Integrated Silviculture Strategy

Fraser Timber Supply Area

Harvest, Silviculture and Retention Strategy

V 1.8

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Prepared for:
BC Ministry of Forests, Lands and Natural Resource Operations and Rural Development
Resource Practices Branch
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Table of Contents

List of Figures

List of Tables

Acknowledgements

The Resource Practices Branch (RPB) of the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) commissioned this project. 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, and Ecologic Research (Steve Wilson) providing facilitation for stakeholder meetings and expert advice in topics regarding habitat supply and biodiversity.

The overall provincial project coordination from FLNRORD was carried out by Paul Rehsler and Craig Wickland. Craig Wickland also provided regional perspective and expertise in silviculture, Jack Sweeten was the lead representative of the Chilliwack Natural Resource District and provided guidance from the district's perspective. Bryce Bancroft from Symmetree Consulting Group Ltd. provided general professional advice and coordination with other similar ongoing provincial projects.

The authors would like to acknowledge and thank the following individuals who participated in the Fraser TSA stake holder group meetings throughout this project and contributed to the completion of this project (Table 1).

Table 1: Members of the Fraser TSA ISS stakeholder group

Name	Organization (Member or Representative)
Ann Wong	FLNRORD
Antti Makitalo	Forest Ecosystem Solutions Ltd.
Bryce Bancroft	Symmetree
Catherine Charman	FLNRORD
Cheryl Power	UBC Research Forest
Cynthia Collins	Matsqui First Nation
Craig Wickland	FLNRORD
Dean Cherkas	Seabird Island First Nation
Ed Korpela,	FLNRORD
Elske von Hardenberg,	Teal Jones Group
Enrique Sanchez	BCTS
Eric Pegura	BCTS
Jack Sweeten	FLNRORD
Jeff McWilliams	B. A. Blackwell and Associates Ltd.
Jim Brown	FLNRORD
Joe Campbell	Boothroyd Band
Keri Ardell	Ts'elxweyeqw Forestry Limited Partnership
Kevin Webber	Ts'elxweyeqw Forestry Limited Partnership
Leonard Feldes	FLNRORD
Lucy Stad	FLNRORD
Matt Wealick	Cascade Lower Canyon Community Forest
Mike Davidson	Boothroyd Band
Mike Gould	People of the River Referrals Office
Paul Rehsler	FLNRORD
Qingcen Cai	BCTS
Rachyl Lukie	FLNRORD
Rick Campbell	Boothroyd Band
Rob Sandberg	Teal Jones Group

Name	Organization (Member or Representative)
Samantha Peters	Cawathil First Nation
Scott Barrett	FLNRORD
Shaotang Deng	BCTS
Stephanie Ewen	Infinity Pacific
Steve Wilson	Ecologic Research
Steven Patterson	Yale First Nation
Terrie Davidson	Boothroyd Band
Tonianne Mynen	FLNRORD
Vincent Dufour	Infinity Pacific
Wes Staven	Douglas First Nation

During the project, the several working groups were formed to facilitate work under specific topics. These groups are shown in Table 2.

Table 2: Fraser TSA ISS working groups

Silviculture Working Group	Organization
Jeff McWilliams	B. A. Blackwell and Associates
Jack Sweeten	FLNRORD
Rob Sandberg	Teal Jones Group
Elske von Hardenberg,	Teal Jones Group
Craig Wickland	FLNRORD
Wildfire Working Group	**Organization**
Jack Sweeten	FLNRORD
Craig Wickland	FLNRORD
Ed Korpela	FLNRORD
Wildlife/Biodiversity/Habitat Working Group	**Organization**
Steve Wilson	Ecologic Research
Bryce Bancroft	Symmetree
Jack Sweeten	FLNRORD
Louise Waterhouse	FLNRORD
Melissa Todd	FLNRORD
Ann Wong	FLNRORD
Kevin Webber	Ts'elxweyeqw Forestry Limited Partnership
Samantha Peters	Cawathil First Nation

Executive Summary of the Integrated Silviculture Strategy (ISS)

<table>
<tr><td>Timber Supply</td><td colspan="2">This analysis built a dataset like the one constructed for the Fraser TSA Timber Supply Review (TSR). The data incorporated additional THLB netdowns and management objectives that reflect the goals and objectives of the ISS. In the course of the project, meetings and field tours revealed that Swiss Needle Cast (SNC), root rot (RR) and elk impacted tree growth and regeneration success in the TSA on some growing sites. These forest health agents were incorporated in the analysis as a scenario. This scenario was adopted as the new base line for silviculture scenario comparisons. The ISS Base Case (forest health incorporated) has a THLB of 219,490 ha and predicts a harvest level of 1,172,100 m^3 per year for 75 years after which the harvest forecast is reduced to the long-term harvest level (LTHL) of 1,097,050 m^3 per year.

The ISS Selected Management Scenario was chosen as it improved both the short- and long-term harvest forecast, and the value of the future timber supply. The ISS Selected Scenario harvest level is predicted to be 3.4 % higher than that of the ISS Base Case between years 1 and 75 (1,211,900 m^3 per year vs. 1,172,100 m^3 per year), 10.5% higher between years 76 and 130 (1,211,900 m^3 per year vs. 1,097,050 m^3 per year), and 12.7% higher in the long term (1,237,000 m^3 per year vs. 1,097,050 m^3 per year).</td></tr>
<tr><td>Objective</td><td colspan="2">Maintain or increase timber supply. Increase the value of future timber supply.</td></tr>
<tr><td>General Strategy</td><td colspan="2">Apply harvest and silviculture strategies to achieve objectives.</td></tr>
<tr><td>Harvest Strategy</td><td colspan="2">Over the next 10 years approximately 34.4% of the harvest – on average 417,300 m^3 annually – should to come from stands older than 140 (age classes 8 and 9), while the approximate share of age classes 3 and 4 (41 to 80 years) should not be more than 43.6% of the harvest.

Most of the harvest in the next 10 years is predicted to come from hemlock-balsam stands (49.2%). This reflects the species profile in the TSA. The shares of Douglas fir and Cedar are forecasted at 30.5% and 13.0% respectively. While most of the hemlock-balsam harvest is expected to come from older stands, a significant volume in the forecast originates from younger (age classes 3, 4 and 5) hemlock-balsam stands. Most of the Douglas fir harvest is predicted to come from age class 4 stands.

Approximately 97% of the short-term harvest (10 years) is predicted to come from stands where ground-based harvesting can be employed. For the harvest forecast to hold, only a modest amount of the harvest must come from helicopter operable stands. Of all the helicopter-operable volume harvested in the timber supply model in the first 10 years of the planning horizon, 66.3 % is hemlock-balsam, 25.5% is cedar stands and 10.4% is Douglas fir.

Approximately 75% of the harvest over the next 10 years is predicted to come from the Stave (46.5%) and Harrison (28.9%) timber supply blocks (TSB). The contribution of the Chilliwack TSB is predicted to be 12.7%, while the share of the Yale TSB is 7.7%. The total predicted share from the Maple Ridge, Nahatlach and Pitt TSBs is little over 4%.</td></tr>
<tr><td>Major Silviculture Strategies</td><td>Timber Volume and Value Over Time</td><td>The ISS Selected Management Scenario included the Value Scenario which was designed to maximize the production value (volume times value) of the harvest over the long term.

Where timber is a primary objective, intensive management for timber volume and value under this strategy is directed to the green and yellow silviculture zones (sites with best returns and lowest risks) and away from red zones (sites with the poorest site productivities or highest risks).

The silviculture strategy for existing managed stands consists of fertilization of portions of Fd dominated stands every 10 years between 30 and 70 years of age.

For future stands on medium to good sites with limited risks, the strategy promotes the establishment of a mosaic of ecologically suitable single species stands with increased densities specifically designed to optimize the production and value of each species. The species portfolio for each BEC unit was developed with consideration for climate change and forest health risks primarily at the landscape-level. Fertilization of Fd leading future managed stands every 10 years from age 30 to age 70 forms an essential part of the strategy. Further considerations are:
➢ Use average expected genetic worth for each species from seed available under the Climate Based Seed Transfer (CBST) rules;
➢ Consider guidance on species portfolios from the Climate Change Informed Species Selection (CCISS) tool;
➢ Where root rot is a hazard, employ stumping on operable sites before establishment of Fd and Hw leading stands;
➢ Reduce Fd % on SNC hazard sites;
➢ Include Cw planting and juvenile spacing favoring Cw where ecologically appropriate;
➢ Focus on Fd and Cw, where appropriate to maximize timber value;
➢ Assume high future log prices for all enhanced regimes</td></tr>
</table>

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<tr><td></td><td></td><td>
To balance overall reforestation costs and deliver more cost-effective basic silviculture, promote reduced densities and modified species mixes on elk hazard sites.
The silviculture strategy sets an incremental silviculture target of 1,321 ha of fertilization of Fd leading stands per year for the first 5 years at the cost $660,000 per year. The fertilization program is set to decrease somewhat to 966 ha per year in the second 5-year period starting 6 years from today. The annual cost is projected at $480,000 for years 6 to 10. The size of the fertilization program is forecast to climb modestly at year 11 and then stay relatively stable for the next 40 years.
No spacing is expected over the next 10 years. A modest Cw spacing program is predicted to start in year 16 and continue with annual spacing areas ranging from 240 ha to 400 ha.
This strategy proposes to plant higher densities on selected sites in the TSA. Approximately 410 ha and 495 ha of the increased density planting are predicted annually for years 1 to 5 and 6 to 10 respectively. The predicted annual incremental planting costs for years 1 to 5 are $284,765 and $354,923 for years 6 to 10.
To balance overall reforestation costs and to achieve more cost-effective basic silviculture, this strategy also proposes to reduce planting densities for high and moderate elk hazard areas. The reduced planting densities are predicted to be applied on 261 ha annually for years 1 to 5 and on 259 ha annually for years 6 to 10. The predicted annual reduction in planting costs due to reduced densities is -$267,734 for years 1 to 5 and -$271,375 for years 6 to 10. The savings from reduced planting densities in high and moderate elk hazard areas can be used to compensate for the costs for higher planting densities for the enhanced regimes.
</td></tr>
<tr><td>Fire Prevention Strategies</td><td>Treatment of High Fire Risk Stands in the Urban Interface</td><td>
The strategy is to determine actual fire threat levels in the urban interface areas through field surveys and prescribe appropriate treatments. Treatments may focus on reducing the canopy bulk density, reducing the overall density of the stand, and /or reducing on-ground fuels.
Potential treatments for existing stands are partial harvesting, juvenile spacing and pruning. All treatments should also include slash treatments to reduce short term hazard. Treatments to reduce fire risk within the urban interface will be carried out in accordance with community wildfire protection plans.
Treatments to reduce fire risk were not modeled due to relatively low amount (hectares) of high threat (risk) polygons within the TSA.
In case of new plantations, consideration should be given to using fire management stocking standards located at:
https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/land-based-investment/forests-for-tomorrow/fire_management_stocking_standards_guidance_document_march_2016.pdf
</td></tr>
<tr><td>Silviculture Program</td><td>Annual Treatment Schedule</td><td>
Years 1-5
<table>
<tr><th rowspan="2">Treatment/Activity</th><th colspan="2">Years 1 to 5</th></tr>
<tr><th>Area (ha)</th><th>Annual Costs ($)</th></tr>
<tr><td>Fertilization</td><td>1,321 ha</td><td>$660,000</td></tr>
<tr><td>Increased (or reduced) Planting Densities</td><td>671 ha</td><td>$17,030</td></tr>
<tr><td colspan="2">Annual Total</td><td>$677,030</td></tr>
</table>
</td></tr>
<tr><td></td><td></td><td>Years 6-10</td></tr>
</table>

Treatment/Activity	**Years 6 to 10**	
	Area (ha)	Annual Costs ($)
Fertilization	966 ha	$480,000
Increased (or reduced) Planting Densities	754 ha	$83,550
Annual Total		$563,550

Outcomes	Timber Volume Flow Over Time	The ISS Selected Scenario harvest level is predicted to be 3.4 % higher than that of the ISS Base Case between years 1 and 75 (1,211,900 m3 per year vs. 1,172,100 m3 per year), 10.5% higher between years 76 and 130 (1,211,900 m3 per year vs. 1,097,050 m3 per year), and 12.7% higher in the long term (1,237,000 m3 per year vs. 1,097,050 m3 per year).
	Timber Value	In the long term, the ISS Selected Management Scenario is predicted to create significantly more timber value from managed stands
	Northern Spotted Owl	The Northern Spotted Owl objectives are not impacted by the ISS Selected Management Scenario and the proposed strategies.
	Habitat Northern Goshawk	Northern goshawk (NOGO) forage habitat objectives can be met within the forage areas without timber supply impacts relative to the ISS Base Case.
	Marbled Murrelet	Most Marbled Murrelet (MAMU) habitat in the Fraser TSA is located in the NHLB and scenarios had little impact on habitat supply.
	Elk	In general, the silviculture strategy acknowledges that moderate to high elk use and valuable forests are not very compatible. The analysis and resulting strategy were developed based on current elk populations and damage estimates, as well as expected population growth and range expansion consistent with current government objectives for elk. As noted in the silviculture zoning analysis and discussions, current plans for elk are likely to produce significant downward pressure on the TSA's ability to produce value timber. It may be beneficial to continue to develop integrated plans for healthy elk populations and value timber.
Colocation Opportunities	OGMA	Analyzing the colocation opportunities of reserves revealed that there may be an opportunity to co-locate at least some of the spatial reserves in the TSA. Other spatial reserves overlap OGMAs and in the course of time all late seral requirements in the TSA can be met from the NHLB.

1 Introduction

The Resource Practices Branch (RPB) of the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) is developing a new management unit planning framework; Integrated Silviculture Strategy (ISS). The ISS is a sustainable forest management planning framework with the objective to integrate all aspects of landscape-level and operational planning for each Timber Supply Area (TSA).

The ISS will integrate Type 4 Silviculture Strategies with timber supply review (TSR) to reduce duplication and redundancies where possible by sharing inventories, management zones, analysis units, Timber Harvesting Land Base (THLB) definitions and management assumptions. It is expected that the ISS process will improve the linkages to landscape level fire management, the Cumulative Effects Framework, the Forest and Range Evaluation Program's (FREP) multiple resource values assessments (MRVA) and other regional, management unit level or landscape level plans and strategies.

2 Context

This document is the fourth of four documents that make up an ISS. The documents are:

1 Situation Analysis – describes in general terms the current situation for the unit. The Situation Analysis forms the starting point for the initial planning group meeting to identify opportunities.

2 Data Package - describes the information that is material to the analysis including data inputs and assumptions.

3 Modeling and Analysis report –provides modeling outputs and rationale for choosing an ISS Selected Scenario.

4 Integrated Silviculture Strategy – represents the ISS Selected management scenario which is the basis for the first iteration of the ISS. It includes an investment strategy and provides treatment options, associated targets, timeframes and expected benefits.

When the ISS is complete, a spatial operations schedule will provide direction for harvesting and a land base investment schedule will guide Forest for Tomorrow (FFT) Annual Operating Plans.

3 Study Area

The Fraser TSA is in south-western BC and includes Metro Vancouver as well as Abbotsford, Chilliwack, Mission, Hope, and smaller communities. The TSA is bounded by Georgia Strait and Howe Sound on the west, the Soo and Lillooet TSAs to the north, the Merritt TSA to the east, and the Canada-USA border to the south (Figure 1). The TSA includes much the Fraser Canyon and the southern Coast Mountains, as well as the entire Fraser Valley floodplain and delta. The total area of the TSA is 1,648,628 hectares.

The Fraser TSA is part of the FLNRORD Coast Region, and is administered by the FLNRORD, Chilliwack Natural Resource District in Chilliwack.

