Type 4 Silviculture Strategy

Silviculture Strategy – 100 Mile House TSA

Version 1.7

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Acknowledgements

The Ministry of Forests, Lands and Natural Resource Operations (FLNRO), Resource Practices Branch commissioned this project in 2012. The project was completed by Forest Ecosystem Solutions Ltd. (Antti Makitalo) with B.A. Blackwell and Associates Ltd. (Jeff McWilliams) providing expert advice and direction in all aspects of silviculture.

The overall provincial project coordination from FLNRO was carried out by Paul Rehsler. Bill Olsen represented the 100 Mile House Natural Resource District and provided guidance from the district's perspective. Bryce Bancroft from Symmetree Consulting Group Ltd. provided all the information for the species deployment sections of this strategy. The 100 Mile Natural Resource District licensees and other government representatives participated in the various workshops held throughout this project and provided valuable feedback.

The authors would like to acknowledge and thank all those individuals who contributed in the completion of this project.

1. Introduction

1.1. Context

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

1. Situational Analysis – describes in general terms the situation for the unit – this could be in the form of a PowerPoint presentation with associated notes or a compendium document.
2. Data Package - describes the information that is material to the analysis including the model used, data inputs and assumptions.
3. Modeling and Analysis report –provides modeling outputs and rationale for choosing a preferred scenario.
4. **Silviculture Strategy –provides treatment options, associated targets, timeframes and benefits.**

1.2. Project Objectives

The Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) initiated a Type 4 silviculture strategy for the 100 Mile House Timber Supply Area (TSA) in 2012. The strategy will help MFLNRO work towards the government’s strategic objectives such as:

- Best return from investments and activities on the forest and range land base;
- Encourage investments to benefit forest and range resources;
- Manage the pest, disease and wildfire impacts;
- Mitigate mid-term timber supply shortage caused by the MPB;
- Maximize timber growth in the provincial forests.

This silviculture strategy is a result of collaboration and sharing of ideas involving MFLNRO Victoria staff, MFLNRO local staff, other government and industry stakeholders, and other professionals. The ultimate goal is a realistic strategy that will be owned and championed by district staff and licensees. In particular, this silviculture strategy will present:

- A fully rationalized plan to guide the expenditure of public silviculture funds to improve the future timber supply and habitat supply;
- A plan with a consistent format and content so that expanding it to regional and provincial levels is feasible and facilitates comparisons between management units;
- A plan containing the right information in the right format so that it can be utilized by government and industry for resource management related decision making;
- Silviculture regimes and associated standards that may potentially be adopted in forest stewardship plans as required standards for basic silviculture operations.
- An introduction of climate change into future management decision making.

1.3. Executive Summary of the Silviculture Strategy

<table>
<tr><td>Timber Supply</td><td colspan="2">The growing stock losses to the MPB will reduce the mid-term timber supply in the 100 Mile House TSA. The estimates for this reduction vary; in this analysis the mid-term harvest level was predicted to decrease to approximately 757,000 m^3 per year between years 6 and 40. The mid-term harvest forecast in the latest TSR by MFLNRO was higher at 890,000 m^3 per year.
Many of the attacked and killed pine stands might not get salvaged. These stands pose a fire threat to the forest and surrounding communities for several decades; they also reduce the future timber supply .by not producing timber at their inherent capacity.
The MPB outbreak has impacted young existing managed stands as well. The extent and the severity of the MPB impacts in young stands is not known; however, some of these younger stands may be so severely impacted that they have become or will become unproductive requiring rehabilitation.</td></tr>
<tr><td>Objective</td><td colspan="2">Mitigate the impact of the MPB, particularly on the mid-term timber supply.</td></tr>
<tr><td>General Strategy</td><td colspan="2">Maximize salvage and apply silviculture to improve quantity and quality of timber supply.</td></tr>
<tr><td rowspan="3">Working Targets</td><td>Timber Volume Flow Over Time</td><td>**Short Term** (1-5 years): Maximize salvage of dead pine without compromising the mid term by overcutting the green component. Suggest enhanced monitoring of green cut until next AAC determination. Suggest next AAC determination after the salvage period ends.
Mid Term (6 to 80 years): Maximize mid-term harvest without compromising the long-term harvest level.
Long Term (>80 years): Maintain highest stable growing stock.</td></tr>
<tr><td>Timber Quality</td><td>**Short Term** (1-5 years): Maximize the recovery of sawlog before the stands deteriorate.
Mid Term (6 to 80 years): Regenerate harvested areas with silviculture practices that improve timber quality; minimum log size 0.6 m3.
Long Term (>80 years): Regenerate harvested areas with silviculture practices that improve timber quality; minimum log size 0.6 m3.</td></tr>
<tr><td>Habitat Supply</td><td>**Short Term** (1-5 years): Support key habitat modeling initiatives and incorporate the results into next iteration of strategies. Develop plans for age class imbalances and recruitment and management of AC 8 and 9.
Mid Term (6 to 80 years): No specifics.
Long Term (>80 years): No specifics..</td></tr>
<tr><td>Major Silviculture Strategies</td><td>Timber Volume Flow Over Time</td><td>**Years 2013 – 2017**
Fertilize stands closest to harvest first. Start multiple application fertilization regimes; priority order Sx, Fd, Pl.

Survey existing managed stands for growth and yield, and pests and diseases.

Explore opportunities to space dry belt Fd stands; start a small spacing program.

Monitor salvage operations in MPB attacked stands to determine when rehabilitation programs should be considered

Years 2018 - 2023
Continue Fertilization with increased target area providing that stand conditions and stand health warrant it.
Rehabilitate dead pine stands that will not be salvaged; priority order:</td></tr>
</table>

<table>
<tr><td></td><td></td><td>younger stands with no merchantable volume first, stands with potential merchantable volume second.

Continue spacing dry belt Fd stands at a small scale; increase program size if early results prove promising.

Start using higher establishment densities in basic silviculture.</td></tr>
<tr><td></td><td>Timber Quality</td><td>Start using higher establishment densities in basic silviculture -</td></tr>
<tr><td></td><td>Habitat Supply</td><td>Develop plans for age class imbalances and recruitment and management of AC 8 and 9.</td></tr>
<tr><td>Silviculture Program Scenarios</td><td>Program</td><td>Years 1-5
<table>
<tr><th>Priority</th><th>Treatment</th><th>Target Area (ha/yr)</th><th>Unit Cost ($/ha)</th><th>Target Funding ($M/yr)</th></tr>
<tr><td>1</td><td>Surveys and Studies</td><td></td><td></td><td>$200,000</td></tr>
<tr><td>2</td><td>Fertilize</td><td>600</td><td>$500</td><td>$300,000</td></tr>
<tr><td>3</td><td>Space Dry Belt Fd</td><td></td><td></td><td>$50,000</td></tr>
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<tr><td></td><td></td><td>Years 6-10
<table>
<tr><th>Priority</th><th>Treatment</th><th>Target Area (ha/yr)</th><th>Unit Cost ($/ha)</th><th>Target Funding ($M/yr)</th></tr>
<tr><td>1</td><td>Studies and Surveys</td><td></td><td></td><td>$200,000</td></tr>
<tr><td>2</td><td>Rehab</td><td>750</td><td>$2,000</td><td>$1,500,000</td></tr>
<tr><td>3</td><td>Fertilize</td><td>1,000</td><td>$500</td><td>$500,000</td></tr>
<tr><td>4</td><td>Space Dry Belt Fd</td><td></td><td></td><td>$50,000</td></tr>
<tr><td>5</td><td>Enhance</td><td>1,000</td><td>$300</td><td>$300,000</td></tr>
</table></td></tr>
<tr><td>Outcomes</td><td>Timber Volume Flow Over Time</td><td>A 4.5% increase in harvest between years 21 and 45. 5.7% increase between years 41 and 50 and a 15.2% higher harvest level between years 51 and 70.</td></tr>
<tr><td></td><td>Timber Quality</td><td>Fertilized stands are predicted to have larger mean diameters.</td></tr>
<tr><td></td><td>Habitat Supply</td><td>Not modeled.</td></tr>
<tr><td>Recommendations</td><td>Inventories and Monitoring</td><td>1. Investigate alternative methods to cost-effectively develop an accurate inventory for Dry Belt Fd stands.

2. Existing managed stands: support the development of a protocol for, and implementation of, “mid-rotation” surveys from which the data can be used to accurately and efficiently develop growth and yield assumptions, include a timber quality assessment to help forecast future merchantability.

3. Promote the establishment of a YSM permanent sample plot network in the TSA as soon as possible.</td></tr>
<tr><td></td><td>Site Index</td><td>4. Conduct localized site index studies to increase confidence in site index estimates.</td></tr>
<tr><td></td><td>Modelling Approaches</td><td>5. Support the development of new approaches to stand level and forest level modeling of Dry Belt Douglas fir multi-storied stands.</td></tr>
<tr><td></td><td>Complete</td><td>6. Complete additional sensitivity analyses using different minimum</td></tr>
</table>

	Additional Sensitivity Analysis	harvest criteria and harvesting rules to better assess possible future outcomes. Stand level modeling for quality is integral part of this. 7. Given the importance of managed stands to the mid-term timber supply, complete additional sensitivity analysis relative to the growth and yield inputs for modelling the growth and yield of existing managed stands. As part of this process, complete further assessments and analysis on damaged pine-leading existing stands.
	Implementation of strategies	8. Establish a task force to investigate how an enhanced reforestation strategy can be implemented. 9. Establish a task force to investigate ways to implement large-scale rehabilitation programs. 10. Establish a task force to evaluate existing appraisal allowances and the cutting permit administration system and, if necessary, recommend ways to adequately support appropriate management of Dry Belt Fd stands.
	Quality Assessments	11. Support the development of projects to assess managed stand values resulting from different harvesting/treatment regimes. Projects could include valuations of standing timber using industrial and government log grades and prices and milling studies.
	Prioritization of the Landbase	12. Develop GIS-based prioritization of the TSA relative to expected investment returns from silviculture (e.g.: zonation based on site index, haul distance and terrain and harvest constraints).
	Operational research and adaptive management trials	13. Establish fertilization screening and area-based volume response trials in even-aged managed Douglas fir stands in the IDFdk3. 14. Establish silviculture system trials in Dry Belt Douglas fir stands to assess different uneven and even-aged approaches.

