Type 4 Silviculture Strategy

Data Package – Prince George TSA

Version 4.6

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1 Introduction

Incremental silviculture can have a significant influence on the future quality and quantity of timber supply and habitat. A Type 1 Incremental Silviculture Strategy identifies issues, objectives, and treatment regimes using the most recent timber supply analysis and other existing data. A Type 2 Strategy uses in-depth stand and forest-level modeling to further develop those strategies. Incremental silviculture strategies have been completed in most management units in BC and are the basis for public investments in silviculture.

A Type 1 Strategy was completed for the Prince George Timber Supply Area (TSA) in March 2000. An update to the original strategy was completed by Industrial Forestry Service Ltd. in March 2003. This update incorporated the changes resulting from Timber Supply Review (TSR) II in 2002 and the increasing impacts of the Mountain Pine Beetle (MPB) epidemic.

The subsequent severity of the MPB epidemic led to an updated Type 1 Strategy in 2006 and a Type 2 Strategy in 2008. These strategies recommended silviculture and management actions designed to alleviate the predicted timber supply shortfall and increase the quality of the timber supply and habitat supply in the TSA.

The past strategies (2006 and 2008) recommended the following broad management directions:

1. Mitigate the effects of the MPB epidemic on the timber supply through incremental silviculture by:
    a. Promptly reforesting and/or rehabilitating the MPB killed stands;
    b. Increasing the growth and yield of natural non-pine leading stands;
    c. Increasing the growth and yield of existing non-pine leading stands;
    d. Assessing the current backlog and impeded stands and treating these stands where beneficial.

2. Manage the risk to timber supply caused by the MPB epidemic by:
    a. Promptly reforesting and/or rehabilitating the MPB killed stands;
    b. Prescribed burning;
    c. Fire breaks, general planning considering fire risk.

3. Initiate a review of basic silviculture practices in the context of the MPB epidemic and future risks of pests and diseases by focusing on:
    a. Planting and regeneration densities;
    b. Desired species composition.

4. Keep options open for the future through:
    a. Planting and regeneration densities;
    b. Desired species composition;
    c. Density control;
    d. Increasing the productivity of stands by fertilization.

1.1 Project Objectives

The Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) has initiated a Type 4 Silviculture Strategy for the Prince George TSA. The strategy will help MFLNRO work towards the government's strategic objectives such as:

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

The silviculture strategy will be a result of collaboration and sharing of ideas involving MFLNRO regional and provincial headquarters (branch) staff, MFLNRO district staff, other government and industry stake holders, and other professionals. The ultimate goal is a realistic strategy that will be owned and championed by district staff and licensees. In particular, this strategy will produce:

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

1.2 Methodology

The following process is used to prepare this strategy:

1. Identify forest level timber supply and habitat issues. Summarize the issues by time frame (short-term, mid-term and long-term).
2. By accessing local knowledge and analyzing existing information, identify possible solutions and treatment opportunities.
3. Clarify goals and objectives.
4. Define potential strategies and treatment regimes.
5. Conduct a stand-level analysis of the proposed treatment regimes to determine responses and costs. These results are used as input to the forest-level analysis.

6. Conduct forest-level (TSA) analysis to evaluate strategies with respect to short-term, mid-term, and long-term timber and habitat supply and quality issues. The forest-level analysis provides a variety of output products so that the selection of an appropriate strategy can be based on future timber quality and quantity, habitat supply, and forest condition.
7. Select an appropriate strategy with appropriate components for the short-, mid-and long-term.
8. Define an annual incremental silviculture program spatially for the first ten years.

This report presents the findings from the stakeholder consultation and provides an overview of the TSA timber supply, datasets, current land base assumptions to determine the timber harvesting land base (THLB), and the existing management assumptions as applied in the TSA. Also shown are the proposed treatment regimes and scenarios for the TSA.

1.3 Stakeholder Consultation

Workshops were held in the Prince George Resource District boardroom in January and May of 2012 and June 2013 to facilitate the key aspects of the project. The sessions were lead by Antti Makitalo, RPF, of Forest Ecosystem Solutions Ltd. (FESL), Bryce Bancroft, RPBio MRM, of Symmetree Consulting Group Ltd., Jeff McWilliams, RPF of Bruce Blackwell and Associates Ltd. and Paul Rehsler, RPF, of FLNRO. Participants reviewed and discussed the key issues and objectives and helped identify or refine treatment opportunities.

1.3.1 Issues and Potential Strategies Discussed at the Workshop

The workshop participants brought up timber and habitat supply related issues and opportunities. The following topics were discussed.

1. Optimal/higher planting densities; general consensus was that higher establishment densities and stocking standards were required for maintaining management and product options, for risk management against pests and diseases, and generally for viable future forests.

   The group suggested that the impact of higher establishment densities on the quantity and quality of timber should be tested in this analysis.

   Impact: late midterm, long-term.

2. Commercial Thinning; while not highly ranked in terms of priority, it was suggested that commercial thinning would be considered as a treatment option.

   Impact: mid-term and long-term.

3. Growth and yield of stands established before 1987; these stands are usually modeled as natural stands in timber supply analyses. It is believed that their productivity is likely higher and should be modeled as such. This was not considered a significant issue but worth investigating.

   Impact: while not a strategy, higher than currently believed yields may have a mid-term impact.

4. Intensive Zones; consider establishing intensive forest management (IFM) zones, where IFM would be emphasized.

   Impact: mid-term and long-term.

5. Improvement of Planning Tools; some participants felt that the current suite of planning tools (RESULTS etc.) is not user friendly or conducive to improving forest management.

6. Consulting Community; there was a concern over the currently small pool of qualified consultants. Long-term stability is required for this to improve. This may turn out to be a constraint for completing incremental silviculture programmes.

7. Financial Return; it was felt that a better understanding of the financial return of silviculture investments at the stand and forest level would be desirable. Economic rotations should be considered and tested in some cases. Possible and increased investment at establishment (1st year) is required (higher establishment densities).

   Impact: mid-term and long-term.

8. Fertilization; focus on late age class 2 stands to increase mid and long-term timber supply. Also, older age classes can be fertilized. Pine stands must be included; otherwise candidate areas will remain small. Test early harvest of some of these fertilized stands. Also, consider thinning higher density fertilized stands.

   This analysis will include fertilization scenarios testing outcomes at varying funding levels.

   Impact: mid-term and long-term.

9. Site Index; it was suggested that the most up-to-date site indices should be used in silviculture strategy investigations. Also, while not likely funded under FFT, it is important to find funding for work that improves site index information in the TSA.

   Impact: while not a strategy changes in site index can impact mid- and the long-term.

10. Species diversity/deciduous; Species diversity should be promoted even more. Consider unconventional species such as western larch. Allow more deciduous in establishment and at free growing. Consider no brushing in favour of conifer if deciduous established, mostly in backlog areas.

    Impact: long-term.

11. Consider risks in management; health (pests and diseases), fire, climate change, site productivity. The analysis should attempt to rank risk related to treatments or lack of them.

    Impact: short-term mid-term and long-term.

12. Multiple Accounts; Consider multiple accounts approach in management; hydro, habitat, roads, forests may all benefit from similar management actions.

13. Enhanced Productivity or Rehabilitation of Dead Pine Stands that will not get harvested; mostly small pine and dead pine that will not be harvested, in some cases patchy fires as well. The analysis should test different levels of rehabilitation and develop a strategy given limited funding, i.e. what are the most attractive candidates for rehabilitation?

Impact: mid-term and long-term.

14. Silviculture strategy as input in other plans; in the past these strategies have been largely ignored in other land use/resource plans. They should be considered when preparing other resource plans.
15. Genetic worth; use the best possible seed; flexibility should be considered in standards. An example was provided for 700 m elevation standard versus 800 m elevation planting site.

    Impact: mid-term and long-term.
16. Advanced regeneration; Investigate and consider utilizing where makes sense; this will likely be incorporated in the analysis provided that these stands can be identified and defined.

    Impact: mid-term and long-term.
17. Incentives to Industry; provide incentives to industry through appraisal and tenure reform to encourage intensive forest management and acceptance of higher stocking standards
18. .Invest in infrastructure to provide access to areas that are currently not available for harvesting due to lacking infrastructure and high cost. This analysis will test the impact on including parts of supply block A in Fort St James in the THLB.

    Impact: short, mid and long term.

1.3.2 Ranking of Strategies

The two top ranked strategies to mitigate the mid-term timber supply were fertilization treatments of existing and future stands, and rehabilitation of dead pine stands.

1.4 Context

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

1. Situational Analysis – describes in general terms the situation for the unit – this could be in the form of a PowerPoint presentation with associated notes or a compendium document.

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

3. Modeling and Analysis report –provides modeling outputs and rationale for choosing a preferred scenario.

4. Silviculture Strategy –provides treatment options, associated targets, timeframes and benefits.

Note that for the Prince George TSA, the situational analysis is not a separate document, rather it is included in this data package.

1.5 Study Area

The Prince George Timber Supply Area (TSA) covers 8.0 million hectares of the north-central interior of British Columbia. It is composed of the Prince George (3.4 million hectares), Vanderhoof (1.4 million hectares), and Fort St. James (3.2 million hectares) resource districts. Figure 1 illustrates the TSA location and the boundaries of three resource districts within the Prince George TSA.

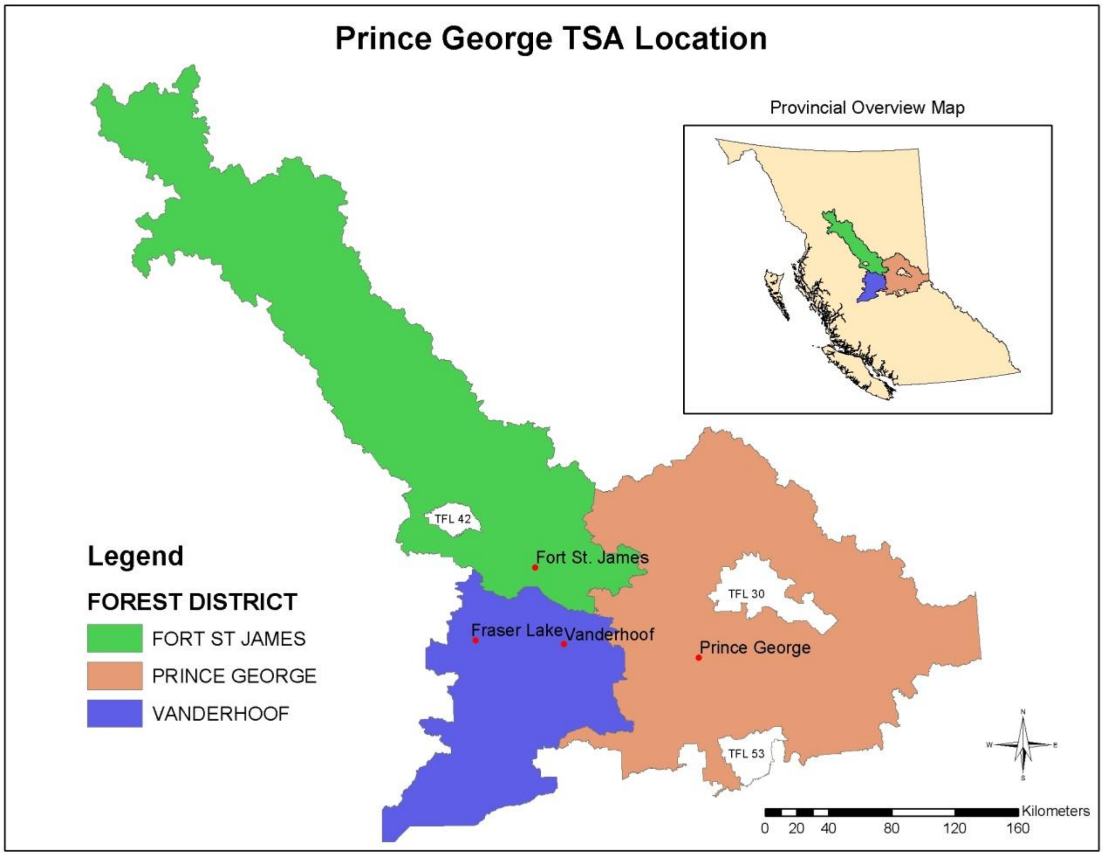

Figure 1: Location of the Prince George TSA

Due to the large size of the TSA, variable landscapes exist from flat and gentle slopes in the middle and southwest to higher elevations along the Rocky Mountains. The forests in the flatter areas consist mostly of lodgepole pine and white spruce. The eastern parts of the TSA are spruce and subalpine fir dominated in higher elevations and western red cedar and western hemlock dominated in lower elevations. The Omineca and Skeena mountain ranges are located in the north west of the TSA where lodgepole pine mostly occupies the valley bottoms. Spruce and subalpine fir are the prevalent tree species in the lower and the upper slopes.

The Crown Forested Land Base (CFLB) in the Prince George TSA is 5,242,481 ha. The Timber Harvesting Land Base (THLB), area that is considered available for logging, is 3,096,125 ha.

Table 1 shows the breakdown of CFLB and THLB in each district, as reported by FLNRO (2011). The Prince George Resource District is the largest resource district with 1,377,451 ha of THLB followed by the Fort St James Resource District with 978,917 ha of THLB. The Vanderhoof Resource District is the smallest reource district and has a THLB of 739,757 ha.

Table 1: CFLB and THLB; Prince George TSA

District	CFLB	THLB
Fort St James Resource District	2,012,989	978,917
Prince George Resource District	2,192,863	1,377,451
Vanderhoof Resource District	1,036,629	739,757
Entire TSA	**5,242,481**	**3,096,125**

Pine leading stands are the most prevalent in the THLB, accounting for 47% (over 1.5 million ha) of the THLB area (Figure 2).

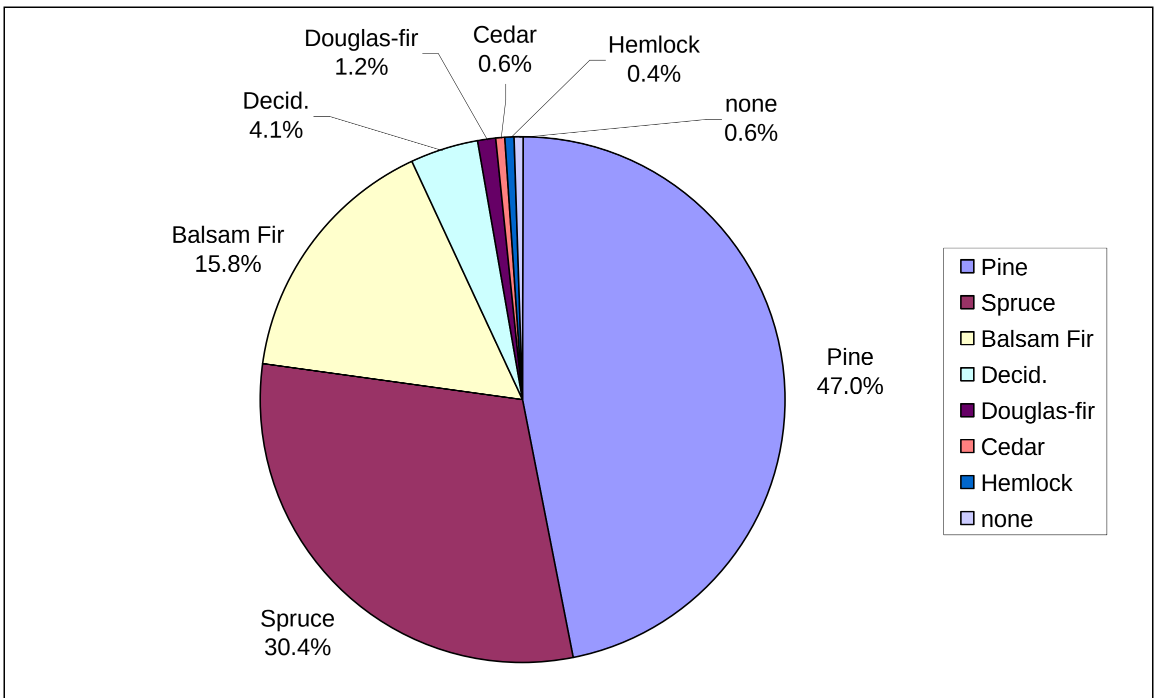

Figure 2: THLB area by leading species (%)

Most of the Prince George TSA falls in the Sub-Boreal Spruce (SBS) biogeoclimatic (BEC) zone, as shown in Figure 3. There is also a significant amount of Englemann Spruce – Subalpine Fir (ESSF), and some minor areas of Interior Cedar-Hemlock (ICH), Sub-Boreal Pine and

Spruce (SBPS), Boreal White and Black Spruce (BWBS), Spruce-Willow-Birch (SWB) and Montane Spruce (MS).

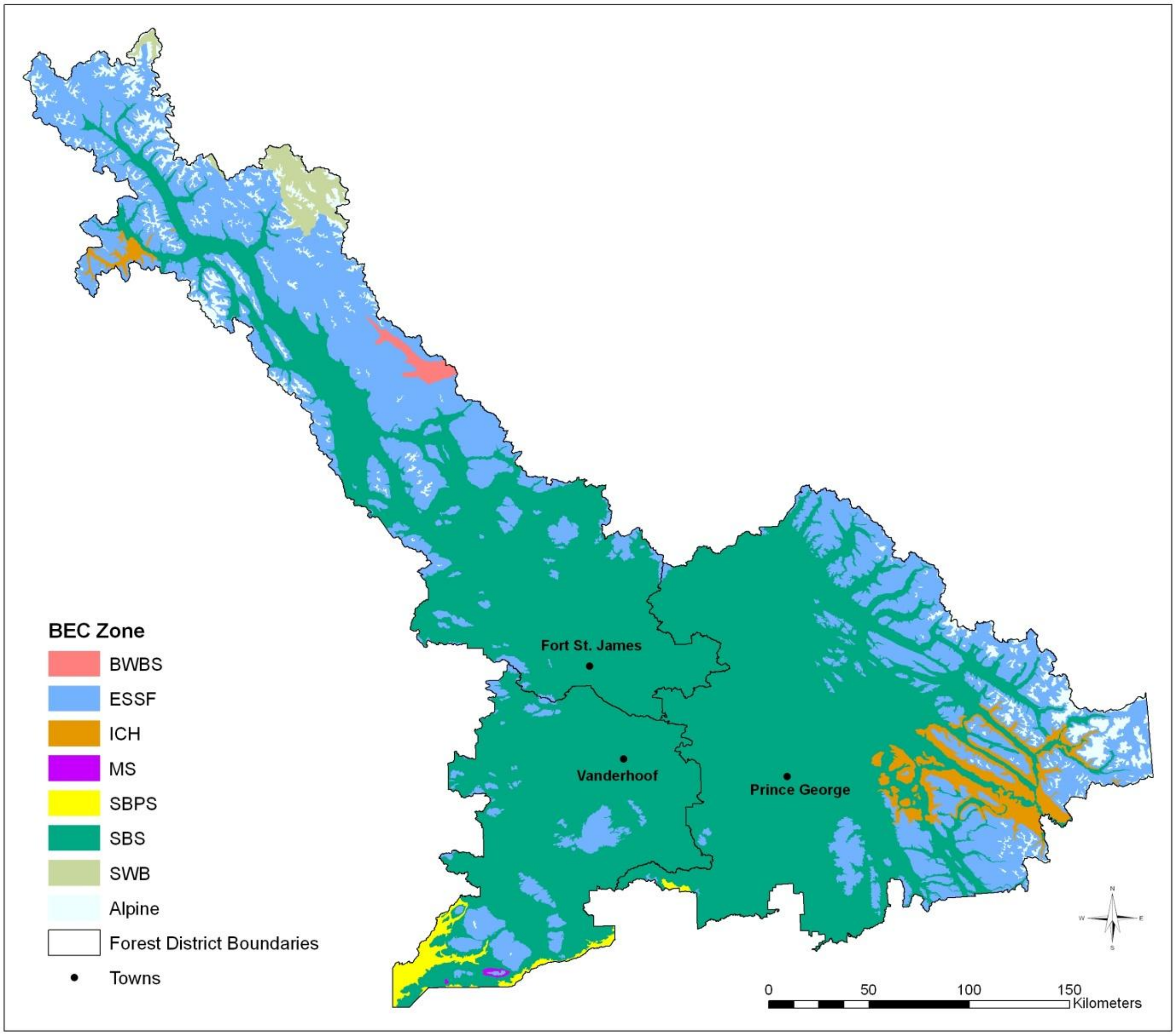

Figure 3: BEC Zones in the Prince George TSA

The Prince George TSA is divided into eight supply blocks; these are shown in Figure 4.