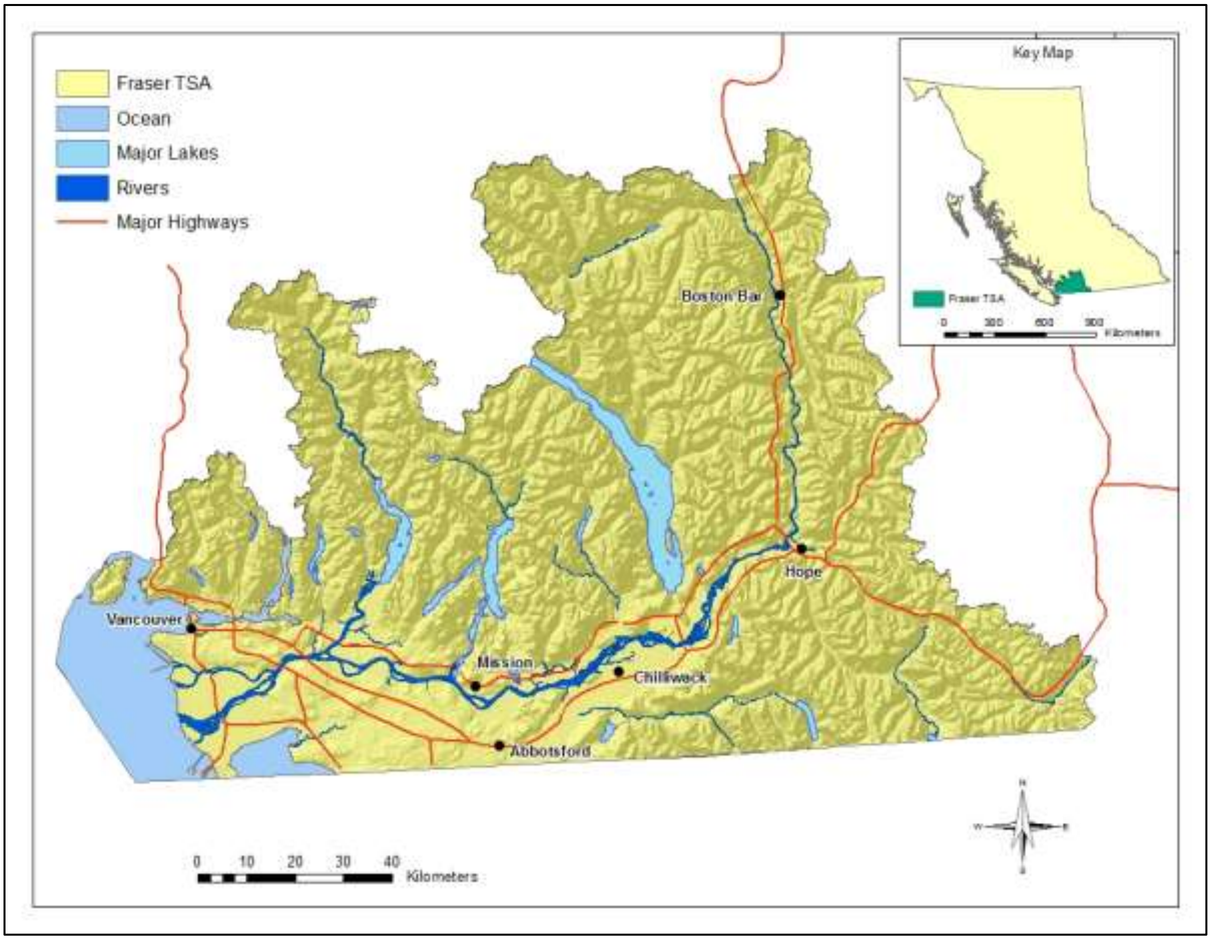

Figure 1: Fraser TSA location map

4 Critical Issues

Critical issues were identified during several stakeholder group meetings. The most important critical issues are listed below. Many of the critical issues cannot not be solved through this planning process; however, they are identified in this report.

4.1 Characterizing of Current Management

The Chief Forester of British Columbia (BC) determines the annual allowable cut (AAC) for all management units in BC. The AAC determination process is guided by provincial laws and policy with the emphasis on accounting for current and reasonably expected management. The Chief Forester rarely speculates about land use decisions and only approved and implemented plans are incorporated into timber supply reviews with uncertainties tested through sensitivity analyses.

The Fraser ISS stakeholder group decided to incorporate impending land use decisions and voluntary deferrals in this analysis. In addition, the stakeholder group discussed impacts of constraints, and logistical and economic issues, which are often not fully accounted for in timber supply reviews.

4.1.1 Constraints Related to the Land Base

4.1.1.1 Legal and non-legal constraints

The accounting for forest cover constraints, such as cutblock adjacency, visually effective green-up and wildlife tree retention may not be adequate in timber supply analyses. These types of constraints often require forest cover retention and the control of the rate of harvest. As an example, it can be difficult to efficiently harvest remaining, adjacent timber in a visually sensitive area after the initial harvest.

The scale and distribution of stand level retention is not well understood. Better reporting and monitoring of stand level retention would contribute to more accurate analysis of the impacts of management to meet these objectives.

Voluntary actions to account for many First Nations values are often not accounted for as THLB netdowns or constraints in TSR. In the Fraser TSA the S'ólh Téméxw Use Plan is observed in operations. For this reason, the S'ólh Téméxw Use Plan was considered in this analysis in all scenarios.

Some stakeholders felt that the multiple spatially explicit netdowns and constraints in the Fraser TSA reduce the THLB and constrain the timber supply more than necessary. The significant spatial constraints are the S'ólh Téméxw Use Plan, old growth management areas (OGMA), Spotted Owl wildlife habitat areas (WHA) and ungulate winter ranges. Co-locating OGMAs, Spotted Owl no-harvest areas and the S'ólh Téméxw Use Plan no-harvest areas was investigated in this project.

In his rationale for the AAC determination in 2016, the Chief Forester concluded that there was uncertainty regarding the size of the operable land base. While this analysis did not revise the operable land base, the Chilliwack Natural Resource District identified areas within the THLB that are deemed to have low potential for harvest due to their species composition, age and location. These stands were removed from the THLB (12,773 ha), in addition to those that were deemed inoperable as per the available operability classification.

4.1.1.2 Emerging Constraints

Strategic decisions regarding and NOGO and marbled murrelet (MAMU) are expected to further reduce the THLB, but less than in other TSAs because both species are at the edges of their range in the THLB areas of the Fraser TSA. Colocation opportunities with other values should be investigated, if new WHAs for these species are established.

Completion of existing, enabled processes such as OGMA spatialization and allocation of the remaining THLB budget associated with the Integrated Wildlife Management Strategy (IWMS) will reduce uncertainty with respect to impacts on the THLB.

4.2 Impediments to Long term Value Creation

4.2.1 Tenure and Appraisal Systems and Lack of Harvest Controls

Harvesting rights within TSAs are primarily allocated using volume-based tenure agreements. These tenures have long terms and they are renewable. However, there is no guarantee that a licensee who harvests and reforests a site according to government regulated stocking standards will be able to harvest the regenerated stand. As a result, these tenures do not provide a framework that promotes the licensees to strive and exceed stocking standards in their reforestation. This is especially true if the preferred performance (stocking and species) is more costly. This is a problem, as most long-term strategies that are designed to improve volume and value commonly depend on investments in enhanced reforestation.

Under the current appraisal system major licensees (holders of renewable, long term volume and area based tenures) pay stumpage to the government to harvest timber. Simplistically, stumpage is the residual of the estimated value of the standing timber less agreed upon estimates of historical costs to access, harvest and transport the timber to market, and the costs to administer the license and reforest the harvested area as per the current stocking standards. In general the appraisal system provides little incentive for licensees to make investments in enhanced reforestation, as the licensee typically bears the extra silviculture cost in the short term and the government gets the majority of the increase in value through higher stumpage when the stand is eventually logged. This happens even if the licensee who reforests the site gets to log it again.

Specifically, the Coast Appraisal Manual provides average, per cubic meter allowances for basic silviculture on a Natural Resource District basis. This process means that the licensee foresters have the primary responsibility to decide on which sites they spend more money and which sites they spend less to achieve the stocking standards. This commonly leads to reforestation which achieves the standards, but is less than optimal relative to developing preferred stands on the better sites.

The appraisal system in its current configuration is an impediment to implementation of strategies that improve the long-term timber value, such as those that have been outlined in the Fraser TSA ISS Selected Management Scenario and in this strategy. On many sites in the Fraser TSA, it is ecologically suitable and consistent with the stocking standards to reforest harvested stands with Fd, Hw or Cw (or combinations). At current log prices, successful reforestation with primarily Cw, where appropriate, would result in a significantly more valuable stand than using either Fd or Hw.

While a Cw reforestation strategy is likely to produce a more valuable stand for a licensee to harvest in the future, the main beneficiary of the increased value will be the government as the recipient of significantly higher stumpage. On the other hand, the licensee potentially must deal with higher costs and risks associated with planting Cw due to ungulate browse, and brush and Hw competition. This short-term cost impediment is more problematic, if the preferred Cw strategy is based on planting higher densities than are required by the current stocking standards.

Another factor influencing the viability of investments in silviculture is the lack of linkage between the assumptions that support the investment decision and whether those assumptions hold true in operations. While the public are the primary investors in improvements in forest management, the licensees control the timing of harvest. Substantial investments can be wasted, if managed stands are harvested at ages contrary to the silviculture investment rationale.

In summary, value strategies, such as the one presented in this report, cannot be implemented effectively without changes to regulations, and the tenure and stumpage system. The value strategy is based on initial investments in enhanced reforestation on preferred sites. These stands can then become preferred candidates for subsequent investments. It is of critical importance that all silviculture investments are consistent with a long-term plan considering expected harvest ages. Only in this way, can the public be confident that investments in forestry are viable. The current tenure and stumpage systems, and regulations do not provide an adequate incentive for the licensees to make investments on public forest lands in BC, nor do they allow the government to invest in basic reforestation on sites logged by licensees.

4.2.2 Conflicts between Resiliency, Diversity and Valuable Forests

Due to a lack of cohesive, integrated and current land use objectives in most areas in British Columbia and a lack of awareness of the importance of managed stands to our forest economy, our reforestation practices over the last 30 years have been dominated by stand-level approaches where multiple objectives are attempted to be met on every hectare. This approach has led to compromises in management practices and on many sites neither timber nor non-timber objectives are achieved well.

The recent focus on reforestation practices which target stand-level diversity and resiliency as part of an overriding focus of climate change mitigation are the latest examples of strategies which rarely match up with producing value forests consistent with timber supply expectations. As a result, there is a concern that our current strategies will not support the forest economy as expected.

As part of this project we would like to remind the readers of this report of different and likely better ways to try and achieve resilience, diversity and value in our forests. The Fraser TSA ISS addresses resilience, diversity and value at the landscape-level and through the concepts of silviculture zoning and species portfolios. The value is further addressed through the concept of “un-mixing the mixes” at the stand level.

4.2.3 Uncertainties with Growth and Yield and Modeling of Managed Stands

Our current knowledge of the growth and yield of managed stands is lacking, and our modeling of these stands is simplistic. Modeling of managed stands for TSR or other strategic analysis projects relies on silviculture data which does not provide accurate information for the attributes required for growth and yield modelling (e.g.: TASS or TIPSY). In addition, modeling of managed stands commonly uses broad groups (analysis units) which rely on averages of wide-ranging attributes. Furthermore, given the high proportion of mixed species in managed stands and the common use of models such as TIPSY (not designed to model mixed species stands), our forecasts of future species compositions and rotation ages is uncertain. In the Fraser TSA, forecasting of the growth and yield of Cw provides a good example.

During the last 30 years Cw has been commonly planted on many sites in mixes with other species or in small patches. When modeling with TIPSY, the proportions of each planted species in a stand are assumed to remain constant throughout the rotation. However, field observations indicate that Fd or Hw tend to overtop Cw in mixed stands due to its significantly lower site index than other species on many medium to good sites in the Fraser TSA. As a result, the future harvest of Cw is likely to be significantly less than forecasted with TIPSY. TASS accommodates site index differences in forecasts of mixed stands and modeling Cw/Hw and Cw/Fd stands appears to be more realistic with TASS, which is why it was used in this project for modelling the growth and yield of managed stands.

This project took a detailed approach to growth and yield modelling, and split managed stands into 3 eras. Furthermore, the BEC and slope/aspect framework was used to further refine the analysis unit groupings. The available RESULTS planting and inventory data from recently reforested stands and professional opinion from Fraser TSA silviculture practitioners were used to formulate the managed stand yield curve inputs.

Given the importance of managed stands to the timber supply and timber value in many areas of British Columbia, more focus is needed on assessing and monitoring the growth and yield, and health of existing managed stands. Data and information collected through mid-rotation stand monitoring should be used to inform growth and yield models and improve timber supply forecasts for future managed stands.

4.2.4 Confusion over Timber Quality and Timber Objectives: Value versus Volume

The current provincial target for premium logs is 10% of the AAC for each TSA. In the past, a premium log was frequently defined by such characteristics as species, taper (lack of), tightness of grain, clear wood, and size. In practice, piece size is the only characteristic that could be tracked and modeled in various analyses. The volume or proportion of large logs was the main surrogate for quality.

Today many of the above-listed traits still define quality; however, bigger is only better if the rest of the log quality attributes (e.g.: taper, rate of growth, knot size/distribution) are the same or better in the bigger log. This often leads to the common misconception that managed trees grown to the same size as naturally grown mature trees in less than half the time will have the same quality and value. We need to understand that there are trade-offs between growing fewer trees to become larger as fast as possible, versus spreading the site growth potential over more stems.

It is not always clear whether the quality of managed stands is as expected. Furthermore, the quality expectations are often not defined; nor are they integrated and traded off with volume production. There is often confusion over timber objectives: maximum volume or maximum production value. Simplistically, the value of forest production is the volume harvested times the value of the harvest. Most of the past harvest in British Columbia has come from mature, natural forests. Their quality, while important, was not specifically managed for. However, as we transition to harvesting managed forests, there are significant trade-offs between volume and value. Some strategies could favour volume (e.g., shorter rotations with more Pl in the interior and more Hw on the coast) and some could favour value (e.g., longer rotations with more Fd in the interior and more Cw on the coast).

In an effort to learn more about the opportunities and trade-offs associated with volume and value strategies, this project used generic industrial coastal British Columbia second growth log sort specifications and recent market values to track the production value (together with the volume) for the managed stand portion of the harvest forecasts for each of the different scenarios tested. In addition, timber strategies were specifically developed to try to maximize volume and to maximize production value. The project participants chose the scenario that emphasized value as the selected strategy for this project.

This strategy utilizes higher establishment densities on medium to good productivity timber-producing sites in lower risk and lower cost areas to encourage the development of high quality trees with fewer, smaller branches and less stem taper. These stands should be preferred candidates for potential subsequent investments in density management and fertilization.

Data and information collected through mid-rotation stand monitoring discussed above should also be used to inform on the quality aspects of managed stands.

4.2.5 Mid-Term versus Long-Term Timber Supply Trade-Offs

There is a concern about the harvest of young stands – significantly younger than their culmination age - in many coastal management units. The following issues were discussed at the stakeholder meetings of the Fraser TSA ISS:

- As noted above, current legislation and policies do not allow the Crown to control the age or location of the prospective harvest, providing that the Cutting Permit application is consistent with existing legislation and policies. This causes additional challenges to long term stewardship.
- What are the mid and long-term implications of harvesting 2nd growth stands as per current trends, where many young stands are harvested before their culmination age?

  A sensitivity analysis tested the impact of setting a high harvest priority on Douglas fir leading stands younger than 115 years old. The timber supply was reduced by 1.7% for the first 40 years compared to the ISS Base Case.
- What are the mid and long-term implications of not harvesting the older high elevation hemlock-balsam stands or limiting the harvest of these stands?

  In the ISS Base Case, stands (mostly hemlock-balsam) that were deemed to have low potential for harvest due to their species composition, age and location were removed from the THLB (12,773 ha in total). Including these stands in the THLB increased the harvest forecast modestly by 1.2% over the entire planning horizon.
- In an effort to model current practise, limits were placed on the harvest of old stands and particularly hemlock-balsam stands that remain in the THLB. These limits constrained the timber supply. Not setting any limits on the harvest of hemlock-balsam stands increased the harvest forecast by 17.8% over the first 45 years of the planning horizon.

5 Strategic Objectives

Provincial timber management goals and objectives include working targets for the provincial timber supply. The provincial goals and objectives in turn provide direction to all the TSAs. The stakeholder group did not set specific targets for the Fraser TSA. Rather, the objectives were stated more generically as shown in Table 3.

Table 3: Management objectives for the Fraser TSA

Value	Objective	Performance measure/indicator	Notes
First Nations / cultural	Improve local employment	Person-years of employment in communities	Requires training, capacity building. Not modeled or tracked.
	Sustain non-timber values	Availability of monumental cedar	Spatial distribution important – need to be near communities. Not modeled, managed operationally.
		Availability of trees for bark-stripping	Need to be proactive with referrals to better understand context and interactions rather than just reacting to individual proposals. Not modeled, managed operationally.
		Managed access to preferred areas	Not modeled, managed operationally.
		Distribution and abundance of suitable moose, deer and elk habitat	Assume that UWR and elk recovery plan will provide adequate habitat. Additional habitat through S'ólh Téméxw Use Plan, which is modeled.
		Protection of spiritual sites.	Provided through S'ólh Téméxw Use Plan, which is modeled.
		Protection of resource harvesting areas.	Locations must be known. Not modeled, managed operationally.
		Maintain and enhance culturally sensitive waterways	Provided through S'ólh Téméxw Use Plan, which is modeled.
Biodiversity	Protect Northern Goshawk nesting areas and foraging habitat	Protect nest sites (breeding habitat) with a 200 m buffer.	Remove from THBL in all scenarios.
		Forage habitat: maintain 40% within each foraging territory.	Report in in the ISS Base Case and test the impact of enforcing the target. The TSA contains only two foraging areas.
	Protect Norther Spotted Owl Habitat	Nesting and foraging habitat in LTOHA and MFHA.	Protected through legislation. Track nesting and foraging habitat in LTOHA and MFHA.
	Maintain/improve tree species diversity	Predicted harvest by species and predicted growing stock by species.	Reforestation regimes follow climate change species portfolios to reduce risk. Objective is to achieve species diversity at the landscape level, rather than stand level.

