Williams Lake TSA – Type 4 Silviculture Strategy

Silviculture Strategy

Version 1.0

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Project 419-25

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BRITISH COLUMBIA

Strategy at a Glance

<table>
<tr><td>Historical Context</td><td colspan="2"> The most recent timber supply review completed in 2007 increased the uplift harvest level from 3.768 M m^3/yr to 5.770 M m^3/yr. This included two AAC partitions: 1) 450,000 m^3/yr attributable to the three western supply blocks and 2) 107,000 m^3/yr attributable to the harvesting of problem forest timber types. 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 1.9 M m^3/yr for twenty-five years before increasing to a long-term level of 3.5 M m^3/yr. This analysis builds upon details learned from previous analyses and established a base case scenario that achieved an initial harvest level at 3.20 M m^3/yr for 5 years that declined sharply to 2.36 M m^3/yr in years 6-10 and then to a mid-term trough at 1.76 M m^3/yr until year 50. After this, the harvest level rises in a series of steps to reach a long-term level of harvest level of approximately 3.57 M m^3/yr in year 120. </td></tr>
<tr><td>Objective</td><td colspan="2">Mitigate impacts from past mountain pine beetle (MPB) and wildfires on mid-term timber supply.</td></tr>
<tr><td>General Strategy</td><td colspan="2">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.</td></tr>
<tr><td rowspan="3">Working Targets</td><td>Timber Volume Flow Over Time:</td><td>**Short-Term** (1-10yrs): Maximize salvage of dead pine using the actual harvest level of 3.2 M m^3/yr; salvage - harvest older stands before they deteriorate below minimum merchantability (~80 m3/ha).
Mid-Term (11-110yrs): Maximize mid-term harvest levels by accepting decreased long-term harvest levels.
Long-Term (≥110yrs): Maintain the highest stable growing stock over time.</td></tr>
<tr><td>Timber Quality:</td><td>After the salvage period, harvest stands once they achieve minimum merchantability (~110 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 (11-110 yrs): Maximize stand values to the extent possible as the main focus is on maximizing recoverable volume.
Long Term (≥110yrs): Regenerate newly harvested areas with silviculture practices that improve timber quality.</td></tr>
<tr><td>Habitat Supply:</td><td>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.</td></tr>
<tr><td rowspan="2">Major Silviculture Strategies</td><td>Timber Volume Flow Over Time:</td><td>**Years 2011-2020** (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, Fd, Pl; apply multiple treatments on Sx where possible.
• Space eligible dry-belt Fd stands.
• Employ enhanced basic silviculture practices on stands currently being salvaged.
Years 2021-2030 (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. Also consider rehabilitating stands damaged by spruce budworm (east TSA).
• Increase fertilization levels with same approach.
• Continue to space eligible dry-belt Fd stands.
• Continue to employ enhanced basic silviculture practices.
• Start to explore opportunities for partial cutting within constrained areas while maintaining the appropriate non-timber values.</td></tr>
<tr><td>Timber Quality:</td><td>• 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.</td></tr>
</table>

<table>
<tr><td></td><td>Habitat Supply:</td><td colspan="3">• 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.</td></tr>
<tr><td>Silviculture Program Scenarios</td><td>Potential Program</td><td colspan="3">Years 2011-2020

Priority | Treatment | Target Area (ha/yr) | Unit Cost ($/ha) | Target Funding ($M/yr)
1 | Rehab | 2,371 | 1,750 | 4.150
2 | Fertilize | 667 | 525 | 0.350
3 | Space Fd | 467 | 750 | 0.350
4 | Enhanced Basic | 345 | 725 | 0.250
5 | Investigate | n/a | n/a | 0.150

Years 2021-2030

Priority | Treatment | Target Area (ha/yr) | Unit Cost ($/ha) | Target Funding ($M/yr)
1 | Rehab | 2,286 | 1,750 | 4.000
2 | Fertilize | 952 | 525 | 0.500
3 | Space Fd | 467 | 750 | 0.350
4 | Enhanced Basic | 345 | 725 | 0.250
5 | Partial Cut | 533 | 563 | 0.300
6 | Investigate | n/a | n/a | 0.150
.</td></tr>
<tr><td>Outcomes</td><td>Timber Volume Flow Over Time:</td><td colspan="3">Short Term (years 2011-2020)
• No forecasted changes relative to the base case scenario.
Midterm (years 2021-2030)
• Harvest level increase of 22% relative to base case scenario.</td></tr>
<tr><td></td><td>Timber Quality:</td><td colspan="3">• Targets were not implemented as the analysis focused on maximizing mid-term volume.</td></tr>
<tr><td></td><td>Habitat Supply:</td><td colspan="3">• 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.</td></tr>
<tr><td>Related Plans and Strategies</td><td colspan="2">Climate Change
Tree Species Deployment
Land Use Plans
Landscape Level Biodiversity
Forest Health
Wildfire Management</td><td>Ecosystem Restoration
Enhanced Retention
Secondary Structure
Watershed Management
Wildlife Habitat
Recreation</td><td>Range Management
Invasive Plants
Tree Improvement and Seed Transfer
Forest Inventory</td></tr>
<tr><td>Recommendations</td><td>Implementing Strategies</td><td colspan="3">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.</td></tr>
<tr><td></td><td>Data Gaps and Information Needs</td><td colspan="3">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 appropriately in future forest-level analyses.</td></tr>
</table>

		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 to limit the harvest of small pine. 17. Develop a base case sensitivity to incorporate deciduous stand volumes. 18. Develop a PCT and Fertilization strategy that includes subsequent thinnings of identified stand types (i.e., more area). 19. Aggregate resultant polygons into spatially-appropriate blocks for modelling and mapping operationally.
	Related Plans and Strategies	20. Develop a consistent, coordinated map base to host the various strategies and multiple values. 21. Periodically check, update and add hyperlinks to information on related plans and strategies. 22. Encourage activities and develop programs that will aid in prioritizing and maintaining adequate road systems throughout the TSA.
	Monitoring	23. Develop a coordinated monitoring program to ensure outputs from the various silviculture treatments employed meet expectations.
References	1. Williams Lake TSA Type 4 Silviculture Strategy – 2012 Situational Analysis, Version 1.0, September 2012. 2. Williams Lake TSA Type 4 Silviculture Strategy – Data Package, Version 3.0, September 2013. 3. Williams Lake TSA Type 4 Silviculture Strategy – Modelling and Analysis Report, Version 1.1, September 2013. 4. Williams Lake 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 Williams Lake Timber Supply Area (TSA) to help government and licensees better understand the current and future timber and habitat supply situation in the Williams Lake 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 data package report[1] and modelling and analysis report[2] for this project. Further discussion on this summary can be accessed from these sources.

[1] Forsite Consultants Ltd. 2013. *Williams Lake TSA - Type 4 Silviculture Strategy, Data Package.* Technical Report.