1.4. Summary of the Situational Analysis

1.4.1. Land Base

The 100 Mile House Timber Supply Area (TSA), about 1.23 million hectares in size, is located in south-central British Columbia. The TSA boundaries are identical to those of the 100 Mile House Natural Resource District, which is one of three districts in the Cariboo Forest Region. The TSA is bounded on the west by the Fraser River, on the east by the Cariboo Mountains and Wells Grey Park, on the north by the Williams Lake TSA, and on the south by the Kamloops TSA.

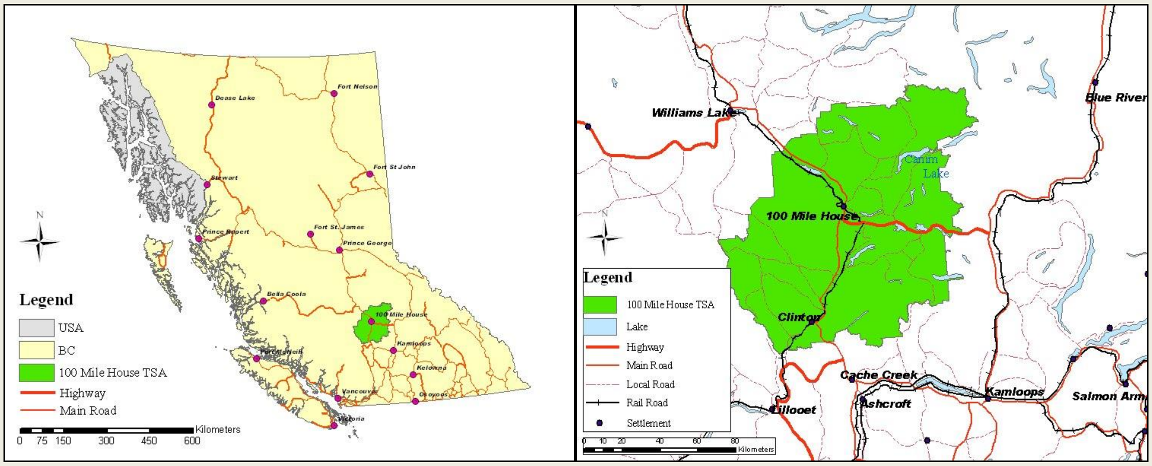

Figure 1: Location of 100 Mile House TSA

The climate in the 100 Mile House TSA is variable and affected by the diverse topography. The TSA has 2 mountain ranges, one in the southwest and the other in the northeast. These ranges are divided by a flat plateau. The climate in the west is hot and dry, while the eastern parts of the TSA can receive significant amount precipitation.

The dominant tree species are lodgepole pine and Douglas-fir with other tree species occurring such as spruce, subalpine fir (balsam), western red cedar, western hemlock and deciduous species.

Approximately 830,249 hectares of the TSA are considered productive forest while 80 percent or 662,103 hectares of the productive forest are classified as timber harvesting land base (THLB) and available for harvesting. The THLB netdown is shown in Table 1.

The dominant biogeoclimatic zone variants in the 100 Mile House TSA are interior Douglas fir (IDF) forest types and sub-boreal spruce (SBS) forest types. Some Englemann spruce-subalpine fir (ESSF), interior cedar-hemlock (ICH) and montane spruce (MS) types also exist (Figure 2).

Table 1: 100 Mile House TSA netdown summary

Description	Gross Area (ha)	Net Area removed (ha)
Total Area	1,237,629	1,237,629
Non-Crown Land	161,159	161,159
Woodlots and K2W	47,880	5,026
Clinton Community Forest Agreement	65,444	65,290
Canim Lake First Nations Replaceable Forest Licence	21,444	21,416
Crown-Owned Land		**984,738**
Non-Forest - Rock	30,427	26,297
Non-Forest - Water	58,458	54,711
Non-Forest - Vegetated	120,219	61,518
Existing Roads (semi-spatial)	19,123	11,963
Crown Forested Land Base (CFLB)		**830,249**
Non-THLB Crown Lands	54,387	43,584
Non Commercial	1,563	530
OGMA (Permanent and Rotational)	109,749	80,075
Parks (Goal 2 Protected Areas)	5,714	2,340
Slope (inoperable > 70%)	11,251	2,668
Slope (cable >50% and <70%)	27,014	3,849
Low Productivity Site	14,399	5,375
Wildlife Habitat Areas	19,655	10,012
Class A Lake Buffers	6,062	999
Riparian Reserve and Management Zones	24,753	15,372
Recreation Trails	6,797	3,342
Timber Harvesting Land Base (THLB)		**662,103**
WTP reduction (for modelling only)	138,679	138,679
Timber Harvesting Land Base (THLB) for model		**523,524**

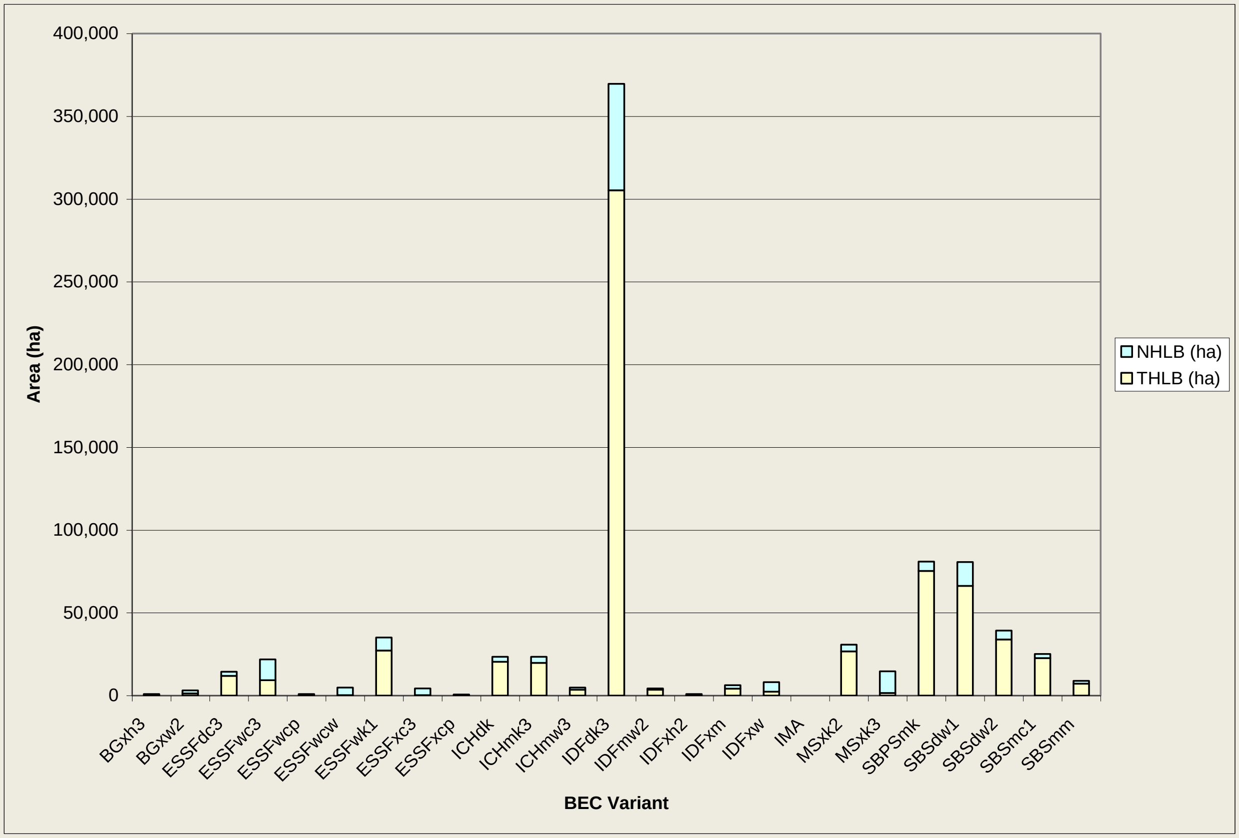

Figure 2: BEC Variants in the 100 Mile House TSA

The productivity of the growing sites in the 100 Mile House TSA is average. Table 2 shows the average site indices for natural and managed stands for different species groups.

Table 2: Average site productivity in the 100 Mile House TSA

Site Index Type	Balsam	Pine	Spruce	Douglas fir	Deciduous
VRI Site Index Average (THLB) used for natural stands:	12.46	14.22	15.83	13.11	16.41
SIBEC average (THLB) used for managed stands:	17.11	19.11	18.66	18.96	19.68

1.4.2. Historical and Current AAC

The current AAC in the 100 Mile House TSA is 2.0 million m^3 per year. It was increased in 2006 from 1.334 million m^3 (Table 3) in response to the MPB epidemic to facilitate salvage of the attacked pine stands. The Deputy Chief Forester maintained the AAC at 2.0 million m^3 per year in her November 2013 determination until November 7, 2018. From this date on she reduced the AAC to 1.0 million m^3 per year until the next AAC determination. No more than 500,000 m^3 of the current AAC is attributable to live trees.

Table 3: Historical and current AAC

	1996	2002	2006	Current to Nov 7, 2018	Nov 7, 2018 until the next AAC determination
AAC (million m^3)	1.362	1.334	2.0	2.0	1.0

1.4.3. Age Class Distribution

The current age class distribution for the 100 Mile House TSA is presented in Figure 3. The increased harvest due to the MPB salvage is reflected in the age class distribution. 21% of the THLB is between 0 and 20 years old and 39% of the THLB is younger than 41 years of age. Age class 3 and 4 are under-represented at 7.4% and 4.8% of the THLB respectively, which characterizes the timber supply problem in the TSA; these age classes are the potential sources for the mid-term timber supply.

