Type 4 Silviculture Strategy

Draft Modelling and Analysis Report – Prince George TSA

Version 2.11

Draft

Prepared by:
Forest Ecosystem Solutions Ltd
227 – 998 Harbourside Drive
North Vancouver, BC
V7P 3T2
604-998-2222
amakitalo@forestecosystem.ca

Prepared for:

BC Ministry of Forests, Lands and Natural Resource Operations
Resource Practices Branch
PO Box 9513 Stn Prov Govt
Victoria, BC V8W 9C2

Table of Contents

List of Figures

List of Tables

1 Introduction

This document is the third of four documents that make up a type IV Silviculture Strategy, the documents are:

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

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

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

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

1.1 Analysis 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.

A type 4 analysis is not timber supply review (TSR). This is an important point when interpreting any of the analysis results. The type 4 analysis, while projecting timber supply, establishes a base line against which silviculture investment scenarios are compared. Analysis assumptions used in this analysis are detailed in the Data Package (FESL, 2013), one of the documents that make up the Type 4 Silviculture Strategy.

While we attempted to ensure that most of the analysis assumptions in this analysis are consistent with those used in the latest formal TSR, differences exist. Most notable are the mountain pine beetle related assumptions dealing with the merchantability of beetle killed timber, i.e. shelf life. The shelf life assumptions are discussed in detail in the data package with some discussion also included in this document.

In this analysis all unharvested stands with more than 50% mortality were assumed to breakup and continued growing using the age of the new regeneration as a new start age. This method of modelling constrains the timber supply in those areas where green-up requirements or seral stage requirements are limiting factors on timber supply.

The latest TSR included spatial elements in the modelling of timber supply; minimum block sizes were incorporated in the Base Case. This analysis did not attempt to form blocks, nor did it enforce block size minimums or maximums.

2 Base Case

2.1 Model Output

2.1.1 Harvest Forecast

Figure 1 illustrates the Type 4 Base Case harvest forecast. The initial harvest level of 12.4 million m^3 per year is maintained for 5 years. At year 6 the harvest is brought down to 6.3 million m^3 per year where it stays until year 50. The harvest can be increased to 8.6 million m^3 between years 51 and 55, and to 9.8 million m^3 between years 55 and 125. The long-term harvest level (LTHL) of 10.7 million m^3 per year is reached at year 126.

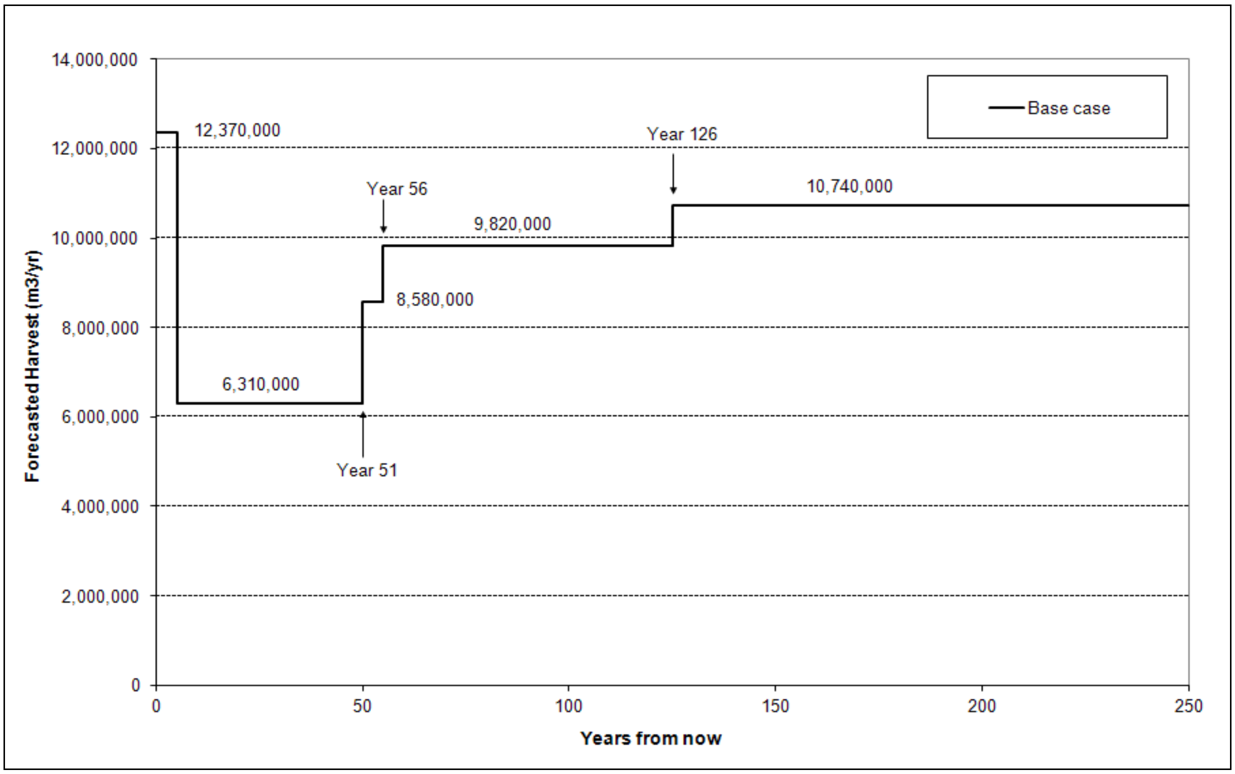


Figure 1: Harvest forecast; Base Case

Figure 2 shows the growing stock levels in the Base Case. The stability of the growing stock in the long run is an indicator of sustainable harvest.

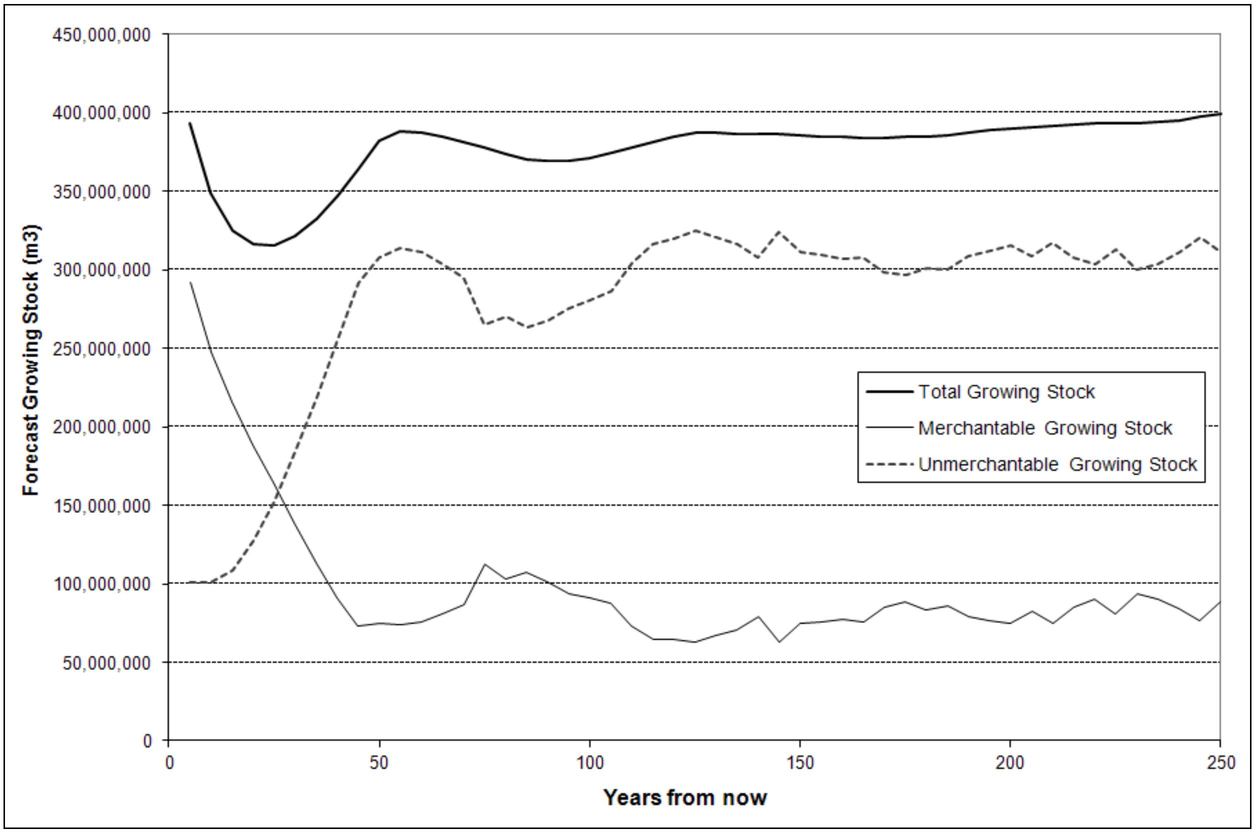


Figure 2: Predicted growing stock; Base Case

Figure 3 shows the volume of harvest by species. Almost all the dead pine is harvested in the first 5 years of the model, with a small amount harvested between years 6 and 10.

Figure 4 illustrates the harvest forecast by yield type. We divided the output into 6 classes: High severity MPB attacked (>50% dead), low severity MPB attacked (<=50% dead), natural (no MPB attack), MPB attacked regen, existing managed, and future managed. Note that while only 33% of the first 5 years harvest is dead pine, 96% of that harvest is MPB attacked stands (50% of which is high severity attack stands). The other species shown in Figure 3 for years 1-5 are mostly the live component of the MPB-attacked stands.

The category MPB attacked regen includes both the live overstory that remains after the pine has broken up, and the new regeneration. The harvest of these stands begins at year 41, with the majority of harvest occurring in years 71-75.

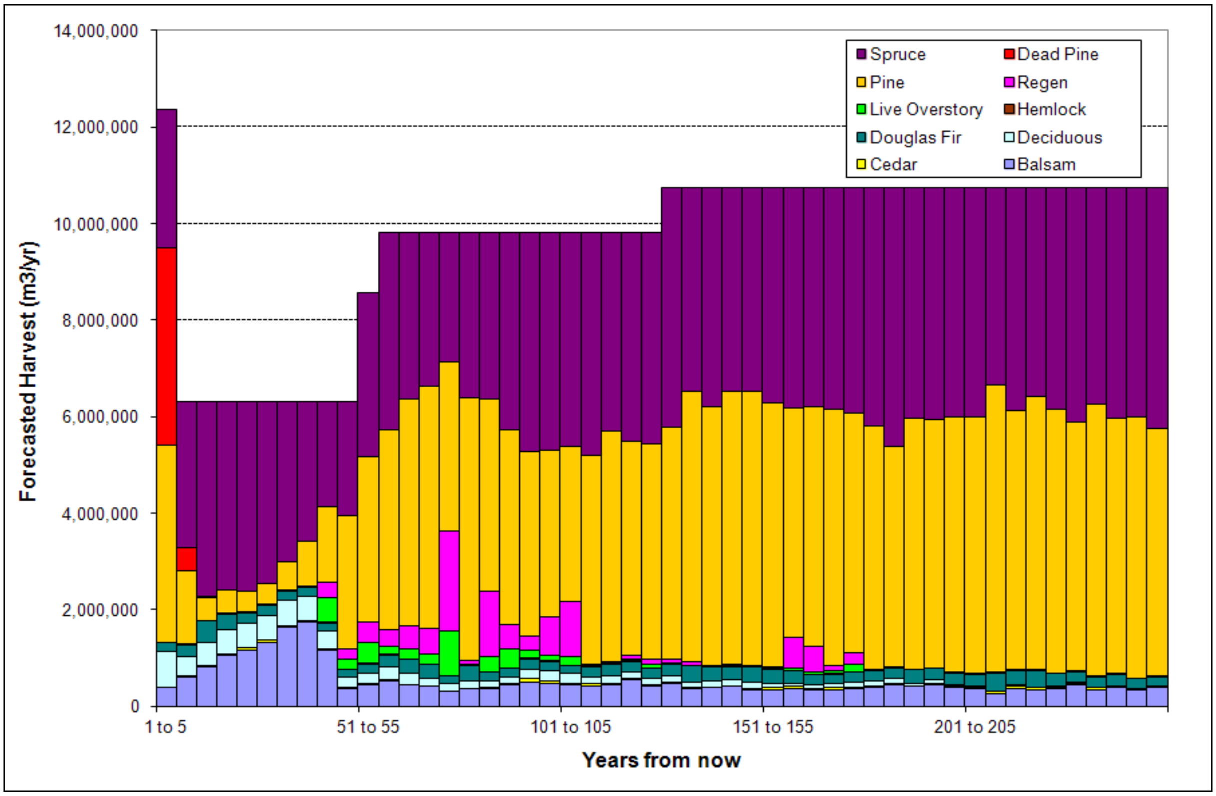


Figure 3: Harvest forecast by species; Base Case

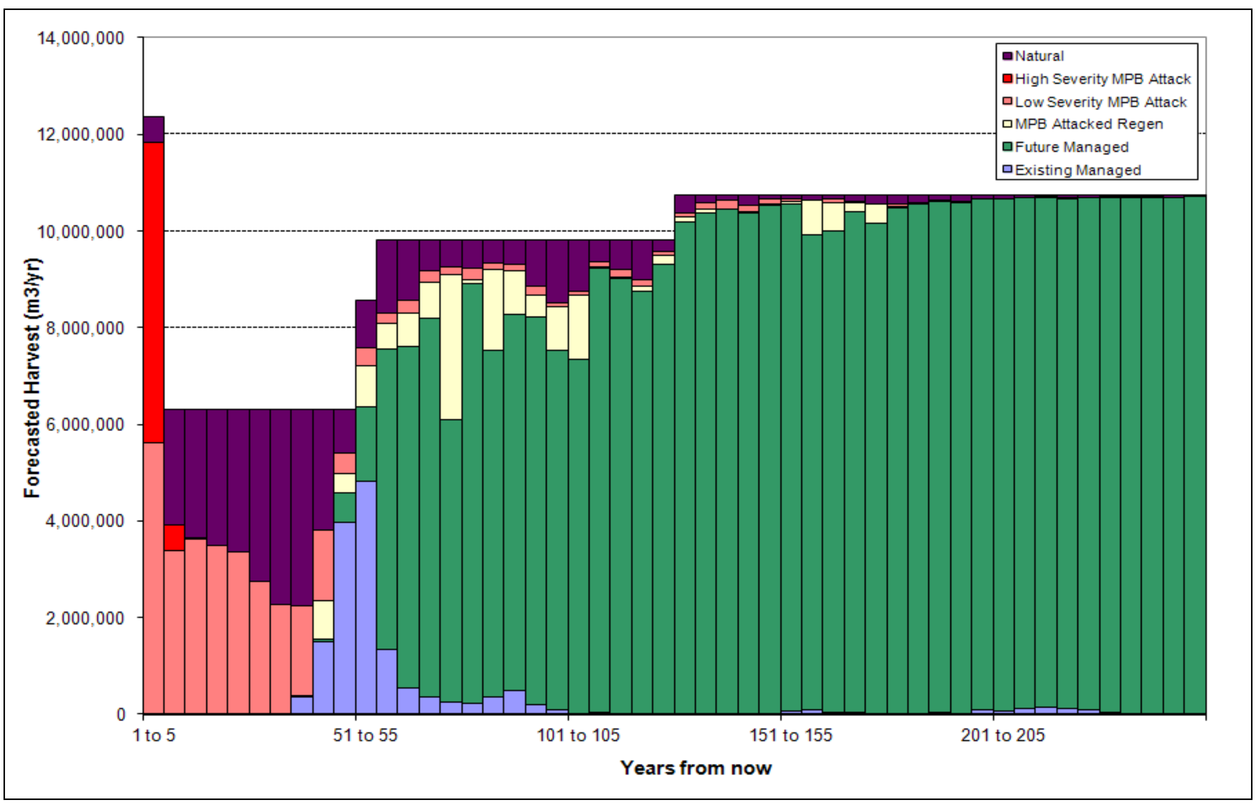


Figure 4: Harvest forecast by yield type; Base Case

Large areas of the Prince George TSA are affected by MPB attack as shown in Table 1. Slightly less than a quarter of the high severity stands are harvested in the model before the shelf life makes them unmerchantable. The high severity attack stands are set to break-up and regenerate naturally. These regenerated stands are composed of the surviving live overstory and the new regeneration. Most of these stands will eventually reach the minimum harvest volume and be harvested (these are the MPB Attacked Regen stands in Figure 4). Low severity stands do not break-up in the model; many of these stands have enough remaining volume that even after all the pine volume decreases to zero the stands can eventually be harvested. Figure 5 shows the location of the stands that breakup in the model. Most of the breakup occurs in the Vanderhoof Natural Resource District.

Table 1: MPB Attack and harvest; reference population is stands 60 or older in 2012

Attack Severity	THLB Area (ha)	Percent Harvested before breakup	Percent breakup	Percent Harvested after regeneration	Percent Never Harvested
Low (<= 50 % stand dead)	749,640	74%			26%
High (> 50% stand dead)	566,245	23%	77%	69%	8%
Total	1,315,885	52%			18%

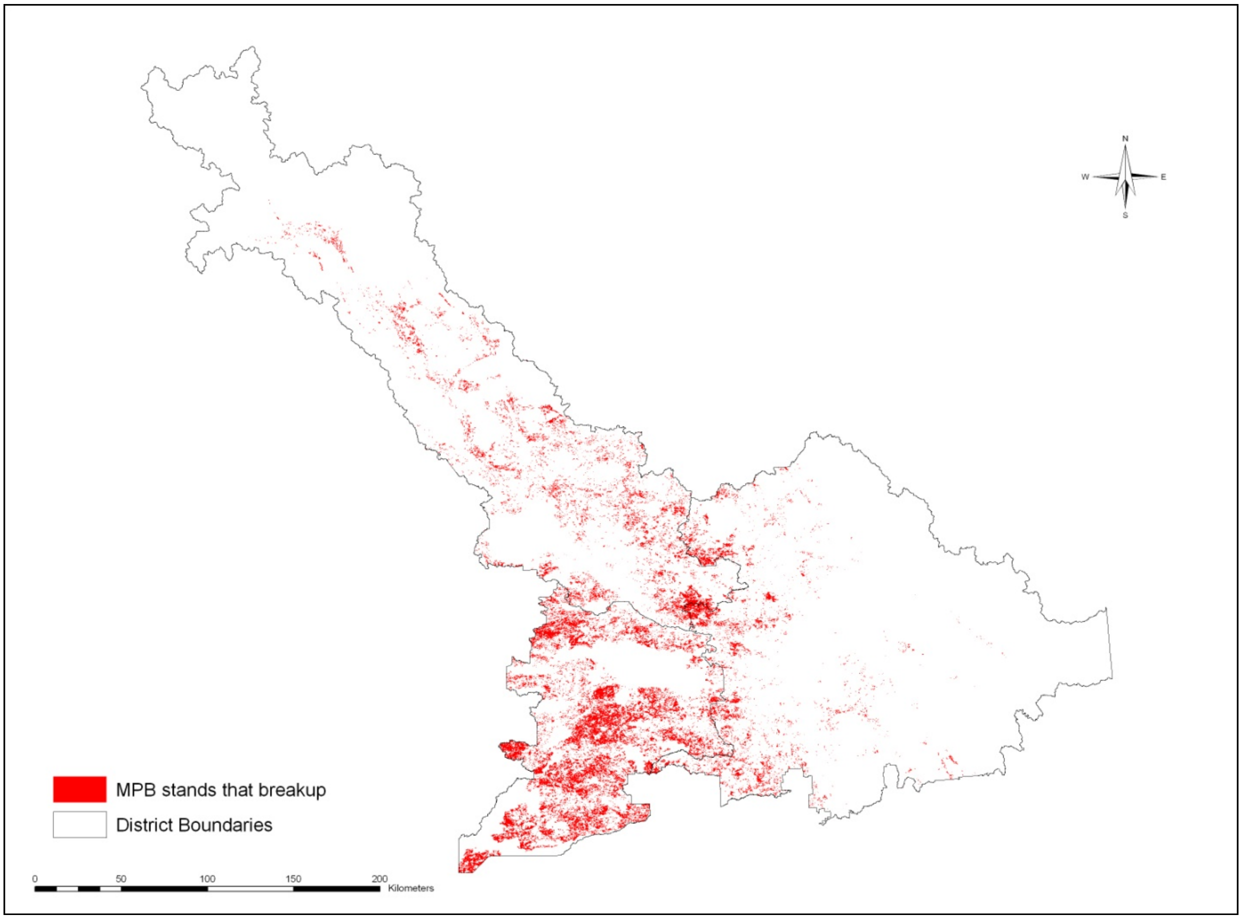


Figure 5: High severity MPB stands that breakup in the model

Figure 6 shows the forecasted harvest volume broken down by age class. The mid tem is almost entirely dependent on age class 8 stands (age 141-250). The majority of future harvesting (long term) consists of stands between 61 and 80 years old (age class 4).

Figure 7 illustrates the forecasted harvest by volume per hectare. Small volumes are prevalent in the first 5 years due to salvage; approximately 50% of the harvest is predicted to come from stands containing less than 300 m^3 per ha. The same applies to the end of the mid-term. The majority of the long-term harvest is predicted to be between 300 and 400 m^3/ha.

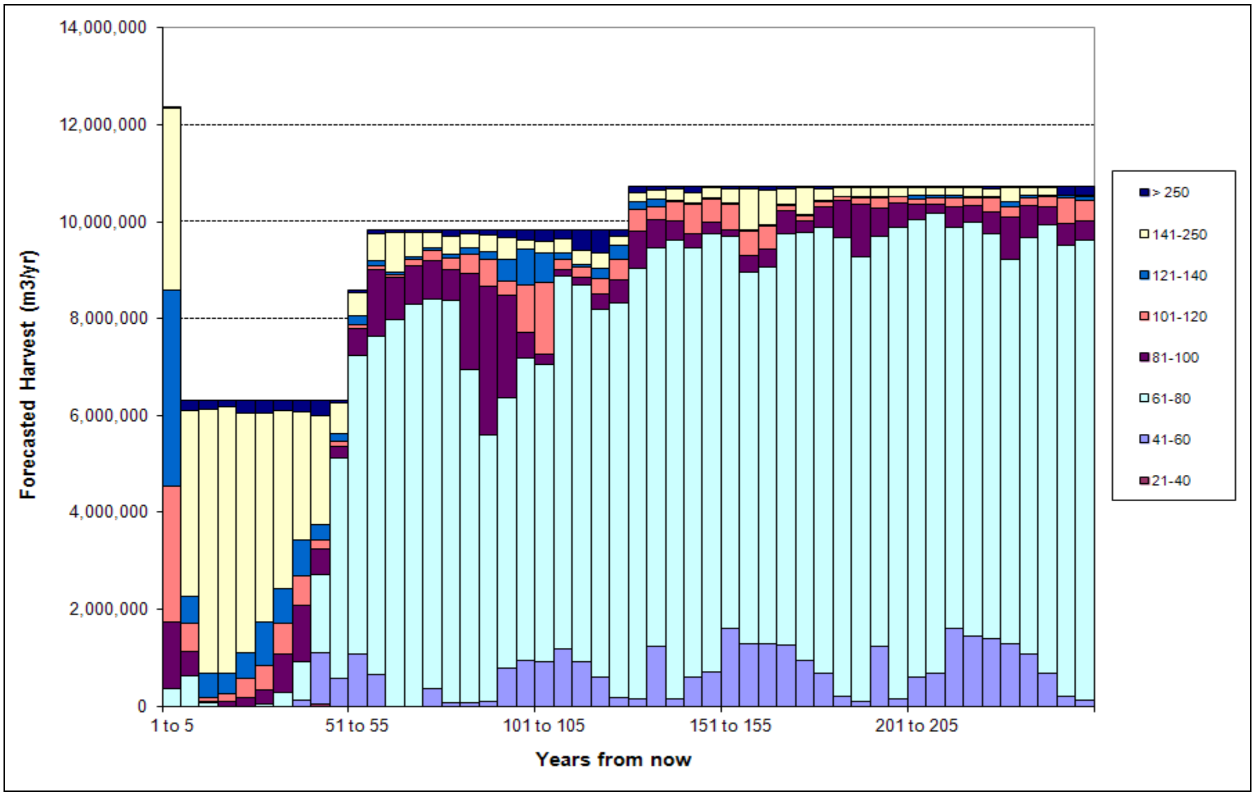


Figure 6: Harvest forecast by age class; Base Case

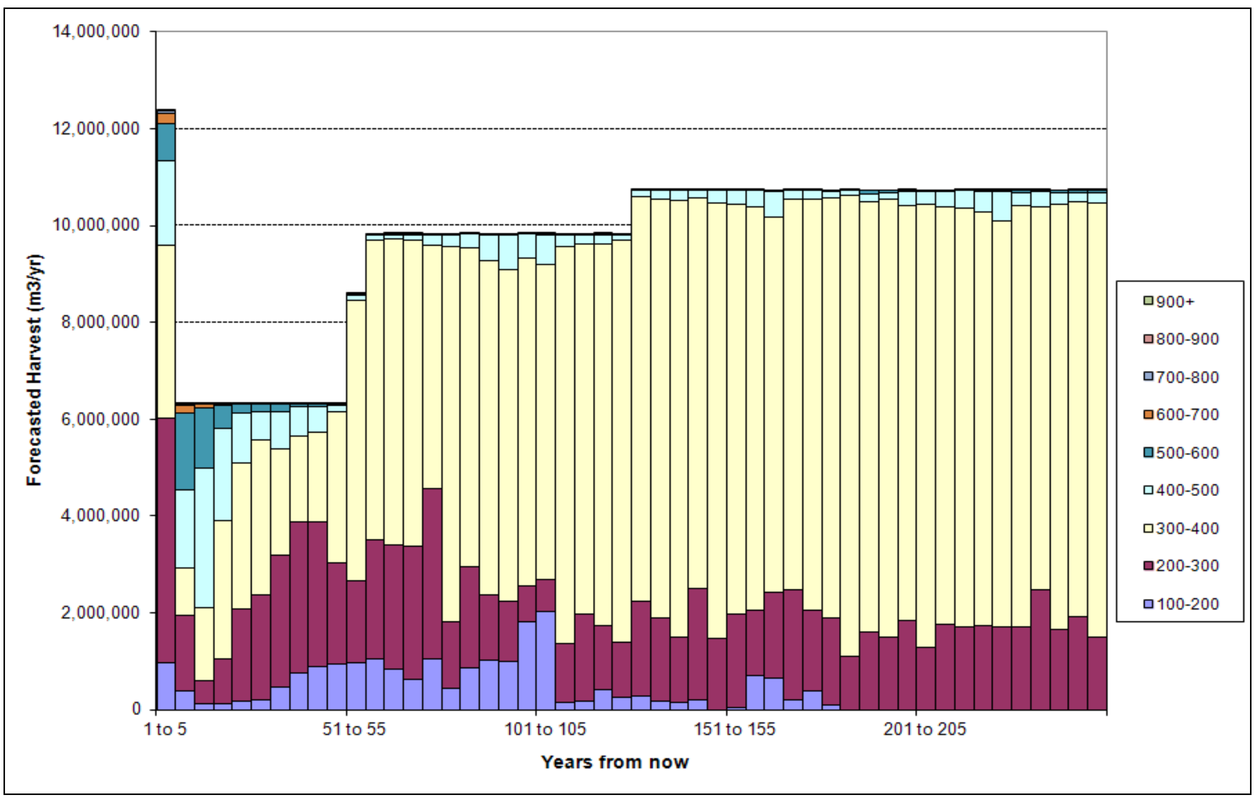


Figure 7: Harvest forecast by volume per ha class; Base Case

Figure 8 shows the forecasted harvest by district. After the pine salvage is complete, there is almost no harvest from Vanderhoof until the end of the near midterm. Harvest priorities were set for pine leading stands in Prince George and Vanderhoof to be salvaged first. The salvage in Fort St. James starts only after no more salvage is left in the other two districts. However, as the salvage in Vanderhoof and Prince George is completed in the first 5 years, the Fort St. James salvage harvest starts immediately.

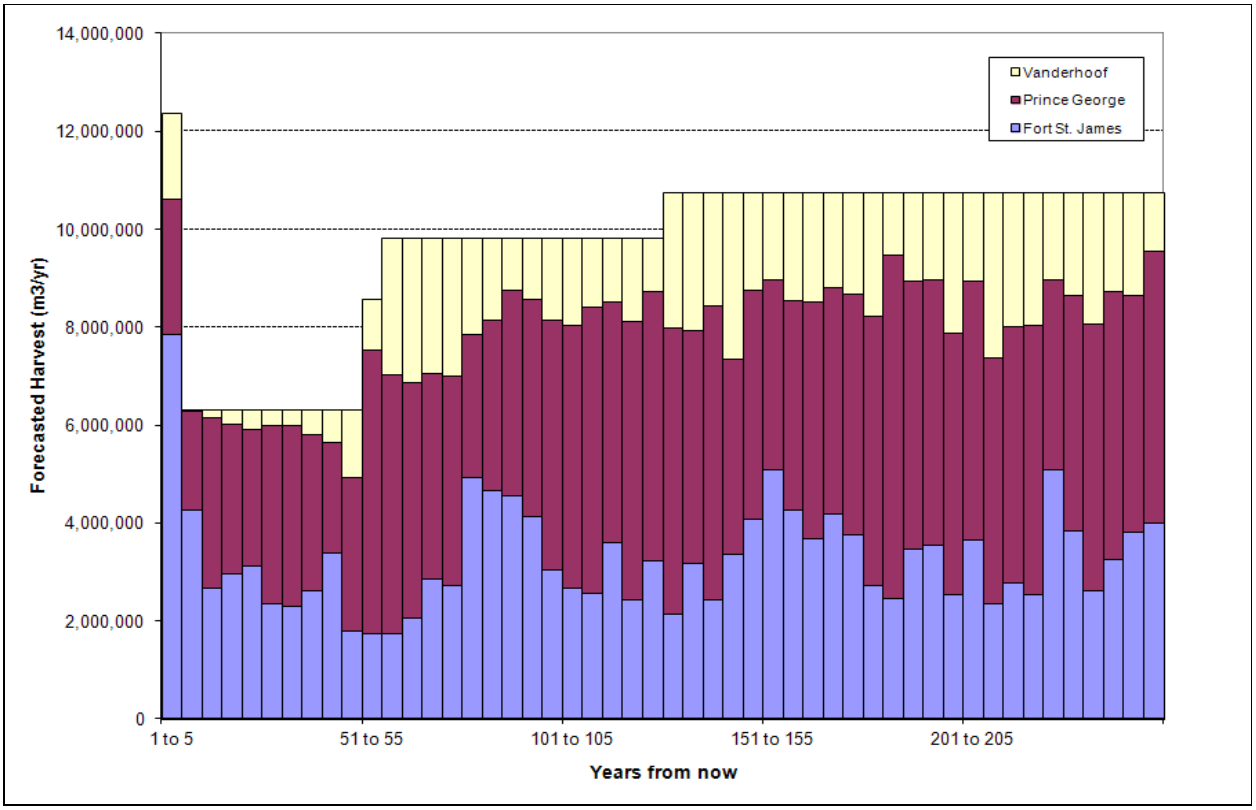


Figure 8: Harvest forecast by resource district; base case

2.1.1.1 Harvest Forecast by District

Figure 9, Figure 10, and Figure 11 show the forecasted harvest by yield type for each district. A large portion of the harvest in Fort St. James is predicted to come from attacked pine stands (high and low severity) in the short and medium term. In the Prince George Resource District there is some salvage, but the majority of the mid-term harvest is forecasted to come from unattacked natural stands. There is almost no harvest from Vanderhoof in the mid-term until year 41, when the managed stands become available. Note the difference in scale for Vanderhoof (Figure 11).

Figure 12, Figure 13, and Figure 14 show the forecasted harvest species distribution for each resource district. A significant portion of the mid-term harvest in Fort St. James and Prince George is predicted to be balsam. Naturally regenerated stands developing below the surviving understory (regen) make up a high proportion of the harvest in Vanderhoof during years 71-110.