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

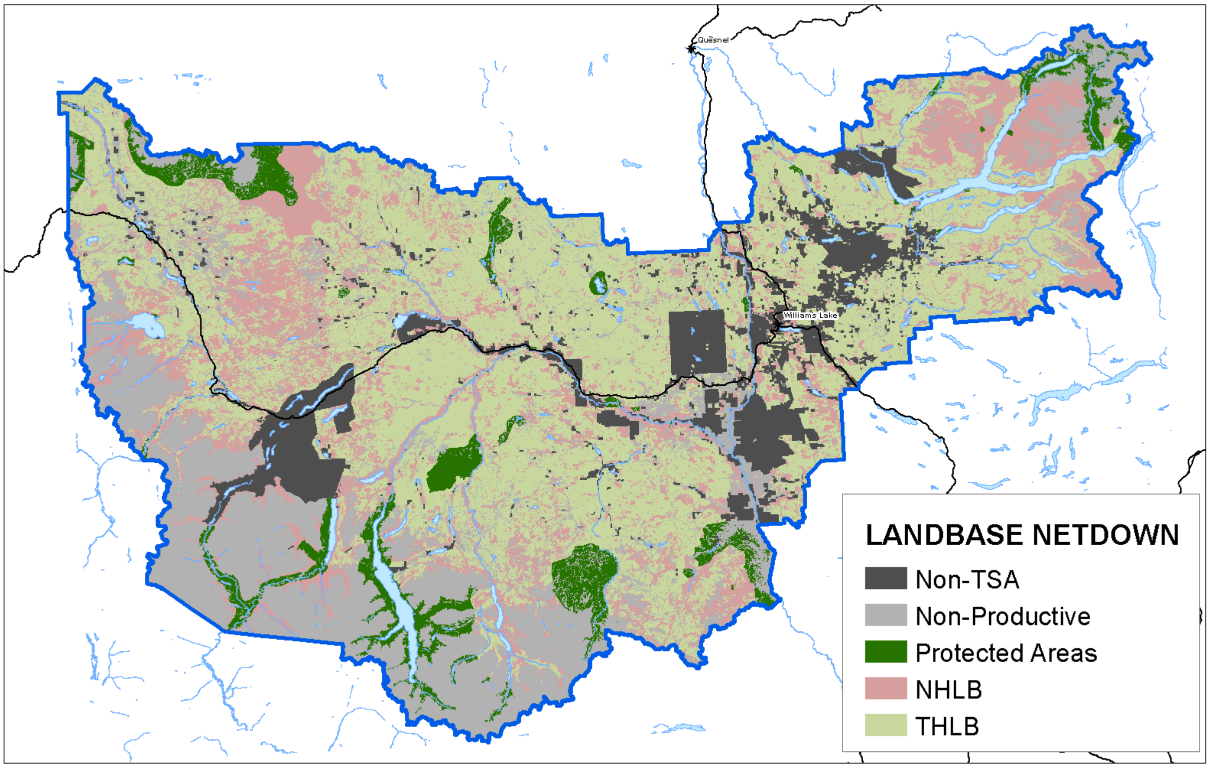


Figure 1 Williams Lake TSA overview map

The Williams Lake TSA (Figure 1) covers approximately 4.9 M hectares of land. Excluding First Nations reserves, private lands, non-forest, woodlots, and community forests, the remaining forest management land base (FMLB) is 3.2 M ha (65% of total area). The FMLB is grouped into the non-harvestable land base (NHLB – 1.4 M ha; 44% of FMLB), which includes area set aside for biodiversity, wildlife or because the site is too poor to grow trees economically, and the timber harvesting land base (THLB - 1.8 M ha; 56% of FMLB). Lodgepole pine comprises about 61 percent of the total mature volume on the THLB.

Table 1 TSA land base area summary

	Gross Areas (Ha)	Effective Areas (Ha)	Percent of Total Area (%)	Percent of FMLB (%)
Total Area	**4,941,569**	**4,941,569**	**100.0%**	
less:				
Non TSA (Woodlots, Non-Crown)	481,919	481,919	9.8%	
Non-Forest / Non-Productive	1,410,422	1,260,518	25.5%	
Forest Management Land Base		**3,199,132**	**64.7%**	**100.0%**
less:				
Parks and Protected Areas	593,375	250,724	5.1%	7.8%
Candidate Goal2 Protected Areas	14,503	9,313	0.2%	0.3%
Environmentally Sensitive Areas	212,598	88,923	1.8%	2.8%
Low Productivity Stands	1,982,556	415,567	8.4%	13.0%
Physically/Economic Inoperable	511,396	66,450	1.3%	2.1%
Northern Caribou No-Harvest	41,206	25,064	0.5%	0.8%
Mountain Caribou No-Harvest	172,443	74,178	1.5%	2.3%
WHA Grizzly No-Harvest	1,996	846	0.0%	0.0%
WHA Data Sensitive No-Harvest	91	26	0.0%	0.0%
OGMA (Permanent and Rotation)	296,690	179,187	3.6%	5.6%
Scenic Area – Preservation	14,056	1,480	0.0%	0.1%
Lakeshore Management Class A	19,169	7,742	0.2%	0.2%
Critical Habitat for Fish	51,643	12,657	0.3%	0.4%
Buffered Trail Areas	46,013	14,476	0.3%	0.4%
Community Areas of Special Concern	436,140	28,341	0.6%	0.9%
Riparian Management	433,898	69,161	1.4%	2.2%
Roads, Trails, and Landings (Aspatial @ 4.1%, 6.2%)		** 69,304*	1.4%	2.2%
Wildlife Tree Retention (Aspatial @ DCC 3.6%, DCH 5.0%)		** 79,148*	1.6%	2.5%
Timber Harvesting Land Base		**1,806,546**	**36.6%**	**56.5%**

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

1.3.1 Age Class Distribution

Considering the magnitude of area affected by the MPB and fire across the spectrum of age classes, we can expect a large shift of future stands into a narrow age class range. Once mature, these stands will become available for harvest again in a common period. It will be necessary to find ways to break up this age class cohort and minimize the risk of future MPB outbreaks.

After applying assumptions to reflect changes in stand age from disturbances (i.e., fire, insects and harvesting) the current age class distribution on the THLB and Non-THLB are shown in Figure 2.

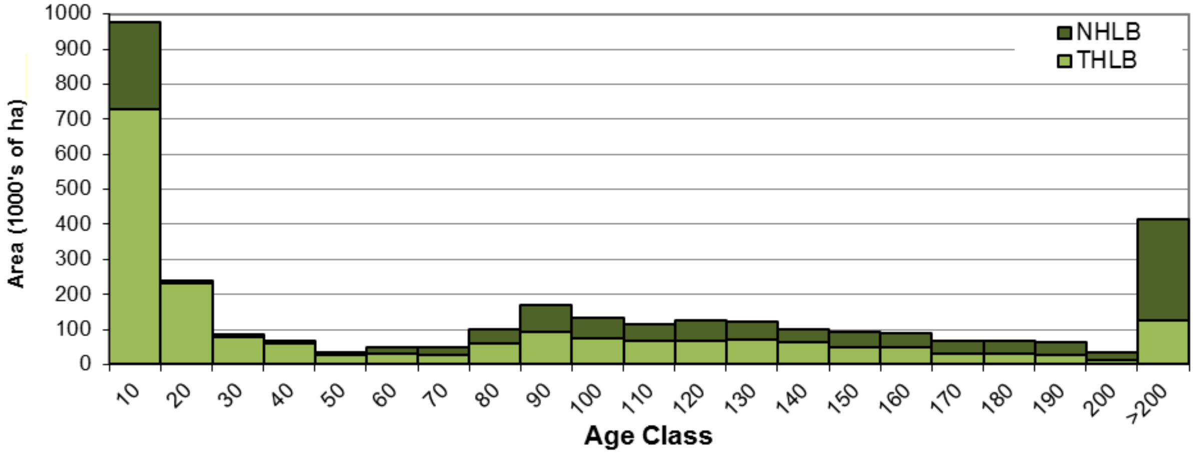
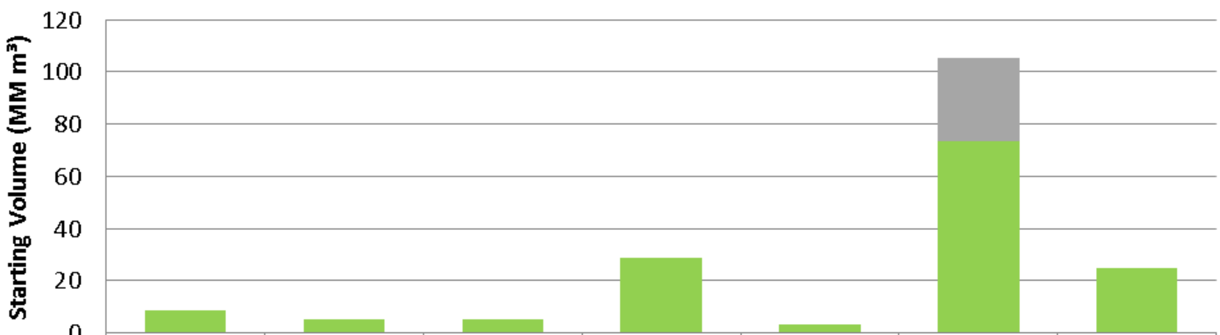