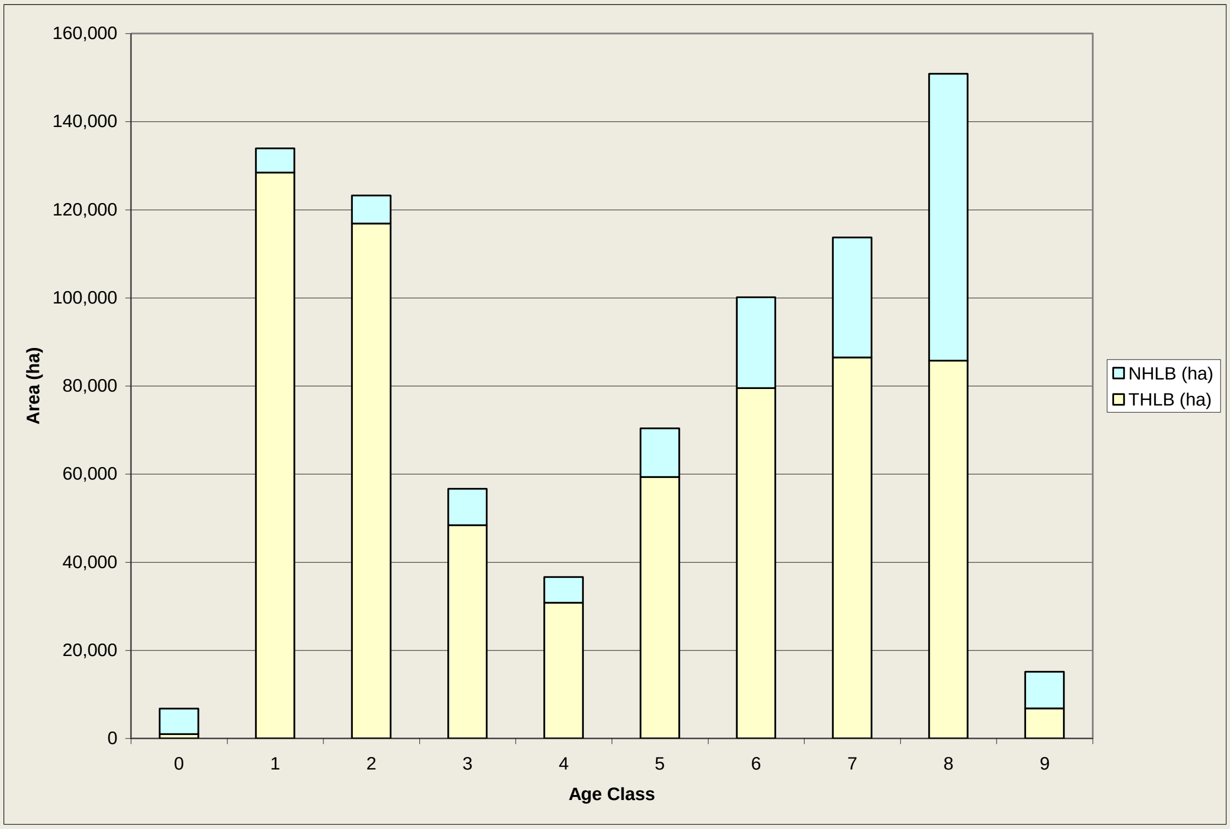

Figure 3: Current age class distribution in the 100 Mile House TSA

1.4.4. MPB in the 100 Mile House TSA

The latest version of the British Columbia Mountain Pine Beetle Model (BCMPB v9) predicts a total mature pine kill of 41.6 million cubic metres for the 100 Mile House TSA by 2021. This is approximately 73% of the mature pine that was on the timber harvesting land base in 1999.

Douglas-fir bark beetle, spruce bark beetle and balsam bark beetle also impact the timber supply. The current management direction is to give first harvest priority to pine stands with a pine component greater than 70% and spruce stands with the White spruce/Engelmann spruce (Sw/Se) component greater than 70%. Prioritizing the harvest of spruce stands is intended to prevent the spread of spruce beetle.

1.4.5. Shelf Life

The merchantability of beetle-killed wood remains an important uncertainty in timber supply analyses. In this analysis shelf life is defined as the time a stand remains economically viable for sawlog harvesting. The shelf life starts at the year of death; defined as when cumulative kill reaches 50%. This analysis assumed that a time period of 17 years from the average time of death is required until the stand becomes entirely unmerchantable. The merchantability is assumed to decline to 0 in 17 years. The shelf life for other product types may be longer; however, it was not modeled in this analysis.

1.4.6. Growing Stock

The total growing stock in the modelling THLB is estimated at approximately 49 million m^3. This estimate excludes the dead volume lost due to decay as described above. Spruce accounts for 22% of this volume with Douglas fir at 22% as well. 10% of the growing stock is in deciduous species while balsam and other conifer constitute approximately 5% in total. The remainder of the volume (40%) consists of pine; however, more than half of it is dead (23% of total growing stock) (Table 4, Figure 4).

Table 4: Growing stock by species in the 100 Mile House TSA

Species	Million m^3		
	Live	Dead	Total
Balsam	2,139,440	0	2,139,440
Deciduous	4,735,605	0	4,735,605
Douglas fir	11,117,993	0	11,117,993
Pine	8,843,839	11,165,679	20,009,518
Spruce	10,887,205	0	10,887,205
Other Conifer	531,352	0	531,352
Grand Total	38,255,435	11,165,679	49,421,113

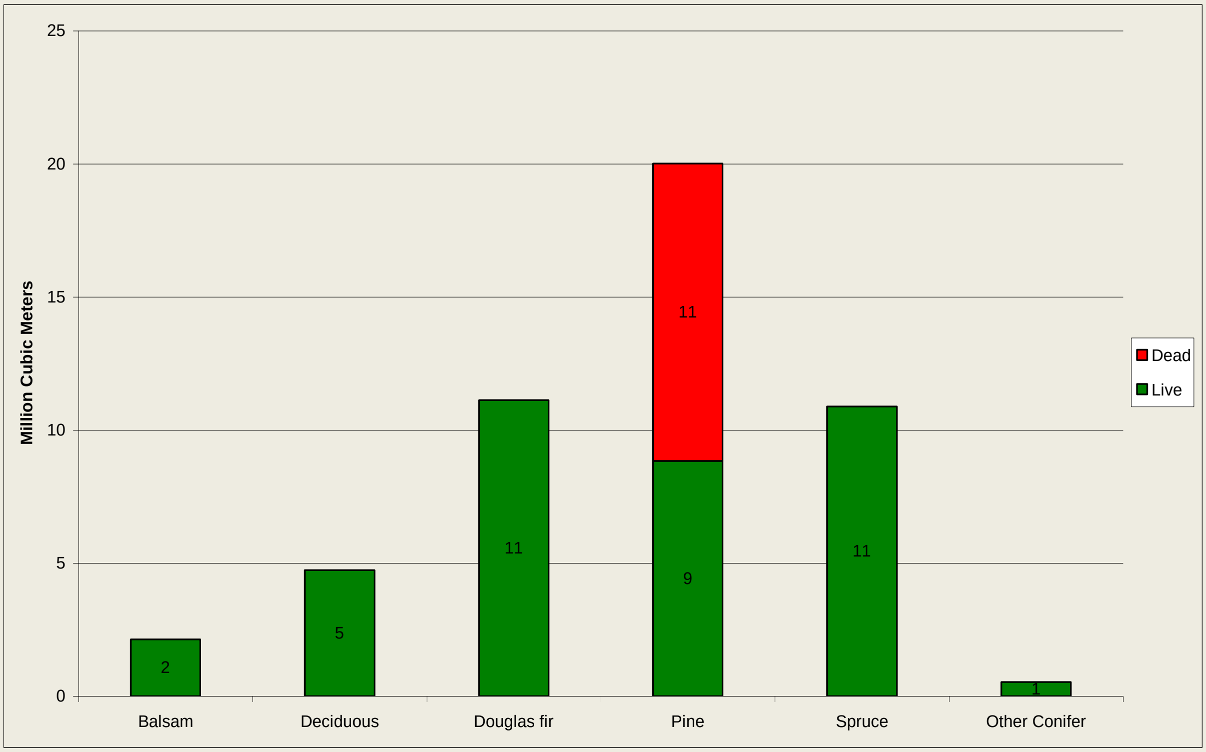

Figure 4: Growing stock by species in the 100 Mile TSA

1.4.7. Timber Supply

The impacts of the MPB infestation on the timber supply in the 100 Mile House TSA are multiple and severe. The growing stock losses to the MPB will reduce the mid-term timber supply. The estimates for this reduction vary; in this analysis the mid-term harvest level was predicted to decrease to approximately 757,000 m^3 per year between years 6 and 40, a considerable drop from the current AAC of 2.0 million m^3 per year. The mid-term harvest forecast in the latest TSR by MFLNRO was higher at 890,000 m^3 per year. The difference was mostly caused by the different shelf life assumptions between the two analyses. The TSR assumed 100% retention of merchantability for 15 years, after which the dead pine volume is no longer usable.

Many of the attacked and killed pine stands will not get salvaged. This analysis estimated that up to 60,000 ha of dead stands might remain on the landscape; these stands pose a fire threat to the forest and surrounding communities for several decades. They reduce future timber supply as it is expected that it may take several decades until these stands will become productive again.

Studies have shown that some of the dead pine stands may contain adequate advanced regeneration and non-pine species of residual trees, i.e. secondary structure to contribute to the mid-term timber and long-term timber supply. The extent of these stands in the TSA is not known, nor is the growth and yield of them.

The MPB outbreak has impacted young existing managed stands as well. The extent and the severity of the MPB impacts in young stands is not known; however, some of these stands will likely not grow as originally predicted. Some of these younger stands may be so severely impacted that they will not reach merchantability within a reasonable timeframe and therefore require rehabilitation.

The success of basic silviculture is crucial to future timber supply. Basic silviculture is also the basis for future incremental treatments. Initial stocking densities must be sufficient to ensure the production of a reasonable volume of timber on a given site.

1.4.8. Timber Quality

The ongoing salvage operations are facing a declining timber quality due to decaying dead timber and smaller piece sizes. After the salvage period ends – within the next 5 years – the harvest will move on to green timber. The early mid-term harvest volume is predicted to come from green spruce, Douglas fir and pine. The harvest of managed stands starts between years 26 and 30 and by year 35 makes up about 60% of the total harvest. During the rest of the mid-term, managed stands make up approximately 90% of the harvest. The health, quality and performance of the managed stands are crucial to the mid-term timber supply. Many of the young pine stands have been impacted by the MPB. Incidents of stem rusts in immature pine also occur; these have negative effects on both stand productivity and wood quality. These forest health issues may impact the timber supply and merchantability in the mid-term even if the young pine stands survive the current MPB infestation.

