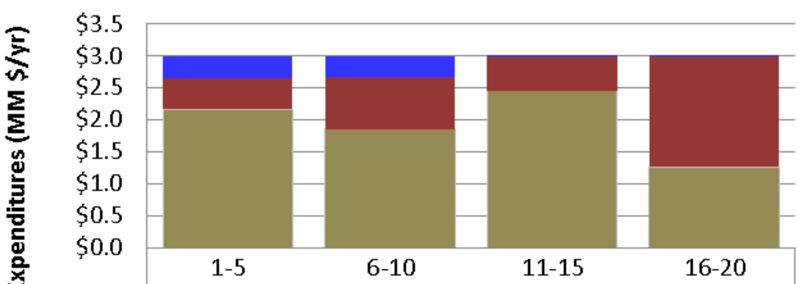
In this analysis, the model results suggest that the higher budget level ($7 M/yr) is the preferred strategy since compared to all other strategies explored, this strategy produced the:

- Highest increase in the mid-term harvest level (166,000 m³/yr or 29%)
- Highest increase in rise-to-the-long-term harvest levels (137,000 m³/yr or 12%)
- Highest increase in long-term harvest levels (102,000 m³/yr or 7%)

It is not appropriate to simply apply the modelling output as the preferred strategy. Adapting outputs from the strategic plan into a tactical plan requires interpretation of the learning achieved from the individually modelled silviculture scenarios and in depth understanding of the modelling assumptions and limitations.

While the preferred strategy aims to achieve the working targets discussed above, the primary goal is to deliver more timber volume throughout the mid-term trough (11-80 yrs from now). A diverse suite of activities was recommended to reduce financial risk and uncertainty while providing the means to address multiple values. The preferred strategy also incorporated reasonable transitions from one activity to another when significant changes in the program are scheduled.

Figure 7 shows the expenditures by treatment activity for the next 20 years under the preferred silviculture strategy. Since a constant funding level of $7 M/yr budget is unlikely to occur, this preferred strategy was adjusted by adopting the modelling output from the $7 M/yr budget scenario but reducing the budget to $3 M/yr (more likely) by reducing the area treated under rehabilitation. This provides a more diverse mix of treatments and still provides the option to allocate funding in excess of the $3 M/yr towards rehabilitation treatments. The sections below describe the rationale for determining this mix of activities.



	1-5	6-10	11-15	16-20
PCT	341,000	324,000	11,000	4,000
Fert	495,000	816,000	530,000	1,732,000
Rehab	2,164,000	1,860,000	2,459,000	1,264,000

Figure 7 Expenditures by activity for the preferred silviculture strategy

2.3.1 Rehabilitation

Rehabilitation is the key activity to the overall strategy and currently the highest priority that warrants the majority of available funding. It focuses on ameliorating poorly performing stands severely impacted by MPB to provide more harvest opportunities during the forecasted timber supply shortage (mid-term) while increasing the effective landbase in the long-term.

The general approach for implementing this activity is as follows:

- During the salvage period, focus on treating younger stands without merchantable volume – including fire-damaged areas;

- After the salvage period, shift priority onto stands that optimize various aspects including: merchantable volume, site productivity, haul distance, road access and fire risk.

Funding for rehabilitation may involve expanding the ITSL[10] initiative towards that awards projects through a competitive pricing (minimized cost) process.

The success of this activity depends, in part, on the proponents developing opportunities to improve utilization of merchantable material, improve markets for low quality fibre and/or sequestering carbon credits.

2.3.2 Fertilization

Fertilization plays an important role in the overall strategy despite the limited number of stands currently available to treat. There is no immediate incentive to fertilize since there is still plenty of time to treat these stands that will not be harvested until the end of the mid-term.

The general approach for implementing this activity is as follows:

- Treat stands progressively closest to harvesting to minimize risk of loss and maximize the net present value.
- Prioritize stands according to species types: 1) spruce, 2) pine.

Fertilization will likely continue to be delivered through the Land Base Investment program.

2.3.3 Pre-Commercial Thinning and Fertilization

This is considered a much lower priority than the previous treatments. According to the current forest inventory, there are limited opportunities for this treatment and volume gains are marginal. However, more opportunities may actually exist in the field plus this treatment may be regarded as a cleaning treatment that prepares stands for other treatments, including fertilization (i.e., volume gains over fewer stems), or improving wildlife habitat.

3 Related Plans and Strategies

When implementing the preferred silviculture strategy described above, it will be important to consider and incorporate elements from other related strategies. The following section provides a brief introduction to these initiatives, an explanation of how and where they might influence or integrate with planned silviculture treatments or actions, a discussion on how they might be impacted by climate change, and references to more information.

3.1 Climate Change

The rate of change in climate over the last 100 years is equivalent to the rate of change of the preceding 1000 years. Rapid change in climate is an overarching pressure on the forest, affecting both timber and environmental values. Table 6 provides links to other sources for information on climate change.

10 ITSL – Innovative Timber Sales License – Means to market mountain pine beetle-attacked, pulp and other timber

Table 6 Sources for information on climate change

Source	Link
Overview of Guidance to Adapt Forest Management for Climate Change in the Kamloops TSA	www.for.gov.bc.ca/ftp/HFP/external/!publish/Web/FFESC/reports/NelsonrevisedK2adaptationguidanceoverview120607.pdf
Successional Responses to Natural Disturbance, Forest Management, and Climate Change	jem.forrex.org/index.php/jem/article/viewFile/171/113
Climate-based seed transfer modelling	www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr048.htm
Tree species regeneration vulnerability assessment for the central Interior of BC	www.for.gov.bc.ca/ftp/hfp/external/!publish/web/ffesc/reports/FFESC-Technical-Report_ProjectA2_Nitschke.pdf
Kamloops Future Forest Strategy II	www.for.gov.bc.ca/ftp/HFP/external/!publish/Web/FFESC/reports/Nelsonfinalreport.pdf
Transdisciplinary vulnerability assessment, Nadina Forest District	bvcentre.ca/research/project/a_multi-scale_trans-disciplinary_vulnerability_assessment
Stand/landscape level decision-support to reduce drought & disturbance risks	www.for.gov.bc.ca/hfp/future_forests/council/#completed-projects
Climate Change in Prince George Summary of Past Trends and Future Projections 31 August 2009	pacificclimate.org/sites/default/files/publications/Werner.ClimateChangePrinceGeorge.Aug2009.pdf
Preliminary Analysis of Climate Change in the Cariboo-Chilcotin Area of British Columbia	pacificclimate.org/sites/default/files/publications/Werner.ClimateChangeCaribooChilcotin.Sep2008.pdf
Effects of Climate on Mortality of Young Planted Lodgepole Pine	foothillsresearchinstitute.ca/Content_Files/Files/FGYA/FGYA_2008_12_Qknte12_EffectsClimateMortalityYoungLodgepolePine.pdf
Impacts of Climate on Forest Health - Lodgepole pine ecosystems 2010	foothillsresearchinstitute.ca/Content_Files/Files/FGYA/FGYA_2010_10_Poster_ImpactsClimateChangeOnForestHealth.pdf
Managing Risk and Uncertainty in Lodgepole Pine – A Shifting Paradigm	www.growthmodel.org/wmens/m2011/Dempster.pdf
Pacific Climate Impacts Consortium	www.pacificclimate.org/tools-and-data/plan2adapt
ClimateBC Map – UBC Centre for Forest Conservation Genetics	www.genetics.forestry.ubc.ca/cfcg/ClimateBC40/Default.aspx

To encourage more discussion and possible modelling in future silviculture strategies, the sections below include a brief discussion of how climate change might affect each related plan and strategy.