Figure 2 Current age class distribution across the forest management land base

1.3.2 Growing Stock and Volume Profile

The total growing stock is currently 172.1 M m^3 of which approximately 31.7 M m^3 is considered dead pine. Figure 3 shows that pine comprises the majority of the volume on the land base with Douglas-fir and spruce representing 17% and 14%, respectively.



	DE	BA	CW	FD	HW	PL	SX
Dead						31,751,000	
Live	8,787,000	5,292,000	5,180,000	28,832,000	3,054,000	73,414,000	24,623,000

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

1.3.3 Site Productivity Profile

The distribution of natural and managed stand site indices across the THLB is shown in Figure 4. The area-weighted average site index of the THLB for natural stands is 12.1 m. After the THLB is converted into managed stands the average site index increases to 16.0 m.

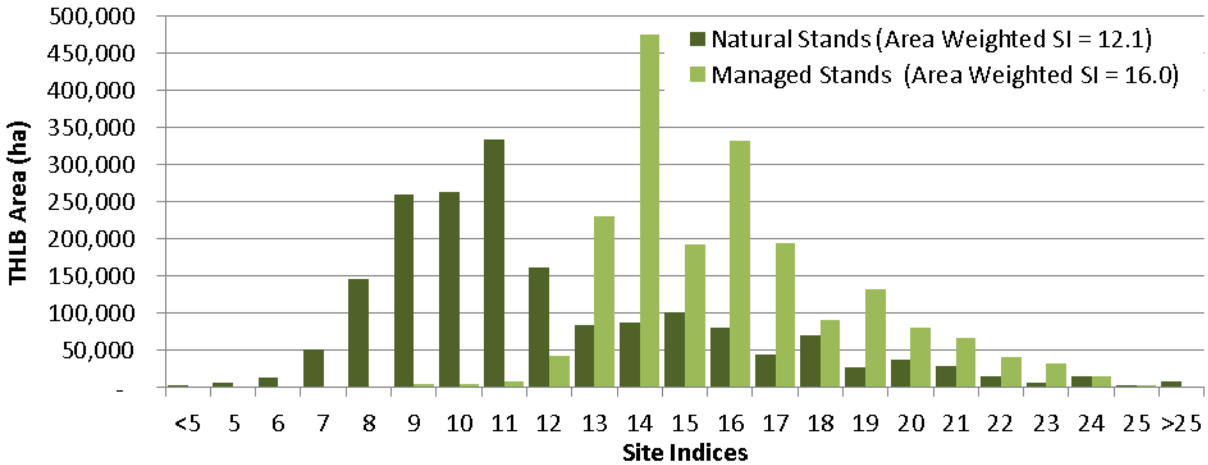


Figure 4 Site productivity distributions on the timber harvesting landbase

1.4 Key Issues and Considerations

This section summarizes material from the situational analysis[3] for this project. Further discussion on this summary can be accessed from that source.

1.4.1 Harvest Levels

For the past 30 years, the AAC for the TSA has been dynamic. Table 2 shows how the AAC has reflected several MPB outbreaks, establishment of partition cuts, including MPB salvage, specific supply blocks, deciduous stands and problem forest types (PFT). The current AAC of 5,770,000 cubic metres per year remains in effect until a new AAC is determined (currently underway and expected by 2014). The 2007 AAC rationale states that this harvest level “is predicated on directing the entire AAC at stands with at least 70 percent pine that are located west of the Fraser River.”

Table 2 Historical and current AAC

Determination	1981	1985	1989	1992	1996	2003	2007
AAC (M m^3/yr)	2.500	3.750	4.093	3.975	3.807	3.768	5.77
Partitions	n/a	MPB	MPB, WSB	MPB, Dec	WSB, PFT	MPB; WSB; PFT	WSB, PFT

Figure 5 shows the volume of timber harvested over a ten year period (2001 to 2011) and indicates that recent harvest levels have fallen relative to historic levels, while the pine volume proportion has remained relatively consistent (~73%). A simple assessment conducted in this project suggests that between 2007 and 2011, approximately 56% [4] of the harvested area occurred west of the Fraser River (68% in 2011). In general, current harvest levels (3.3 M m^3/yr) are well below the AAC and focused significantly, but not exclusively, in the west.

[3] Forsite Consultants Ltd. 2012. *Williams Lake TSA - Type 4 Silviculture Strategy, Situational Analysis.* Technical Report.

[4] Summarized by examining FTA Forest Tenure Cut Block polygons in June 2012.

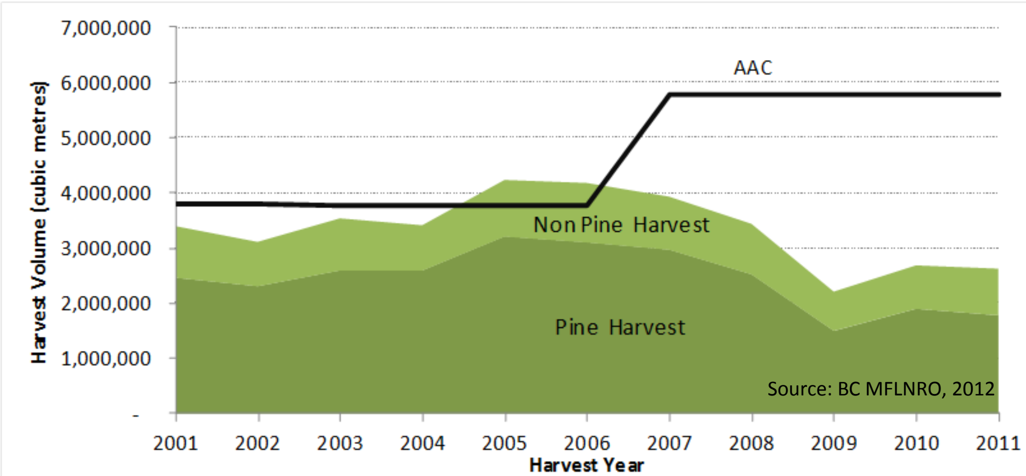


Figure 5 Historic harvest volumes

1.4.2 Forest Inventory

The current forest inventory of the Williams Lake TSA is comprised of a series of projects spanning the last fifty years. Most of the TSA east of the Fraser River has been updated to the current Vegetation Resources Inventory (VRI) standard. Conversely, west of the Fraser River, the vast majority of the TSA is based on older inventories rolled-over from the previous Forest Inventory Planning (FIP/FC1) standard – with the notable exception of a large area near Alexis Creek that was part of the Lignum VRI project.