Value	Objective	Performance measure/indicator	Notes
	Protect Species at Risk	Enforced though legislation.	Review existing reserves; can incremental protections be rationalized to maintain/improve current situation?
Timber/economic	Increase utilization and future value of high-elevation HemBal sites	Area converted to higher value stands Carbon sequestration	Explore stand conversion opportunities. Not modeled or tracked.
	Increase value of deciduous stands	Area converted to higher-value stands	Explore stand conversion opportunities. Explore opportunities to intensively managed Dr on appropriate sites. Not modeled or tracked.
	Maximize species/product value	$/ha	Silviculture strategies will test in modelling.
	Minimize impacts of forest health issues	Proportion of forest with forest health issues and/or cost-effectiveness of responses	Modified species selection and reduced planting investments in elk areas. Limit the amount of Fd in SNC hazard zones. Stumping and species selection in areas susceptible to root rot. Will be modeled.
	Maximize volume	Vol/ha and annual harvest	Use high genetic gain seed, fertilize where feasible. Fertilization and genetic gain accounted for in modelling.
	Increase harvest in highly constrained areas	Proportion of harvest that is partial harvesting.	Permitting challenges Small volume but takes pressure off young stands. Final or next harvest pass may be challenging. Not modeled.
	Improve marketability of wood products	Revenue captured above present cost	FN mark or certification for marketing? Not modeled or tracked.
	Manage even flow of revenue	Even flow of revenue.	Variation is expected in revenue flow due to markets. Value of future stands tracked in the model.
	Promote product diversity		Some concern of managing for poles, peelers Difficult to predict future markets Not modeled or tracked.
	Continued access to timber	Access maintained	Not modeled or tracked.
	Improved understanding of growth and yield of managed stands.		Work with FAIB to promote more YSM plots and mid-rotation timber cruise. Not modeled or tracked.
Recreation/visuals	Maintain visual quality objectives	Disturbance in visual quality areas.	Protected through legislation. Modeled as per legislation.

Value	Objective	Performance measure/indicator	Notes
	Minimize fire risk in interface areas	Area of fuel treatments in high risk interface areas	Not modeled or tracked. Strategy will contain recommendations.
Water	Maintain community watershed function	Water quality Water quantity	Modeled as per legislation.

6 ISS Base Case Analysis Assumptions

The TSR *analysis* assumptions were revised through stakeholder meetings to reflect current management in the Fraser TSA. Table 4 shows the core ISS Base Case assumptions in a nutshell.

Table 4: ISS Base Case assumptions

Objectives and overall assumptions	Characterize current management to the extent practicable
Land base assumptions	• Follow the latest TSR with updates to ownership etc. • Remove prospective FNWL outside of BCTS operating area from the TLHB; • Remove known NOGO nests and nest buffers from the THLB; • Incorporate the S'ólh Téméxw Plan in the analysis (netdowns); • Incorporate proposed Northern Goshawk (NOGO) WHAs and nests currently outside of WHAs in the analysis; • Use most TSR assumptions as they are; • Remove areas considered uneconomic from the THLB (in addition to TSR definition of uneconomic); • THLB 219,490 ha.
Harvest assumptions	• Incorporate available proposed harvest into the harvest forecast; • Use highest volume first harvest rule; • Incorporate the S'ólh TéméxwPlan in the analysis (harvest constraints); • Set harvest priority based on distance from road and timber supply block; • Limit the harvest of stands older than 115 years to around 460,000 m^3 per year; • Maintain the harvest of HemBal around 50% of total harvest until natural HemBal stands are mostly harvested; • Limit alder harvest to 10,000 m^3 per year; • Minimum harvest criteria; combination of min harvest volume and 95% MAI culmination • Include other deciduous in conifer leading stands in harvest and modelling (biodiversity values and silviculture implications).
Silviculture and log assumptions	• BEC and slope/aspect based analysis units for managed stands; • CWHms1 split into submontane and montane components • Use the provincial site index layer as the site index source for managed stands; • Use TASS for modelling the growth and yield of managed stands; • Incorporate past treatments (juvenile spacing and fertilization); • Separate existing managed stands into eras to reflect different management • Use generic industrial second growth log sort specifications and market values to track production value from harvested managed stands
Habitat assumptions	• Spotted Owl legal requirements as per TSR; • Report on nesting and foraging habitat in each LU as per the Spotted Owl model; • Report on Marbled Murrelet habitat; • Report on potential NOGO forage habitat.

7 Management Scenario Overview

7.1 Silviculture Zones

The THLB in the Fraser TSA was zoned based on suitability for investment in silviculture treatments for timber production. Three zones were developed: green, yellow and red. Green depicts areas where management actions and investments are generally recommended due to higher site productivity, lower harvest costs and reduced anticipated risks from constraints and other risks to future harvest. In the yellow zone caution is recommended, while the red zones denote areas where management actions and investments in forest management should be avoided due to costs and risks. Table 5 details the zoning criteria.

The THLB areas for green and yellow zones are presented in Table 6 and Table 7. The silviculture zones for the TSA are illustrated in Figure 2. Approximately 56% of the THLB is within the red zone and therefore a low priority for silviculture investments for timber production. The key reasons for the low priority are the S'ólh Téméxw Plan and elk hazard, with lesser contributors being visuals and high fire hazard areas within the WUI. On the other hand, only about 4% of the THLB is classified as the green zone. The Fraser TSA is a very constrained land base and, a difficult area to rationalize sizeable investments for timber production.

Table 5: THLB zoning, Fraser TSA

Category	Data Source	Green (good)	Yellow (caution)	Red (stop)
Site Productivity	Managed Stands (AU)	CWH ds1/all; dm/all; CWH vm1/all; CWH vm2/warm/all; CWH ms1s/warm, cool/G	CWH vm2/cool/G; CWH ms1s/warm, cool/M-P; CWH ms1m/warm; IDF/cool	CWH ms1m/cool; CWH vm2/cool/M-P IDF/warm; ESSF/all; MH/all;
Costs	Operability	Ground	Cable	Heli
	Areas eligible for Isolated allowance in appraisal manual	Regular truck	Upper Pitt and Upper Stave	N/A
Constraints to Harvest	Potential land use issues (First Nations interest areas, non-forestry development, public interest, etc.)	No	Hemlock Resort Area; Slesse Creek FN interest area; Bowen Island; Hatzic drainage public interest area	N/A
	VQO	Modification or none	Partial Retention	Preservation, Retention
	Community Watersheds	No	Yes	N/A
	Legal WHAs	No	Constrained harvest zone	
	Draft WHAs; Northern Goshawk	No	Forage areas	Nesting areas
	First Nations values; S’ólh Téméxw Plan	No	Other Stó:lō constrained areas (watersheds, cultural buffers etc.)	Within Sanctuaries
Forest Health	Elk hazard to reforestation. Based on v.3 of Steve Wilson's Roosevelt Elk Winter Range Model and mapped Elk Zones	Low Hazard or not located within units that are managed for elk	Moderate to high hazard to reforestation, and outside of Pitt, Stave, Chehalis and West Harrison Elk Zones.	Moderate to high ranking and within Pitt, Stave, Chehalis and West Harrison Elk Zones
Fire Hazard	Fire Hazard; High to extreme within 2km buffer (WUI)	Outside WUI	Within WUI and outside of high to extreme fire hazard	Within WUI and within high to extreme fire hazard

Table 6: Silviculture zone areas by era

Silviculture Zone	Description	THLB (ha)
Green	EM contemporary	1,765 ha
Green	EM Old	2,587 ha
Green	Natural	4,764 ha
Yellow	EM contemporary	14,477 ha
Yellow	EM Old	20,656 ha
Yellow	Natural	51,258 ha
Total		**95,508 ha**

Table 7: Silviculture zone areas

Silviculture Zone	THLB (ha)
Green	9,117 ha
Yellow	86,392 ha
Red	123,982 ha
Total	**219,490 ha**

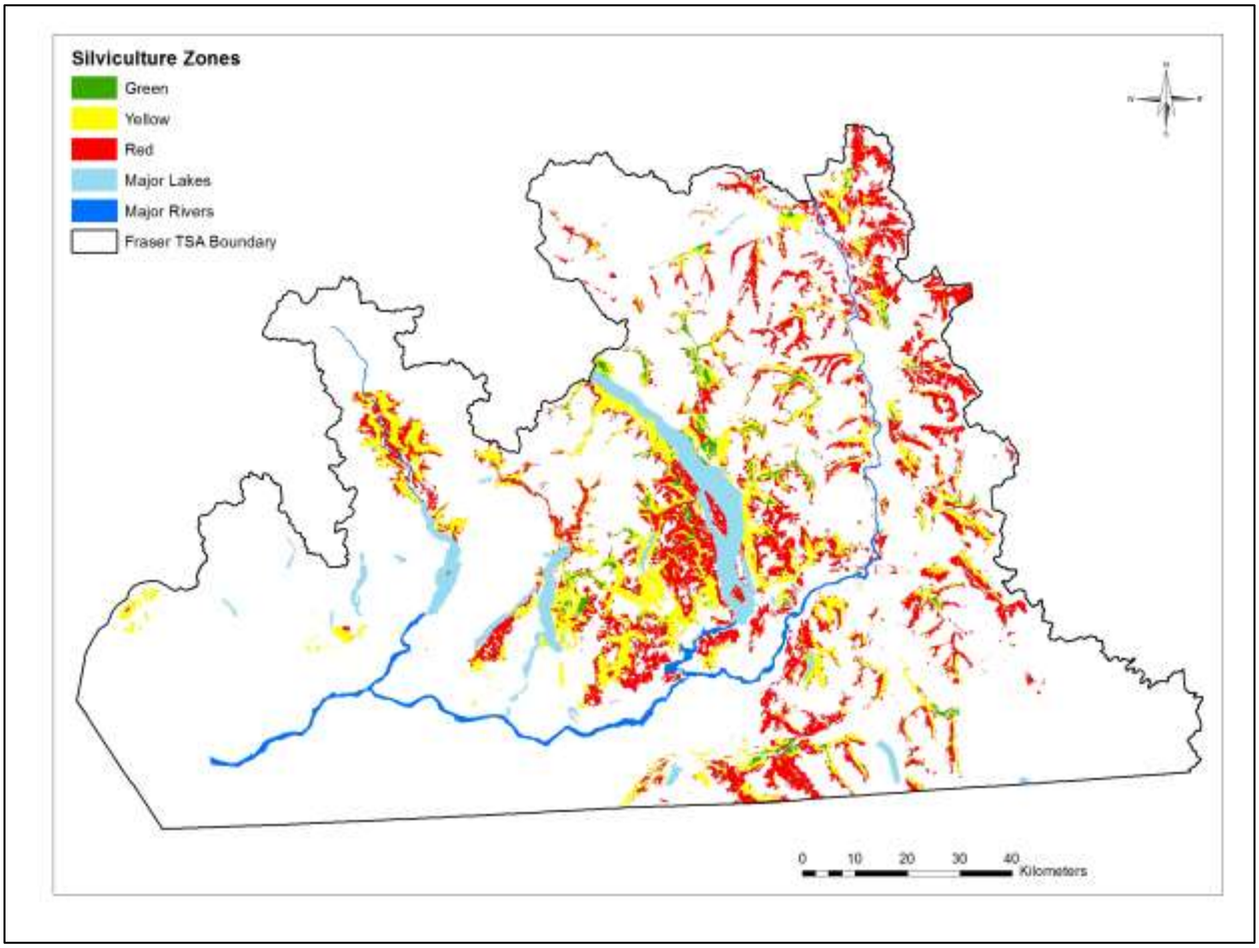

Figure 2: Fraser TSA silviculture zones

7.2 Management Scenarios

Table 8 summarizes the tested scenarios.

Table 8: Management Scenario summary

Scenario	Description
ISS Base Case	Current practice, best available information
Remove OGMAs and use the S'ólh Téméxw Plan and other NHLB areas as vehicles for managing old growth	This scenario removed all OGMAs and reclassified the land base within them as THLB, where appropriate. The THLB in this scenario was 230,128ha, 5 % larger than in the ISS Base Case of 219,490 ha. The intent of this scenario was to investigate whether the S'ólh Téméxw Plan and other existing constraints in the land base provide adequate retention for old growth. The achievement of old growth was tracked by landscape unit (LU) and BEC as per the Old Growth Order.
Forest Health and Elk Scenario (Swiss Needle Cast, Root Rot and Elk Impacts) Becomes new Base Case	A Silviculture/Timber Working Group (WG) was formed at the beginning of this project to help develop managed stand yield curves for the ISS Base Case. The ISS Base case inputs were finalized, and the yield curves developed in early 2018. In the summer of 2018, the WG had meetings and field tours and became concerned about Swiss Needle Cast (SNC), root rot (RR) and elk impacts on some growing sites. As a result, these forest health agents were incorporated in the analysis as a scenario. This scenario was adopted as the new base line for silviculture scenario comparisons after consultation with the Fraser TSA ISS implementation group.
Scenarios below were compared to the Swiss needle cast, root rot and elk Impact scenario	
Volume Strategy 1	Portions of Fd leading existing and future managed stands were fertilized on green and yellow silviculture zones every 10 years from 30 to 70 years.
Volume Strategy 2	The second volume strategy (Volume Strategy 2) involved revised reforestation regimes for future stands. For medium to good sites which are expected to be managed primarily for timber, a mosaic of ecologically suitable single species stands with enhanced densities specifically designed to optimize the production and value of each species were established ("unmix the mixes"). The species portfolio for each BEC unit was developed with consideration for climate change through the use of Climate Change Informed Species Selection (CCISS) tool and forest health risks; Average expected genetic worth for each species from seed available under the Climate Based Seed Transfer rules was used; On operable sites, where root rot is a hazard, stumping was assumed with Fd and Hw regimes; On SNC hazard sites, the Fd percent was reduced in species portfolios; Reduced stocking was assumed on sites with high or moderate elk hazard; High future log prices were assumed for all enhanced regimes; Fd stands were fertilized every 10 years from 30 to 70 years.
Value Strategy	Value Strategy is like Volume Strategy 2 with the following exceptions: Include Cw planting and juvenile spacing favoring Cw, where ecologically appropriate on yellow and green silviculture zones; In addition to Cw, focus on Fd where appropriate to maximize timber value.
ISS Selected Scenario	See section 8

Table 9 provides a summary of the scenario results for various indicators. The pluses and minuses depict a somewhat subjective classification of predicted indicator values for each scenario. Positive results relative to objectives are depicted with pluses and negative results with minuses.

Table 9: Scenario results summary (Forest health and elk scenarios as point of comparison)

Scenario	Volume	Value	NOGO Forage Habitat	MAMU Habitat	Spotted Owl LTOH	Spotted Owl MFHA	Old Seral
S'ólh Téméxw Plan (remove OGMAs)	+	0	0	0	0	0	-
Volume Scenario 1	+	0	0	0	0	0	0
Volume Scenario 2	++	+	0	0	0	0	0
Value Scenario	+	++	0	0	0	0	0

8 ISS Selected Management Scenario

Significant conclusions from the learning scenarios and sensitivity analyses include:

- The analysis assumed that the predicted harvest follows recent harvest trends; the harvest of old stands and hemlock-balsam stands was limited to their approximate share of recent harvest. Furthermore, the harvest of younger hemlock-balsam stands was limited to their approximate share of the timber profile in the medium term. These assumptions constrain the timber supply over the next 45 years significantly.
- Old growth retention targets as expressed in the Order Establishing Provincial Non-Spatial Old Growth Objectives (Old Growth Order) can be met entirely from the NHLB over time, even if the all OGMAs are placed back in the THLB. Other THLB netdowns (spotted owl, S'ólh Téméxw Plan and UWR as examples) make this possible.
- Accounting for potential impacts of Elk damage and losses to Swiss Needle Cast and root rot reduces the harvest forecast significantly. Despite the uncertainties associated with some of the assumptions and the modelling, the scenario incorporating these health agents was adopted as the new reference forecast (Base Case forest health incorporated) for comparisons against three silviculture scenarios completed in this project.
- Biodiversity indicators (i.e., NOGO forage, MAMU and SPOW habitat) were insensitive to changes in management (silviculture treatments).