3.2 Tree Species Deployment

Concerns have been expressed about the diversity of tree species over time and the lack of clear objectives (e.g., Auditor General's report[11]). A recent report from FLRNO[12] focuses on the harvested landbase and provides an assessment of the species distribution from a variety of data sources and points in time.

Building on the methodology developed as part of pilot project[13] inventory data were used to produce summaries of species composition by age class. Information was also gathered for the Lakes TSA on the projected shifts to BEC subzone from climate change. Using the existing inventory, ecologically-based species benchmarks were developed for each BEC variant based on professional opinion and field experience. These benchmarks were expected to be feasible from both ecological and silvicultural perspectives, and desirable at the landscape level regardless of the management objectives.

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[11] http://www.bcauditor.com/pubs/2012/report11/timber-management

[12] Species Monitoring Report Lakes TSA, May 2012, MCMFLNRO Resource Practices Branch

[13] Mah, S., K. Astridge, C. DeLong, C. Wickland, M. Todd, L. McAuley, B. Heemskerk, E. Hall, A. Banner, D. Coates, and P. LePage. 20・2. A landscape-level species strategy for forest management in British Columbia: exploration of development and implementation issues. Prov. B.C., Victoria, B.C. Tech. Rep. 067.

This approach is a first step in managing species at the landscape scale. Future iterations may recommend finer scales and promote not only species direction but provenances as well. Sowing requests will be used to help track direction in the short term. These trends and targets should be revised yearly comparing sowing requests to the trend/target, particularly once the harvest moves from Pl dominated stands.

Table 7 summarizes the direction towards a desired percentage by species by Biogeoclimatic subzone. This information is for planted stock and may not fully reflect the species diversity that will emerge through additional natural regeneration over time. At times, the nature of the stands being logged (i.e., pine stands that are suited to pine), suggests the trend should remain the same.

Table 7 Guidance for tree species deployment on harvested areas

BEC		Pl	Sx	Bl	Fd	Lw	Comments
ESSFmc	Current	75/43	20/40	6/15			Maintain the trend of reduced reliance of Pl. Maintain the trends for Sx and Bl (expect Bl naturals).
	Target	5-10	40	50			
	Trend	---	---	---			
SBSdk	Current	80/60	20/40		0/5	0/2	Maintain the trend of reduced reliance of Pl. Maintain use of Sx and aim for the 30% target. Promote Fd towards the 20% target at the landscape Promote Lw use and manage towards target.
	Target	30	40		20-25	10-15	
	Trend	---	---		---	↑	
SBSmc	Current	70/59	20/40	7/2	0/1	0/1	Maintain reduced reliance of Pl and aim for the 25% target. Maintain present trend and practice for Sx by planting 40% Sx at cutblock level. Promote Fd on non-frost prone sites. Maintain the trends, use Lw where suited (e.g., non-frost prone sites). Maintain Bl with naturals.
	Target	25-20	40-45	20-30	10-20	0-5	
	Trend	---	---	---	↑	---	

Current = proportions logged/planted
Trend = whether it is desired to increase (↑), decrease (↓) or maintain (---) the proportion logged/planted
Target = a biological target for the unit to trend towards where feasible

Table 8 provides links to other sources for information on tree species deployment.

Table 8 Sources for information on tree species deployment

Source	Link
Landscape-Level Species Strategy	www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr067.pdf
Species Monitoring Report - Province	www.for.gov.bc.ca/hfp/sof/species/Spp%20Monitoring%20Report%20-%20Province%20(May%2010,%202012).pdf
A Short History of the Control of Species Selection for Reforestation in BC	www.for.gov.bc.ca/hfp/silviculture/Stocking_stds/How%20Species%20Have%20Been%20ControlledDraftver2%20(2).pdf

3.3 Land Use Plans

The Lakes Land and Resource Management Plan (LRMP), legal orders, Sustainable Resource Management Plans (SRMP) and Forest Stewardship Plans (FSP) provide a framework for land use and forest management in the Lakes TSA and establish areas for non-timber values. However, MPB impacts are not limited to areas available for timber harvest. Lands reserved to provide protection for sensitive species, riparian, wildlife tree recruitment, and old growth representation, are also affected both directly by increased mortality of pine and indirectly by impacts of roads, water quality and quantity, and associated habitat impacts.

Until land use plans and other strategies are revisited and amended to address the severe changes in forest structure, prescribing foresters are guided by the established objectives.

Climate change is not expected to impact land use plans directly but rather influence objectives applied in future plans.

Table 9 provides links to other sources for information on land use plans.

Table 9 Sources for information on land use plans

Source	Link
Lakes LRMP	www.ilmb.gov.bc.ca/slrp/lrmp/smithers/lakes/index.html
Order Cancelling Land Use Objectives 1-5 and 7 of the Lakes LRMP	www.ilmb.gov.bc.ca/slrp/lrmp/smithers/lakes/index.html
Lakes Higher Level Plan Order	archive.ilmb.gov.bc.ca/slrp/lrmp/smithers/lakes/legal_documents/files/Lakes_HLP_Final.pdf
Lakes North SRMP	www.ilmb.gov.bc.ca/slrp/srmp/north/lakes_north/index.html
Lakes South SRMP	www.ilmb.gov.bc.ca/slrp/srmp/north/lakes_south/index.htm

3.4 Landscape Level Biodiversity

The loss of mature and old forest over recent years will have significant impacts on associated aquatic, terrestrial and water values. In many cases, appropriate thinning can accelerate old growth attributes. While these management opportunities exist, none of the silviculture strategies explored in this analysis aimed to maintain or improve future forest condition towards established mature seral targets.

Stand structures that serve to connect habitats across a landscape will be impacted by accelerated salvage harvesting, reduced retention and the risk of large-scale fires and can result in disproportionate impacts to species at risk or those confined to isolated pockets of suitable habitat. Connectivity is provided in the Lakes TSA through various mechanisms including strategies that prescribe retention for specific resource management zones, conservation legacy areas, mature and old seral retention, and riparian management provisions.

Prescribing foresters can enhance connectivity by increasing retention levels in large cutblocks within riparian areas, gullies, connectivity corridors and surrounding wildlife habitat features.

Climate change is expected to impact landscape biodiversity through increased forest disturbance. This may be mitigated by treatments designed to reduce risk of damage from wildfire or pests.

Table 10 provides links to other sources for information on landscape level biodiversity.

Table 10 Sources for information on landscape level biodiversity

Source	Link
Successional Responses to Natural Disturbance, Forest Management, and Climate Change	jem.forrex.org/index.php/jem/article/viewFile/171/113
Current State of Knowledge Regarding Secondary Structure in MPB Impacted Landscapes	www.for.gov.bc.ca/hts/pubs/MPB_Impacted_Stands_Report_January_20_2012.pdf

3.5 Forest Health

The forest health strategy [14] aims to recommend actions to address forest health issues. A list of significant forest health agents and current strategies is provided in Table 11.