1.4.3 Timber Supply

The prevalence of pine-leading stands on the TSA (61% of the THLB), and very high mortality rates (86%) 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[5].

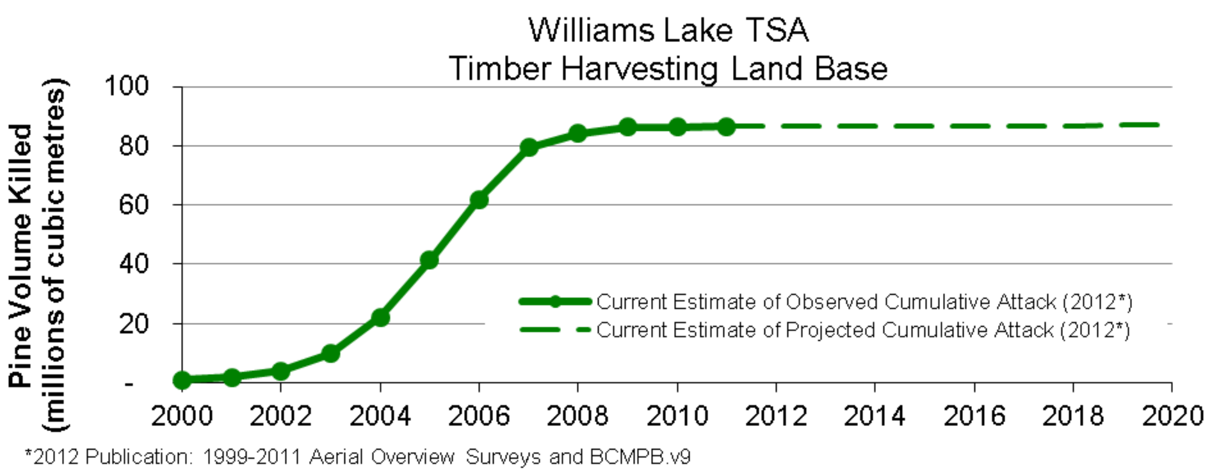


Figure 6 Data and projections of cumulative volume killed by the MPB.

[5] 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).*

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 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 30 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 15 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.

1.4.4 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 50 years from now), the harvest is expected to consist of young, low volume, small piece sizes from stands that are 40 to 70 years old.
- Minimum merchantability criteria reflect the smallest average piece size or stand volume acceptable for harvesting. Reducing the minimum timber quality expectations can often 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.

1.4.5 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.

1.4.6 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.

1.4.7 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 (e.g., 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.

1.4.8 Uneven-aged management in dry-belt Douglas-fir

The Interior Douglas-fir (IDF) BEC zone comprises 23% of the THLB. For decades, Douglas-fir stands in dry-belt ecosystems were harvested using partial cutting systems and restocked by natural regeneration. However, little reliable information is available for these uneven-aged stands that will become a necessary portion of the harvest profile moving forward.

In concert with this silviculture strategy, through the Williams Lake Silviculture Subcommittee, an IDF Strategy[6] was developed to highlight opportunities to address knowledge gaps with forest

[6] Day, K. and McWilliams, J. IDF Strategy for Williams Lake and 100 Mile TSAs. March 2013. 17pp.

management in the IDF that should increase timber productivity from this significant component of the Williams Lake TSA. This IDF Strategy provides a background of the management issues along with a number of recommendations for further work.

2 Silviculture Strategies

2.1 Working Targets

Provincial Timber Management Goals and Objectives (under development) will provide context and direction for the Williams Lake 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 Williams Lake TSA:

Table 3 Working Targets

Indicator	Working Targets
Timber Volume Flow Over Time:	**Short-Term** (1-10yrs): Maximize salvage of dead pine using the actual harvest level of 3.2 M m^3/yr; salvage - harvest older stands before they deteriorate below minimum merchantability (~80 m^3/ha). **Mid-Term** (11-110yrs): Maximize mid-term harvest levels by accepting decreased long-term harvest levels. **Long-Term** (≥110yrs): Maintain the highest stable growing stock over time.
Timber Quality:	After the salvage period, harvest stands once they achieve minimum merchantability (~110 m^3/ha) and maintain a supply of peeler logs (200,000m^3/yr of Sx/Fd 8"top, 17'2").
	Short-Term (1-10yrs): Capture economically viable sawlog volumes before stands deteriorate. **Mid-Term** (11-110 yrs): Maximize stand values to the extent possible as the main focus is on maximizing recoverable volume. **Long Term** (≥110yrs): 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 (typically $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	80m3 pre/post shelf-life	Impact to the harvest forecast by maintaining the same (110 m³/ha and 80 m³/ha) minimum harvest criteria for pine-leading stands throughout the planning period – for both natural and managed stands
	110m3 pre/post shelf-life	
	Revised Shelf-Life	Effect on the harvest forecast from implementing a revised shelf-life assumption that is similar to the Mid-term Analysis but reduced the decay period from 20 to 15 years.
	Harvest sequence (1)	Effect on short- and mid-term harvest levels from an immediate reduction in the current AAC uplift: (2) establishing the highest flat-line harvest level throughout the short- and mid-term, (1) steadily increasing only the first term harvest level while accepting some loss in harvest level throughout the mid-term.
	Harvest sequence (2)	
Silviculture Strategies	Single Fertilization	Impact to harvest flows from applying fertilizer one time throughout the rotation of pine, Douglas-fir and spruce stands.
	Multiple Fertilization	Impact to harvest flows from applying fertilizer multiple times throughout the rotation of pine, Douglas-fir (every 10 years) and spruce stands (every 5 years).
	Spacing dry-belt Fd	Impact to harvest flows from spacing stagnant thickets in the second and third layers of dry-belt Douglas-fir stands.
	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.
	Enhanced Basic Reforestation	Impact to harvest flows from enhancing basic reforestation practices where current performance is not optimal (achieving minimum well-spaced trees/ha versus target well-spaced trees/ha).
	Partial cut in constrained areas	Impact to harvest flows from a single removal of 1/3 of the volume within stands currently constrained for visuals, lakeshore management, mature-plus-old seral and watershed ECA requirements.
	Mix Strategies ($3 M/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) $5 M/year
	Mix Strategies ($5 M/yr)	

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

Scenario	Timber Supply			Timber Quality	Old + Mat Seral	Scenic	Lakeshore Mgmt	Comm. Watershed	Hydrology
	Short	Mid	Long						
Single Fertilization	Nil	↑	↑↑	Nil	↓	(↑)	(↑)	(↑)	(↑)
Multiple Fertilization	Nil	↑↑	↑↑	(↓)	↓	(↑)	(↑)	↑	↑
Spacing dry-belt Fd	Nil	↑	Nil	↑↑	Nil	Nil	Nil	Nil	Nil
Rehabilitation	Nil	↑↑	↑↑↑	↑	↓↓	↑↑	Nil	↓	↓↓
Enhanced Basic Reforestation	Nil	↑↑	↑↑↑	↑	↓	(↑)	(↑)	↑	↑
Partial cut in constrained areas	Nil	↑↑↑	Nil	Nil	(↑)	Nil	Nil	Nil	(↓)
Mix Strategies ($3 M/yr)	(↓)	↑↑↑	↑↑↑	↑	↓	↑	↓	↑	↑
Mix Strategies ($5 M/yr)	(↓)	↑↑↑	↑↑↑	↑↑	↓	↑	↓	↑	↑

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 Williams Lake TSA will begin to experience a severe shortage of available volume in 30 years (33.4 M m³; ~36% 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[7], that the harvest flow is very sensitive to assumptions involving salvage effort, shelf-life, and minimum harvest criteria.
- 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.
- 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.