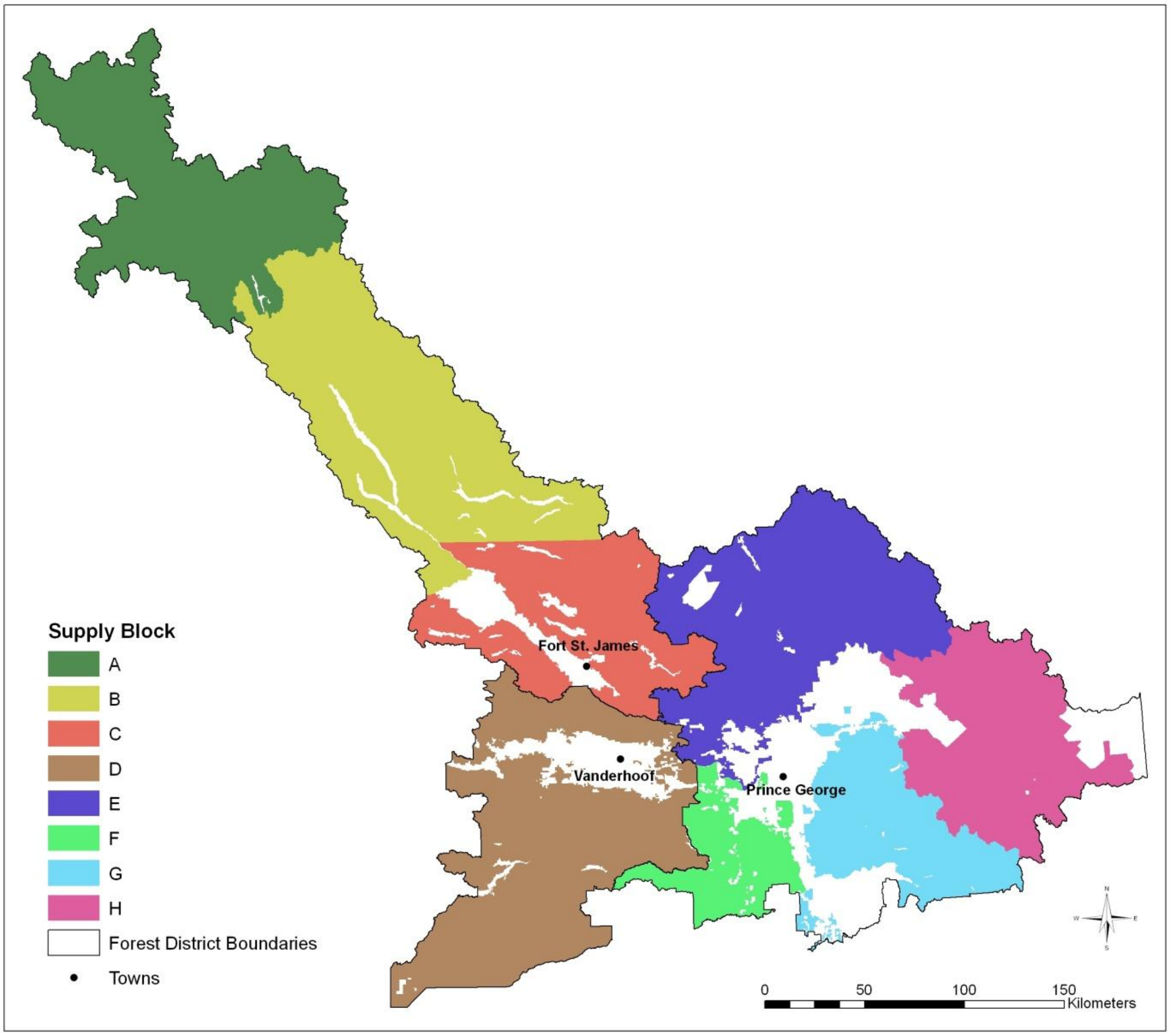

Figure 4: Supply Blocks in the Prince George TSA

Biodiversity targets in the TSA are defined and reported by NDU/merged BEC units, which are shown in figure 6. There are 25 units in the Prince George district, 17 in Fort St. James, and 7 in Vanderhoof.

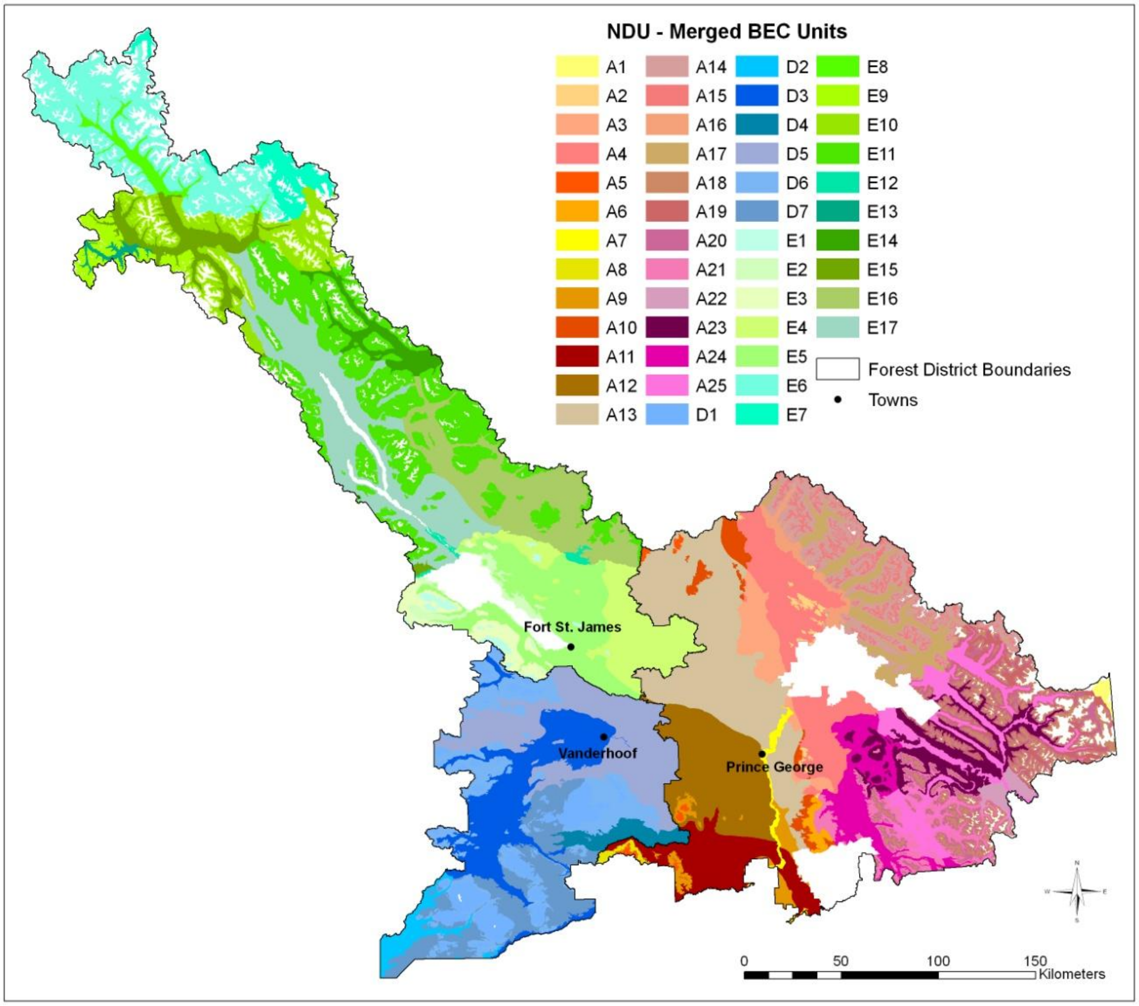

Figure 5: NDU/Merged BEC units in the Prince George TSA

1.5.1 Land and Resource Management Plans

Land and Resource Management Plans (LRMPs) provide management direction for integrated resource management; this direction reflects a local vision for the management of land base. LRMPs emphasize integrated resource management and include strategies for a wide range of different objectives such as specific species management (caribou for example), stability of timber supply, recreation, tourism, mineral exploration etc.

Resource management in all resource districts within the Prince George TSA is directed by LRMPs. The Vanderhoof LRMP was approved in 1997 while the Prince George and Fort St. James LRMPs were approved in 1999.

In 2005 the ILMB initiated the Vanderhoof LRMP Review and Amendment Project. This project took a cooperative approach and involved stake holders and the public. The objective of the project was to ensure that the values recognized in the LRMP are considered with respect to the MPB epidemic and salvage operations.

2 Timber Supply Issues

2.1 Historical and Current AAC

The Prince George TSA was established 1978. Since its creation the AAC has been determined many times (Table 2). The last three determinations (2002, 2004 and 2011) set the AAC significantly higher to facilitate timely harvest of stands affected by mountain pine beetle.

Table 2: History of AAC in the Prince George TSA

Year	AAC m^3	Notes
1986	8,605,000	
1987	8,855,000	Facilitate use of small pine in Vanderhoof
1988	9,255,000	Encourage harvest in the Takla Sustut supply blocks
1989	9,501,093	Facilitate harvest in balsam leading stands, spruce beetle salvage
1989	9,313,463	Creation of TFL 53
1991	9,280,499	Creation of TFL 52
1991	9,180,499	TSL expiry
1996	9,363,661	Facilitate hemlock looper salvage
2002	12,244,000	Facilitate MPB salvage
2004	14,944,000	Facilitate MPB salvage
2011	12,500,000	Facilitate MPB salvage

The 2011 determination also created a partition of 3.5 million m^3 annually for non-pine species with the goal to focus harvesting on dead and dying pine stands while retaining non-pine stands for the mid-term.

2.2 Mountain Pine Beetle Epidemic

The mountain pine beetle (MPB) epidemic is the most important issue affecting the timber supply in the Prince George TSA. Several past analyses (FLNRO 2011, FESL 2008) have predicted the impact of the MPB. While each of these analyses has used somewhat different approaches and assumptions, they generally have projected similar timber supply trends. Depending on the analysis, the mid-term timber supply is predicted to drop down to between 6.4 million m^3 and 7.3 million m^3 annually within the next 5 to 10 years (Figure 6). The latest timber supply review (TSR4) predicted a mid-term drop all the way down to between 4 and 6 million m^3, depending on the scenario, for a short period of time.

The mid-term timber supply deficit is expected to last 40 to 60 years depending on the analysis assumptions. Eventually, when the timber supply recovers, the long-term harvest level is expected to be between 8.7 million m^3 and 9.2 million m^3 annually.

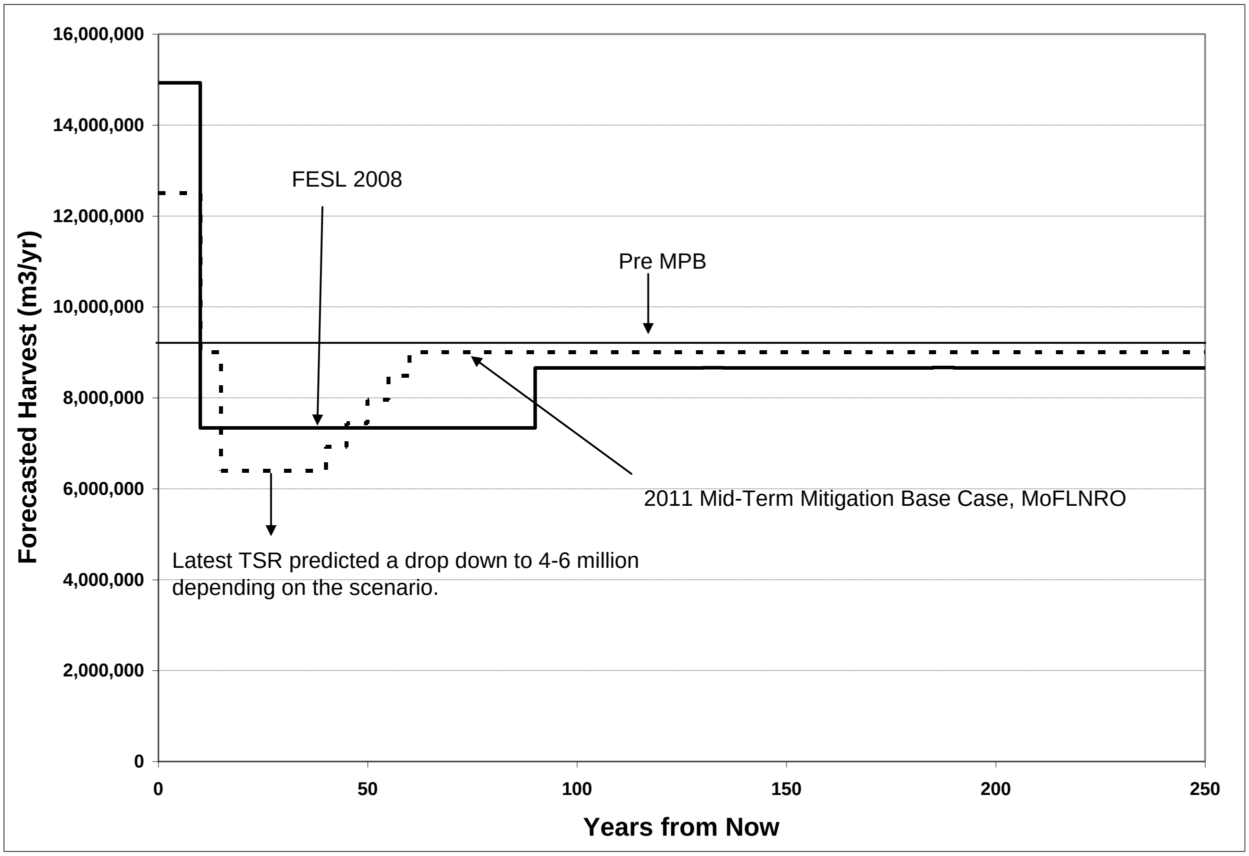

Figure 6: Various timber supply predictions for the Prince George TSA

2.3 Economically Available Harvest

The last TSR used the combination of minimum harvest volume per hectare and cycle time for log haul as the criterion for economically available harvest. As a result, 939,390 ha of otherwise productive forest were removed from the timber harvesting land base as uneconomical to harvest. The maximum cycle times used were 7.7 hours for road haul and 3.9 hours for rail. The minimum harvest volumes were 182 m^3 per ha for road haul areas and 246 m^3 per ha for rail areas.

In 2011, the FLNRO investigated timber supply mitigation options in the TSA and discovered that if no cycle time limitations were used, and if the minimum harvest volume per ha were reduced to 140 m^3 per ha, most of the predicted mid-term timber supply deficit would disappear. This means that there likely is an adequate supply of timber in the TSA to maintain the current level of industrial activity, however, a large part of this timber supply is not economically viable to harvest in the current market conditions. Improved commodity prices may reduce the areas that are currently considered uneconomic to harvest; however, it is probable that large tracts of timber will remain outside of the THLB.

2.4 Continued Salvage of Dead and Dying Pine Stands

Previous analyses have shown that harvesting all attacked pine stands and immediately reforesting them would have a positive impact on the mid-term timber supply. For this reason, the FLNRO has promoted pine salvage in recent years. The harvest focus on pine has generally been successful as indicated by Table 3. While the harvest has not generally reached the AAC, approximately 75% of the total harvest in the TSA consists of pine.

Table 3: AAC vs. harvest in the Prince George TSA (source FLNRO)

Category	2006	2007	2008	2009	2010	2011
AAC		14,944,000	14,944,000	14,944,000	14,944,000	12,500,000
Harvest		12,664,212	11,483,426	10,941,650	11,245,628	10,804,670
Surplus		2,279,788	3,460,574	4,002,350	3,698,372	1,695,330
% of AAC		85%	77%	73%	75%	86%
% Pine	72%	72%	76%	77%	74%	

How much of the dead or dying pine stands can still be harvested will have a significant impact on the timber supply within the Prince George TSA. The FLNRO predicts that that an additional 160 million m^3 of timber will still come from salvaged pine stands.

According to the area licensees, the shelf life of the killed wood varies depending on the area and end use. Harvesting of stands that have been dead up to 10 years still occurs in many areas. After about 10 years, the harvest opportunities for traditional forest products diminish. The licensees report that in many cases the dead stands tend to blow down before the actual end of the shelf life.

Timber supply projections rely on the continued harvest of pine leading stands for at least another 5 to 10 years. If these projections do not hold true, the mid-term timber supply may be worse than predicted. Possible reasons why less pine than predicted might get harvested are:

- Silviculture cost may limit salvage of dead pine stands on poorer sites, not logging costs; regeneration standards on some poor sites may require significant silviculture investment, which must be weighed against small volumes, often reduced further by decreasing recovery by decaying timber.

- The haul distance for some of the dead pine stands may not warrant their harvest given the lower grade timber and reduced recovery.

According to the projections by the FLNRO at least 70 million m^3 of pine stands will remain unsalvaged after 10 years, most of them located in the southern part of the Vanderhoof Resource District. While this timber is a potential source for biofuel operations, it will also remain as a fire threat and a possible drag on the mid-term timber supply unless treated and rehabilitated.

2.5 Harvest Species and Harvest Locations

Due to the MPB impacts described above, the mid-term timber supply is dependent on the assumption that substantial harvest must occur in the Fort St. James Resource District (from 50% to 90% at times) and a large part of this harvest must come from balsam leading stands. The timber supply in Vanderhoof is severely impacted for decades to come due to the lack of local mature growing stock as a result of the MPB epidemic. In Prince George the harvest is also constrained by the MPB impacts, however, it is also limited by the Prince George TSA Biodiversity Order, as discussed below. Planning for this large shift in species and locations harvested will be a major challenge in the mid-term.

2.6 Age Class Distribution and Mid-Term Timber Supply

The current age class distribution for the Prince George TSA is presented in Figure 7. The increased harvest due to the MPB salvage is reflected in the age class distribution. Twenty one percent of the THLB is between 0 and 20 years old and 32% of the THLB is younger than 41 years of age.

Age class 3 is under – represented, which characterizes the timber supply problem in the TSA; these age classes are the potential sources of timber for the mid-term timber supply.

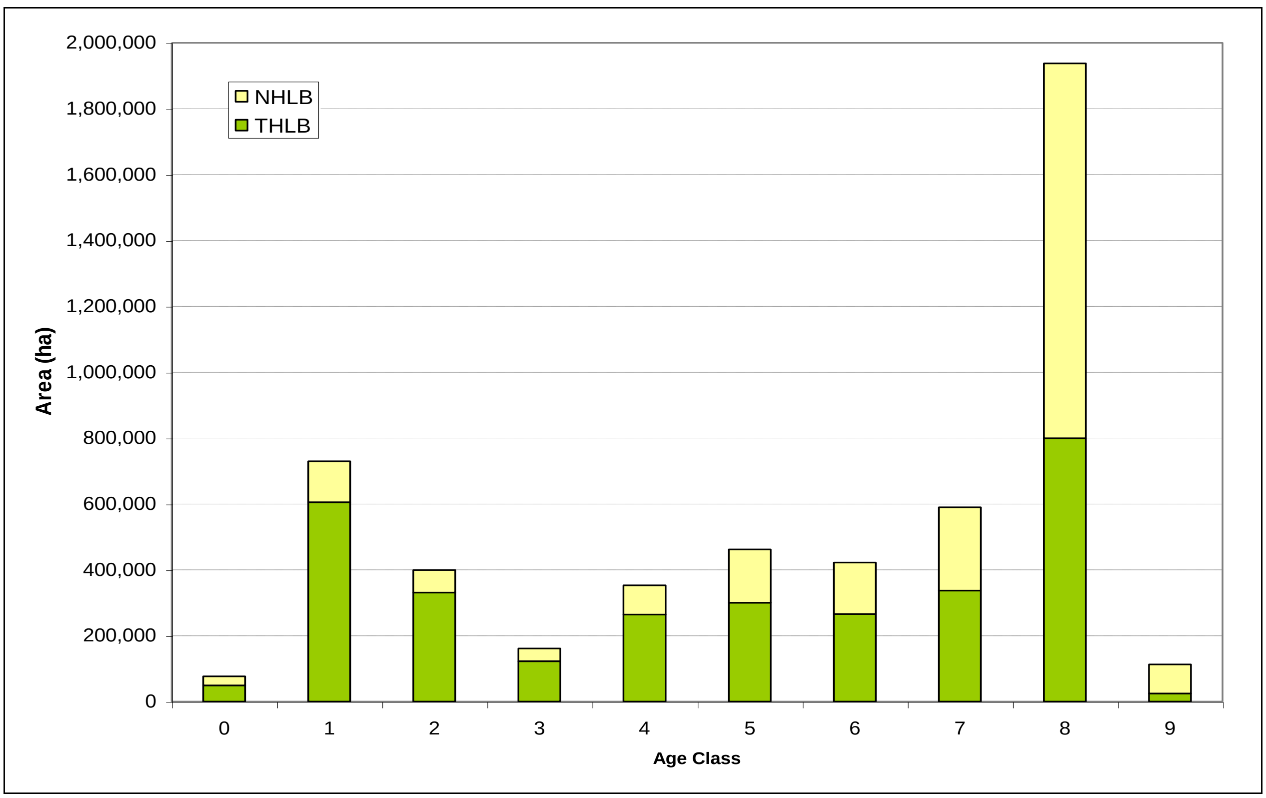

Figure 7: Current age class distribution in the Prince George TSA

Figure 8 shows the age class distribution by leading species for the THLB in the Prince George TSA. Current age class 1, 2 and 3 stands are the stands that will support the mid-term timber supply. The small size of age class 3 limits forest management options to some extent. Further, from 30 to 35 years onwards, 30% and later 60% of harvest is predicted to come from current age class 1 and 2 pine leading stands. While this provides a potential silviculture opportunity, it also will challenge us to maintain the quality of these stands over time.