Table 11 Forest health agents and strategies for high and very high priority pests

Agent	Strategy
Mountain pine beetle	Apply tactical matrix based on the following: • Tactic 1: single tree harvesting of infested trees. • Tactic 2: small patch sanitation (< 1.0 hectare patches) • Tactic 3: small clear-cut (between 1.0 and 5.0 hectares **or** less than 2000m^3 **or** a non-clear-cut system) • Tactic 4: standard harvest practices (clear-cut and clear-cut with reserves) • Tactic 5: no treatment; leave as is
Spruce beetle	Apply tactical matrix based on the following: • Tactic 1: Fall and Burn • Tactic 2: conventional trap trees • Tactic 3: single tree harvesting of infested trees • Tactic 4: small patch sanitation (< 1.0 hectare patches) • Tactic 5: small clearcut (between 1.0 and 5.0 hectares or greater than 500m^3 and less than 2000m^3). • Tactic 6: standard harvest practices (clearcut and clearcut with reserves) • Tactic 7: no treatment
Rusts: • Comandra • Stalactiform • Western gall	• Increase planting densities 2200-2500 stems per hectare; • Plant non-host species such as Hybrid spruce, Subalpine fir, Western Larch and Interior Douglas fir; • No spacing in high risk areas; • Conduct silviculture surveys during the spore window (June thru July); • Continue to report survey information in RESULTS.
Warren's root collar weevil	In high hazard areas, especially SBSmc subzones in areas where adjacent standing MPB-killed trees have been dead for 5 years, consider the following tactics: • Include a general assessment of root collar weevils within the area to be harvested and the adjacent mature pine stands for an indication of weevil populations; • Delay planting by 2-3 years. Seedlings will not be attacked until they have a root collar of at least 2 cm; • Plant a less susceptible tree species along cutblock edges. Host species are mainly Lodgepole pine, but also Engelmann, white, and hybrid spruce; • Reduce duff layers. This includes treatments such as broadcast burning, scarification mounding and disc-trenching; • Increase planting density. Recommend higher than 1600 sph in anticipation of mortality; • Delay spacing until stand is at least 20 years old; • Produce hazard and risk mapping.

Source: Nadina Forest District, Forest Health Strategy 2010-2011, April 2010, 52p.

Climate change is expected to increase the frequency and intensity of severe wind-throw events and outbreaks of insects - particularly bark beetles[15], and pathogens [16]; undoubtedly leading to more challenging decisions regarding silviculture investments and priorities.

[14] Nadina Forest District, Forest Health Strategy 2010-2011, April 2010, 52p.

Table 12 provides links to other sources for information on forest health.

Table 12 Sources for information on forest health

Source	Link
Nadina District (Morice and Lakes TSA) Forest Health Strategy	www.for.gov.bc.ca/hfp/health/TSA_strategies.htm
MFLNRO Forest Health Program	www.for.gov.bc.ca/hfp/health/index.htm
Forest health and climate change: A BC perspective	bcwildfire.ca/ftp/HFP/external/!publish/ClimateChange/FRPA/Workshop/Forest_Health_CC.pdf

3.6 Wildfire Management

The BC Wildfire Management Strategy [17] aims to encourage healthier ecosystems, reduce the risk of loss to communities, recognize and plan for climate change, and enable more cost-effective wildfire response. The five strategies that aim to achieve these goals are to:

- Reduce the hazards and risks associated with wildfire in and around communities and other high-value areas.
- Plan and implement careful use of controlled burning in appropriate ecosystems under suitable conditions to reduce hazards and risks and achieve healthy forests and grasslands (also see Section 0).
- Allow wildfires to burn in areas where there is minimal risk to identified values. Monitor these wildfires and intervene only when necessary to reduce unwanted losses. Ensure that plans adequately consider the management of wildland fire at all appropriate scales.
- Develop a high level of public awareness and understanding about wildfire and its management.
- Burn-P3 modelling is used to help prioritize areas at risk, set objectives for wildfire risk reduction on the landscape, and support subsequent operational management planning over the next few years. The Wildfire Management Branch's goal is to complete this initiative for all management units in BC by 2015.

3.6.1 Planning Silviculture Activities to Address Wildfire Impacts

Silviculture activities should be planned to recognize and protect values that are at risk from wildfire. Ideally, projects should be located within areas of reduced wildfire risk and aligned in larger, more cohesive units that can be easily identified as a priority value for suppression. The process below describes the silviculture activities that can be deployed to address different wildfire risks and management objectives.

There are two key components to evaluating silviculture treatments from a wildfire management perspective:

1. Design treatments that reduce wildfire risk and consequences to life, property and other values, and

[15] Carroll, A. 2012 Predicting Forest Insects Disturbance under Climate Change. http://www.for.gov.bc.ca/ftp/HFP/external/!publish/Web/FFESC/reports/Carrollfinalreport.pdf

[16] Woods, A.J., Heppner, D., Kope, H.H., Burleigh, J. and Maclauchlan, L. 2010. Forest health and climate change: A British Columbia perspective, The Forestry Chronicle, Volume 86, Number 4. 11p.

[17] British Columbia Wildland Fire Management Strategy, September 2010, 21p.

2. Locate treatments to minimize the likelihood of loss of the investment from wildfire.

At this time, it is recommended that the burn probability map (Burn-P3) be used in conjunction with local input on values and risk, to identify and prioritize candidate treatment areas based on wildfire hazard. As Fire Management Plans evolve they will include landscape level wildfire management objectives and strategies based on local input. Proposed treatments should be consistent with Fire Management Plan objectives and strategies (when they are available) and contribute to the development of a fire resilient landscape. Communities that have been identified as the highest risk should be targeted for amelioration treatments first. Other communities with lower risk, and other values outside of the wildland urban interface (WUI) (e.g., critical infrastructure, critical habitat, community watersheds) at high risk from wildfire, should be considered a high priority for amelioration treatments.

Table 13 illustrates the relationship between forest management activities and fire management. It is intended to assist prescribing foresters to consider wildfire risk when planning silviculture treatments. For example, a lower priority is assigned to proposed treatment areas where silviculture activities are likely to contribute to the fire hazard, or where there is a high probability of long term silviculture investments being lost to wildfire or fuel reduction treatments in the interface. Alternatively, a higher priority is assigned to proposed treatment areas where activities will likely mitigate the risk of losses from wildfires and have a higher likelihood of growing to a commercial harvest age. It is generally preferable to locate silviculture investments in low or moderate fire risk areas, however, under some circumstances, silviculture investments can be made in areas of higher fire risk, provided appropriate hazard mitigation is part of the investment and the resulting treated stand does not increase the hazard to communities and other values over time.

Although Table 13 does not specifically discuss prescribed burning, it can be an effective tool to reduce fuel loading and accomplish other objectives. Consideration should be given to how the planned treatment fits in with adjacent areas, and how it contributes to the creation of effective landscape level fuel breaks and a fire resilient landscape.

Table 13 Forest management priorities for wildfire management

Treatments		Treatment Outcome (Fire Perspective)	Lower priority where…	Higher priority where…
Harvesting	Clearcut	Reduce fuel loading and eliminate crown fire risk (short term)		High values and high hazards exist; create fuel breaks
	Partial cut	Reduce crown bulk density - reduce crown fire risk (1); may increase surface fuel loading (2)		High risk interface area (3) identifies a need to treat fuels; mitigate risk
Silviculture	Enhanced Reforestation	May have surface fire potential, depending on residual slash load and grass/ herbaceous fuel loading	Burn probability is highest; avoid lost silviculture investments	
	Alternate Reforestation (4)	May have surface fire potential, depending on residual slash load and grass/ herbaceous fuel loading		Burn probability is highest; mitigate losses and protect values
	Prescribed Burn / Ecosystem Restoration	Maintains a natural fire return interval		High values exist with high hazard and risk; treat fuels and improve forest health/habitat