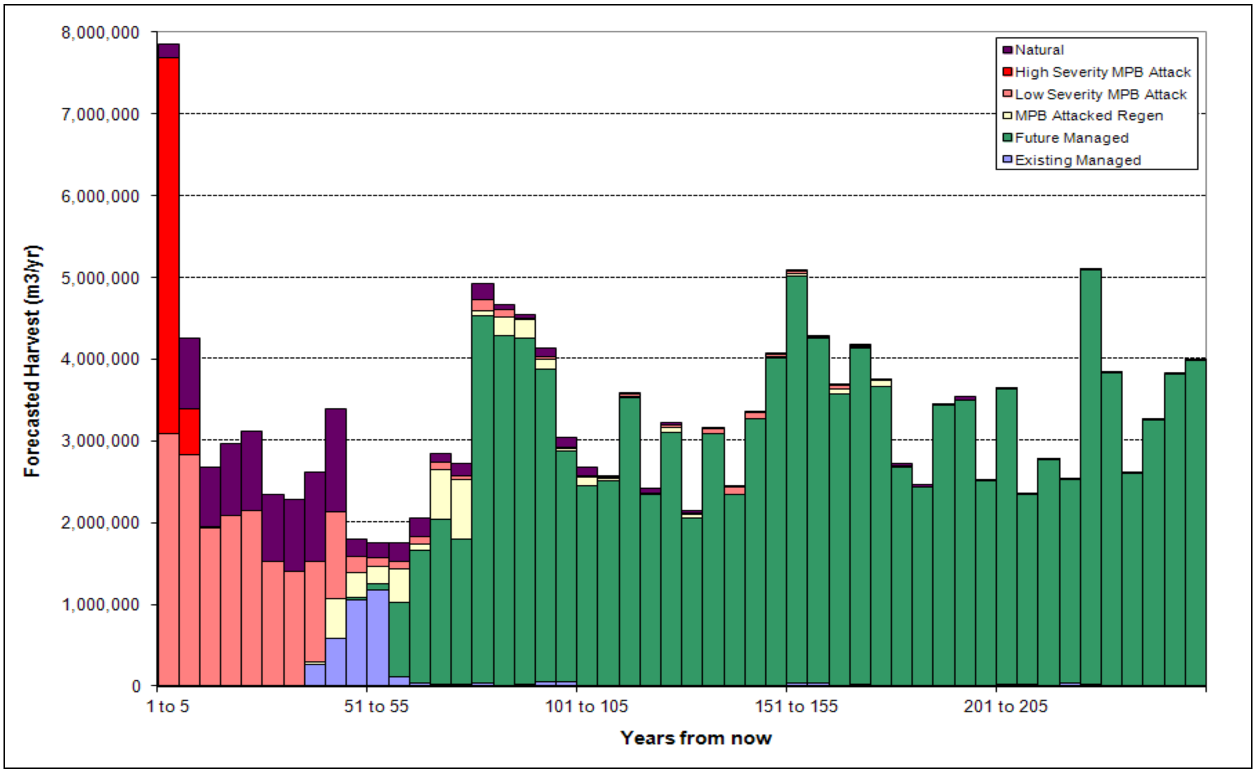


Figure 9: Base Case harvest forecast by yield type; Fort St. James Resource District

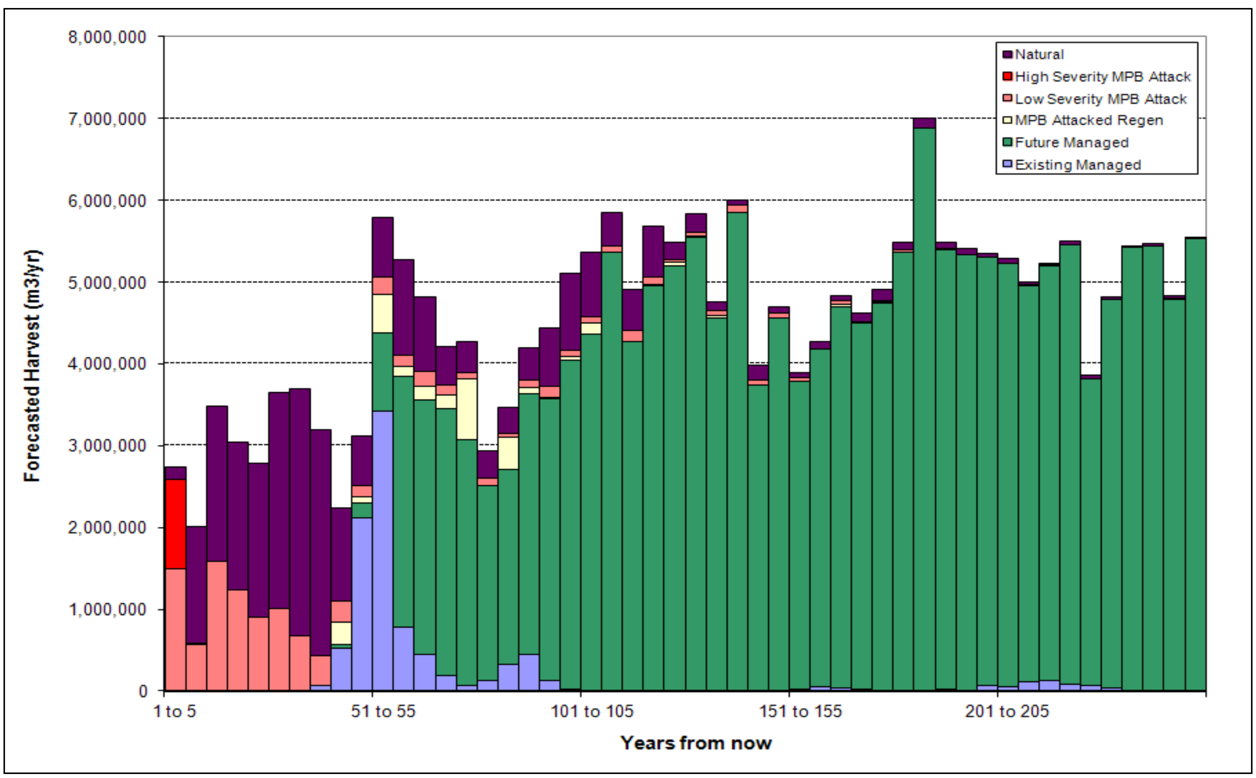


Figure 10: Base Case harvest forecast by yield type; Prince George Resource District

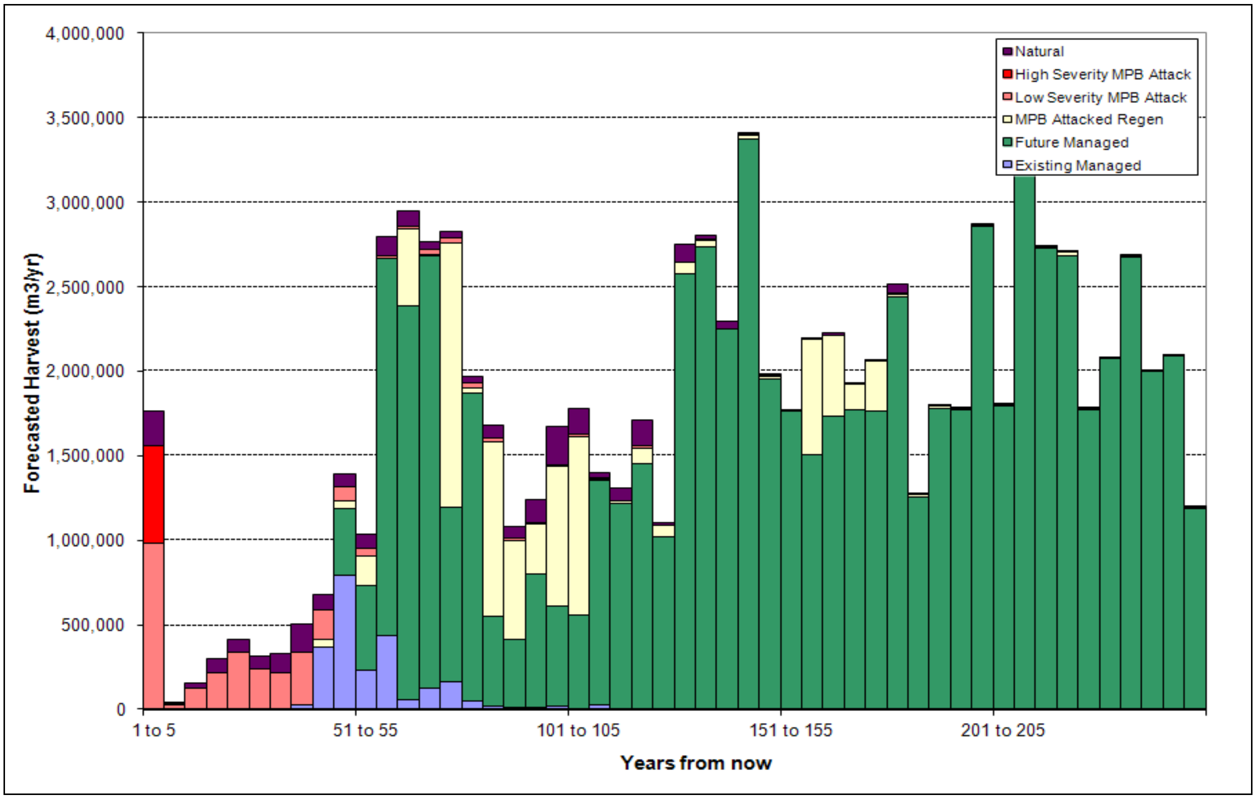


Figure 11: Base Case harvest forecast by yield type; Vanderhoof Resource District

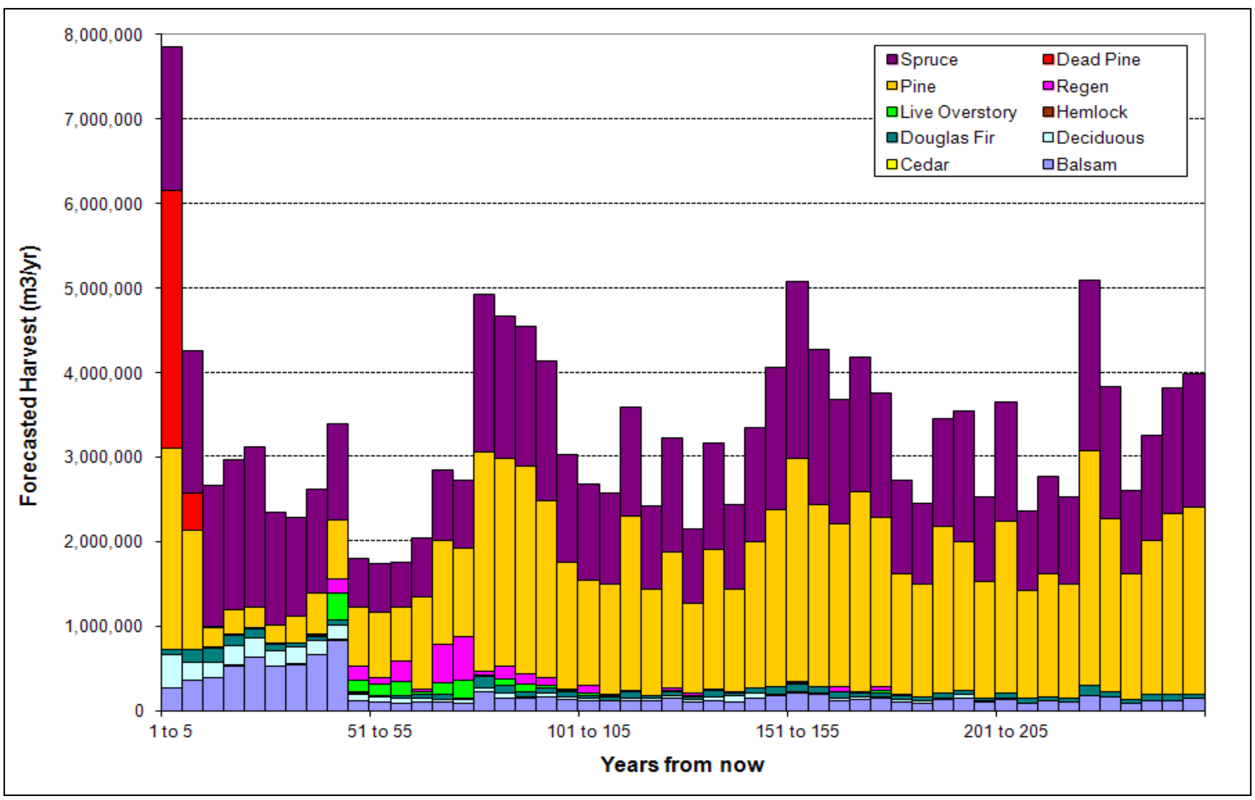


Figure 12: Base Case harvest forecast by species; Fort St. James Resource District

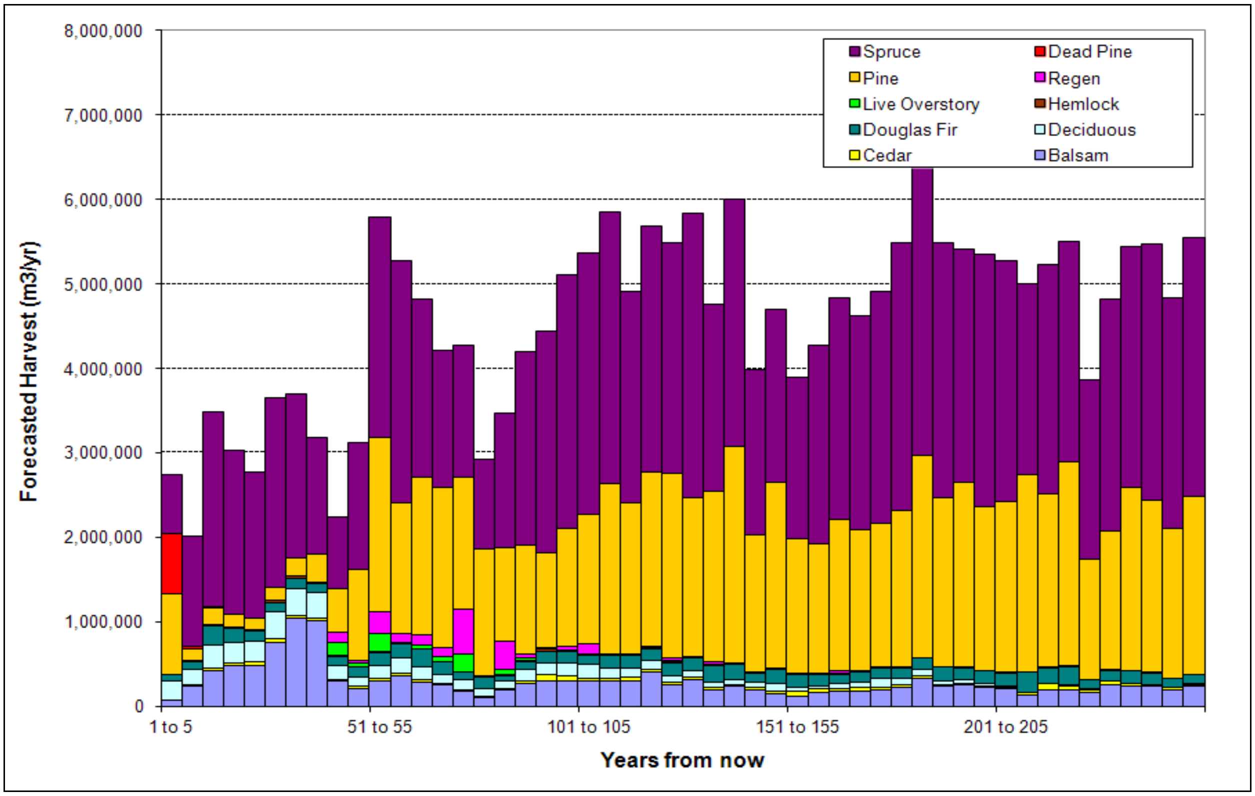


Figure 13: Base Case harvest forecast by species; Prince George Resource District

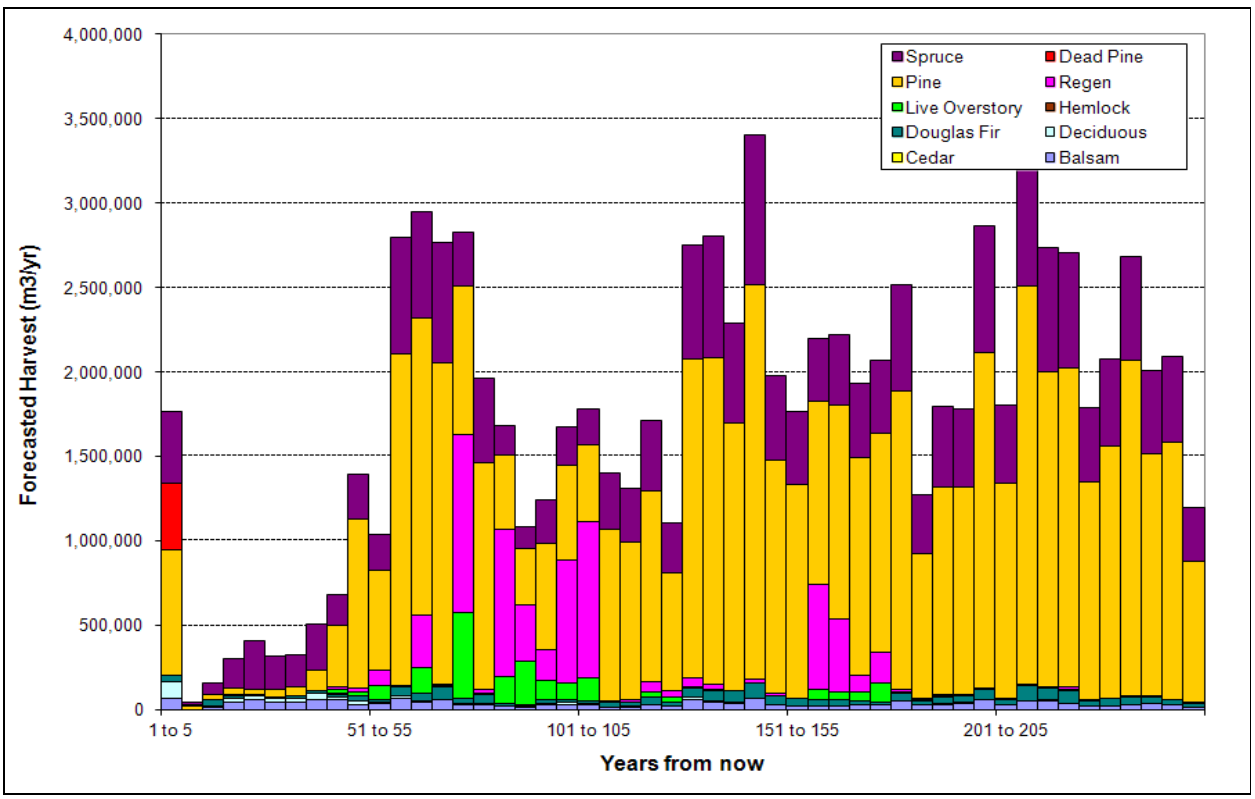


Figure 14: Base Case harvest forecast by species; Vanderhoof Resource District

Figure 15, Figure 16, and Figure 17 show the forecasted harvest by age class in the three resource districts. The pattern is similar in Fort St. James and Prince George with the mid-term harvest consisting mostly of older stands (141 - 250) and the long-term harvest consisting mainly of age class 4 stands (age 61-80). The mid-term harvest level is low in Vanderhoof consisting mostly of age class 8 stands. In the long term, there is more variation in Vanderhoof with more harvest of older age classes (81-100); however the long-term harvest is predicted to come predominantly from age class 4 stands as well.

Figure 18, Figure 19, and Figure 20 illustrate the predicted Base Case harvest for each district by volume per hectare classes. In Prince George and Fort St. James the mid-term harvest is predicted to consist of a variety of volume classes; in both resource districts most of the mid-term harvest in the model comes from stands with per ha volumes between 200 - 400 m^3 per ha with significant harvest also predicted in the 400 – 500 m^3 per ha class. In the long-term, the harvest in Prince George and Fort St. James is predicted to consist of stands with stand volumes between 300 and 400 m^3/ha.

The long-term trend is somewhat different in Vanderhoof. More of the volume is predicted to be harvested from stands with a smaller volume per ha; approximately half of the long-term volume is forecasted to come from stands with stand volumes less than 300 m^3 per ha.

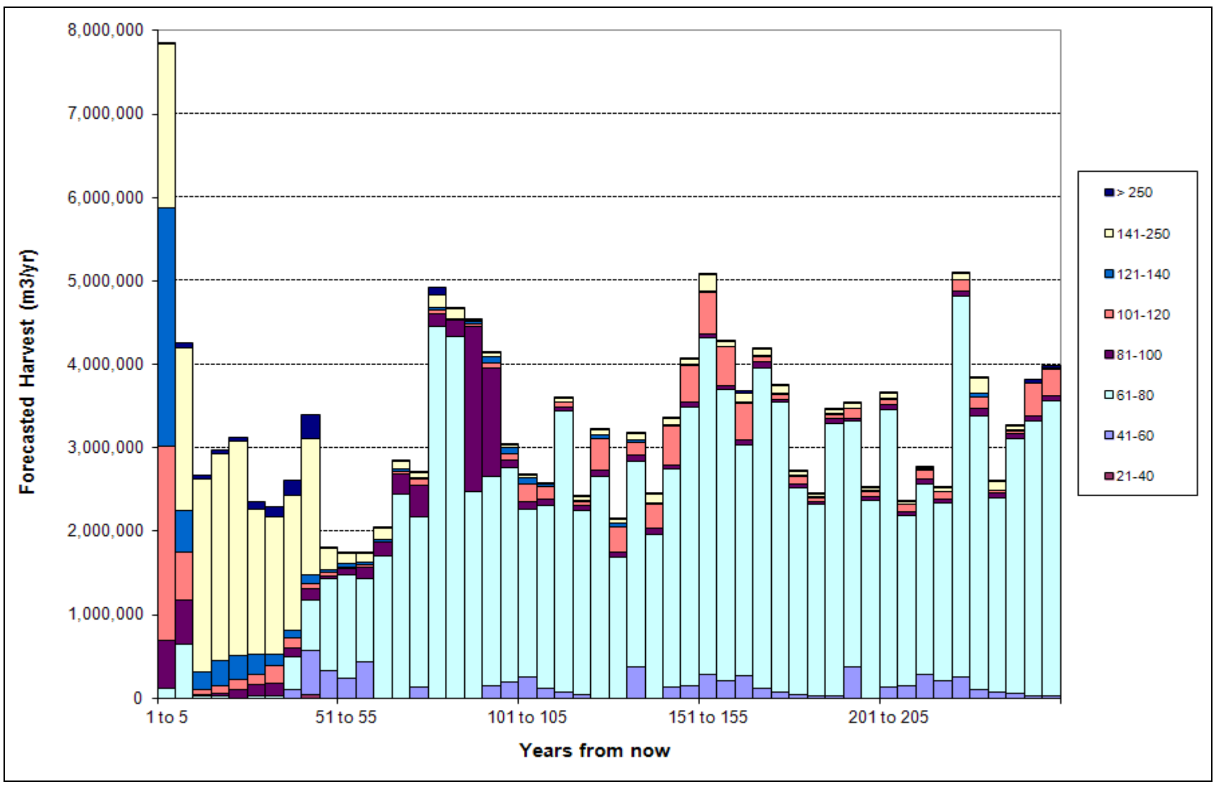


Figure 15: Base Case harvest forecast by age class; Fort St. James Resource District

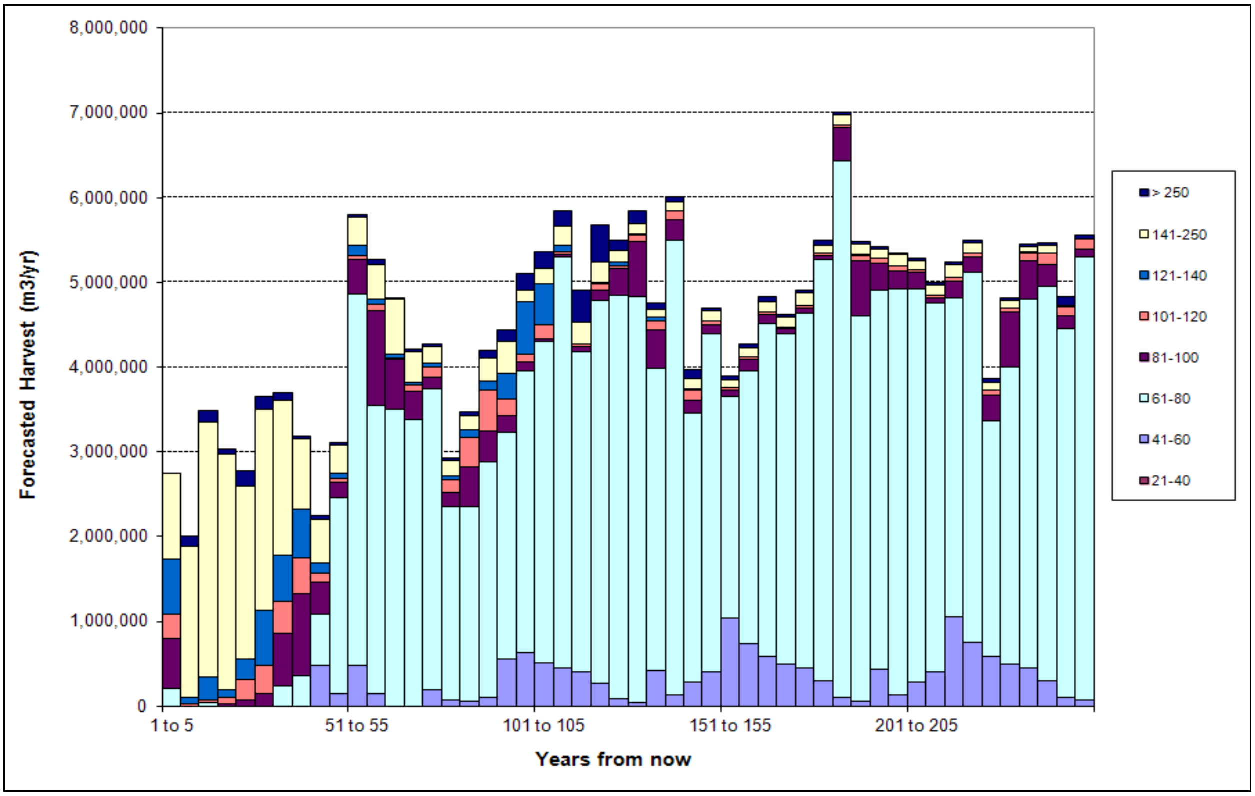


Figure 16: Base Case harvest forecast by age class; Prince George Resource District

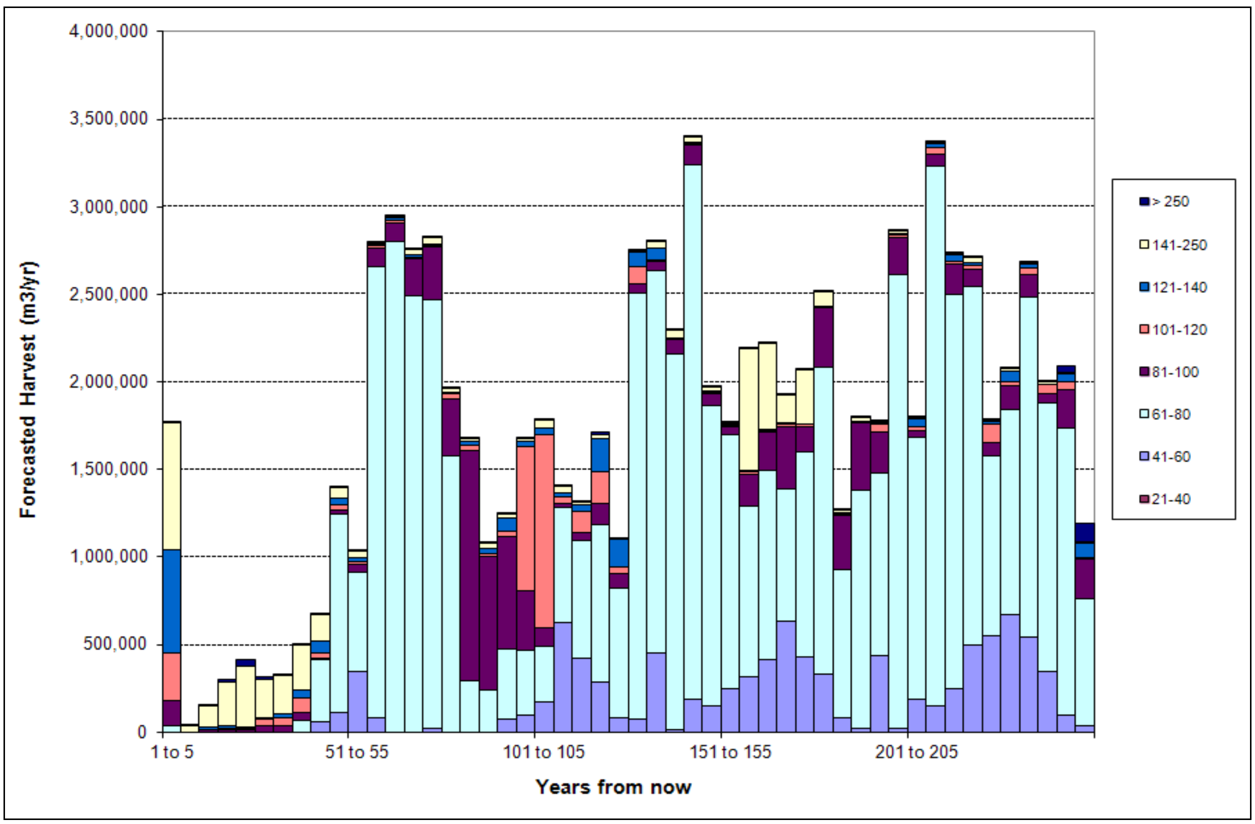


Figure 17: Base Case harvest forecast by age class; Vanderhoof Resource District

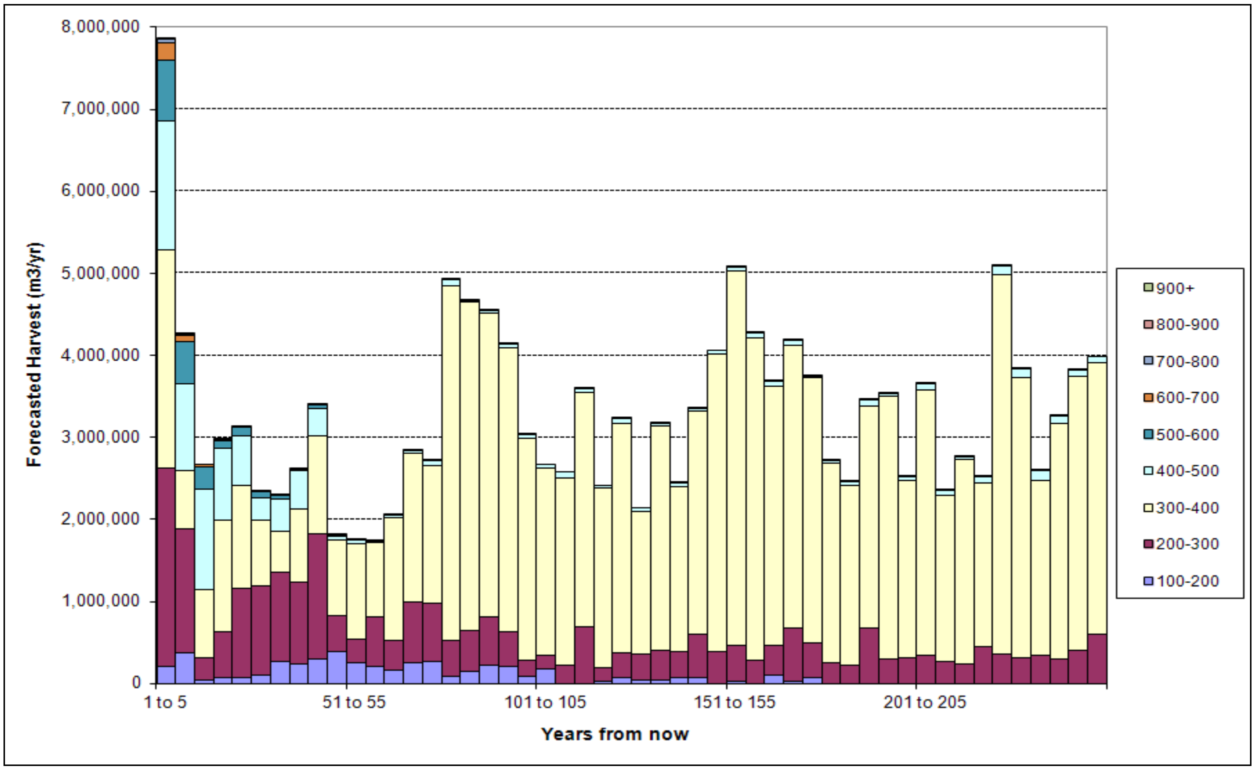


Figure 18: Base Case harvest forecast by volume per hectare class; Fort St. James Resource District

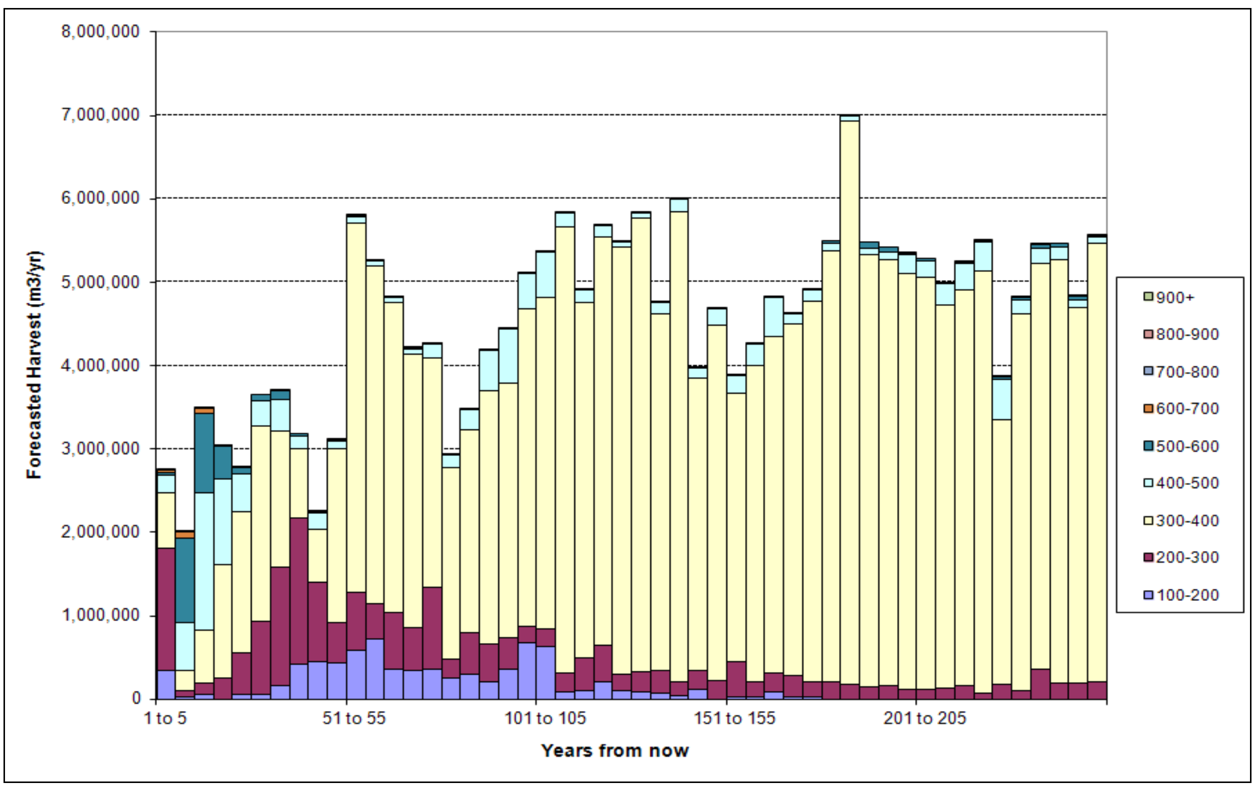


Figure 19: Base Case harvest forecast by volume per hectare class; Prince George Resource District

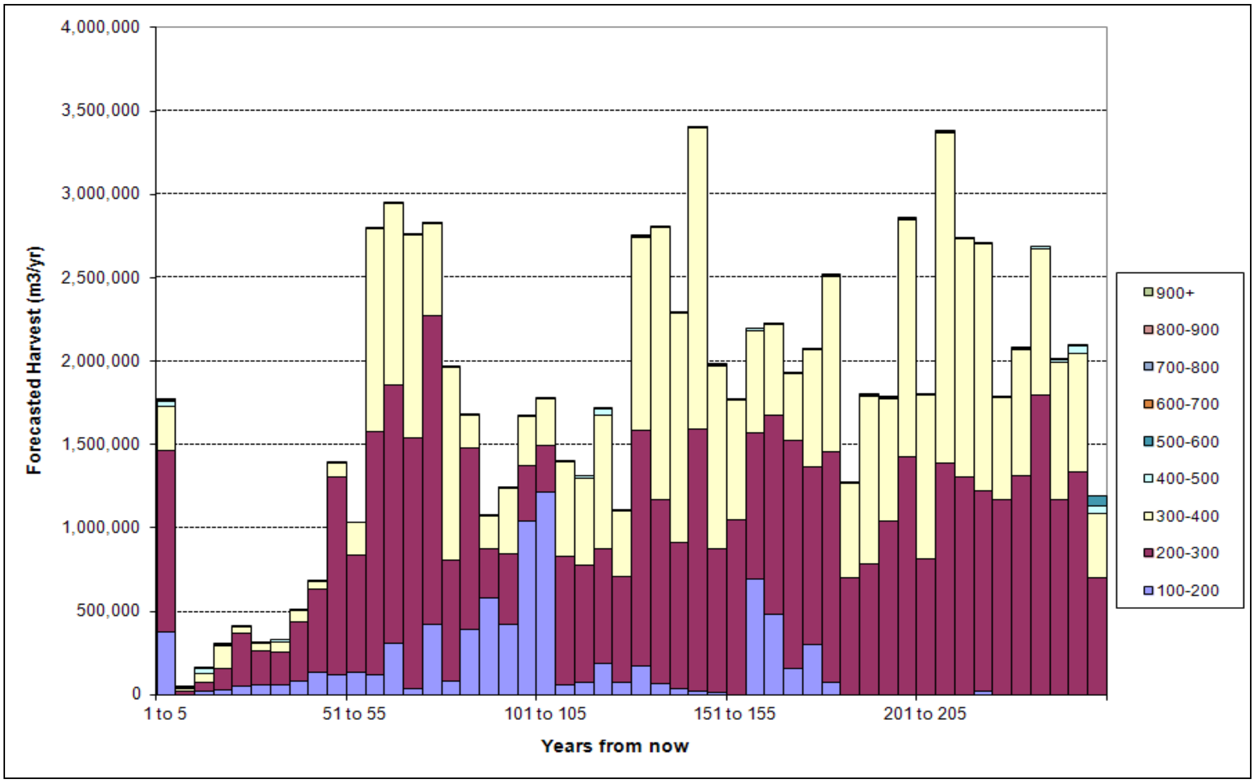


Figure 20: Base Case harvest forecast by volume per hectare class; Vanderhoof Resource District

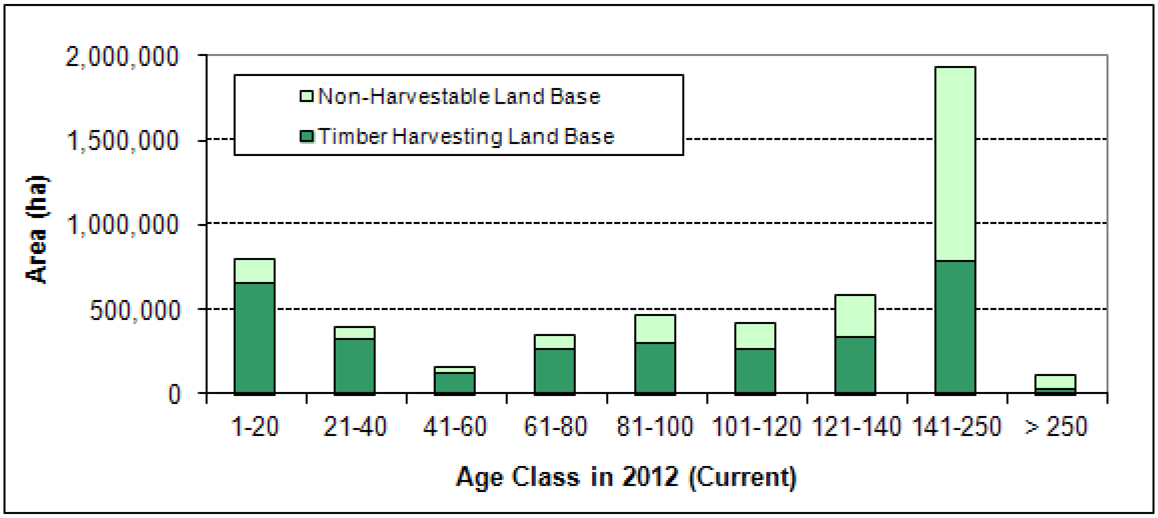
2.1.2 Non-Timber Value Outcomes

2.1.2.1 Age Class Distribution

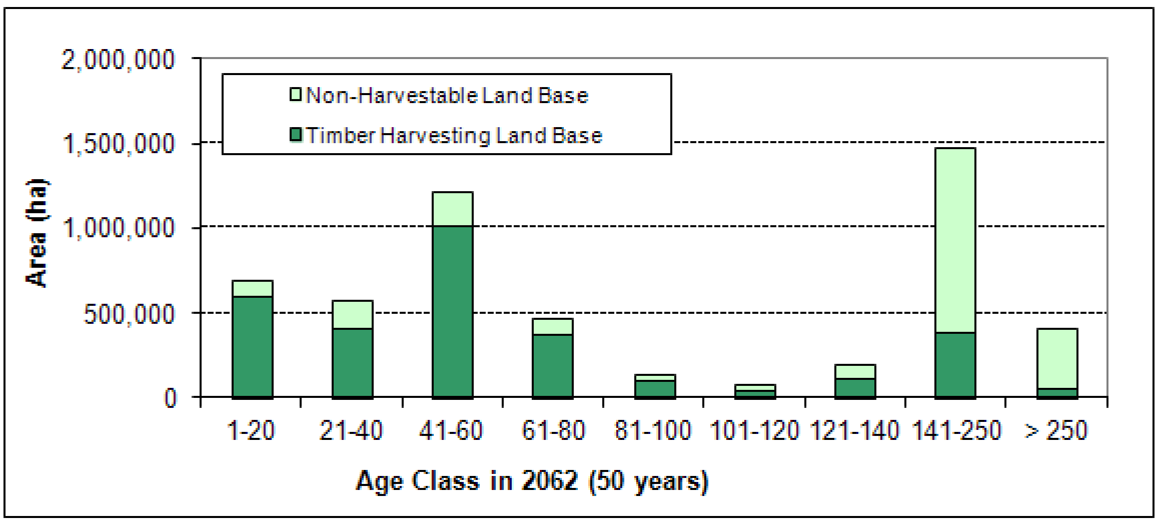
Figure 21 illustrates the predicted development of age classes in the Prince George TSA over a period of 250 years. The increased harvest due to the MPB salvage is reflected in the current (2012) age class distribution. Twenty one percent of the THLB is between 0 and 20 years old and 32% of the THLB is younger than 41 years of age. Age class 3 is under-represented in 2012, which characterizes the timber supply problem in the TSA; this age class is the potential source for the mid-term timber supply.