1.4.9. Biodiversity and Habitat Supply

The loss of mature and old forest due to the MPB infestation and associated salvage has a significant impact on aquatic and terrestrial habitat and other values. Overall biodiversity is likely reduced while connectivity and patch size objectives are affected. Seral stage objectives are compromised in the short term with large areas of the forest dying and eventually falling down.

The visual quality is impacted; salvage operations change the visual quality in the harvested areas. In areas where dead trees are not salvaged, the visual quality is obviously affected as well.

In watersheds, water quality and peak flows are likely affected by increased harvesting and the prevalence of dead trees. Ecologic functions of lakeshore areas and riparian areas are impacted; these impacts will extend to fisheries as well.

Natural resource management in the 100 Mile House TSA is directed by the Cariboo-Chilcotin Land Use Plan (CCLUP) and associated Land Use Order (April 18, 2011) and guiding documents. It is a legal higher level plan established by cabinet under the Forest Practices Code in January 1996. It covers 100 Mile House, Quesnel and Williams Lake timber supply areas. The plan is a representation of economic, social and environmental values of the people and communities in the region. Sub-regional level planning further refined and mapped land uses and was carried out in consultation with industry, interest groups and local First Nations. The plan consists of specific land use designations that direct operations including those of salvage.

2. Silviculture Strategies

2.1. Working Targets

Provincial timber management goals and objectives that include working targets for the provincial timber supply are currently under development. The provincial goals and objectives will in turn provide direction to all the TSAs. The stakeholder group agreed to a set of targets for the 100 Mile House TSA in the workshop held at 100 Mile House in December 4, 2013. The targets are listed in Table 5.

Table 5: Targets for various indicators

Indicator	Target
Harvest Volume over Time	**Short Term (1-5 years):** Maximize salvage of dead pine without compromising the mid term by overcutting the green component. Suggest enhanced monitoring of green cut until next AAC determination. Suggest expedited next AAC determination. **Mid Term (6 to 80 years):** Maximize mid-term harvest without compromising the long -term harvest level. **Long Term (>80 years):** Maintain highest stable growing stock.
Timber Quality	**Short Term (1-5 years):** Maximize the recovery of sawlog before the stands deteriorate. **Mid Term (6 to 80 years):** Regenerate harvested areas with silviculture practices that improve timber quality; minimum log size 0.6 m^3. **Long Term (>80 years):** Regenerate harvested areas with silviculture practices that improve timber quality; minimum log size 0.6 m^3.
Habitat	**Short Term (1-5 years):** Support key habitat modeling initiatives and incorporate the results into next iteration of strategies. Develop plans for age class imbalances and recruitment and management of AC 8 and 9. **Mid Term (6 to 80 years):** No specifics. **Long Term (>80 years):** No specifics.

2.2. Scenario Overview

In addition to the base case eight scenarios were constructed and compared to the base case. One was a sensitivity analysis testing the impact of harvest scheduling on the mid-term timber supply. Seven were silviculture strategy scenarios testing the impact of various silviculture treatments on timber supply, particularly the mid-term timber supply. These learning scenarios directed the final two composite scenarios. In the composite scenarios different silviculture treatments were combined into two scenarios; one with an annual budget of $300,000 for the first 5 years, the other with an annual budget of $2.3 million for the same time period. All the scenarios are summarized in Table 6.

Table 6: Scenario summary

Type	Scenario	Description
Base Case		Current practice, best available information
Base Case Sensitivities	Low initial harvest	Test the impact of limiting the harvest to 1.334 million m^3/year in the first 5 years.
Silviculture Strategies	Rehabilitation of dead pine stands	Test the impact of rehabilitating dead pine stands. Incidental recovered volumes are not assumed to contribute to timber supply.
	Rehabilitation of dead pine stands and fertilization	Test the impact of rehabilitating dead pine stands and fertilizing the rehabilitated stands up to 4 times at ages 25, 35, 45 and 55.
	Fertilization 1	Test the impact of fertilizing previously fertilized existing managed stands. The stands were fertilized once or twice. The candidate population was 3,340 ha.
	Fertilization 2	Test the impact of fertilizing previously fertilized existing managed stands and the fertilization of currently 20-30 year-old pine stands. The stands were fertilized 1 to 4 times depending on their age. The candidate population was 5,340 ha.
	Fertilization 3	Test the impact of fertilizing previously fertilized existing managed stands, the fertilization of currently 20-30 year-old pine stands and the fertilization of stands currently between 1 and 10 years old. The stands were fertilized 1 to 4 times depending on their age. The candidate population was approximately 30,000 ha.
	Enhanced reforestation	Test the impact of increased planting densities with alternative species mixes.
	Enhanced reforestation with fertilization	This scenario combined increased planting densities and fertilization of all suitable future stands. The future stands were fertilized at ages 25, 35, 45 and 55.
	Combination of Strategies ($300,000 /year)	This scenario included rehabilitation of dead pine stands, fertilization of existing stands and increased planting densities. Maximum budget was set at $300,000/year for the first 5 years and $2.3 million for later periods.
	Combination of Strategies ($2.3 M/year)	This scenario included rehabilitation of dead pine stands, fertilization of existing stands and increased planting densities. Maximum budget was set at $2.3 M/year.

Table 7 summarizes the relative impacts of the various silviculture scenarios on timber supply relative to the predicted harvest in the base case. The short term is defined as the next 5 years. The mid term is divided into two components: near mid term and far mid term. This was necessary as many of the tested scenarios had significant mid-term impacts; however, these impacts are predicted to take place later in the mid term. The focus of this analysis and strategy – while on the mid-term timber supply in general – emphasizes the mitigation of timber supply as close to today as possible.

The near mid term in this analysis is defined as the time between years 6 and 40, while the far mid term extends from year 41 to year 70. We call the remainder of the planning horizon (150 years) “long term” even if the long-term harvest level is not always reached by this time.

Table 7: Scenario timber supply impacts

Scenario	Timber Supply			
	Short Term	Near Mid Term	Far Mid Term	Long Term
Rehabilitation of dead pine stands	0	0	++	0
Rehabilitation of dead pine stands and fertilization	0	0	+++	0
Fertilization 1	0	0	0	0
Fertilization 2	0	Marginal +	Marginal +	0
Fertilization 3	0	++	+	0
Enhanced reforestation	0	0	+++	++
Enhanced reforestation with fertilization	0	0	+++	+++
Combination of Strategies ($300,000 /year)	0	0	++	+++
Combination of Strategies ($2.3 M/year)	0	+	+++	+++

Notes:

- The timber supply in the 100 Mile House TSA will be reduced significantly in 5 years. The shortage of available volume is expected to last at least until year 40.
- Shelf life assumptions used in the analysis are subject to uncertainty. The timber supply is sensitive to these assumptions.
- Decreasing the harvest immediately increases the early mid-term harvest compared to the base case. This increase comes at a cost: the total loss of harvest in the short term is greater than the total gain the mid term.
- The near mid-term timber supply is dependent of age class 7, 8 and 9 spruce and Douglas fir stands and pine stands that survived the MPB attack. After year 25, existing managed stands are predicted to form the majority of harvest. The health and condition of these stands is unknown.
- Rehabilitation of unharvested dead pine stands has no timber supply impact until year 41. Note that this analysis assumed no timber recovery from these stands at the time of rehabilitation. Rehabilitation will reduce overall fire hazard significantly. This impact was not modeled and is not shown in the analysis outcomes.
- Fertilization had no impact on timber supply until year 21; after that the potential impact in the mid term is significant. The fertilization impacts are less significant in the far mid term and in the long term.
- The candidate area for fertilizing existing managed stands contains a large area of existing managed pine stands. The health and condition of these stands is unknown; the candidate population as modeled may be overstated.
- The best return in fertilization is achieved by fertilizing stands once approximately 10 years before harvest.
- Fertilization of young stands is risky due to the long return period; investments can be lost due to fires, pests and diseases.

- Enhanced reforestation (higher densities) has a significant impact on timber supply in the late mid term and long term. The difference in yield between the higher density stands and base case modeled stands contributed to this of impact. Note that the modelling did not account for the increased resiliency and buffer against pests and diseases of these stands. This point was considered in preparing this silviculture strategy.
- The composite scenarios had a modest positive mid-term timber supply impact; the impact was 4.5% increase in harvest between years 21 and 45 in both cases. Later in the planning horizon the higher budget of Composite Scenario 2 increased the harvest more; 8.9% versus 5.7% between years 41 and 50.

2.3. Preferred Silviculture Strategy

The preferred silviculture strategy was designed by the 100 Mile House TSA stakeholder group. It sets a modest incremental silviculture target of 600 ha of fertilization per year for the next 5 years at the cost $300,000 per year. The annual fertilization program is set to increase to 1,000 ha per year in the post salvage period starting 6 years from today. The rehabilitation of dead pine stands will start at year 6 as well, and by this time, enhanced basic silviculture will be considered for the silviculture program. The annual budget for the first 5-year period is $550,000 and at $2.55 million for years 6 to 10.

Using a $300,000 annual budget for the first 5 years and $2.3 million for consecutive 5 year periods resulted in a 4.5% increase in harvest between years 21 and 45. The increase was more pronounced between years 41 and 50 at approximately 5.7%. A 15.2% higher harvest level was achieved between years 51 and 70. No increases in the LTHL were observed.

Table 8 shows the projected expenditures by treatment for the preferred strategy. Note that Dry Belt Douglas fir management modelling in this analysis was limited to stand level investigation of understory spacing.

Table 8: Projected annual costs by treatment for the preferred strategy

Treatment/Activity	Years 1 to 5	Years 6 to 10
Surveys and Studies	$200,000	$200,000
Increased Planting Densities	$0	$300,000
Fertilization	$300,000	$500,000
Rehabilitation	$0	$1,500,000
Dry Belt Douglas fir understory spacing	$50,000	$50,000
Total	$550,000	$2,550,000

2.3.1. Surveys and Studies

$200,000 annually is allocated for surveys and studies in the next 10 years. These studies will help to gain a better understanding of the condition of existing managed stands. The studies and surveys will also help in determining which stands in the 100 Mile House TSA are best candidates for rehabilitation. The budget allocation for studies and surveys was not included in the modelling scenarios.