Treatments		Treatment Outcome (Fire Perspective)	Lower priority where…	Higher priority where…
	Spacing to normal stocking levels	Reduce fuel loading – lower fire intensity; may increase surface fuel loading	Burn probability is highest; avoid lost silviculture investments	
	Spacing to lower densities combined with fuel reduction	Reduce fuel loading – lower fire intensity (5)		High values exist to protect community and Infrastructure High risk interface area (3) identifies a need to treat fuels; mitigate risk Burn probability and fire intensity criteria are the highest; mitigate fuel loading
	Fertilization	May increase crown bulk density and higher surface fuel loading (due to increased growth of understory vegetation)	Burn probability is highest (except in interface); avoid lost silviculture investments Avoid treating areas in the WUI (increased fuel loading and crown bulk density).	Burn probability is lower; avoid lost silviculture investments. Treat areas outside of the WUI.
	Pruning	Increase crown base height. Pruned branches will increase surface fuel loading unless they are removed, or decay over time.		Burn probability is lower; avoid lost silviculture investments. High risk interface areas – provided surface fuel loading is reduced concurrent with the pruning treatment.
Rehabilitate	Knockdown and site preparation	Reduce fuel loading and eliminate crown fire risk (short term)		High risk interface area (3) identifies a need to treat fuels; mitigate risk
	Plant and brush	May have surface fire potential, depending on residual slash load	Burn probability is highest; avoid lost silviculture investments	

(1) This treatment may also increase crown fire potential in certain areas due to increased air flow through the stand. Care needed with surface fuel load and crown base height

(2) Higher surface fuel loading can result in more intense surface fires. Higher intensity surface fires have the potential to increase crown fire potential.

(3) Identified through a Community Wildfire Protection Plan (CWPP) or Provincial Strategic Threat Analysis (PSTA)

(4) Encourage deciduous or other fire resistant species

(5) Intensity (I) is a function of the heat of combustion (H), weight of the fuel (W) and rate of spread of a fire (R) I=HWR

It is important to recognize that most of the treatments discussed in Table 14 have a limited amount of time where they will be effective from a fire management perspective. As trees and other vegetation grow, ingress may occur, and fuels accumulate, the wildfire hazard will increase. It is important to design treatments to be effective over the long term, or plan for follow-up treatments to maintain effectiveness.

To illustrate how wildfire management might be considered to prioritize silviculture treatments, Figure 8 shows an example of two types of treatments: fertilization (green) and pre-commercial thinning (pink) in relation to areas within and outside of a community interface area. Applying the principles in Table 13, silviculture treatments can be planned to maximize the protection of life, property and other values, while minimizing the risk of losing the silviculture investment to future wildfire as follows:

1. Fertilization of an area with high burn probability within the interface area is a low priority in untreated stands (i.e., high probability of losing the investment from future fuel reduction treatments).
2. Fertilization in an area with moderate burn probability and outside the interface area is a higher priority (i.e., high probability of the treated stand reaching maturity and being harvested). Outside of the interface areas traditional pre-commercial thinning may be acceptable; although this may not be acceptable immediately adjacent to the WUI (i.e., creating a large fuel load immediately adjacent to the WUI may not be consistent with risk mitigation).
3. Spacing to lower densities and fuel reduction in an area with high burn probability within the interface area is a high priority (i.e., reduced risk to life and property, with the potential for some future harvest volume). Within the interface areas: combine the pre-commercial thinning with concurrent fuel reduction treatments, selection for fire resistant species, and reduced stocking levels.

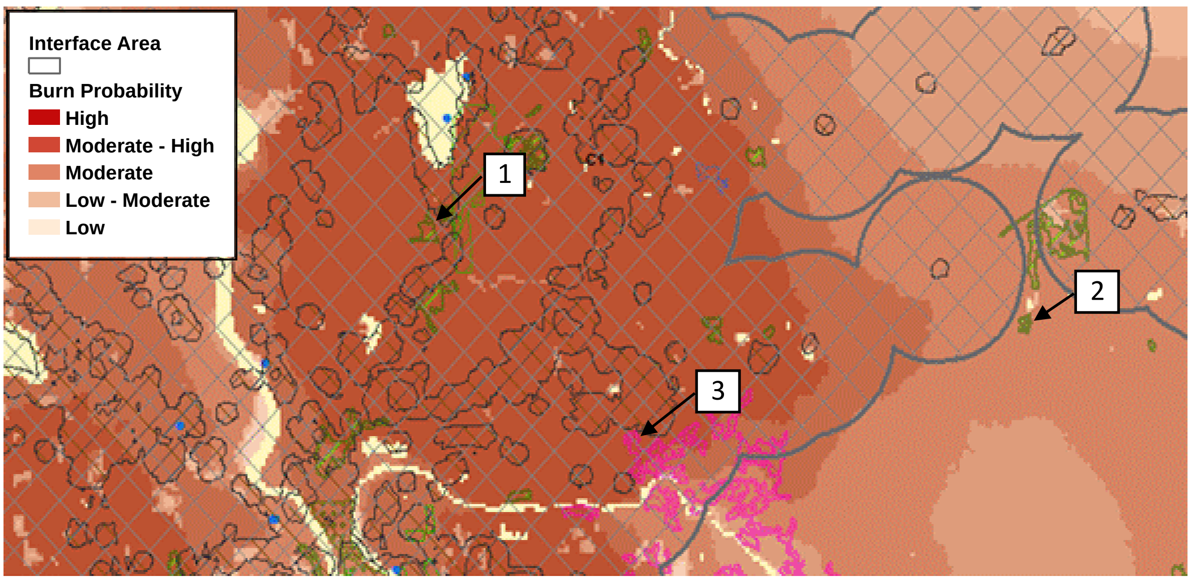

Figure 8 Map showing burn probability, interface areas and candidate treatment areas

3.6.2 Trends in Wildfire Impacts

Changing weather, climate and fuel types are expected to result in longer fire seasons, more area burned and more extreme wildfire behaviour[18] resulting in reduced suppression success. Limited firefighting capacity will focus on protecting interface values first and will likely result in more ecological and timber values being lost to wildfire.

With over 7 million hectares of hazardous fuels in full response zones[19] provincially[20], Wildfire Management Branch is not capable of responding to all wildfires in a major wildfire event.

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[18] de Groot, W.J., Flannigan, M.D., and Cantin, A.S. (2013). Climate change impacts on future boreal fire regimes. Forest Ecology and Management. 294:35-44.

[19] Full response zones are areas where a wildfire requires immediate, aggressive initial attack and or sustained suppression action until the fire is declared out.

[20] Haughian, S., Burton, P., Taylor, S., Curry, C. 2012. Expected Effects of Climate Change on Forest Disturbance Regimes in British Columbia. BC Journal of Ecosystems and Management 13 (1) 1 – 24. Published by Forrex: Forest Extension for Research and Natural Resources. British Columbia. Canada.

Consequently, wildfire response priorities may limit suppression actions to the protection of communities and critical infrastructure during mass wildfire starts which are often triggered by lightning. In these situations, protecting natural resource values becomes a very low priority, as was experienced during the 1985, 1994, 1998, 2003, 2009, and 2010 wildfire seasons, when wildfire response was often focused entirely on interface fires. At fire intensities exceeding 4,000 kW/m most fire control efforts (direct fire control) are unlikely to succeed and may be limited to flank attacks or curtailed completely until extreme wildfire behaviour ameliorates[21].

Due to the predicted extreme intensity of some MPB fuel fires, suppression success may be very limited until major weather changes occur. This was evident in the 2010 wildfires that affected the Lakes TSA.

Climate change is expected to increase the frequency and intensity of wildfires[22]; undoubtedly leading to more challenging decisions regarding silviculture investments and priorities. Table 14 shows the expected impacts on wildfires due to climate change using a relatively conservative estimate of 25% increase in burned area each decade over the next four decades (i.e., into the mid-term period) and the projection of recently burned areas in the Lakes TSA (12,600 ha in the THLB since 2003[23]). The projected total impact on the THLB is 81,900 ha or 12.3 million m^3 (at 150 m^3/ha).