In the course of time the age class distribution remains unbalanced; age class 1 area stabilizes after the first 50 years and remains relatively constant after that. Age classes 2 and 3 remain stable throughout the planning horizon, while age classes 4, 5, 6 and 7 decrease and almost cease to exist. This is caused by the retention of mature and old, and old forest; the harvest of these seral stages is limited which leads into the harvest of mostly age class 4 stands as discussed above. As a result, the forest outside of the areas that are reserved for mature and old, and old never ages beyond age 80. This is a potential risk factor as no reserves or recruitment opportunities exist in case of large-scale fires or other natural disasters that may occur in mature and old or old forest in the future.

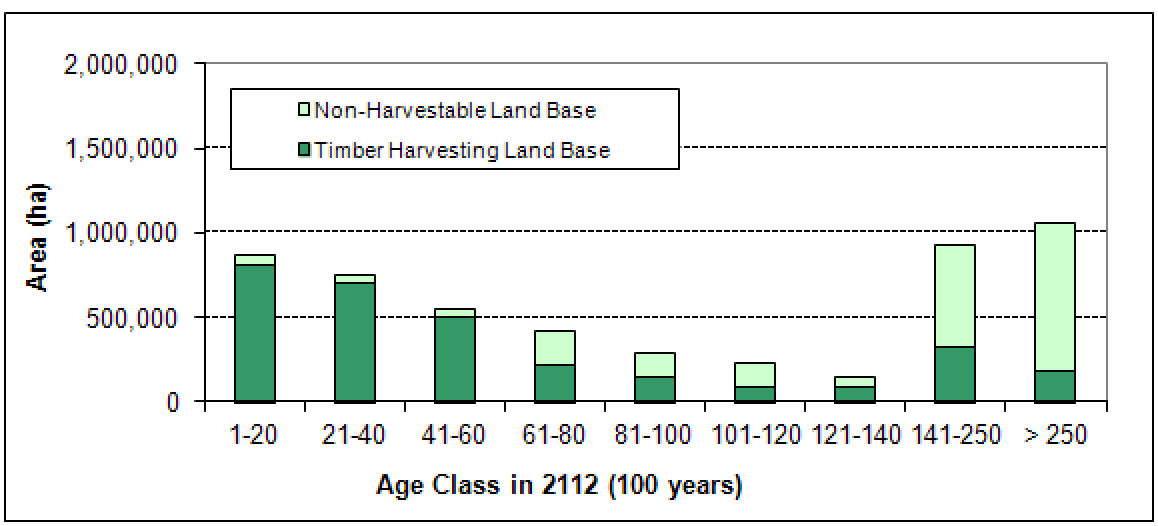
Figure 22 shows the current age class distribution for each resource district while Figure 23 illustrates the predicted age class distribution at year 250 by district. The trends described for the TSA apply here as well.



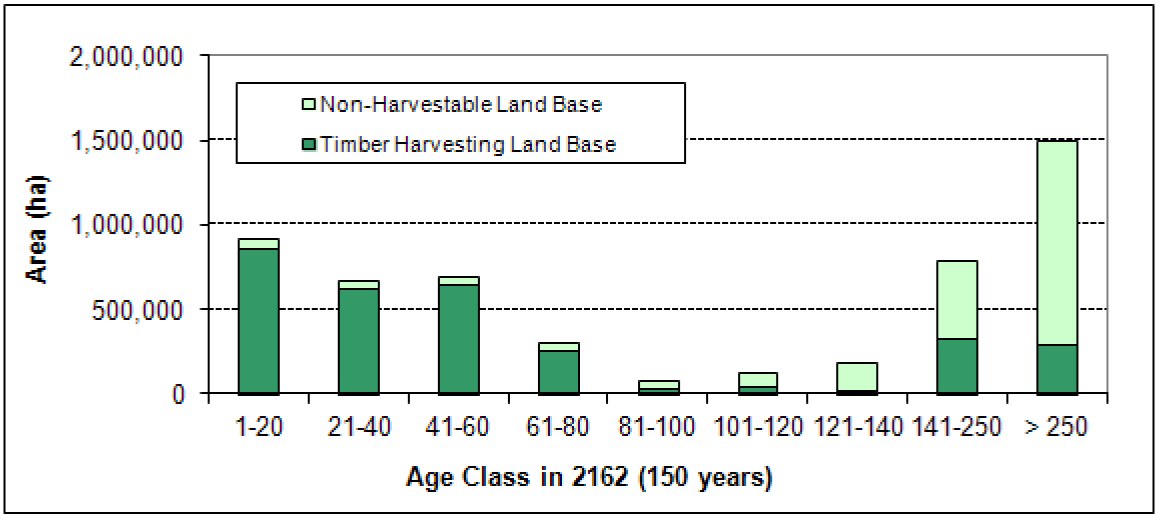
2,000,000
1,500,000
1,000,000
500,000
0
Area (ha)
Non-Harvestable Land Base
Timber Harvesting Land Base
1-20
21-40
41-60
61-80
81-100
101-120
121-140
141-250
> 250
Age Class in 2012 (Current)

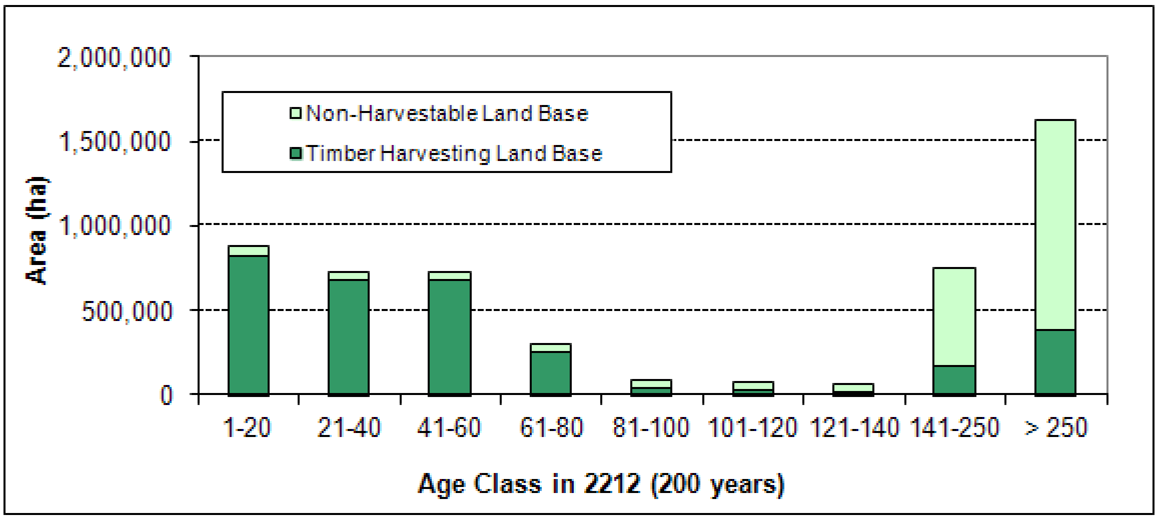


2,000,000
1,500,000
1,000,000
500,000
0
Area (ha)
Non-Harvestable Land Base
Timber Harvesting Land Base
1-20
21-40
41-60
61-80
81-100
101-120
121-140
141-250
> 250
Age Class in 2062 (50 years)



2,000,000
1,500,000
1,000,000
500,000
0
Area (ha)
Non-Harvestable Land Base
Timber Harvesting Land Base
1-20
21-40
41-60
61-80
81-100
101-120
121-140
141-250
> 250
Age Class in 2112 (100 years)





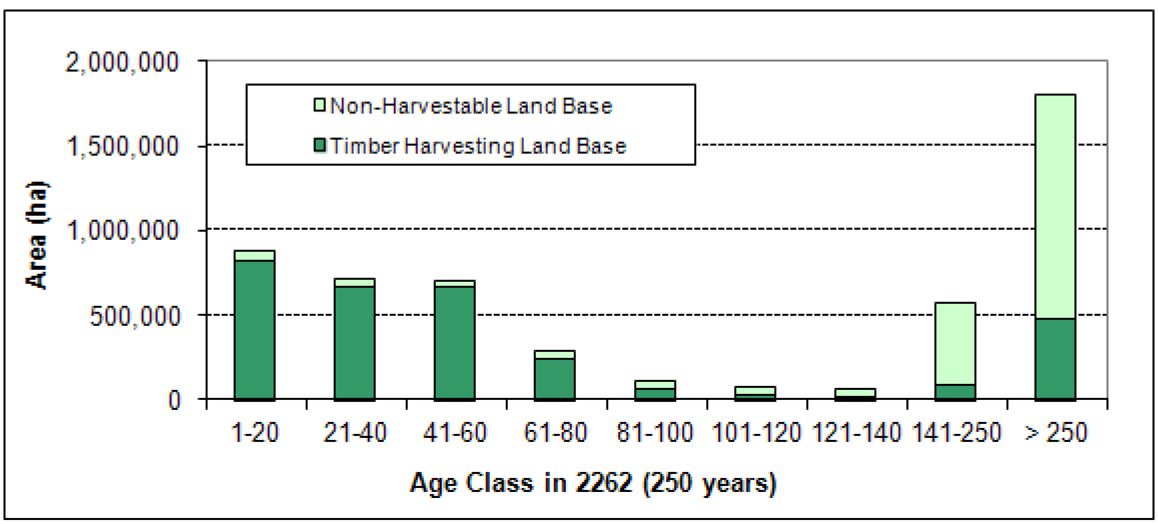
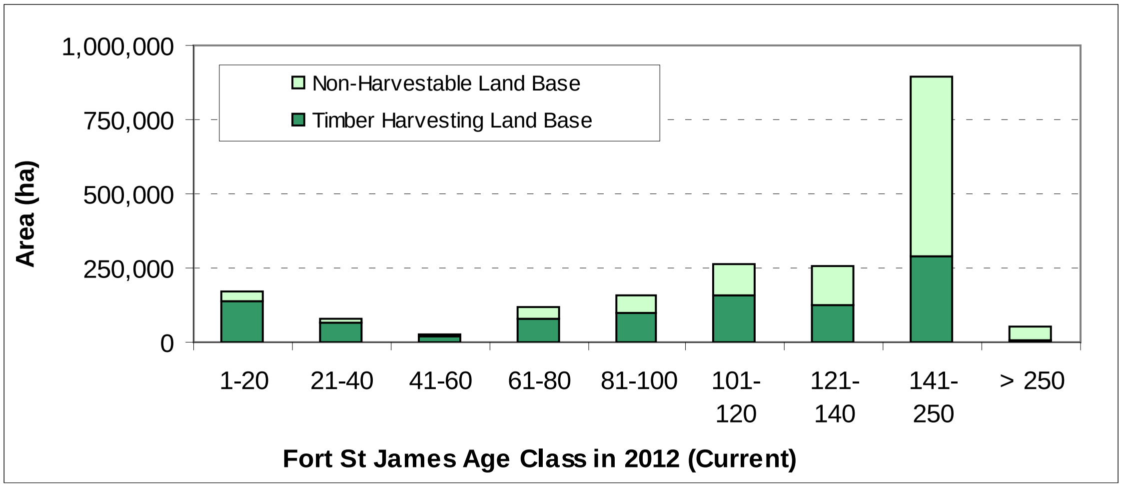
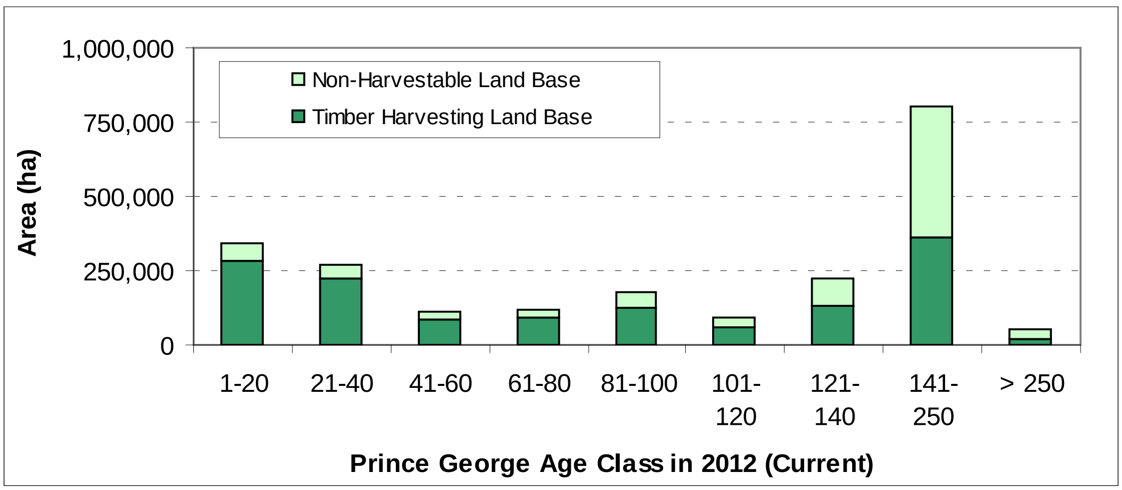


Figure 21: Forecasted age class distribution in the THLB and NHLB over the next 250 years





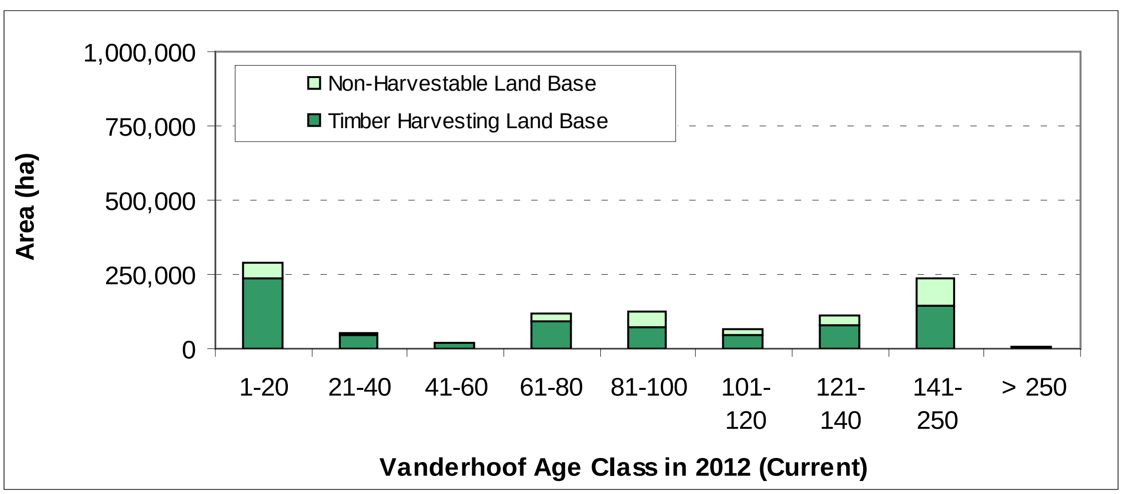
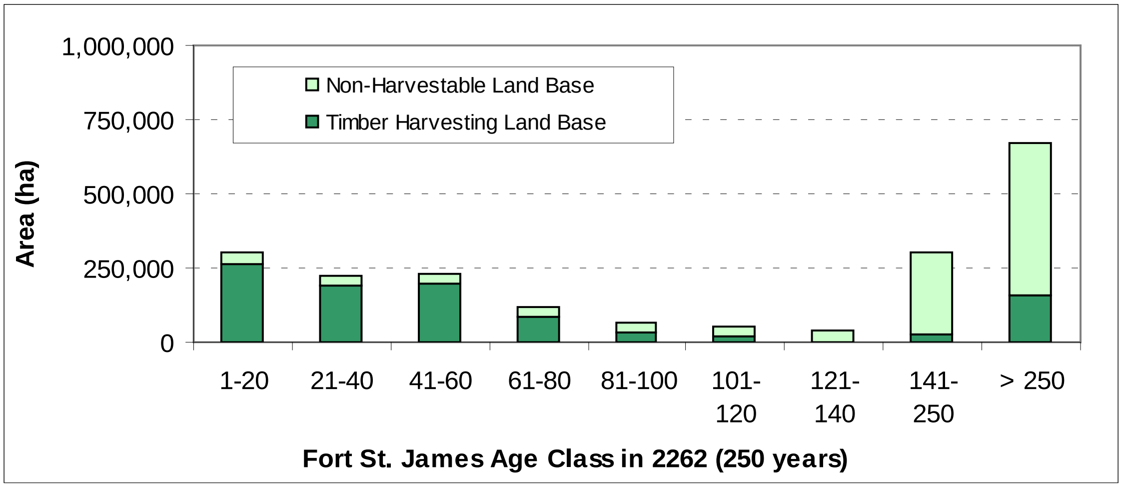
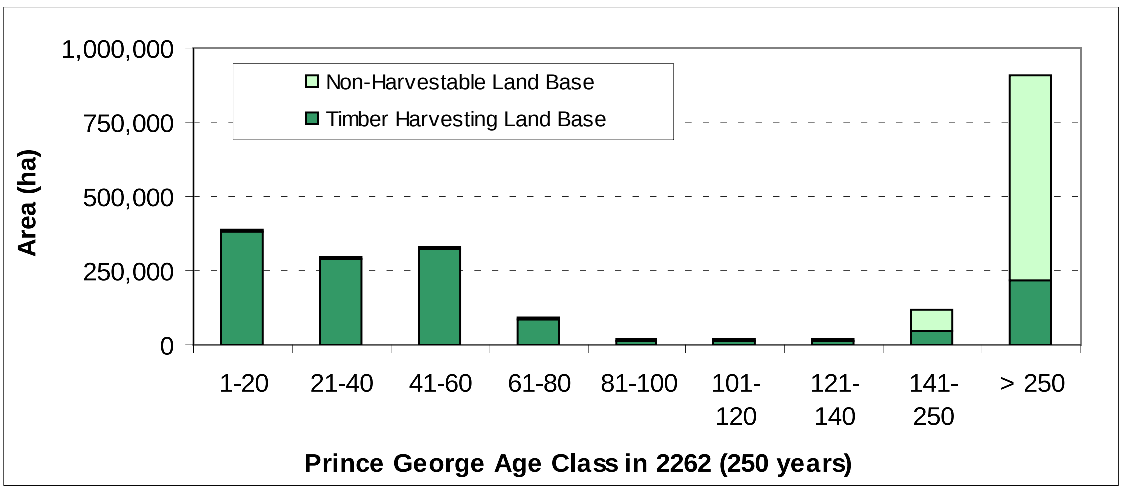


Figure 22: Current age class distributions; Fort St. James, Prince George and Vanderhoof Resource Districts





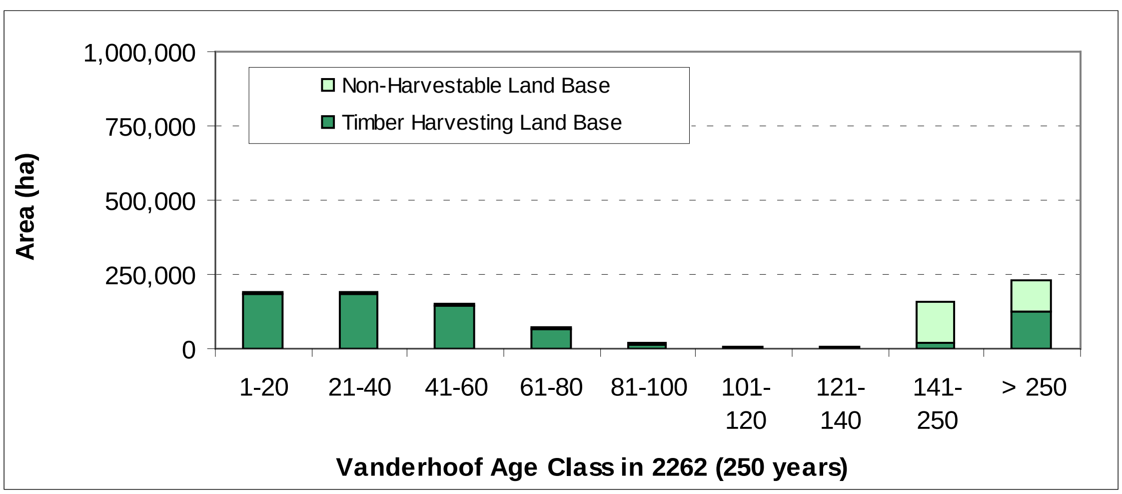


Figure 23: Forecasted future age class distributions; Fort St. James, Prince George and Vanderhoof Resource Districts

2.1.2.2 Landscape level biodiversity

In the Prince George TSA, biodiversity is managed through the Prince George TSA Biodiversity Order. 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. Interior old forest retention and patches were not modelled in this analysis; only the old forest targets were enforced.

Figure 24 shows an example of biodiversity target that is in violation during the mid-term. This example is unit A8, in the Prince George Natural Resource district. Unit A8 is in the Moist Interior Plateau NDU with BEC subzones SBSmc2 and SBSmc3. The CFLB area of this unit is 9,218 ha with the minimum target for old forest of 12%. The age of old is defined as older than 120. This unit is in violation from year 21 to 95, due to pine mortality. High severity MPB attacked stands breakup and have their ages reset 20 years after the MPB attack. The regenerating MPB attacked stands contribute to the biodiversity targets starting 120 years from now, though currently existing age class 2 stands are recruited and help meet the biodiversity targets in this unit 100 years from now.

In contrast, Figure 25 shows unit E16 from the Fort St. James Natural Resource district. This unit is in the Omineca Valley NDU with the total CFLB area of 263,704 ha. The BEC subzone is SBSmk1. The unit is not constraining as the target of 16% of old forest (older than 120) is mostly met in the NHLB portion of the land base even during the mid-term.

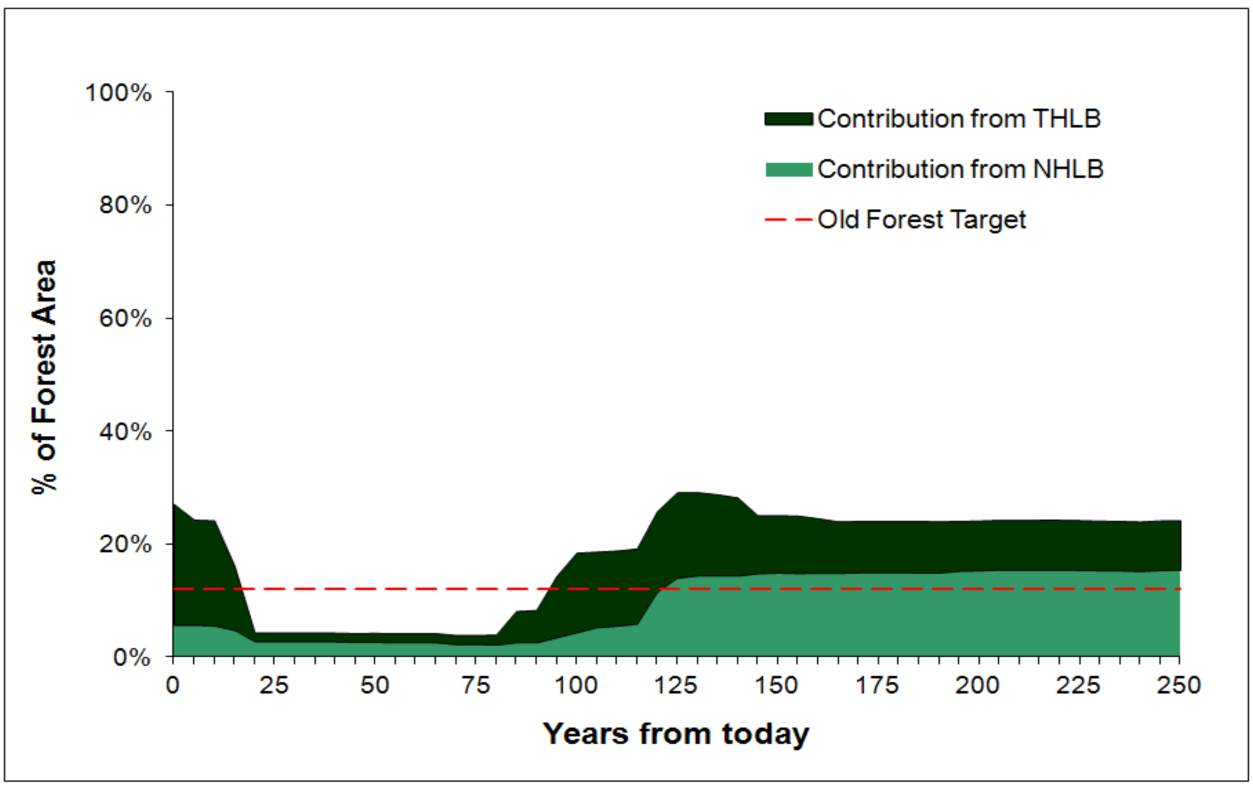


Figure 24: Example of a constraining landscape level biodiversity unit; A8, Moist Interior Plateau

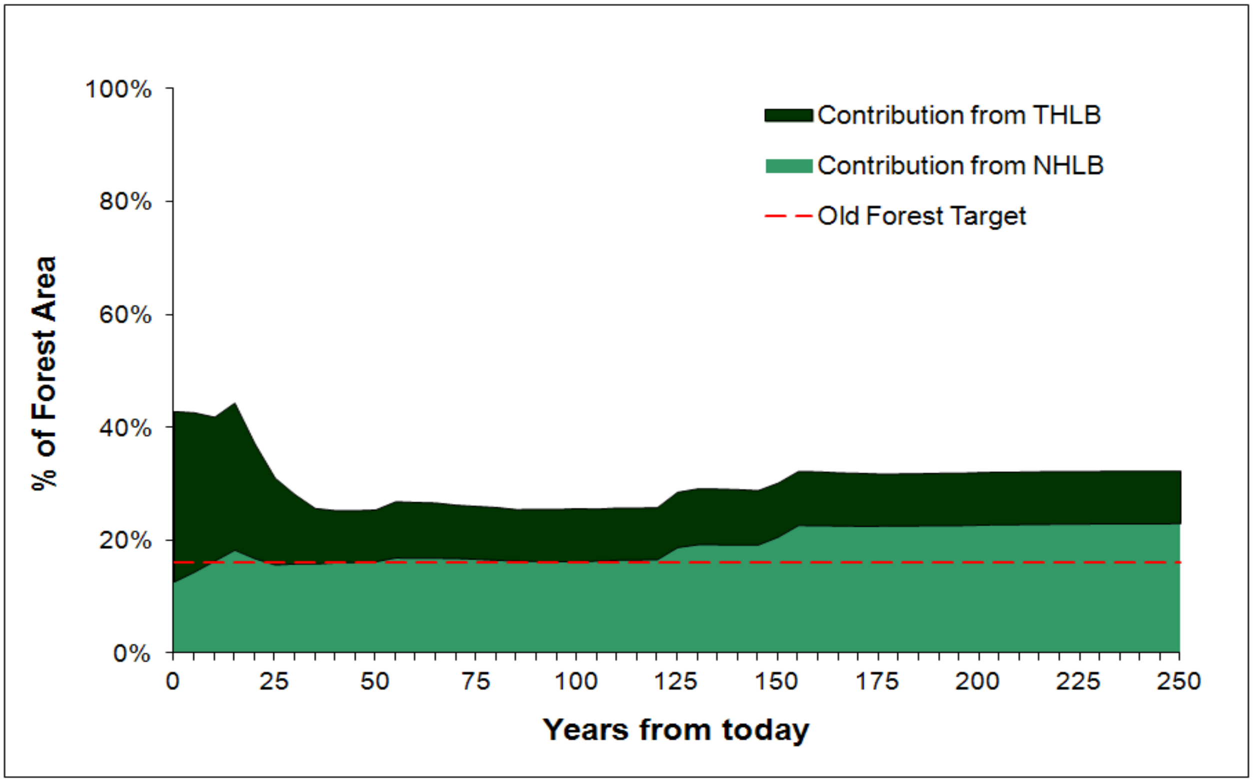


Figure 25: Example of a non-constraining landscape level biodiversity unit; unit E16 Omineca Valley

Table 2 shows the status of each NDU/Merged Biogeoclimatic Unit in years 2012, 2032, and 2062. The units that are shown in red are in violation (2012) or predicted to be in violation. In the Prince George Resource District five units are currently in violation while four units are forecasted to be in violation during all or part of the mid-term. In Fort St. James one unit (E1) is currently in violation; however, no units are predicted to be in violation during the mid-term. In Vanderhoof, three units are predicted to be in violation during the mid-term.

Table 2: Summary of Old Forest percent forecast by NDU/Merged BEC over 50 years

				Percent of Old Forest		
Unit #	**NDU/Merged Biogeoclimatic Units**	**CFLB Area (ha)**	**Old Forest Target**	**Current (2012)**	**Year 20 (2032)**	**Year 50 (2062)**
A1	Boreal Foothills - Plateau ESSFwcp3, ESSFwc3, ESSFmvp2, ESSFmv2	7,019	33%	80%	89%	90%
A2	McGregor Plateau ESSFwc3, ESSFwk2, ESSFwk1	15,879	26%	45%	68%	68%
A3	McGregor Plateau SBSmk1, SBSmh	69,240	12%	38%	25%	19%
A4	McGregor Plateau SBSwk1, SBSvk	228,676	26%	26%	26%	26%
A5	Omineca - Mountain ESSFwk2, ESSFmv3, ESSFmv1	13,995	29%	26%	23%	29%
A6	Moist Interior - Mountain ESSFwk1	16,391	29%	45%	61%	42%
A7	Moist Interior - Plateau SBSmh	4,226	17%	30%	42%	51%
A8	Moist Interior - Plateau SBSmc3, SBSmc2	9,218	12%	27%	4%	4%

				Percent of Old Forest		
Unit #	NDU/Merged Biogeoclimatic Units	CFLB Area (ha)	Old Forest Target	Current (2012)	Year 20 (2032)	Year 50 (2062)
A9	Moist Interior - Plateau SBSmw	33,409	12%	15%	10%	15%
A10	Moist Interior - Plateau SBSwk1	48,445	17%	37%	25%	24%
A11	Moist Interior - Plateau SBSdw2, SBSmc2	127,310	12%	23%	11%	12%
A12	Moist Interior - Plateau SBSdw3	158,901	12%	22%	13%	19%
A13	Omineca - Valley SBSmk1	367,502	12%	26%	16%	20%
A14	Wet Mountain ESSFmvp2, ESSFwcp3, ESSFmv2, ESSFwk2	148,526	50%	80%	89%	90%
A15	Wet Mountain ESSFwc3	23,659	84%	74%	87%	92%
A16	Wet Mountain SBSwk1	35,892	26%	41%	34%	28%
A17	Wet Mountain SBSvk	121,691	50%	70%	67%	50%
A18	Wet Trench - Mountain ESSFwcp3	10,496	80%	79%	89%	93%
A19	Wet Trench - Mountain ESSFmm1, ESSFmmp1, ESSFmvp2, ESSFmv2, ESSFwk2	69,692	48%	82%	87%	87%
A20	Wet Trench - Mountain ESSFwc3	95,770	80%	84%	90%	91%
A21	Wet Trench - Mountain ESSFwk1	114,230	48%	58%	63%	48%
A22	Wet Trench - Valley ICHwk3	28,060	53%	62%	68%	53%
A23	Wet Trench - Valley ICHvk2	150,776	53%	61%	65%	55%
A24	Wet Trench - Valley SBSwk1, SBSmw, SBSmk1	133,175	30%	27%	30%	30%
A25	Wet Trench - Valley SBSvk	159,766	46%	45%	48%	46%
E1	Moist Interior Mountain ESSFmv1, ESSFmvp1, ESSFmv3	19,009	41%	40%	56%	59%
E2	Moist Interior Plateau SBSdk	27,079	17%	38%	36%	45%
E3	Moist Interior Plateau SBSmc2	61,203	17%	44%	35%	33%
E4	Moist Interior Plateau SBSmk1, SBSwk3	184,815	12%	24%	16%	15%
E5	Moist Interior Plateau SBSdw3	217,536	12%	34%	27%	26%
E6	Northern Boreal Mountains ESSFwvp, ESSFmcp, ESSFmc, ESSFwv	117,446	37%	82%	88%	88%
E7	Northern Boreal Mountains SWB	30,705	37%	78%	83%	73%
E8	Northern Boreal Mountains SBSmc2	36,146	26%	82%	80%	83%
E9	Omineca Mountain ESSFwvp, ESSFwv, ESSFmcp	26,231	58%	86%	89%	95%
E10	Omineca Mountain SWB, ESSFmc	100,800	41%	83%	86%	84%
E11	Omineca Mountain ESSFmvp3, ESSFmv3	378,817	41%	69%	75%	70%
E12	Omineca Valley SBSdk, SBSdw3	10,790	16%	48%	35%	29%
E13	Omineca Valley ICHmc1	13,283	23%	91%	91%	89%
E14	Omineca Valley BWBSdk1	65,031	16%	65%	62%	43%
E15	Omineca Valley SBSmc2	104,809	16%	73%	71%	65%
E16	Omineca Valley SBSmk1	263,704	16%	43%	37%	25%

				Percent of Old Forest		
Unit #	NDU/Merged Biogeoclimatic Units	CFLB Area (ha)	Old Forest Target	Current (2012)	Year 20 (2032)	Year 50 (2062)
E17	Omineca Valley SBSwk3	356,256	16%	56%	48%	32%
D1	Moist Interior - Mountain ESSF	134,558	29%	42%	30%	29%
D2	Moist Interior - Plateau SBPSmc	47,031	17%	45%	11%	15%
D3	Moist Interior - Plateau SBSdk	162,084	17%	30%	18%	20%
D4	Moist Interior - Plateau SBSdw2	46,718	12%	27%	9%	12%
D5	Moist Interior - Plateau SBSdw3	197,077	17%	30%	15%	17%
D6	Moist Interior - Plateau SBSmc2, MSxv	237,355	12%	32%	13%	13%
D7	Moist Interior - Plateau SBSmc3	211,412	12%	32%	13%	16%

2.1.2.3 Ungulate Winter Range

There are several ungulate winter range (UWR) orders within the Prince George TSA. Each of these has restrictions on harvesting that are detailed in the Data Package (FESL, 2013). Approximately 232,000 ha (4%) of the CFLB is within UWR areas.

Figure 26 shows the target for one UWR unit. The example is UWR number U7-011, unit VD-005. This mule deer winter range area of 862 ha (CFLB) has a minimum target of 40%, i.e. 40% of the CFLB area is expected to be older than 140 years throughout the planning horizon. This unit is in violation for almost the entire planning horizon. The violation later in the planning horizon is caused by natural succession in the NHLB.