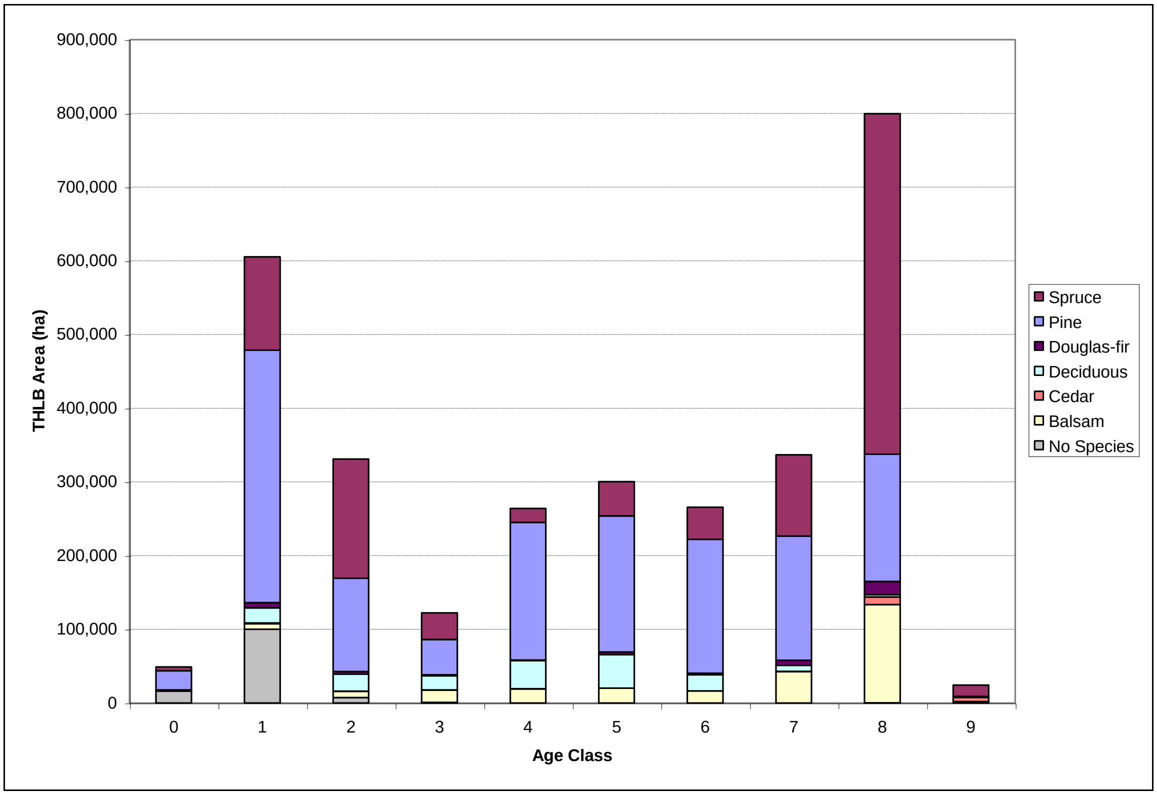

Figure 8: Age class distribution by leading species for the THLB

2.7 Biodiversity Management

In the Prince George TSA, biodiversity is managed through the Prince George TSA Biodiversity Order (2004). The order establishes landscape biodiversity objectives throughout the Prince George Timber Supply Area for old forest retention; old interior forest and young forest patch size distribution. The targets are set for natural disturbance unit (NDU) and merged biogeoclimatic (BEC) unit combinations, rather than combinations of landscape units and BEC variants. The NDUs are large geographic areas that are based on natural disturbance regimes.

In most other TSAs throughout British Columbia, biodiversity is managed either via old growth management areas (OGMA), which are spatially explicit areas of old growth forest, or via the Provincial Order Establishing Provincial Non-Spatial Old Growth Objectives often referred to as the "Provincial Old Growth Order". Past analyses have shown that in the Prince George TSA the adoption of the TSA based biodiversity order has little impact on the timber supply at the TSA level. However, there are localized impacts, particularly in the Prince George Resource

District where the mid-term timber supply is dependent on the harvest of older non-pine leading conifer stands, which are heavily constrained due to the TSA biodiversity order. When the timber supply in the Prince George Resource District is limited by the biodiversity order, most of the TSA harvest must take place in Fort St. James.

The current approach to biodiversity management classifies all pine stands that meet the old age requirement as old, regardless of their condition. This includes dead, unsalvaged pine stands. At some point in the future these dead stands will not represent the late seral stage, which will undoubtedly constrain the timber supply. Table 4 shows the current old growth surplus/deficit for each NDU/merged biogeoclimatic unit. There are seven units currently in deficit, A4, A5, A15, A18, A24, A25, and E1.

Table 4: Current surplus/deficit of old seral by NDU/Merged biogeoclimatic unit

Unit #	NDU/Merged Biogeoclimatic Units	Total CFLB (ha)	Target (%)	Target (ha)	Current Old (ha)	Surplus/Deficit (ha)
A1	Boreal Foothills - Plateau ESSFwcp3, ESSFwc3, ESSFmvp2, ESSFmv2	7,019	33%	2,316	5,587	3,270
A2	McGregor Plateau ESSFwc3, ESSFwk2, ESSFwk1	15,879	26%	4,129	7,214	3,085
A3	McGregor Plateau SBSmk1, SBSmh	69,240	12%	8,309	26,390	18,081
A4	McGregor Plateau SBSwk1, SBSvk	228,676	26%	59,456	58,597	-859
A5	Omineca - Mountain ESSFwk2, ESSFmv3, ESSFmv1	13,995	29%	4,059	3,694	-364
A6	Moist Interior - Mountain ESSFwk1	16,391	29%	4,753	7,442	2,689
A7	Moist Interior - Plateau SBSmh	4,226	17%	718	1,280	561
A8	Moist Interior - Plateau SBSmc3, SBSmc2	9,218	12%	1,106	2,512	1,406
A9	Moist Interior - Plateau SBSmw	33,409	12%	4,009	4,925	916
A10	Moist Interior - Plateau SBSwk1	48,445	17%	8,236	18,142	9,907
A11	Moist Interior - Plateau SBSdw2, SBSmc2	127,310	12%	15,277	29,674	14,397
A12	Moist Interior - Plateau SBSdw3	158,901	12%	19,068	35,258	16,190
A13	Omineca - Valley SBSmk1	367,502	12%	44,100	97,048	52,948
A14	Wet Mountain ESSFmvp2, ESSFwcp3, ESSFmv2, ESSFwk2	148,526	50%	74,263	118,290	44,027
A15	Wet Mountain ESSFwc3	23,659	84%	19,874	17,586	-2,288
A16	Wet Mountain SBSwk1	35,892	26%	9,332	14,834	5,502
A17	Wet Mountain SBSvk	121,691	50%	60,846	85,295	24,450
A18	Wet Trench - Mountain ESSFwcp3	10,496	80%	8,397	8,262	-135
A19	Wet Trench - Mountain ESSFmm1, ESSFmmp1, ESSFmvp2, ESSFmv2, ESSFwk2	69,692	48%	33,452	57,165	23,713
A20	Wet Trench - Mountain ESSFwc3	95,770	80%	76,616	80,086	3,471
A21	Wet Trench - Mountain ESSFwk1	114,230	48%	54,830	66,781	11,951
A22	Wet Trench - Valley ICHwk3	28,060	53%	14,872	17,345	2,473
A23	Wet Trench - Valley ICHvk2	150,776	53%	79,911	91,343	11,431

Unit #	NDU/Merged Biogeoclimatic Units	Total CFLB (ha)	Target (%)	Target (ha)	Current Old (ha)	Surplus/Deficit (ha)
A24	Wet Trench - Valley SBSwk1, SBSmw, SBSmk1	133,175	30%	39,953	35,327	-4,626
A25	Wet Trench - Valley SBSvk	159,766	46%	73,492	71,688	-1,804
E1	Moist Interior Mountain ESSFmv1, ESSFmvp1, ESSFmv3	19,009	41%	7,794	7,546	-248
E2	Moist Interior Plateau SBSdk	27,079	17%	4,603	10,182	5,578
E3	Moist Interior Plateau SBSmc2	61,203	17%	10,405	27,232	16,828
E4	Moist Interior Plateau SBSmk1, SBSwk3	184,815	12%	22,178	45,082	22,904
E5	Moist Interior Plateau SBSdw3	217,536	12%	26,104	73,096	46,992
E6	Northern Boreal Mountains ESSFwvp, ESSFmcp, ESSFmc, ESSFwv	117,446	37%	43,455	96,575	53,120
E7	Northern Boreal Mountains SWB	30,705	37%	11,361	23,863	12,502
E8	Northern Boreal Mountains SBSmc2	36,146	26%	9,398	29,654	20,256
E9	Omineca Mountain ESSFwvp, ESSFwv, ESSFmcp	26,231	58%	15,214	22,511	7,297
E10	Omineca Mountain SWB, ESSFmc	100,800	41%	41,328	84,018	42,690
E11	Omineca Mountain ESSFmvp3, ESSFmv3	378,817	41%	155,315	260,996	105,681
E12	Omineca Valley SBSdk, SBSdw3	10,790	16%	1,726	5,178	3,451
E13	Omineca Valley ICHmc1	13,283	23%	3,055	12,041	8,986
E14	Omineca Valley BWBSdk1	65,031	16%	10,405	42,075	31,670
E15	Omineca Valley SBSmc2	104,809	16%	16,769	76,462	59,693
E16	Omineca Valley SBSmk1	263,704	16%	42,193	113,006	70,813
E17	Omineca Valley SBSwk3	356,256	16%	57,001	200,854	143,853
D1	Moist Interior - Mountain ESSF	134,558	29%	39,022	56,054	17,032
D2	Moist Interior - Plateau SBPSmc	47,031	17%	7,995	21,385	13,390
D3	Moist Interior - Plateau SBSdk	162,084	17%	27,554	48,894	21,340
D4	Moist Interior - Plateau SBSdw2	46,718	12%	5,606	12,518	6,912
D5	Moist Interior - Plateau SBSdw3	197,077	17%	33,503	60,011	26,508
D6	Moist Interior - Plateau SBSmc2, MSxv	237,355	12%	28,483	75,486	47,003
D7	Moist Interior - Plateau SBSmc3	211,412	12%	25,369	68,146	42,776

2.8 Timber Quality Issues

After the MPB-related salvage is completed, most of the harvest will depend on mature stands of non-pine species. Balsam bark beetles have periodically attacked portions of the Fort St. James Resource District. The health of mature non-pine species in the TSA is a concern for the mid-term timber supply.

The timber supply towards the end of the mid-term is predicted to be at least partly dependent on currently young, managed stands. The timing and magnitude of silviculture investments in these immature stands could have significant timber supply impacts. Many of these stands are pine-leading with observed and surveyed MPB infestations. The magnitude and frequency of this attack in young stands is uncertain.

There are also incidents of stem rusts in immature pine. Conartium spp. and Endocronartium spp. and needle blights such as Dothistroma have negative effects on both stand productivity and wood quality of pine. These forest health issues may impact timber supply and merchantability in the mid-term even if the young pine stands survive the current MPB infestation.

3 Modelling Approach

3.1 Model

For this analysis Forest Simulation Optimization System (FSOS) is used for modelling.

FSOS can operate as both a simulation and a heuristic optimization model using the same database. Simulation allows for sensitivity analysis and utilizes a hard constraint-based approach. Optimization is a target-oriented approach representing a shift in modeling approach from "what can we take from the forest" to "what can we create in the forest." Blocking and scheduling is conducted separately in simulation, and simultaneously in optimization. Scheduling in simulation progresses one period at a time, while optimization planning considers all periods at the same time. Data can be spatial and/or non-spatial. FSOS accommodates overlapping resource values and constraints and can account for multiple values such as timber, silvicultural treatments, carbon allocation, biodiversity, wildlife, and visual quality. Algorithms employed in FSOS include simulated annealing, Tabu search algorithms, and Hill Climbing.

3.2 Data Sources

The data and assumptions for this project were downloaded from the Provincial Land and Resource Data Warehouse (LRDW). This base case of this analysis is considered to reflect current management in the Prince George TSA. Table 5 lists all the spatial data layers used in the analysis, with their source and vintage.

Table 5: Spatial Data Sources

Layer Name	Description	Source	Vintage
r1_dist	District boundaries	LRDW (FADM_DIST)	2010
r2_rmz	Resource Management Zones	ILMB LRMP ftp site ftp://ftpprg.env.gov.bc.ca/pub/outgoing/srm/rii/arc/landuse/rmz/ (lzone_dva.zip, qzone_dpg.zip, qzone_dja.zip)	2002
r3_ndu	Natural Disturbance Units	MOFR	2003
r4_abec	Biogeoclimatic Ecosystem Classification	LRDW (BEC_POLY)	2009

Layer Name	Description	Source	Vintage
r5_tsb	Timber Supply Blocks	LRDW (FADM_TSA), modified based on information from Canfor Prince George	2010
r6_lu	Landscape Units	LRDW (RMP_LU_SVW)	2009
r7_plan_cell	Planning Cells	Canfor Prince George	1999
r8_psyu	Public Sustained Yield Units	LRDW (FADM_PSYU)	2010
r9_licop	Licensee Operating Areas	Canfor Prince George	2009
r10_oper	Operability	Canfor Prince George (data initially received for a 2007 project)	2003
r11_uwr	Ungulate Winter Range	LRDW (WCP_UWR_SP)	2010
r12_esa	Environmentally Sensitive Areas	Extracted from old forest cover data	1999
r13_vli	Visual Landscape Inventory	LRDW (REC_VLND)	2010
r14_cws	Community Watersheds	LRDW (COM_WS_PUB)	2010
r15_stab	Terrain Stability Mapping	Canfor Prince George (data initially received for a 2007 project)	2003
r16_wha	Wildlife Habitat Areas	LRDW (WCP_WHAPLY)	2010
r17_ogma	Old Growth Management Areas	LRDW (OGMA_LEG_C, OGMA_NLEGC)	2009
r18_cult	Cultural Heritage Trails	Ministry of Tourism, Culture and the Arts	2010
o1_tltyp	Landtype Classification	Kelly Izzard, Ministry of Forests and Range	2008
o2_parks	Parks and Protected Areas	LRDW (PKS_PTD_AR)	2010

Layer Name	Description	Source	Vintage
o3_resfor	Research Forests	Downloaded from the research forest websites for previous project	?
o4_clp	Crown Land Plan	ILMB	2006
o5_wdlt	Woodlots and Community Forests	LRDW (FTN_MG_L_P)	2010
o6_tfl	Tree Farm License	LRDW (FADM_TFL)	2010
o7_trty8	McLeod Lake Treaty 8	Ministry of Forests and Range, Prince George (received initially for 2007 project)	1997
o8_desig	Designated Areas	Land Use Coordination Office (LUCO), (ltn_pt13_aip_20080214, yekooche_pat13_20071031)	2008
r9_ir	Indian Reserves	LRDW (CLAB_INRES)	2010
	VRI	LRDW (veg_comp_lyr_r1_poly.gdb)	2011
	PEM	Canfor Prince George (initially received for 2009 ERA project)	2008
	Depletions	Licensees and RESULTS	2009
	Roads	Kelly Izzard, Ministry of Forests and Range	2008
	Land Base determination	Barry Snowdon, Ministry of Forests and Range	2008 and 2012

3.2.1 District Boundaries

The district boundaries on LRDW (FADM_DIST) are very slightly different from the district boundaries used for the past several years (TFDS). Most of the change is along the edge of TFL53 in the Prince George district.

3.2.2 Resource Management Zones

The RMZ data has not changed since 2002. However, this data includes parks and TFLs which are separate layers in the resultant. Before adding RMZ layers to the resultant, the park boundaries and TFL boundaries were matched up to avoid creating "sliver" polygons along these boundaries.

3.2.3 Natural Disturbance Units

This data is unchanged from previous projects. The natural disturbance units and ndu/merged-bec units have formed the basis for the biodiversity analysis (LLOWG) completed for the Prince George TSA licensee group over the last several years.

3.2.4 Biogeoclimatic Ecosystem Classification

The provincial BEC dataset was last updated in 2009. Although BEC is included in the PEM data, the PEM does not cover the entire study area, so this provincial BEC layer is used as well. If the two sources of BEC information disagree, the PEM data is used in the analysis.

3.2.5 Supply Blocks

This data is part of the Timber Supply Areas data on LRDW (FADM_TSA). However, in consultation with Frank Ogiamen at Canfor Prince George, problems with the data were discovered. Based on Frank Ogiamen's comments, the supply blocks were modified by removing all planning cells from supply block I and filling missing data in others.

3.2.6 Landscape Units

Landscape units are sometimes used for reporting and/or analysis units. These were included in the resultant. The data was downloaded from LRDW in 2009, and has not changed since then.

3.2.7 Planning Cells

Planning cells are used in the TSR4 resultant to determine economic operability. The spatial data was initially provided by Canfor, however, in February 2012, Barry Snowdon of FLNRO provided the planning cells used in TSR4, including the hauling time for each planning cell.

3.2.8 Public Sustained Yield Units

PSYU data was acquired from LRDW and added in the dataset as a separate layer.

3.2.9 Licensee Operating Areas

This data was provided by Canfor as the most up-to-date version available. There are some areas that are considered too far away to be worth harvesting. They are described as "Existing Volume" in the operating area data.

3.2.10 Operability

Physical Operability data was originally part of the old FC1 forest cover data, and is unchanged.

3.2.11 Ungulate Winter Range

The UWR layer from LRDW was compared spatially with the approved UWR orders on http://www.env.gov.bc.ca/wld/frpa/uwr/approved_uwr.html to ensure that the data on LRDW is the most current. All the spatial boundaries and polygon attributes matched, so the LRDW layer was used in the resultant. A new UWR (u-7-019) was approved in 2010 and was therefore not included in TSR4 or the LRDW layer. This layer was downloaded from the LRDW in March 2012 and added to the resultant.

3.2.12 Environmentally Sensitive Areas

ESA data was originally part of the old FC1 forest cover data, and it is no longer maintained. Where terrain stability mapping does not exist, the ESA soil category is used instead. As there is only limited terrain stability mapping coverage in the Prince George TSA, the ESA data is needed as well.

3.2.13 Visual Landscape Inventory

The most up-to-date VLI data was downloaded from LRDW and used in the preparation of the resultant dataset.

3.2.14 Community Watersheds

There is only one community watershed in the TSA located in the Prince George Resource District.

3.2.15 Terrain Stability Mapping

Terrain stability mapping is available for part of the TSA. There is no existing terrain mapping in Vanderhoof, but approximately 40% of Prince George and Fort St. James have terrain stability mapping. A field called terr_flag was added to the terrain stability layer. This field indicates where terrain mapping is available, so that ESA can be used outside these areas.

3.2.16 Wildlife Habitat Areas

There is only one small polygon of WHA in the Prince George district.

3.2.17 Old Growth Management Areas

OGMAs have been defined in the southern part of the Prince George district. There are both legal (approved) OGMAs and non-legal (proposed) OGMAs. These two layers were combined to make the OGMA layer in the resultant.

3.2.18 Cultural Heritage Trails

Cultural data was received from the Ministry of Tourism, Culture and the Arts, and it contains the heritage trails as well as a lot of small points (buffered). The small points were omitted from the resultant because of size constraints. The trails as received from the MTCA were buffered various amounts. The buffer widths of each trail were calculated using the formula (width = area / (perimeter / 2)). Based on these calculated widths, the trails were buffered to make a total width of 200m, based on information in the TSR4 Data Package. Any trail with a buffer wider than 200m was left as is.

3.2.19 Land Type

Land Type is basically an ownership layer created for TSR4. It was provided to us in December 2009 by Kelly Izzard. For more information on this layer, please consult the TSR4 Data Package.

3.2.20 Parks

The latest version of the Parks and Protected Areas layer was downloaded from LRDW. In comparison with the parks in the Land Type layer, there are few small differences. However, as some of the park area was not classified as park in Land Type, actual park boundaries were added to the dataset get the total park area in the TSA.

3.2.21 Research Forests

Research forests were not incorporated into the TSR4 analysis. However, the research forest boundaries were included in the resultant to facilitate a better understanding of the data.

3.2.22 Crown Land Plan

Crown Land Plan Agricultural Development Areas (ADA) and Settlement Reserve Areas (SRA) are areas that can be harvested once, after which they are removed from the THLB. This data is part of the TSR4 Land Type dataset; however, large areas of ADA and SRA were classified as something else due to overlap issues.

3.2.23 Woodlots and Community Forests

Latest version of woodlot and community forest data was downloaded from LRDW to update the Land Type layer.

3.2.24 Tree Farm Licenses

There are 2 TFLs within the Prince George TSA, TFL30 and TFL53. Note that TFL 42 has been converted to a community forest.

3.2.25 McLeod Lake Treaty 8 Area

Some of the area that used to be Treaty 8 has been reclassified as Indian Reserves. After discussions with John Pousette, Deanna Lask and Stacy Perkins (FLNRO, Prince George), it was determined that the remaining Treaty 8 areas are still considered Treaty 8 and have not been changed.