Table 14 Expected impacts of climate change on wildfires

Increase in Area Burned	Period	Projected Area Burned (ha)
25%	2012 – 2022	15,750
50%	2022 – 2032	18,900
75%	2032 – 2042	22,050
100%	2042 – 2052	25,200

Silviculture priorities and investments should be designed to address the increased frequency and intensity of wildfires [22] due to climate change.

Table 15 provides links to sources for information on wildfire management.

[21] Hirsh, K., Martell, D. 1996. A Review of Initial Attack Fire Crew Productivity and Effectiveness. Int. J. Wildland Fire 6 (4): 199 – 215. IAWF. USA.

[22] Woods, A.J., Heppner, D., Kope, H.H., Burleigh, J. and Maclauchlan, L. 2010. Forest health and climate change: A British Columbia perspective, The Forestry Chronicle, Volume 86, Number 4. 11p.

[23] BC Ministry of Forests, Lands and Natural Resource Operations. 2011. Provincial 2003 to 2010 Wildfire Mapping Update Project, Resources Practices Branch MFLNRO. 18p.

Table 15 Sources for information on wildfire management

Source	Link
BC Wildland Fire Management Strategy	bcwildfire.ca/prevention/PrescribedFire/
Provincial Strategic Threat Analysis Northwest Fire Centre Fire Center Contact –Shannon IrvineShannon.Irvine@gov.bc.ca	Contact Shannon Irvine
Regional District Community Wildfire Protection Plans, Northwest Fire Center Contact - Shannon IrvineShannon.Irvine@gov.bc.ca	Contact Shannon Irvine
Community Wildfire Protection Plans Northwest Fire Center Contact - Shannon IrvineShannon.Irvine@gov.bc.ca	Contact Shannon Irvine
Burn-P3 Modelling - Dana Hicks Fire Management Specialist Contact Dana.Hicks@gov.bc.ca	cfs.nrcan.gc.ca/pubwarehouse/pdfs/25627.pdf
Forest health and climate change: A BC perspective	bcwildfire.ca/ftp/HFP/external/!publish/ClimateChange/FRPA/Workshop/Forest_Health_CC.pdf
Innovative Timbre Sale Licences (ITSL) – Stand Selection Policy	www.for.gov.bc.ca/hcp/fia/landbase/fft/ITSL-FLTC-Stand-Selection-Policy-20120920.docx.
Silvicultural Regimes for Fuel Management in the Wildland Urban Interface or Adjacent to High Landscape Values	www.for.gov.bc.ca/ftp/HFP/external/!publish/LBIS_web/Guidance/FFT%20guidance%20-Silvicultural%20Regimes%20for%20Fuel%20Management%20in%20the%20WildLand%20Urban%20Interface_V2.3.pdf

3.6.3 A Landscape Perspective

A landscape perspective that considers the likely occurrence and impacts of unsuppressed wildfire is critical to protecting the viability of an adequate timber supply and non-timber values (e.g., critical habitat, community water supplies.). A risk assessment identifies hazards in proximity to key values across the landbase Landscape-level fire management objectives (e.g., reduce fire size, reduce fire intensity) are prepared and strategies are identified to make the landscape more resilient to wildfire, which will help to reduce losses to timber supply and environmental values in a bad fire year.

The following strategies can contribute to ameliorating the impacts of wildfire:

- Update and implement Fire Management Plans and strategies to increase fire resiliency and lower wildfire risk to key values.
- Prioritize silviculture programs, ecosystem restoration treatments, and operational timber harvesting (including BCTS FFT ITSL's) on areas that align with landscape-level objectives to reduce wildfire risk to communities, environmental values, and timber.
- Ensure silviculture projects are strategically located within areas of reduced wildfire risk and are aligned in larger, more cohesive units that can be easily identified as a priority value for suppression.
- Locate pre-commercial thinning combined with fuel reduction activities in areas that can buffer high value mid-term timber supply and silviculture investment areas, from crown fires and create more effective wildfire suppression options.

- Ensure that management unit timber objectives, silviculture regimes and stocking standards, integrate wildfire risk reduction strategies, that allows for modified harvesting, fuel reduction and/or the use of alternative species in areas with high or very high wildfire probability.
- Implement stocking standards that are designed to reduce wildfire risk (under development) in and adjacent to high risk/high value areas.
- Implement practices that are designed to reduce wildfire risk in and adjacent to high risk / high value areas (e.g. fuel reduction, thinning to lower densities, retaining fire resistant species[24], etc.).
- Support better integration of Ecosystem Restoration, Forests for Tomorrow, and Fuel Management program planning, to ensure that the right treatments are occurring in the right stands, to achieve the desired patterns of open forest and grassland ecosystem in the interior of BC.
- Build linkages between wildfire management and resource management at the local level to integrate fire into strategic and operational planning and implementation.

3.7 Ecosystem Restoration

In fire-maintained ecosystems of BC's interior, decades of fire suppression and the absence of prescribed burning has contributed to trees encroaching into areas that were historically grassland, as well as, increased tree densities in areas previously considered to be open forests. This type of ecological change reduces ecosystem resiliency to climate change pressures and contributes to many other negative trends.

While there is a more formal ER program developing in the areas east of the TSA, there does not appear to be a consolidated or coordinated approach to ecosystem restoration in the Lakes TSA.

Ecosystem restoration is not a direct, obvious or significant strategy to mitigate the falldown in mid-term timber supply and was therefore not included with this analysis. However, there may be instances where stands currently outside of the THLB could undergo certain restoration treatments, such as partial harvesting or commercial thinning, to return them to an open forest condition. In this case, if the timing is appropriate, the harvested volumes might contribute to the mid-term timber supply.

Difficulties will arise when attempting to fit natural ranges of variability into modern concerns of a changing climate. Climate change concepts must then be applied as best as possible into restoration processes.

Table 16 provides links to other sources for information on ecosystem restoration.

Table 16 Sources for information on ecosystem restoration

Source	Link
Provincial Ecosystem Restoration Strategy	www.for.gov.bc.ca/hra/Restoration/index.htm
Northern Interior Strategic Regional Restoration Plan	www.for.gov.bc.ca/hfd/library/documents/bib98256_NorthernInterior.pdf
Society for Ecological Restoration in North Central BC	www.sernbc.ca
Ecosystem Restoration Guidelines	www.env.gov.bc.ca/fia/documents/restorationguidelines.pdf

[24] Care is needed in species selection, spruce is inherently more flammable than pine based on crown base height.

3.8 Secondary Stand Structure

Section 43.1 of the Forest and Range Practices Act Forest Planning and Practices Regulation requires forest licensees to protect secondary structure (i.e., understory advanced regeneration and non-pine canopies) in MPB affected areas. Harvesting in areas with little to no secondary stand structure and retaining areas with good densities of high-quality secondary stand structure is expected to improve the mid-term timber supply as areas with suitable secondary structure should develop into merchantable stands sooner than if they were clearcut and reforested. Secondary structure is typically considered during operational planning. Suitable stands are either excluded from proposed cutblocks or harvested in a way that protects the understory regeneration.

Since protecting secondary structure is a legal requirement, licensees are expected to incorporate results and strategies into their respective FSPs. Accordingly, licensee and FLNR staff have committed to collect secondary stand structure information from visual surveys during cruise checks and the monitoring of survey results.

Stands retained for secondary structure should also be identified to ensure that planned silviculture treatments will not conflict with accessing these areas for harvesting in the future. Otherwise, no other silviculture treatments are considered within these stands.