The analysis results of the various management scenarios were presented to the Fraser TSA ISS stakeholder group in February 2019. The group agreed that the value scenario should become the ISS Selected Management Scenario and the ensuing tactical silviculture treatment schedule should be adopted; the scenario provides the following benefits:

- Highest estimated value of all scenarios;
- Higher long-term volume compared to the Base Case (forest health incorporated);

- No negative impact on biodiversity indicators.

The ISS Selected Management Scenario is predicted to increase the harvest forecast in the short and medium term between 3.4% and 10.5%; the long-term increase is predicted at 12.7%.

8.1 ISS Selected Management Scenario Results

Figure 3 illustrates a harvest forecast comparison between the scenario that incorporated elk and forest health and the ISS Selected Scenario. The predicted harvest level of the ISS Selected Scenario is 3.4% higher until year 70 (1,211,900 m^3 per year vs. 1,172,100 m^3). The long-term harvest level (LTHL) of this scenario is 12.7% higher at 1,237,000 m^3 per year.

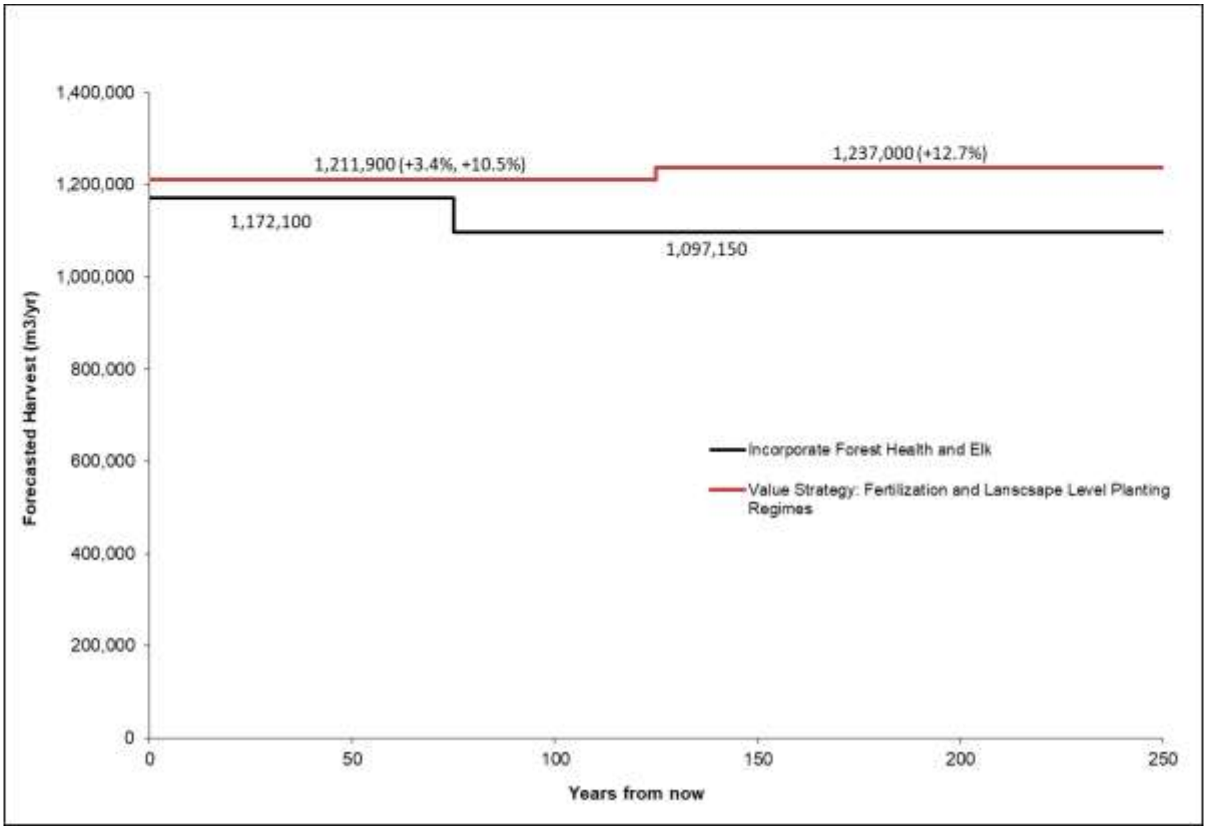

Figure 3: Harvest forecast; ISS Selected Management Scenario

The analysis results for the ISS Selected Management Scenario are described in detail in the Modelling and Analysis Report (FESL, 2019). The summary is provided below:

- On average stands are harvested 6 years younger than in the Forest Health and Elk Scenario;
- The increased growth through the use of stumping on root rot sites, enhanced densities with higher genetic worth and fertilization on priority timber sites, result in a higher average harvest volume and a higher long-term growing stock compared to the Forest Health and Elk Scenario. Reduced intensity reforestation regimes on elk hazard sites, are factored into the forecast and appear to be compensated for by the enhanced regimes elsewhere.
- Where timber is a primary objective, the ISS Selected Management Scenario favours management for Cw over hemlock-balsam and Fd on medium to good sites in ecologically

suitable areas to create value. The predicted harvest of Cw volume relative to total harvest volume increases over time at the expense of hemlock-balsam harvest volume.

- The ISS Selected Management Scenario relies on the harvest of older age classes at the beginning of the planning horizon; about 40% of the harvest is expected to come from stands older than 120 during the first 40 years.

  In the long term, most of the harvest is expected to come from stands older than 80 (54% on average). Approximately 30% of the long-term harvest is predicted to come from age class 4 stands (61 to 80 years old), while approximately 16% of it is forecasted to consist of stands younger than 60.

- In the long term, the ISS Selected Management Scenario is predicted to create significantly more timber value from managed stands.

Harvest forecasts rely on a variety of assumptions that are subject to uncertainty. Forest level analyses attempt to use the best available information and the most current analyses assumptions. Consequently, forecasts assume that the forest is harvested as modeled. The forest is also assumed to grow as predicted through growth and yield modelling.

If forest practices and/or growth and yield differ significantly from the assumptions used in the analysis, the truly available timber supply can be substantially different from the forecast.

9 Harvest Strategy (10 Years)

The various strategies presented in this report are intended to form the basis for a set of tactical plans. These plans estimate planned management activities spatially and temporally. Tactical plans need to be consistent with the ISS Selected management scenario, i.e. the proposed operational harvesting and treatments should trend towards the objectives identified in this project and not jeopardize the achievement of those objectives.

It is important to note that in practice, tactical plans are prepared through iterative analyses – operational staff interaction and usually include a significant field component. First iterations of model-created treatment areas (harvest, silviculture) are used as a starting point for the preparation of the operational schedules. The final schedules are eventually incorporated back into to the spatial timber supply model to test the schedule in terms of its overall sustainability and consistency with the existing strategic plans. This process can be detailed and time consuming, particularly in determining access, block sizes/layout and related costs.

The strategies and tactical plans in this project have not been prepared using the above described process. No detailed costs, issues with access and block sizes etc. have been considered. As a result, the presented strategies and plans are conceptual and should be taken as guidelines when developing final operational harvest schedules or tactical silviculture treatment plans (e.g., fertilization or spacing).

9.1 Age Classes and Species

The Fraser TSA has a significant volume of second growth timber due to the long logging history extending back to the early 20th century. Approximately 60% of the THLB is younger than 60 years, while about 20% of the THLB is older than 140. Age classes 5, 6 and 7 are not well represented in the THLB. Approximately 75% of the old growth stands in the THLB are hemlock-balsam leading.

In the harvest forecast 34.4% of the harvest in the first 10 years is predicted to come from stands older than 140 (age classes 8 and 9), while the combined share of age classes 3 and 4 (41 to 80 years) is predicted to be 43.6% of the harvest (Table 10).

Table 10: Predicted harvest by age class

Years	Total Harvest by Age Class (m^3)							Total
	Age Class							
	3	4	5	6	7	8	9	
1 to 5	882,831	1,824,793	858,902	230,989	103,486	505,909	1,652,590	6,059,500
6 to 10	517,917	2,059,109	764,782	452,275	250,657	456,235	1,558,525	6,059,500
Total	**1,400,747**	**3,883,902**	**1,623,684**	**683,264**	**354,144**	**962,144**	**3,211,115**	**12,119,000**
Years	**Total Harvest by Age Class (%)**							**Total**
	Age Class							
	3	4	5	6	7	8	9	
1 to 5	14.6%	30.1%	14.2%	3.8%	1.7%	8.3%	27.3%	100.0%
6 to 10	8.5%	34.0%	12.6%	7.5%	4.1%	7.5%	25.7%	100.0%
Total	**11.6%**	**32.0%**	**13.4%**	**5.6%**	**2.9%**	**7.9%**	**26.5%**	**100.0%**

Most of the harvest in the next 10 years is predicted to come from hemlock-balsam stands (49.2%). This reflects the species profile in the TSA. The shares of Douglas fir and Cedar are forecasted at 30.5% and 13.0% respectively (Table 11). Note that while the majority of hemlock-balsam harvest is expected to come from older stands, a significant volume in the forecast originates from younger (age classes 3, 4 and 5) hemlock-balsam stands (Figure 4). Most of the Douglas fir harvest is predicted to come from age class 4 stands (Figure 4).

Table 11: Predicted harvest by species

Years	Species					Total
	Alder	**HemBal**	**Cedar**	**Douglas fir**	**Other**	
1 to 5	308,790	3,107,443	792,196	1,712,078	138,993	6,059,500
6 to 10	322,005	2,849,187	786,760	1,982,237	119,312	6,059,500
Total	**630,795**	**5,956,630**	**1,578,956**	**3,694,314**	**258,305**	**12,119,000**
Years	**Species**					**Total**
	Alder	**HemBal**	**Cedar**	**Douglas fir**	**Other**	
1 to 5	5.1%	51.3%	13.1%	28.3%	2.3%	100.0%
6 to 10	5.3%	47.0%	13.0%	32.7%	2.0%	100.0%
Total	**5.2%**	**49.2%**	**13.0%**	**30.5%**	**2.1%**	**100.0%**

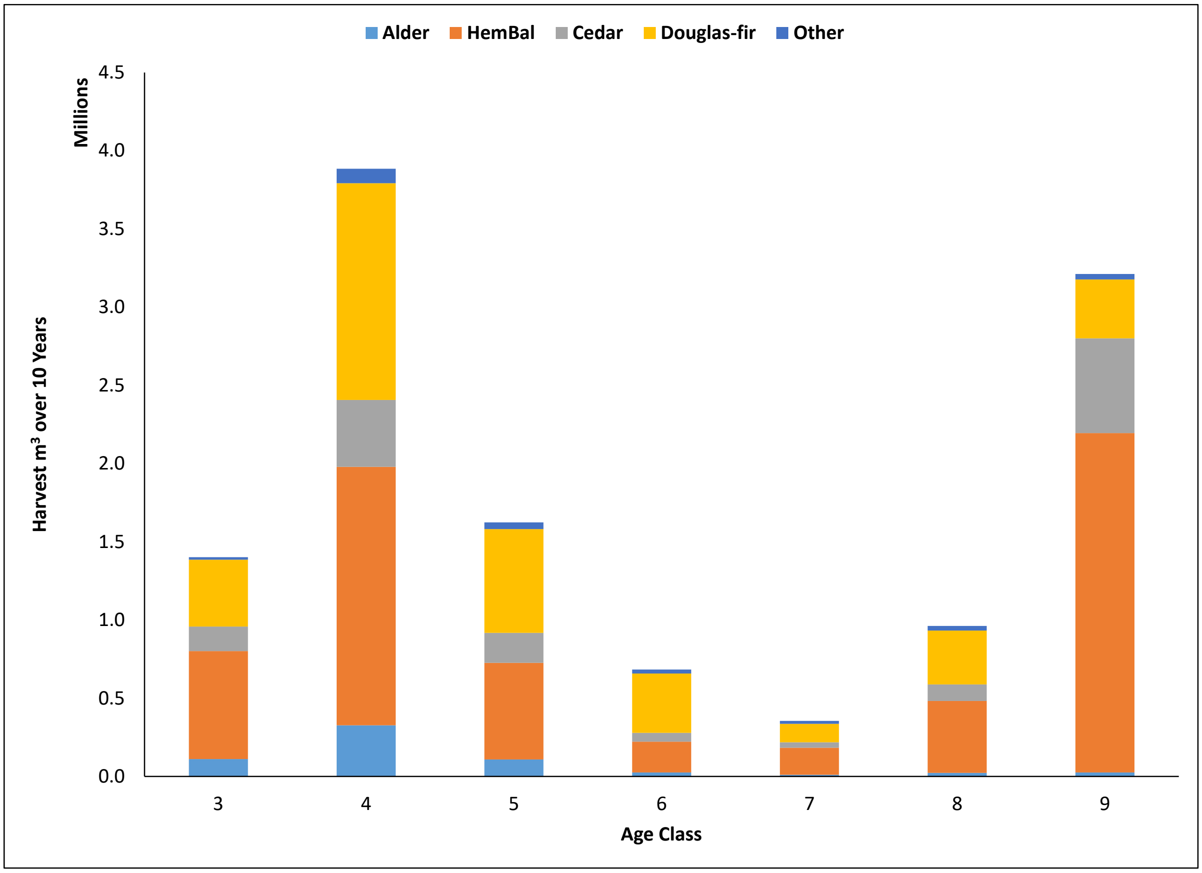

Figure 4: 10-Year harvest forecast by age class and species

9.2 Harvest Method

Approximately 97% of the short-term harvest (10 years) is predicted to come from stands where ground-based harvesting can be employed (Table 12). For the harvest forecast to hold, only a modest amount of the harvest must come from helicopter operable stands. Of all the helicopter-operable volume harvested in the timber supply model in the first 10 years of the planning horizon, 66.3 % is hemlock-balsam, 25.5% are cedar stands and 10.4% is Douglas fir (Table 13).

Table 12: Predicted harvest by harvest method in the West zone

Years	Harvest by Method (m^3)		Total
	Ground	Heli	
1 to 5	5,950,828	108,672	**6,059,500**
6 to 10	5,761,497	298,003	**6,059,500**
Total	**11,712,325**	**406,675**	**12,119,000**
Years	**Harvest by Method %**		**Total**
	Ground	Heli	
1 to 5	98.21%	1.8%	**100.00%**
6 to 10	95.08%	4.9%	**100.00%**
Total	**96.64%**	**3.4%**	**100.00%**

Table 13: Predicted helicopter harvest by species

Years	Helicopter Harvest by Species (m^3)					
	Alder	HemBal	Cedar	Douglas fir	Other	Total
1 to 5	180	84,679	15,645	7,875	293	108,672
6 to 10	1,581	172,944	88,088	34,618	772	298,003
Total	**1,761**	**257,622**	**103,734**	**42,494**	**1,065**	**406,675**
Years	**Helicopter Harvest by Species (%)**					
	Alder	**HemBal**	**Cedar**	**Douglas fir**	**Other**	**Total**
1 to 5	0.2%	77.9%	14.4%	7.2%	0.3%	100.0%
6 to 10	0.5%	58.0%	29.6%	11.6%	0.3%	100.0%
Total	**0.4%**	**63.3%**	**25.5%**	**10.4%**	**0.3%**	**100.0%**

9.3 Timber Supply Blocks

Approximately 75% of the harvest over the next 10 years is predicted to come from the Stave (46.5%) and Harrison (28.9%) timber supply blocks (TSB). The contribution of the Chilliwack TSB is predicted to be 12.7%, while the share of the Yale TSB is 7.7%. The total predicted share from the Maple Ridge, Nahatlach and Pitt TSBs is little over 4%. The predicted shares of all TSBs are shown in Table 14.

Table 14: Predicted harvest by timber supply block

Years	Harvest by Supply Block (m^3)							
	Chilliwack	Harrison	Maple Ridge	Nahatlach	Pitt	Stave	Yale	Total
1 to 5	608,388	1,203,668	90,442	112,345	100,217	3,316,524	627,915	6,059,500
6 to 10	934,716	2,297,836	81,667	31,402	95,671	2,315,627	302,580	6,059,500
Total	**1,543,104**	**3,501,504**	**172,110**	**143,748**	**195,888**	**5,632,152**	**930,495**	**12,119,000**
Years	**Harvest by Supply Block (%)**							
	Chilliwack	**Harrison**	**Maple Ridge**	**Nahatlach**	**Pitt**	**Stave**	**Yale**	**Total**
1 to 5	10.0%	19.9%	1.5%	1.9%	1.7%	54.7%	10.4%	100.0%
6 to 10	15.4%	37.9%	1.3%	0.5%	1.6%	38.2%	5.0%	100.0%
Total	**12.7%**	**28.9%**	**1.4%**	**1.2%**	**1.6%**	**46.5%**	**7.7%**	**100.0%**

9.4 Spatial Harvest Schedule

The harvest schedule for the first 10 years of the planning horizon created by the model is presented in Figure 5, Figure 6 and Figure 7.