3.2.26 Designated Areas

Areas designated under part 13 of the *Forest Act* are generally Agreement-in-principal lands, and they are excluded from the CFLB. There are two areas of Part 13 Designated in the Prince George TSA, the L'heidl Tenneh in Prince George District, and the Yekooche in Fort St. James District. The boundaries of these areas were received from the Land Use Coordination Office in March 2010.

3.2.27 Indian Reserves

The most current version of the Federal Indian Reserves dataset was downloaded from LRDW.

3.2.28 Forest Inventory Data

The current forest inventory in the Prince George TSA is a Phase 2 vegetation resource inventory (VRI). The inventory was projected to Jan 1, 2011 by LRDW and phase 2 adjustments were added to the inventory attributes when growth and yield curves were calculated by the MFLNRO.

Depletions to January 2012 were updated from the RESULTS database. In addition licensee depletions to March 31, 2012 were added to the inventory. All the recent fires since year 2000 were also incorporated in the data.

3.2.29 Predictive Ecosystem Mapping (PEM)

Predictive Ecosystem Mapping has been completed for almost the entire TSA: Vanderhoof Resource District in 2004, Prince George and Fort St. James Resource Districts in 2008. These datasets were produced by Timberline, and provided to FESL by Canfor in February 2009.

The size of the study area requires some processing to reduce the polygon count in the resultant. The PEM dataset is large. It was processed to reduce the number of polygons. All non-forested site series were assigned a code of 00. The dataset was then dissolved on site series 1. This reduced the total PEM polygon count from 700,760 to 172,879. However, using only site series 1 may results in a loss of accuracy. To compensate for this, the top three deciles for the new polygons were calculated. Table 6 shows an example of how the new deciles would be calculated when 4 original polygons are combined. In the example, six different site series are represented with the three largest being 01, 03 and 04. Site series 05, 06, and 00 are eliminated.

Table 6: Example of PEM decile calculation

Polygon Id	Area (ha)	Decile 1	Decile 2	Decile 3
Original PEM				
1	25	50% 01	30% 04	20% 05
2	10	40% 01	40% 06	20% 00
3	50	60% 01	40% 03	
4	15	80% 01	10% 05	10% 06
Processed PEM				
1	90	68% 01	23% 03	9% 04

Using this methodology resulted in an overall change in the PEM data of 4.7% from the original. Using only the leading site series would have changed the PEM by 19.3%, which was considered unacceptable.

3.2.30 Depletions

The VRI data from LRDW contains depletions from the RESULTS database up to December 2010. However, FESL has in-house the depletions supplied each year by the licensees as part of the LOWG project, and has also downloaded the RESULTS openings from LRDW. The LOWG depletions are current up to March 2012, and have been verified by the licensees as correct. RESULTS records are current up to January 2012. A comparison between the LOWG, RESULTS and VRI depletions showed that there are significant discrepancies between the three datasets. These discrepancies are spatial as well as tabular (harvest dates).

All depletion datasets were included in the resultant and where date conflicts existed, it was assume that the LOWG dates (received directly from the licensees) are correct.

3.2.31 Roads

TSR4 did a lot of work on cleaning up the roads data in the Prince George TSA. This process is described in the TSR4 Data Package. This data was provided to us on July 16, 2010.

3.2.32 Land Base Definition

The TSR4 land base definition was provided to FESL in February 2012 by Barry Snowdon of FLNRO. The data consisted of spatial VRI polygons, with a percent Crown Forested Land Base (CFLB), Legally Logable Land Base (LLLB), and Timber Harvesting Land Base (THLB) calculated for each polygon. Because of feature id changes between the 2009 and 2011 VRI, it was decided to rate this data into the resultant, rather than link on feature id, to ensure that land base data existed for each resultant polygon.

3.3 Building the Resultant

FESL has developed a standardized methodology for resultant building. We add the various input layers in order from coarsest to finest and use our proprietary software, the Polygon Manipulation Tool (PMT) to clean up slivers. Any important linework is “locked down” in the

PMT so that important information does not get lost. Ownership data (private land, Indian Reserves, park boundaries etc) are always locked down as are datasets with very small polygons.

With a study area as large as the Prince George TSA, the minimum polygon size needs to be selected such that the timber supply modeling using forest estate models is feasible. This must be done without sacrificing data accuracy. At a 0.25 ha minimum polygon size, the resultant dataset contains approximately two million polygons. A maximum polygon count of fewer than one million polygons is desired to successfully run the forest estate model. A minimum polygon size of around 2 hectares achieved this target.

3.4 Age 2012 Calculation

The VRI dataset is projected to 2011 and includes some recent depletions; the licensee submissions from the LOWG project includes depletions up to March 2012; the RESULTS dataset includes depletions up to January 2012. In some cases, the VRI projected age reflects the date of the depletion, however this is not consistent. Based on the date of the air photos used for the inventory, all depletions prior to 1995 were assumed to be accounted for in the existing VRI data. For the purposes of calculating the age in 2012, the regeneration delay for harvested blocks is assumed to be 1 year, with 1-year-old trees planted. The regeneration delay for a wildfire is assumed to be 10 years for natural regeneration.

The following rules were used to update age:

1) For depletions since 1995, calculate expected age (2011-harvest date), and compare with VRI age
2) If VRI age is less than expected age, keep VRI age (may be regeneration delay)
3) If VRI age is greater than expected age, use expected age
4) For burns since 1995, calculate expected age as 2011 – fire year – 10, and repeat steps 2 and 3
5) If VRI age is null and there is a harvest date before 1995, use expected age (2011-harvest date)
6) If VRI age is null, with no harvest date, and polygon is CFLB, assume age = 0
7) For all other records, use VRI age
8) Add 1 year to all records to project to 2012.

3.5 MPB

The latest MPB outbreak projection (BCMPB v.9) was used to model the MPB. In the Prince George TSA more spread is predicted and continuous mortality is forecasted for the next 10 years. This was factored into the analysis.

3.6 Site Index

There are three sources for site index data in the Prince George TSA. These are VRI, RESULTS, and SIBEC. VRI site index was used for all natural stands. For managed stands, RESULTS site index (measured in the field) was used where available; otherwise the SIBEC site index was used. Tables 9, 10 and 11 show a comparison of the average site index in the VRI and SIBEC. Note that SIBEC values were not available for deciduous stands. Note that the RESULTS site index was used only for existing managed stands and where a spatial linkage to the data set could be established.

Table 7: Fort St. James District Average Site Index by Leading Species in the THLB

DJA Site Index Source	Balsam	Deciduous	Douglas Fir	Pine	Spruce
VRI Site Index (used for natural stands)	10.1	16.7	15.6	16.8	14.5
SIBEC Site Index (used for managed stands)	14.5		19.1	19.7	17.8

Table 8: Prince George District Average Site Index by Leading Species in the THLB

DPG Site Index Source	Balsam	Cedar	Deciduous	Douglas Fir	Hemlock	Pine	Spruce
VRI Site Index (used for natural stands)	13.1	9.7	18.6	17.9	13.3	18.4	15.2
SIBEC Site Index (used for managed stands)	19.4	16.8		21.0	19.9	20.6	19.7

Table 9: Vanderhoof District Average Site Index by Leading Species in the THLB

DVA Site Index Source	Balsam	Deciduous	Douglas Fir	Pine	Spruce
VRI Site Index (used for natural stands)	9.5	17.5	16.0	15.1	12.6
SIBEC Site Index (used for managed stands)	13.3		18.8	18.2	17.7

4 Base Case

4.1 Key Assumptions

The following key assumptions are employed in this analysis:

- Silviculture opportunity evaluation is not limited by factors such as the availability of funding, funding source, or the ability to deliver a program. However, the final preferred strategy will be plausible.
- “Normal” market conditions will prevail in terms of demand and prices for timber and fibre.

4.2 Land Base Assumptions

Landbase assumptions define the crown forested land base (CFLB) and timber harvesting land base (THLB). The THLB is designated to support timber harvesting while the CFLB is identified as the broader land base that can contribute toward meeting non-timber objectives (i.e. biodiversity).

The netdown classification is an exclusionary procedure. Once an area has been removed, it cannot be deducted further along in the process. For this reason, the gross area of netdown factors (e.g. inoperable) is often greater than the net area removed; a result of overlapping resource issues.

The classifications of the land base in the Prince George TSA are:

Excluded Land Base (EXLB) — private lands, non-forested areas, and roads are excluded from the CFLB. These areas are excluded because they do not contain forest or are not managed by the Forest Service.

Non-Harvestable Land Base (NHLB) — the portion of the CFLB where harvesting will not occur according to current forest practices. The NHLB includes some areas that are currently not harvestable due to economic considerations, so there is a possibility that some or all of these areas could become harvestable under different economic conditions.

Timber Harvesting Land Base (THLB) — the productive forested land that is harvestable according to current forest practices and legislation.

For this analysis, the land base will be defined using the data provided by Barry Snowdon (see section 3.2.32 above). This ensures that our land base will be as close as possible to the TSR 4 land base area, however, using aspatial percentages to define the land base, as was done in TSR 4, limits the changes that can be made to the land base netdown for modeling scenarios.

The netdown process for defining the land base is described in the TSR4 Technical record and data package (FLNRO 2008, 2011). Table 10 gives the net areas from the TSR4 land base

Table 10: Netdown table from TSR4 Technical Record

	Total Net Area (ha)
Total Area	**7,965,504**
Area based tenures	800,419
Non-forest	1,866,307
Roads, Rail, Transmission lines	56,297
Crown Forested Land Base (CFLB)	**5,242,481**
Parks	332,144
Unstable Terrain	162,149
Problem Forest Types	143,945
Ungulate Winter Range	127,941
Resource Management Zones	16,483
Preservation VQO	1,784
Recreation	4,068
Old Growth Management Areas	15,361
First Nations	24,318
Agricultural Development and Settlement	25,013
Not Economic	939,390
WTPs and Riparian	353,759
Current Timber Harvesting Land Base (THLB)	**3,096,126**

4.2.1 Comparison of land base areas

The total CFLB, LLLB and THLB areas in the TSR 4 technical record versus the datasets received from FLNRO are shown in Table 11. There are some small differences between the areas reported in the technical record and the spatial data received from FLNRO.

Table 11: Land base area summary

	Technical Record[1]		FLNRO Spatial		
	CFLB (ha)	THLB (ha)	CFLB (ha)	LLLB (ha)	THLB (ha)
Fort St James District	2,012,989	978,917	2,011,663	1,524,933	978,427
Prince George District	2,192,863	1,377,451	2,190,590	1,603,116	1,376,151
Vanderhoof District	1,036,629	739,757	1,035,677	804,155	739,214
Entire TSA	**5,242,481**	**3,096,125**	**5,237,930**	**3,932,204**	**3,093,792**

[1] There are no figures for LLLB in the technical record.

4.3 Forest Management Assumptions

Management assumptions define how non-timber values are reflected or addressed in the model and how forest management in the TSA occurs.

4.3.1 Base Case Management Assumptions

Management zones are geographically specific areas that require unique management considerations. Multiple resource issues may be present on the same forest area. The forest estate model FSOS can accommodate multiple overlapping resource layers by establishing target levels for each layer. The model then schedules harvest units that best meet the target levels for all resource layers as a whole.

The assumptions used in the base case model are listed in Table 12, and described in further detail below.

Table 12: Management Assumptions –Base Case

Criteria	Assumption
Visuals	Targets and green-up heights determined based on average slope and visual quality objectives. These limits apply to the CFLB, by scenic polygon.
Ungulate Winter Ranges	Multiple UWR orders apply to the Prince George TSA. The old and young seral targets of the orders apply to the CFLB by UWR polygon.
Seral Stage Targets	Targets for old seral requirements must be met as described in the Landscape Biodiversity Objective Order. These targets apply to the CFLB by NDU/BEC polygons.
Herrick Creek	Old seral and green-up targets were applied to the CFLB within the Prince George LRMP Herrick Creek Old Growth Areas.
Initial Harvest Rate	The initial harvest rate was set at the current AAC for the PGTSA (12.5 million m^3/yr)
Harvest Rule	Relative oldest first, queue by age/minimum harvest age. Priority on MPB-attacked stands. Priority within each district closer to milling facilities. Salvage in Prince George and Vanderhoof first before salvaging in Fort St. James.
Minimum Harvest Criteria	182 m^3/ha on the road portion of the TSA and 246 m^3/ha on the rail portion of the TSA. For managed stands, the minimum harvest age was 95 percent of the culmination age, or the age when the above minimum volume criteria was reached, whichever was greater.
Harvest Quality Objectives	Aim at harvesting managed stands at greater than 300 m^3 per ha.
Silvicultural Systems	Clearcut with reserves

4.3.1.1 Visuals

Visual quality objectives were set-up as described in the TSR 4 Data Package (2008). Each individual scenic area polygon was assigned a maximum allowable alteration and visually effective green-up (VEG) height based on its average slope and visual quality objective. The midpoints of the percent alteration in perspective view are shown in Table 13 for each visual quality objective. Preservation VQO polygons were restricted from harvest. The allowable alteration in plan view used for modelling was determined by multiplying the perspective view alteration by the plan to perspective (P2P) ratio for the slope class of the scenic area (Table 14). For example a partial retention scenic area with an average slope of 22 percent would have a maximum allowable alteration of 4.3 * 3.04 = 13.1 percent and a VEG height of 5 m.

Table 13: VQO percent alteration in perspective view

EVQO_CD	VQO	Permissible % alteration in perspective view	Midpoint % alteration in perspective view
P	Preservation	0	0
R	Retention	0 - 1.5	0.8
PR	Partial retention	1.6 - 7.0	4.3
M	Modification	7.1 - 18.0	12.6
MM	Maxumum modification	18.1 - 30.0	24.1

Table 14: VQO P2P ratios and VEG height by slope class

Slope %	0 - 5	5.1 - 10	10.1 - 15	15.1 - 20	20.1 - 25	25.1 - 30	30.1 - 35	35.1 - 40	40.1 - 45	45.1 - 50	50.1 - 55	55.1 - 60	60.1 - 65	65.1 - 70	70.1 +
P2P ratio	4.68	4.23	3.77	3.41	3.04	2.75	2.45	2.22	1.98	1.79	1.6	1.45	1.29	1.17	1.04
VEG tree height (m)	3	3.5	4	4.5	5	5.5	6	6.5	6.5	7	7.5	8	8.5	8.5	8.5

4.3.1.2 Ungulate Winter Ranges

Ungulate winter range (UWR) orders that apply to the Prince George TSA are summarized in Table 15. Units that were restricted from harvesting were removed from the THLB in the TSR 4 land base classification.

The U-7-019 UWR order was approved in 2010, and not included in the TSR 4 land base classification. This UWR order specifies that no timber harvesting is permitted within the mountain goat winter range and therefore these stands were restricted from harvesting.

The U-7-003, U-7-012 and U-7-13 UWR orders also contain areas that harvesting was not permitted. Due to the TSR 4 land base being rated onto the resultant data, some of these UWR polygons contained some THLB area. These units were also explicitly restricted from harvesting.

Table 15: UWR orders and forest cover objectives

UWR Order	Cover Requirements	Unit Number
U-5-001	The dqu_14 unit has a high stand structure habitat class and is managed with a 200 year rotation and a	dqu_14

UWR Order	Cover Requirements	Unit Number
	40 year return interval. This was modelled with a maximum of 20% of the UWR polygon may be less than 40 years old and a minimum of 20 % must be over 160 years old.	
U-7-002	A minimum of 40% of each UWR polygon must be more than 140 years old.	1, 2, 3, 4, 5, 11, 12, 14
	A minimum of 50% of each UWR polygon must be more than 140 years old.	9, 10, 15, 16, 17, 18
U-7-003	A minimum of 20% of each UWR polygon must be more than 100 years old and a maximum of 20% of each UWR may be less than 3m in height.	P-001, P-004, P-005, P-009, P-013, P-015, P-017, P-018, P-026, P-028, P-029, P-039, P-042, P-044, P-046, P-047, P-050, P-051, P-052, P-059, P-061, P-062, P-063, P-070, P-073, R-003, R-008, R-009, R-010, R-014, R-016, T-005, T-009, T-010, T-012
	A maximum of 30% of the volume of each UWR polygons could be harvested every 80 years. This target was approximated in FSOS by setting two requirements: 1) a maximum of 30%of the area may be younger than 80 years and 2) a minimum of 30% of the area must be more than 160 years old.	R-015, R-017, T-001, T-002, T-004, T-007, T-008, T-011, T-013, T-015, T-017, T-018, T-019
U-7-011	A Minimum of 40% of the UWR must be more than 140 years old.	VD-003, VD-004, VD-007
	A Minimum of 50% of the UWR must be more than 140 years old.	VD-005, VD-006, VD-001, VD-002
U-7-012	The non-terrestrial lichen habitat (NTLH) and terrestrial lichen habitat (TLH) are managed through a two-pass system with a 140 year rotation. Cover requirements were applied to two aggregate areas: Williamson Lake and Johnny Lake. This requirement was modelled by specifying that a maximum of 50% of the aggregate unit could be less than 70 years old.	Williamson Lake NTLH: LE-1-001 Williamson Lake TLH: LE-1-002, LE-1-003, LE-1-004, LE-1-005, LE-1-006, LE-1-007, LE-1-008, LE-1-009 Johnny Lake NTLH: LE-2-001 Johnny Lake TLH: LE-2-011, LE-2-012, LE-2-013, LE-2-014, LE-2-015, LE-2-017, LE-2-018
U-7-013	A Minimum of 40% of each UWR polygon must be more than 140 years old.	PGD-004, PGD-008, PGD-010, PGD-011, PGD-013, PGD-015, PGD-023, PGD-026, PGD-027, PGD-028, PGD-029, PGD-031, PGD-038, PGD-040, PGD-041, PGD-042, PGD-043, PGD-044, PGD-045, PGD-046, PGD-047, PGD-048, PGD-049, PGD-050, PGD-051, PGD-052, PGD-055, PGD-063, PGD-064, PGD-065
	A Minimum of 50% of each UWR polygon must be more than 140 years old.	PGD-001, PGD-002, PGD-012, PGD-014, PGD-019, PGD-020, PGD-021, PGD-022, PGD-035, PGD-054, PGD-066
U-7-015	The non-terrestrial lichen habitat (NTLH) and terrestrial lichen habitat (TLH) are managed through	Upper Omineca NTLH: 9a-001, 9b-001, 9c-001

UWR Order	Cover Requirements	Unit Number
	a two-pass system with a 140 year rotation. Cover requirements were applied to two aggregate areas: Upper Omineca and Mid Omineca West. This requirement was modelled by specifying that a maximum of 50% of the aggregate unit could be less than 70 years old.	Upper Omineca TLH: 9a-002, 9a-003, 9a-004, 9a-005, 9a-006, 9a-007, 9b-002, 9c-002, 9c-003 Mid Omineca West NTLH: 10-001 Mid Omineca West TLH: 10-002, 10-003, 10-004
U-7-019	No harvest permitted	

4.3.1.3 Seral Stage Targets

Landscape level biodiversity was modelled based on the Prince George TSA Biodiversity Order. This specified old forest retention, old interior forest retention and young forest patch size targets by merged biogeoclimatic units. Interior old forest retention and patches will not be modelled in this analysis, but old forest targets will be enforced and are shown in Table 16 for each merged unit.

In addition to old forest targets, there were minimum old forest targets in some units for non-pine leading stands. Since during modelling these targets were applied to only the non-pine leading portion of the unit, the old forest target for the non-pine subset of the unit was calculated as the non-pine old forest target of the entire unit (CFLB Area * percent non-pine leading old forest target) divided by the non-pine CFLB area.