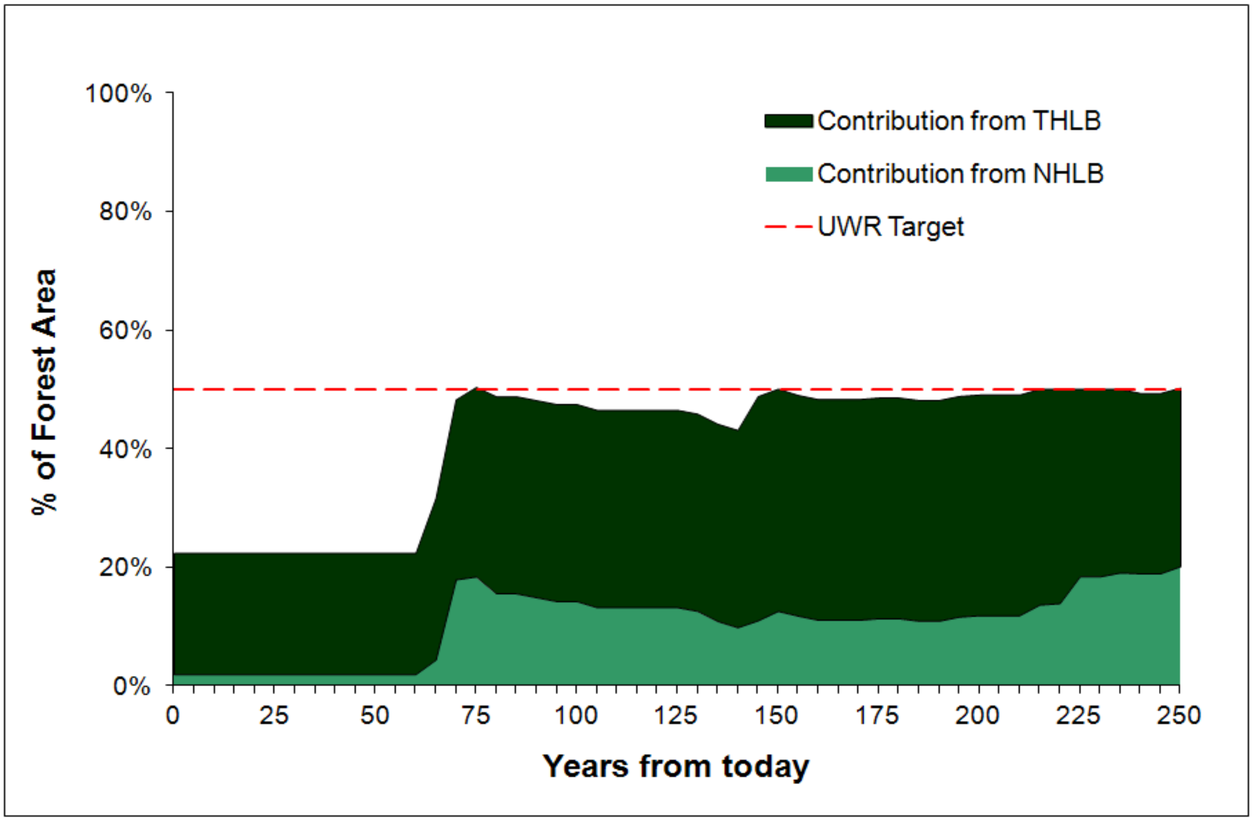


Figure 26: A UWR unit in violation or severely constrained over the modelling period; UWR 7-011, VD-005

2.1.2.4 Visual Quality Objectives

Visually effective green-up (VEG) heights were used to model the protection of visual values. For the VQO areas, the targets range from 0% to 30% as the maximum that can be under the minimum height. The targets are described in more detail in the Data Package (FESL, 2013).

Figure 27 shows an example of a VQO target, for Partial Retention areas within Vanderhoof Resource District, with an average slope between 5% and 10%. This area has a total of 27,285 ha of CFLB with the target of maximum of 18% that can be less than 3.5m in height. This unit is in violation during the mid-term due to the accelerated harvest and the breakup of dead pine.

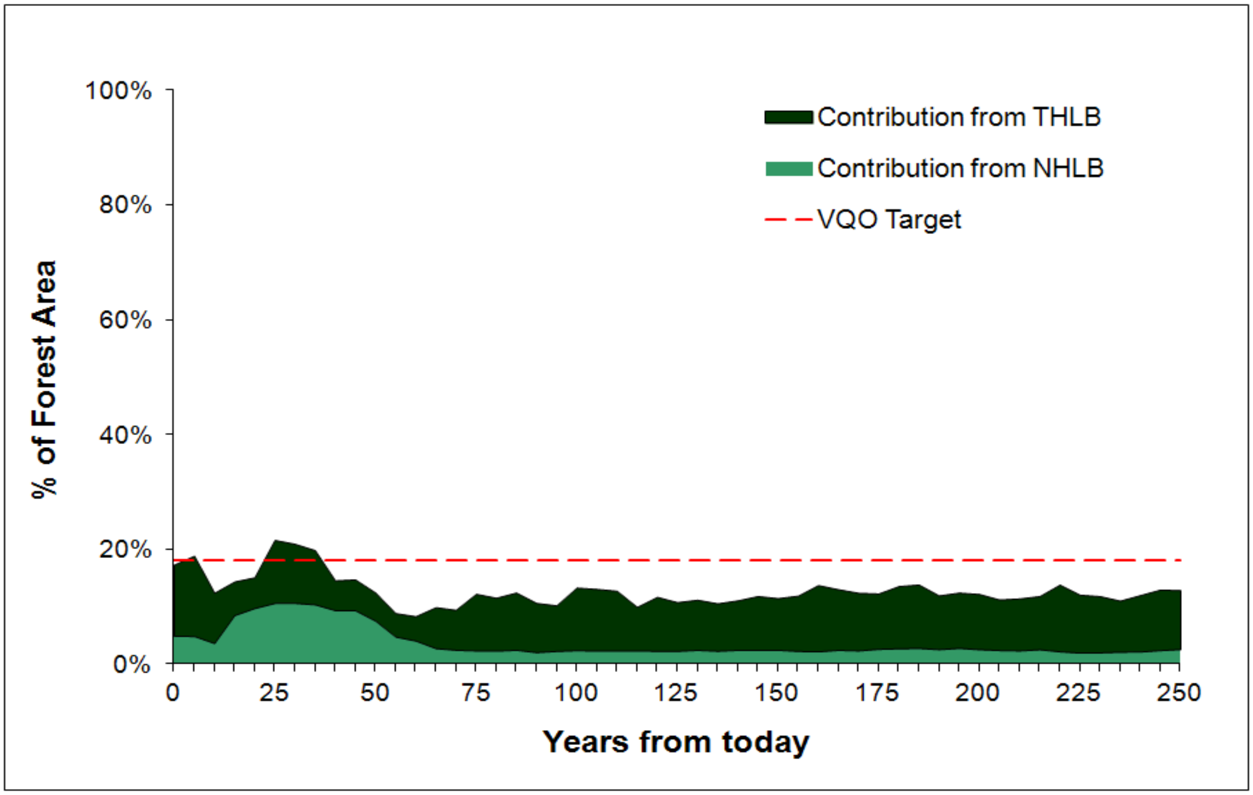


Figure 27: Example of VQO target

2.2 Sensitivity Analyses

The focus on the harvest of dead pine stands is important for the mid-term timber supply; if these stands do not get harvested, the forest estate model will attempt to meet the harvest target from green spruce and balsam stands that should be left to supply the timber for the mid-term. In the Base Case 436,000 ha of severely attacked pine stands were not harvested in spite setting the model harvest priorities in such a way as to maximize the harvest of these stands. The potential reasons for this are many:

1. The lack of harvest in these stands may reflect reality and the volume of merchantable timber within them; the MPB killed timber may already be past its shelf life and does not get harvested because the merchantable volume for sawlog production has diminished and the stands are not economic to harvest. If this is the case, the short-term harvest should likely be lower than modeled in the Base Case to conserve growing stock for the mid-term.

2. The Base Case analysis employed 5-year time steps in the forest estate model. Some MPB attacked stands may be merchantable with an adequate volume per ha at the start of the planning horizon and the first 5-year period. However, due to the shelflife assumptions used in the model the merchantable volume may have declined and become unmerchantable by the midpoint of the 5-year period when the harvest takes place in the forest estate model. The sensitivity analysis below tested the potential impact of a 5-year time step on the volume of harvested dead pine (Section 2.2.1)

3. Other factors that may limit MPB salvage are biodiversity objectives and visual quality objectives. The sensitivity analysis below tests the impact of biodiversity objectives and visual quality objectives on the harvest of dead pine (Section 2.2.2).

2.2.1 Impact of 5-year time steps on MPB salvage

The forest estate model was run for 5 years with 1-year time steps to test whether the 5-year time steps had an impact on the salvage of high severity MPB attacked stands,. The result is shown in Table 3. Using 1-year time steps resulted in a moderate 2.6% increase in the salvage of high severity attack MPB stands compared to the Base Case. The bias created by 5-year time steps is negligible compared to the total area of high severity attack MPB stands (436,000 ha) that remain unharvested in the Base Case

Table 3: High Severity MPB salvage, 1-year time steps for 5 years

High Severity MPB	Base Case	1-year time steps	
	Salvage (ha)	Salvage (ha)	Difference from Base Case (ha)
50-70 MPB attack	87,916	90,406	2,490
70-90 MPB attack	37,952	38,572	619
>90 MPB attack	6,817	7,168	351
Total	**132,685**	**136,146**	**3,461**

2.2.2 Impact of biodiversity objectives and visual quality objectives on MPB salvage

Table 4 shows the result of a timber supply run where all the biodiversity and visual constraints were removed; removing these constraints resulted in an insignificant increase in salvage. In cases where greater than 70 percent of the stand was dead, the salvage was decreased from the Base Case. Further investigation revealed that the biodiversity targets in the Base Case forced the salvage to move to the Fort St James Resource District which enabled these dead stands to be salvaged earlier while they were still merchantable. In the model run with no biodiversity or visual constraints, the model was free to harvest all high priority Vanderhoof and Prince George District dead pine stands before moving on to the Fort St. James salvage. For severely attacked categories (70%+ mortality) this was too late and the volume was lost.

Table 4: High Severity MPB salvage, under different modelling conditions

High Severity MPB	Base Case	No biodiversity or VQO	
	Salvage (ha)	Salvage (ha)	Difference from Base Case (ha)
50-70 MPB attack	87,916	90,229	2,314
70-90 MPB attack	37,952	36,869	-1,083
>90 MPB attack	6,817	6,434	-384
Total	**132,685**	**133,532**	**847**

3 Strategies and Scenarios

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 are 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 which 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. This strategy was not modeled using scenario analysis.

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. The impact of fertilization treatments were investigated through scenario analysis.

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. In the Base Case a total of 436,000 ha dead pine stands were not harvested and were assumed to break up in the forest estate model. 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 impact of rehabilitating MPB-attacked stands was investigated through scenario analysis.

4. Enhanced 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 with 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 and partial cutting.

   This analysis tested the potential impacts of enhanced reforestation.

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.

This analysis investigated the impact of including currently uneconomical areas (due to lack of access) on the mid-term timber supply. Upon harvesting these stands would become managed stands providing long term benefits as well.

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 than that in the Base Case.

   This analysis tested the timber supply impact of allowing smaller piece sizes in the future harvest of existing managed stands and future managed stands.

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.

3.1 Harvest Scheduling

3.1.1 Lower Initial Harvest

This scenario tested the impact of lowering the initial harvest level to 9.364 million m^3 per year. This initial harvest level is the pre-MPB AAC prior to 2006, when the AAC was increased to current 12.5 million m^3 per year to facilitate accelerated harvesting and salvaging of attacked and dead pine stands.

Figure 28 shows the forecasted harvest for this scenario compared to the Base Case. While the mid-term harvest is slightly higher (270,000 m^3/yr above the Base Case), it does not offset the decrease in the initial harvest level and the decrease in harvest between years 56 and 125. Overall, this scenario provides 10 million m^3 less total harvest between years 1 and 125 when compared to the Base Case.

Regardless of the lower initial harvest level, non-attacked natural stands are still harvested in the short term in this scenario (Figure 29). This is the result of the harvest priority that was set for the model; pine stands older than 60 years of age were to be harvested first regardless of their attack status. As not all the pine stands were attacked, some of the harvest in the model took place in the older pine stands that were not attacked by the MPB. The harvest of dead pine in this scenario is almost 4 million m^3 less than in the base case (Table 5).

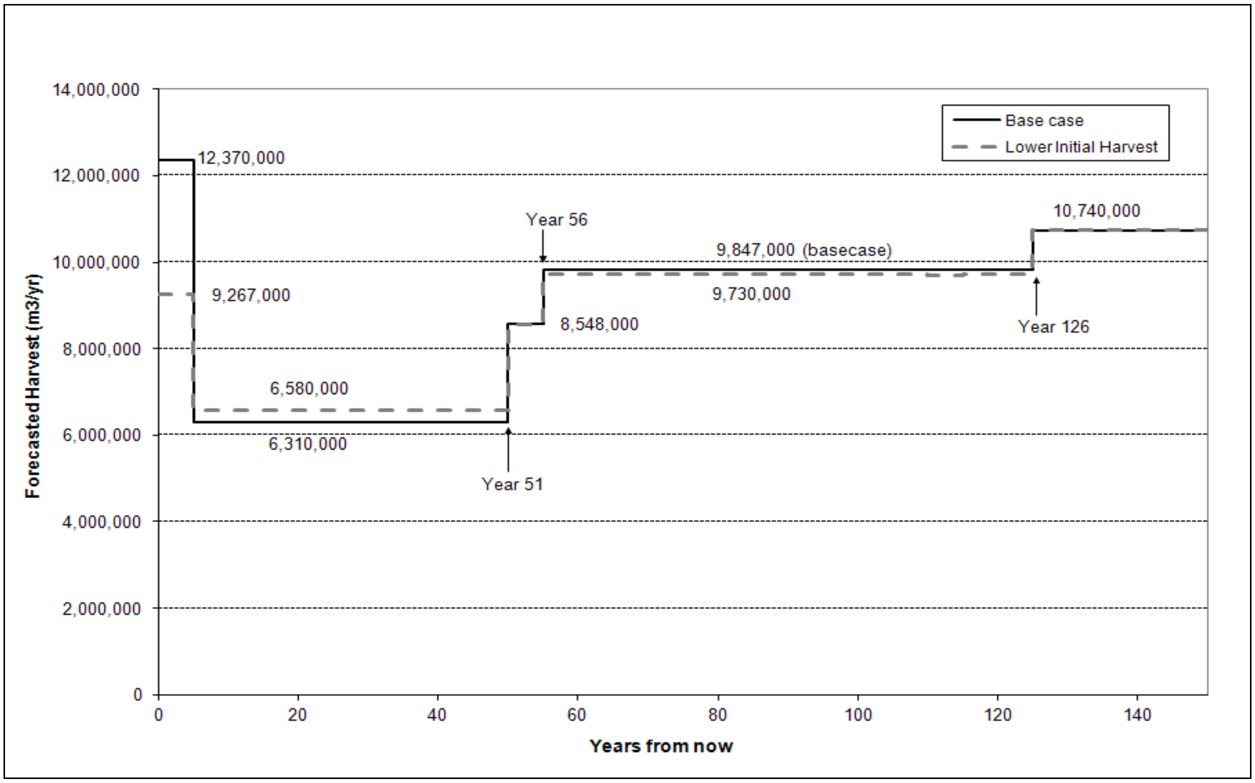


Figure 28: Harvest forecast, lower initial harvest scenario

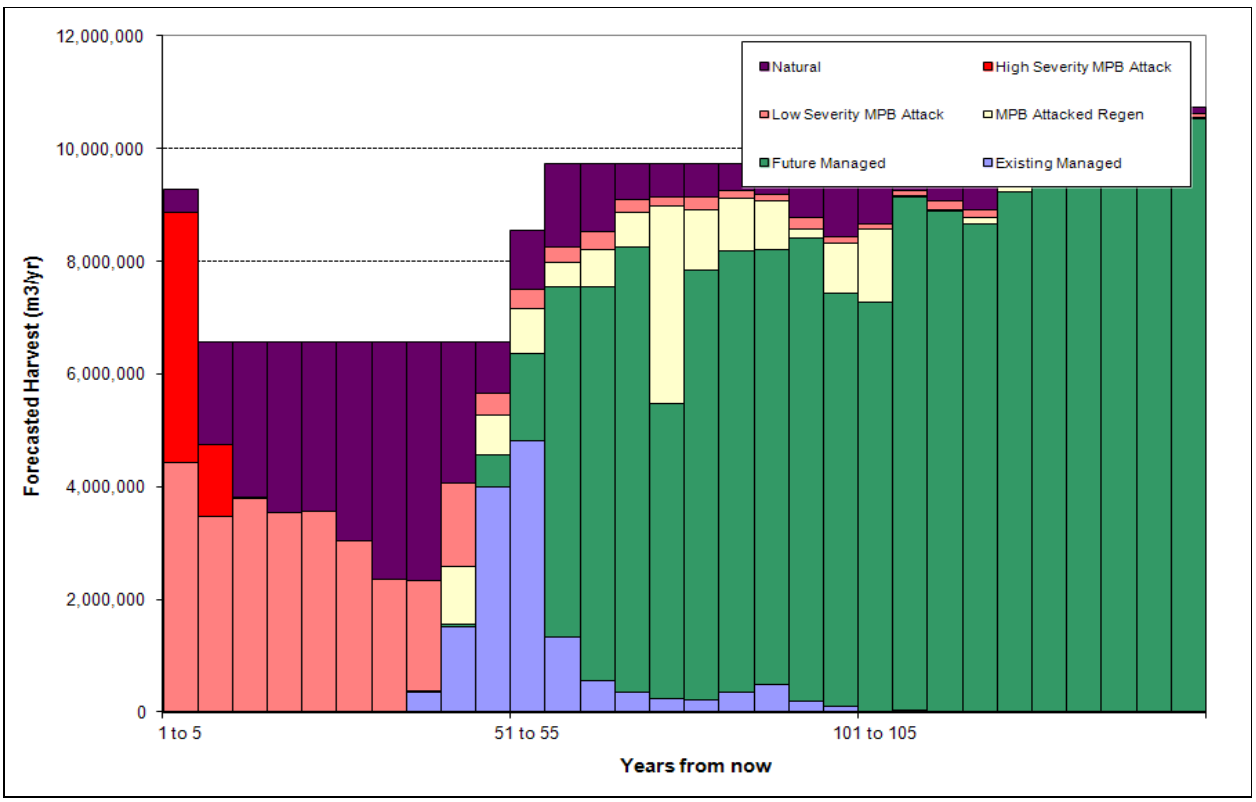


Figure 29: Harvest forecast by yield type; lower initial harvest scenario

Table 5: Dead pine harvest throughout the planning horizon

	Base case (m^3)	Lower initial harvest (m^3)	Difference (m^3)
Dead pine harvest	22,838,070	18,843,394	-3,994,676

The lower short-term harvest results in less harvest in all yield type categories (high severity MPB, low severity MPB and natural stands) (Table 6). While much of the dead pine component of the high and low severity MPB stands deteriorates by the second five year period, the remaining live overstory in these stands allows them to contribute to the midterm harvest level. The later harvesting of these stands (overstory) - compared to the base case - allows some natural stands to be harvested later in this scenario than in the base case.

Table 6: Comparison of Lower Initial Harvest scenario harvest by yield type

Years from now	Difference between lower initial harvest and base case (m^3/anually)		
	High Severity MPB Attack	Low Severity MPB Attack	Natural
1 to 5	-1,750,231	-1,192,777	-157,099
6 to 10	720,305	104,514	-557,924
11 to 15	3,402	169,413	94,428
16 to 20	756	41,408	225,098
21 to 25	0	208,418	59,026
26 to 30	0	285,699	-18,079
31 to 35	0	88,060	179,163
36 to 40	0	103,597	171,804
41 to 45	0	19,652	16,803
46 to 50	0	-24,640	11,776

3.1.2 Impact of Minimum Harvest Criteria on the Mid-Term Timber Supply

This scenario tested the impact of using minimum harvest volumes alone for the minimum harvest criteria, instead of MAI culmination as in the Base Case. The minimum harvest volumes employed were 182m^3/ha in the road portion of the TSA and 246m^3/ha in the rail portion accessible portion of the TSA. These volumes were the same as those used in the latest TSR and were generally lower than the ones that were modeled in the Base Case as a result of the MAI culmination rule.

Figure 30 shows the resulting harvest level compared to the Base Case. As the model harvested managed stands at smaller volumes they were harvested sooner than in the Base Case. The harvest of existing managed stands (currently age 16 to 25) in this scenario starts at year 26 (36 in the Base Case) and between years 31 and 35 approximately 50% of the volume is predicted to come from existing managed stands. The midterm harvest level in this scenario - at 8.4 million m^3/year - is 33% higher than that of the Base Case. The long term harvest level of 9.2 million m^3/year starts at year 91; however it is 14% lower than the Base Case harvest level of 10.7 million m^3/year.

The increased harvest during the midterm results in a lower total growing stock as compared to the Base Case (Figure 31).

Figure 32 shows the harvest by species for this scenario. The increased harvest in the mid-term is almost entirely attributable to the harvest of existing managed pine and spruce stands starting at year 26.

The harvest by yield type is shown in Figure 33. The lower minimum harvest criteria in managed stands allow their harvest to start 26 years from now, while in the Base Case the managed stand harvest started at year 36.

The harvest by age class is displayed in Figure 34. Compared to the Base Case, much more of the mid-term and future harvest is composed of age class 3 stands. This is also reflected in Figure 35 illustrating the predicted stand volumes for this scenario. The harvesting of younger stands in the future results is much lower stand volumes than in the Base Case. Note that since the minimum harvest volume is 182 m^3/ha the lowest class shown is 182 to 200 m^3/ha.

Figure 36 illustrates the harvest forecast in this scenario by resource district. Significant harvest during the midterm in Vanderhoof starts 15 years sooner than in the Base Case due to the lower MHA for managed stands. Most of these stands are pine stands contributing to the harvest of pine starting 26 years from now.

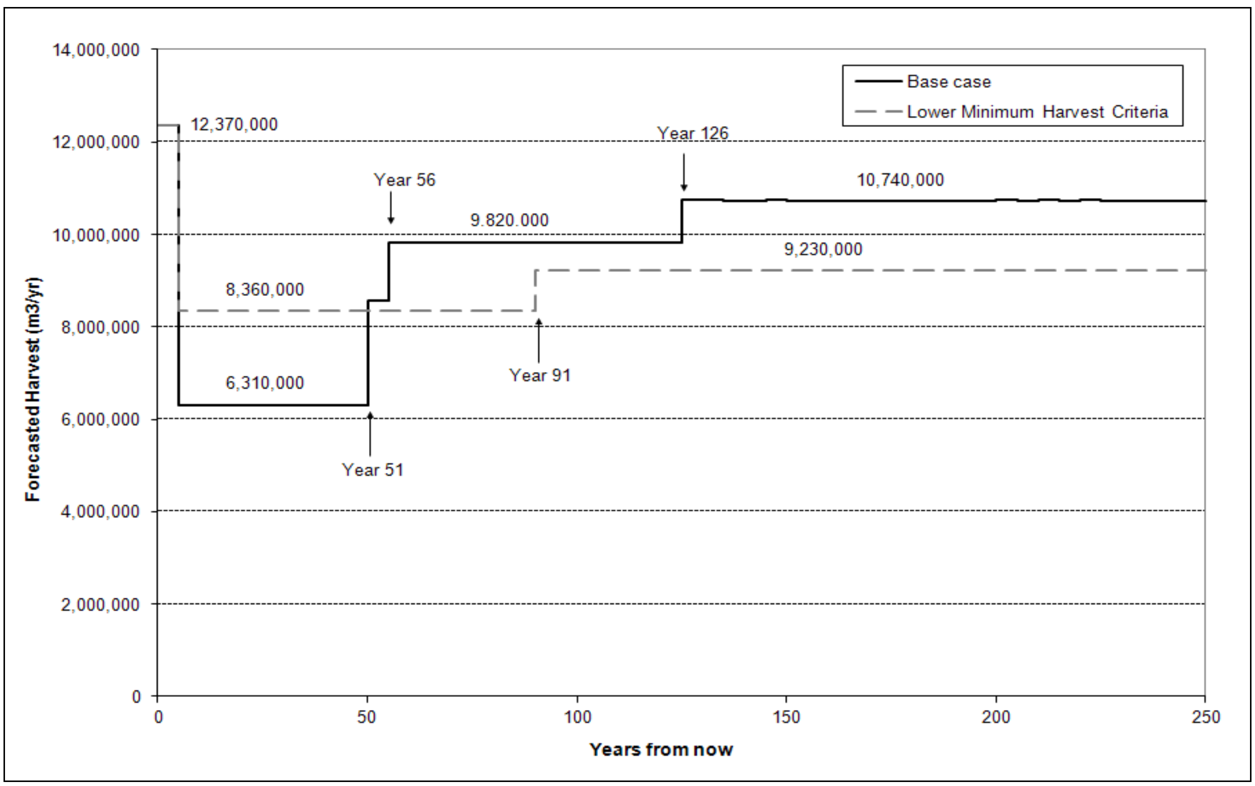


Figure 30: Harvest forecast; lower minimum harvest criteria

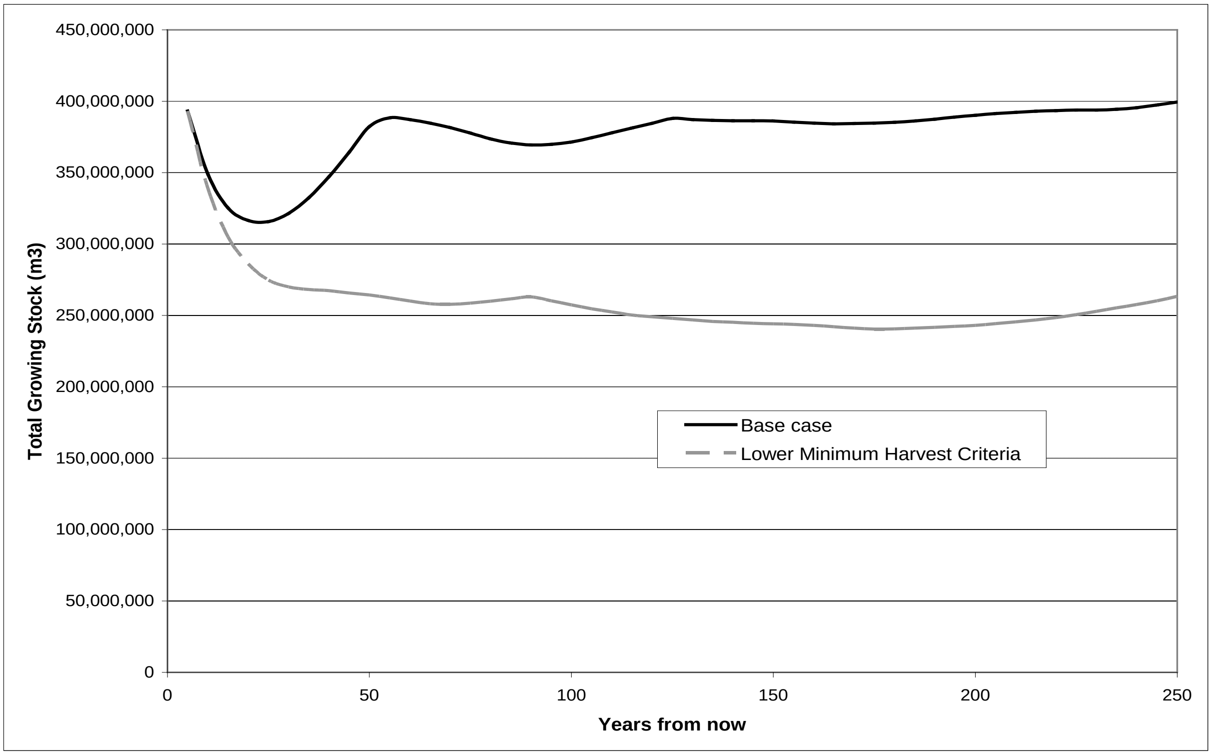


Figure 31: THLB growing stock; Base Case and lower minimum harvest criteria

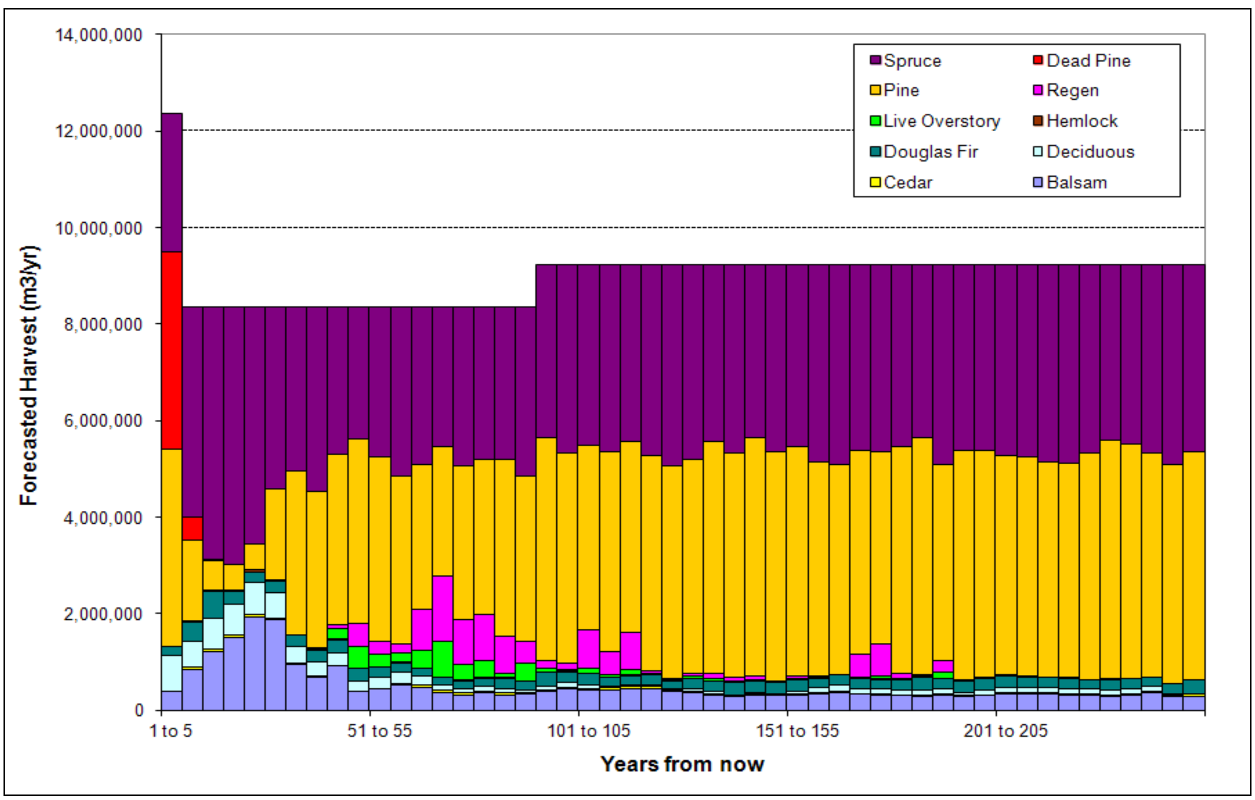


Figure 32: Harvest forecast by species; lower minimum harvest criteria

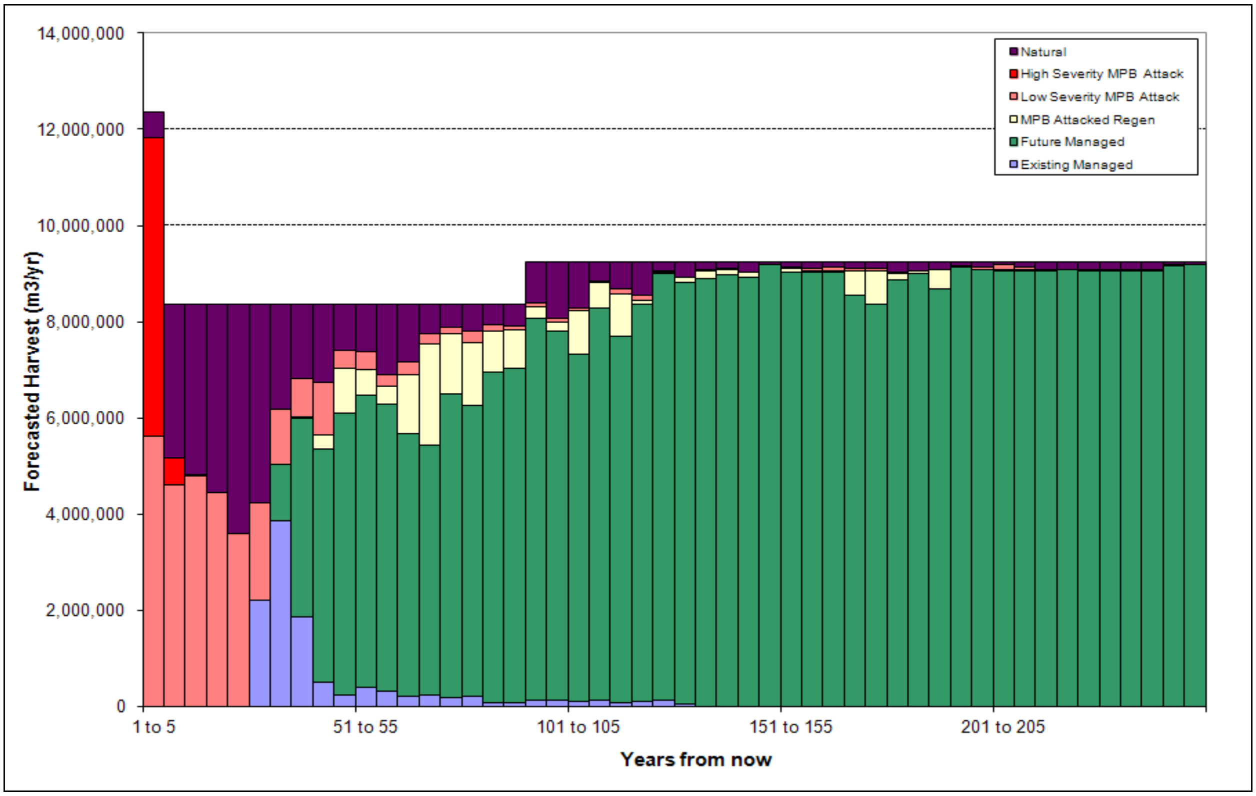


Figure 33: Harvest forecast by yield type; lower minimum harvest criteria scenario