Areas temporarily protected for secondary structure will ultimately be harvested, so they were still considered within the THLB in this analysis and no further constraints or treatments were applied.

Table 17 provides links to other sources for information on protecting secondary structure.

Table 17 Sources for information on protecting secondary structure

Source	Link
Mid-Term Timber Supply assessment	www.for.gov.bc.ca/hfp/mountain_pine_beetle/mid-term-timber-supply-project/secondary%20stand%20structure_summary_june_11.pdf
Silviculture Survey Reference Documents	www.for.gov.bc.ca/hfp/silviculture/Silviculture_Surveys.html

3.9 Watershed Management

In the latest AAC rationale[25], the Chief Forester encouraged licensee and district staff to continue to consider ways of mitigating negative impacts on hydrologic integrity during operations and, for the next timber supply analysis, incorporate assumptions with hydrologic changes.

Changes in hydrology can be estimated by equivalent clear cut area (ECA) and road density. Significant increases in ECA, road density, kilometres of road ditches, and numbers of stream crossings, increase the risk of increased peak flows and impacts on channel morphology. Risk can be reduced by accelerating hydrological green-up and an increased emphasis on maintaining vegetation within riparian ecosystems. This is especially important for all fish-bearing streams, wetlands, fishery-sensitive watersheds and community watersheds.

Silviculture treatments can also impact ECAs in various ways. Table 18 describes treatment impacts that can be used to prioritize stands for tactical and operational planning.

25 Williams Lake Timber Supply Area – Rationale for Allowable Annual Cut (AAC) Determination, Effective April 18, 2007, Jim Snetsinger, Chief Forester.

Table 18 Silviculture impacts on ECA

Treatment	Impact on ECA	Rationale
Fertilizing	Positive	Fertilizing will increase the growth rates of treated stands, and reduce the time to canopy closure, thus potentially expediting hydrological recover of ECA areas. This is expected to have a positive impact towards reducing ECA.
Spacing and Fertilizing	Negative	Though fertilizing is anticipated to have a beneficial impact, removal of stems will lengthen time to canopy closure and thus slow hydrologic recovery.
Shortened Rotation	Negative	Increased % of landbase in a non-recovered condition due to the reduction in rotation age will keep ECA levels higher.
Knockdown and Plant (salvage)	Negative in short- term; Positive in the mid-term.	Increased ECA due to the additional salvage harvest. Negative impact is shorter term (5-10 years), however it does result in an expedited recovery in the mid-term (i.e. >10 years)
Commercial Thinning	Nil	Assuming that Commercial Thinning maintains a stocked stand and decent crown closure, the impacts of removing individual trees should (in theory) not increase or decrease the amount of ECA within a priority watershed. As a result the anticipated impact is considered nil.
Planting	Positive	Where there are NSR areas, for example, just doing planting will help increase the rate of recovery and earlier reduction in ECA.

Climate change is expected to have many important effects on watershed processes that in turn will affect values such as water quality, water supplies, slope stability, and terrestrial and aquatic habitats[26]. Developing effective responses to these effects will likely involve local-level strategies.

Table 19 provides links to other sources for information on watershed strategies.

Table 19 Sources for information on watershed strategies

Source	Link
Identification of Watershed Sensitivities, Hazards, and Risks for Sixty Two Watersheds in the Lakes TSA	http://www.for.gov.bc.ca/hfd/library/FIA/2011/LBIP_9207001.pdf
Fisheries Sensitive Watersheds	www.env.gov.bc.ca/wld/frpa/fsw/index.html

3.10 Wildlife Habitat

The Identified Wildlife Management Strategy (IWMS) provides direction, policy, procedures and guidelines for managing species at risk and regionally important wildlife. Legal objectives are also established through wildlife habitat areas (WHA) for caribou, deer, moose and grizzly bear.

Many species at risk and those of management concern are negatively affected by roads which will increase significantly to salvage MPB. Given the vulnerability of forest-dependent species and large areas of MPB impacted timber, increased emphasis on managing road impacts is warranted.

Based on predictive ecosystem mapping, research wildlife ecologists have been working to assess alternate management strategies that best achieve wildlife stewardship goals. Results from these models were not available in time to include with this analysis, however, these may be incorporated to identify areas where silviculture treatments might benefit or degrade habitat.

[26] R.G. Pike, T.E. Redding, R.D. Moore, R.D. Winkler, and K.D. Bladon. 2010. Compendium of forest hydrology and geomorphology in British Columbia. FORREX Forum for Research and Extension in Natural Resources (Chapter 19 Climate Change Effects on Watershed Processes in British Columbia).

This analysis applied general wildlife measures and appropriate modelling assumptions for spatially-defined areas, but no direct linkages between wildlife habitat strategies and the silviculture treatments were explored. In practice, prescribing foresters must consider how designated habitat areas might be impacted by the silviculture treatments and prioritize them accordingly.

Wildlife trees are managed through results and strategies stipulated in FSPs, the Chief Forester's guidance, licensee discretion and stewardship principles. While MPB impacts can enhance the availability of wildlife trees and CWD, at least in the short- to medium-terms, actions such as salvage, road building, and safety issues associated with roads, replanting and stand tending can result in the loss of non-pine wildlife trees and CWD. These features are also vulnerable to intense fires promoted by large areas of dead pine (i.e. high levels of surface fuel loading from coarse woody debris and standing dead trees) and climate change. Strategies that retain limited amounts of coarse woody debris and wildlife trees that balance ecological benefits with wildfire risk reduction through time, should be considered when planning silviculture treatments.

Climate change will likely impact wildlife habitat through increased forest disturbance reducing live structure while creating additional dead trees. This may be mitigated by treatments designed to reduce risk of damage from wildfire or pests.

Table 20 provides links to other sources for information on wildlife habitat.

Table 20 Sources for information on wildlife habitat

Source	Link
Identified Wildlife Management Strategy	www.env.gov.bc.ca/wld/frpa/iwms/index.html
Ungulate Winter Ranges	www.env.gov.bc.ca/wld/frpa/uwr/index.html
Wildlife Habitat Areas	www.env.gov.bc.ca/wld/frpa/iwms/wha.html
Fisheries Sensitive Watersheds	www.env.gov.bc.ca/wld/frpa/fsw/index.html

3.11 Tree Improvement and Seed Transfer

The Forest Genetics Council of BC is appointed by B.C.'s chief forester to guide the full range of forest genetic resource management activities, including tree improvement (tree breeding and seed orchards), genetic conservation, genecology, climate-based seed transfer, and seed-use policy in the province. The Council provides a forum for stakeholder representatives to set goals and objectives, and to oversee the development and delivery of business plans to fulfill them. The annual FGC Business Plan outlines the activities and budgets of the seven subprograms that constitute the provincial forest genetic resource management program.

Direct linkages between tree improvement and the silviculture treatments explored in this project exist where planting is a component of the silviculture treatment (e.g., rehabilitation scenario). In these cases, planting trees germinated from select seed can significantly increase volume production that contributes to addressing mid-term timber supply issues. Prescribing foresters commonly use of select seed in normal operations so no further considerations are expected in adapting these practices for the silviculture treatments or actions described above.

Climate based seed transfer is one of the key features of BC's overarching Climate Change Adaptation Strategy. Planting seedlings adapted to future climates (assisted migration) is recognized as a key strategy to address climate change, as it will help maintain healthy, productive forests, and ensure capture of gains obtained from decades of selective breeding.

Table 21 provides links to other sources for information on tree improvement and seed transfer.