Table 16: Landscape Biodiversity Order objectives for CFLB and non-pine leading CFLB

Unit Label	Min % of CFLB as Old Forest	Age of Old Forest	Min % of CFLB as non-pine Old Forest	CFLB Area (ha)	Non-pine leading CFLB area (ha)	Min % of Non-pine leading CFLB as Old Forest
A1	33	140		7,019	6,072	
A2	26	140		15,879	15,512	
A3	12	120	9	69,240	48,843	12.8
A4	26	140	23	228,676	189,143	27.8
A5	29	140	12	13,995	6,614	25.4
A6	29	140	28	16,391	15,564	29.5
A7	17	120	14	4,226	3,878	15.3
A8	12	120	1	9,218	1,129	8.2
A9	12	120	3	33,409	12,932	7.8
A10	17	120	14	48,445	38,099	17.8
A11	12	120	2	127,310	36,284	7.0
A12	12	120	4	158,901	62,880	10.1
A13	12	120	6	367,502	175,228	12.6
A14	50	140		148,526	147,849	
A15	84	140		23,659	23,639	
A16	26	140		35,892	34,006	
A17	50	140		121,691	116,883	

Unit Label	Min % of CFLB as Old Forest	Age of Old Forest	Min % of CFLB as non-pine Old Forest	CFLB Area (ha)	Non-pine leading CFLB area (ha)	Min % of Non-pine leading CFLB as Old Forest
A18	80	140		10,496	10,404	
A19	48	140		69,692	68,854	
A20	80	140		95,770	94,697	
A21	48	140		114,230	109,296	
A22	53	140		28,060	26,364	
A23	53	140		150,776	143,970	
A24	30	140	27	133,175	107,635	33.4
A25	46	140		159,766	142,635	
E1	41	140	33	19,009	12,555	50.0
E2	17	120	13	27,079	19,848	17.7
E3	17	120	10	61,203	29,261	20.9
E4	12	120	4	184,815	68,039	10.9
E5	12	120	6	217,536	109,617	11.9
E6	37	140		117,446	116,554	
E7	37	140		30,705	21,438	
E8	26	140		36,146	36,061	
E9	58	140		26,231	26,079	
E10	41	140		100,800	93,445	
E11	41	140		378,817	327,369	
E12	16	120	9	10,790	5,572	17.4
E13	23	140		13,283	13,250	
E14	16	120	10	65,031	32,500	20.0
E15	16	120	13	104,809	81,868	16.6
E16	16	120	10	263,704	129,417	20.4
E17	16	120	12	356,256	204,553	20.9
D1	29	140	16	134,558	40,750	52.8
D2	17	120	3	47,031	5,198	27.1
D3	17	120	5	162,084	38,773	20.9
D4	12	120	2	46,718	8,250	11.3
D5	17	120	5	197,077	47,354	20.8
D6	12	120	3	237,355	40,134	17.7
D7	12	120	2	211,412	29,583	14.3

4.3.1.4 Herrick Creek

In the Herrick Creek Old Growth Areas, a minimum of 25% of the CFLB must be older than 120 years, and a maximum of 25% may be less than 3m in height.

4.3.1.5 Initial Harvest Level

The initial harvest rate is 12,500,000 m^3 per year, which equals the current approved AAC. The approach taken in the analysis is to maintain this initial harvest rate as long as possible to facilitate the salvage of the MPB killed pine.

The partitions set up within the AAC determination are incorporated in the analysis. They are:

- A maximum of 3.5 million m^3 of harvest per year is allowed from non-pine species, and non-cedar and non-deciduous leading stands;
- A maximum of 23 000 m^3 of harvest per year is allowed from cedar-leading stands; and
- A maximum of 160 000 m^3 of harvest per year is allowed from deciduous-leading stands in Prince George and Fort St. James Resource Districts.

In addition to the partitions described above the FLNRO expects that a maximum of 875 000 m^3 of harvest comes from spruce-leading stands. This condition was also modeled during the first 5 years of the planning horizon.

The long-term harvest level will be established so that the long-term growing stock remains stable towards the end of the planning horizon.

4.3.1.6 Harvest Priority

In the base case analysis, the older pine leading stands (>= 60% pine, > 60 years old) will have the highest harvest priority to facilitate salvage of MPB impacted stands. As in the TSR 4 analysis, the pine salvage was also ordered by district, with the Prince George and Vanderhoof districts prioritized for salvage before the Fort St. James Resource District.

The TSR 4 myzone priorities were also incorporated for pine and non-pine leading stands. Myzones were a classification by planning cell of how many milling centres timber could be hauled to. The number of milling centres varied from 3 to 0, with areas closer to more mills being given a priority for pine salvage or regular harvesting once the salvage was complete.

After this, a “relative oldest first” harvest rule will be applied to rank stands for harvest. The oldest stands are selected for harvest once they satisfy minimum harvest age or other criteria. Stand selection and scheduling for harvest will also be determined by the forest cover rules that are in place.

4.3.1.7 Minimum Harvest Criteria

Minimum harvest age is the earliest age at which stands become eligible for harvest within the timber supply model. Minimum harvest ages can have a profound effect on harvest levels by creating acute timber supply shortages, or “pinch points”, that constrain the harvest during the planning horizon. In practice, most forest stands are harvested beyond the minimum harvest age due to economic considerations and constraints on harvesting which arise from managing for other forest values.

For the base case analysis, the minimum harvest age for natural stands is the earliest possible age that a forest stand meets 182 m^3/ha on the road portion of the TSA and 246 m^3/ha on the rail portion of the TSA. For managed stands, the minimum harvest age was 95 percent of the culmination age, or the age when the minimum volume criteria were reached, whichever was greater.

4.3.1.8 Silvicultural Systems

All regeneration regimes will be based on clear cutting. In areas where partial harvesting is preferred to manage for non-timber attributes, area retention will be applied as a surrogate for basal area or volume retention in the timber supply.

This silviculture strategy will consider other related strategies and if feasible incorporate components of them in modelling and strategy development.

4.3.1.9 Not Satisfactorily Restocked Areas (NSR)

Current not satisfactorily restocked (NSR) information was acquired from the Silvicultural RESULTS dataset for the Prince George TSA. NSR records are defined as natural, plantable or not plantable.

Table 17 shows the NSR areas for each resource district from RESULTS, broken down by NSR type, and for the plantable NSR, further broken down by reference year. Any NSR from 2007 to 2012 is assumed to be current NSR and accounted for in depletions.

Table 17: NSR areas for each resource district

Resource District	NSR Category	Reference Year	Area (ha)
Fort St. James	NAT		29.2
	NPL		54.2
	PL	pre-1990	43.2
		1990-1999	166.2
		2000-2006	607.7
		2007-2012	16,704.2
Prince George	NAT		801.6
	NPL		1,333.7
	PL	pre-1990	0
		1990-1999	51.9
		2000-2006	4,738.9
		2007-2012	25,406.9
Vanderhoof	NAT		4,335.9
	NPL		84.0
	PL	pre-1990	0
		1990-1999	94.9
		2000-2006	1,781.6
		2007-2012	19,855.2

4.3.1.10 Forest Health

A forest health strategy may recommend actions to prevent future forest health problems and address current ones. The growth and yield assumptions for this analysis account for MPB and balsam bark beetle through the modelling of natural stand yields and the shelf life of the MPB killed timber. The overall harvesting strategy in the TSA is to salvage as much dead pine as possible.

There are incidents of stem rusts in immature pine. Conartium spp. and Endocronartium spp. and needle blights such as Dothistroma have negative effects on both stand productivity and wood quality of pine. These forest health issues impact the timber supply and merchantability of pine stands in the mid-term even if the young pine stands survive the current MPB infestation. This silviculture strategy will promote forest management strategies that will attempt to reduce the incidents of diseases in future stands.

4.3.1.11 Climate Change

There is no climate change strategy for the Prince George TSA yet. While this analysis will not incorporate climate change into modelling directly, climate change will be considered when designing and recommending future silviculture treatments.

4.4 Growth and Yield Assumptions

Growth and yield assumptions define the net volumes that are realized when natural and managed stands are harvested. They also describe various tree and stand attributes over time (i.e., volume, height, diameter, presence of dead trees, etc.).

The growth and yield assumptions used in this analysis are different from those used in TSR4 analysis. However, the primary tools used to create the yields are the same (TIPSY v.4.3, VDYP v.7) as well as the base assumptions for developing the yields (i.e. utilization, decay, waste, breakage, OAFs).

The major differences from TSR 4 were different analysis unit classifications for natural and managed stands and different techniques were used for modelling MPB attack and volume losses. Table 18 summarizes the growth and yield criteria and assumptions used for the Base Case run.

Table 18: Growth and Yield Assumptions – Base Case

Criteria	Assumptions
Analysis Units	All stands were stratified for the purpose of assigning potential treatments and transitions (yield curve post-harvest), and existing natural and managed stands were aggregated to simplify the analysis. See Section 0 for further details on this process.
Stand Projection	VDYP7 was used for natural stands and TIPSY 4.3 for existing and future

Models	managed yield curves
Managed Stand Definition	Stands established between 1987 and 1997 were considered exiting managed, while those established after 1997 were considered future managed stands
Utilization Levels	Sawlog specifications for pine (12.5 dbh) and others (17.5 dbh)
Decay, Waste, and Breakage	VDYP7 default reductions to stand volume for DWB according to BEC Zone
TIPSY OAFs	Applied provincial default and Operational Adjustment Factors (OAF1 - 15%; OAF2 - 5%)
Existing Inventory	Provincially maintained VRI
Site Index Assignments	Inventory site index was used for natural stands. SIBEC and RESULTS SI (where available) was used for existing managed stands, while SIBEC was used for future managed stands.
Volume Reductions	Reductions were made to pine leading stands to account for MPB.
Genetic Gains	TSR4 genetic worth assumptions were applied.
Regeneration Assumptions	Specific assumptions based on leading species, site quality, and licensee practices.
Not satisfactorily restocked (NSR)	Current and backlog NSR were not modeled. All NSR areas were assumed to be stocked with a starting age of 0.
Unsalvaged Losses	An un-salvaged losses representing endemic levels of fire, insect, and wind was assumed (same as TSR4) and removed from the total harvest.
MPB impacted stand yields, Unsalvaged MPB impacted timber, and shelf-life	If not harvested, the dead portion of the stand dropped down to 0 m³/ha after 15 years. The remaining live portion grow on the same yield curve (proportioned) and the regenerating volume (source VDYP7 factored by attack severity %) was added to the post-attack live volume with a 0 year regeneration delay.
Condition of MPB-Impacted Young Stands	Existing managed stands yield curves and natural stands less than 60 years old were factored down based on survey data used in TSR 4.
Balsam Bark Beetle impacted stands	Reductions to balsam leading stands in Fort St. James to account for balsam bark beetle attack were based on survey data used in TSR 4.

4.4.1 Analysis Units

An analysis unit represents forest stands with similar tree species, growth rates and management regimes. As this analysis investigates opportunities to mitigate the mid-term timber supply in the Prince George TSA, it is important that the analysis units are designed in such a way that they facilitate understanding and modeling of potential silvicultural treatment regimes.

Natural and managed yield curves were produced for each analysis unit with the following high level approach:

1. Natural stand analysis units for stands older than 25 years of age were developed using VDYP 7. These analysis units are based on the leading species, site index and yield

curve volume at age 140. Some of these stands may be candidates for late rotation fertilization and rehabilitation (dead pine).

2. Managed stands established between 1987 and 1997 were grouped into analysis units based on BEC label and site series. These stands are potential candidates for fertilization treatments and in some cases spacing treatments. Yield curves for these analysis units were developed using TIPSY.

3. Managed stands established since 1997 and future managed stands were grouped into analysis units based on BEC label and site series. Further stratification may be used to facilitate modelling of silviculture treatments if warranted by existing data. These stands are potential candidates for fertilization treatments and in some cases spacing treatments. Yield curves for these analysis units were developed using TIPSY.

4.4.1.1 Natural Stands

Natural stand analysis units for the Prince George TSA were defined based on leading species, site index, and yield curve volume at age 140.

Table 19 lists the natural stand analysis units, their site indices and volume cut-offs. There were seven leading species groups, two to seven SI groups per species group and two to four volume groups per SI group. Due to their small area, deciduous, Cedar, Fir and Hemlock leading analysis units were subdivided by site index only.

Table 19: Natural Stand Analysis Units in the Prince George TSA

Analysis Unit Base Name	Leading Species	Site Index Range (m)	Volume (age 140) Range (m^3/ha)
Ba_1_low	B, BA, BL, BM, BP	< 6	< 90
Ba_1_high			>= 90
Ba_2_low		>= 6 and < 9	< 70
Ba_2_med			>= 70 and < 160
Ba_2_high			>= 160 and < 250
Ba_2_higher			>= 250
Ba_3_low		>= 9 and < 12	< 150
Ba_3_med			>= 150 and < 260
Ba_3_high			>= 260 and < 350
Ba_3_higher			>= 350
Ba_4_low		>= 12 and < 16	< 200
Ba_4_med			>= 200 and < 320
Ba_4_high			>= 320 and < 410
Ba_4_higher			>= 410
Ba_5_low		>= 16	< 290
Ba_5_med			>= 290 and < 480
Ba_5_high			>= 480
Pl_1_low	P, PA, PL, PLI,	< 11	< 80

Analysis Unit Base Name	Leading Species	Site Index Range (m)	Volume (age 140) Range (m^3/ha)
Pl_1_med	PM		>= 80 and < 150
Pl_1_high			>= 150
Pl_2_low		>= 11 and < 13	< 120
Pl_2_med			>= 120 and < 220
Pl_2_high			>= 220
Pl_3_low		>= 13 and < 15	< 180
Pl_3_med			>= 180 and < 290
Pl_3_high			>= 290
Pl_4_low		>= 15 and < 17	< 230
Pl_4_med			>= 230 and < 340
Pl_4_high			>= 340
Pl_5_low		>= 17 and < 19	< 300
Pl_5_med			>= 300 and < 400
Pl_5_high			>= 400 and < 500
Pl_5_higher			>= 500
Pl_6_low		>= 19	< 350
Pl_6_med			>= 350 and < 470
Pl_6_high			>= 470 and < 540
Pl_6_higher			>= 540
Sx_1_low	S, SB, SE, SS, SW, SX, SXW	< 9	< 90
Sx_1_med			>= 90 and < 230
Sx_1_high			>= 230
Sx_2_low		>= 9 and < 12	< 170
Sx_2_med			>= 170 and < 310
Sx_2_high			>= 310
Sx_3_low		>= 12 and < 15	< 220
Sx_3_med			>= 220 and < 400
Sx_3_high			>= 400
Sx_4_low		>= 15 and < 17	< 170
Sx_4_med			>= 170 and < 260
Sx_4_high			>= 260 and < 450
Sx_4_higher			>= 450
Sx_5_low		>= 17 and < 20	< 280
Sx_5_med			>= 280 and < 440
Sx_5_high			>= 440
Sx_6_low		>= 20 and < 24	< 360
Sx_6_med			>= 360 and < 510
Sx_6_high			>= 510
Sx_7_low		>= 24	< 470
Sx_7_med			>= 470 and < 630
Sx_7_high			>= 630
D_low	AC, ACT, AT, E, EP, QG, W, WS	< 14	All
D_med		>= 14 and < 21	All
D_high		>= 21	All
Cw_low	CW	< 7	All

Analysis Unit Base Name	Leading Species	Site Index Range (m)	Volume (age 140) Range (m^3/ha)
Cw_med		>= 7 and < 12	All
Cw_high		>= 12	All
Fd_poor	FD, FDI, L, LT	< 11	All
Fd_low		>= 11 and < 15	All
Fd_med		>= 15 and < 20	All
Fd_high		>= 20	All
Hw_poor	H, HM, HW	< 16	All
Hw_good		>= 16	All

The analysis units in Table 19 were further subdivided based on the age at death and severity of mountain pine beetle attack. Data from the BCMPB v9 analysis and forecast was used for this process. For attacked stands, the age at death was divided into 5-year increments, starting at age 60. The attack severity was defined based on the maximum percent of the stand that was dead, or predicted to be dead in the future. The five severity classes were defined as follows:

- Class 1: >0-<=25% dead
- Class 2: >25-<=50% dead
- Class 3: >50-<=70% dead
- Class 4: >70-<=90% dead
- Class 5: >90% dead

This process increased the number of natural stand analysis units from 71 to 5,339. An example analysis unit name for an MPB-attacked stand is MPB_Pl_2_med_25-50_80; the stand is pine-leading, with site index between 11 and 13 m and volume at age 140 between 120 and 220 m^3/ha. The MPB attack age at death is 80, and the severity of attack is class 2.

For the NHLB, all stands were classified into analysis units using the species and site index classes as above (volume was not considered). MPB-attacked NHLB stands were further split based on attack severity. Stands with an attack severity of >50% dead (class 3, 4, 5) were grouped together, as were those with a severity <=50% dead (class 1, 2). Growing stock losses due to MPB were not tracked in the NHLB yield curves.

4.4.1.2 Existing Managed and Future Managed Stands

Stands that are currently between 15 and 25 years old (established between 1987 and 1997) are potential candidates for silviculture treatments. Treating these stands can have a positive impact on the mid-term timber supply. Possible treatments include fertilization, juvenile spacing and commercial thinning.

Managed stand analysis units were based on leading PEM site series. Small site series were grouped with similar ecosystem to form analysis units (Table 20). The grouping of ecosystems together resulted in 60 managed analysis units.

Managed analysis units were divided into existing and future managed. Existing managed analysis units were used for stands that regenerated between 1987 and 1997. Future managed analysis units were applied to stands that regenerated after 1997 and all future stands.

Table 20: Managed Analysis Unit Groupings

Analysis Unit Number	Managed Analysis Unit	Site series within Analysis Unit
1	BWBSdk1 01	BWBSdk1 08, BWBSdk1 11, BWBSdk1 09, BWBSdk1 07, BWBSdk1 06, BWBSdk1 05, BWBSdk1 04, BWBSdk1 03, BWBSdk1 02, BWBSdk1 01, BWBSdk1 00, BWBSdk1 10
2	ESSFmv1 01	ESSFmc 00, ESSFmc 08, ESSFmv1 02, ESSFmv1 01, ESSFmv1 00, ESSFmm1 01, ESSFmc 10, ESSFmc 07, ESSFmc 06, ESSFmc 05, ESSFmc 04, ESSFmc 03, ESSFmc 01, ESSFmv1 05, ESSFmc 02
3	ESSFmv1 03	ESSFmv1 03
4	ESSFmv1 04	ESSFmv1 04
5	ESSFmv3 01	ESSFmv3 00, ESSFmv3 01, ESSFmv3 02, ESSFmv3 03, ESSFmv3 04, ESSFmv3 07, ESSFmvp 00, ESSFmvp1 00
6	ESSFwc3 01	ESSFwc3 03, ESSFwcp 00, ESSFwc3 02, ESSFwc3 01, ESSFwc3 00
7	ESSFwk1 01	ESSFwk1 01, ESSFwk1 02, ESSFwk1 03, ESSFwk1 04, ESSFwk1 05, ESSFwk1 06, ESSFwk1 07, ESSFwk1 00
8	ESSFwk2 01	ESSFwk2 06, ESSFxv1 04, ESSFwv 01, ESSFwv 03, ESSFwk2 00, ESSFwk2 04, ESSFwk2 02, ESSFwk2 01, ESSFwk2 05, ESSFxv1 01
9	ICHvk2 01	ICHvk2 05, ICHvk2 06, ICHvk2 04, ICHvk2 03, ICHvk2 02, ICHvk2 00, ICHmc1 05, ICHmc1 04, ICHmc1 01, ICHmc1 03, ICHmc1 02, ICHvk2 01, ICHvk2 07
10	ICHwk3 01	ICHwk3 03, ICHwk3 09, ICHwk3 08, ICHwk3 07, ICHwk3 06, ICHwk3 04, ICHwk3 01, ICHwk3 00, ICHwk3 05
11	ICHwk4 01	ICHwk4 08, ICHwk4 07, ICHwk4 03, ICHwk4 06, ICHwk4 01, ICHwk4 00, ICHwk4 04, ICHwk4 05
12	SBPSdc 01	SBPSdc 00, SBPSdc 01, SBPSdc 04, SBPSdc 05, SBPSdc 07, SBPSdc 08
13	SBPSmc 01	SBPSmc 04, SBPSmk 08, SBPSmk 06, SBPSmk 01, SBPSmc 07, SBPSmc 05, SBPSmc 03, SBPSmc 02, SBPSmc 01, SBPSmc 00, SBPSmc 06
14	SBSdk 01	SBSdk 00, SBSdk 01, SBSdk 02, SBSdk 04, SBSdk 07, SBSdk 08, SBSdk 10
15	SBSdk 01/05	SBSdk SI
16	SBSdk 03	MSxv 08, MSxv 07, MSxv 06, MSxv 04, MSxv 03, MSxv 01, MSxv 00, SBSdk 03

Analysis Unit Number	Managed Analysis Unit	Site series within Analysis Unit
17	SBSdk 05	SBSdk 05
18	SBSdk 06	SBSdk 06
19	SBSdk 09	SBSdk BF, SBSdk 09
20	SBSdw1 01	SBSdw1 01, SBSdw1 09, SBSdw1 08, SBSdw1 07, SBSdw1 00, SBSdw1 04, SBSdw1 03
21	SBSdw2 01	SBSdw2 01, SBSdw2 00, SBSdw2 09, SBSdw2 03, SBSdw2 08, SBSdw2 02, SBSdw2 11, SBSdw2 05, SBSdw2 04, SBSdw2 10
22	SBSdw2 06	SBSdw2 06
23	SBSdw2 07	SBSdw2 07
24	SBSdw3 01	SBSdw3 10, SBSdw3 09, SBSdw3 08, SBSdw3 04, SBSdw3 03, SBSdw3 02, SBSdw3 00, SBSdw3 01
25	SBSdw3 01/04	SBSdw3 SI
26	SBSdw3 05	SBSdw3 05
27	SBSdw3 06	SBSdw3 06
28	SBSdw3 07	SBSdw3 07
29	SBSmc2 01	SBSmc2 12, SBSmc2 11, SBSmc2 09, SBSmc2 07, SBSmc2 00, SBSmc2 04, SBSmc2 01
30	SBSmc2 02	SBSmc2 02
31	SBSmc2 03	SBSmc2 03
32	SBSmc2 05	SBSmc2 05
33	SBSmc2 06/08/10	SBSmc2 06, SBSmc2 08, SBSmc2 10
34	SBSmc3 01	SBSmc3 09, SBSmc3 06, SBSmc3 02, SBSmc3 08, SBSmc3 00, SBSmc3 03, SBSmc3 01
35	SBSmc3 01/05	SBSmc3 SI
36	SBSmc3 04	SBSmc3 04
37	SBSmc3 05	SBSmc3 05
38	SBSmc3 07	SBSmc3 07
39	SBSmh 01	SBSmh 09, SBSmh 07, SBSmh 08, SBSmh 01, SBSmh 04, SBSmh 00, SBSmh 05, SBSmh 06
40	SBSmk1 01	SBSmk1 00, SBSmk1 01, SBSmk1 10
41	SBSmk1 02/03/04	SBSmk1 02, SBSmk1 03, SBSmk1 04
42	SBSmk1 05	SBSmk1 05
43	SBSmk1 06	SBSmk1 06
44	SBSmk1 07	SBSmk1 07
45	SBSmk1 08	SBSmk1 08
46	SBSmk1 09	SBSmk1 09

Analysis Unit Number	Managed Analysis Unit	Site series within Analysis Unit
47	SBSmw 01	SBSmw 07, SBSmw 10, SBSmw 09, SBSmw 08, SBSmw 06, SBSmw 04, SBSmw 03, SBSmw 02, SBSmw 00, SBSmw 01
48	SBSvk 01	SBSvk 07, SBSvk 10, SBSvk 08, SBSvk 03, SBSvk 02, SBSvk 01, SBSvk 00
49	SBSvk 04	SBSvk 04
50	SBSvk 05	SBSvk 05
51	SBSvk 06	SBSvk 06
52	SBSwk1 01	SBSwk1 04, SBSwk1 00, SBSwk1 11, SBSwk1 10, SBSwk1 09, SBSwk1 07, SBSwk1 06, SBSwk1 02, SBSwk1 01
53	SBSwk1 03	SBSwk1 03
54	SBSwk1 05	SBSwk1 05
55	SBSwk1 08	SBSwk1 08
56	SBSwk1 12	SBSwk1 12
57	SBSwk3 01	SBSwk3 05, SBSwk3 08, SBSwk3 06, SBSwk3 03, SBSwk3 02, SBSwk3 00, SBSwk3 01
58	SBSwk3 04	SBSwk3 04
59	SBSwk3 07	SBSwk3 07
60	SBSwk3a 01	SBSwk3a 00, SBSwk3a 01, SBSwk3a 02, SBSwk3a 03, SBSwk3a 04, SBSwk3a 05, SBSwk3a 06, SBSwk3a 07, SBSwk3a 08

4.4.2 Regeneration assumptions

Regeneration assumptions for existing managed and future managed stands were based on queries of the forest cover silviculture and planting data in the RESULTS database. Data summaries were separated for stands harvested between 1987 and 1997 (existing managed) and those harvested after 1997 (future managed). Regeneration assumptions were primarily based on planting records, with the densities and species composition modified if the silviculture data (free growing) was vastly different. Large increases of species over the planted composition were attributed to natural ingress. In cases where the silviculture density was used instead of the planting density, TIPSY was used to estimate the initial density from the silviculture total well spaced density.