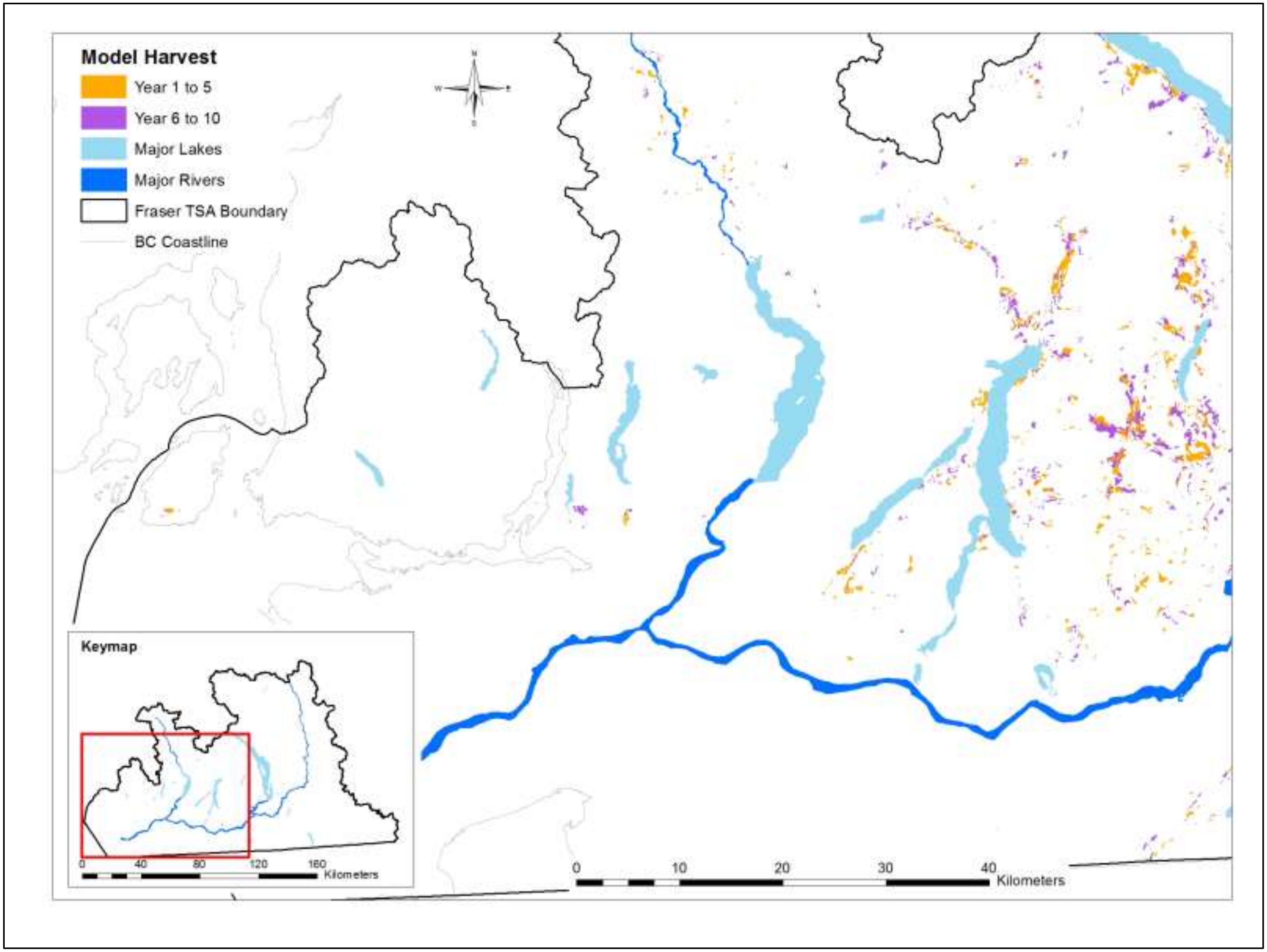

Figure 5: Conceptual harvest schedule, West; years 1 to 10

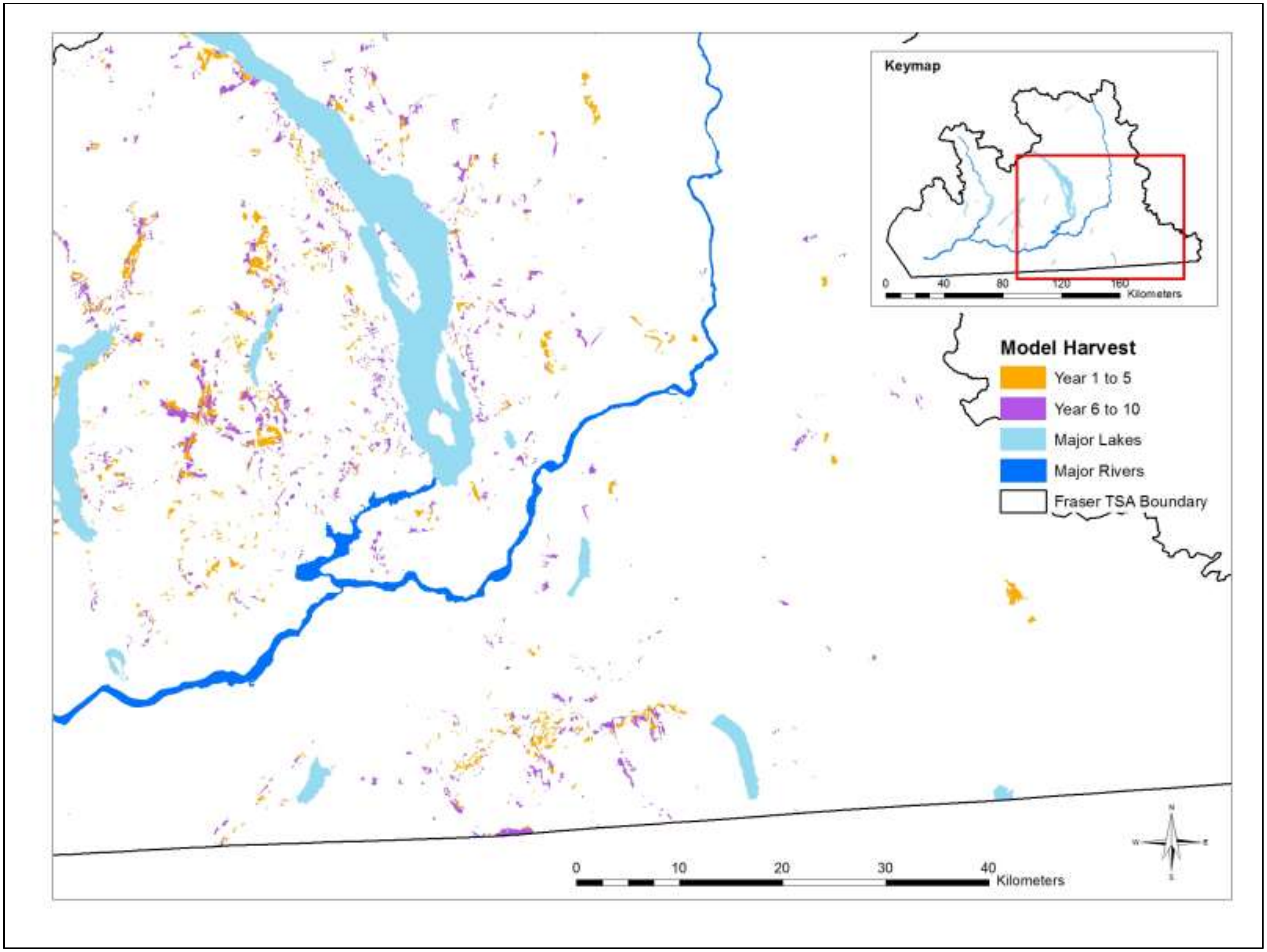

Figure 6: Conceptual harvest schedule, East; years 1 to 10

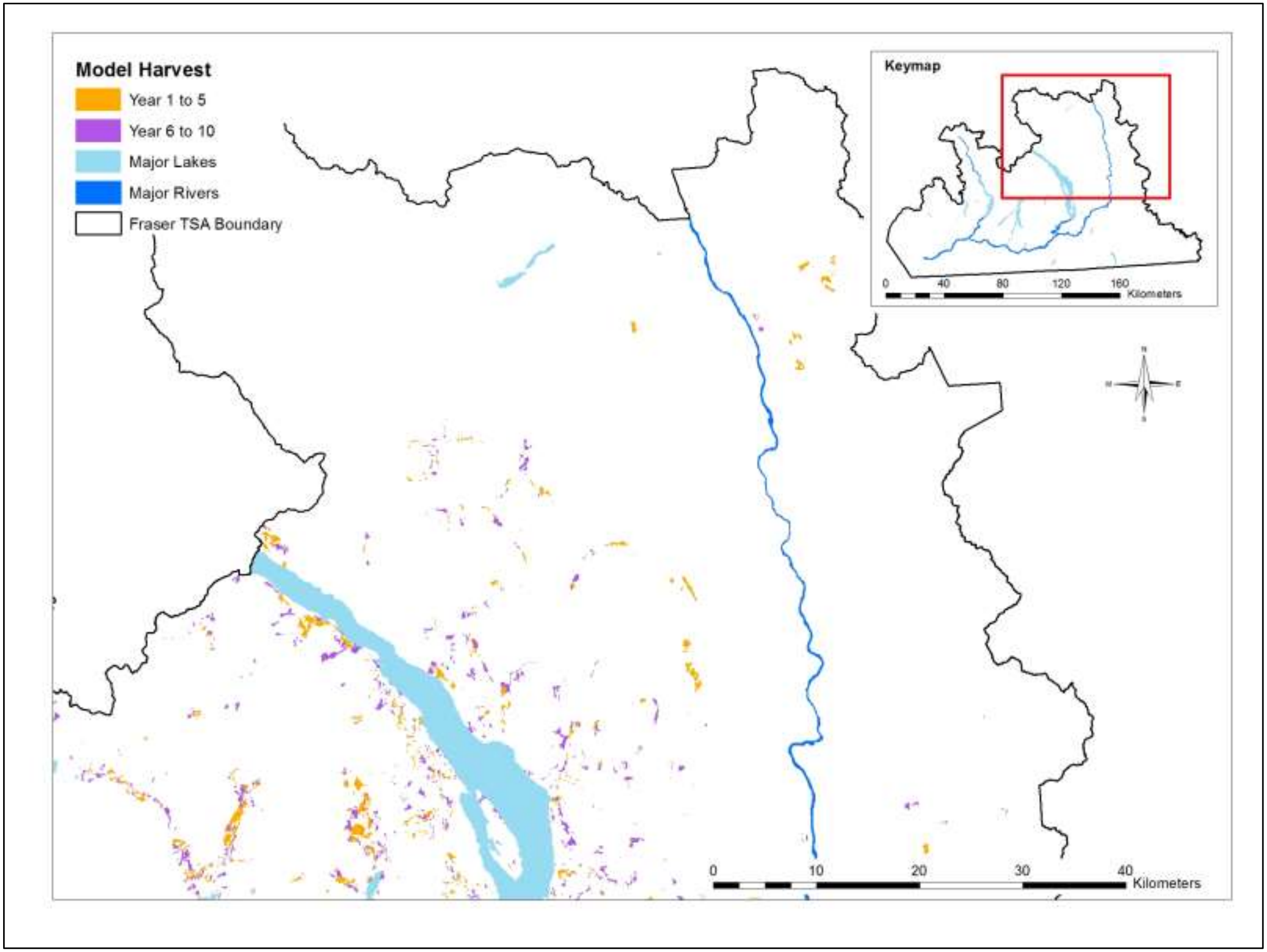

Figure 7: Conceptual harvest schedule, North; years 1 to 10

10 Silviculture Strategy

This silviculture strategy was designed by the Fraser TSA silviculture working group.

10.1 Existing Managed Stands

The strategy consists of fertilizing portions of the existing old managed and contemporary managed Fd leading stands in parts of the green and yellow silviculture zones every 10 years from age 30 to age 70.

10.2 Future Managed Stands

For medium to good sites which are expected to be managed primarily for timber, a mosaic of ecologically suitable single species stands with enhanced densities specifically designed to optimize the production and value of each species were established ("unmix the mixes"). The species portfolio for each BEC unit was developed with consideration for climate change through the use of Climate Change Informed Species Selection (CCISS) tool and forest health risks. Fertilization of Fd leading future managed stands every 10 years from age 30 to age 70 forms an essential part of the strategy. Further considerations are:

- Use average expected genetic worth for each species from seed available under the Climate Based Seed Transfer (CBST) rules;
- On operable sites where root rot is a hazard, employ stumping with Fd and Hw regimes;
- Reduce the Fd % on SNC hazard sites;
- Include Cw planting with enhanced densities and juvenile spacing favoring Cw where ecologically appropriate;
- Focus on planting Fd and Cw, where appropriate to maximize timber value;
- High future log prices were assumed for all enhanced regimes;
- Reduced reforestation intensities were assumed on elk hazard sites.

Table 15 shows the chosen species profiles and regimes for future managed stands to be managed with a timber emphasis on green and yellow silviculture zones. The recommendation for other BEC units is to follow current regeneration practises as modeled in the Base Case (forest health incorporated).

Table 15: Species portfolios and regimes for the value strategy; future managed stands

BEC Unit	Sp1/Target Planting (sph)/ Treatments	Sp2/Target Planting (sph)/ Treatments	Sp3/Target Planting (sph)/ Treatments
CWHds1 cool all (RR)	Fd/1600/stump/fert, 80%	Cw/1400/JS900, 20%	
CWHdm cool all (RR, SNC)	Base Case (Fd80Cw20/1,200), fert, 60%	Cw/1400/JS900, 40%	

BEC Unit	Sp1/Target Planting (sph)/ Treatments	Sp2/Target Planting (sph)/ Treatments	Sp3/Target Planting (sph)/ Treatments
CWHms1s warm all	Fd/1600/fert, 50%	Cw/1400/JS900, 30%	Base Case (Fd25Cw22Hw44Ba9/1600) +fert, 20%
CWHms1s cool all	Fd/1600/fert, 50%	Cw/1400/JS900, 50%	
CWHms1m warm	Fd/1600/fert, 50%	Cw/1400/JS900, 50%	
CWHvm1 cool all (SNC, weevil)	Cw/1400/JS900,80%	HwSx/1200, 20%	
CWHvm2 warm all	Cw/1400/JS900,70%	Fd/1600/fert, 30%	

10.3 Silviculture Regimes in Elk Hazard Areas

Experience has shown that in moderate and high elk hazards areas, reforestation regularly fails and requires multiple efforts to fill-in plant the failed plantations. Producing valuable timber is not likely possible in these areas. The proposed reforestation strategy in moderate and high elk hazard areas aims at creating forests which will contribute to non-timber values, while providing modest timber value with more cost-effective basic silviculture. The resulting stands are predicted to have lower stocking (compared to the current non-elk stocking standards) and modified species compositions. The strategy assumes that the saved expenditures can be allocated to enhanced reforestation in green and yellow silviculture zones. Table 16 shows the chosen species profiles for the management of elk.

Table 16: Species portfolios and regimes for elk hazard areas for the value strategy for future stands

BEC Unit	Sp1/Target Planting (sph)/ Treatments	Sp2/Target Planting (sph)/ Treatments
CWHdm cool good (RR, SNC, Elk)	HwSs/600, 50%	Dr/900, 50%
CWHvm1 cool good (RR, Elk)	HwSs/600, 50%	Dr/900, 50%

10.4 Fertilization

The silviculture strategy sets an incremental silviculture target of 1,321 ha of fertilization of Fd leading stands per year for the first 5 years at the cost $660,000 per year. This does not include any treatments for carbon sequestration. This program size is similar to what has been achieved recently in the TSA. The fertilization program is set to decrease somewhat to 966 ha per year in the second 5-year period starting 6 years from today. The annual cost is projected at $480,000 for years 6 to 10. Assuming all aspects of the silviculture strategy are implemented, the size of the fertilization program is forecast to climb modestly at year 11 and then stay relatively stable for the next 40 years (Table 17).