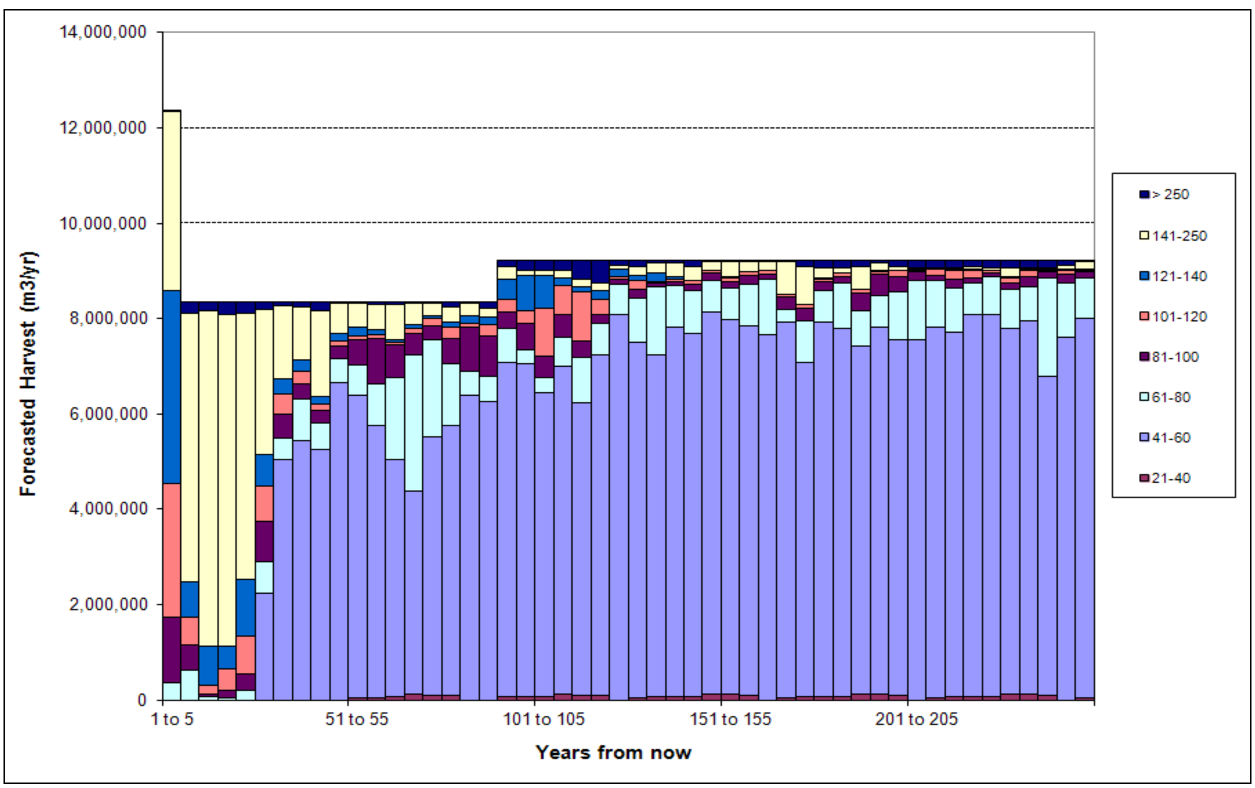


Figure 34: Harvest forecast by age class; lower minimum harvest criteria

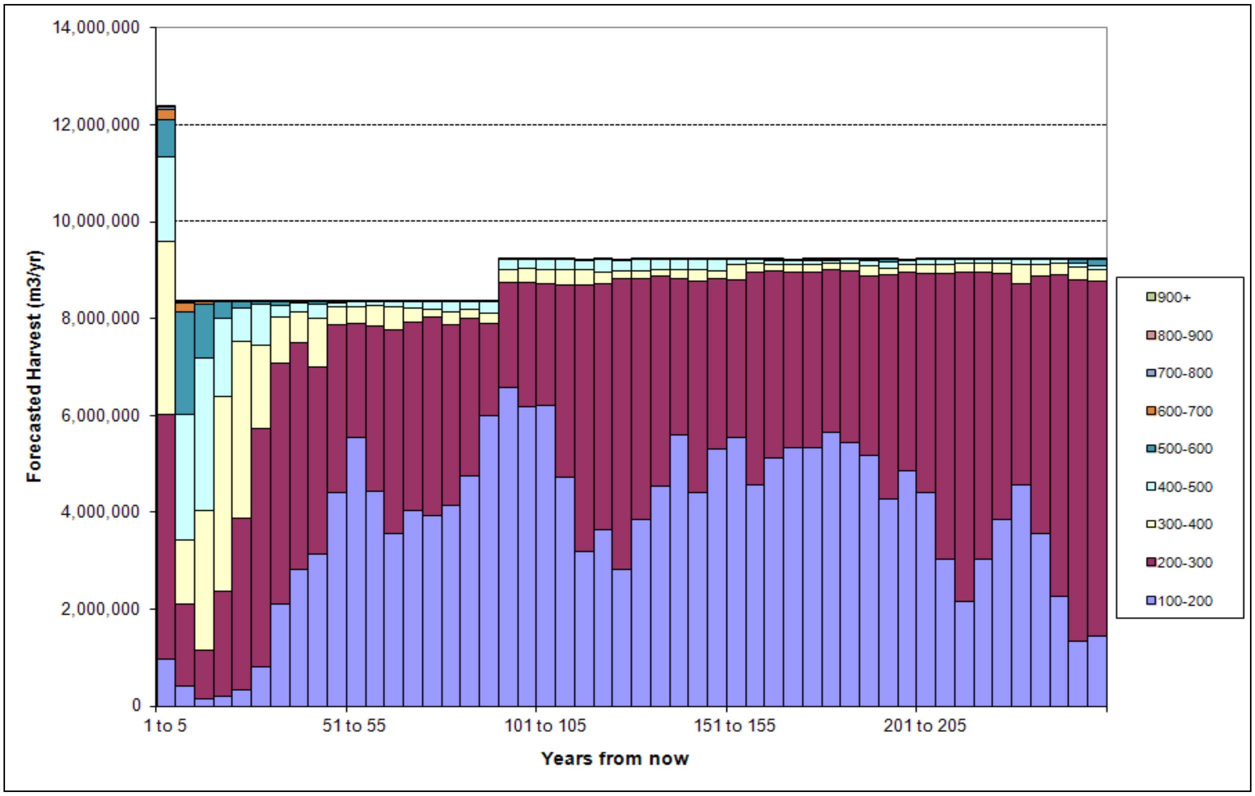


Figure 35: Harvest forecast by volume class, lower minimum harvest criteria

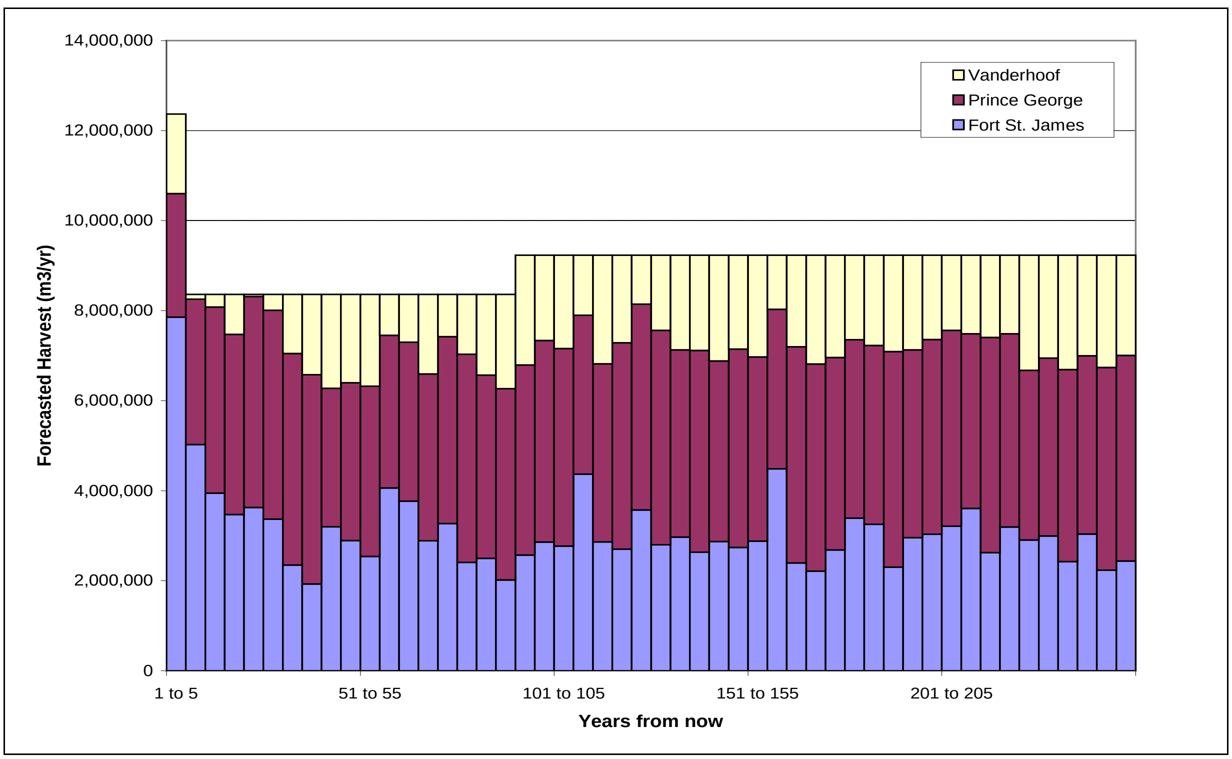


Figure 36: Harvest forecast by Natural Resource District; lower minimum harvest criteria

3.2 Silviculture Scenarios

3.2.1 Opportunities

The Base Case provides a starting point for assessing potential silviculture strategies that may improve the mid-term timber supply in the Prince George TSA (Figure 37). In the Base Case approximately 436,000 ha of severely attacked dead pine stands were not harvested; these stands remain in the landscape as a potential fire hazard. They will also stay as a drag on the timber supply for years to come. The rehabilitation of these stands or a portion of them will reduce the fire hazard and likely increase the timber supply in the late mid-term and the early long term. Most of the rehabilitation opportunities are in the Vanderhoof Resource District.

There are limited opportunities to increase the growth and yield of natural stands in the Prince George TSA. The harvest in the near mid-term comes mostly from age class 8 stands, which are too old for incremental silviculture treatments (fertilization). Opportunities exist in natural stands that are currently between 26 and 60 years old. These opportunities are in the Prince George and Fort St. James Resource Districts (Figure 38 and Figure 39). In Vanderhoof, the small merchantable growing stock and limited harvest for the next 45 years provides few opportunities for improving the mid-term through silvicultural treatments of natural stands (Figure 40).

The harvest of existing managed stands starts in the Base Case between years 36 and 40. Increasing the growth and yield of existing managed stands that are currently between 15 and 25 years old may allow for a higher mid-term harvest level or an earlier shift to higher level of harvest. Locally, most opportunities appear to exist in the Prince George Resource District due to a larger inventory of age class 2 and 3 stands.

There are uncertainties associated with the health and quality of the age class 2 and 3 stands. Therefore, the assumptions used in the Base Case to model these stands are also subject to uncertainty and risk. One of the priorities for the Prince George TSA stakeholders is an assessment of the managed stands that will dominate the harvest in the late mid-term.

Improving basic reforestation in the TSA was rated high as an action item with the TSA stakeholder group. This strategy is expected to impact mostly the long term timber supply.

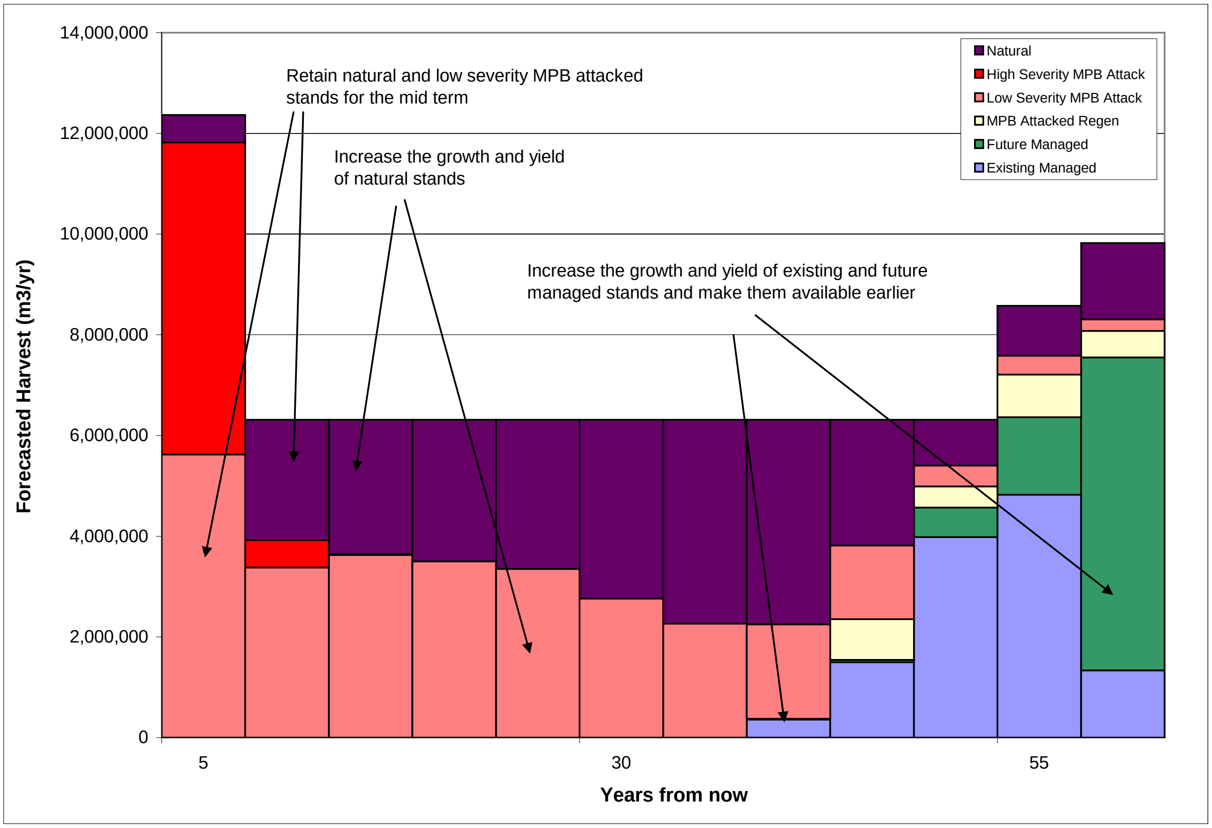


Figure 37: Base Case; mid-term silviculture opportunities, entire TSA

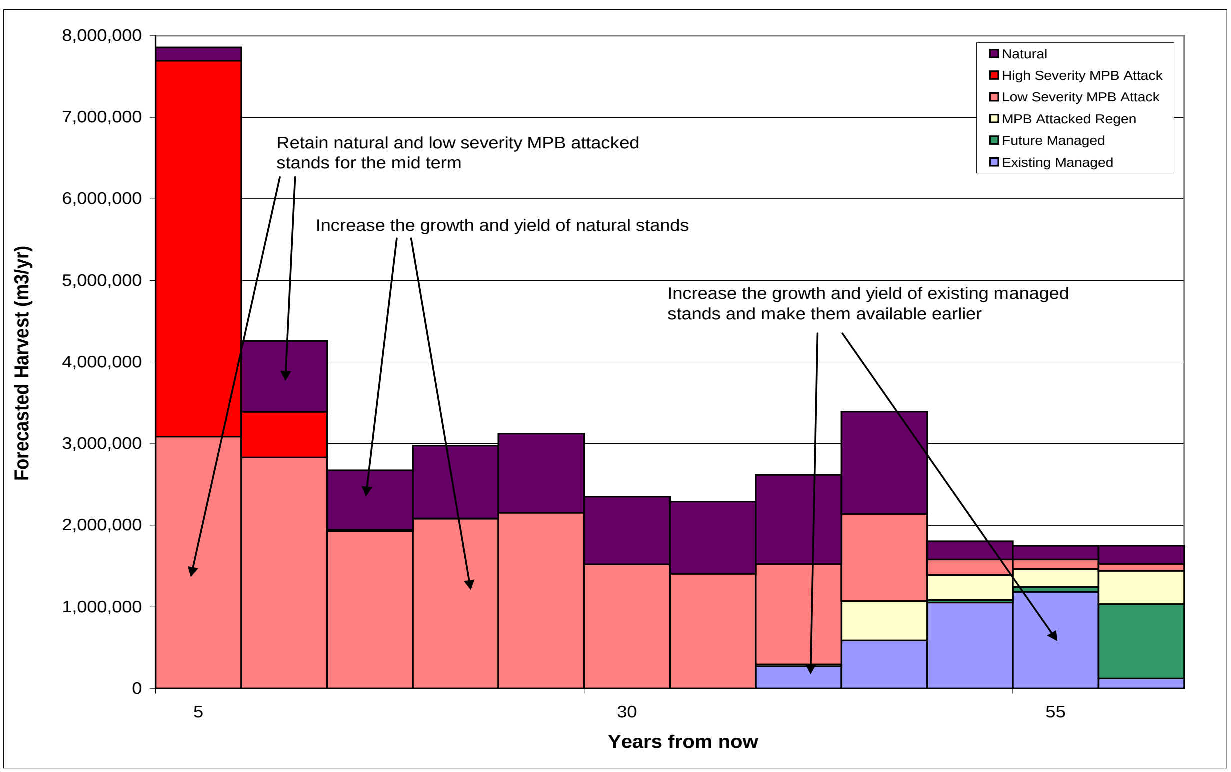


Figure 38: Mid-term silviculture opportunities in Fort St. James Resource District

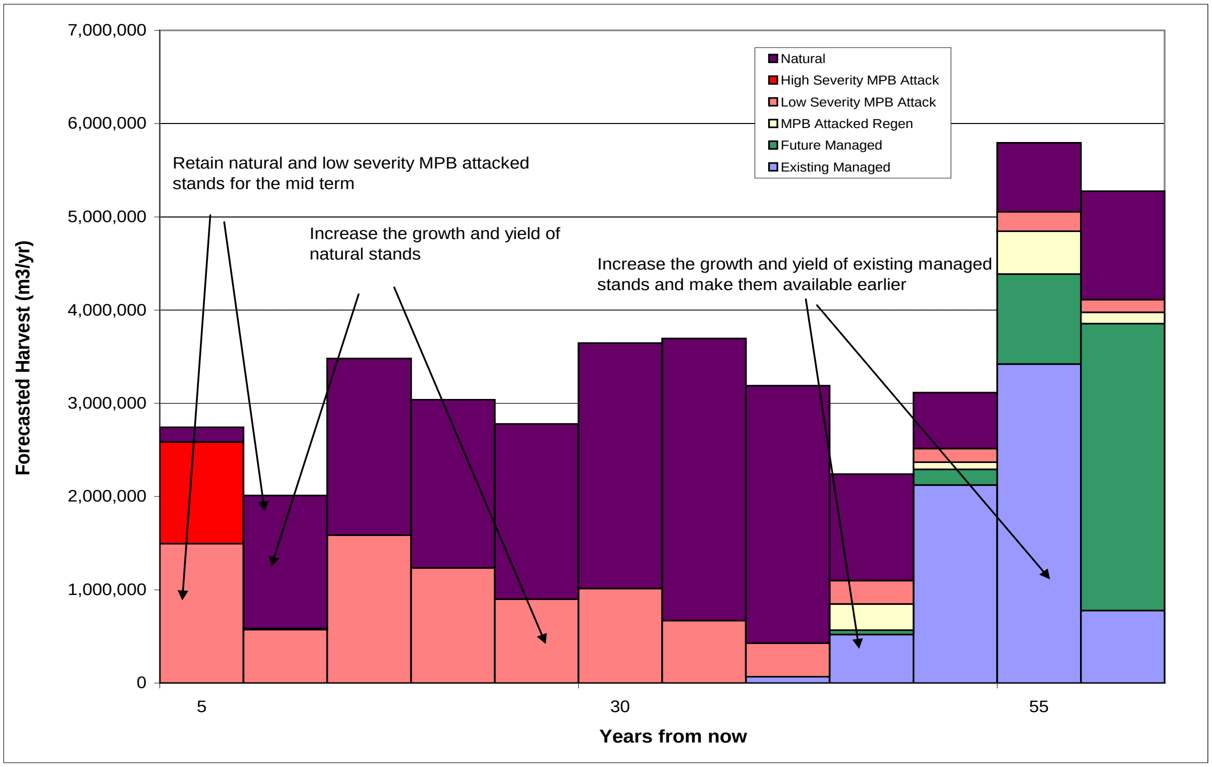


Figure 39: Mid-term silviculture opportunities in Prince George Resource District

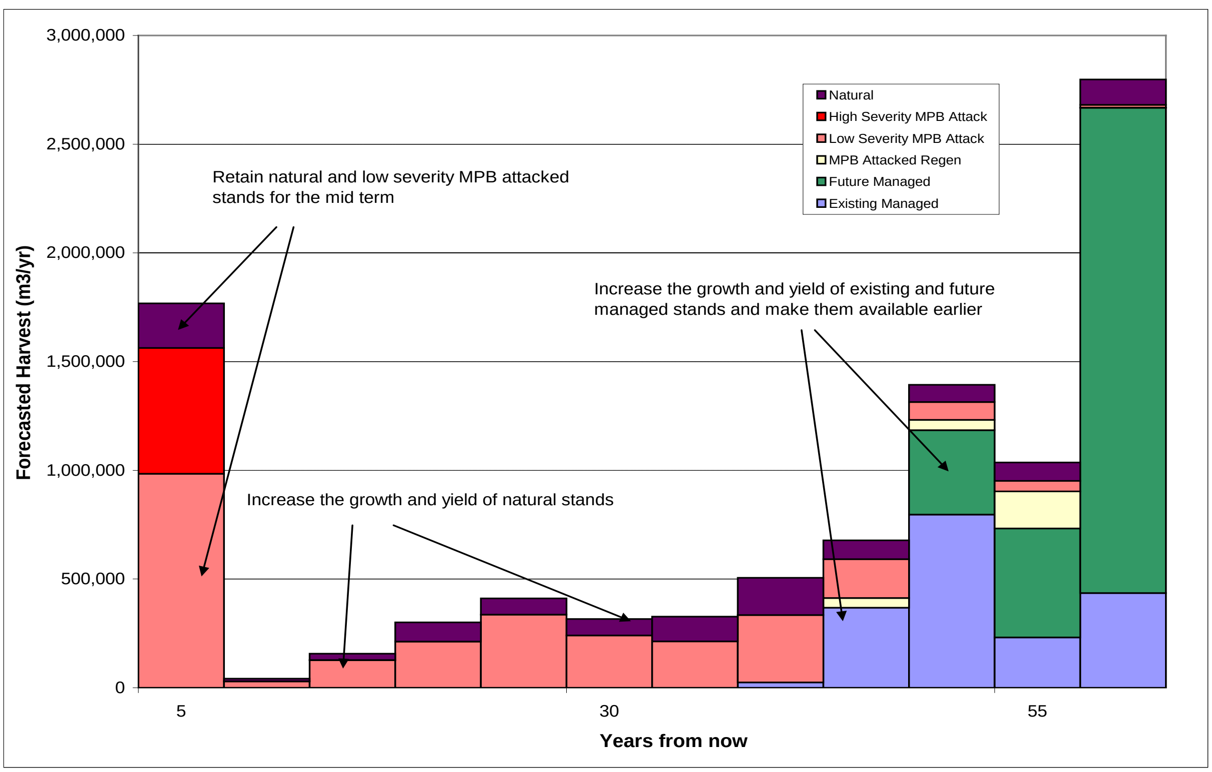


Figure 40: Mid-term silviculture opportunities in the Vanderhoof Resource District

3.2.2 Scenario Approach

In many of the following scenarios the bookend approach was adopted. Initially, the timber supply impacts were tested by treating all the theoretically available areas in the model regardless of access, financial feasibility or actual condition of the treated stands. This was expected to generate the maximum theoretical treatment impacts. Subsequently, the intent is then to use stand-level analysis to identify the preferred stand types for treatment and net down the treatment populations based on the stakeholders estimates of the extent of the opportunity areas in the TSA. Next, the desired treatments are combined into one scenario, the preferred scenario. This scenario will then form the basis for the silviculture strategy in the Prince George TSA. All the silviculture scenarios were run for the period of 150 years.

3.2.3 Rehabilitation of Dead Pine 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 eventually salvaged by the TSA licensees.

In the Base Case approximately 436,000 ha of MPB attacked stands were not harvested within the first 20 years; these stands had lost most of their merchantable sawlog volume due to decay and were assumed to break up in the timber supply model. This population was reduced by removing stands with less than 70% dead trees as the residual volumes in these stands can contribute to the timber supply later in the midterm. The remaining area of 282,888 ha was considered to be the maximum treatable area. While significant areas exist in Fort St. James and Prince George Districts, the majority of the area is located in the Vanderhoof Natural Resource District (Table 7).

Table 7: Rehabilitation population areas (ha) by Natural Resource District

Scenario	Fort St. James	Prince George	Vanderhoof	Total
Rehab MPB	57,843	51,070	173,975	282,888

The theoretical spatial locations of the treated stands are shown in Figure 41. This area was assumed to be treated during the first 5 years at the total cost of $566 million ($2,000 per ha); **$113 million annually over the next 5 years**. The assumed rehabilitation treatment consisted of overstory removal followed by planting. Note that in this scenario incidental volumes that may be covered during rehabilitation operations were not included in the mid-term timber supply.

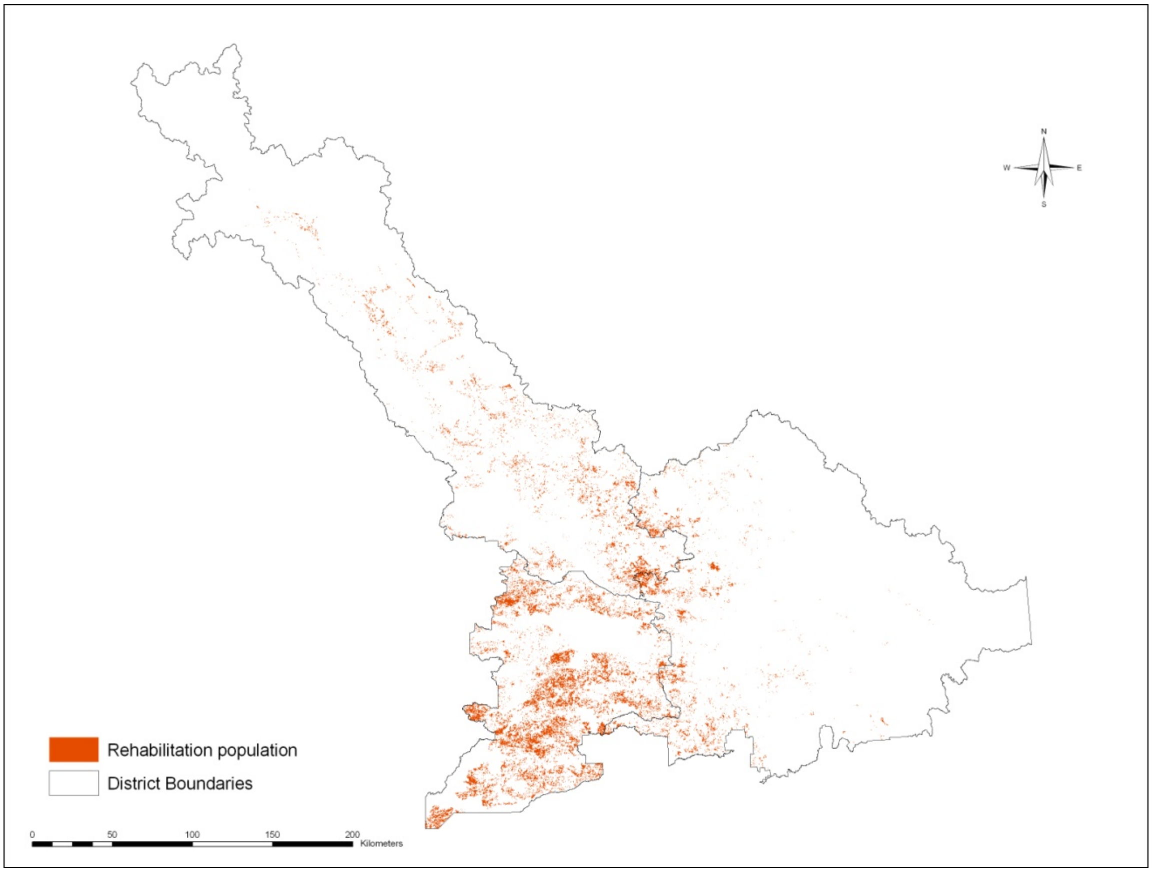


Figure 41: Theoretical location of rehabilitated stands

As shown in Figure 42, the harvest level up to year 60 is the same or slightly lower than that of the Base Case. The annual harvest increases by 800,000 m^3/year or 8% over the Base Case harvest level from year 61 to year 125. This result was surprising; it was expected that a large rehabilitation program such as the one modeled in this scenario would have a positive mid-term timber supply impact.

Further investigation revealed that the lack of timber supply response to this treatment was caused by at least two factors:

1. The MAI culmination rule was used as the minimum criterion for harvest eligibility. This rule prevents the harvest of the rehabilitated stands until late in the mid-term. This is illustrated in Figure 43; the rehabilitated stands do not become available for harvesting until year 61 with most of the harvest occurring in years 71-75. It is probable that in an operational context some flexibility would exist as to the actual minimum harvest criteria and some of these stands would be harvested prior to their modeled minimum harvest ages.

2. In the Base Case the unharvested stands were set to break up at year 20; their ages were adjusted to 20 in the timber supply model. This age change caused a corresponding change in the seral stages of these stands as in most cases mature and old seral stages were switched to an early seral stage. While the change in seral stages constrained the Base Case harvest in the mid-term, the Base Case assumptions allowed the older attacked pine stands to contribute to biodiversity targets for the first two decades of the planning horizon. Rehabilitating these stands was found to be even more constraining. When all the unharvested stands are converted to managed stands (age set to 0 minus regeneration lag) at the beginning of the planning horizon, they immediately cease to contribute to

biodiversity targets. This can be seen in Figure 42 between years 31 to 50 where this scenario has a slightly lower harvest level than that of the Base Case, and between years 51 and 60 where the difference is more notable.

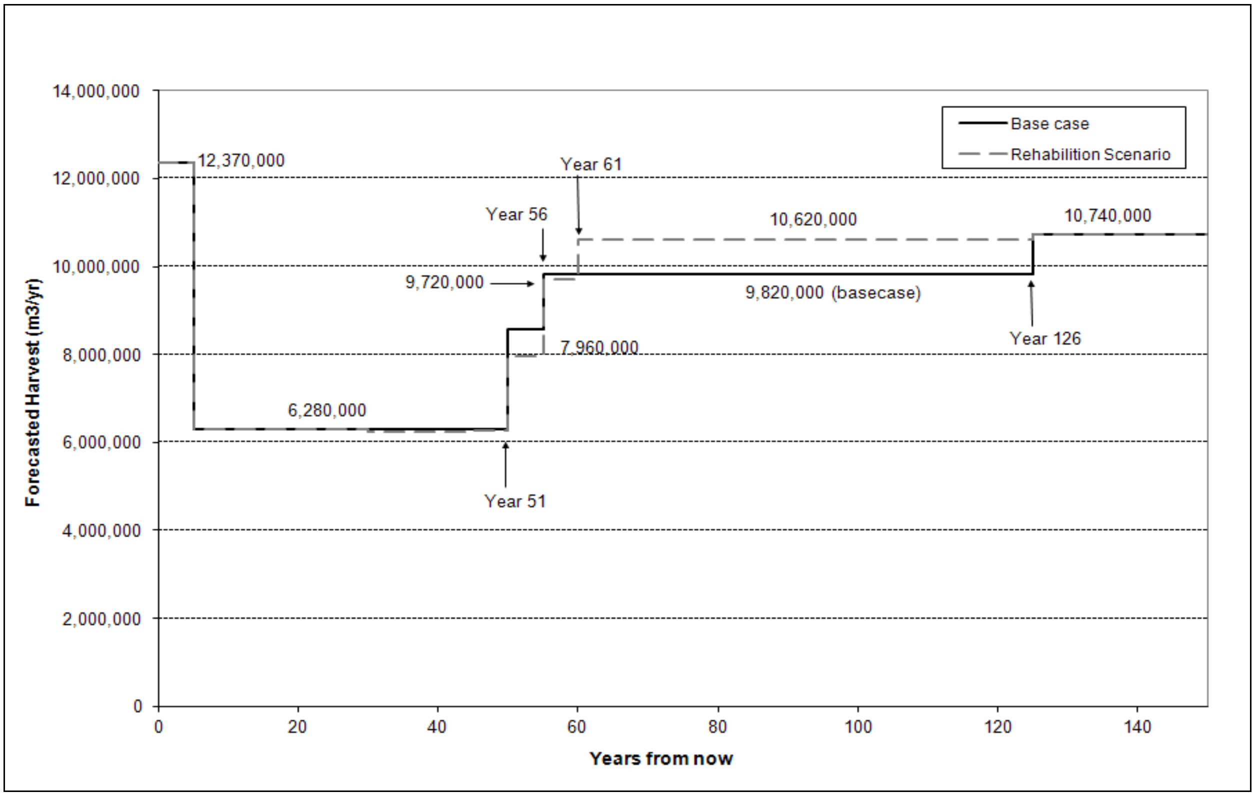


Figure 42: Harvest forecast; rehabilitation of dead pine stands

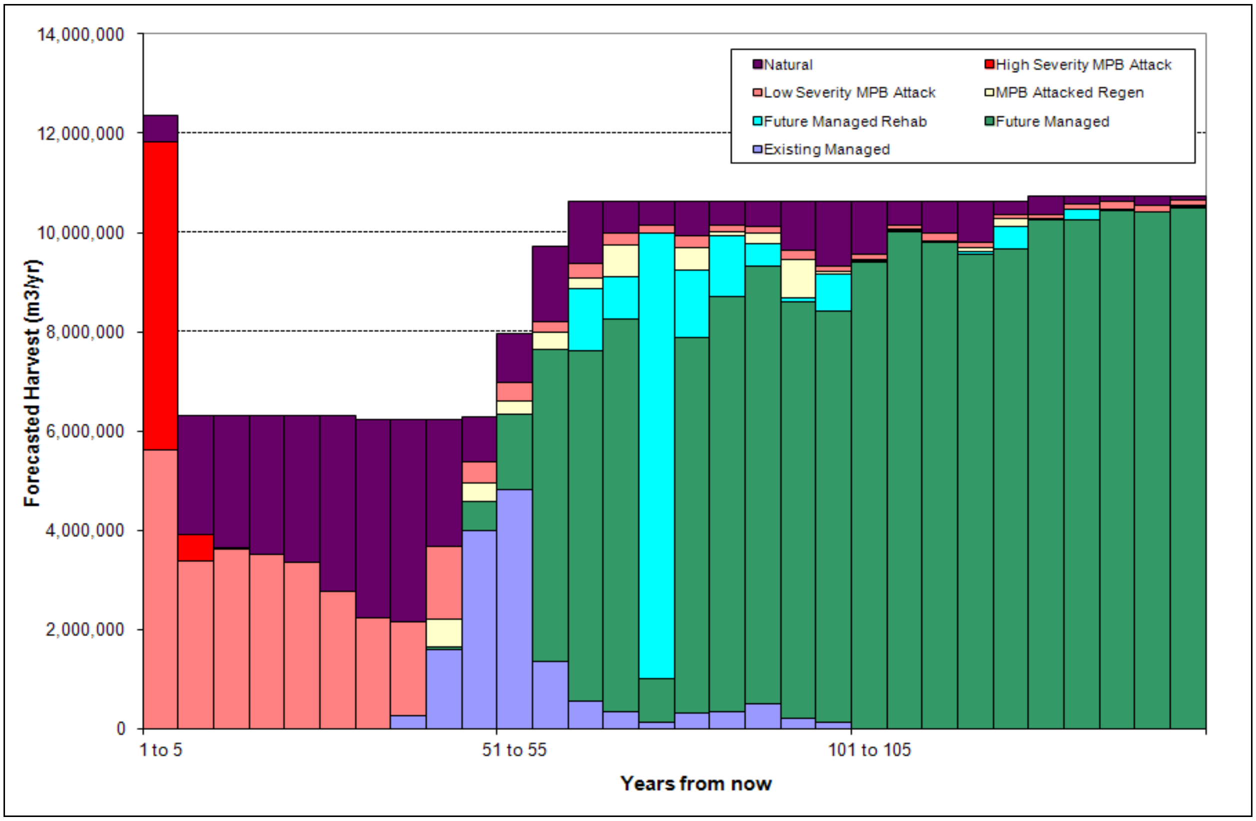


Figure 43: Harvest forecast by yield type; rehabilitation of dead pine stands

3.2.4 Rehabilitation and Fertilization

In this scenario, all the rehabilitated stands were also fertilized up to four times at age 25, 35, 45, and 55. The population is the same as shown in Table 7. The initial cost is the rehabilitation cost with the addition of fertilization at $600/ha starting in year 26. The costs for this scenario are shown in Table 8. The area and cost for fertilization in years 56-60 are lower because some stands are harvested before year 56.

Table 8: Annual treatment areas and costs for rehabilitation and fertilization

Years	Treatment	Annual Treatment Area (ha)	Annual cost
1-5	Rehab	56,578	$113,155,381
26-30	Fertilize	56,520	$33,911,965
36-40	Fertilize	56,520	$33,911,965
46-50	Fertilize	56,520	$33,911,965
56-60	Fertilize	51,974	$31,184,288

The constraints discussed above under section 3.2.3 prevented any additional harvest in the mid-term. As with the previous scenario, the mid-term harvest was actually slightly lower than that of the Base Case. Including fertilization increased the harvest between years 56 to 125 by 820,000 m^3/year over the Base Case; however, the harvest in years 126 to 150 was slightly lower (Figure 44). The rehabilitated stands that are fertilized become available for harvest 5 years earlier than in the rehabilitation only scenario (Figure 45).