Genetic gain was applied to future managed stands based on the TSR 4 regeneration assumptions. The TSR 4 genetic gain information was THLB area weighted by the analysis units used in this analysis.

The regeneration assumptions for the base case analysis are shown in Table 21, for existing managed stands, and Table 22 for future managed stands.

Table 21: Regeneration assumptions for existing managed stands

AU Number	AU Bec	AU Site Series	Site Index	Initial Density	Planted Spp Comp.				Percent Planted	Natural Spp Comp.						Nat. Regen Delay	Percent Natural	OAF1	OAF2
					spc1	pct1	spc2	pct2		Spp1	Pct1	Spp2	Pct2	Spp3	Pct3				
1	BWBSdk1	01	20.8	1545	PL	95	SW	5	99	BL	100					3	1	0.85	0.95
2	ESSFmv1	01	16.0	1663	PL	74	SW	26	93	BL	100					3	7	0.85	0.95
3	ESSFmv1	03	13.1	1655	PL	85	SW	15	95	BL	100					3	5	0.85	0.95
4	ESSFmv1	04	15.1	1505	SW	64	PL	36	91	BL	100					3	9	0.85	0.95
5	ESSFmv3	01	14.5	1515	SW	75	PL	25	86	BL	100					3	14	0.85	0.95
6	ESSFwc3	01	16.6	1100	SW	90	PL	10	87	BL	100					3	13	0.85	0.95
7	ESSFwk1	01	15.1	1608	SW	94	PL	6	87	BL	100					3	13	0.85	0.95
8	ESSFwk2	01	15.4	1515	SW	100			81	BL	100					3	19	0.85	0.95
9	ICHvk2	01	22.4	1586	SW	70	PL	30	85	FDI	73	BL	14	HW	13	3	15	0.85	0.95
10	ICHwk3	01	21.6	1718	SW	85	PL	15	94	FDI	67	BL	33			3	6	0.85	0.95
11	ICHwk4	01	25.1	1200	SW	58	PL	42	91	HW	56	FDI	44			3	9	0.85	0.95
12	SBPSdc	01	15.1	1430	SW	88	PL	12	100									0.85	0.95
13	SBPSmc	01	16.2	1786	PL	97	SW	3	100									0.85	0.95
14	SBSdk	01	19.6	1535	PL	88	SW	12	95	AT	80	FDI	20			3	5	0.85	0.95
15	SBSdk	01/05	19.4	1544	PL	90	SW	10	96	AT	75	FDI	25			3	4	0.85	0.95
16	SBSdk	03	16.9	1580	PL	96	SW	4	99	FDI	100					3	1	0.85	0.95
17	SBSdk	05	19.8	1552	PL	93	SW	7	97	AT	67	FDI	33			3	3	0.85	0.95
18	SBSdk	06	21.9	1380	PL	60	SW	40	91	FDI	89	BL	11			3	9	0.85	0.95
19	SBSdk	09	16.8	1200	PL	50	SW	50	100									0.85	0.95
20	SBSdw1	01	21.8	1570	PL	91	SW	9	88	BL	58	FDI	42			3	12	0.85	0.95
21	SBSdw2	01	19.9	1818	PL	84	SW	16	90	FDI	90	BL	10			3	10	0.85	0.95
22	SBSdw2	06	20.1	1763	PL	94	SW	6	92	FDI	100					3	8	0.85	0.95
23	SBSdw2	07	18.1	1701	PL	90	SW	10	100									0.85	0.95
24	SBSdw3	01	21.2	1633	PL	85	SW	15	92	FDI	75	AT	25			3	8	0.85	0.95
25	SBSdw3	01/04	19.8	1633	PL	85	SW	15	92	FDI	75	AT	25			3	8	0.85	0.95
26	SBSdw3	05	19.4	1683	PL	87	SW	13	99	FDI	100					3	1	0.85	0.95
27	SBSdw3	06	18.1	1612	PL	77	SW	23	99	BL	100					3	1	0.85	0.95
28	SBSdw3	07	22.2	1497	SW	57	PL	43	97	BL	67	FDI	33			3	3	0.85	0.95
29	SBSmc2	01	18.2	1668	PL	77	SW	23	96	BL	75	AT	25			3	4	0.85	0.95
30	SBSmc2	02	16.9	1665	PL	88	SW	12	98	BL	100					3	2	0.85	0.95
31	SBSmc2	03	15.1	1903	PL	99	SW	1	98	BL	100					3	2	0.85	0.95

AU Number	AU Bec	AU Site Series	Site Index	Initial Density	Planted Spp Comp.				Percent Planted	Natural Spp Comp.						Nat. Regen Delay	Percent Natural	OAF1	OAF2
					spc1	pct1	spc2	pct2		Spp1	Pct1	Spp2	Pct2	Spp3	Pct3				
32	SBSmc2	05	19.2	1774	PL	68	SW	32	93	BL	100					3	7	0.85	0.95
33	SBSmc2	06/08/10	19.7	1518	SW	72	PL	28	94	BL	100					3	6	0.85	0.95
34	SBSmc3	01	19.4	1497	PL	89	SW	11	100									0.85	0.95
35	SBSmc3	01/05	18.7	1638	PL	90	SW	10	100									0.85	0.95
36	SBSmc3	04	18.8	1753	PL	96	SW	4	99	SB	100					3	1	0.85	0.95
37	SBSmc3	05	18.0	1779	PL	92	SW	8	100									0.85	0.95
38	SBSmc3	07	19.3	1499	PL	54	SW	46	98	BL	50	SB	50			3	2	0.85	0.95
39	SBSmh	01	19.3	1449	SW	71	PL	29	84	FDI	87	BL	13			3	16	0.85	0.95
40	SBSmk1	01	20.5	1695	PL	63	SW	37	95	BL	80	FDI	20			3	5	0.85	0.95
41	SBSmk1	02/03/04	18.0	1711	PL	93	SW	7	93	FDI	71	BL	29			3	7	0.85	0.95
42	SBSmk1	05	21.2	1732	PL	84	SW	16	93	FDI	57	BL	43			3	7	0.85	0.95
43	SBSmk1	06	18.4	1665	PL	80	SW	20	98	SB	50	BL	50			3	2	0.85	0.95
44	SBSmk1	07	21.1	1572	SW	72	PL	28	96	BL	100					3	4	0.85	0.95
45	SBSmk1	08	22.3	1515	SW	82	PL	18	96	BL	100					3	4	0.85	0.95
46	SBSmk1	09	19.4	1378	SW	81	PL	19	94	BL	100					3	6	0.85	0.95
47	SBSmw	01	22.1	1973	PL	72	SW	28	85	FDI	73	BL	27			3	15	0.85	0.95
48	SBSvk	01	20.0	1398	SW	97	PL	3	95	BL	100					3	5	0.85	0.95
49	SBSvk	04	21.1	1412	SW	89	PL	11	95	BL	100					3	5	0.85	0.95
50	SBSvk	05	19.1	1469	SW	99	PL	1	96	BL	100					3	4	0.85	0.95
51	SBSvk	06	19.2	1295	SW	99	PL	1	95	BL	100					3	5	0.85	0.95
52	SBSwk1	01	21.3	1590	SW	61	PL	39	94	BL	67	FDI	33			3	6	0.85	0.95
53	SBSwk1	03	20.5	1537	PL	71	SW	29	95	FDI	80	BL	20			3	5	0.85	0.95
54	SBSwk1	05	20.5	1786	PL	67	SW	33	85	FDI	67	BL	20	AT	13	3	15	0.85	0.95
55	SBSwk1	08	18.4	1520	SW	87	PL	13	95	BL	80	FDI	20			3	5	0.85	0.95
56	SBSwk1	12	16.1	2086	SW	78	PL	22	78	BL	73	SB	27			3	22	0.85	0.95
57	SBSwk3	01	20.9	1701	PL	58	SW	42	95	BL	100					3	5	0.85	0.95
58	SBSwk3	04	20.3	1727	PL	83	SW	17	94	BL	100					3	6	0.85	0.95
59	SBSwk3	07	22.7	1641	SW	82	PL	18	93	BL	100					3	7	0.85	0.95
60	SBSwk3a	01	16.3	1000	PL	74	SW	26	91	FDI	56	BL	44			3	9	0.85	0.95

Table 22: Regeneration assumption for future managed stands

AU Number	Site Index	Initial Density	Planted Species Composition										Percent Planted	Natural Spp Comp.		Nat. Regen Delay	Percent Natural	OAF1	OAF2
			spc1	pct1	gw1	spc2	pct2	gw2	sp3	pct3	sp4	pct4		Spp1	Pct1				
1	15.4	1300	PL	90	0.78	SW	10	0					100					0.85	0.95
2	15.0	1231	PL	66	1.06	SW	34	9.45					95	BA	100	3	5	0.85	0.95
3	12.0	1340	PL	72	1.05	SW	28	9.26					95	BA	100	3	5	0.85	0.95
4	18.0	1237	PL	54	1.04	SW	46	9.2					95	BA	100	3	5	0.85	0.95
5	12.0	1573	SW	72	13.27	PL	28	0.78					90	BA	100	3	10	0.85	0.95
6	15.0	1200	SW	100	8.88								98	BA	100	3	2	0.85	0.95
7	15.0	1566	SW	98	11.15	PL	2	0.76					85	BA	100	3	15	0.85	0.95
8	15.0	1509	SW	100	12.25								85	BA	100	3	15	0.85	0.95
9	22.8	1327	SW	69	17.58	PL	15	0.76	FD	9	CW	7	98	HW	100	3	2	0.85	0.95
10	22.0	1327	SW	80	15.83	PL	10	0.76	FD	5	CW	5	98	HW	100	3	2	0.85	0.95
11	25.6	1150	SW	90	17.66	PL	10	0.76					95	BA	100	3	5	0.85	0.95
12	20.1	1403	PL	55	1.06	SW	45	18					100					0.85	0.95
13	18.7	1403	PL	98	1.05	SW	2	16.77					100					0.85	0.95
14	19.5	1340	PL	73	0.99	SW	26	17.52	FD	1			100					0.85	0.95
15	19.0	1427	PL	74	1	SW	25	17.51	FD	1			100					0.85	0.95
16	16.2	1377	PL	85	0.98	SW	15	17.46					100					0.85	0.95
17	19.1	1513	PL	75	1.01	SW	25	17.5					100					0.85	0.95
18	21.9	1368	PL	61	0.97	SW	33	17.6	FD	6			100					0.85	0.95
19	12.0	1100	PL	50	1.03	SW	50	17.7					100					0.85	0.95
20	21.8	1415	PL	56	0.76	SW	36	18	FD	8			100					0.85	0.95
21	19.6	1300	PL	65	1.24	SW	25	18	FD	10			100					0.85	0.95
22	19.9	1302	PL	67	1.31	SW	22	0	FD	11			100					0.85	0.95
23	18.0	1266	PL	73	1.28	SW	22	18	FD	5			100					0.85	0.95
24	21.5	1372	PL	67	1.04	SW	27	17.9	FD	6			100					0.85	0.95
25	19.9	1372	PL	67	1.04	SW	27	17.9	FD	6			100					0.85	0.95
26	19.2	1274	PL	78	1.08	SW	21	17.9	FD	1			100					0.85	0.95
27	18.0	1514	PL	68	1.14	SW	29	18	FD	3			100					0.85	0.95
28	21.0	1404	PL	54	1.18	SW	39	17.8	FD	7			95	BA	100	3	5	0.85	0.95
29	17.9	1371	PL	72	1.05	SW	28	16.89					95	BA	100	3	5	0.85	0.95
30	16.2	1282	PL	78	1.06	SW	22	16.8					100					0.85	0.95
31	14.7	1421	PL	82	1.06	SW	18	17.3					100					0.85	0.95

AU Number	Site Index	Initial Density	Planted Species Composition										Percent Planted	Natural Spp Comp.		Nat. Regen Delay	Percent Natural	OAF1	OAF2
			spc1	pct1	gw1	spc2	pct2	gw2	sp3	pct3	sp4	pct4		Spp1	Pct1				
32	19.1	1407	PL	70	1.05	SW	30	16.7					95	BA	100	3	5	0.85	0.95
33	20.0	1350	PL	50	1.06	SW	50	16.66					95	BA	100	3	5	0.85	0.95
34	19.5	1277	PL	80	1.04	SW	20	16.92					100					0.85	0.95
35	19.0	1296	PL	88	1.03	SW	12	17.11					100					0.85	0.95
36	18.3	1432	PL	79	1.04	SW	21	16.8					100					0.85	0.95
37	17.9	1315	PL	88	1.02	SW	12	17.3					100					0.85	0.95
38	19.3	1176	PL	78	1.04	SW	22	17					100					0.85	0.95
39	18.0	1300	SW	50	15.92	FD	50						100					0.85	0.95
40	20.1	1353	PL	50	0.78	SW	48	17.9	FD	2			95	BA	100	3	5	0.85	0.95
41	18.3	1260	PL	80	0.78	SW	15	17.96	FD	5			100					0.85	0.95
42	20.9	1377	PL	66	0.78	SW	32	17.8	FD	2			100					0.85	0.95
43	17.6	1421	PL	74	0.78	SW	24	17.9	FD	1	SB	1	100					0.85	0.95
44	22.6	1441	PL	53	0.78	SW	47	17.8					95	BA	100	3	5	0.85	0.95
45	22.1	1443	SW	76	17.8	PL	23	0.78	FD	1			95	BA	100	3	5	0.85	0.95
46	18.9	1530	SW	74	17.8	PL	26	0					95	BA	100	3	5	0.85	0.95
47	22.4	1393	PL	58	0.93	SW	38	17.7	FD	4			100					0.85	0.95
48	19.7	1546	SW	99	17.9	PL	1	0.77					95	BA	100	3	5	0.85	0.95
49	21.1	1597	SW	98	17.7	FD	2						95	BA	100	3	5	0.85	0.95
50	18.9	1419	SW	100	17.9								95	BA	100	3	5	0.85	0.95
51	18.0	1667	SW	100	17.9								95	BA	100	3	5	0.85	0.95
52	21.1	1461	SW	52	17.9	PL	46	0.77	FD	2			95	BA	100	3	5	0.85	0.95
53	20.4	1401	PL	82	0.78	SW	16	17.8	FD	2			100					0.85	0.95
54	20.4	1445	PL	53	0.78	SW	43	17.9	FD	4			95	BA	100	3	5	0.85	0.95
55	18.0	1535	SW	85	17.9	PL	14	0.77	FD	1			90	BA	100	3	10	0.85	0.95
56	12.0	1413	PL	81	0.78	SW	19	17.9					100					0.85	0.95
57	20.6	1464	PL	55	0.77	SW	45	16.6					95	BA	100	3	5	0.85	0.95
58	20.1	1356	PL	61	0.77	SW	38	16.6	FD	1			95	BA	100	3	5	0.85	0.95
59	22.2	1442	SW	68	16.6	PL	32	0.77					95	BA	100	3	5	0.85	0.95
60	20.6	1464	PL	55	0.78	SW	45	16.82					95	BA	100	3	5	0.85	0.95

4.4.3 Modelling of MPB Impacted Stands 60 Years and Older

Each THLB attacked stand greater than 60 years old at the time of the MPB attack was modelled as shown in Table 23. The year of death is defined as the year when the cumulative kill reaches 50%. If the cumulative kill does not reach 50% by the end of the BCMPB projection (2026), the year of death is the weighted average year of attack for the stand. The percent dead is the pine component of the stand multiplied by the maximum cumulative percent killed from the BCMPB v9 data. The percent live is 100% minus percent dead.

Table 23: MPB attack modelling in the THLB

Severity of Attack	Stand Component	Timing	Yield/Volume Projection
>50% dead	Dead overstory	Adjusted at year of death	VDYP, shelf life of 16 years. Volume remains at 100% for 1 year, falls to 80% at year 2, then drops linearly to 0 at year 16.
	Live overstory	Adjusted at year of death	Total yield times percent live.
	Regeneration	Stand is assumed to break up after shelf life is over. Age reset to 20, 20 years after year of death.	Live overstory volume after MPB attack preserved, new regeneration curve based on VDYP curve. VDYP regeneration curves were multiplied by average % dead, so that the regenerating portion is not overestimated. >50% and <=70% attack stands were considered greened up as soon as they regenerated. Higher attack severity stands (>70%) were considered greened up when their regeneration curve height met green-up requirements.
<=50% dead	Dead overstory	Adjusted at year of death	VDYP, shelf life of 17 years. Volume remains at 100% for 2 years then drops linearly to 0 in 15 years.
	Live overstory	Adjusted at year of death	Total yield times percent live.
	Regeneration	Assume no regeneration	Stand will continue to grow on the live overstory yield curve.

Each stand may have up to three yield curves associated with it:

- ***yield** curve for dead timber (percent dead * VDYP volume) that remains static for 1 year, falls to 80% at year 2, then drops linearly to 0 m³/ha at year 16. This volume is lost if it is not harvested before the total volume per ha falls below the minimum harvest volume.*
- ***post-attack live curve** ((100% minus percent dead)*VDYP volume (all MPB attacked stands).*
- ***regeneration curve** (original VDYP curve * percent dead); this curve starts at age zero at the year of death.*

These three curves were added together to make the composite curve for the stand, then the curves for all stands within each analysis unit were averaged to make the final curves used in the model.

Figure 9 provides an example of how both a post-attack dead volume yield curve, post-attack live curve and a regenerating curve were derived from an original VDYP yield curve, then combined.