2.3.2. Increased Planting Densities

Increased planting densities are a priority in the 100 Mile House TSA. Implementing this component of the strategy showed timber supply impacts the far mid term and the long term. The modelling did not account for potential timber quality improvements such as smaller knot sizes, stem shape and fibre length, or higher resiliency towards damaging agents and climate change. Higher densities also provide options for future silviculture treatments.

There is no current funding mechanism for increased planting densities; this strategy component is not funded under the Land Base Investment Program. For this reason, this treatment will not be adopted as part of the silviculture strategy until the funding mechanism for it has been determined though industry government consultation.

2.3.3. Fertilization

The candidate area for fertilization in the 100 Mile House TSA is modest; fertilization is not generally recommended in the IDF and past fertilization in other BEC variants of the TSA have not always been successful. The condition of the candidate stands needs to be evaluated before operational fertilization takes place. The best financial return in fertilization is achieved by fertilizing stands younger than 80 years of age once approximately 10 years before harvest; however this population is limited. The modelling results are based on multiple fertilization treatments of younger stands; the multiple fertilization regimes should be followed operationally as well. The Land Base Investment Program is expected to fund fertilization.

2.3.4. Rehabilitation of Dead Pine Stands

Rehabilitation of MPB killed pine stands is a potential opportunity to mitigate the late mid-term timber supply and reduce fire risk at the landscape and local levels. However, the TSA licensees and government staff believe that most of the forest killed by the MPB will be salvaged and subsequently reforested. For this reason, the rehabilitation of unsalvaged dead stands will not start until the post salvage period, after 2017.

Rehabilitation of dead pine stands is projected to have a modest far mid-term impact; however, it may provide more mid-term harvest than shown in the modelling results, should the rehabilitated stands contain any merchantable volume. Based on stand-level financial analysis rehabilitation may be financially favourable, if the total costs can be kept at around $1500 per hectare or below. A simplified forest level economic analysis showed that rehabilitation of dead pine stands created the largest net present value at the forest level.

The stands with no merchantable volume should be the first priority for rehabilitation, while stands that may still contain merchantable volume even after the salvage period is over should be rehabilitated during the mid term when a timber shortage is projected to exist.

Rehabilitation treatments can be funded through the Land Base Investment Program; however other funding sources such as Innovative Timber Sale Licenses (ITSL) should be considered.

2.3.5. Understory spacing in Dry Belt Douglas fir Stands

Spacing of over-dense understories in appropriate multi-storied Douglas fir stands can improve health and vigour in these stands and contribute to mid-term timber supply. This treatment (amongst others) was a recommendation of an IDF Strategy completed for the 100 Mile House and Williams Lake TSAs (Day and McWilliams, 2013) as a component of a Type 4 Silviculture Strategy for each TSA. Initially funding is required to identify candidate areas for treatment and prescription development. Subsequently funding will be used to complete the treatments.

2.4. Other Strategies Examined with Stand-level Analysis

2.4.1. Rehabilitation of Dead and Damaged Managed Pine-leading Stands

Managed stand yields and quality are critical to the mid-term timber supply. There are concerns that some existing pine-leading managed stands may not contribute to the mid-term timber supply as expected due to the damage caused the MPB and other agents. Rehabilitation of these stands may be beneficial to the late mid and long term timber supply. However; before proceeding with rehabilitation, these stands should be assessed with appropriate stand level data and analysis. A simple stand-level analysis was presented in the Analysis and Modelling Report to help frame future discussions on this issue.

2.5. Suggested Strategies which were not Assessed

These strategies were suggested and discussed during workshop sessions but were not prioritized for analysis.

1. Additional dry belt Douglas fir treatments from as identified in the IDF Strategy completed for the 100 Mile House and Williams Lake TSAs (Day and McWilliams, 2013):
    - Overstory removal and spacing of partially harvested dry belt Douglas-fir Stands;
    - Spacing low density, diseased and damaged pine stands in the IDF to favour existing layer 3 and 4 Douglas-fir.
2. Repression spacing of over-dense pine

    According to the district staff, small areas of repressed over-dense pine stands exist in the TSA. Spacing these stands may be beneficial. This treatment was not modeled in the analysis due to the small area involved; however, spacing repressed over-dense pine stands will remain as one of the candidate treatments for the 100 Mile House TSA silviculture strategy.
3. Spacing/cleaning of diseased, damaged poor quality pine leading stands in the SBS and ICH to favor existing Douglas-fir and spruce stocking.

    According to the 100 Mile Forest District staff there are low productivity pine leading stands with significant Douglas-fir component in the district where the stands may benefit from spacing to favor Douglas-fir and possibly spruce if present. As with the spacing of over-dense pine stands, the inventory file does not provide adequate detail for these stands to facilitate modeling. However, this treatment will remain as an option for the silviculture strategy.
4. Under planting of low density, poor quality young pine stands in the IDF

    There is evidence that some existing managed pine leading stands in the IDF are of such poor quality that they may benefit from rehabilitation and/or under planting Douglas-fir. The area of these stands is not known, nor is there inventory and growth and yield data that would support modeling of these stands.
5. Converting non-forested area into THLB

    Converting non-productive areas is always a viable option to increase timber production. Generally the timber supply impact occurs in the long term. The district does not have readily available candidate areas for this conversion; however, this treatment remains as an option in the silviculture strategy.
6. Increased use of western larch for reforestation

There is stakeholder interest in promoting the use of western larch in reforestation strategies in portions of the TSA. The seed zones from western larch have recently been expanded, but before widespread use of this species can be considered in this area, trials and analysis are required.

3. Related Plans and Strategies

The presented silviculture strategy needs to be integrated with other plans and strategies that exist in the 100 Mile House TSA. These are briefly described below with operational notes where necessary.

3.1. Climate Change

Climate change is projected to impact both timber supply and environmental values and it must be accounted for in longer term plans and strategies. The speed and the scope of this predicted change is not known; however, it is expected that ecological niches of tree species will be altered. The occurrence of various diseases is also expected to rise as a result of the stress brought on by climate change. Table 9 provides links and references to some climate change information sources.

Table 9: Climate change information sources

Source or Publication	Link
Climate Change in BC	
Plan2Adapt - Regional projections of future climate scenarios	pacificclimate.org/tools-and-data/plan2adapt
Climate Overview 2007 – Hydro-climatology and Future Climate Impacts in BC. 2009.	http://pacificclimate.org/docs/publications/PCIC.ClimateOverview.Revised.March2009.pdf
Regional Analysis for Columbia Basin	http://pacificclimate.org/sites/default/files/publications/Murdock.CBT2007-2010Update.Jul2011.pdf
Regional Analysis for Cariboo-Chilcotin	http://pacificclimate.org/sites/default/files/publications/Werner.ClimateChangeCaribooChilcotin.Sep2008.pdf
Regional Analysis for Prince George	http://pacificclimate.org/sites/default/files/publications/Werner.ClimateChangePrinceGeorge.Aug2009.pdf
Regional Analysis for Vanderhoof to Fraser Lake	http://www.pacificclimate.org/project/infrastructure-and-climate-riskyellowhead-highway
Climate WNA (Western North America) for historical and future climate information	pacificclimate.org/tools-anddata/climatewna
Environment Canada Climate Data and Information Archive – Historical Normals and Averages	http://www.climate.weatheroffice.gc.ca/climate_normals/index_e.html
Selecting and Using Climate Change Scenarios for British Columbia. Murdock & Spittlehouse, 2011	http://pacificclimate.org/news/2012/new-publication-selecting-and-using-climate-change-scenarios-britishcolumbia
Regional Forestry Related Climate Change Assessments	
West Kootenays - *Resilience and climate change: Adaption potential for ecological systems and forest management*	http://www.westkootenayresilience.org/
Kamloops TSA – *Kamloops future forest strategy*	http://k2kamloopstsa.com/
Morice & Lakes TSAs – *Multi-scale trans-disciplinary vulnerability assessmen*	http://bvcentre.ca/research/project/a_multi-scale_trans-disciplinary_vulnerability_assessment/
Clayquot – *Building on traditional and scientific knowledge to build resilience in the face of climate change*.	http://ecotrust.ca/clayoquot/building-traditional-and-scientific-knowledge-develop-resiliency-face-climate-change
Vanderhoof – *Assessing potential biophysical and socio-economic impacts of climate change on forest-based communities – a methodological case study.*	http://publications.gc.ca/collections/collection_2009/nrcan/Fo133-1-415E.pdf
Northwest Skeena – *Climate change adaptation planning for Northwest Skeena communities*.	http://brinkmanforest.com/ffesc/

Source or Publication	Link
Quesnel TSA – *Integrating Climate Change Adaptation Strategies with Sustainability and Socioeconomic Objectives.*	http://biod.forestry.ubc.ca/FFESC/ (PPT only)
Climate Change Impacts for BC Forests	
BC Journal of Ecosystem and Management on Climate Change Volume 13 No. 1 **(**2012) Published by FORREX Forum for Research and Extension in Natural Resources	http://jem.forrex.org/index.php/jem
Climate Impacts on BC Watershed Hydrology. 2008. Pike et. al. (4 pgs)	http://cbtadaptation.squarespace.com/storage/ClimateImpactsonBCWatershedHydrology.pdf
Climate Change Effects on Watershed Processes in British Columbia, Chapter 19. 2010. Pike, R.G. et al. in: R.G Pike, T.E. Redding, R.D. Moore, R.D. Winkler, K.D. Bladon (Eds.), Compendium of Forest Hydrology and Geomorphology in British Columbia. BC Ministry of Forests and Range, Forest Sciences Program, Victoria, B.C. and FORREX Forest Research Extension in Natural Resources, Kamloops, BC Land Management Handbook 66 (48 pgs).	http://pacificclimate.org/sites/default/files/publications/Pike.Ch19ForestHydrology.Dec2010.pdf
Climate Change Adaptation and Biodiversity – Background & summary reports. 2009. SFU - ACT. (72 pgs).	http://act-adapt.org/biodiversity/
Ecological resilience and complexity: A theoretical framework for understanding and managing BC's forest ecosystems in a changing climate. 2009. Campbell et. al. MOF Technical Report 055. (36 pgs).	http://www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr055.pdf
PCIC Forest pest and tree species suitability project	http://pacificclimate.org/project/forest-pests-and-treespecies-suitability-future-climates
Adapting Forest Management to Climate Change	
Reducing Uncertainty and Risk through Forest Management Planning, 2012. Kenneth Day and David Manuel Pérez.(Submitted - will be posted on BCCFA website)	
Climate Change and Forest Management in Canada:Impacts, Adaptive Capacity and Adaptation Options, 2011. Johnston, et. al.	http://www.sfmn.ales.ualberta.ca/en/Publications/~/media/sfmn/Publications/StateofKnowledgeReports/Documents/SOK2010ClimateChangeJohnstonetalEn.ashx
*Vulnerability of Canada's Tree Species to Climate Change and Management Options for Adaptation, 2011.*Johnston, et. al.	http://www.ccfm.org/pdf/TreeSpecies_web_e.pdf
Climate Change Adaptation and Extreme Weather – SFU ACT Background & Summary reports.	http://actadapt.org/extreme-weather/
Impacts to Adaptation: Canada in a Changing Climate. 2007. Natural Resources Canada. (See Synthesis - 20 pg and the BC chapter – 56 pg)	http://adaptation.nrcan.gc.ca/assess/2007/index_e.php
Analyzing and Deciding How to Adapt Forest Management Systems	
A structured decision-making approach to climate change adaptation in the forest sector. 2005. Ohlsen, D. W.,McKinnon G. A. and Hirsch, K.G. The Forestry Chronicle. VOL. 81, No. 1. *Alberta Sustainable Resource Development Climate Change Adaptation Framework*	http://www.srd.alberta.ca/MapsPhotosPublications/Publications/ClimateChangeAdaptationFramework.aspx