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

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

- Because of the 30-year response period, spacing dense thickets of dry-belt Douglas-fir must be carried out early on to provide harvest level gains at the end of the mid-term.
- 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.
- The enhanced basic silviculture strategy (planting at higher densities with improved genetic stock) makes some treated stands available for harvest within 35 years. This results in significant timber supply gains near the end of the mid-term (30-50 years from now), as well as, in the long-term (110+ years). Given the current elevated harvest levels, significant opportunities exist for this strategy. While licensees may be able to shift towards this strategy, this strategy requires administrative changes that provide incentives for excellence (vs. regulating minimums).
- Partial harvesting within constrained areas is the only strategy identified to help fill in the front of the mid-term. Provided forest cover and ecosystem functions remain intact, or improve, this strategy can borrow volume that is otherwise available later in the forecast (i.e., no extra volume).
- Both Composite Scenarios ($3M/yr and $5M/yr budgets) are similar in treatment selections and proportions. Using a 2% discount rate, they both provide positive NPV at the forest level.
- 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 solid basis for developing a preferred silviculture strategy.

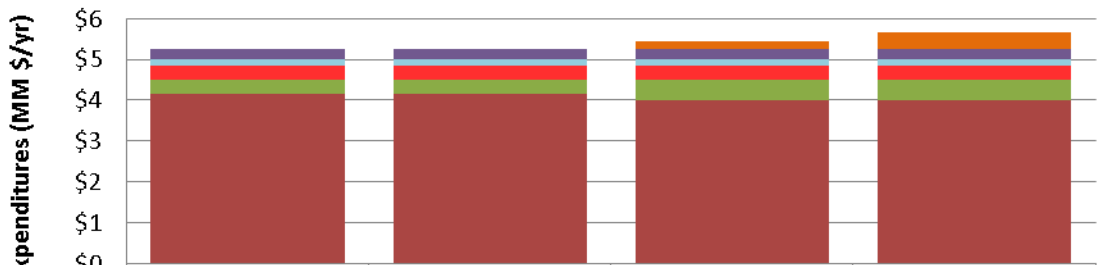
In this analysis, the model results suggest that the higher budget level ($5 M/yr) is the preferred strategy since compared to all other strategies explored, this strategy produced the:

- Highest increase in the mid-term harvest level (501,000 m^3/yr or 28%)
- The second highest increase in rise-to-the-long-term harvest levels (284,000 m^3/yr or 10%) – Rehabilitation was highest at 13%
- Highest increase in long-term harvest levels (600,000 m^3/yr or 17%)
- Highest total NPV over the planning horizon ($182 MM)

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 (11-50 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.



	Years 0-5	Years 6-10	Years 11-15	Years 16-20
Partial Cut	-	-	200,000	400,000
Enhanced Basic	250,000	250,000	250,000	250,000
Investigate	150,000	150,000	150,000	150,000
Other PCT	-	-	-	-
Space Fd	350,000	350,000	350,000	350,000
Fertilize	350,000	350,000	500,000	500,000
Rehabilitate	4,150,000	4,150,000	4,000,000	4,000,000

Figure 7 Expenditures by activity for the preferred silviculture strategy

The sections below describe the rationale for determining this mix of activities.

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. Also consider rehabilitating stands damaged by spruce budworm (east TSA).

Funding for rehabilitation may involve expanding the ITSL[8] 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 continues to play 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) Douglas-fir, 3) pine.
- Apply multiple treatments on spruce stands where possible

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

2.3.3 Space Dry-Belt Douglas-fir

Stand management within multi-aged Douglas-fir stands of the IDF is expected to provide even greater benefits than those described in the modelling assumptions: both the number of eligible stands and the gains in stand yield are likely underestimated. Further investigation is required to quantify these and other opportunities[9].

Ameliorating the dense thickets could also be considered as a means of fuel reduction to mitigate fire risk or for improving wildlife habitat characteristics. Accordingly, this activity is among the higher priorities for the Williams Lake TSA.

2.3.4 Other Pre-Commercial Thinning

With an impending timber supply shortage, less focus was applied to activities that are not expected to increase the amount or access to timber volume flow over time. While there may be some opportunities to improve piece size, set up additional stands for fertilization (i.e., repressed Pl or cleaning) or improve habitat supply, pre-commercial thinning was regarded as a lower priority due to the limited opportunities and questionable timber quality benefits. It is likely more beneficial to defer this density management activity until commercial thinning allows logs to be extracted.

2.3.5 Enhanced Basic Reforestation

The enhanced basic reforestation activity is most attractive in the near term for stands regenerated from salvage harvesting as incremental volumes are expected to contribute to the harvest at the end of the mid-term trough. In addition to the timber supply benefits, the higher density stands with this activity could result in timber quality improvements such as lower knot sizes, reduced risks from damaging agents and climate change, and provide options for further stand management.

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

9 Day,K. and McWillilams, J. 2013. IDF Strategy for Williams Lake and 100 Mile TSAs. 17pp.

Unfortunately, some immediate opportunities may be lost until a mechanism to fund this activity is developed.

2.3.6 Partial Cutting in Constrained Areas

Partial Cutting in constrained areas (i.e., only mature plus old seral, scenic, lakeshore management zones and hydrological constraints) is not expected to take place right away. Instead, it is implemented throughout the mid-term, when available timber volumes are lowest, to leverage volume from areas that are otherwise inaccessible. This treatment is most applicable throughout the mid-term period (11-50 years from now). Other than perhaps a few operational trials, this activity does not contribute to the preferred strategy in the short-term.

2.3.7 Other Considerations

The Williams Lake TSA is large. It would be appropriate to divide the TSA into compartments and develop individual programs that address the needs for each specific compartment.

It was never intended that all silviculture treatments presented would be eligible under a single funding source. Ensuring opportunities associated with the preferred silviculture strategy are recognized and implemented requires detailed examination of various funding mechanisms s (e.g., appraisal cost allowance, land base investment program, carbon credits, innovative timber sale licenses, etc.).

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 sources for information on climate change.

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
Adapting to Climate Change in the San Jose Watershed	www.williamslakecouncilofcanadians.ca/Home_files/San%20Jose%20watershed%20report%20-%20FINAL.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[10]). A recent report from FLRNO[11] 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[12] inventory data were used to produce summaries of species composition by age class and the projected shifts to BEC variant 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

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

[11] Species Monitoring Report Williams Lake TSA, May 2012, MCMFLNRO Resource Practices Branch

[12] 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.

to be feasible from both ecological and silvicultural perspectives and desirable at the landscape level regardless of the management objectives.