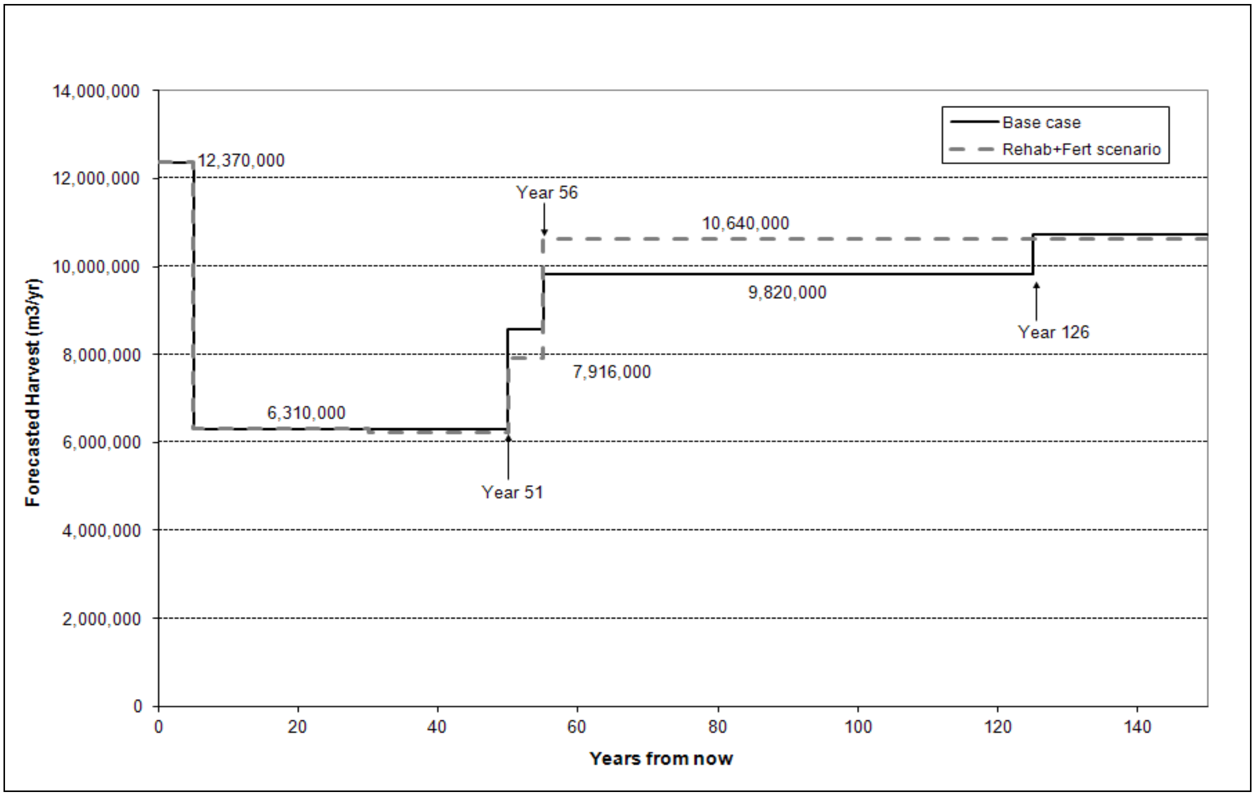


Figure 44: Harvest forecast; rehabilitation of dead pine stands and fertilization

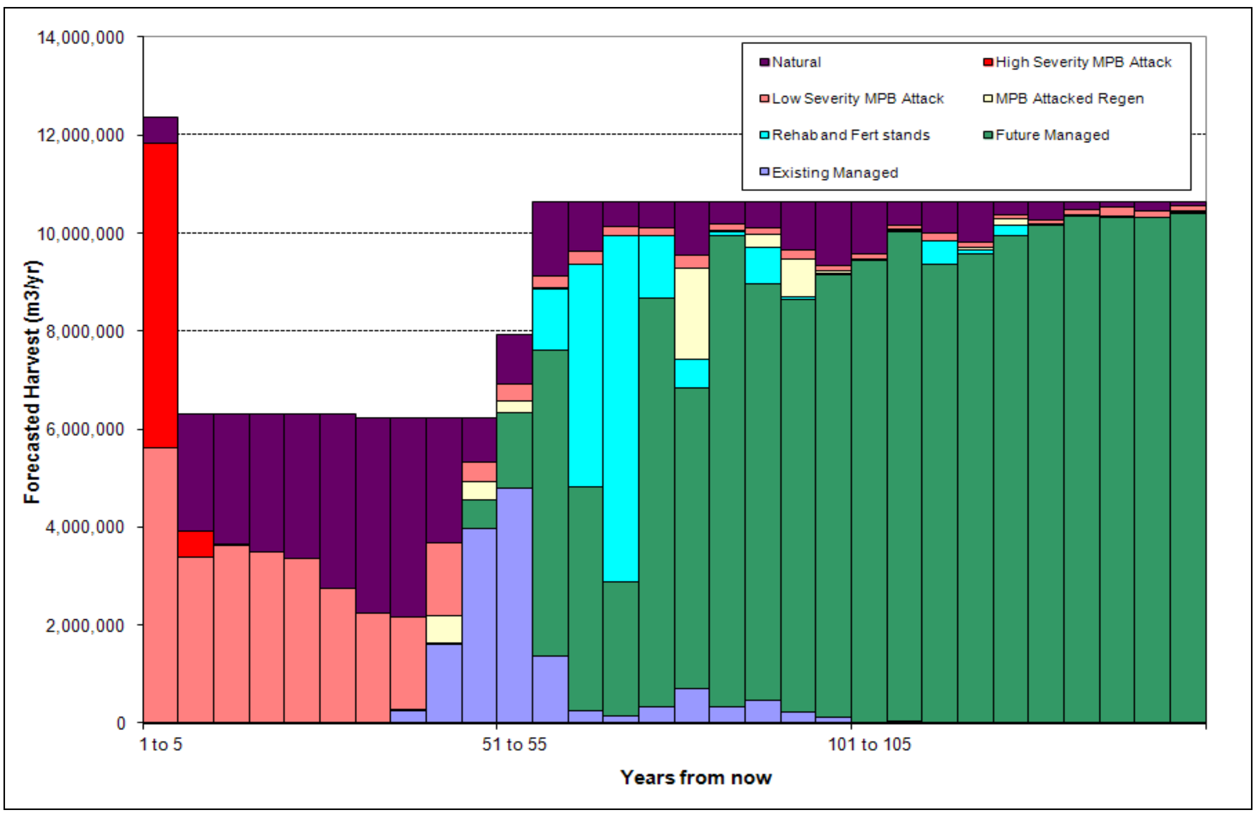


Figure 45: Harvest forecast by yield type; rehabilitation and fertilization

3.2.5 Fertilization

Three fertilization populations were explored:

- Young Natural Stands (ages 26 to 60)
- Existing Managed Stands (ages 16 to 25)
- Current Future Managed Stands (ages 0 to 15)

The areas of these populations are shown in Table 9, and the locations in Figure 46.

Table 9: Fertilization population areas by Natural 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

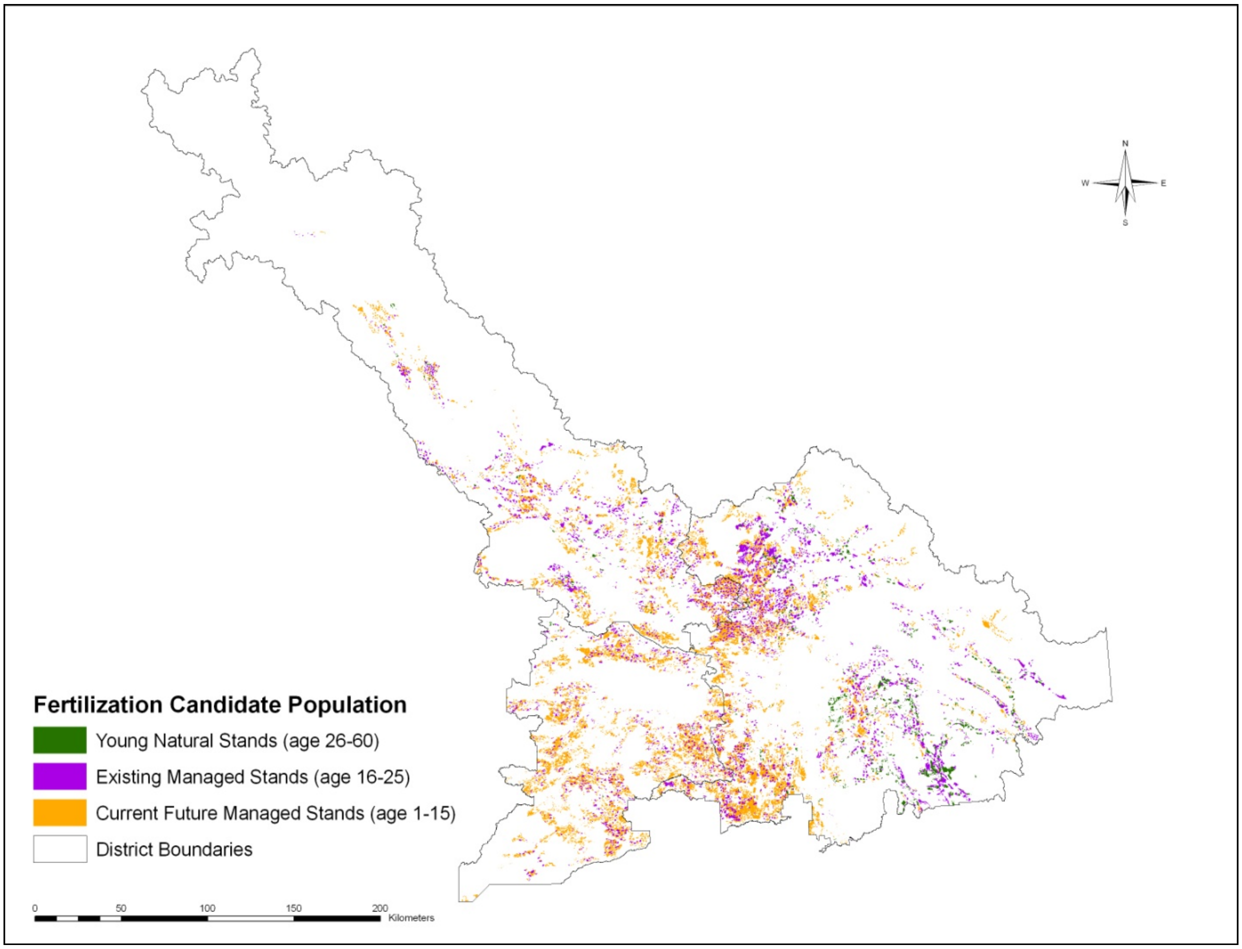


Figure 46: Location of fertilization candidate stands in the Prince George TSA

Fertilization of these populations potentially allows the midterm harvest level to be increased due to either increasing the productivity and volumes at harvest or by allowing stands to be harvested at the same volumes as unfertilized stands but at younger ages.

Four fertilization scenarios were constructed to explore different levels of fertilization in the Prince George TSA. The four scenarios were:

1. Fertilization of young natural stands only;
2. Fertilization of existing managed stands only;
3. Fertilization of existing managed and current future managed stands;
4. Fertilization of all candidate stands.

3.2.6 Fertilization of Young Natural Stands

A total of 48,063 ha of natural stands between 26 and 60 years of age were fertilized in the model. The younger stands had up to 3 fertilization treatments before final harvest, while those over age 45 only had a single treatment. The older natural stands may be harvested soon after fertilization treatments, allowing the investment to be quickly recovered. The candidate fertilization population in this scenario by natural resource district is shown in Table 10.

Table 10: Fertilization population areas by Natural 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
Total	4,910	42,256	897	48,063

Six natural analysis units were selected as fertilization candidates. These are shown in Table 11, along with the minimum harvest ages (MHA) for each. Two of the analysis units are Douglas Fir-leading, while the other four are spruce-leading.

By fertilizing the stands, the minimum harvest volume (MHV) can be met at an earlier age.

Table 11: Fertilization analysis units and minimum harvest ages; young natural stands

Natural Analysis Unit	Area (ha)	MHV (m3/ha)	Base Case MHA	Fertilized MHA by number of treatments		
				1 (age 46-55)	2 (age 36-45)	3 (age 26-35)
Fd_high	805	182	65	64	62	61
Fd_med	1,635	182	82	82	80	77
Sx_5_med	30,105	182	84	84	82	79
Sx_5_high	2,822	182	62	62	61	60
Sx_6_med	9,631	182	70	70	69	67
Sx_6_high	3,066	182	57	57	56	55

The annual fertilization areas and costs for this scenario are shown in Table 12. Almost every candidate stand was fertilized in the first decade with second and third fertilization treatments of younger stands occurring in the future. Figure 47 illustrates the theoretical locations of the fertilized stands in this scenario for the first 10 years.

Table 12: Annual fertilization costs; young natural stands

Years	Annual Fertilization Area (ha)	Annual Cost
1-5	5,556	$3,333,492
6-10	4,703	$2,821,640
11-15	3,790	$2,273,870
16-20	4,328	$2,596,820
21-25	2,912	$1,747,042
25-30	3,224	$1,934,366

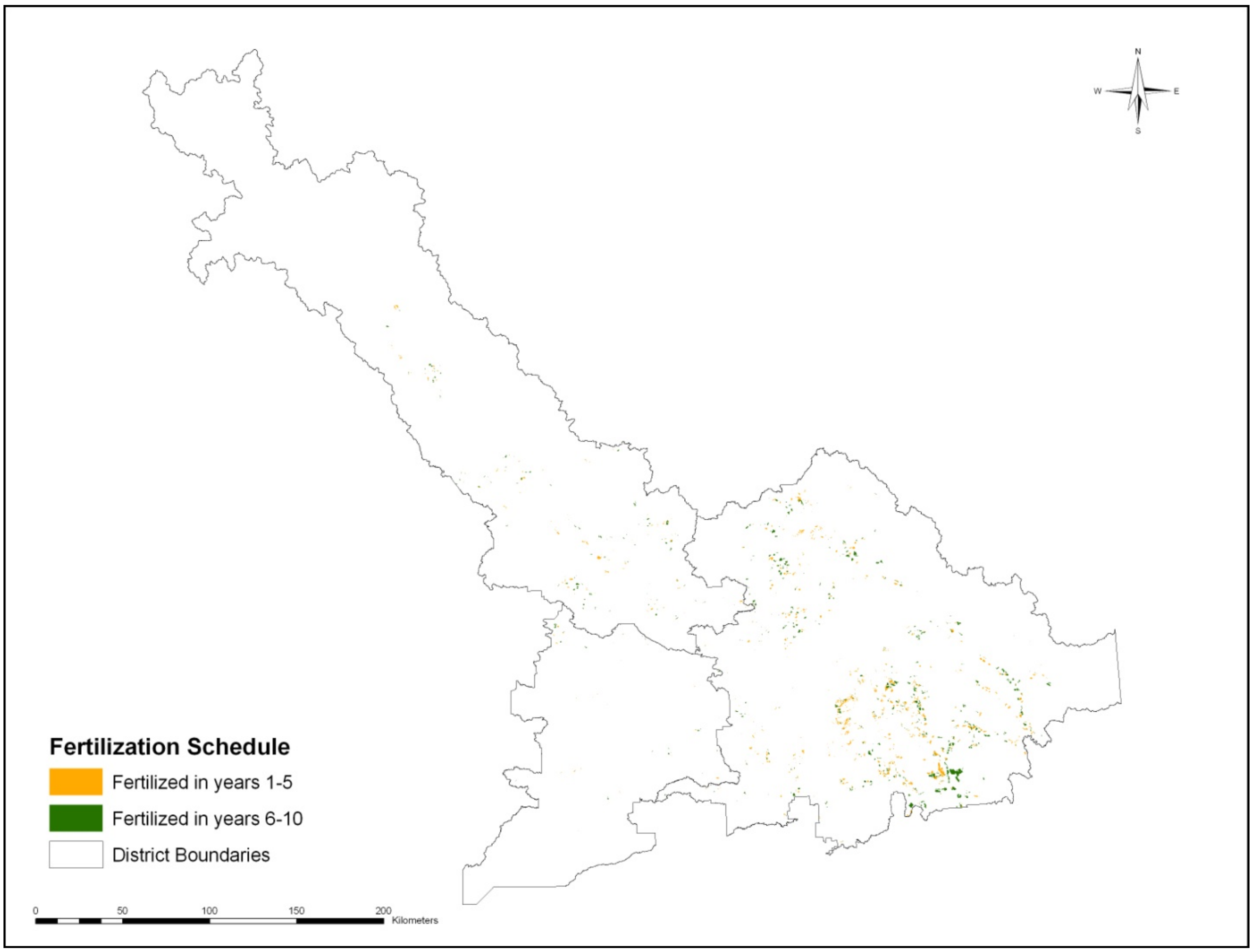


Figure 47: Fertilized stands; young natural stands

This scenario increased the midterm harvest level by approximately 30,000 m^3 per year. Fertilizing young natural stands also allowed the first step up to the long term harvest level to take place five years earlier than in the Base Case (Figure 48). However, the harvest level was somewhat lower than that of the Base Case between years 56 to 125 (50,000 m^3 per year).

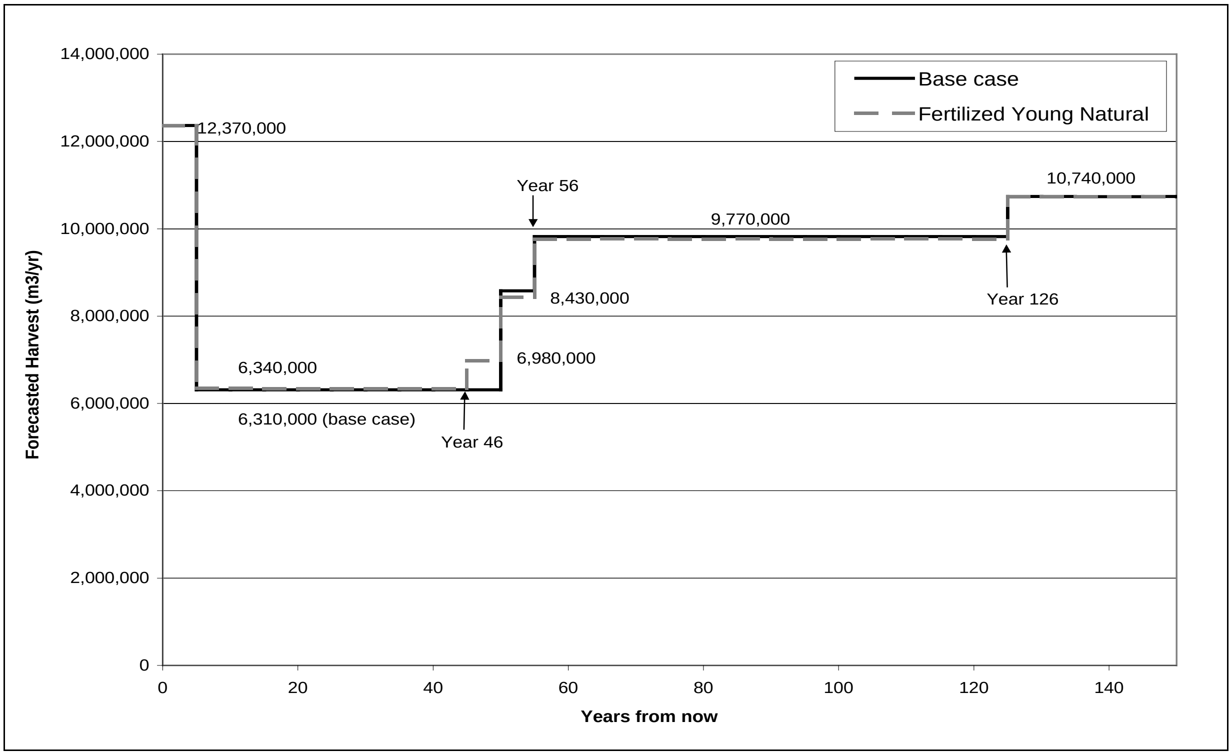


Figure 48: Harvest forecast; fertilization of young natural stands

The harvest of fertilized natural stands begins 31 years from now as illustrated in Figure 49. The fertilization of these stands allows for a slightly higher volume of older natural stands to be harvested during the mid-term before the switch to younger stands occurs.

Some of the younger natural stands (ages 26 to 35) are not harvested until the start of the step up to the long term harvest level, 46 to 55 years from now.

Figure 50 illustrates the forecasted harvest by resource district for this scenario while Figure 51 demonstrates the resource district harvest forecast differences between the fertilization scenario and the Base Case. There is a large increase in harvest from the Prince George Resource District in years 46-50, followed by a decrease in years 56-65. Similarly, a large increase in harvest from Fort St. James in years 61-65 is followed by a decrease in years 66-70.

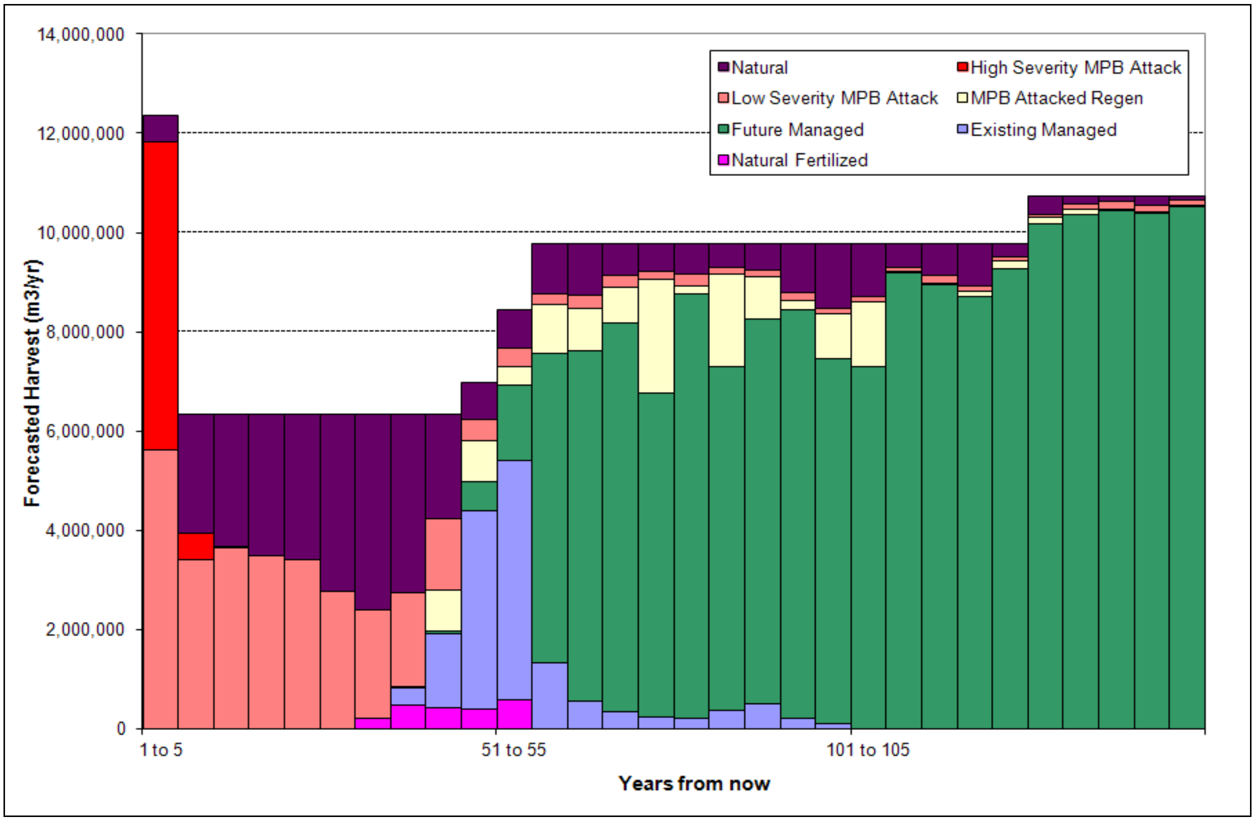


Figure 49: Harvest forecast by yield type; fertilization of young natural stands

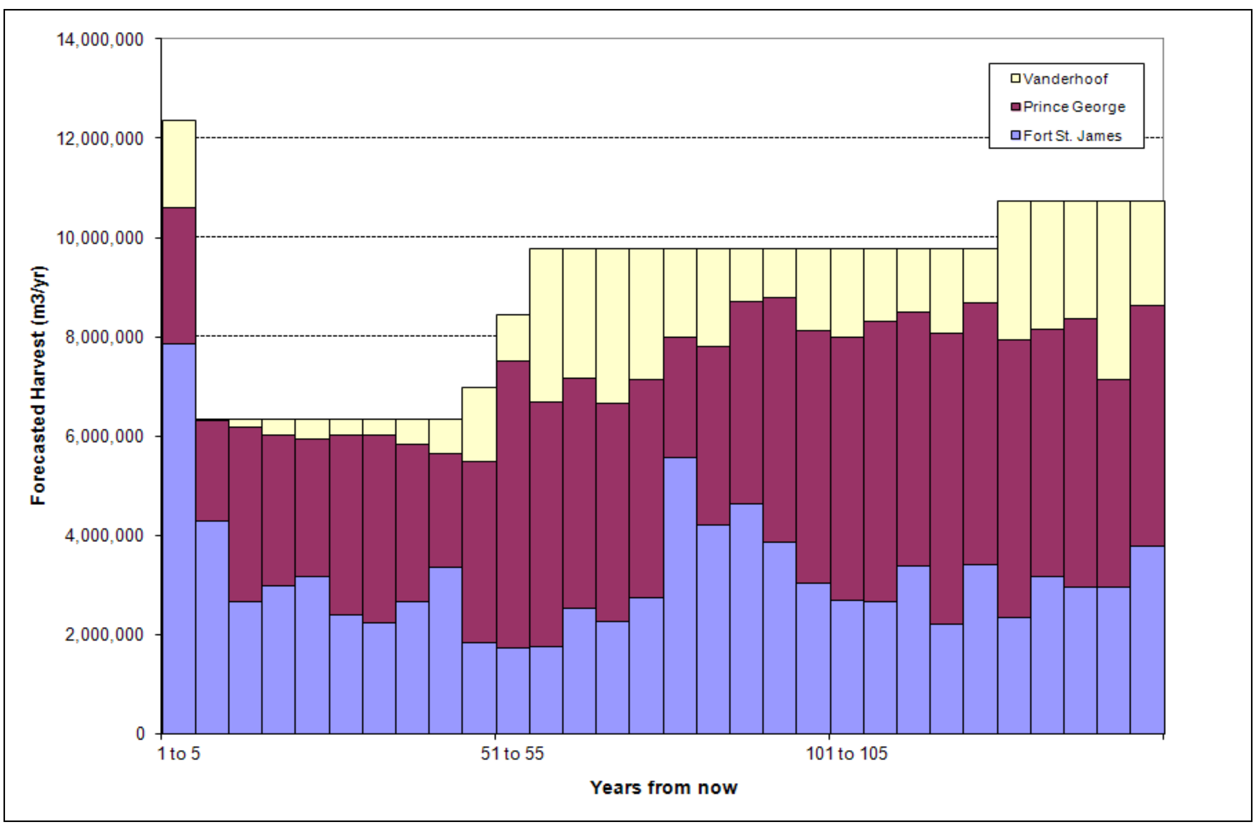


Figure 50: Harvest forecast by district; fertilization of young natural stands

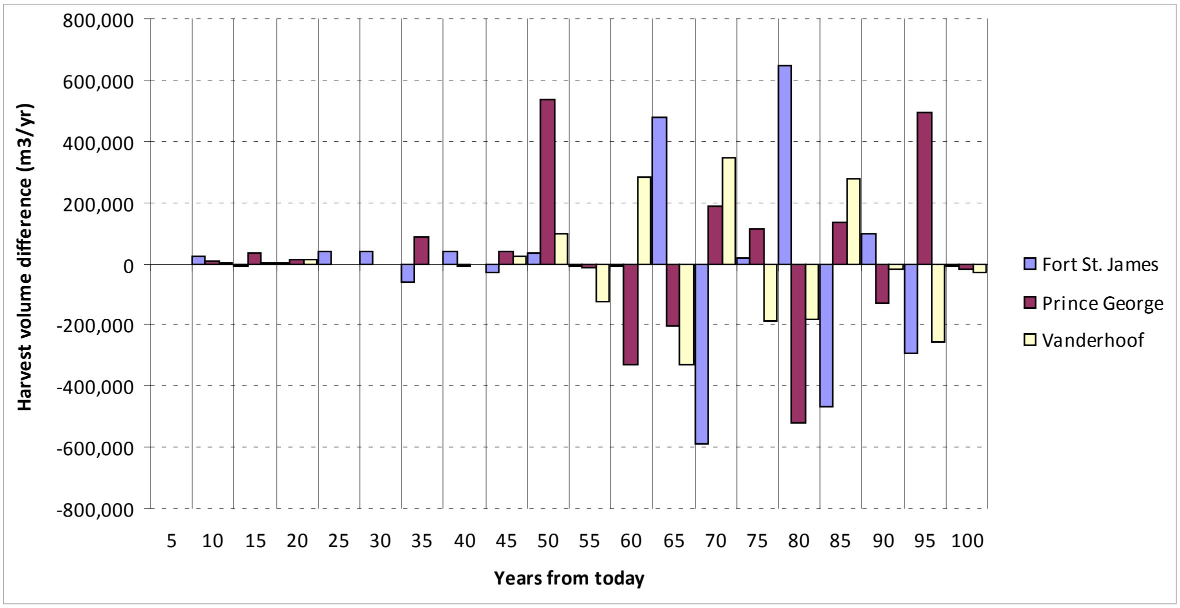


Figure 51: Forecasted harvest difference from Base Case by district; fertilization of young natural stands

3.2.7 Fertilization of Existing Managed Stands

In the Prince George TSA there are 265,335 ha of existing managed stands (aged 16 to 25), of which 215,758 ha (81%) are classified as theoretical candidates for fertilization. These stands received up to 4 fertilization treatments in the analysis. The candidate fertilization population in this scenario by natural resource district is shown in Table 13.

Table 13: Fertilization population areas by Natural Resource District; existing managed stands

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

Thirty-nine analysis units were selected as fertilization candidates out of a total of 60 existing managed analysis units. As described in the data package, the managed stand analysis units are defined based on site series. The analysis units fertilized in this scenario are shown in Table 14. Approximately 30% of the fertilized area consists of spruce-leading stands; the majority are pine-leading. Fertilizing these stands enabled the minimum harvest age to be lowered by 6 to 12 years from the Base Case.

Figure 52 illustrates the theoretical locations of the fertilized stands in this scenario for the first 10 years.

Table 14: Fertilization analysis units and minimum harvest ages; existing managed stands

Analysis Unit	Leading Species	Area (ha)	Base Case MHA	Fertilized MHA
EM_ICHvk2_01	Spruce	3,538	69	62
EM_ICHwk3_01	Spruce	1,984	69	61
EM_ICHwk4_01	Spruce	2,394	59	56
EM_SBSdk_01	Pine	2,133	64	56
EM_SBSdk_01/05	Pine	1,678	64	56
EM_SBSdk_03	Pine	191	69	59
EM_SBSdk_05	Pine	505	59	52
EM_SBSdk_06	Pine	467	69	62
EM_SBSdw1_01	Pine	102	59	53
EM_SBSdw2_01	Pine	10,007	69	60
EM_SBSdw2_06	Pine	2,053	59	52
EM_SBSdw3_01	Pine	16,618	59	53
EM_SBSdw3_01/04	Pine	8,698	64	56
EM_SBSdw3_05	Pine	578	64	55
EM_SBSdw3_06	Pine	1,042	74	62
EM_SBSmc2_01	Pine	13,240	74	63
EM_SBSmc2_02	Pine	331	74	63
EM_SBSmc2_05	Pine	677	74	63
EM_SBSmc3_01	Pine	5,370	64	55
EM_SBSmc3_01/05	Pine	600	64	55
EM_SBSmc3_04	Pine	707	59	52
EM_SBSmc3_05	Pine	2,781	64	55
EM_SBSmh_01	Spruce	2	83	75
EM_SBSmk1_01	Pine	54,713	69	60
EM_SBSmk1_02/03/04	Pine	779	69	59
EM_SBSmk1_05	Pine	6,379	59	53
EM_SBSmk1_06	Pine	1,118	69	59
EM_SBSmw_01	Pine	3,274	64	58
EM_SBSvk_01	Spruce	16,140	78	69
EM_SBSvk_04	Spruce	2,218	74	65
EM_SBSvk_05	Spruce	1,061	83	73
EM_SBSvk_06	Spruce	329	83	75
EM_SBSwk1_01	Spruce	34,872	69	61
EM_SBSwk1_03	Pine	2,481	69	60
EM_SBSwk1_05	Pine	1,237	69	61
EM_SBSwk1_08	Spruce	1,509	83	74
EM_SBSwk3_01	Pine	8,300	69	60
EM_SBSwk3_04	Pine	4,896	64	56
EM_SBSwk3_07	Spruce	757	64	58
Total		215,758		

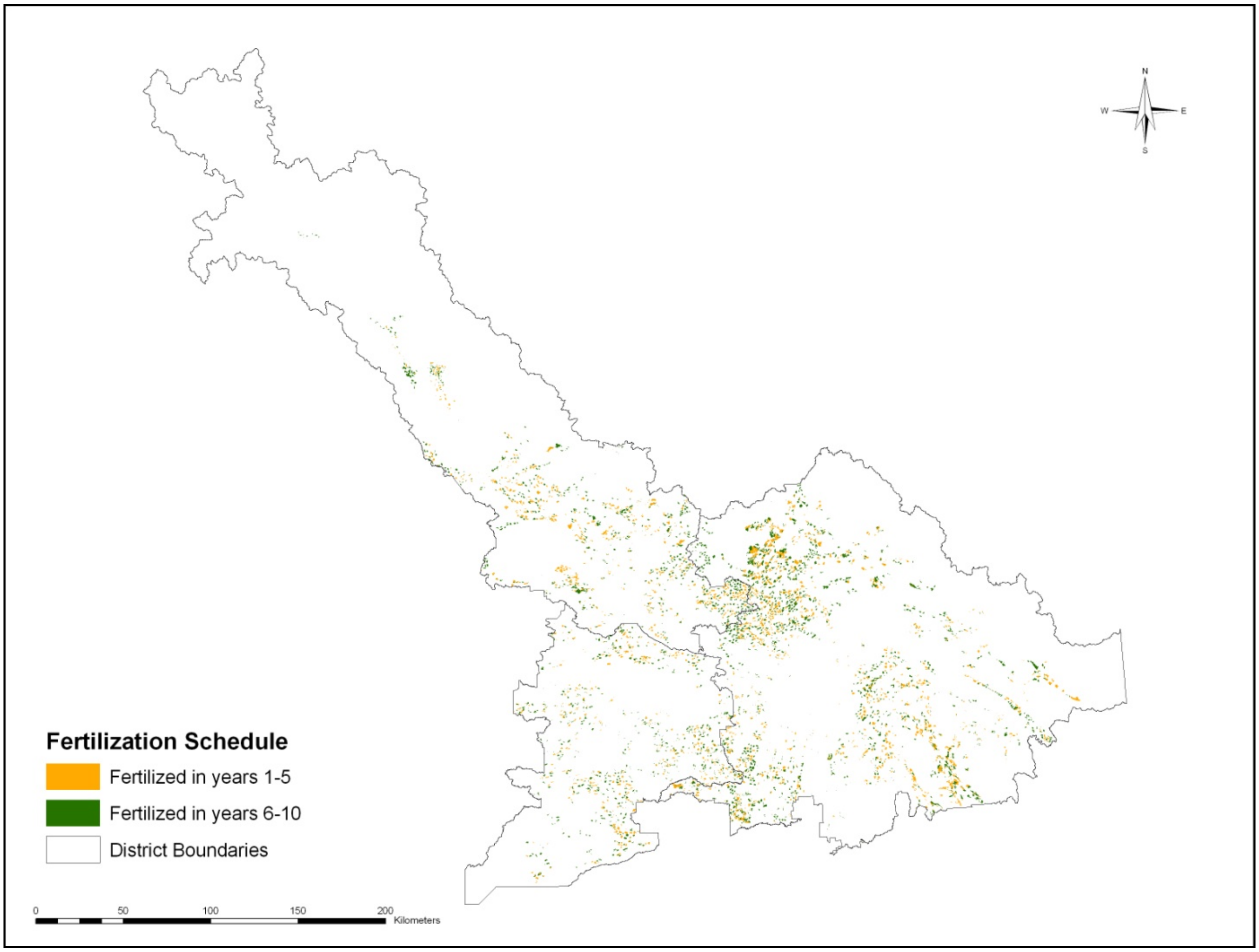


Figure 52: Fertilized stands; existing managed stands

The annual costs of treating all of these stands are shown in Table 15. Since each stand is fertilized every ten years up to four times, the fertilization costs continue for four decades.

Table 15: Annual fertilization area and costs; existing managed stands

Years	Annual Fertilization Area (ha)	Annual Cost
1-5	25,067	$15,040,092
6-10	22,943	$13,766,086
11-15	20,208	$12,124,906
16-20	22,943	$13,766,086
21-25	20,208	$12,124,906
26-30	22,943	$13,766,086
31-35	20,208	$12,124,906
36-40	15,425	$9,254,817

Figure 53 illustrates the harvest forecast for this scenario. Fertilization of existing managed stands increased the midterm harvest level by approximately 470,000 m^3 per year. However, the first step up to the long-term harvest level is delayed by five years and the harvest between years 51 to 60 is 2% less than that of the Base Case.

The fertilized existing managed stands begin to make significant contributions to the midterm harvest after 35 years as shown in Figure 54. This is five to ten years sooner than in the Base Case. The accelerated availability of the existing managed stands allows the midterm harvest level to be increased, since the harvest can switch to the fertilized stands once the natural stands are depleted.

Figure 55 illustrates the forecasted harvest by resource district for this scenario while Figure 56 demonstrates the resource district harvest forecast differences between the fertilization scenario and the Base Case. Early in the mid-term (years 6 through 40), the harvest increase is relatively evenly distributed between Fort St. James and Prince George resource districts. After the fertilized stands become available in year 36, there is a sharp increase in the harvest from Prince George, matched by a decrease in Fort St. James (year 41-45).