Table 17: Annual fertilization area and costs

Year	Annual Fertilization Area (ha)	Annual Costs
5	1,321	$660,326
10	966	$482,931
15	1,837	$918,310
20	1,504	$751,944
25	1,796	$897,755
30	1,381	$690,314
35	1,718	$859,067
40	1,417	$708,280
45	1,920	$960,021
50	1,804	$901,877

The treated stands are contemporary and old existing managed Fd stands. The annual predicted fertilization areas by BEC are shown in Table 18.

Figure 8, Figure 9 and Figure 10 illustrate the predicted fertilization areas spatially (Note; the district maintains a landscape-level fertilization plan that includes areas planned for treatment over the next 2 to 3 years. This district plan will provide a more accurate estimate of the spatial location for fertilization over the next few years).

Table 18: Fertilization areas by BEC

BEC	Years 1 to 5	Years 6 to 10
	Area (ha)	Area (ha)
CWHdm Cool	0	16
CWHdm Warm	125	66
CWHds1 Cool	50	45
CWHds1 Warm	178	184
CWHms1m Warm	129	53
CWHms1s Cool	230	198
CWHms1s Warm	293	279
CWHvm1 Cool	0	3
CWHvm1 Warm	103	45
IDFww Cool	213	76
Total	**1,321**	**966**

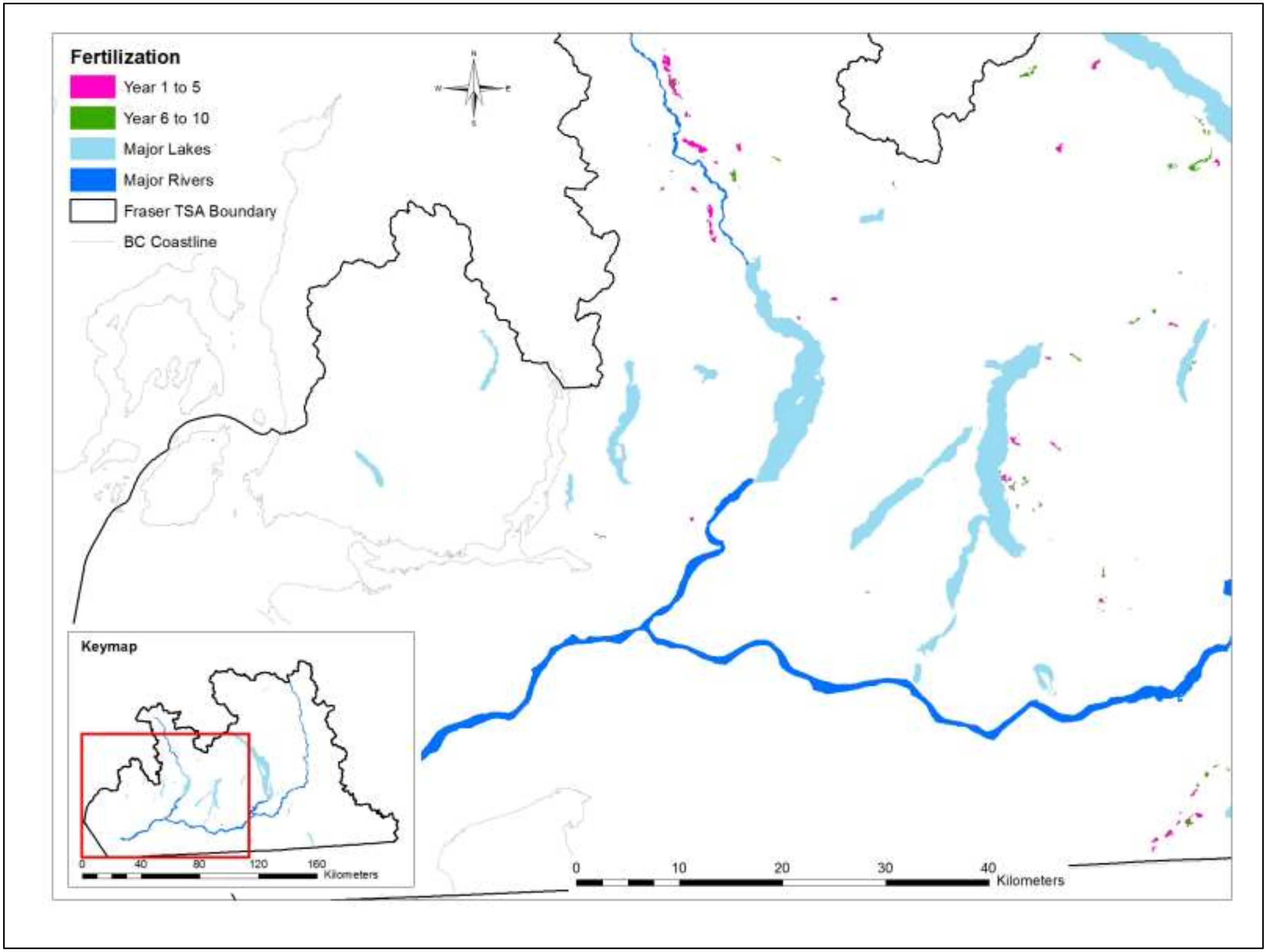

Figure 8: Predicted areas for fertilization, West

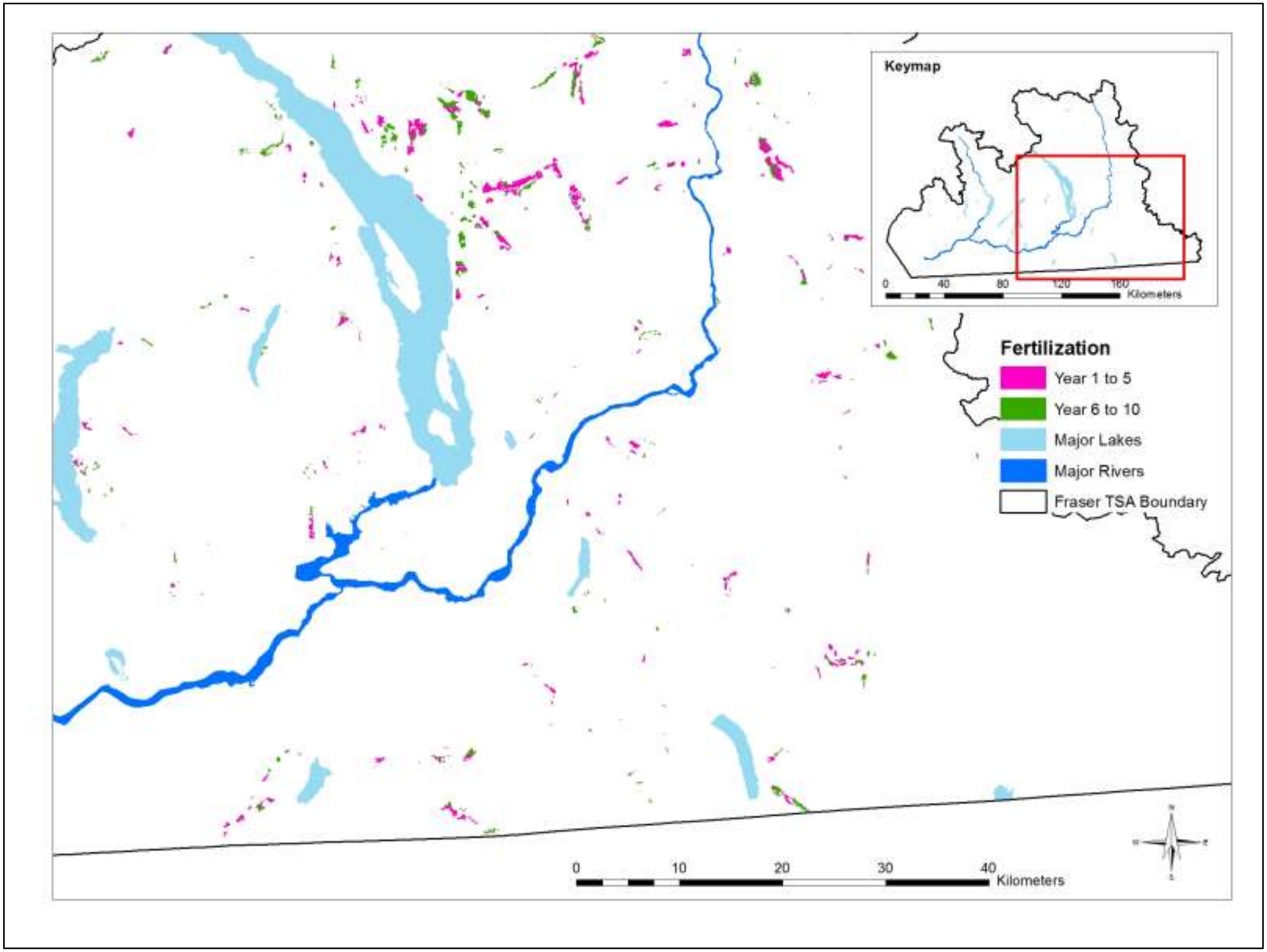

Figure 9: Predicted areas for fertilization, East

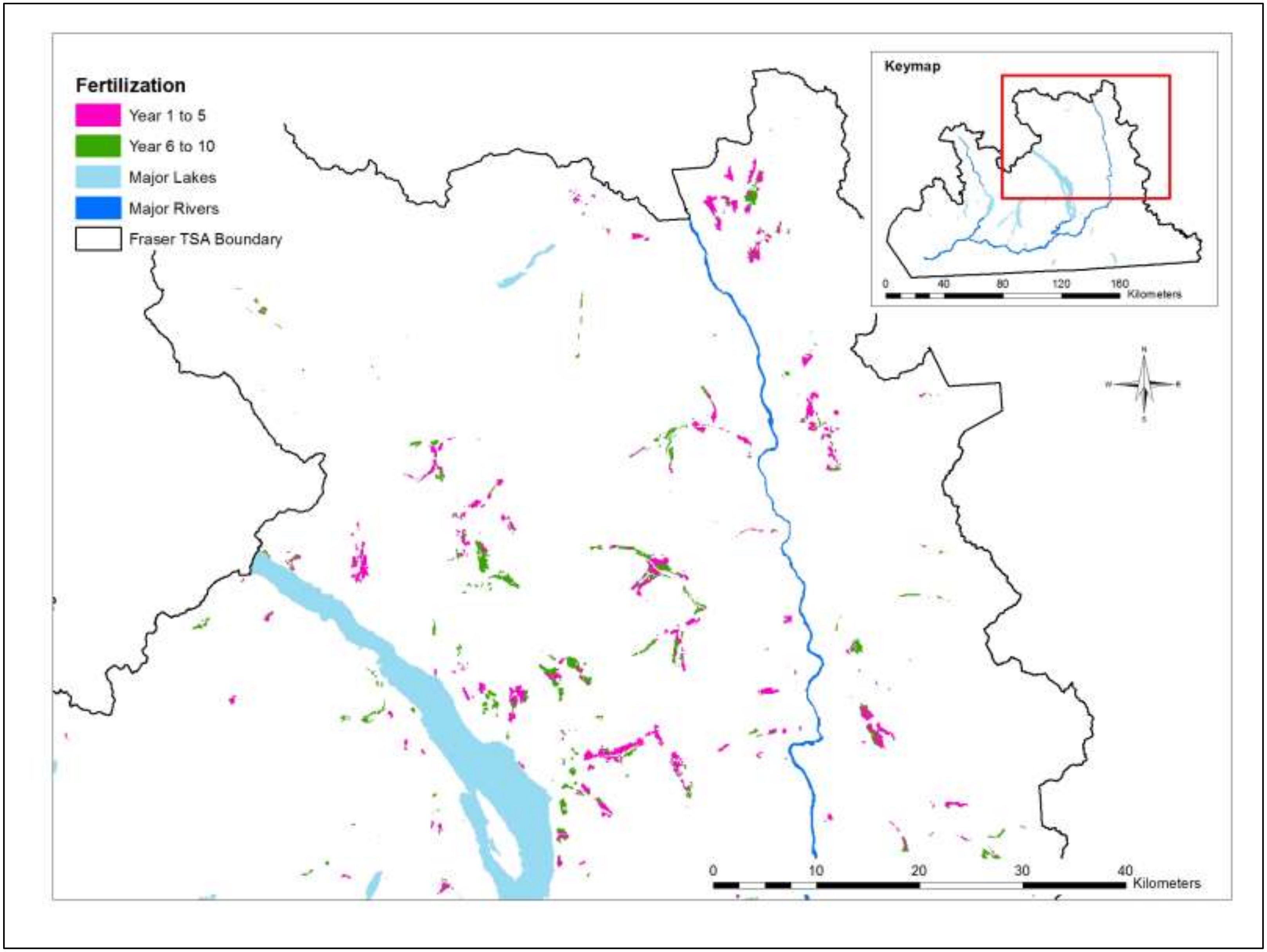

Figure 10: Predicted areas for fertilization, North

10.5 Spacing

The strategy does not include any plans for juvenile spacing of existing stands as the ISS stakeholders and the timber and silviculture working group did not feel this treatment was a priority in the TSA. However, it was noted that there could be small areas of existing, young intensively managed Dr which may require spacing in the next few years in support of value creation. As Dr spacing is already supported by the Land Base Investment Program (LBIS), it could be considered a supportable activity for the TSA even though it was not assessed and analyzed in this project. It is recommended that the district assesses the opportunity areas and proceed to try and secure funding for the small areas of potentially treatable sites.

In addition, there was discussion in the timber and silviculture working group that spacing be considered for young Fd stands significantly impacted by SNC (with the spacing designed to promote species conversion away from Fd). More work will be required to assess these opportunities and need for this type of treatment.

The silviculture strategy includes Cw planting with enhanced densities and juvenile spacing favoring Cw on appropriate sites. Spacing is recommended to be part of the regime to ensure that not too much of the planted Cw gets overtopped by faster growing natural infill such as Hw and Fd. However, significant natural infill is unlikely to be common on many sites where the Cw is planted. As a result, it is unlikely that spacing will be required on many sites. Alternatively, it is proposed that any “brushing” of competing conifers can be done pre-free growing as this is much cheaper than spacing free growing stands. The assumption in this strategy that all enhanced Cw stands need to be spaced at $2500 per hectare is conservative.

No Cw spacing is expected over the next 10 years. A modest Cw spacing program is predicted to start in year 16 and continue with annual spacing areas ranging from 240 ha to 400 ha.

10.6 Enhanced Reforestation and Reduced Densities in Elk Areas

As shown above in Table 15 this strategy proposes to plant higher densities on selected sites in the TSA. Approximately 410 ha and 495 ha of increased density planting are predicted annually for years 1 to 5 and 6 to 10, respectively. The predicted annual incremental planting costs for years 1 to 5 are $284,765 and $354,923 for years 6 to 10 (Table 19). In addition to the regimes included in this analysis, there is interest amongst some stakeholders in the TSA to establish intensively managed Dr stands on appropriate sites. As there is already an alder strategy in place (coastal) in the TSA and the areas involved were deemed to be small, this project did not analyse this opportunity.

This strategy also proposes to reduce planting densities for high and moderate elk hazard areas as discussed above (Table 19). The reduced planting densities are predicted to be applied on 261 ha annually for years 1 to 5 and on 259 ha annually for years 6 to 10. The predicted annual reduction in planting costs due to reduced densities is -$267,734 for years 1 to 5 and -$271,375 for years 6 to 10.

Table 19 also shows the net costs of increased and decreased planting densities. In the table the savings from reduced planting densities in high and moderate elk hazard areas are used to compensate for the costs for higher planting densities.

Table 19: Projected annual area and costs for increased and reduced density planting

Treatment/Activity	Years 1 to 5		Years 6 to 10	
	Area (ha)	**Costs ($)**	**Area (ha)**	**Costs ($)**
Increased Planting Densities	410 ha	$284,765	494 ha	$354,923
Reduced Planting Densities (Elk)	261 ha	-$264,734	259 ha	-$271,375
Annual Total (net)	**671 h**	**$17,031**	**753 ha**	**$83,548**

10.7 Annual Treatment Costs

The total predicted short-term treatment costs are $677,030 annually during the first 5 years and $563,550 annually between years 6 and 10 (Table 20).

Table 20: Projected annual area and costs by treatment for the silviculture strategy

Treatment/Activity	Years 1 to 5		Years 6 to 10	
	Area (ha)	**Costs ($)**	**Area (ha)**	**Costs ($)**
Fertilization	1,321 ha	$660,000	966 ha	$480,000
Increased (or reduced) Planting Densities	671 ha	$17,030	754 ha	$83,550
Annual Total		**$677,030**		**$563,550**

10.8 Surveys and Studies of Other Potential Opportunities

In this analysis, managed stands were grouped into analysis units based on leading species, growth rating and management status. This grouping inherently assumes that any stand belonging to a group exhibits certain characteristics, such as site index, density and species distribution identically. All stands within an analysis unit are assumed to grow and respond to silviculture treatments in a similar fashion. In practice, this is not the case. The actual stands within each analysis unit will vary in site index, species composition and physical condition. Some may not be suitable candidates for silviculture treatments for a variety of reasons.