When completed, Table 7 provides direction towards a desired percentage by species by Biogeoclimatic subzone. This guidance was informed by ecological benchmarks based on historical levels as well as the plausible impacts of climate change as interpreted by local ecologists and silviculturalists. These trends will be tracked yearly and evaluated to determine if the trends are being achieved. A narrative describing progress will be provided. This is meant as a first step in management of 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.

Table 7 Guidance for tree species deployment on harvested areas

BGC Zone	Desired Trend by Species								Comments
	Pl	Sx	Fd	Lw	Cw	Hw	Pw	Py	
ESSFdc									
ESSFwc									
ICHmk									
ICHmw									
ICHwk									
IDFmw									
MSdm									
IDFdk									
IDFxh									
MSxk									
ESSFxc									

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 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 Central Cariboo Land Use Plan (CCLUP), legal orders, Sustainable Resource Management Plans (SRMP) and Forest Stewardship Plans (FSP) provide a framework for land use and forest management in the Williams Lake 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 sources for information on land use plans.

Table 9 Sources for information on land use plans

Source	Link
CCLUP	ilmbwww.gov.bc.ca/slrp/lrmp/williamslake/cariboo_chilcotin/index.html
Williams Lake SRMPs (7)	www.ilmb.gov.bc.ca/slrp/lrmp/williamslake/cariboo_chilcotin/srmp.html

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. One example, the partial cut scenario, was explored as a silviculture strategy for extracting some timber throughout the mid-term while maintaining or improving current and/or future condition of established mature seral management areas and other identified areas.

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 Williams Lake 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 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 [13] aims to recommend actions to address forest health issues. A list of significant forest health agents and current strategies is provided in Table 11.

[13] Chilcotin Forest District & Central Cariboo Forest District, Williams Lake Timber Supply Area Forest Health Strategy 2011/2012, March 2011, 30p.

Table 11 Forest health agents and strategies

Category	Agent	Strategy
Bark Beetles	Douglas-fir bark beetle (1)	Suppression action in most areas; monitor for some remote areas and parks in the Chilcotin.
	Spruce bark beetle (1)	Suppression action.
	Mountain pine beetle (2)	Salvage action.
Defoliators	Western spruce budworm (2)	Treat moderate and severely defoliated high-value stands with B.t.k..
	Gypsy moth (1)	Monitor through the use of a trapping program in conjunction with District and regional staff and the Canadian Forest Service. Early detection of this defoliator is critical.
	Aspen Serpentine Leaf Miner	Monitor – no treatments planned.
	Two Year Cycle Budworm	Monitor – no treatments planned.
	Western Hemlock Looper	Monitor and identify stands in need of rehabilitation.
	Weevils	Monitor individual stands affected.
Diseases	Lophodermella Needle Cast	Monitor.
	Elytroderma Needle Cast	Monitor and document the extent of damage through stand density monitoring surveys. Increase general awareness of the disease in young pine stands.
Rusts	Comandra blister rust, Stalactiform blister rust, and Western gall rust (2)	Monitory young stands (especially pure pine) and consider these pests when prescribing stocking or spacing treatments (i.e., increase minimum stocking to offset mortality).
Dwarf Mistletoe	Pl dwarf mistletoe	Monitor young pine stands and conduct sanitation spacing post-harvest to limit the spread of disease.
Root Diseases	Armillaria, Tomentosus	Monitor and treat detected infestation areas as in accordance with provincial guidebooks.
Abiotic Injuries	Windthrow	Harvest Douglas-fir and spruce blowdown within one year of a windthrow event to reduce opportunities for bark beetle build-up.
	Drought and Flood Damage	Monitor.
	Wildfire	Monitor and treat affected areas as appropriate. MCH is recommended along fireguards as a preventative measure for Douglas-fir beetle where it is not possible to conduct salvage operations.

(1) Very high priority forest health agent (Bold text)

(2) High priority forest health agent (Bold text)

One of the key forest health strategies that can protect stands contributing to the mid-term timber supply is to treat Douglas-fir stands attacked by western spruce budworm and spruce stands attacked by spruce beetle.

Climate change is expected to increase the frequency and intensity of severe wind-throw events and outbreaks of insects - particularly bark beetles[14], and pathogens [15]; undoubtedly leading to more challenging decisions regarding silviculture investments and priorities.

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

[14] 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

[15] 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.

Table 12 Sources for information on forest health

Source	Link
Williams Lake 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 [16] 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.
- 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.
- Implement land, natural resource and community planning that incorporates management of wildland fire at all appropriate scales.
- Develop a high level of public awareness and understanding about wildfire and its management.

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
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,

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

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
	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	Burn probability is highest (except in interface); avoid lost silviculture investments	Burn probability is highest within interface; avoid lost silviculture investments due to high fire extinguishment priority
	Pruning	Increase crown base height but will increase surface fuel loading		High risk interface areas – increase height to live crown.
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.

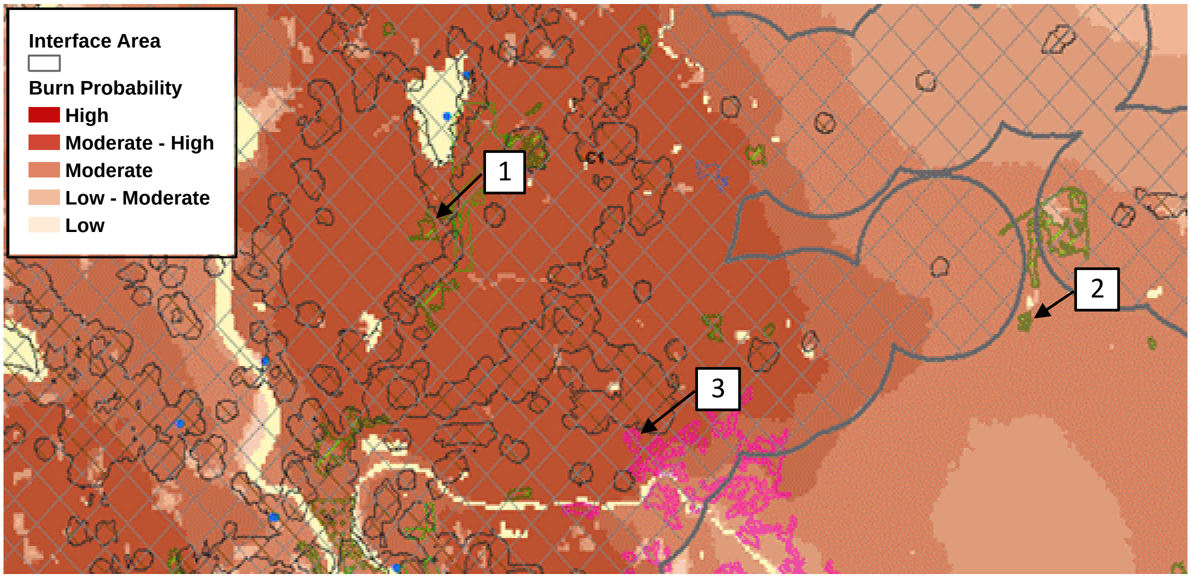

Figure 8 Map showing burn probability, interface areas and candidate treatment areas

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[17] 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[18] provincially[19], Wildfire Management Branch is not capable of responding to all wildfires in a major wildfire event. 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[20].

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 Cariboo.

[17] 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.

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

[19] 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.