Table 21 Sources for information on tree improvement and seed transfer

Source	Link
Forest Genetics Council of BC	www.fgcouncil.bc.ca/
MFLNRO Tree Improvement Branch	www.for.gov.bc.ca/hti/index.htm
Climate Change Adaptation Strategy	www.for.gov.bc.ca/het/climate/actionplan/index.htm
Forest Stewardship Action Plan for Climate Change Adaptation	www.for.gov.bc.ca/ftp/HFP/external/!publish/ClimateChange/Adaptation/MFLNR_CCAdaptation_Action_Plan_2012_final.pdf

3.12 Forest Inventory

The MFLNRO's forest inventory program includes both forest inventory and stand growth modelling sub-programs. Data and models produced by this program are used to characterize current, and forecast future, forest condition. This includes implementation plans and image acquisition for photo interpretation that is scheduled to begin 2013/14.

While direct linkages do not appear to exist between the forest inventory and the silviculture treatments explored in this project, information derived from this program is critical to the design of silviculture regimes. Reliability of the forest inventory demands continuous updates to reflect changes in the forest from harvesting, silviculture, pests, fire and other catastrophic events.

To address the impacts of climate change a concerted effort to capture baseline information and relate it to climate variables and growth is needed. This is an area that requires further direction to inform modeling and future yield projections.

Table 22 provides links to other sources for information on the forest inventory program.

Table 22 Sources for information on the forest inventory program

Source	Link
Forest Inventory Strategic Plan	www.for.gov.bc.ca/hts/vri/

4 Recommendations

With any forest level analysis and planning process, opportunities for improvement are recognized throughout the process. This section provides recommendations to improve data sources, analysis approaches, or other issues that could lead to improvements in the next forest-level analysis. This section offers suggestions for special funding initiatives or needs for a full-phase approach to manage a specific issue (e.g., best management practices for stands in the dry-belt Douglas-fir area).

New developments in silviculture practices and strategies are sometimes listed as adaptive management documents[27] prepared under the Forests for Tomorrow (FFT) program, as well as, standard operating procedures for undertaking Type 4 analyses (currently being developed).

[27] www.for.gov.bc.ca/hcp/fia/landbase/fft/adaptive_management.htm

4.1 Recommendations for Implementing Strategies

Rehabilitation

When licensees assess areas for harvest, they make decisions to harvest or not harvest based on their consideration of costs and the potential recoverable revenue. Currently, there is no process to track stands deemed unsalvageable. Such a system could be used to flag areas as potential rehabilitation candidates.

Recommendation 1: Develop a process to track and report unsalvageable stands.

Future analyses would benefit from a study of the actual costs incurred and values realized through rehabilitation across various methods and stand types.

Recommendation 2: Track actual treatment costs.

In overall success of the rehabilitation strategy depends on the maintenance and in some cases strategic development of road access to stands in more remote locations.

Recommendation 3: Develop an access management plan.

Enhanced Basic Silviculture

Despite the obvious gains, it is unlikely that enhanced basic silviculture will become a viable silviculture strategy until a funding mechanism is established. This may be delivered through the current appraisal system by incorporating acceptable enhanced basic reforestation costs within the silviculture allowance for the stumpage calculation.

Recommendation 4: Establish a task force to develop guidance on how enhanced basic silviculture can be incorporated in the current appraisal system as a silviculture cost allowance used in the stumpage calculation.

4.2 Recommendations for Data Gaps and Information Needs

Further information and research are needed to support or refine silviculture strategies for the Lakes TSA. Recommendations for these data and research needs are described below.

The forest inventory for this analysis was based on an amalgamation of a several separate projects completed over many years, using distinct standards: Forest Inventory Projection (FIP) and Vegetation Resource Inventory (VRI). All forest-level analyses rely most heavily on the forest inventory to assign the operable landbase, determine an appropriate starting inventory and describe how existing stands develop through the short and mid-terms. Given the dynamic nature of our forests, it is unreasonable to expect this inventory to provide an accurate depiction of stands at a large scale. However, the some modifications could improve these estimates for developing tactical plans.

Updating the forest inventory with disturbance impacts from harvesting, fire, insects and disease is clearly essential for estimating forest conditions at the beginning of a harvest forecast, as well as, for applying stand regeneration assumptions based on actual data. Moreover, silviculture strategies typically require key forest attributes (e.g., species composition, age and stand density) to determine stands that are eligible for various treatments. The forest update process, therefore, is a very important component of these analyses that currently requires much effort to complete; mostly due to poor or missing data that is highly complex and often disjointed.

Recommendation 5: Strengthen the inventory update process to reflect available RESULTS data and where possible, impacts from natural disturbances (e.g., harvesting, fire, insects and disease).

The current standards for undertaking forest-related inventories aim to provide reasonable estimates at a management unit level (small scale). Less emphasis is placed on estimating stand boundaries and attributes appropriate at larger scales. Consequently, unique stands, such as those with repressed pine or insufficient stocking, are often overlooked. Identifying these unique stands in the forest inventory would help in developing silviculture strategies for tactical plans.

While the LVI underway now is designed to be appropriate for strategic-level analyses, it is not an appropriate source for developing tactical plans. Besides the general uncertainty associated with data accuracy, the detailed features of this raster dataset create a significant challenge for spatially representing candidate treatment areas.

Recommendation 6: Apply adjustments to the VRI to account for MPB impacts for future Type 4 analyses (rather than using the LVI).

In this analysis, yield projections for the post-attack regenerating stands were assumed to regenerate according to modified yield curves for the remaining live overstory plus randomly-assigned yield curves reflecting understory regeneration. These were developed using general modelling assumptions but not field verified.

Recommendation 7: Improve yield assumptions for post-attack regenerating stands.

Forest Health Impacts

It was quite apparent from the results of this analysis that assumptions used to model MPB impacts have profound effects on forest dynamics – particularly assumptions for percent mortality, shelf-life and understory regeneration.

Estimates of tree mortality from fire, insects and disease are based on a combination of overview flights and ground assessments in both old and young stands. These data are essential for adjusting stand yield predictions for the current inventory and projecting future growth, as well as, estimating non-salvaged losses. Live volume estimates in MPB-impacted stands played a significant role in defining the mid-term harvest level in this analysis.

Recommendation 8: Confirm estimates of live volume remaining on MPB-impacted stands.

Site Index

Site index is a key variable for projecting the growth of existing and future managed stands. SIBEC data used in this analysis provides average site indices at the site series level identified through ecosystem or biophysical mapping. Compared to site index adjustment projects[28], the SIBEC estimates consistently show higher estimates of productivity for managed stands.

Applying average site indices across the forest causes some loss of resolution at a stand-level, particularly on the extreme sites (for both moisture and nutrients). As a result, some candidate stands may actually be inappropriate for specific treatments. Improving site index estimates across a full spectrum of site series and verifying the ecosystem mapping would enhance future silviculture strategies.

Recommendation 9: Continue monitoring managed stand yields against predicted yields and consider approaches to differentiate the location and productivity of extreme sites.

[28] JS Thrower and Associates, 2007.

Past Incremental Silviculture Treatments

Ideally, silviculture strategies would incorporate past treatments to ensure that appropriate stands are selected for future treatments (e.g., multiple fertilization). At a minimum, the tactical plan should include the spatial extent of past treatments to improve how operational plans are prepared. Unfortunately, spatial and attribute data for past incremental silviculture treatments is not readily available and must be captured or derived through a combination of methods.

Recommendation 10: Streamline the process for retrieving information on past incremental silviculture treatments and verify that the data is accurate and complete.