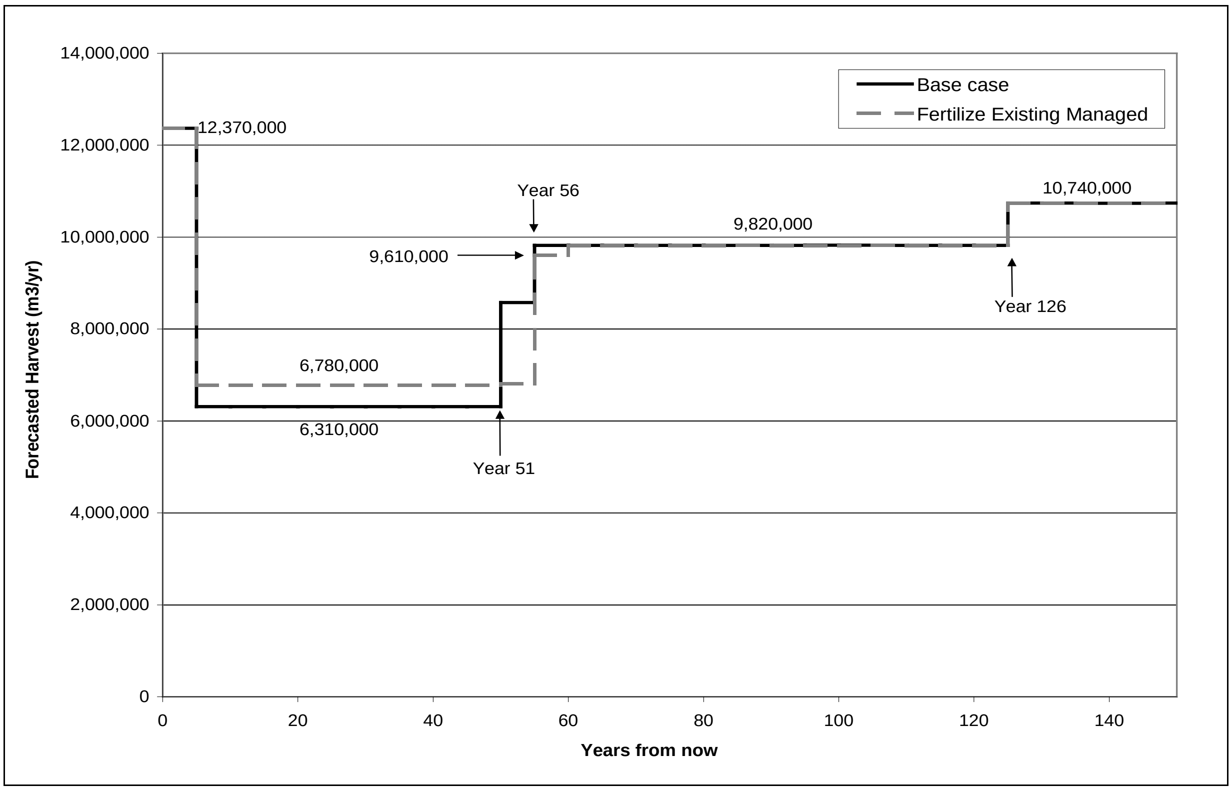


Figure 53: Harvest forecast; fertilization of existing managed stands

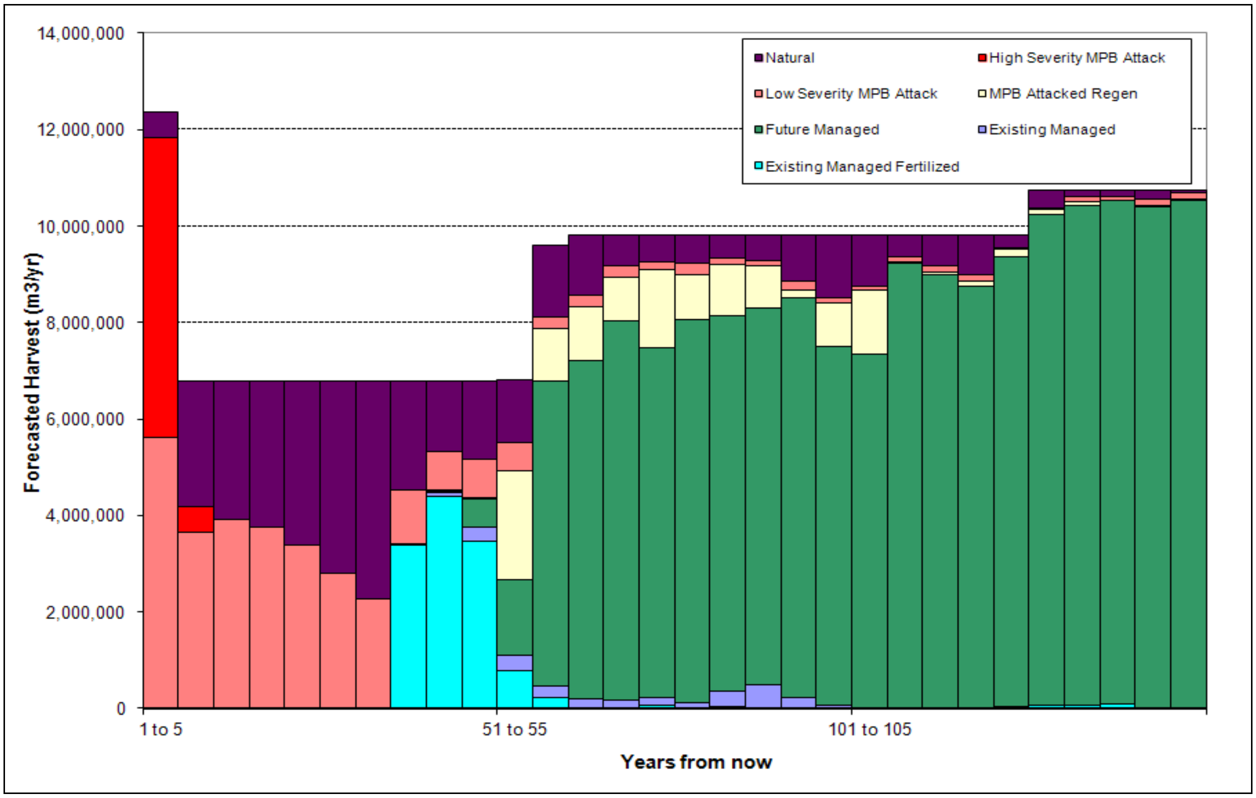


Figure 54: Harvest forecast by yield type; fertilization of existing managed stands

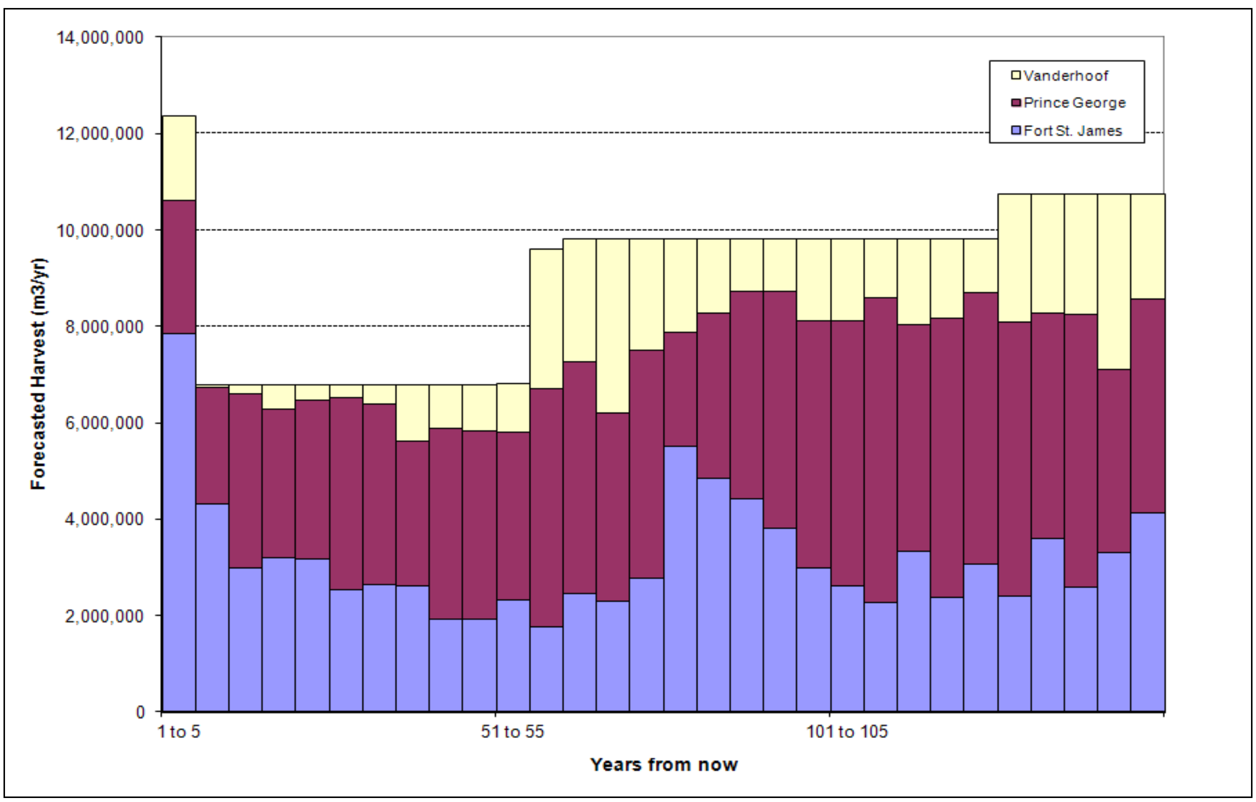


Figure 55: harvest forecast by district; fertilization of existing managed stands

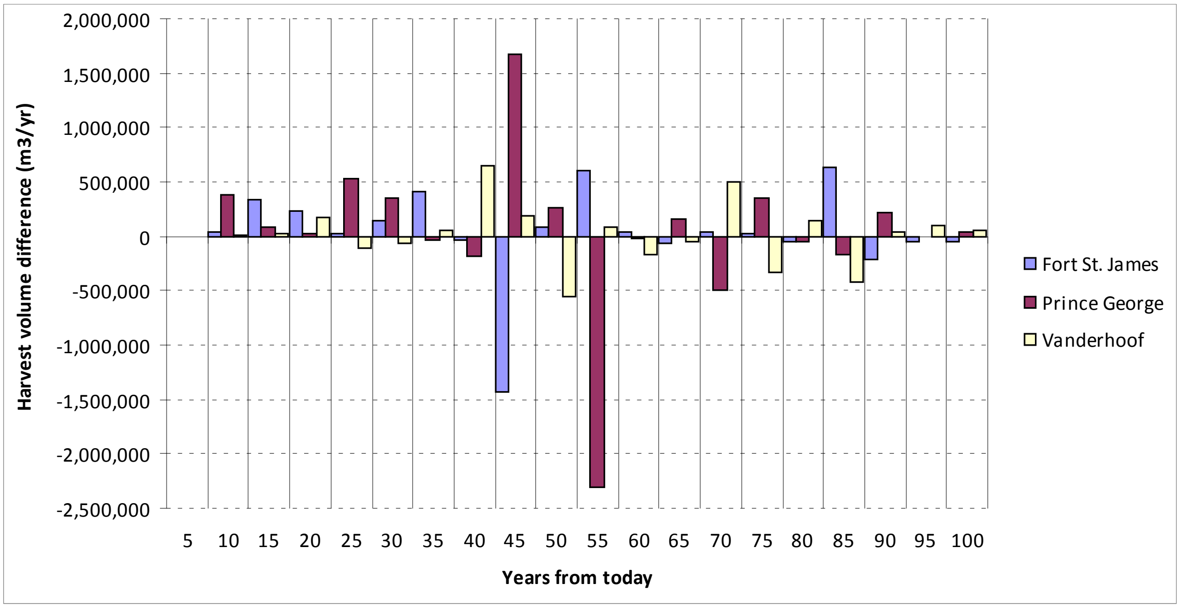


Figure 56: Forecasted harvest difference from Base Case by district; fertilization of existing managed stands

3.2.8 Fertilization of Existing and Current Future Managed Stands (All Managed Stands)

Adding the current future managed stands (current ages 0 to 15) to the population of existing managed stands in the previous scenario results in a candidate population of 615,531 ha. This is 82% of the total current managed stand area (747,924 ha). The current future managed stands received up to four fertilization treatments. The candidate fertilization population in this scenario is shown by resource district in Table 16.

Table 17 shows the fertilization analysis units for the category of current future managed stands (for existing managed see above), with their leading species, areas, and comparison of minimum harvest ages to the Base Case.

Figure 57 illustrates the theoretical locations of the fertilized stands in this scenario for the first 10 years.

Table 16: Fertilization population areas by Natural Resource District; all managed stands

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

Table 17: Fertilization analysis units and minimum harvest ages; current future managed stands

Analysis Unit	Lead Species	Area (ha)	Base Case MHA	Fertilized MHA
FM_ICHvk2_01	Spruce	2,193	59	55
FM_ICHwk3_01	Spruce	930	64	59
FM_ICHwk4_01	Spruce	922	55	53
FM_SBSdk_01	Pine	11,220	69	60
FM_SBSdk_01/05	Pine	9,202	69	60
FM_SBSdk_03	Pine	2,024	78	67
FM_SBSdk_05	Pine	4,035	69	60
FM_SBSdk_06	Pine	2,930	64	57
FM_SBSdw1_01	Pine	489	64	57
FM_SBSdw2_01	Pine	31,025	69	60
FM_SBSdw2_06	Pine	8,797	69	60
FM_SBSdw3_01	Pine	45,565	69	61
FM_SBSdw3_01/04	Pine	26,746	69	60
FM_SBSdw3_05	Pine	5,535	74	64
FM_SBSdw3_06	Pine	3,482	69	60
FM_SBSmc2_01	Pine	42,955	69	61
FM_SBSmc2_02	Pine	2,240	83	72
FM_SBSmc2_05	Pine	3,038	64	57
FM_SBSmc3_01	Pine	16,762	59	53
FM_SBSmc3_01/05	Pine	1,764	64	56
FM_SBSmc3_04	Pine	3,845	74	64
FM_SBSmc3_05	Pine	8,117	69	60
FM_SBSmk1_01	Pine	76,149	69	61
FM_SBSmk1_02/03/04	Pine	2,451	74	63
FM_SBSmk1_05	Pine	10,315	74	64
FM_SBSmk1_06	Pine	6,183	78	67
FM_SBSmw_01	Pine	10,859	64	58
FM_SBSvk_01	Spruce	10,153	69	62
FM_SBSvk_04	Spruce	352	64	58
FM_SBSvk_05	Spruce	754	74	66
FM_SBSvk_06	Spruce	488	78	69
FM_SBSwk1_01	Spruce	22,834	64	58
FM_SBSwk1_03	Pine	2,440	64	56
FM_SBSwk1_05	Pine	944	59	54
FM_SBSwk1_08	Spruce	592	78	70
FM_SBSwk3_01	Pine	14,407	78	69
FM_SBSwk3_04	Pine	6,204	69	61
FM_SBSwk3_07	Spruce	833	59	55
Total		399,773		

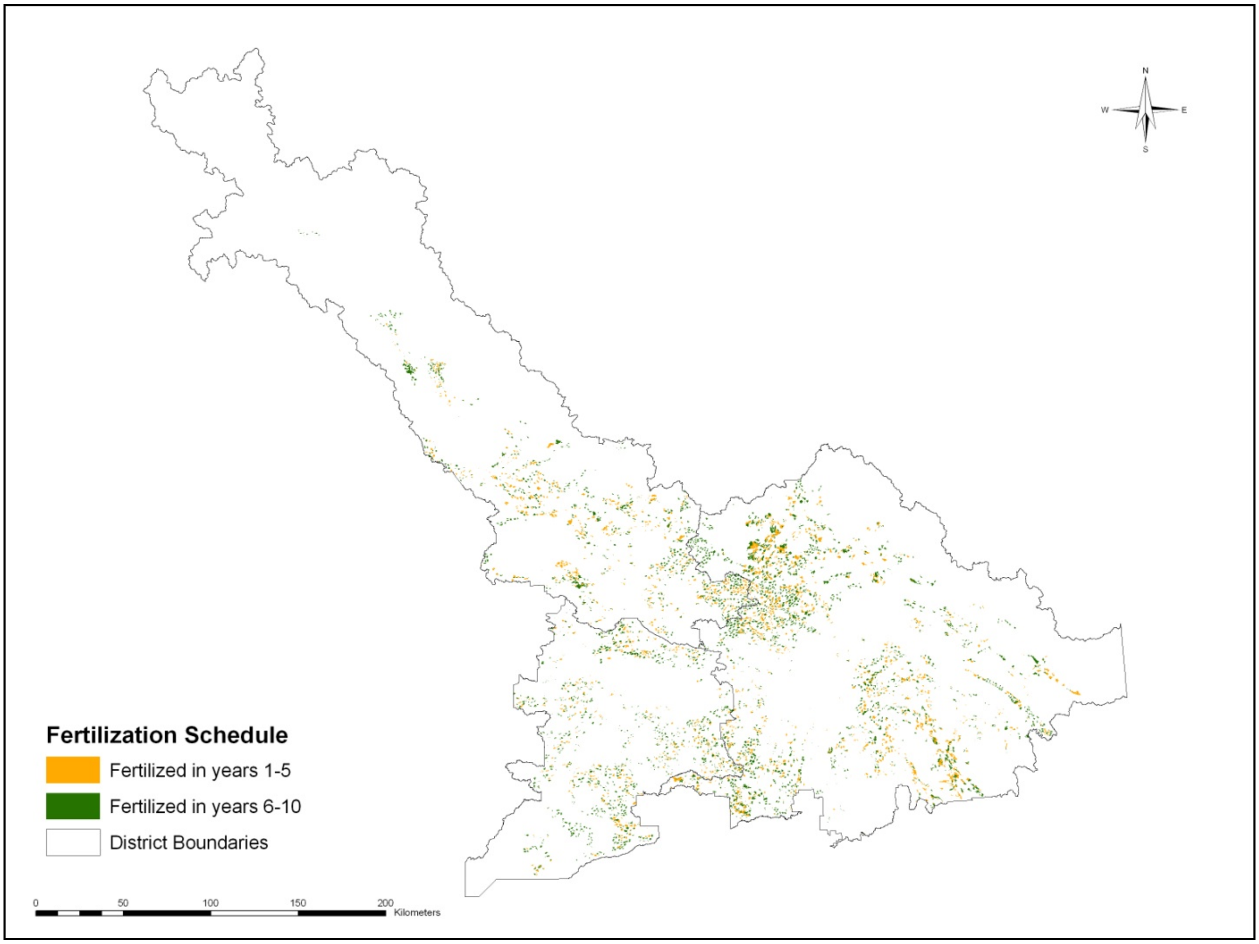


Figure 57: Fertilized stands; all managed stands

The annual costs to fertilize all of the managed stands are shown in Table 18. The younger current future managed stands don't reach the age of their first fertilization treatments until 6 to 11 years from now. Once they are included in the treatments the fertilization cost (and area) increases.

Table 18: Annual fertilization area and cost; managed stands

Years	Annual Fertilization Area (ha)	Annual Cost
1-5	25,067	$15,040,092
6-10	28,184	$16,910,240
11-15	41,732	$25,039,021
16-20	57,950	$34,769,992
21-25	65,156	$39,093,761
26-30	57,950	$34,769,992
31-35	62,516	$37,509,545
36-40	49,216	$29,529,826
41-45	43,288	$25,972,826
46-50	28,154	$16,892,141
51-55	22,732	$13,639,286

The impact of fertilizing all managed stands is illustrated in Figure 58. This scenario allowed the midterm harvest level to be increased by 1,000,000 m^3/year over the Base Case. Also, the increase towards the long term harvest level starts five years earlier than in the Base Case; however the second step to the long term harvest level was delayed 15 years compared to the Base Case.

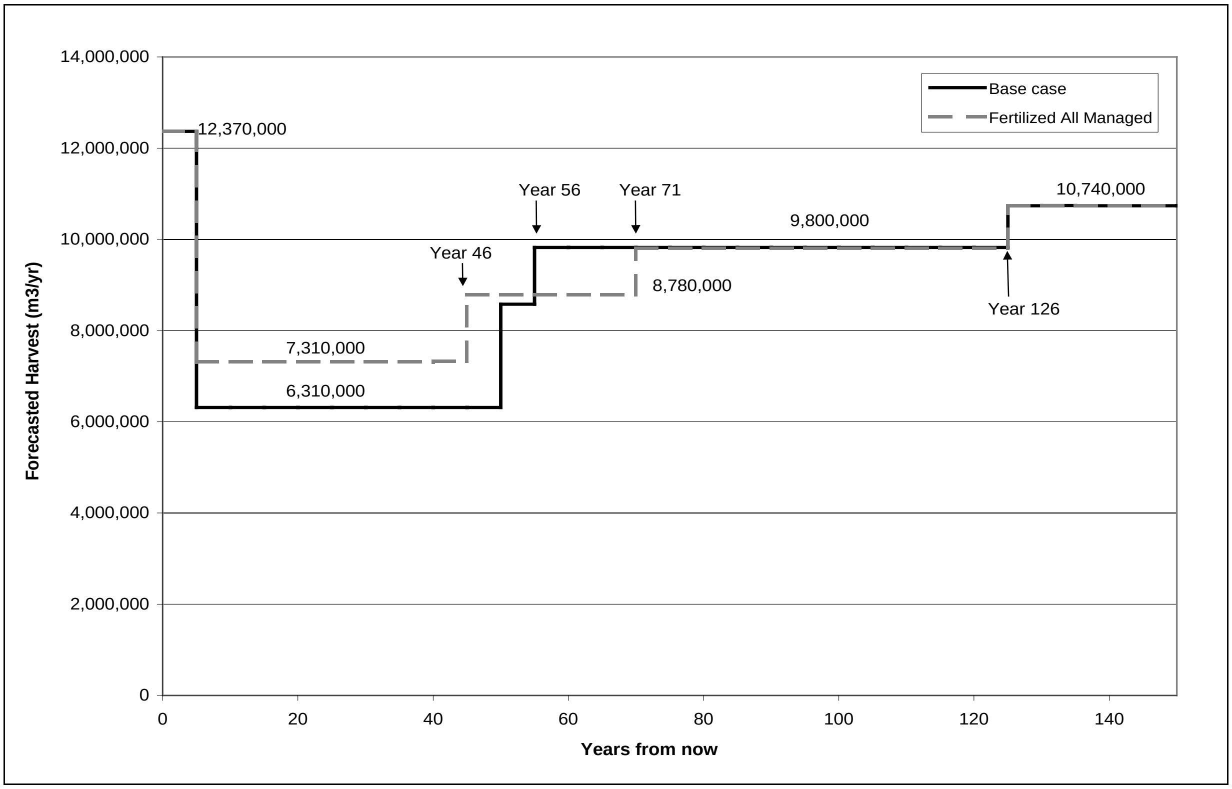


Figure 58: Harvest forecast; fertilization of all managed stands

The 15 year delay in the second step towards the long term harvest level is due to earlier harvest of the fertilized managed stands. They are also harvested at younger ages than they otherwise would have been in the Base Case scenario. The fertilized existing managed stands become available starting at year 31; this is five years sooner than the non-fertilized stands in the Base Case (Figure 59). The younger harvest ages are notable between years 31 and 40 and are depicted in Figure 60. In the Base Case, the managed stand harvest started later. This left them to be available to support the rise in the harvest level between years 56 and 70.

Figure 61 illustrates the forecasted harvest by resource district for this scenario while Figure 62 demonstrates the resource district harvest forecast differences between the fertilization scenario and the Base Case. Most of the mid-term increase in harvest comes from the Prince George and Fort St. James Resource Districts.

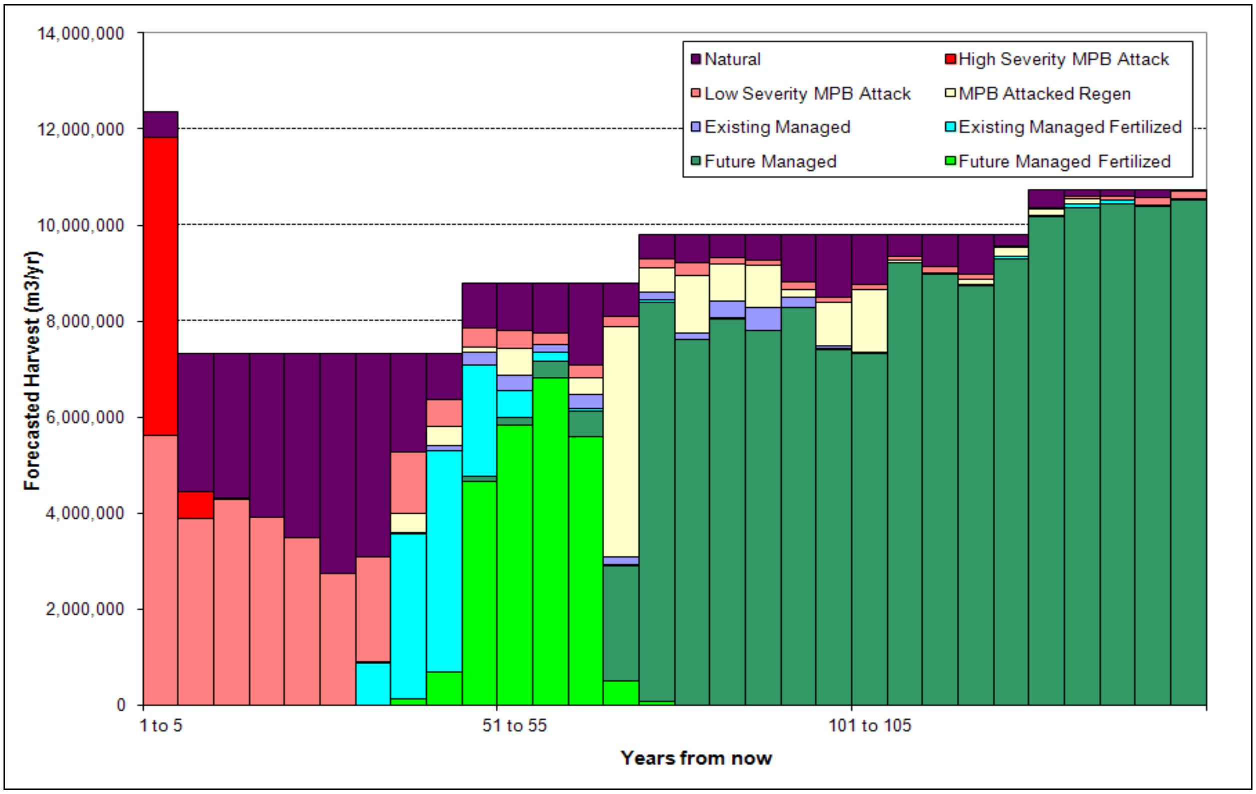


Figure 59: Harvest forecast by yield type; fertilization of all managed stands

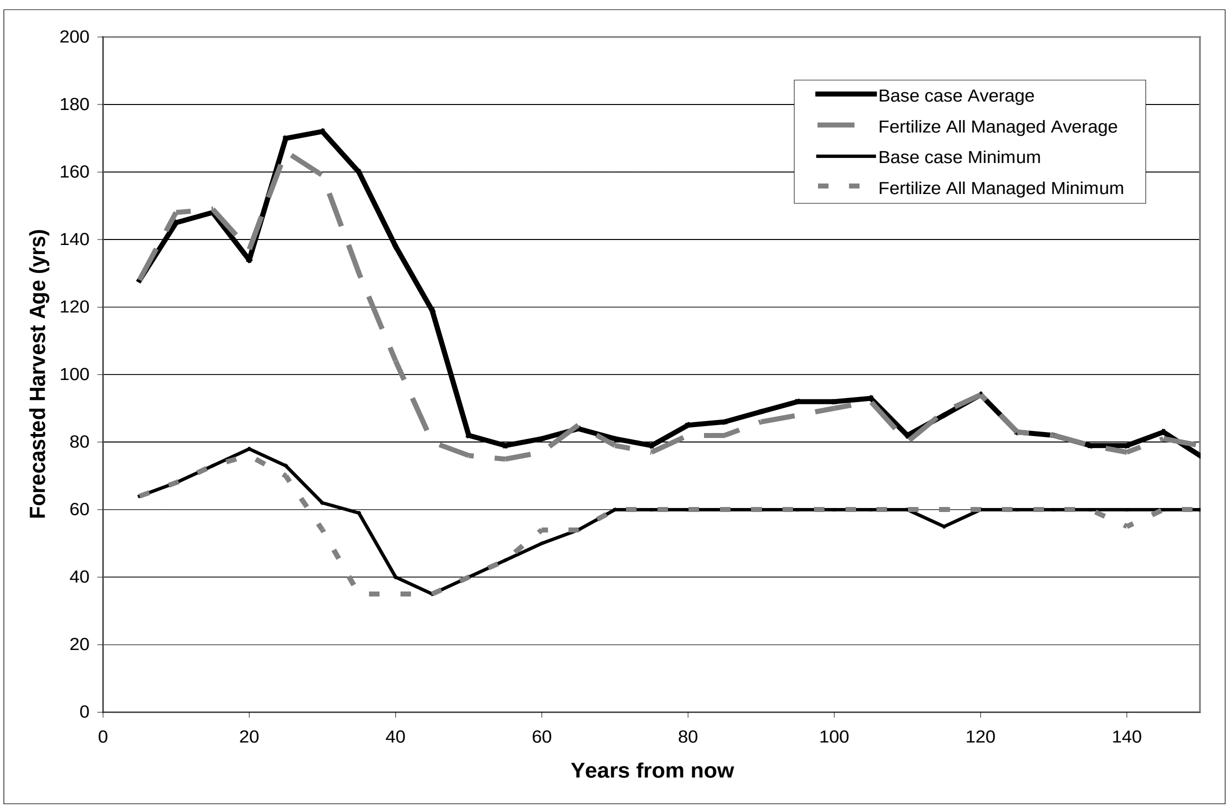


Figure 60: Forecasted average and minimum harvest ages, fertilization of all managed stands

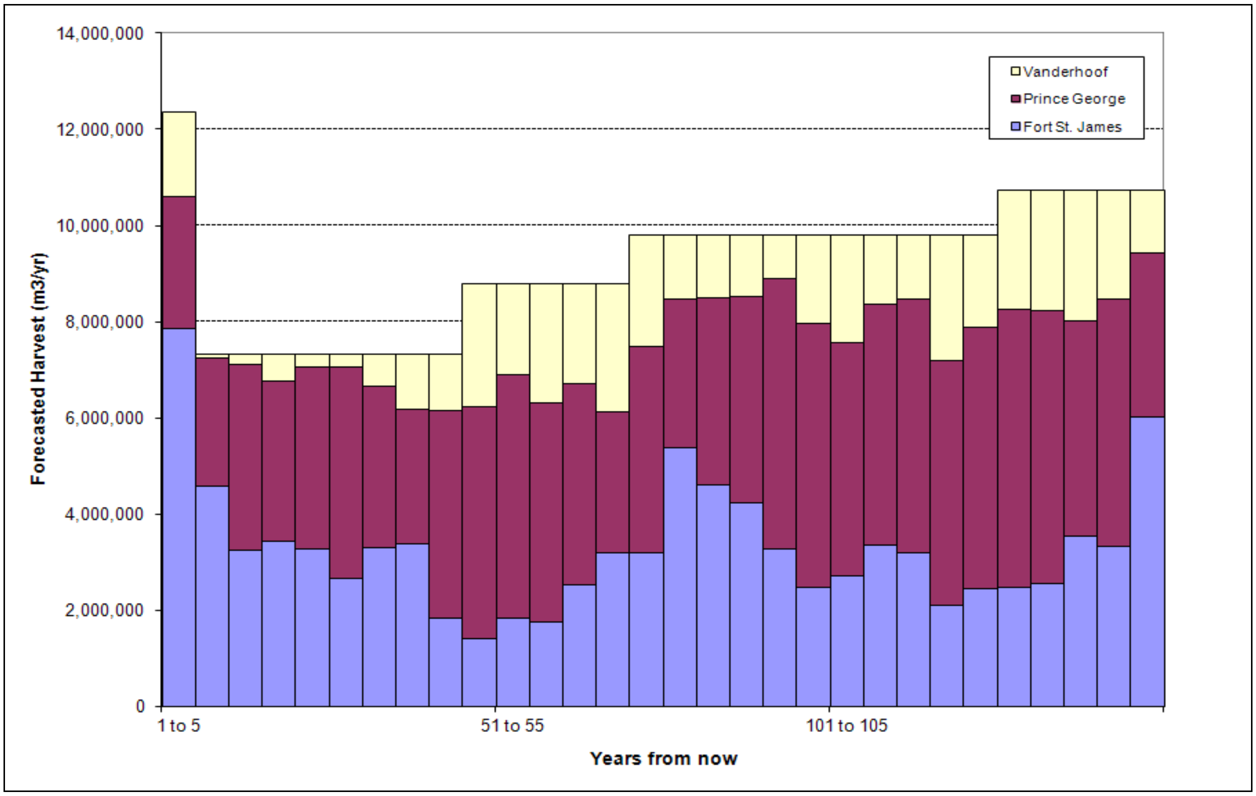


Figure 61: Harvest forecast by district; fertilization of all managed stands

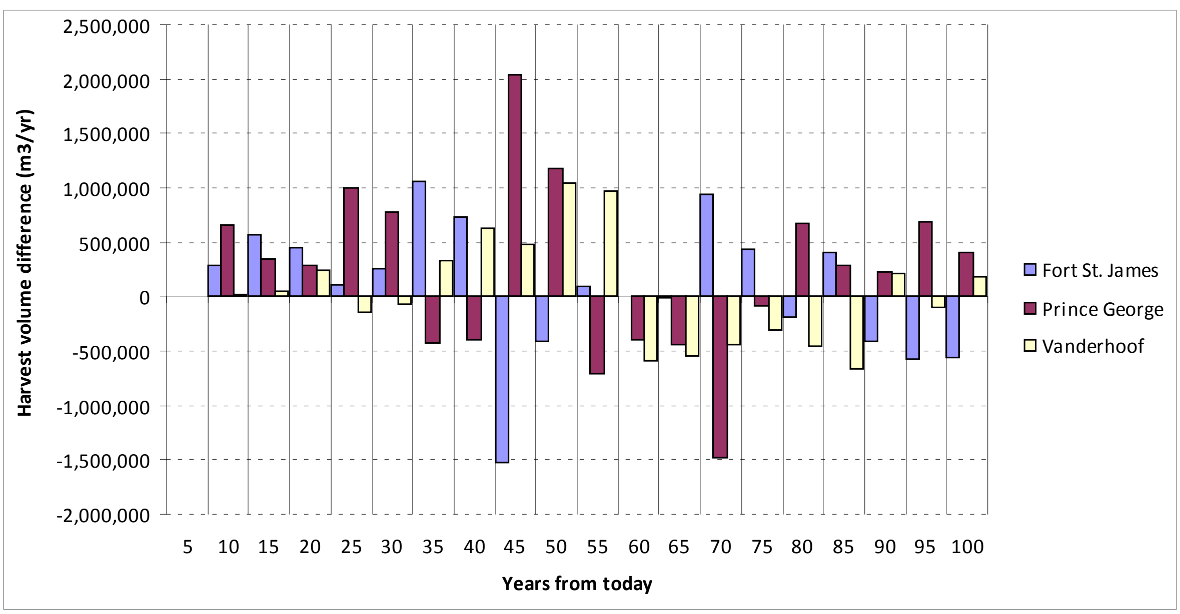


Figure 62: Forecasted harvest difference from Base Case by district; fertilization of all managed stands

3.2.9 Fertilization of All Managed and Young Natural Stands

This scenario used the entire candidate fertilization population as detailed above in Section 3.2.5, Table 9. With the natural stands added to the managed stands, the total potential treatment area is 663,594 ha.

Figure 63 illustrates the theoretical locations of the fertilized stands in this scenario for the first 10 years. The annual treatment areas and costs are shown in Table 19.

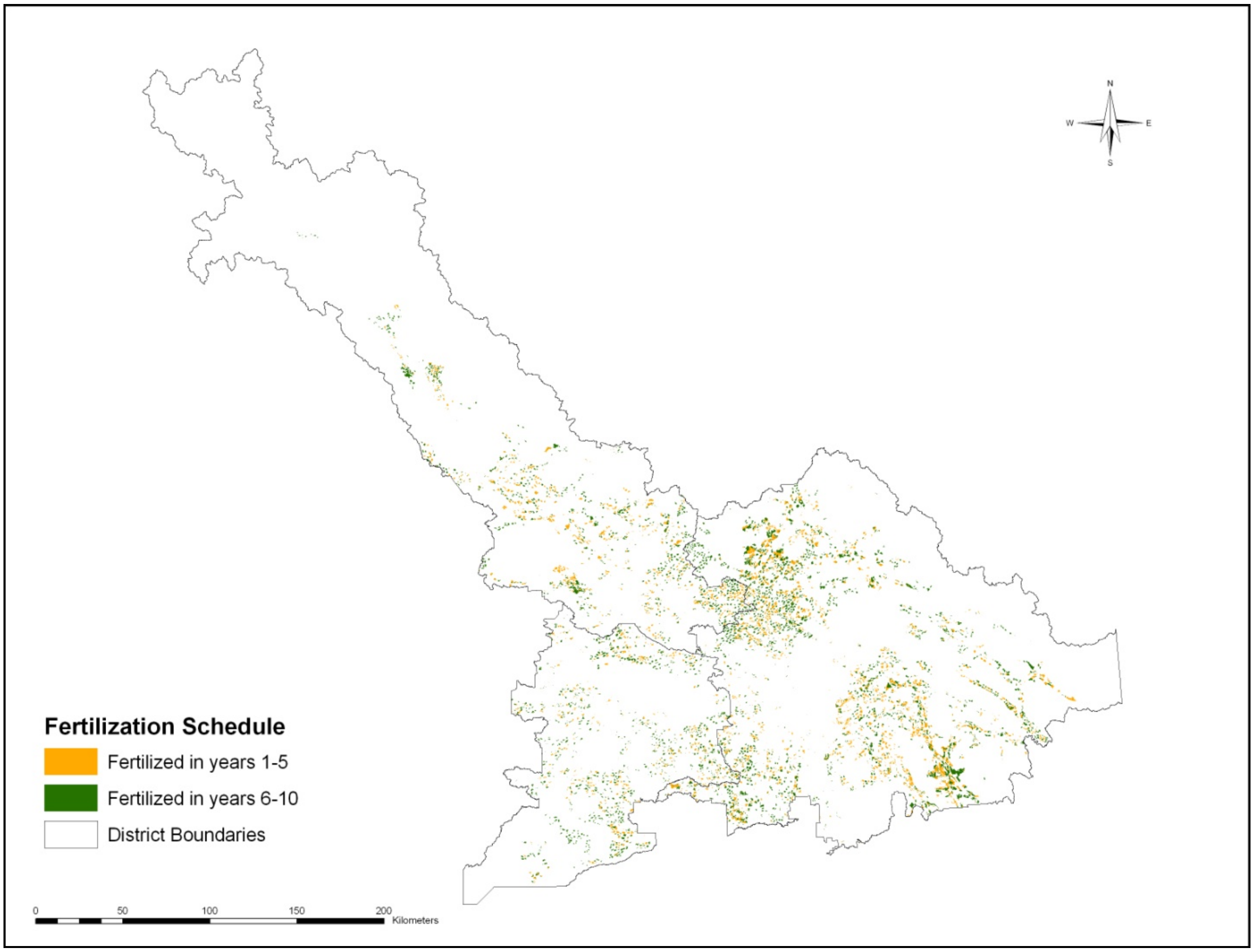


Figure 63: Fertilized stands; young natural stands and all managed stands

Table 19: Annual fertilization area and cost; entire candidate population

Years	Annual Fertilization Area (ha)	Annual cost
1-5	30,623	$18,373,583
6-10	32,886	$19,731,881
11-15	45,521	$27,312,890
16-20	62,278	$37,366,812
21-25	68,068	$40,840,802
26-30	61,174	$36,704,358
31-35	62,516	$37,509,545
36-40	49,216	$29,529,826
41-45	43,288	$25,972,826
46-50	28,308	$16,984,781
51-55	22,732	$13,639,286

By fertilizing all the young natural, existing managed and current future managed stands the midterm harvest level was increased by 1,030,000 m^3 per year over the Base Case harvest level (Figure 64). The first step towards the long term harvest level was also moved forward by five years beginning at year 46. However, by harvesting more timber in the midterm the second step to the long term harvest level is delayed until year 71. Between years 71 and 150 the harvest level is slightly lower than that in the Base Case. The Base Case long term harvest level is reached at year 151 (not shown).