[20] 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.

Climate change is expected to increase the frequency and intensity of wildfires[21]; 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 Williams Lake TSA (84,700 ha in the THLB since 2003[22]). The projected total impact on the THLB is 550,500 ha, or over 82.5 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	105,875
50%	2022 – 2032	127,050
75%	2032 – 2042	148,225
100%	2042 – 2052	169,400

Silviculture priorities and investments should be designed to address the increased frequency and intensity of wildfires [21] due to climate change.

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

Table 15 Sources for information on wildfire management

Source	Link
BC Wildland Fire Management Strategy	bcwildfire.ca/prevention/PrescribedFire/
Provincial Strategic Threat Analysis Caribou Fire Center. Contact Bev Atkins@gov.bc.ca	ground.hpr.for.gov.bc.ca/maps/cariboo/index.htm
Cariboo Regional District Community Wildfire Protection Plan. Contact Bev Atkins@gov.bc.ca	www.crd-director.com/section.php?cid=163
Burn-P3 Modelling Cariboo Fire Management Specialist Contact – Mike Black@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
Fuel Management Guidance for WUI areas in the IDF BEC Zone in the Williams Lake TSA	afrf.forestry.ubc.ca/files/2012/04/FuelMgtGuidance_WUI_IDF_WLTSA.pdf
Harvesting and Thinning Guidance for Treatments in WUI areas of TSA 29	afrf.forestry.ubc.ca/files/2012/03/WUITreatmentBMPswAppendix.pdf
DRAFT Community Wildfire Protection Plan for the 108 Greenbelt Lands	www.crd-director.com/reports/108-mile-greenbelt-cwpp-31-march.pdf

[21] 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.

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

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[23], 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 too many other negative trends.

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

The current ecosystem restoration plan[24] established a grassland benchmark used to facilitate the restoration of open-grassland habitat and legally established under the Cariboo-Chilcotin Land Use Plan. The ecosystem restoration plan also prioritized locations for restoration treatments, including prescribed burning and /or mechanical thinning. Most priority areas identified for treatment are located within the western part of the 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 or even grassland condition. In this case, if the timing is appropriate, these harvested volumes might then 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 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
Cariboo-Chilcotin Grasslands Strategy and Cariboo-Chilcotin Ecosystem Restoration Plan	www.ilmb.gov.bc.ca/slrp/lrmp/williamslake/cariboo_chilcotin/news/files/reports/grasslands_strat/index.html
Ecosystem Restoration Guidelines	www.env.gov.bc.ca/fia/documents/restorationguidelines.pdf
Cariboo-Chilcotin Ecosystem Restoration Plan: Grassland Benchmark	archive.ilmb.gov.bc.ca/slrp/lrmp/williamslake/cariboo_chilcotin/news/files/cc_er_strplan_blackwell_grassland_benchmark_2007.pdf
Ecosystem Restoration Contribution to Timber Supply	trench-er.com/public/library/files/restoration-timber-supply.pdf

3.8 Enhanced Retention

In the latest AAC rationale[25], the Chief Forester encouraged district staff and licensees to develop strategic plans to ensure that retention planning is addressed as harvest levels increase[26]. While formal enhanced retention strategies were developed for adjacent TSAs, there does not appear to be a coordinated approach to increase stand level retention for the Williams Lake TSA.

Encouraging heterogeneity across the landscape should improve the resiliency of forest ecosystems in the face of changing climate [27].

Table 17 provides links to sources for information on the enhanced retention.

[24] B.A. Blackwell & Associates Ltd., Cariboo-Chilcotin Ecosystem Restoration Plan: Grassland Benchmark, November 2007, 47p. (plus maps)

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

[26] BC Ministry of Forests, Forest Science Program, Forest Stewardship in the Context of Large-Scale Salvage Operations: An Interpretation Paper, Technical Report 19, 2004, 18p.

[27] Gayton, D., and P. Lara Almuedo. 2012. Post-disturbance management of biodiversity in BC forests. BC Journal of Ecosystems and Management 13(1):1–9.

Table 17 Sources for information on enhanced retention

Source	Link
Forest Stewardship in the Context of Large-Scale Salvage Operations	www.for.gov.bc.ca/hfd/pubs/docs/tr/tr019.pdf
Chief Forester Guidance on Landscape and Stand-level Structural Retention in Large-Scale Mountain Pine Beetle Salvage Operation	www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/cf_retention_guidance_dec2005.pdf

3.9 Secondary 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. However, a formal process for reporting these areas was not clearly 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 18 provides links to sources for information on protecting secondary structure.

Table 18 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
Abundance of secondary structure in the Cariboo–Chilcotin	cfs.nrcan.gc.ca/pubwarehouse/pdfs/31195.pdf

3.10 Watershed Management

In the latest AAC rationale[28], the Chief Forester requested that district staff, in cooperation with licensees and Ministry of Environment specialists, continue to investigate, monitor and report on the potential impacts that MPB-invested stands and salvage harvesting operations have on hydrology.

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

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

ecosystems. This is especially important for all fish-bearing streams, wetlands, fishery-sensitive watersheds and community watersheds.

Assessment of watershed risk requires a sound understanding of watershed hazards or the likelihood of events taking place (e.g., landslide, high peak flows) and the values or consequence that are at risk (e.g., fish/fish habitat, highways or life & limb). Recently, a GIS-based watershed risk analysis[29] prioritized management activities based on their potential positive or negative influence of watershed risk. This risk analysis was used to designate "priority watersheds" and flag stands that warrant consideration for silviculture or other treatments that provide both increased timber supply benefits and decreased watershed risk.

Priority watersheds were identified as basins and sub-basins that are:

- high risk to fish and fish habitat
- high risk to social values, and
- high equivalent clearcut area (ECA) (>30% based on the methodology implemented within the risk analysis).

The original intent was to incorporate watershed priorities into this silviculture strategy analysis, but after a series of discussions, it was decided to simply describe the silviculture treatments impacts on ECA in general terms. Table 19 describes how these treatment impacts can be used to prioritize stands for tactical and operational planning.

Table 19 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[30]. Developing effective responses to these effects will likely involve local-level strategies.

[29] Forsite Consultants Ltd. 2012. Cariboo GIS-Based Watershed Risk Analysis . Ministry of Forests Lands and natural Resource Operations.

[30] 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).

Table 20 provides links to sources for information on watershed strategies.

Table 20 Sources for information on watershed strategies

Source	Link
Cariboo Watershed Risk Analysis	ftp://ftp.geobc.gov.bc.ca/pub/outgoing/Randy%20at%20forsite/Cariboo%20River%20Watershed%20Risk%20Assessment%20Report.doc
Fisheries Sensitive Watersheds	www.env.gov.bc.ca/wld/frpa/fsw/index.html

3.11 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 ungulate winter ranges (UWR) for mule deer and through wildlife habitat areas (WHA) for American White Pelican, Data Sensitive Species, Northern Caribou and Mountain Caribou. The Cariboo-Chilcotin Land Use Plan (CCLUP) identified grizzly bear habitat, high value wetlands for moose and critical fish habitat.

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.

While this analysis incorporated landbase netdowns and forest cover constraints to address UWRs, WHAs and critical fish habitat, it did not incorporate any further constraints associated with the additional wildlife species identified in the CCLUP.