Genetic Worth

Tree improvement and seed transfer guidelines play a significant role in the transition and long-term periods of the harvest forecast. Provided adequate seed supply is maintained, benefits will be realized as volume gains, increased survivability linked to assisted migration, and reduced forest health impacts.

Recommendation 11: Continue supporting the tree improvement program and ensure that genetic gains are closely monitored and applied in future forest-level analyses.

Product Profiles

In this analysis, product profiles were derived from the harvest forecast based on species and age class distributions so targets for specific products could not be assigned. Future silviculture strategies could be improved by exploring opportunities to improve these assumptions by tracking harvested products over time and using models (.e.g., SYLVER) to generate profiles.

Studies on product profiles and harvested material are also valuable to inform the criteria used to assign minimum harvest age, which can have a profound impact on both harvest levels and product profiles.

Recommendation 12: Investigate the linkages between desired product profiles, minimum merchantability and harvest ages.

Riparian Management

Riparian buffers were used as spatial netdowns to the operable landbase. Areas identified for riparian management were derived by buffering classified linear and polygon features for stream, lakes and wetlands. Since this landscape-level classification was completed in 2005, it is very likely that better information is now available from various sources.

Recommendation 13: Update stream network and classification used to assign riparian areas.

Road Network

In this analysis, landbase netdowns for existing and future roads were done aspatially as a complete classified road network was not available. When available spatially, this information can improve the accuracy of the landbase netdown process. Moreover, spatially explicit road systems can improve future analyses by incorporating more detailed economic criteria such as haul distance.

Recommendation 14: Develop a current, classified road network with associated widths.

Retention Areas

Section 3.4 discusses aspects of landscape-level biodiversity that will be negatively impacted over the next decade. Mapping the current retention areas would help to identify deficiencies and focus priorities for additional retention and silviculture treatments.

Recommendation 15: Map and track areas designated for long-term retention.

Landscape Level Fire Management Plans

A landscape perspective that considers the likely occurrence and impacts of unsuppressed wildfire is critical to protecting the viability of an adequate timber supply and non-timber values (e.g., critical habitat, community water supplies.). Landscape-level fire management objectives (e.g. reduce fire size, reduce fire intensity, etc.) need to be prepared, and strategies identified and implemented to make the landscape more resilient to wildfire, which will help to reduce losses to timber supply and environmental values in bad fire years.

Recommendation 16: Develop a Landscape Fire Management Plan including the mapping of strategic landscape level fuel breaks and associated management objectives and strategies that contribute to a fire resilient landscape.

4.3 Recommendations for Modelling

Base Case Sensitivity – Young Stand Mortality

This sensitivity was intended to explore higher impacts to account for higher estimates of mortality in young stands due to forest health agents. However, this sensitivity was not undertaken as it was identified as a lower priority within the available budget.

Recommendation 17: Develop a base case sensitivity that examines increased young stand mortality.

Base Case Sensitivity – Altering Minimum Harvest Criteria

Observations from this and other analyses showed that harvest flow is very sensitive to assumptions involving salvage effort, shelf-life, and minimum harvest criteria. The minimum harvest criteria used for this analysis (140 m^3/ha) may not actually reflect how licensees assess stands during the salvage period – likely much lower as most stands are older with reasonable product profiles. This also affects the criteria used identify eligible stands for the rehabilitation strategy. It is likely then, that the current analysis underestimates the salvage opportunity and overestimates the rehabilitation opportunity.

Recommendation 18: Develop a base case sensitivity that alters the minimum harvest criteria to reflect actual volumes harvested during the salvage period.

Silviculture Strategy – Enhanced Basic Reforestation

This silvicultural strategy was intended to examine the impact to harvest flows by enhancing basic reforestation practices where current performance is not optimal. However, because little data was available to support significant response opportunities, it was not identified as a priority strategy within the available budget.

Recommendation 19: Continue to develop appropriate growth responses for Fd and Lw within the TSA and run the enhanced basic reforestation strategy.

Fertilization – Increase Eligible Stands

The criteria used to identify eligible stands the fertilization strategies excluded: a) all future managed stands, and b) approximately 81,000 ha of medium site (SI 15-19), Pl-leading stands. Provided these stand types are likely be treated in practice, they could provide a significant contribution to the harvest forecast.

Recommendation 20: Develop a modified fertilization strategy that includes more eligible stands.

Fertilization – Modify Responses

The yield responses for Pl used in the fertilization strategies were based on average estimates for acceptable sites across various stand ages. More site- and age-sensitive responses to fertilization for Pl could be generated directly through the TIPSY stand projection model. However, since the differences are not expected to be significant, it may be more appropriate to consider this for future analyses.

Recommendation 21: Develop a modified fertilization strategy that generates Pl responses directly through TIPSY.

Partial-Cutting within Constrained Areas

Analyses for other TSAs included a strategy that examined the impact to harvest flows from a single removal of some volume within stands currently constrained for certain non-timber values (e.g., mature-plus-old seral, visuals, and watershed ECA requirements). This strategy provides additional volume during the mid-term period when available volumes are critically low. The volume removed must maintain sufficient stand conditions to satisfy the non-timber values present.

Recommendation 22: Develop a silviculture strategy that examines an appropriate level of partial cutting within constrained areas.

Defining Treatment Areas

Among other objectives, this project aimed to provide products that will support operational implementation of the strategy. The tactical plan (under construction) generates a map based on a combination of the model's spatial selection of stands treated and the associated forest inventory polygons. For future silviculture strategies, tactical plans could likely be streamlined by first aggregating polygons through blocking or by implementing more spatial controls within the model.

Recommendation 23: Aggregate resultant polygons into spatially-appropriate blocks for modelling and mapping operationally.

4.4 Recommendations for Related Plans and Strategies

General

Approaches for aligning with or at least considering related plans and strategies are discussed in section 3. In most cases, it is not clear how these initiatives should be integrated. A key to coordinating these strategies is to develop a consistent map base for all values. The appropriate agencies should work to align or integrate strategies (particularly forest health, wildfire and wildlife) within a coordinated map base, thus enabling queries to promote multiple objectives, or to avoid or mitigate risk. Meanwhile, prescribing foresters using the tactical plan from this analysis to assist in preparing operational plans should carefully consider the related plans and strategies.

Recommendation 24: Develop a consistent, coordinated map base to host the various strategies and multiple values.

Unfortunately, hyperlinks provided to sources for information on related plans and strategies (section 3) can break. Also, new planning initiatives should be added to this report (or on the FFT website).

Recommendation 25: Periodically check, update and add hyperlinks to information on related plans and strategies.

Access

It is well-accepted that harvest levels in the Lakes TSA will soon be reduced to less than half the current uplift AAC of 2.0M m^3/yr. During this period, one significant challenge will involve the maintenance of adequate access throughout the TSA. This is disconcerting because some activities (e.g., fertilization) require well-maintained road systems for hauling the fertilizer products. Road access is also a key consideration in deciding fire-fighting priorities.

By far, the best way to maintain road systems is by supporting economic opportunities over the landbase. This provides a clear benefit to silviculture strategies that would otherwise require road maintenance to be added to treatment costs.

Recommendation 26: Encourage activities and develop programs that will aid in prioritizing and maintaining road systems adequate throughout the TSA.

4.5 Recommendations for Monitoring

This plan is intended to be periodically updated using results from ongoing implementation efforts, other analyses and better data as they become available. A monitoring program should be developed to ensure outputs meet expectations over time. This should also examine how appropriate the input assumptions were for each strategy and recommend whether they should be revised for a future silviculture strategy.

Recommendation 27: Develop a coordinated monitoring program to ensure outputs from the various silviculture treatments employed meet expectations.