At the last Fraser TSA ISS implementation group meeting in November 2019, there was interest expressed by some stakeholders to explore opportunities for the use of Innovative Timber Sale Licences (ITSL) to harvest uneconomic old HemBal stands and convert them to more productive managed stands. The key idea behind this concept is that if the government funded the reforestation after harvesting and achieved at least a 2% rate of return, some otherwise uneconomic stands could be viable to harvest.

As part of this project, about 10,800 hectares of old HemBal-leading stands previously within the THLB were identified as being uneconomic to harvest. After removing the overlap with the red silviculture zone (areas which are poor choices for investment) about 1,650 hectares of potential ITSL opportunity area remained. Operational assessment would be needed to estimate the harvest costs and timber values of these stands to determine if any opportunities for ITSL's exist. As this work was outside the scope of the Fraser TSA ISS, the district will complete this work in the next field season, if possible.

Another treatment opportunity identified but not analyzed in this project was the rehabilitation of old roads for carbon sequestration and environmental protection.

First Nations were also interested in a long-term plan to ensure the supply of monumental Cw. Concepts discussed included assessing riparian areas to determine the best sites to grow monumental Cw, which were likely to remain close enough to road networks to allow feasible single tree or small group removals. Suitable areas currently void of Cw could be under-planted with Cw and tended as necessary.

Fraser TSA stakeholders noted that Young Stand Monitoring (YSM) was a priority.

11 Wildfire Management

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

- 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. Treatments to reduce fire risk within the urban interface will be carried out in accordance with community wildfire protection plans.

Silviculture treatments can be used to reduce wildfire risk and consequences to safety, infrastructure, property and other values. Treatments such as thinning can reduce wildfire risk at the stand-level, and timber development planning together with silviculture treatments which are designed to create temporal and spatial variation can be valuable tools at the landscape-level. Investments in approaches to reduce fire risk in the WUI were discussed but not analyzed in this project.

On the other hand, intensive silviculture treatments to produce timber should be strategically located in areas with minimal longer-term risk of loss from wildfire. The silviculture zoning described in Section 7.1 is based on this type of prioritization and was used in this project. Table 21 shows generalized forest management priorities for wildfire management.

The Wildland Urban Interface (WUI) is any area where combustible wildland fuels (e.g. vegetation) are found adjacent to homes, farm structures or other buildings. The WUI buffer consists of areas within two kilometres of a community with a density of between six and 250 structures per square kilometre. The data in the Fraser TSA was updated to 2015 for built structures and was provided by FLNRORD for this analysis. It helps identify developed areas that may be at risk due to wildfires and can help guide planning processes for modifying or reducing the amount of forest or range fuels to mitigate the risk of fire in the built environment.

Historically, wildfire planning has been separate from other strategies, such as this. In the Fraser TSA, a Provincial Strategic Threat Analysis (PSTA) of wildfire risk has been completed for the WUI at the strategic level to inform the government's landscape fire management planning and fuel treatment programs. The PSTA risk ratings are based on the VRI, and field observations during this project revealed inaccuracies in the fire threat rating in many observed areas. For this reason, this plan did not identify candidate treatment areas. Rather, it recommends that surveys be carried out to confirm risk ratings in those areas within the WUI, where VRI based ratings indicate concerns. In high or extreme rated areas treatments should be recommended and implemented. Treatments to reduce fire risk were not modeled due to relatively low area of high threat (risk) polygons within the TSA and the inaccuracy of the VRI data as discussed above.

Table 21: Stand-level 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

Treatments		Treatment Outcome (Fire Perspective)	Lower priority where	Higher priority where
	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

11.1 Potential Treatments

At the stand-level silviculture treatments usually focus on reducing the canopy bulk density. For existing stands, this can be accomplished through partial harvesting and in some cases pruning treatments, which also reduce the possibility of ground fires reaching into the tree canopy. Networks of static fuel breaks can also be valuable to landscape-level fire risk reduction.

Wherever new plantations are established in the WUI, consideration should be given to fire management stocking standards:

https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/land-based-investment/forests-for-tomorrow/fire_management_stocking_standards_guidance_document_march_2016.pdf

The intent of a fire management stocking standard is to create and sustain stand conditions that achieve the objectives set for fire management in each area within a WUI. Usually the goal is to reduce the probability of aggressive fire behaviour in a stand, by decreasing the likelihood of crown fire and/or rapid high intensity ground fire. In general fire management stocking standards are not expected to produce optimal stands for timber and therefore should be used mostly within the WUI.

General examples of fire management stocking standards are:

- Increased use of deciduous species in reforestation in high fire threat areas. Deciduous species may also be desirable in contributing positively towards habitat and biodiversity objectives.
- Increased use of species with smaller canopy bulk density; in ecologically suitable sites Pw can be planted and used instead of Fd for a portion of the planted area.
- Reduced stocking densities to set up stands with reduced canopy bulk densities.

In addition to stand-level strategies, at the landscape-level, where it is desirable to have fire resistant and value forests, consideration should be given to developing harvest patterns together with silvicultural strategies which promote fire hazard reduction through development of landscapes with spatial and temporal variation.

12 Habitat

12.1 Spotted Owl

The analysis accounted for the legal spotted owl management requirements; the long-term owl habitat areas (LTOHA) were removed from the THLB and the harvest in managed forest habitat areas (MFHA) was constrained. Nesting and foraging habitat was tracked in each LTOHA and MFHA.

Table 22 shows the predicted spotted owl forage and nesting habitat in each LTOHA within the Fraser TSA. No harvesting can occur in these areas and the area of both forage and nesting habitat is increasing over time.

Within the spotted owl MFHA, a minimum of 10% of the area must be retained as wildlife trees, with a minimum of 40 large-diameter trees retained per hectare in drier ecosystems, and a minimum of 15 large-diameter trees per hectare in wetter ecosystems. No more than 40% of these retained trees can be in established WTP and other reserves.

In this analysis, the retention in MFHA was simulated by reducing the THLB; however, it was not possible to model the above described partial harvesting adequately. Rather, all harvesting in MFHA areas were assumed to be clearcutting. Table 23 presents the predicted spotted owl forage and nesting habitat in each MFHA within the Fraser TSA. Over time both the forage and nesting habitat within MFHAs are forecasted to increase moderately.

Nesting and foraging habitat was also tracked in each landscape unit (LU). Large areas of both foraging and nesting habitat exist in the TSA according to the analysis as shown in Table 24 and Figure 11. Note that the analysis results do not assess how much of the habitat outside of LTOHA and MFHA areas is fragmented (or contiguous).

Table 22: Forecasted spotted owl habitat in LTOHAs

LTOH ID	Forest Area (ha)	THLB Area (ha)	Habitat Type	Habitat (ha)					
				Now	Year 50	Year 100	Year 150	Year 200	Year 250
Spotted Owl LTOH 2-494	4,158	0	Forage	3,335	3,584	3,764	3,764	3,764	3,764
			Nesting	640	1,661	2,837	3,031	3,053	3,053
Spotted Owl LTOH 2-495	2,819	0	Forage	1,293	2,042	2,482	2,490	2,490	2,490
			Nesting	22	927	1,168	1,896	2,311	2,311
Spotted Owl LTOH 2-496	6,569	0	Forage	4,221	4,916	5,817	5,817	5,817	5,817
			Nesting	1,635	2,634	3,786	4,457	5,003	5,003
Spotted Owl LTOH 2-497	9,53	0	Forage	534	766	921	921	921	921
			Nesting	226	226	670	792	844	844
Spotted Owl LTOH 2-498	6,937	0	Forage	4,970	5,896	6,627	6,627	6,627	6,627
			Nesting	2,492	3,668	4,373	5,166	5,885	5,885
Spotted Owl LTOH 2-501	2,417	0	Forage	1,606	1,723	1,753	1,965	1,965	1,965
			Nesting	508	715	1,432	1,482	1,702	1,702
Spotted Owl LTOH 2-502	19,070	0	Forage	12,979	14,567	17,037	17,037	17,037	17,037
			Nesting	6,221	9,445	12,394	13,849	15,095	15,095
Spotted Owl LTOH 2-503	3,061	0	Forage	1,695	2,329	2,935	2,935	2,935	2,935
			Nesting	768	1,226	1,575	2,199	2,789	2,789
Spotted Owl LTOH 2-505	3,081	0	Forage	2,078	2,496	2,974	2,974	2,974	2,974
			Nesting	1,133	1,677	1,996	2,399	2,873	2,873
Spotted Owl LTOH 2-506	3,343	0	Forage	2,407	2,599	3,042	3,042	3,042	3,042
			Nesting	1,302	1,674	2,120	2,287	2,678	2,678
Spotted Owl LTOH 2-507	3,022	0	Forage	2,057	2,307	2,833	2,833	2,833	2,833
			Nesting	497	1,154	1,943	2,156	2,593	2,593
Spotted Owl LTOH 2-508	1,656	0	Forage	1,320	1,619	1,619	1,619	1,619	1,619
			Nesting	690	1,083	1,302	1,455	1,455	1,455
Total	**67,912**	**0**	**Forage**	**46,733**	**53,847**	**61,528**	**61,748**	**61,748**	**61,748**
			Nesting	**20,776**	**32,348**	**43,477**	**49,728**	**55,411**	**55,411**

Table 23: Forecasted spotted owl habitat in MFHAs

MFHA ID	Forest Area (ha)	THLB Area (ha)	Habitat Type	Habitat (ha)					
				Now	Year 50	Year 100	Year 150	Year 200	Year 250
Spotted Owl MFHA 2-497	502	372	Forage	0	75	54	74	77	73
			Nesting	0	0	0	41	55	55
Spotted Owl MFHA 2-499	2,295	1,063	Forage	224	324	467	502	526	498
			Nesting	186	128	159	397	393	393
Spotted Owl MFHA 2-500	10,031	5,571	Forage	4,258	3,675	4,370	4,460	4,298	4,507
			Nesting	2,728	2,489	2,503	3,067	3,094	3,094
Spotted Owl MFHA 2-503	3,067	1,412	Forage	1,446	1,228	1,577	1,579	1,581	1,603
			Nesting	261	672	1,081	1,175	1,328	1,328
Spotted Owl MFHA 2-504	9,826	3,439	Forage	6,117	6,175	6,183	6,267	6,180	6,245
			Nesting	4,101	3,617	3,772	4,375	4,426	4,426
Total	**25,721**	**11,857**	**Forage**	**12,044**	**11,478**	**12,652**	**12,882**	**12,663**	**12,926**
			Nesting	**7,276**	**6,906**	**7,514**	**9,054**	**9,296**	**9,296**

Table 24: Forecasted spotted owl habitat in the Fraser TSA

Spotted Owl Habitat	Forest Area (ha)	THLB Area (ha)	Habitat Type	Habitat (ha)					
				Now	Year 50	Year 100	Year 150	Year 200	Year 250
Total in LTOH	67,912	0	Forage	46,733	53,847	61,528	61,748	61,748	61,748
			Nesting	20,776	32,348	43,477	49,728	55,411	55,411
Total in MFHA	25,721	11,857	Forage	12,044	11,478	12,652	12,882	12,663	12,926
			Nesting	7,276	6,906	7,514	9,054	9,296	9,296
Total in LTOH and MFHA Combined	93,633	11,857	Forage	58,778	65,324	74,180	74,630	74,410	74,674
			Nesting	28,051	39,254	50,991	58,783	64,708	64,708
Total within Fraser TSA when Tracked by LU	**831,182**	**218,947**	**Forage**	**339,190**	**383,909**	**423,755**	**420,789**	**419,699**	**419,378**
			Nesting	**158,408**	**180,117**	**232,922**	**281,544**	**293,696**	**293,243**

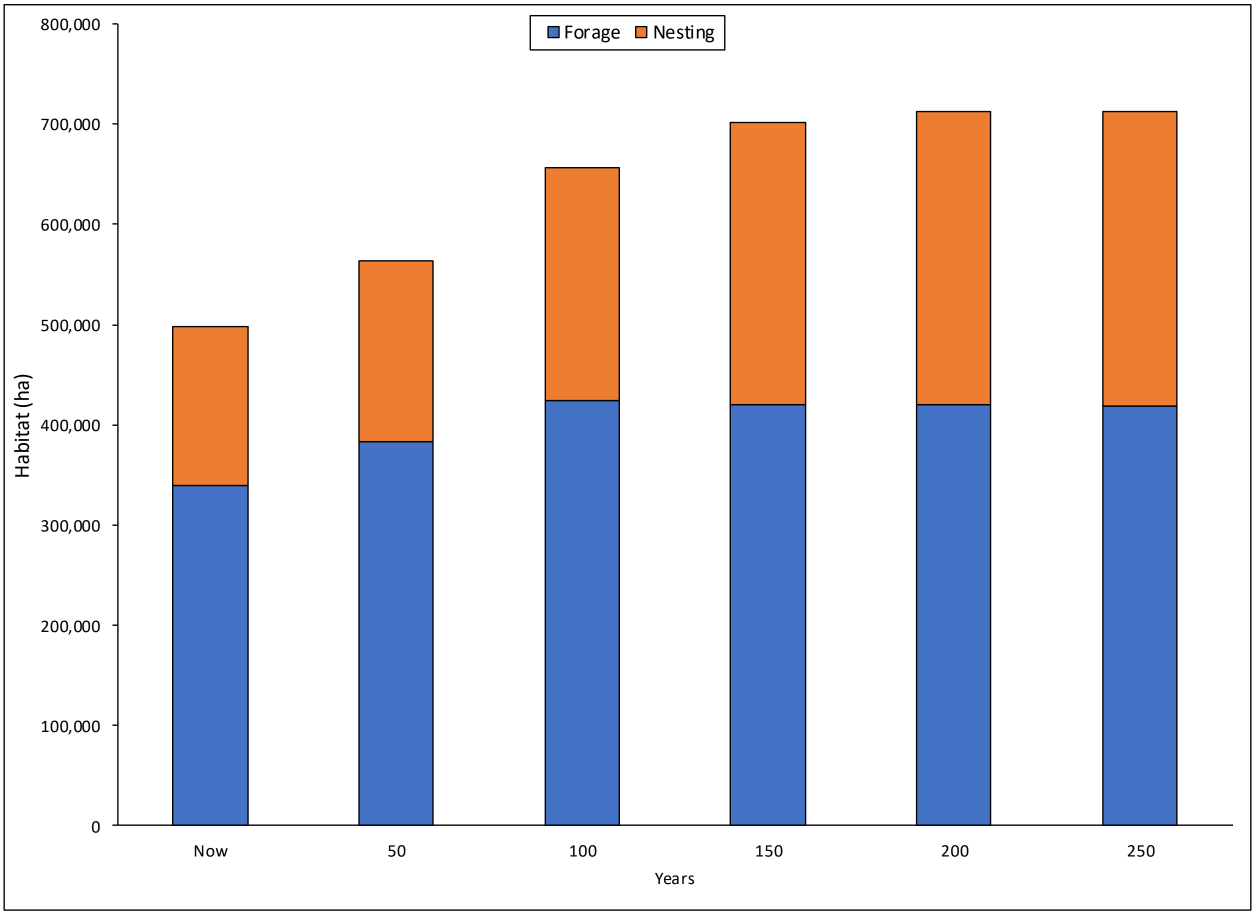

Figure 11: Forecasted spotted owl habitat in the Fraser TSA

12.2 Northern Goshawk

The two draft northern goshawk (NOGO) WHAs were removed from the THLB in the ISS Base Case and all the analysis scenarios. The ISS Base Case was also set up to report on NOGO forage habitat; 2,500 m buffers (1962.5 ha) were placed around the draft WHAs to represent forage areas. There was no provision for the discovery of future nests. The amount of forage habitat was reported for each forage area.

The 40% target for each forage area was incorporated in the ISS Selected Scenario as the desired management direction. While there is only limited area of potential forage area within the Fraser TSA, the analysis indicates that it is possible to manage for NOGO forage habitat for the two draft WHAs in the TSA without timber supply impacts; the forage habitat is achieved from the NHLB.

12.3 Marbled Murrelet

The Marbled Murrelet (MAMU) is an important species in the TSA requiring old growth forest stands for its nesting habitat. All scenarios included MAMU habitat as an indicator. A habitat suitability layer was provided for the analysis by the FLNRORD, South Coast Region. Harvesting a suitable area is assumed to convert it into unsuitable habitat with no recruitment of habitat within the planning horizon of the analysis.