Source or Publication	Link
A framework for assessing vulnerability of forest-based communities to climate change. 2007. Williamson, T.B.; Price, D.T.; Beverly, J.L.; Bothwell, P.M.; Parkins, J.R.; Patriquin, M.N.; Pearce, C.V.; Stedman, R.C. and Volney, W.J.A. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-414.	
Climate Change Barriers and Adaptive Capacity in BC Forest Management	
Removing multi-scale barriers to climate-change adaptation in managed forests of BC. 2012. D. Daust and D. Morgan.	http://bvcentre.ca/files/research_reports/09-12RemovingBarriers.pdf
Achieving climate change adaptation in West Kootenay forest management – Barriers & opportunities. 2012, Pearce. Unpublished Report #8 from the West Kootenay Climate Vulnerability and Resilience Project.	http://www.westkootenayresilience.org/Report8_BarriersOpportunities-Draft.pdf
Adaptive capacity of community forests to climate change – An assessment of the potential role of community forests as governance mechanisms for promoting local adaptation. 2012. E. Furness. Will be posted on BCCFA website.	
Rural Community Climate Change Adaptation	
Pathways to climate resilience: A guidebook for Canadian forest-based communities. 2011. C. Pearce and C. Callihoo. Canadian Model Forest Network.	http://www.modelforest.net/pubs/Pathways_to_Climate_Change_Resilience_Community_Resource_Collection_Final_Feb_2011.pdf
Columbia Basin Trust Communities Adapting to Climate Change Initiative Adaptation Resource Kit	http://adaptationresourcekit.squarespace.com/introduction-to-adaptation-act/
Increasing the resilience of British Columbia's rural communities to natural disturbances and climate change. 2012. Krishnaswamy, A., Simmons, E., & Joseph, L.BC Journal of Ecosystems and Management 13(1):1–15. Published by FORREX Forum for Research and Extension in Natural Resources.	http://jem.forrex.org/index.php/jem/article/viewFile/164/115
General	
Climate change, impacts, and adaptation scenarios: climate change and forest and range management in British Columbia. 2008. D. Spittlehouse. MOF Technical Report 045	http://www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr045.pdf
Climate change and Canada's forests: From Impacts to Adaptation. 2009. Williamson et. al.	http://nofc.cfs.nrcan.gc.ca/bookstore_pdfs/29616.pdf
Ministry of Forest, Lands and Natural Resource Operations Climate Change	https://www.for.gov.bc.ca/het/climate/index.htm
BC Government Climate Action Team – Adaptation	http://www.env.gov.bc.ca/cas/adaptation/index.html
Adaptation to Climate Change Team (Simon Fraser University) (ACT)	http://www.sfu.ca/act/
Resources North Climate Change Network	http://www.resourcesnorth.org/rna/380/nccn
Natural Resources Canada forestry adaptation	http://cfs.nrcan.gc.ca/pages/35
Canadian Council of Forest Ministers – Climate Change	http://www.ccfm.org/english/coreproducts-cc.asp
Climate Change Resource Centre, US Forest Service	http://www.fs.fed.us/ccrc/
North Cascadia Adaptation Partnership	http://northcascadia.org/events.php

Source: 2012 BCCFA Conference and AGM Conference Presentations: http://www.bccfa.ca/index.php/what-we-do/conferences/item/download/112_14e91a620a9e05dda0d75777e84af0b0

3.2. 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, 2012) in this regard. A recent report from MFLRNO focuses on the harvested landbase and provides an assessment of the species distribution from a variety of data sources and points in time (MFLRNO, 2012a).

Building on the methodology developed as part of pilot project (Mah et al, 2012), inventory data were used to produce summaries of species composition by age class. Information was also gathered for the 100 Mile House TSA on the projected shifts in BEC subzone due to climate change. Using the existing inventory, ecologically-based species benchmarks were developed for each BEC variant based on professional opinion and field experience. These benchmarks were expected to be feasible from both ecological and silvicultural perspectives and desirable at the landscape level regardless of the management objectives.

Additionally, BEC related climate change information was used to identify units where species will either be more or less suited over time. This information along with the ecological benchmarks, the present harvesting profile, and an understanding of the feasibility for establishment were used in a workshop of local practitioners to create the desired direction for species at the landscape level for the TSA.

This approach is a first step in managing species at the landscape scale. Future iterations may recommend finer scales and promote not only species direction but provenances as well. The expectation is that species direction will be further refined at appropriate scales incorporating direction that links area specific objectives to the species/provenances used, appropriate densities, and suitable species mixes within and between blocks.

Sowing requests will be used to track direction in the short term. These trends and targets will be used to assess success on meeting the described targets/trends. A narrative to describe the situation moving forward will be part of the next iteration of the Silviculture Strategy. Note, that the direction may be revised once the harvest moves from Pl dominated stands.

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

3.2.1. Species Direction, 100 Mile House TSA

Species direction at the landscape – the following information is for planted stock and may not fully reflect the species diversity that will emerge through additional natural regeneration over time.

There is interest in the 100 Mile TSA to further pursue the use of western larch and western white pine on sites where they are suited. Additional guidance for these two species is desired. Broadleaf species are to be considered as part of fire risk reduction where ecological suited.

The categories used are:

- Current –proportions planted / logged
- Trend – whether it is desirable to
    - Increase,
    - Decrease, or
    - maintain the proportion of planted / logged
- Target – a biological target for the unit to trend towards where feasible

- Note at times the trend is suggested to remain as is due to the nature of the stands being logged, i.e., pine stands that are suited to pine. These trends and targets should be revisited yearly comparing sowing requests to the trend/target, particularly once the harvest moves from pine dominated stands.
- At this time no targets, only desirable trends are provided for the 100 Mile House TSA.

Table 10 indicates the recommended species direction trends in the 100 Mile House TSA for each BEC variant.

Table 10: Species direction for BEC variants

BEC	Category	Pl	Sx	Fd	Comments
ESSFdc	Current	80 / 75	20 / 20	0 / 1	Keep with the pre-harvest level of Pl or less where snow press may be an issue. Plant Sx to match the level harvested. Begin to bring in Fd where feasible, e.g., low elevation south exposures. Lw may be another option to promote.
	Target				
	Trend	--- / ↑	---	↑	
ESSFwc	Current	0 / 35	95 / 40	0 / 5	Maintain the trend of lower reliance on Pl (maintain trend of lower planted vs harvest). Maintain trend for Sx as the main species for reforestation, manage Bl with naturals. Consider use of Fd, Pw, and Cw where feasible.
	Target				
	Trend	↓	---	↑	
ESSFwk	Current	40 / 50	35 / 60	0 / 2	Maintain the trend of lower reliance on Pl (maintain trend of lower planted vs harvest – snow press issues), maintain trend for Sx as the main species for reforestation for the present – may be problematic in longer term with warming climate, manage Bl with naturals. Consider use of Fd, Lw, Pw, and Cw where feasible – consider the potential for snow press when making local decisions.
	Target				
	Trend	↓	---	↑	
ICHdk	Current	45 / 60	27 / 20	0 / 0	Maintain the reduced reliance for Pl - maintain or less than pre-harvest. Maintain or reduce from pre-harvest for Sx. Promote the use of Fd.
	Target				
	Trend	---	---	↑	
BEC	**Category**	**Pl**	**Sx**	**Fd**	**Comments**
ICHmk	Current	45 / 60	27 / 20	0 / 0	Maintain the reduced reliance for Pl - maintain or less than pre-harvest. Maintain or reduce from pre-harvest for Sx. Promote the use of Fd.
	Target				
	Trend	---	---	↑	
	Category	**Lw**	**Cw**	**Pw**	**Comments**
	Current	2 / 0	4 / 0	5 / 0	Maintain the reduced reliance for Pl - maintain or less than pre-harvest. Maintain or reduce from pre-harvest for Sx. Promote the use of Fd.
	Target				
	Trend	---	---	---	
BEC	**Category**	**Pl**	**Sx**	**Fd**	**Comments**
ICHmv	Current	25 / 25	40 / 40	25 / 20	Maintain the trends – promote Fd where suited.
	Target				
	Trend	---	---	---	
IDFdk	Current	95 / 80	3 / 9	2 / 7	Reduce reliance on Pl except on sites unsuitable for other species Maintain (on Pine sites) or reduce the use of Pl – do not shift from Fd to Pl. Maintain or reduce the reliance on Sx, promote Fd – note in frost prone areas it may require shelter. Promote Py using trials, particularly in high risk fire zones – consider seed from US.
	Target				
	Trend	↓	---	↑	
MSxk	Current	95 / 95	5 / 5	0 / 1	Maintain trends for Pl, maintain or reduce for Sx, do not increase Sx above the present proportion used. Promote use of Fd where suited. Use Lw where suited in a limited capacity. Manage At for biodiversity.
	Target				
	Trend	---	---	↑	
SBPSmk	Current	70 / 85	30 / 12	5 / 2	Maintain or promote Pl. Maintain or reduce Sx. Maintain or promote Fd. Maintain or promote broadleaves where deemed appropriate. Use Lw where suited in a limited capacity.
	Target				
	Trend	↑	↓	↑	
SBPSdw	Current	62 / 75	30 / 15	10 / 10	Maintain or reduce reliance on Pl and Sx. Promote the use of Fd and Lw. Maintain broadleaves where deemed appropriate.
	Target				
	Trend	---	↓	↑	
SBSmc	Current	65 / 80	33 / 15	1 / 4	Maintain or reduce reliance on Pl and Sx. Promote the use of Fd . Maintain broadleaves where deemed appropriate..
	Target				
	Trend	---	---	↑	
SBSmm	Current	60 / 80	38 / 25	6 / 15	Maintain trend of each
	Target				
	Trend	---	---	---	

3.3. Land Use Plans and Biodiversity

The Central Cariboo Land Use Plan (CCLUP) and legal orders provide a framework for land use and forest management in the 100 Mile House TSA. The recent MPB and associated salvage logging and fire have resulted in the loss of a significant component of mature and old forest both on the THLB and the non-harvestable land base (NHLB). This has resulted in significant impacts to timber and non-timber values. Climate change is expected to cause further stresses on these resource values into the future.