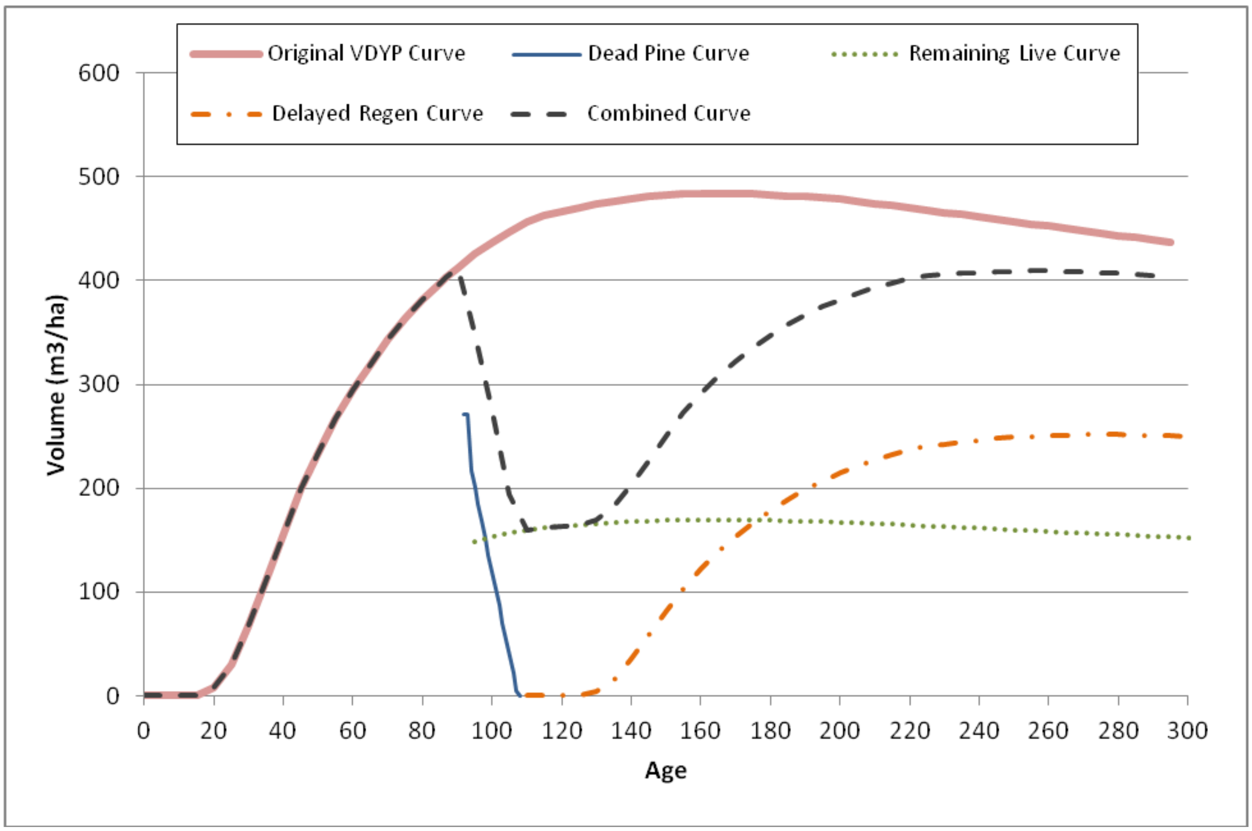

Figure 9: Example of how MPB stand yield curves were generated: pine-leading stand, 65% dead at age 92, no advanced regeneration

In the NHLB, MPB attacked stands with more than 50% dead were assigned to break up 20 years after the year of death and regenerate on the same natural curve with a 5 year regeneration delay. Stands with less than 50% dead were not set to break up; rather they were assumed to continue growing. Growing stock losses due to MPB were not tracked in the NHLB.

4.4.3.1 Shelf Life

The merchantability of beetle-killed wood remains an important uncertainty in timber supply analyses. The status quo shelf life assumptions in most timber supply analyses to date have assumed 100% retention of merchantability for 15 years, after which the volume is no longer usable.

In this analysis shelf life is defined as the time a stand remains economically viable for sawlog harvesting. The shelf life starts when more than 50% of the stand is predicted to be dead. This analysis assumes that a time period of 16 years is required from the average time of death until the stand becomes entirely un-merchantable (the dead volume or a portion of it exists for 15 years). The merchantability is assumed remain at 100% for one year, then decline to 80% after two years and then decline in a linear fashion to 0 at year 16 as shown in

Figure 10. This approach is consistent with other on-going Type 4 silviculture strategies. The shelf life for other product types may be longer; however, it is not modeled in this analysis.

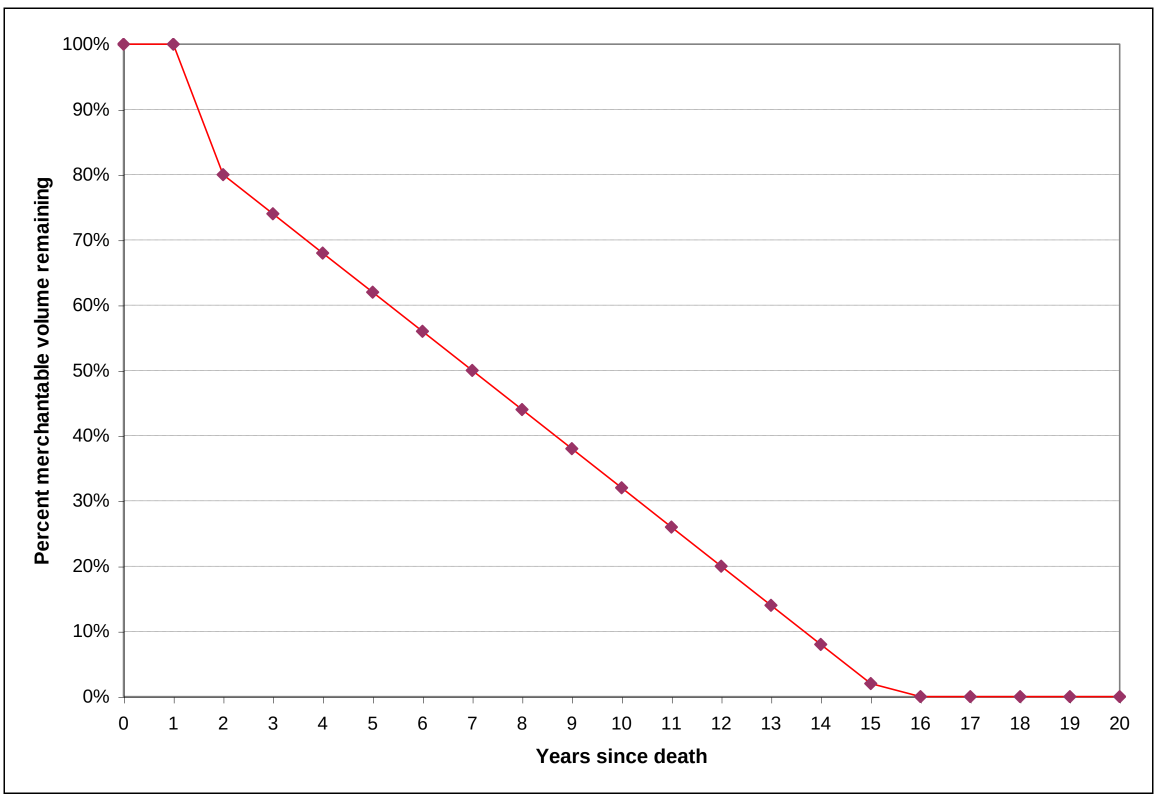

Figure 10: Shelf life for dead pine sawlogs

4.4.3.2 Minimum harvest volume of MPB Impacted stands

The minimum harvest criteria in this analysis are 182 m^3 per ha in the road portion of the TSA and 246 m^3 per ha in the rail portion. The same criteria apply to the MPB impacted stands: unless the sum of live and dead volume is 182 m^3 (or 246 m^3 in the rail area) or more per ha, the stand will not get harvested. Note that the shelf life assumptions in the analysis reduce the merchantable dead volume to zero in 16 years after death. As a result, some stands may be eligible for harvest at the very beginning of the planning horizon but not in 10 years. On the other hand, the regenerating structure and the remaining live trees may reach the minimum harvest criteria over time, and the stand may again become eligible for harvesting.

4.4.3.3 MPB impact in young pine stands (<60 years old)

Data on the MPB attack in young stands were collected in the Prince George TSA for use in the TSR 4 analysis (2008 TSR 4 Data Package). The survey attack data was applied to pine leading stands between 15 and 60 years old by resource district and landscape unit for age class 1 to 3 stands as shown in Table 24. The total percent attack was used to reduce the pine growth and yield in each of the listed age classes and landscape units. As an example, in the Fort St James Resource District, age class 2 pine yield for all age class 2 pine stands was reduced by 14%.

Table 24: Young pine attack estimates by district and landscape unit

Resource District	Landscape Unit	Age Class	Total Percent Attack
Fort St. James	Pinchi	1	5
	Pinchi	2	14
	Pinchi	3	2
	Salmon	1	8
	Salmon	2	14
	Salmon	3	27
	Stuart	1	42
	Stuart	2	4
	Tezzeron	2	1
	Tezzeron	3	24
	Whitefish	1	0.5
	Whitefish	2	6
	Whitefish	3	0.3
Prince George	Bill's	2	67
	Bowron	2	38
	Captain	2	70
	Crooked	2	37
	Crooked	3	75
	Gleason	2	65
	Gregg	1	0
	Gregg	2	58
	Grizzly	2	33
	Haggen	2	17

Resource District	Landscape Unit	Age Class	Total Percent Attack
	Mollie	2	27
	Mud	2	37
	Mud	3	60
	Nechako	2	58
	Nechako	3	60
	Prince	2	40
	Punchaw	2	35
	Punchaw	3	5
	Purden	2	52
	Purden	3	8
	Slender	2	54
	Slender	3	90
	Stony	2	28
	Willow	2	58
	Willow	3	60
Vanderhoof	Blackwater	3	0
	Chilako	2	18
	Chilako	3	17
	Cluculz	2	53
	Cluculz	3	29
	Endako	2	0
	Endako	3	53
	Entiako	3	9.6
	Halett	2	60
	Halett	3	35
	Kluskus	2	0
	Lucas	2	44
	Lucas	3	54.5
	Nechako	2	53
	Nithi	2	0
	Nithi	3	4.2
	Stuart	2	59
	Sutherland	2	0
	Tachick	2	89
	Tachick	3	0
	Tatelkuz	3	15.6

The application of the attack data impacted 131,768 ha young pine stands (THLB) as shown below in Table 25.

Table 25: Young pine attack areas

Resource District	Total Young Pine THLB Area (ha)	Young Pine with Attack THLB Area (ha)	Average Attack Percent
Fort St. James	56,493	28,770	11.9%
Prince George	112,782	67,858	42.1%
Vanderhoof	84,108	35,140	39.3%

4.4.4 Balsam Bark Beetle and Spruce Budworm in the Fort St. James Resource District

Balsam bark beetle and spruce budworm have caused stand mortality and loss of merchantable volume in balsam stands in supply blocks A and B. Data was collected in 2007 to quantify the extent of the mortality and used in TSR 4 analysis (2008 TSR 4 Data Package). The mortality was grouped into 3 severity classes: low, medium and high.

The balsam mortality data used in TSR 4 was obtained from the MFLNRO and applied to natural balsam leading stands in Fort St. James. The areas that the TSR 4 data applied to and the volume reductions are shown in Table 26.

Table 26: Balsam morality areas

Severity Class	THLB Area (ha)	Reduction to Stand Volume
Low	68,609	24%
Medium	13,531	38%
High	3,363	39%

4.4.5 Site Index

Inventory site index was used for all natural stands established prior to 1987. Existing managed stands used RESULTS site indices where available and SIBEC site indices otherwise. Future managed stands used SIBEC site indices.

4.4.6 Stand Projection Models

The variable density yield prediction (Batch VDYP 7.7a.33) model developed by the MFLNRO was used for estimating the timber volumes of natural stands. The yield curves were prepared for each VRI polygon using phase 2 adjusted values as inputs. Average yield curves for natural stands were produced by THLB area weighting of the input curves for each analysis unit. Separate sets of natural yield curves were produced for the NHLB and THLB portions of the TSA.

The table interpolation program for stand yields (BatchTIPSY, 4.3), developed by the MFLNRO, Research Branch was used to estimate timber volumes for existing and future managed stands. The regeneration assumptions described above were used as inputs to the model along with the site indices, forest inventory zone (FIZ), BEC zone, and utilization level for polygons within each analysis unit. Species that differ from the unit they were planted on (i.e. planting spruce in a pine analysis unit) had their site index converted based on the equations presented in the SiteTools 3.3 help file Site Index Conversion page (if a conversion is available). Average yield curves for each analysis unit were produced by area weighting all of the curves within an analysis unit by THLB area.

4.4.7 Utilization Levels

For the Prince George TSA, the utilization standards from the TSR analyses will be applied for stump heights, minimum top diameters and minimum diameter at breast height (dbh) (Table 27). These utilization levels will be used when calculating both natural and managed stand yield curves. As in the TSR 4, the small pine utilization was not modelled.

Table 27: Utilization levels for the Prince George TSA

Species	Minimum diameter @ stump outside bark (cm)	Translated minimum DBH outside bark (cm)	Maximum stump height (cm)	Minimum top diameter inside bark (cm)
Pine	15	12.5	30	10
Cedar > 140 years old	20	17.5	30	15
All other species	20	17.5	30	10
Small pine in supply block D	10	7.5	15	10

4.4.8 Decay, Waste, and Breakage

For natural stands, default reductions to stand volume for decay, waste and breakage were applied to the VDYP7 model according to BEC Zone. Reductions for decay, waste and breakage are also incorporated in the TIPSY model for managed stands as operational adjustment factors that affect both the magnitude and the shape of the yield curve.

4.5 Natural Disturbance Assumptions

4.5.1 Non-Harvestable Land Base

Natural disturbance mechanisms such as fire, insects, disease, and wind activities are constantly happening (seasonally) throughout the Prince George TSA. These events could be thought of as small, common events and extreme, significant events. The common events may occur regularly as relatively small disturbances throughout a stand or landscape. Extreme significant events can be very catastrophic and affect the landscape significantly.

A disturbance function was employed in the analysis to prevent the contributing, non-timber harvesting land base from continually aging and providing a disproportionate and often improbable amount of old forest cover conditions to satisfy landscape biodiversity requirements.

In the Prince George TSA, natural disturbance will be considered only in the non-harvestable land base by applying succession using annual disturbance rates for each merged biogeoclimatic as per Table 28. Disturbed stands regenerate onto natural yield curves with no regeneration delay. The natural disturbance rates are those provided by Craig Delong in 2006.

Table 28: Annual Disturbance Rates

Merged Biogeoclimatic Unit	Disturbance Rate (% of forest/yr)
A1 Boreal Foothills - Mountain ESSFmv2	0.2%
A2 McGregor Plateau ESSFwk2	0.05%
A3 McGregor Plateau SBS mk1	0.2%
A4 McGregor Plateau SBS wk1	0.2%
A5 Omineca - Mountain ESSFmv3	0.2%
A6 Moist Interior - Mountain ESSFwk 1	0.0%
A7 Moist Interior - Plateau SBS mh	0.4%
A8 Moist Interior - Plateau SBS mc 2	0.4%
A9 Moist Interior - Plateau SBS mw	0.4%
A10 Moist Interior - Plateau SBS wk 1	0.4%
A11 Moist Interior - Plateau SBS dw 2	0.4%
A12 Moist Interior - Plateau SBS dw 3	0.4%
A13 Omineca - Valley SBS mk 1	0.3%
A14 Wet Mountain ESSFwk 2	0.0%
A15 Wet Mountain ESSFwc 3	0.0%
A16 Wet Mountain SBS wk 1	0.05%
A17 Wet Mountain SBS vk	0.05%
A18 Wet Trench - Mountain ESSFwcp	0.0%
A19 Wet Trench - Mountain ESSFwk 2	0.0%
A20 Wet Trench - Mountain ESSFwc 3	0.0%
A21 Wet Trench - Mountain ESSFwk 1	0.0%
A22 Wet Trench - Valley ICH wk 3	0.05%
A23 Wet Trench - Valley ICH vk 2	0.05%
A24 Wet Trench - Valley SBS wk 1	0.05%
A25 Wet Trench - Valley SBS vk	0.05%
D1 Moist Interior - Mountain ESSFmv 1	0.1%
D2 Moist Interior - Plateau SBPSmc	0.4%
D3 Moist Interior - Plateau SBS dk	0.4%
D4 Moist Interior - Plateau SBS dw 2	0.4%
D5 Moist Interior - Plateau SBS dw 3	0.4%
D6 Moist Interior - Plateau SBS mc 2	0.4%
D7 Moist Interior - Plateau SBS mc 3	0.4%
E1 Moist Interior - Mountain ESSFmv 1	0.1%
E2 Moist Interior - Plateau SBS dk	0.4%
E3 Moist Interior - Plateau SBS mc 2	0.4%
E4 Moist Interior - Plateau SBS mk 1	0.4%

Merged Biogeoclimatic Unit	Disturbance Rate (% of forest/yr)
E5 Moist Interior - Plateau SBS dw 3	0.4%
E6 Northern Boreal Mountains ESSFmc	0.2%
E7 Northern Boreal Mountains SWB mk	0.2%
E8 Northern Boreal Mountains SBS mc 2	0.2%
E9 Omineca - Mountain ESSFwv	0.0%
E10 Omineca - Mountain ESSFmc	0.2%
E11 Omineca - Mountain ESSFmv 3	0.2%
E12 Omineca - Valley SBS dk	0.3%
E13 Omineca - Valley ICH mc 1	0.2%
E14 Omineca - Valley BWBSdk 1	0.3%
E15 Omineca - Valley SBS mc 2	0.3%
E16 Omineca - Valley SBS mk 1	0.3%
E17 Omineca - Valley SBS wk 3	0.2%

4.5.2 Timber Harvesting Land Base, Non-Recoverable Losses

Unsalvaged losses result from natural events that are epidemic in origin. The primary unsalvaged epidemic losses in the Prince George TSA are from insect infestations, windthrow and fire. Table 29 lists the losses, based on TSR 4 data. The table reflects only volumes that will not be recovered or salvaged.

Table 29: Unsalvaged losses for the Prince George TSA

District	Timber harvesting land base losses (m^3/year) until 2015	Timber harvesting land base losses (m^3/year) after 2015
Fort St. James	96,098	29,741
Vanderhoof	194,627	72,442
Prince George	517,101	290,813
Total	**807,827**	**392,997**

5 Forest Level Silviculture Strategies for Exploration

The strategies that could be employed to improve the timber supply in the Prince George TSA were discussed at the workshop in June 2013 with the district licensees and staff. The discussed strategies are presented below and were explored in this analysis. Some of them were investigated through scenario analysis while others were examined through stand level analysis and operational experience.

The following strategies were explored in this analysis:

1. Assessment of quality and health of managed stands that will be relied on to support the midterm

   This strategy does not provide immediate help in dealing with the mid-term timber supply, however it is crucial for understanding the condition and the growth and yield potential of the existing managed stands that are predicted to form a significant part of the late mid-term timber supply. This strategy will also assist in understanding what improvements may be needed in basic reforestation for establishing productive, resilient future managed stands.

2. Fertilization, single and multiple treatments

   The workshop participants expressed the need to investigate the fertilization potential in the Prince George TSA fully. It was felt that a large fertilization program – if feasible - was required to improve the mid term.

3. Rehabilitating MPB-Attacked Stands

   Many MPB attacked stands have lost so much of their merchantable volume that they are not economical to harvest and will remain in the landscape. These stands are a potential fire hazard and drag to the timber supply. Rehabilitating these stands will likely have a positive impact on the timber supply. The positive impacts will extend to fire hazard abatement and watershed recovery as well.

4. Enhanced basic reforestation

   Improving basic reforestation in the TSA was rated high as a silviculture strategy with the TSA stakeholder group. This strategy is expected to impact mostly the long term timber supply producing more resilient stands within higher yields. This strategy also presents the complementary benefit of producing more high quality logs and improving the economic returns from harvesting. The volume responses and financial returns from potential fertilization treatments are also increased. Furthermore, stands with higher initial densities tend to be better candidates for density management treatments.

5. Expanding the economically operable land base by constructing infrastructure to access currently inaccessible areas.

The stakeholder group felt that substantial silviculture investments may be necessary to improve the mid-term timber supply. As an alternative to silviculture investments, it was suggested that investments to improve access to those areas of the TSA that are not currently economically harvestable be investigated.

6. Exploring the utilization of smaller piece sizes for a portion of the timber supply

   While the stakeholder group agreed that the late mid-term timber supply of existing managed stands (and future managed stands) should not be dependent on small piece sizes, it was considered reasonable that some portion of the harvest would come from stands with a smaller per ha volume that that in the base case.

7. Harvest scheduling

   While not a silviculture strategy, harvest scheduling may impact the mid-term timber supply significantly and reveal previously unexplored management issues. The impact of harvest scheduling was investigated in this analysis.

5.1 Fertilization

Single fertilization treatments can be applied in existing stands. Often best returns are achieved if the fertilized stands are harvested approximately 10 years after treatment. The population of candidate stands is limited by their location, structure, health and site index.

Multiple fertilization treatments can be applied to existing and future stands to improve their growth rates. These treatments, if recommended, will likely focus on existing managed stands, as the focus of this analysis and strategy is to provide direction for silviculture investments within the next 10 years.

The following types of stands were fertilized in the different scenarios:

- Fertilize natural stands, current ages 26 to 60
- Fertilize existing managed stands, current ages 16 to 25
- Fertilize current future managed stands, current ages <=15

Fertilization treatments were not applied to UWR areas or VQO PR or R areas.