There are 21,679 ha of suitable MAMU habitat within the forested area of the Fraser TSA; only 2,100 ha (approximately 10%) are classified as THLB. This suggests that the MAMU could be managed in the TSA without significantly reducing the future harvest. A habitat retention target will be assigned to the TSA, as part of a legal order to support the Province's MAMU recovery efforts. In the analysis the harvest in the THLB portion of the MAMU habitat was not constrained.

13 Opportunities for Colocation of Reserves and Constrained Areas

The Wildlife Habitat Area (WHA) designation under FRPA provides one of many legal means to manage habitat for regionally important wildlife and Species at Risk (SAR) in BC. Implementation of WHAs is guided by policy and procedures established through the Government Actions Regulation (GAR) Policy and Procedures (2013) and Identified Wildlife Management Strategy (IWMS) established in 1999 and amended in 2004.

An implementation plan and related socio-economic analysis form an important part of the WHA establishment process. Its intent is to ensure that the socio-economic impacts resulting from establishing a WHA do not exceed guidance provided by provincial policy.

In general, WHAs are expected to have a maximum of 1% timber supply impact by TSA. For some Species at Risk, such as Marbled Murrelet and Northern Goshawk, the provincial government has waived this requirement pending related land use decisions. Additional WHA designations are expected.

There are a relatively large number of SAR present in the Fraser TSA because of its location in the ecologically distinct Georgia Depression and because of the significant land use pressures associated with the large and growing human population in the region. SAR are discovered during operations and require protection, and over time this *ad hoc* approach to management has led to an inefficient distribution of reserves and leave areas.

In 2015 the Chief Forester initiated the Provincial Stewardship Optimization/THLB Stabilization project. The intent of the project is to optimize placement of forest stewardship reserves while minimizing the timber supply impacts of these reserves and providing more stability for the Timber Harvesting Land-base (THLB). In practical terms, the intent is to find more efficient ways throughout the province to meet all the SAR requirements, and objectives for the 11 FRPA values. This can potentially be done by investigating different combinations of locating the many constraints on timber harvesting. The primary objective is to improve stewardship while simultaneously providing stability to the THLB by optimizing the placement of spatial constraints (colocation), without changes in land use plans or legislation.

In practice, where colocation opportunities exist, they are often small in scale and may require site-level review to ensure that the required habitat elements exist in proposed areas. Plans such as this ISS can only investigate potential colocation opportunities at a landscape level.

13.1 Overlap of No-Harvest Areas

Harvesting in the Fraser TSA does not occur in areas that are reserved primarily for the management of other resource values. Spotted owl WHAs, UWR, non-harvest areas of the S'ólh Téméxw Plan, Parks and OGMAs reduce the THLB significantly. Many of these values overlap and this overlap may provide opportunities to increase the THLB, providing that the set resource management objectives can still be realized.

This project included a learning scenario that removed all the OGMAs as spatial reserves and placed the area back into the THLB. The intent of this scenario was to understand the impact of the OGMA removal on timber supply as well as on the achievement of old growth targets as expressed by the Non-Spatial Old Growth Order. It was expected that at least some of the old growth requirements would be met through overlap with other reserve areas.

The scenario revealed the following:

- Removing OGMAs as reserves and including them in the THLB increased the THLB by 10,638 ha (4.8%); the timber supply forecast was increased by 3.3% throughout the planning horizon.
- The total area reserved for old growth was only marginally larger in the ISS Base Case than in this scenario; approximately 1.5% over time (250 years);
- Late seral targets for all NDT/LU/BEC combinations can be met entirely from the NHLB over time without OGMAs;
- Removing OGMAs increases the THLB by 10,638 ha; however, the achievement of old growth targets from the NHLB is delayed in some NDT/LU/BEC combinations. Table 25 shows a comparison of the area deficit in meeting old growth targets from the NHLB between the ISS Base Case and the No OGMA scenario. The total target for old growth retention in the TSA is 91,827 ha.
- The largest deficits in meeting old growth area targets occur in CWHdm and IDFww variants, 34% and 30% respectively.

Table 25: Old growth retention deficit for the Fraser TSA; ISS Base Case vs. No OGMA Scenario

Scenario	Old Growth Deficit from the NHLB (Area, ha)					
	Now	Year 50	Year 100	Year 150	Year 200	Year 250
ISS Base Case	-12,315	-6,259	-3,219	-588	-1	0
No OGMA Scenario	-14,765	-7,814	-4,826	-1,701	-7	0

The analysis also revealed that in many NDT/LU/BEC combinations, the old seral requirements from the NHLB were projected to be met at the same time in both the ISS Base Case and the No OGMA Scenario. Removing OGMAs in these NDT/LU/BEC combinations would not impact the schedule of meeting the old growth requirements; however, the THLB would increase by 5,363 ha.

14 Conclusions

The preparation of the Fraser TSA ISS was a cooperative process with stakeholders identifying critical issues in the TSA and contributing to the strategy development to address those issues. The most significant conclusions are listed below:

- Compared to TSR, the ISS incorporated risks associated with uncertainties with respect to the land base available for harvest and forest health:
  - ✓ Proposed area-based tenures (FNWL) were incorporated in the analysis and removed from the THLB;

- ✓ Stands with low potential for harvest due to their species composition, age and location were removed from the THLB;
- ✓ S'ólh Téméxw Use Plan was incorporated in the analysis;
- ✓ Proposed NOGO WHAs and nests currently outside of WHAs were considered in the analysis;
- ✓ Elk damage and forest health factors (Swiss Needle Cast, Root Rot) were incorporated in the analysis. The scenario accounting for forest health factors was used as the basis for comparison for silviculture scenarios.

- Many of the critical issues that we identified in the project relate to policy and/ or legislation. Without changes to the key parts of the forest management framework (tenure, stumpage appraisal and land use objectives and FRPA), most of the key opportunities for improvement identified in this strategy cannot or likely will not be implemented.
- Analysis scenarios tested a variety of feasible management strategies.
- The project found significant differences among management scenarios on impacts to various values, particularly projected $-value.
- Chosen biodiversity indicators were generally not sensitive to inputs used in various scenarios. This was expected, because no incremental Spotted Owl management was considered, and the area of THLB affected by current and proposed Northern Goshawk and Marbled Murrelet management is relatively small. However, operators will continue to be challenged by the discovery of other species at risk during operations and the management responses required. These impacts could not be forecasted in the analysis.
- The ISS Selected Management Scenario includes incremental silviculture investments that in the short-term are consistent with recent silviculture programs in the TSA. This scenario is projected to lead to higher long-term timber value while performing at least as well on non-timber values as the comparison scenarios.
- The harvest assumptions must be followed (at least broadly) to achieve the indicated outcomes.

15 Learnings and Recommendations

15.1 Ongoing process

The Fraser TSA ISS is an on-going process. For some time, the analysis file could be used to analyse the implications of proposed legal designations.

15.2 Integration into adaptive management

There is an opportunity to integrate the ISS into planning as part of the adaptive management process that incorporates monitoring results related to past harvest and silviculture investments to management. Furthermore, the implications of emerging issues and the effectiveness of potential management responses can be tested.

15.3 First Nations

The Fraser TSA has the highest concentration of First Nations in the Province; 38 First Nations Bands and 5 tribal organizations have asserted traditional territories. There are an additional 16 First Nations and 7 tribal organizations whose traditional territories extend into the Fraser TSA.

Representatives from Chawathil First Nation, Matsqui First Nation, Boothroyd Band, Ts'elxweyeqw Tribe, Yale First Nation, Seabird Island First Nation and Stó:lō Nation participated in the project.

The Stó:lō Nation has prepared a land use plan: S'ólh Téméxw Use Plan. This plan was incorporated in this project, because it is considered in operations by government and area licensees.

15.4 Coordination with Forest Analysis and Inventory Branch

It was useful to work with the Forest Analysis and Inventory Branch (FAIB) in understanding the data and creating the initial analysis dataset. Feedback from the FAIB analyst Jim Brown throughout the project was helpful.

15.5 Co-location

Analyzing the colocation opportunities of reserves revealed that there may be an opportunity co-locate reserves in the TSA. Other spatial reserves overlap OGMAs and in the course of time all late seral requirements in the TSA can be met from the NHLB. As additional WHAs and other reserves are added to the landbase, co-location opportunities should be periodically re-assessed.

15.6 Incorporation of Provincial Issues

It is important that as provincial issues emerge, there is recognition of those issues and how to incorporate them into a planning process such as the ISS. For example, managing for carbon and the impacts of climate change have been identified as provincial issues and will benefit from future iterations of the ISS.

15.7 Forest Inventory and Other Inventories

It is often difficult to fully analyze and understand some management issues using a strategic resource inventory, as the data may not be collected to the level of interest. As an example, the project attempted to use fire threat ratings in the urban interface areas for treatment prescriptions. However, the fire threat ratings are based on the VRI, which in turn is not sufficiently detailed to provide direction on tactical treatments without field verification. A higher resolution, more tactical inventory would be beneficial for tactical planning.

15.8 Limitations of Growth and Yield Modeling

Data on the growth and yield modeling of mixed species managed stands is lacking, making estimates of future species compositions, yields and timber values problematic. TASS generates more realistic yield forecasts by incorporating some stand dynamics of mixed species in modelling. I also allows for the simulation of stands with both planted and natural trees. However, the use of TASS is complex and time consuming.

Incorporating the BEC data into the development of analysis units as was done in this project is recommended; this ecological framework is strongly tied to management and natural processes.

The impact of pests and diseases on the growth and yield of managed stands is not well understood. Operational foresters continue to express concerns over these impacts and often argue that the growth and yield modelling in BC may not adequately account for pests and diseases.

The level of post-harvest retention on the landscape and its impact on growth and yield is poorly understood. This project, other ISS projects and the TSRs have revealed the need for monitoring the retention levels throughout the province. Also, monitoring of growth and yield impacts of moderate and high levels retention is required.

15.9 Challenges to implementation of the Selected Strategy

15.9.1 Value or Volume

This project identified the need to address the issue of value versus volume as a specific objective from a provincial and localized perspective. While the selected management strategy in this ISS emphasizes actions that favor the long-term value of the harvested timber, the implementation of this strategy may be difficult due to increased upfront costs relative to the long-term benefits for operators. There needs to be clear provincial direction on the use of provincial funding for creation of added value beyond the present approach.

15.9.2 Challenges for Implementation

There are significant challenges to successful implementation of many components of this strategy under the current forest management framework in British Columbia (stumpage appraisal, tenure and regulatory systems). The Crown (the people of BC/government) owns the resource and has passed the responsibility for much of its management to timber tenure holders, including the timing and location of harvest, and basic reforestation.

This system provides for efficient harvest scheduling and timely reforestation with ecologically suitable tree species; however, it does not promote long-term investments by the tenure holders. Furthermore, the current forest management framework can make it difficult for government to invest effectively in incremental silviculture regimes (a series of treatments that span the whole rotation) to meet integrated objectives without appropriate changes in policy.

For example, on areas primarily designated for timber production, the Fraser TSA Selected Management Strategy recommends investments in enhanced basic reforestation (higher densities) on selected sites. Furthermore, on ecologically suitable sites, establishment of Cw is recommended, followed by juvenile spacing and potentially fertilization. Analysis showed that these regimes could contribute to an improvement in the value recovered from the timber harvest over the longer term, if the treated stands are not harvested too soon.

The key to achieving the benefits of this strategy require investments in basic silviculture, spacing and fertilization and that harvesting occurs within a certain age range (generally longer than minimum harvest age). The government does not currently have means to direct investments in enhanced basic reforestation on the Coast, nor does it control the time of harvest.

15.9.3 Following the plan

The implementers of this plan may be tempted to take the figures and specific direction from this strategy and accept them as a “rule”. Rather, they are conceptual and should be taken as guidelines when developing tactical harvest schedules or tactical silviculture treatment plans.

The higher level harvest direction and findings are important. The timber profile and its approximate harvest as per the profile is necessary to realize the forecasted benefits of the selected strategy.

15.10 Recommendations

- Establish local timber objectives with licensees to facilitate the achievement of the harvest strategy.
- Advocate for and develop a TSA-wide tactical plan with licensees to guide the achievement of the harvest and silviculture strategies.
- The ISS should be used to help inform local incremental silviculture investment opportunities developed as part of the Coast Area Integrated Investment Plan.
- Develop a policy proposal for appraisal manual change to allow for enhanced basic reforestation (e.g., increased planting densities). Alternatively look for incremental funding opportunity (e.g., FFT or FESBC for Carbon) for increased planting densities.
- Develop FESBC or FFT proposals to look for opportunities for spacing of Cw plantations overtopped by hemlock ingress.
- Develop a policy proposal for appraisal manual changes to promote stump removal in root disease areas as a specified operation with accurate cost assessment.
- Work with Forest Analysis and Investment Branch to look for modifications to TSR based on the ISS Base Case approach, particularly when modelling the growth and yield of managed stands.
- Better integration of additional landscape level fire management planning – e.g., where to use fire stocking standards, where to place fire breaks. This will require involvement of other landowners and field verification of risks.
- Improve ties to provincial and regional Cumulative Effects initiatives This could include:

- ✓ Aligning ISS indicators with cumulative effects values
- ✓ Incorporating cumulative effects thresholds as ISS management objectives
- ✓ Providing landscape forecasting support for cumulative effects teams
- ✓ Reporting on implications of cumulative effects values and thresholds on timber supply

- Tie all future funded treatments to a risk assessment approach and mapping as described in the Silviculture Strategy.
- Where possible, recommended treatments should be identified in a manner that they can be clearly articulated for funding sources to promote implementation.
- A monitoring plan for implementation is needed to track whether the assumptions provided in this strategy promoting the desired outcomes are being followed. If not, the reasons for not following the assumptions must be understood and addressed.

16 List of Acronyms and Tree Species Codes

16.1 Acronyms

Acronym	Description
AAC	Annual Allowable Cut
AU	Analysis Unit
BCGW	BC Geographic Warehouse
BCTS	BC Timber Sales
BEC	Biogeoclimatic Ecosystem Classification
CBST	Climate Based Seed Transfer
CCISS	Climate Change Informed Species Selection
CFLB	Crown Forested Land Base
DBH	Diameter at Breast Height
DIB	Diameter Inside Bark
EM	Existing Managed
ESA	Environmentally Sensitive Areas
EVQO	Established Visual Quality Objective
EXLB	Excluded Land Base
FAIB	Forest Analysis and Inventory Branch
FC1	Former Forest Cover Inventory Standard
FESL	Forest Ecosystem Solutions Ltd
FLNRORD	Ministry of Forests, Lands, Natural Resource Operations and Rural Development
FMLB	Forest Management Land Base (from VRI)
FNWL	First Nations Woodland License
FREP	Forest and Range Evaluation Program
FSOS	Forest Simulation and Optimization System
GAR	Government Action Regulation
GIS	Geographic Information System
ISS	Integrated Silviculture Strategy
ITG	Inventory Type Group
LCC1	Land Cover Class 1
LTOH	Long Term Owl Habitat
LUP	Landscape Unit Plan
MAI	Mean Annual Increment
MFHA	Managed Forest Habitat Area (Spotted Owl)
MFLB	Managed Forest Land Base (Netdown)
MOE	Ministry of Environment
MRVA	Multiple Resource Values Assessment
NHLB	Non-Harvestable Land Base
NOGO	Northern Goshawk
NRL	Non-Recoverable Losses
NSR	Not Sufficiently Restocked
OAF	Operational Adjustment Factor
OGMA	Old Growth Management Area

Acronym	Description
PSP	Permanent Sample Plot
RMA	Riparian Management Area
RPB	Resource Practices Branch
ROG	Rate of Growth
SNC	Swiss Needle Cast
SRMP	Sustainable Resource Management Plan
SRRMC	Stó:lō Research and Resource Management Centre
STUP	S'ólh Téméxw Use Plan
TASS	Tree and Stand Simulator
TEM	Terrestrial Ecosystem Mapping
TFL	Tree Farm License
TIPSY	Table Interpolation Program for Stand Yields
THLB	Timber Harvesting Land Base
TSA	Timber Supply Area
TSL	Timber Sale License
TSR	Timber Supply Review
UWR	Ungulate Winter Range
VAC	Visual Absorption Capacity
VDYP	Variable Density Yield Prediction
VEG	Visually Effective Greenup
VRI	Vegetation Resource Inventory
VQO	Visual Quality Objective
WG	Working Group
WHA	Wildlife Habitat Area
WTP	Wildlife Tree Patch
WUI	Wildland Urban Interface
YSM	Young Stand Monitoring

16.2 Tree Species Codes

Species Code	Species Name
Ba	Amabilis fir
Cw	Western redcedar
Fd	Douglas fir
Dr	Red alder
Hm	Mountain hemlock
Hw	Western hemlock
Pl	Lodgepole pine
Pw	Western white pine
Ss	Sitka Spruce
Yc	Yellow cedar/Cypress

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