As identified in the 2012 Mid-Term Timber Supply Review for the 100 Mile House TSA (MFLNRO, 2012b) established objectives for non-timber values are expected to impact mid-term supply.

3.4 Forest Health

Fertilization and spacing treatments in younger age stands should only be carried out in healthy stands that have been assessed for forest health factors. Enhanced reforestation, planting a mixture of species will help to offset mortality from forest health agents.

Silviculture investments that enhance the growth of trees need to be balanced against other investments such as forest health spending that may prevent growth losses and mortality from forest health agents. While not specifically recognized in this Type IV strategy, forest health treatments are an important means of mitigating future timber losses and protecting silviculture investments. Spraying for western spruce budworm with Btk is an important treatment for mitigating the growth impacts of western spruce budworm in Douglas-fir leading stands in the 100 Mile District. Spraying with Btk is a relatively cost effective treatment (~$30/ha) with a high rate of return on investment (15%) relative to most silviculture investments. Spacing Douglas-fir stands may reduce the long term hazard from western spruce budworm and reduce the need for spraying in the long term but may require some commitment to budworm spraying to protect these investments in the short term.

Table 11 summarizes the significant forest health issues in the 100 Mile House TSA based on information provided by regional forest health specialists.

Table 11: Priority forest health agents in the 100 Mile House TSA

High	Medium	Low
Western spruce budworm	Western balsam bark beetle	Mountain Pine Beetle
Douglas-fir beetle	Spruce terminal weevil	2 year cycle budworm
Spruce beetle	Armillaria root disease	Hemlock looper
	Western gall rust	Douglas-fir tussock moth
	Comandra blister rust	Lodgepole pine terminal weevil
	Stalactiform blister rust	Warren's root collar weevil
	Elytroderma needle cast	Aspen serpentine leaf miner
	Lodgepole pine dwarf mistletoe	Laminated root rot
	Snow press	Tomentosus root rot
		Atropellis canker
		Lophodermella needle cast

The 2013 Cariboo Forest Health Strategy (MFLNRO, 2013b) confirms that spruce and Douglas-fir beetles are still active and management priorities in the 100 Mile House TSA. Based on feedback from forest district staff and stakeholders, there is a need for an integrated plan for dealing with spruce and Douglas-fir bark beetles.

Stand Development Monitoring carried out by the district indicates the leading damage agent in stands 20-40 years of age were western gall rust, snow press, elytroderma needle cast, comandra blister rust. Elytroderma needle cast is having a significant impact on the growth of some young lodgepole pine stands aged 20-40 years in the 100 Mile House Resource District. The percentage of total trees affected by forest health factors (excluding mountain pine beetle) was high (19%) in the SBPSmk compared to only 8% in the IDFdk3 (Figure 5, MPB = IBM). There is some concern among local foresters that forest health impacts in young pine stands are not being adequately accounted for in timber supply models.

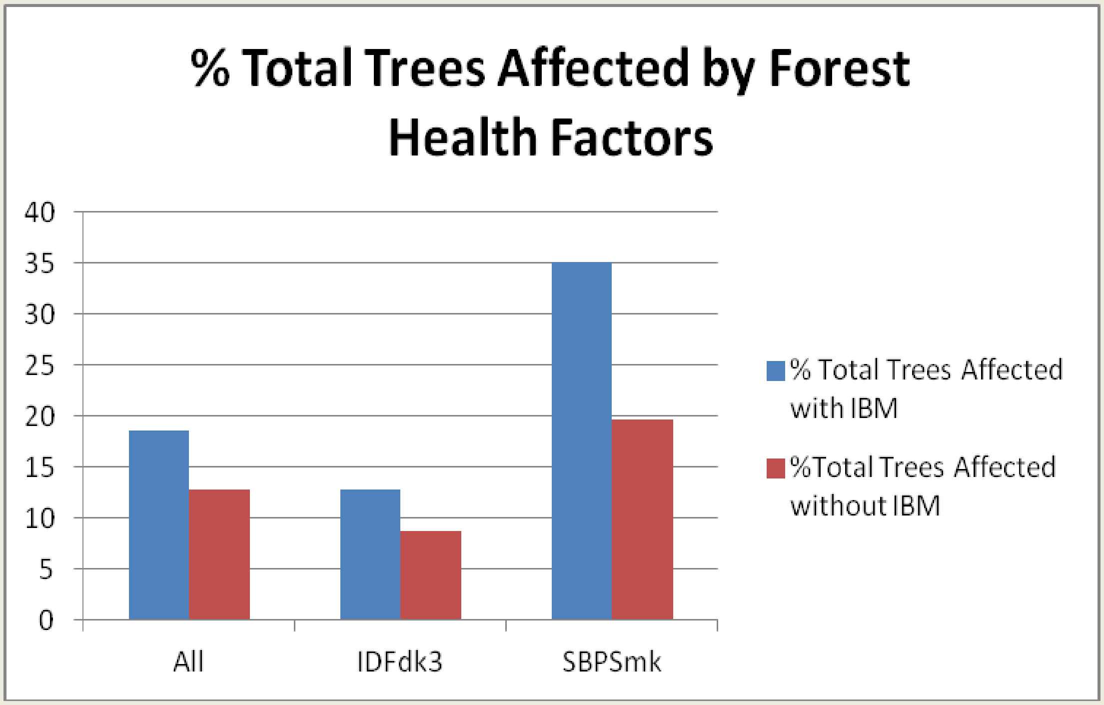

Figure 5: Summary of SDM IBM and non-IBM forest health incidence by BEC variant

Continued monitoring of young stands and un rehabilitated mountain pine beetle killed stands is needed so that the effects of forest health factors can be properly modelled in future analyses.

3.5 Wildfire Management

The BC Wildland Fire Management Strategy (BCFS, 2010) has five main components, two of which directly pertain to this silviculture strategy;

- Reduce fire hazards and risks (particularly in and around communities and other high-value areas) and;
- Implement land, natural resource and community planning that incorporates management of wildland fire at all appropriate scales.

Under the Strategic Wildfire Prevention Initiative, the Cariboo Regional District completed a Community Wildfire Protection Plan (CWPP) in 2006 which included the 100 Mile House TSA (MWS, 2006). The community of 108 Mile also has a CWPP (Day and Rau, 2010) While it is not feasible to integrate detailed plans and strategies from the CWPP's with this silviculture strategy, this would be a desirable outcome in the future.

In general, silviculture treatments should be planned to reduce wildfire risk and consequences to safety, infrastructure, property and other values. For the 100 Mile House TSA the primary treatment which can be used to achieve timber supply objectives and mitigate wildfire risk is the rehabilitation of MPB impacted stands which are not expected to be conventionally harvested. Strategic deployment of thinning treatments of dry belt Douglas fir stands with dense understories can also reduce longer term wildfire risk. Other silviculture treatments (primarily fertilization) should be strategically located to minimize the longer term risk of loss from wildfire.

Currently, wildfire planning is done separately from this silviculture strategy. The first step – burn probability mapping and forest fuel fire risk analysis (Burn-P3) – has been completed for the 100 Mile House TSA (Blackwell, 2013). The second step will be to develop a fire management plan which will utilize the Burn-P3 results and local input on values at risk. Subsequently, the Fire Management Plan should be integrated with the silviculture strategy to prioritize treatments and candidate treatment areas.

Table 12: 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	

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

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

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

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

(4) Encourage deciduous or other fire resistant species

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

3.6 Ecosystem Restoration

Ecosystem Restoration (ER) is defined as the process of assisting with the recovery of an ecosystem that has been degraded, damaged or destroyed by re-establishing its structural characteristics, species composition and ecological process (MFLNRO, 2014a). In the Cariboo, in historically fire maintained ecosystems, the lack of wildfire or similar disturbance has contributed to trees encroaching onto grasslands as well as excessive in-growth of trees in previously open forests. ER activities have been occurring in BC and in the Cariboo over the last 5 to 10 years. Recent ER treatments within grasslands covered by the CCLUP have been directed by the Cariboo-Chilcotin Ecosystem Restoration Plan: Grassland Benchmark (Blackwell, 2007).

ER does not directly impact mid-term timber supply and is therefore not a component of this silviculture strategy. However some of the principles of ER could be applied to the management of dry belt Douglas fir stands in the IDFdk in the 100 Mile House TSA. For example, prescribed burning could be used in conjunction with partial cutting to promote healthier more productive stands and restored ecosystems.

3.7 Enhanced Retention and Secondary Structure

Based on the 2005 Chief Forester's guidance on enhanced retention in MPB impacted landscapes (Chief Forester, 2005), an Enhanced Retention Strategy was finalized for the 100 Mile House Forest District (ERSC, 2007) in 2007. The intent of the strategy is to enhance Chief Forester's current direction based on the analysis of each watershed in the district. The strategy does not specify retention or patch size distribution targets; rather it relies on professional judgment. Current practice is to maintain dispersed and defined wildlife tree retention areas (WTRA) for a full rotation with a target of 7% for WTRAs in non-salvage areas and 20% WTRA retention in pine salvage areas. This silviculture strategy is consistent with these assumptions.