Based on predictive ecosystem mapping, the BC Ministry of Environment (MoE) has been working to create habitat models for moose, mountain caribou, northern caribou, mule deer, elk, white-tailed deer, grizzly bear, marten, lynx, three-toed woodpecker, and northern goshawk. Draft habitat maps from these models were not available in time for inclusion with this analysis however, results may later be incorporated back into the habitat model to identify areas where silviculture treatments might benefit or degrade habitat.

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 and climate change. Strategies to retain coarse woody debris and wildlife trees 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 21 provides links to sources for information on wildlife habitat.

Table 21 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
CCLUP	ilmbwww.gov.bc.ca/slrp/lrmp/williamslake/cariboo_chilcotin/index.html
Williams Lake SRMPs (7)	www.ilmb.gov.bc.ca/slrp/lrmp/williamslake/cariboo_chilcotin/srmp.html

3.12 Recreation

Whereas the CCLUP does not establish objectives specifically for recreation, there are three related objectives:

- maintain visual quality objectives for scenic areas
- maintain visual quality objectives for lakeshore management zones
- maintain a 50 meter management zone on either side of designated trails

The CCLUP final report also provides further direction on significant recreation corridors and a tourism sector strategy that considers access and visual quality. The SRMP proposes objectives and strategies for recreation corridors and trails, backcountry recreation areas and scenic areas.

In this analysis, modelling approaches to address the legal objectives for scenic areas, lakeshore management zones and designated trails were incorporated as either forest cover constraints or a landbase netdown. No changes were incorporated to incorporate recreation activities within the silviculture treatment scenarios.

While direct linkages do not appear to exist between recreation plans and the silviculture treatments explored in this project, prescribing foresters should consider any recreation features that may be affected either positively or negatively.

Climate change is not expected to have any direct impacts on recreation features. It is more likely that these values will be affected indirectly through increased forest disturbance and changes in ecosystem processes such as increased stream temperatures and the subsequent impacts on fish. In some cases treatments to address these processes may be available and should be considered in tactical and operational planning.

Table 22 provides links to sources for information on recreation values.

Table 22 Sources for information on recreation values

Source	Link
CCLUP	ilmbwww.gov.bc.ca/slrp/lrmp/williamslake/cariboo_chilcotin/index.html
Williams Lake SRMPs (7)	www.ilmb.gov.bc.ca/slrp/lrmp/williamslake/cariboo_chilcotin/srmp.html
(Archived) Recreation Corridor Management Strategy	archive.ilmb.gov.bc.ca/slrp/lrmp/williamslake/cariboo_chilcotin/docs/rec_cor.html

3.13 Range Management

The MFLNRO range program allocates and administers, through range use plans, hay cutting and grazing agreements as well as grazing leases on Crown range across the Province. A formal range management strategy or plan is currently unavailable for the TSA.

While direct linkages do not appear to exist between range management activities and the silviculture treatments explored in this project, prescribing foresters should consider how these treatments might affect or be affected by range activities. For example, cattle use within riparian areas and newly planted areas will continue to be a concern for managing both habitat and timber supply. Silviculture treatments could help to retain and enhance existing barriers to cattle accessing these riparian areas.

Table 23 provides links to sources for information on the range program, BC Cattlemen's association and the Guide Outfitters Association of BC.

Table 23 Sources for information on the range management

Source	Link
MFLNRO Range Program	www.for.gov.bc.ca/hra/index.htm
BC Cattlemen's Association	www.cattlemen.bc.ca/default.htm
Guide Outfitters Association of BC	www.goabc.org/

3.14 Invasive Plants

The MFLNRO addresses invasive plant management through operational inventory, survey, treatment, and monitoring activities, and the development of new biological control agents for effective long-term control and rehabilitation of heavily infested areas. To prevent the introduction or spread of prescribed species of invasive plants, the MFLNRO reviews operational plans to ensure that invasive plant concerns are adequately addressed by the plan holder before approval.

Millennium Ecosystem Assessment [31] has identified invasive alien species as a major threat to the resilience of ecosystems in the presence of climate change. Given the substantial environmental and economic costs associated with the risk of biological invasion, prescribing foresters should pay considerable attention to the management of invasive plant species, especially under projected climate change scenarios.

While direct linkages do not appear to exist between invasive plant strategies and the silviculture treatments explored in this project, prescribing foresters can contribute to the program by reporting invasive plant sightings and where appropriate, collaborating with the Invasive Species Council of BC and the MFLNRO on specific treatment and research initiatives[32].

Table 24 provides links to sources for information on strategies for addressing invasive species.

[31] Millennium Ecosystem Assessment, 2005. Ecosystems and human well-being: multiscale assessments, 4: OisLAND press, London.

[32] Numerous tools are available including an App to report invasives, e.g., http://www.bcinvasives.ca/special-events/fight-against-invasive-species-right-at-your-fingertips

Table 24 Sources for information on invasive species

Source	Link
MFLNRO Invasive Alien Plant Program	www.for.gov.bc.ca/hra/plants/
Invasive Species Council of BC	www.bcinvasives.ca/
Cariboo Chilcotin Coast Invasive Plant Committee	www.cccipc.ca/

3.15 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 25 provides links to sources for information on tree improvement and seed transfer.

Table 25 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

3.16 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 completion of a Landscape Vegetation Inventory (LVI) used to represent the state of the forest in the western half of the TSA. Validation of this product is scheduled to occur in 2013.

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 26 provides links to sources for information on the forest inventory program.

Table 26 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[33] prepared under the Forests for Tomorrow (FFT) program, as well as, standard operating procedures for undertaking Type 4 analyses (currently being developed).

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.

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

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 Williams Lake TSA. Recommendations for these data and research needs are described below.

Forest Inventory

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[34], 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.

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 appropriately 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

[34] JS Thrower and Associates, 2007.

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.

4.3 Recommendations for Modelling

Base Case Sensitivity – Limit the Harvest of Small Pine

This sensitivity was designed to reflect the notion that harvesting small pine becomes less economic for stands with longer haul distances. However, the priority for undertaking this scenario was deemed lower than the silviculture strategies proposed so the sensitivity for limiting the harvest of small pine was deferred.

Recommendation 16: Develop a base case sensitivity to limit the harvest of small pine.

Base Case Sensitivity – Incorporate Deciduous Stand Volumes

This sensitivity was intended to determine the impact of merchandizing hardwood logs - not currently being done in for this TSA. However, the priority for undertaking this scenario was deemed lower than the proposed silviculture strategies so the sensitivity for incorporating deciduous material was deferred.

Recommendation 17: Develop a base case sensitivity to incorporate deciduous stand volumes.

Silviculture Strategy – Pre-Commercial Thinning and Fertilization

This strategy was proposed as a way to improve stand quality/health/resilience through leave tree selection, increase stand volumes through fertilization and advance operability in these stands. However, due to the relatively minor amount of eligible area for this treatment, this scenario was not pursued further as it was not identified as a priority strategy within the available budget.

Recommendation 18: Develop a PCT and Fertilization strategy that includes subsequent thinnings of identified stand types (i.e., more area).

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 19: 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 20: 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 21: Periodically check, update and add hyperlinks to information on related plans and strategies.

Access

It is well-accepted that harvest levels in the Williams Lake TSA will soon be reduced to nearly half the current uplift AAC of 5.77 M 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 22: Encourage activities and develop programs that will aid in prioritizing and maintaining adequate road systems 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 23: Develop a coordinated monitoring program to ensure outputs from the various silviculture treatments employed meet expectations.