Fertilization cost was assumed to be $600.00 per ha and the fertilization response was assumed to be standard TIPSY response (Table 30) in managed stands (stands that were modeled with TIPSY). The response in natural stands was assumed to be 10 m^3 per ha per treatment.

Table 30: Standard approximated Tipsy fertilization response

Application Age	Pine Response (gross m^3 per ha)	Spruce Response
25	17	17
35	17	19
45	15	21
55	15	19

5.1.1 Fertilization of Young Natural Stands

Natural stands between the ages of 26 and 60 years old are candidates for fertilization. Six higher productivity Douglas-fir and Spruce natural analysis units (Fd_med, Fd_high, Sx_5_med, Sx_5_high, Sx_6_med, and Sx_6_high) where chosen as candidates for fertilization.

The fertilization regimes were:

- Ages 26 to 35, treated at ages 35, 45, and 55: 33,350 ha
- Ages 36 to 45, treated at ages 45 and 55: 7,796 ha
- Ages 46 to 55, treated at age 55: 5,777 ha
- Ages 56 to 60, treated at age 60: 1,140 ha

Each fertilization treatment was assumed to result in a 10 m^3/ha increase in stand volume, beginning 10 years after the application of fertilizer. Table 31 shows the candidate stand areas by stand type and Table 32 shows the candidate areas by resource district.

Table 31: Fertilization population areas by stand type; young natural stands

Natural Analysis Unit	Leading Species	Site Index Range	Area (ha)
Fd_high	Douglas Fir	>=20	805
Fd_med	Douglas Fir	>=15 and <20	1,635
Sx_5_med	Spruce	>=17 and <20	30,105
Sx_5_high	Spruce	>=17 and <20	2,822
Sx_6_med	Spruce	>=20 and <24	9,631
Sx_6_high	Spruce	>=20 and <24	3,066

Table 32: Fertilization population areas by resource district; young natural stands

Fertilization Population	Fort St. James (ha)	Prince George (ha)	Vanderhoof (ha)	Total (ha)
Young Natural Stands	4,910	42,256	897	48,063

The minimum harvest volumes for the fertilized natural stands were the same as for the base case natural stands: 182 m^3/ha for road areas and 246 m^3/ha for rail areas.

5.1.2 Fertilization of Existing Managed Stands

Existing managed stands between the ages of 16 and 25 are candidates for fertilization. Managed analysis units 9-11, 14-18, 20-22, 24-27, 29-30, 32, 34-37, 39-43, 47-55, and 57-59 were identified as candidates. This resulted in 215,758 ha available for fertilization. The candidate areas by analysis unit area are shown in Table 33, while Table 34 shows the same by resource district.

Table 33: Candidate analysis units for fertilization; current stand age 16 to 25

Analysis Unit #	Managed Analysis Unit	Site Index	Leading Species	Area (ha)
9	ICHvk2_01	22.4	Spruce	3,538
10	ICHwk3_01	21.6	Spruce	1,984
11	ICHwk4_01	25.1	Spruce	2,394
14	SBSdk_01	19.6	Pine	2,133
15	SBSdk_01/05	19.4	Pine	1,678
16	SBSdk_03	16.9	Pine	191
17	SBSdk_05	19.8	Pine	505
18	SBSdk_06	21.9	Pine	467
20	SBSdw1_01	21.8	Pine	102
21	SBSdw2_01	19.9	Pine	10,007
22	SBSdw2_06	20.1	Pine	2,053
24	SBSdw3_01	21.2	Pine	16,618
25	SBSdw3_01/04	19.8	Pine	8,698
26	SBSdw3_05	19.4	Pine	578
27	SBSdw3_06	18.1	Pine	1,042
29	SBSmc2_01	18.2	Pine	13,240
30	SBSmc2_02	16.9	Pine	331
32	SBSmc2_05	19.2	Pine	677
34	SBSmc3_01	19.4	Pine	5,370
35	SBSmc3_01/05	18.7	Pine	600
36	SBSmc3_04	18.8	Pine	707
37	SBSmc3_05	18.0	Pine	2,781
39	SBSmh_01	19.3	Spruce	2
40	SBSmk1_01	20.5	Pine	54,713
41	SBSmk1_02/03/04	18.0	Pine	779

Analysis Unit #	Managed Analysis Unit	Site Index	Leading Species	Area (ha)
42	SBSmk1_05	21.2	Pine	6,379
43	SBSmk1_06	18.4	Pine	1,118
47	SBSmw_01	22.1	Pine	3,274
48	SBSvk_01	20.0	Spruce	16,140
49	SBSvk_04	21.1	Spruce	2,218
50	SBSvk_05	19.1	Spruce	1,061
51	SBSvk_06	19.2	Spruce	329
52	SBSwk1_01	21.3	Spruce	34,872
53	SBSwk1_03	20.5	Pine	2,481
54	SBSwk1_05	20.5	Pine	1,237
55	SBSwk1_08	18.4	Spruce	1,509
57	SBSwk3_01	20.9	Pine	8,300
58	SBSwk3_04	20.3	Pine	4,896
59	SBSwk3_07	22.7	Spruce	757
	Total			**215,758**

Table 34: Fertilization population areas byresource district; existing managed stands (16 to 25 years old)

Fertilization Population	Fort St. James (ha)	Prince George (ha)	Vanderhoof (ha)	Total (ha)
Existing Managed Stands	51,370	128,553	35,836	215,758

Stands were treated at age 25, 35, 45, and 55 using the default fertilization responses for TIPSY.

Minimum harvest volumes for the fertilized stands were set to the minimum harvest volumes of the base case existing managed curves, which were based on the culmination age of the curves.

5.1.3 Fertilization of All Managed Stands

Existing future managed stands between the ages of 0 and 15 year were added as candidates for fertilization to the scenario 2 population. The total candidate area is 399,773 ha. Table 35 shows the candidate areas by analysis unit. The split by district is shown in Table 36.

Table 35: Candidate analysis units for fertilization; current stand age 0 to 60

Analysis Unit #	Managed Analysis Unit	Site Index	Leading Species	Area (ha)
Stands 16 to 25 years old				
9	ICHvk2_01	22.4	Spruce	3,538

Analysis Unit #	Managed Analysis Unit	Site Index	Leading Species	Area (ha)
10	ICHwk3_01	21.6	Spruce	1,984
11	ICHwk4_01	25.1	Spruce	2,394
14	SBSdk_01	19.6	Pine	2,133
15	SBSdk_01/05	19.4	Pine	1,678
16	SBSdk_03	16.9	Pine	191
17	SBSdk_05	19.8	Pine	505
18	SBSdk_06	21.9	Pine	467
20	SBSdw1_01	21.8	Pine	102
21	SBSdw2_01	19.9	Pine	10,007
22	SBSdw2_06	20.1	Pine	2,053
24	SBSdw3_01	21.2	Pine	16,618
25	SBSdw3_01/04	19.8	Pine	8,698
26	SBSdw3_05	19.4	Pine	578
27	SBSdw3_06	18.1	Pine	1,042
29	SBSmc2_01	18.2	Pine	13,240
30	SBSmc2_02	16.9	Pine	331
32	SBSmc2_05	19.2	Pine	677
34	SBSmc3_01	19.4	Pine	5,370
35	SBSmc3_01/05	18.7	Pine	600
36	SBSmc3_04	18.8	Pine	707
37	SBSmc3_05	18.0	Pine	2,781
39	SBSmh_01	19.3	Spruce	2
40	SBSmk1_01	20.5	Pine	54,713
41	SBSmk1_02/03/04	18.0	Pine	779
42	SBSmk1_05	21.2	Pine	6,379
43	SBSmk1_06	18.4	Pine	1,118
47	SBSmw_01	22.1	Pine	3,274
48	SBSvk_01	20.0	Spruce	16,140
49	SBSvk_04	21.1	Spruce	2,218
50	SBSvk_05	19.1	Spruce	1,061
51	SBSvk_06	19.2	Spruce	329
52	SBSwk1_01	21.3	Spruce	34,872
53	SBSwk1_03	20.5	Pine	2,481
54	SBSwk1_05	20.5	Pine	1,237
55	SBSwk1_08	18.4	Spruce	1,509
57	SBSwk3_01	20.9	Pine	8,300

Analysis Unit #	Managed Analysis Unit	Site Index	Leading Species	Area (ha)
58	SBSwk3_04	20.3	Pine	4,896
59	SBSwk3_07	22.7	Spruce	757
	Sub-Total			**215,758**
		Stands 0 to 15 years old		
9	ICHvk2_01	22.8	Spruce	2,193
10	ICHwk3_01	22.0	Spruce	930
11	ICHwk4_01	25.6	Spruce	922
14	SBSdk_01	19.5	Pine	11,220
15	SBSdk_01/05	19.0	Pine	9,202
16	SBSdk_03	16.2	Pine	2,024
17	SBSdk_05	19.1	Pine	4,035
18	SBSdk_06	21.9	Pine	2,930
20	SBSdw1_01	21.8	Pine	489
21	SBSdw2_01	19.6	Pine	31,025
22	SBSdw2_06	19.9	Pine	8,797
24	SBSdw3_01	21.5	Pine	45,565
25	SBSdw3_01/04	19.9	Pine	26,746
26	SBSdw3_05	19.2	Pine	5,535
27	SBSdw3_06	18.0	Pine	3,482
29	SBSmc2_01	17.9	Pine	42,955
30	SBSmc2_02	16.2	Pine	2,240
32	SBSmc2_05	19.1	Pine	3,038
34	SBSmc3_01	19.5	Pine	16,762
35	SBSmc3_01/05	19.0	Pine	1,764
36	SBSmc3_04	18.3	Pine	3,845
37	SBSmc3_05	17.9	Pine	8,117
40	SBSmk1_01	20.1	Pine	76,149
41	SBSmk1_02/03/04	18.3	Pine	2,451
42	SBSmk1_05	20.9	Pine	10,315
43	SBSmk1_06	17.6	Pine	6,183
47	SBSmw_01	22.4	Pine	10,859
48	SBSvk_01	19.7	Spruce	10,153
49	SBSvk_04	21.1	Spruce	352
50	SBSvk_05	18.9	Spruce	754
51	SBSvk_06	18.0	Spruce	488
52	SBSwk1_01	21.1	Spruce	22,834

Analysis Unit #	Managed Analysis Unit	Site Index	Leading Species	Area (ha)
53	SBSwk1_03	20.4	Pine	2,440
54	SBSwk1_05	20.4	Pine	944
55	SBSwk1_08	18.0	Spruce	592
57	SBSwk3_01	20.6	Pine	14,407
58	SBSwk3_04	20.1	Pine	6,204
59	SBSwk3_07	22.2	Spruce	833
	Subtotal			**399,773**
	Total			**615,531**

Table 36: Fertilization population areas by resource district; managed stands (0 to 25 years old)

Fertilization Population	Fort St. James (ha)	Prince George (ha)	Vanderhoof (ha)	Total (ha)
Existing Managed Stands (16-25 years old)	51,370	128,553	35,836	215,758
Current Future Managed Stands (0-15 years old)	86,448	177,545	135,780	399,773
Total	**137,818**	**306,098**	**171,616**	**615,531**

As in scenario 2, stands were treated at ages 25, 35, 45, and 55.

Minimum harvest volumes for the fertilized stands were set to the minimum harvest volumes of the base case existing managed stand curves.

5.1.4 Scenario 4

All possible stands <= 60 years old were fertilized. This adds the natural scenario 1 population to the managed scenario 3 population of stands. The total candidate population for this scenario was 663,594 ha (Table 37).

Table 37: Fertilization population areas by resource district

Fertilization Population	Fort St. James (ha)	Prince George (ha)	Vanderhoof (ha)	Total (ha)
Young Natural Stands	4,910	42,256	897	48,063
Existing Managed Stands	51,370	128,553	35,836	215,758
Current Future Managed Stands	86,448	177,545	135,780	399,773
Total	**142,728**	**348,354**	**172,513**	**663,594**

5.2 Rehabilitating MPB-Attacked Stands

It is likely that many MPB attacked stands have lost so much of their merchantable volume that they are not economical to harvest and will remain in the landscape. These stands are a potential fire hazard and drag to the timber supply. Rehabilitating these stands will likely have a positive impact on the timber supply. The positive impacts will extend to fire hazard abatement and watershed recovery as well.

The challenge in the analysis is to define the candidate stand population, as it is difficult to determine which stands may not be salvaged by the TSA licensees.

5.2.1 Rehabilitation Only

Stands that remained unharvested in the timber supply model due lost dead pine volume were used as a starting point. This population was further reduced by removing stands with < 70% dead pine as the residual volumes in these stands can contribute to the timber supply later in the midterm.

This left 282,888 ha of pine stands that were set to be rehabilitated in the model. This population represents an upper limit to the area available for rehabilitation and in practice candidate areas would be further reduced based on criteria such as site productivity and access.

All rehabilitation was set to take place within the first 5 years of the planning horizon at the cost of $2,000 per ha.

5.2.2 Rehabilitation and Fertilization

In addition to rehabilitating the stands, a scenario was also run to fertilize the rehabilitated stands in the hopes of making them merchantable sooner. The population of stands to rehabilitate was the same as in scenario 1. The stands were treated at ages 25, 35, 45, and 55 using the TIPSY default fertilization responses. The fertilization cost was assumed to be $600 per ha.

5.3 Enhanced Basic Silviculture Scenarios

Two scenarios were completed; the first scenario increased the planting density to 1700 stems per hectare while the second scenario also fertilized these stands at ages 25, 35, 45, and 55. The treatment area was the same in both scenarios.

5.3.1 Enhanced Basic Silviculture

This scenario investigated the impact of increasing planting densities for all future stands. A portion of the future managed stands were planted with a higher density of trees. The candidate site types cover approximately 77% of the total THLB and are shown in Table 38. Table 39 shows the treatment area by resource district. The enhanced reforestation costs are assumed to be $0.57/tree.

Table 38: Enhanced basic silviculture areas by analysis unit (ha)

AU Number	AU Bec	AU Site Series	Site Index	Initial Density	Enhanced Density	Road Area (ha)	Rail Area (ha)
2	ESSFmv1	01	15.0	1231	1700	63,562	948
3	ESSFmv1	03	12.0	1340	1700	21,146	
4	ESSFmv1	04	18.0	1237	1700	11,623	
5	ESSFmv3	01	12.0	1573	1700	93,506	445
6	ESSFwc3	01	15.0	1200	1700	1,353	
7	ESSFwk1	01	15.0	1566	1700	59,883	
8	ESSFwk2	01	15.0	1509	1700	8,779	8
9	ICHvk2	01	22.8	1327	1700	44,965	166
10	ICHwk3	01	22.0	1327	1700	11,794	
11	ICHwk4	01	25.6	1150	1700	16,809	
12	SBPSdc	01	20.1	1403	1700	1,678	
13	SBPSmc	01	18.7	1403	1700	2,432	
14	SBSdk	01	19.5	1340	1700	37,519	
15	SBSdk	01/05	19.0	1427	1700	28,652	
17	SBSdk	05	19.1	1513	1700	12,704	
18	SBSdk	06	21.9	1368	1700	14,515	
21	SBSdw2	01	19.6	1300	1700	86,439	
22	SBSdw2	06	19.9	1302	1700	18,021	
23	SBSdw2	07	18.0	1266	1700	17,038	
24	SBSdw3	01	21.5	1372	1700	229,895	
25	SBSdw3	01/04	19.9	1372	1700	94,521	
26	SBSdw3	05	19.2	1274	1700	27,311	
27	SBSdw3	06	18.0	1514	1700	13,486	
28	SBSdw3	07	21.0	1404	1700	23,718	
29	SBSmc2	01	17.9	1371	1700	150,938	30,084
32	SBSmc2	05	19.1	1407	1700	10,871	732
34	SBSmc3	01	19.5	1277	1700	63,870	
35	SBSmc3	01/05	19.0	1296	1700	12,302	
36	SBSmc3	04	18.3	1432	1700	13,202	
37	SBSmc3	05	17.9	1315	1700	39,209	
38	SBSmc3	07	19.3	1176	1700	8,107	
40	SBSmk1	01	20.1	1353	1700	430,907	
42	SBSmk1	05	20.9	1377	1700	72,447	
44	SBSmk1	07	22.6	1441	1700	27,883	
47	SBSmw	01	22.4	1393	1700	34,292	

AU Number	AU Bec	AU Site Series	Site Index	Initial Density	Enhanced Density	Road Area (ha)	Rail Area (ha)
50	SBSvk	05	18.9	1419	1700	17,624	
52	SBSwk1	01	21.1	1461	1700	286,748	
53	SBSwk1	03	20.4	1401	1700	23,151	
54	SBSwk1	05	20.4	1445	1700	17,484	
57	SBSwk3	01	20.6	1464	1700	128,829	2,856
58	SBSwk3	04	20.1	1356	1700	49,165	1,228
59	SBSwk3	07	22.2	1442	1700	15,165	540
Total						**2,343,543**	**37,008**

Table 39: Enhanced basic silviculture areas (ha) within each resource district

Scenario	Fort St. James	Prince George	Vanderhoof	Total
Enhanced Reforestation	799,075	982,591	598,884	2,380,550

5.3.2 Enhanced Basic Silviculture with Fertilization

In this scenario a subset of the enhanced stands were also fertilized at ages 25, 35, 45, and 55. The treatment areas are shown in Table 40. The fertilization cost was assumed to be $600.00 per ha.

The minimum harvest volume for the enhanced silviculture yield curves was set to the minimum harvest volume of the base case future managed stand yield curves; this is the volume the base case yield curves achieved at 95% of the mai culmination age.

Table 40: The fertilized enhanced basic silviculture areas by analysis unit (ha)

AU Number	AU Bec	AU Site Series	Site Index	Initial Density	Enhanced Density	Road Area (ha)	Rail Area (ha)
9	ICHvk2	01	22.8	1327	1700	44,965	166
10	ICHwk3	01	22	1327	1700	11,794	
11	ICHwk4	01	25.6	1150	1700	16,809	
14	SBSdk	01	19.5	1340	1700	37,519	
15	SBSdk	01/05	19	1427	1700	28,652	
17	SBSdk	05	19.1	1513	1700	12,704	
18	SBSdk	06	21.9	1368	1700	14,515	
21	SBSdw2	01	19.6	1300	1700	86,439	
22	SBSdw2	06	19.9	1302	1700	18,021	

AU Number	AU Bec	AU Site Series	Site Index	Initial Density	Enhanced Density	Road Area (ha)	Rail Area (ha)
24	SBSdw3	01	21.5	1372	1700	229,895	
25	SBSdw3	01/04	19.9	1372	1700	94,521	
26	SBSdw3	05	19.2	1274	1700	27,311	
27	SBSdw3	06	18	1514	1700	13,486	
29	SBSmc2	01	17.9	1371	1700	150,938	30,084
32	SBSmc2	05	19.1	1407	1700	10,871	732
34	SBSmc3	01	19.5	1277	1700	63,870	
35	SBSmc3	01/05	19	1296	1700	12,302	
36	SBSmc3	04	18.3	1432	1700	13,202	
37	SBSmc3	05	17.9	1315	1700	39,209	
40	SBSmk1	01	20.1	1353	1700	430,907	
42	SBSmk1	05	20.9	1377	1700	72,447	
47	SBSmw	01	22.4	1393	1700	34,292	
50	SBSvk	05	18.9	1419	1700	17,624	
52	SBSwk1	01	21.1	1461	1700	286,748	
53	SBSwk1	03	20.4	1401	1700	23,151	
54	SBSwk1	05	20.4	1445	1700	17,484	
57	SBSwk3	01	20.6	1464	1700	128,829	2,856
58	SBSwk3	04	20.1	1356	1700	49,165	1,228
59	SBSwk3	07	22.2	1442	1700	15,165	540
Total						**2,002,835**	**35,606**

5.4 Expanding the economically operable land base by constructing infrastructure to access currently inaccessible areas

The stakeholder group felt that as an alternative to silviculture investments, investments to improve access to those areas of the TSA that are not currently economically harvestable be investigated. In the base case, areas that never reached a minimum harvest volume or were too far away were considered not economic.

The last TSR and the base case of this analysis used the combination of minimum harvest volume per hectare and cycle time for log haul as the criterion for economically available harvest. As a result, 939,390 ha of otherwise productive forest were removed from the timber harvesting land base as uneconomical to harvest. The maximum cycle times used were 7.7 hours for road haul and 3.9 hours for rail. The minimum harvest volumes were 182 m^3 per ha for road haul areas and 246 m^3 per ha for rail areas correspondingly.

A scenario was constructed with the assumption that improving the infrastructure (road building) would allow acceptable cycle times to parts of supply block A in Fort St. James, therefore increasing the THLB. Areas within supply block A that met the minimum harvest volume for the rail area with current cycle times greater than 3.9 and less than or equal to 5 hours were switched from NHLB to THLB. The increased THLB was 24,502 ha. The costs for this scenario are unknown and were not modeled.

5.5 Combination of treatments

The final or preferred silviculture strategy will be a combination of various treatments and strategies. It will be developed together with the Prince George TSA stakeholder group.

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