Where suitable secondary structure exists in MPB-impacted stands, it should improve future timber supply (MOFR, 2008). Currently legislation requires the protection of suitable secondary structure in pine-leading stands in the 100 Mile House TSA either by not harvesting or by harvesting with protection of the secondary structure. In developing the rehabilitation scenario for this silviculture strategy, stands which were assumed to have suitable secondary structure were excluded from the candidate population.

3.8 Watershed Management

There are widespread concerns in BC over the potential impacts of the recent widespread MPB infestation and the resulting salvage logging on hydrology. Key concerns relative to salvaging relate to equivalent clear cut area (ECA) and road density and associated maintenance. GIS-based watershed risk analysis has been completed for the TSA (Forsite, 2013) which found that several large watersheds had high risk rankings for fish and social elements. These risks can be reduced by strategically placing fuel breaks to minimize the impacts of future large-scale wildfire and by accelerating green-up with prompt reforestation. For this silviculture strategy there was no linkage made between treatment scenarios and high risk watersheds. This could be of interest in the future.

3.9 Recreation

Many areas within the 100 Mile House TSA are important for recreation. While the CCLUP does not have specific recreation objectives, it includes related objectives for visual quality and management zones along designated trails. This analysis was consistent with the CCLUP objectives for scenic areas and corridors along designated trials. Silviculture treatment scenarios were not applied to areas with a Visual Quality Objective of Retention and designated trail corridors. Otherwise there is no direct linkage between recreation values and this silviculture strategy.

3.10 Range Management

MFLNRO, through the Range Program, administers range use plans and hay and grazing agreements or leases on crown land in BC. In the Cariboo, range and forest activities commonly utilize the same land. Legislation requires that range tenure holders which may be affected by forestry treatments be notified in advance. There is no formalized range strategy for the 100 Mile House TSA. Of the treatments proposed in this silviculture strategy, only rehabilitation of MPB-impacted stands is expected to have a material impact on range values. On the other hand, heavy cattle use of newly planted, rehabilitated areas could reduce the benefits of the reforestation. Otherwise there are no direct links between range management and this silviculture strategy.

3.11 Invasive Plants

Invasive plants pose a threat to our native environment and are a threat to biodiversity (MFLNRO, 2014b). MFLNRO is primarily responsible for minimizing the impacts of invasive plants on crown forest land in BC. In addition, in the Cariboo, the non-profit group, Cariboo Chilcotin Coast Invasive Plant Committee works in cooperation with other organizations to minimize the negative impacts caused by invasive plants (CCCIPC, 2014). Legislation requires licensees to report invasive plants when they are found in forestry operating areas and take actions to prevent their spread. There is no direct consideration of invasive plants in this silviculture strategy.

3.12 Tree Improvement and Seed Transfer

Use of improved seed and climate-based seed transfer procedures are two key ways the Forest Genetics Council of BC guides forest genetic resource management activities. All mitigation scenarios in this silviculture strategy involving planting assume the use of the best select seed available. In addition climate change tree species adaption strategies are being developed in conjunction with evolving climate based seed transfer rules. The use of western larch could be expanded in the TSA.

3.13 Inventories and Monitoring

The government forest inventory and stand growth modelling programs are used to analyze current and forecast future forest conditions. Accurate mid-term timber supply forecasts and development of strategic mitigation measures depend on good inventories and modelling. This is especially true for managed stands.

A network of permanent sample plots (PSPs) has not yet been established in the 100 Mile House TSA under the Young Stand Monitoring (YSM) program. Local stakeholders would like to see this program deployed in the TSA as soon as possible.

3.14 Habitat

The CCLUP, legal objectives under FRPA and the Identified Wildlife Management Strategy (IWMS) provide legal and policy management direction relative to species at risk, regionally important wildlife and critical habitat. Several ungulate winter ranges (UWRs) exist within the 100 Mile House TSA. In addition there are several Caribou wildlife habitat areas (WHA). These WHAs have specific retention and re-entry requirements for harvesting.

There are also areas in the 100 Mile House TSA where non-timber management objectives are a priority. These are the Benchmark Grassland Area, an American Badger WHA and a Great Basin Spadefoot WHA. In these areas some harvesting is allowed for habitat restoration purposes.

This analysis incorporated landbase netdowns and forest cover constraints to address WHAs, UWRs and riparian areas but did not include further constraints or management for any additional habitat considerations.

As the current MPB infestation and the resulting extensive salvage logging and climate change are expected to have significant impacts on wildlife and habitat, it is expected that habitat modelling will be completed over the next few years and the results of this planning can then be integrated into updated silviculture strategies.

4. Recommendations

This section provides a summary of recommendations for improved data, analysis approach and additional analysis. In addition, recommendations are made for strategic projects that are traditionally not funded through silviculture treatment programs.

4.1. Inventories and Monitoring

There is a general agreement among the 100 Mile TSA stakeholders that the current forest inventory does not adequately represent the dry belt Douglas fir multi-storied stands.

Recommendation 1: Investigate alternative methods to cost-effectively develop an accurate inventory for these stands (e.g.: the use of LIDAR technology together with a stand structure classification system).

The data used to set the initial establishment conditions for existing managed stands for the base case come from RESULTS data through silviculture surveys which are commonly more than 10 years old. As conditions in young stands often change rapidly in terms of crop tree species composition, ages and heights before crown closure, the older RESULTS data may no longer accurately reflect the existing conditions. In addition, some of the older RESULTS data is not spatially linked and, therefore cannot be used to develop appropriate growth and yield assumptions.

Recommendation 2: Due to the importance of these stands for the late mid-term timber supply and the uncertainty associated with their current condition and development, support the development of a protocol for, and implementation of, "mid-rotation" surveys from which the data can be used to accurately and efficiently develop growth and yield assumptions. If possible, these surveys could include a timber quality assessment to help forecast future merchantability.

Recommendation 3: Promote the establishment of a YSM permanent sample plot network in the TSA as soon as possible.

4.2. Site Index

Site indices in the 100 Mile TSA are based on the BEC classification. The site index data is available from the MFLNRO as a provincial layer, which provides a site index estimate by species for a 100 m by 100 m grid throughout the TSA. Practicing foresters generally agree that the provincial site index data appear to represent broad site index averages in a reasonable manner. However, the distribution of the site index data is often disputed, as it contains generally little or no poor or very good sites. Localized site index studies are required to increase the reliability of site index estimates.

Recommendation 4: Conduct localized site index studies to increase confidence in site index estimates and make adjustment to he provincial site index layer where warranted. .

4.3. Modelling Approaches

Recommendation 5: Support the development of new approaches to stand level and forest level modeling of dry belt Douglas fir multi-storied stands. It would be desirable for the forest level modelling to interface with stand-level modelling software such as $PROGNOSIS_{BC}$.

4.4. Complete Additional Sensitivity Analysis

As there is expected to be pressure during the mid-term to harvest a significant component of managed stands below biological culmination age, it would be desirable to assess how this could impact timber supply and quality. This investigation could facilitate new or modified mitigation responses.

Recommendation 6: Complete additional sensitivity analyses using different minimum harvest criteria and harvesting rules to better assess possible future outcomes. Stand level modeling for quality is integral part of this.

Recommendation 7: Given the importance of managed stands to the mid-term timber supply, complete additional sensitivity analysis relative to the growth and yield inputs for modelling the growth and yield of existing managed stands. As part of this process, complete further assessments and analysis on damaged pine-leading existing stands.

4.5. Implementation of Strategies

Despite the importance of enhanced reforestation strategies, which broadly include increased densities and species diversification to reduce the reliance on pine and to meet climate change mitigation challenges, it is unlikely that these types of treatments can be implemented without changes to policy. The provincial stocking standards will need to be revised and a new or revised funding mechanism developed.

Recommendation 8: Establish a task force to investigate how an enhanced reforestation strategy can be implemented. The task force should consist of like-minded adjacent management units.

Due to the potential importance of rehabilitation strategies to MPB mitigation and the potential magnitude of the areas available for treatment, there is a need to find efficient, cost effective solutions for program delivery.

Recommendation 9: Together with like-minded adjacent management units, establish a task force to investigate ways to implement large-scale rehabilitation programs (more ITSLs, variations of FLTCs; ways for major licensees to participate).

Before significant harvesting begins again in dry belt Douglas fir stands (after the MPB salvage), it is important to ensure that partial cutting regimes which promote management of productive, healthy Douglas fir stands for timber and non-timber values are adequately supported and promoted through the appraisal and cutting permit systems.

Recommendation 10: Together with like-minded adjacent management units, establish a task force to evaluate existing appraisal allowances and the cutting permit administration system and, if necessary, recommend ways to adequately support appropriate management of these sites for productive Douglas fir stands.

4.6. Quality Assessments of Different Managed Stand Regimes

Given the importance of minimum harvest criteria, including impacts on timber quality, mid-term timber supply and value recovery, it is important to increase our understanding of the linkage between yields, values and costs associated with different silviculture regimes (species mixes and densities).

Recommendation 11: Support the development of projects to assess managed stand values resulting from different harvesting/treatment regimes. Projects could include valuations of standing timber using industrial and government log grades and prices and milling studies.

4.7. Prioritization of the Landbase as a Framework for Silviculture Investments

Given that funding for silviculture is expected to be limited, it is important to prioritize investments. Good to medium sites within reasonable distances from infrastructure will likely make up the core, managed timber harvesting landbase into the future.

Recommendation 12: Develop GIS-based prioritization of the TSA relative to expected investment returns from silviculture (e.g.: zonation based on site index, haul distance and terrain and harvest constraints).

4.8. Establish operational research and adaptive management trials

It is necessary to expand our knowledge and understanding of dry belt Douglas fir stands to facilitate their management for multiple values. This can be accomplished through silviculture system and harvesting method trials.

Recommendation 13: Establish silviculture system trials in dry belt Douglas fir stands to assess different un-even and even-aged approaches.

Currently there are no research results assessing fertilization responses for Douglas fir in the IDFdk3. Given the high proportion of the TSA within this BEC variant and the potential to manage Douglas fir under an even-aged, shelterwood silviculture system, there may be future opportunities for fertilization. Screening trials and area based response estimates are required.

Recommendation 14: Establish fertilization screening and area-based volume response trials in even-aged managed Douglas fir stands in the IDFdk3.

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