Figure 65 illustrates the predicted harvest by yield type. The fertilized young natural stands are harvested slightly earlier than the existing managed stands while the current future managed stands come online at year 41.

Figure 66 illustrates the forecasted harvest by resource district for this scenario while Figure 67 demonstrates the resource district harvest forecast differences between the fertilization scenario and the Base Case.

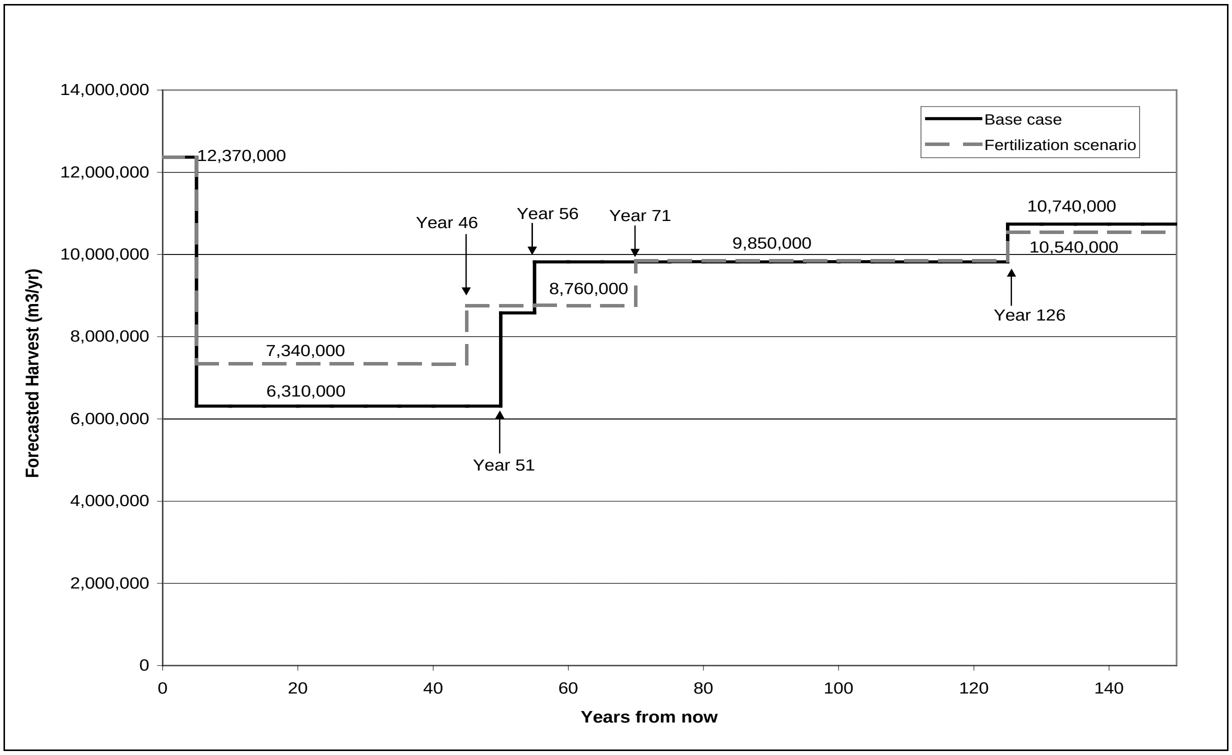


Figure 64: Harvest forecast; fertilization of all eligible stands <= 60 years old

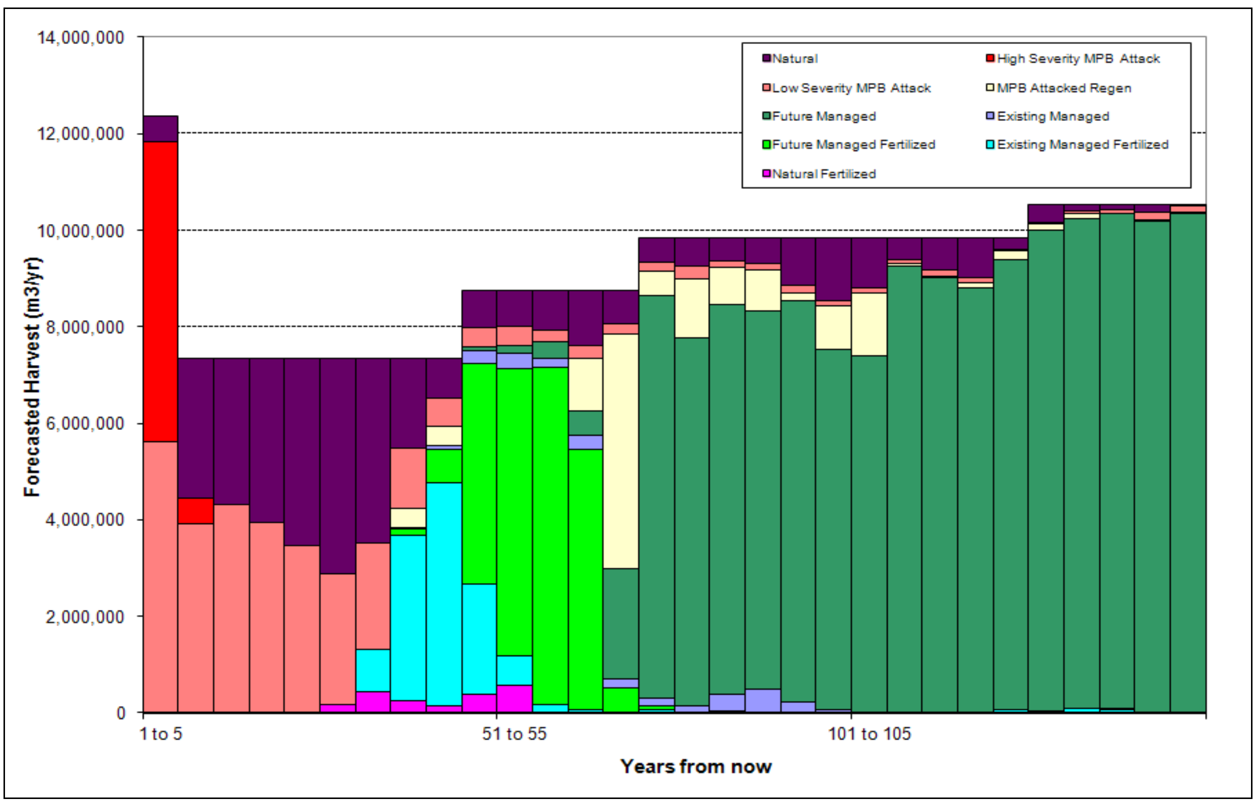


Figure 65: Harvest forecast by yield type; fertilization of all eligible stands <= 60 years old

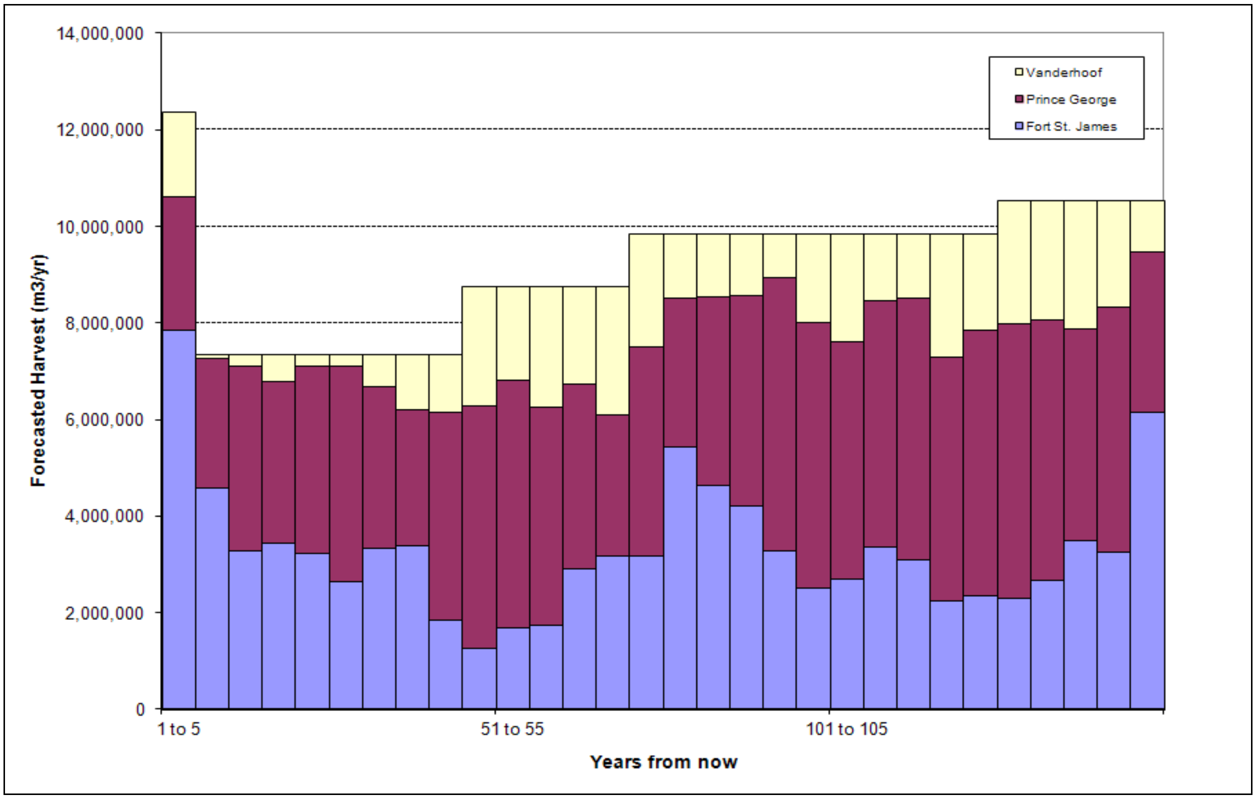


Figure 66: Harvest forecast by resource district; fertilization of all eligible stands <= 60 years old

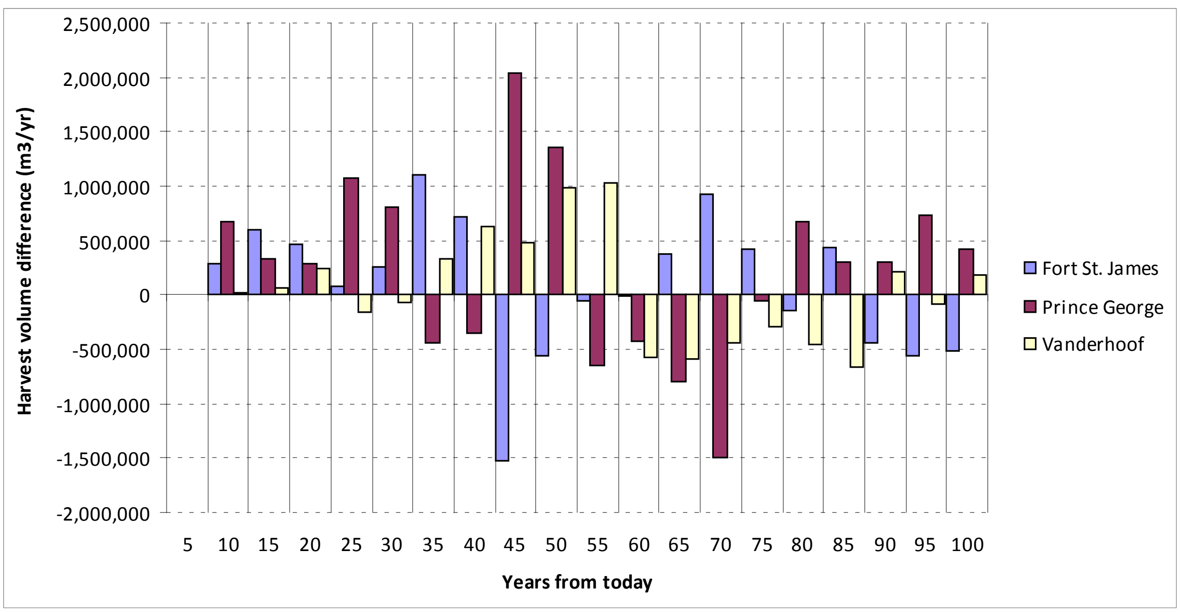


Figure 67: Forecasted harvest difference from Base Case by district; fertilization of all eligible stands <=60 years old

3.2.10 Comparison of Fertilization Scenarios

Each of the fertilization scenarios increases the midterm harvest (years 6-50), but also reduces the harvest somewhat in years 51 to 125. Most of the fertilization costs occur during the midterm, with the exception of final fertilization of some current future managed (currently less than 10 years old) stands between years 51 and 55. Table 20 shows a comparison of the annual fertilization costs for each scenario.

Table 20: Annual cost comparison for all fertilization scenarios

Years	Natural Stands	Existing Managed Stands	All Managed Stands	Young Natural and All Managed Stands
1-5	$3,333,492	$15,040,092	$15,040,092	$18,373,583
6-10	$2,821,640	$13,766,086	$16,910,240	$19,731,881
11-15	$2,273,870	$12,124,906	$25,039,021	$27,312,890
16-20	$2,596,820	$13,766,086	$34,769,992	$37,366,812
21-25	$1,747,042	$12,124,906	$39,093,761	$40,840,802
26-30	$1,934,366	$13,766,086	$34,769,992	$36,704,358
31-35		$12,124,906	$37,509,545	$37,509,545
36-40		$9,254,817	$29,529,826	$29,529,826
41-45			$25,972,826	$25,972,826
46-50			$16,892,141	$16,984,781
51-55			$13,639,286	$13,639,286

Table 21 shows a harvest gain (or loss) comparison for each fertilization scenario for the period of 150 years.

Table 21: Comparison of change in harvest forecast fertilization scenarios

Years	Base Case	Young Natural Stands		Existing Managed Stands		All Managed Stands		Young Natural Stands and All Managed Stands	
	Harvest Volume m^3/yr	Change from Base Case (m^3/yr)	Change from Base Case (%)	Change from Base Case (m^3/yr)	Change from Base Case (%)	Change from Base Case (m^3/yr)	Change from Base Case (%)	Change from Base Case (m^3/yr)	Change from Base Case (%)
1 to 5	12,370,000	0	0.0%	0	0.0%	0	0.0%	0	0.0%
5 to 10	6,310,000	30,000	0.5%	470,000	7.4%	1,000,000	15.8%	1,030,000	16.3%
11 to 15	6,310,000	30,000	0.5%	470,000	7.4%	1,000,000	15.8%	1,030,000	16.3%
16 to 20	6,310,000	30,000	0.5%	470,000	7.4%	1,000,000	15.8%	1,030,000	16.3%
21 to 25	6,310,000	30,000	0.5%	470,000	7.4%	1,000,000	15.8%	1,030,000	16.3%
26 to 30	6,310,000	30,000	0.5%	470,000	7.4%	1,000,000	15.8%	1,030,000	16.3%
31 to 35	6,310,000	30,000	0.5%	470,000	7.4%	1,000,000	15.8%	1,030,000	16.3%
36 to 40	6,310,000	30,000	0.5%	470,000	7.4%	1,000,000	15.8%	1,030,000	16.3%
41 to 45	6,310,000	30,000	0.5%	470,000	7.4%	1,000,000	15.8%	1,030,000	16.3%
46 to 50	6,310,000	670,000	10.6%	470,000	7.4%	2,470,000	39.1%	2,450,000	38.8%
51 to 55	8,580,000	-150,000	-1.7%	-1,800,000	-21.0%	200,000	2.3%	180,000	2.1%
56 to 60	9,820,000	-50,000	-0.5%	-210,000	-2.1%	-1,040,000	-10.6%	-1,060,000	-10.8%
61 to 65	9,820,000	-50,000	-0.5%	0	0.0%	-1,040,000	-10.6%	-1,060,000	-10.8%
66 to 70	9,820,000	-50,000	-0.5%	0	0.0%	-1,040,000	-10.6%	-1,060,000	-10.8%
71 to 75	9,820,000	-50,000	-0.5%	0	0.0%	-1,040,000	-10.6%	30,000	0.3%
76 to 80	9,820,000	-50,000	-0.5%	0	0.0%	-1,040,000	-10.6%	30,000	0.3%
81 to 85	9,820,000	-50,000	-0.5%	0	0.0%	-1,040,000	-10.6%	30,000	0.3%
86 to 90	9,820,000	-50,000	-0.5%	0	0.0%	-1,040,000	-10.6%	30,000	0.3%
91 to 95	9,820,000	-50,000	-0.5%	0	0.0%	-1,040,000	-10.6%	30,000	0.3%
96 to 100	9,820,000	-50,000	-0.5%	0	0.0%	-1,040,000	-10.6%	30,000	0.3%
101 to 105	9,820,000	-50,000	-0.5%	0	0.0%	-1,040,000	-10.6%	30,000	0.3%
106 to 110	9,820,000	-50,000	-0.5%	0	0.0%	-1,040,000	-10.6%	30,000	0.3%
111 to 115	9,820,000	-50,000	-0.5%	0	0.0%	-1,040,000	-10.6%	30,000	0.3%
116 to 120	9,820,000	-50,000	-0.5%	0	0.0%	-1,040,000	-10.6%	30,000	0.3%
121 to 125	9,820,000	-50,000	-0.5%	0	0.0%	-1,040,000	-10.6%	30,000	0.3%
126 to 130	10,740,000	0	0.0%	0	0.0%	0	0.0%	-200,000	-1.9%
131 to 135	10,740,000	0	0.0%	0	0.0%	0	0.0%	-200,000	-1.9%
136 to 140	10,740,000	0	0.0%	0	0.0%	0	0.0%	-200,000	-1.9%
141 to 145	10,740,000	0	0.0%	0	0.0%	0	0.0%	-200,000	-1.9%
146 to 150	10,740,000	0	0.0%	0	0.0%	0	0.0%	-200,000	-1.9%

3.2.11 Enhanced Reforestation

This scenario investigated the impact of increasing planting densities for all future stands. In the model, 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 area. Table 22 shows the treatment areas by natural resource district. Two scenarios were completed; the first scenario increased the planting density to 1,700 stems per hectare while the second scenario also fertilized most of these stands at ages 25, 35, 45, and 55.

Table 23 shows the analysis units that were treated in this scenario along with their areas in the road and rail portions of the TSA, and a comparison of the minimum harvest ages to the Base Case.

Table 22: Enhanced reforestation areas (ha) within each Natural Resource District

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

Table 23: Summary of analysis units; enhanced reforestation

Analysis Unit	Base Case Density	Enhanced Density	Road Area (ha)	Rail Area (ha)	Base Case MHA	Enhanced MHA
ESSFmv1_01	1,231	1,700	63,562	948	93	90
ESSFmv1_03	1,340	1,700	21,146		116	113
ESSFmv1_04	1,237	1,700	11,623		93	91
ESSFmv3_01	1,573	1,700	93,506	445	116	117
ESSFwc3_01	1,200	1,700	1,353		102	101
ESSFwk1_01	1,566	1,700	59,883		97	98
ESSFwk2_01	1,509	1,700	8,779	8	102	103
ICHvk2_01	1,327	1,700	44,965	166	59	59
ICHwk3_01	1,327	1,700	11,794		64	64
ICHwk4_01	1,150	1,700	16,809		55	55
SBPSdc_01	1,403	1,700	1,678		83	83
SBPSmc_01	1,403	1,700	2,432		59	58
SBSdk_01	1,340	1,700	37,519		69	68
SBSdk_01/05	1,427	1,700	28,652		69	68
SBSdk_05	1,513	1,700	12,704		69	69
SBSdk_06	1,368	1,700	14,515		64	64
SBSdw2_01	1,300	1,700	86,439		69	68
SBSdw2_06	1,302	1,700	18,021		69	68
SBSdw2_07	1,266	1,700	17,038		78	76
SBSdw3_01	1,372	1,700	229,895		69	69
SBSdw3_01/04	1,372	1,700	94,521		69	68
SBSdw3_05	1,274	1,700	27,311		74	72
SBSdw3_06	1,514	1,700	13,486		69	69
SBSdw3_07	1,404	1,700	23,718		59	59
SBSmc2_01	1,371	1,700	150,938	30,084	69	68
SBSmc2_05	1,407	1,700	10,871	732	64	63
SBSmc3_01	1,277	1,700	63,870		59	57
SBSmc3_01/05	1,296	1,700	12,302		64	62
SBSmc3_04	1,432	1,700	13,202		74	73
SBSmc3_05	1,315	1,700	39,209		69	66
SBSmc3_07	1,176	1,700	8,107		69	66
SBSmk1_01	1,353	1,700	430,907		69	68
SBSmk1_05	1,377	1,700	72,447		74	73
SBSmk1_07	1,441	1,700	27,883		64	64
SBSmw_01	1,393	1,700	34,292		64	64

Analysis Unit	Base Case Density	Enhanced Density	Road Area (ha)	Rail Area (ha)	Base Case MHA	Enhanced MHA
SBSvk_05	1,419	1,700	17,624		74	74
SBSwk1_01	1,461	1,700	286,748		64	64
SBSwk1_03	1,401	1,700	23,151		64	63
SBSwk1_05	1,445	1,700	17,484		59	59
SBSwk3_01	1,464	1,700	128,829	2,856	78	78
SBSwk3_04	1,356	1,700	49,165	1,228	69	68
SBSwk3_07	1,442	1,700	15,165	540	59	59

The incremental costs for enhanced reforestation are assumed to be $0.57/tree. The annual costs and treatment areas for 100 years are shown in Table 24.

Table 24: Annual costs; enhanced reforestation

Years	Annual treatment area (ha)	Annual cost
1-5	39,209	$7,230,524
6-10	15,417	$2,633,367
11-15	12,976	$2,241,412
16-20	14,792	$2,516,204
21-25	15,991	$2,724,108
26-30	16,727	$2,711,926
31-35	17,341	$2,765,280
36-40	20,477	$3,349,384
41-45	21,283	$3,773,819
46-50	20,521	$3,797,678
51-55	25,717	$4,612,623
56-60	27,488	$5,103,748
61-65	29,342	$5,464,629
66-70	30,305	$5,726,326
71-75	31,376	$5,953,699
76-80	25,758	$4,838,404
81-85	27,976	$5,183,833
86-90	24,427	$4,258,779
91-95	25,660	$4,720,875
96-100	25,787	$4,746,503

Increasing the establishment density of future stands had no impact on the mid-term harvest level. There was a slight increase in harvest level starting at year 56 as shown in Figure 68. The annual harvest from year 56 to 125 was 30,000 m^3 per year higher than that of the Base Case while the harvest between years 126 and 150 was up 200,000 m^3 per year over the Base Case. The enhanced stands do not become available for harvest until year 71 (Figure 69). For this reason the impact is not seen until late in the planning horizon. The impact is rather small because the Base Case establishment densities are already reasonably high and the increased densities do not generally enhance the growth and yield of the treated stands significantly as depicted in Figure 70. The example illustrated in Figure 70 was chosen because in this analysis unit - ESSFmv1 01 - the increase in growth and yield due to higher establishment density was among the highest. Note that it is expected that the higher establishment densities will increase the overall resiliency of the managed stands; this will have timber supply implications in the event of pest and disease epidemics.

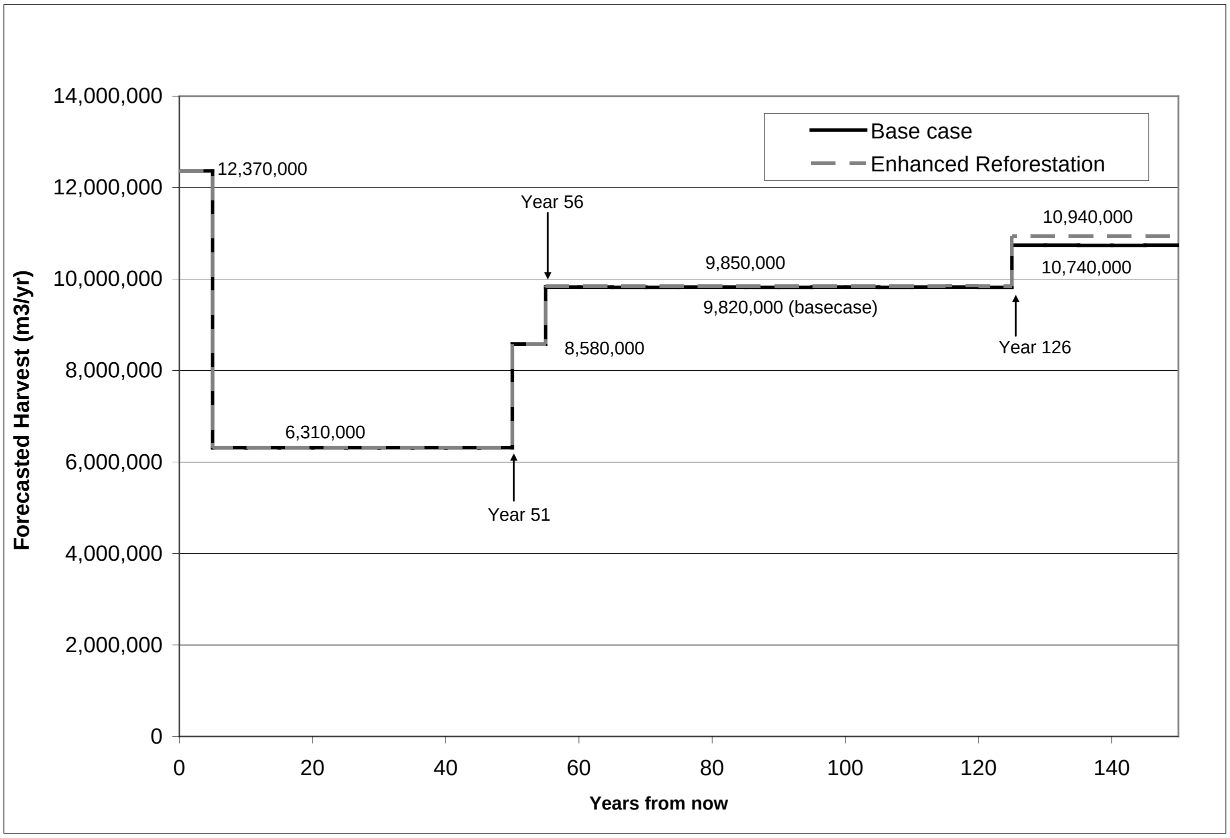


Figure 68: Harvest forecast; enhanced reforestation

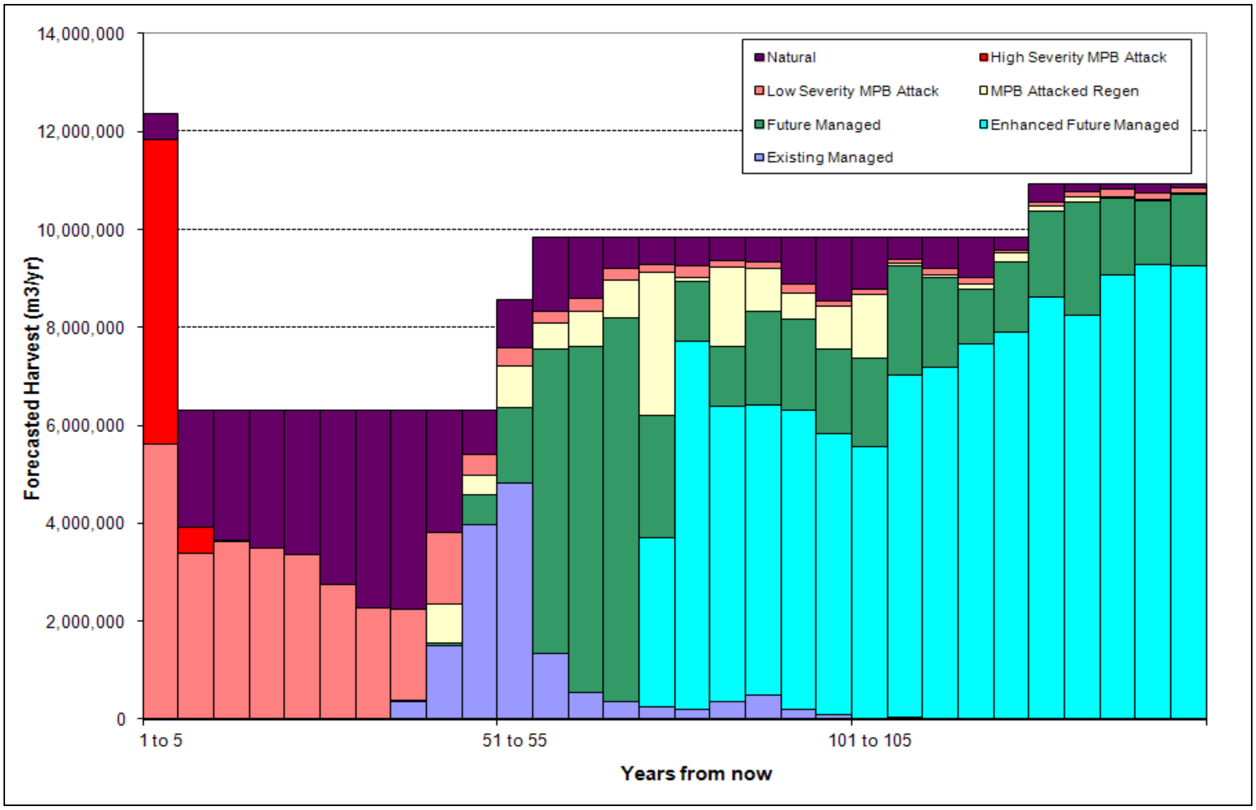


Figure 69: Harvest forecast by yield type; enhanced reforestation

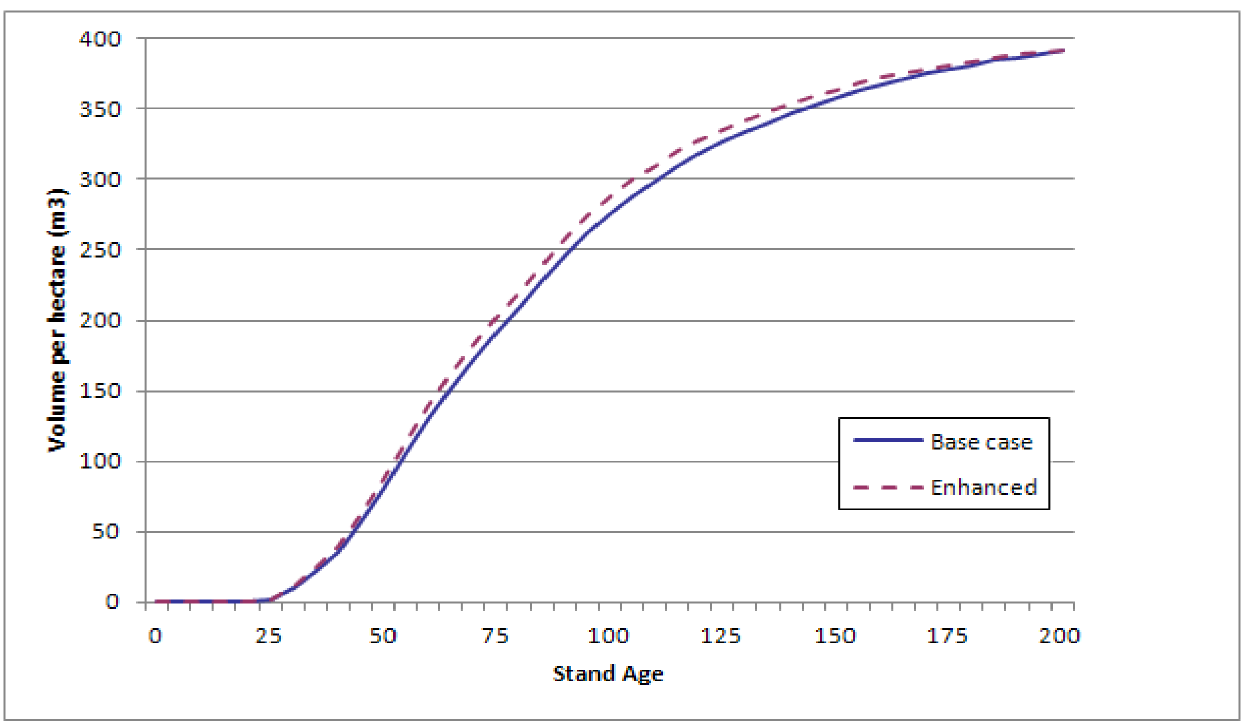


Figure 70: Comparison of a yield curve between Base Case stand and enhanced reforestation stand, ESSF mv1 01

3.2.12 Enhanced Reforestation and Fertilization Scenario

This scenario added up to four fertilization treatments to a subset of the enhanced silviculture population from the previous scenario. Fertilization occurred at ages 25, 35, 45, and 55. The areas and minimum harvest ages of the analysis units that were fertilized are shown in Table 25. The total area fertilized was 2,038,442 ha, 86% of the enhanced reforestation population. The fertilization costs were assumed to be $600/ha. The predicted annual costs are shown in Table 26.

Table 25: Summary of analysis units; enhanced reforestation and fertilization

Analysis Unit	Road Area (ha)	Rail Area (ha)	Base Case MHA	Enhanced MHA	Enhanced Fertilized MHA
ICHvk2_01	44,965	166	59	59	55
ICHwk3_01	11,794		64	64	58
ICHwk4_01	16,809		55	55	52
SBSdk_01	37,519		69	68	59
SBSdk_01/05	28,652		69	68	59
SBSdk_05	12,704		69	69	59
SBSdk_06	14,515		64	64	56
SBSdw2_01	86,439		69	68	59
SBSdw2_06	18,021		69	68	59
SBSdw3_01	229,895		69	69	60
SBSdw3_01/04	94,521		69	68	59
SBSdw3_05	27,311		74	72	61
SBSdw3_06	13,486		69	69	60
SBSmc2_01	150,938	30,084	69	68	60
SBSmc2_05	10,871	732	64	63	56
SBSmc3_01	63,870		59	57	51
SBSmc3_01/05	12,302		64	62	54
SBSmc3_04	13,202		74	73	62
SBSmc3_05	39,209		69	66	57
SBSmk1_01	430,907		69	68	60
SBSmk1_05	72,447		74	73	63
SBSmw_01	34,292		64	64	57
SBSvk_05	17,624		74	74	65
SBSwk1_01	286,748		64	64	58
SBSwk1_03	23,151		64	63	55
SBSwk1_05	17,484		59	59	53
SBSwk3_01	128,829	2,856	78	78	68
SBSwk3_04	49,165	1,228	69	68	60
SBSwk3_07	15,165	540	59	59	54

Table 26: Annual costs; enhanced reforestation and fertilization

Years	Planting		Fertilizing		Total Annual Treatment Area (ha)	Total Annual Cost
	Annual treatment area (ha)	Annual cost	Annual Treatment Area (ha)	Annual Cost		
1-5	39,209	$7,230,524			39,209	$7,230,524
6-10	15,417	$2,633,367			15,417	$2,633,367
11-15	12,976	$2,241,412			12,976	$2,241,412
16-20	14,792	$2,516,204			14,792	$2,516,204
21-25	15,991	$2,724,108			15,991	$2,724,108
26-30	16,727	$2,711,926	36,520	$21,911,971	53,247	$24,623,897
31-35	17,341	$2,765,280	14,117	$8,470,315	31,458	$11,235,595
36-40	20,477	$3,349,384	48,283	$28,969,568	68,759	$32,318,952
41-45	21,283	$3,773,819	26,912	$16,147,059	48,194	$19,920,877
46-50	20,521	$3,797,678	60,781	$36,468,505	81,301	$40,266,183
51-55	25,717	$4,612,623	39,563	$23,737,568	65,279	$28,350,191
56-60	31,710	$5,927,102	74,000	$44,399,836	105,710	$50,326,938
61-65	36,295	$6,792,371	57,056	$34,233,732	93,351	$41,026,103
66-70	33,236	$6,228,283	57,181	$34,308,622	90,417	$40,536,905
71-75	29,717	$5,708,376	62,317	$37,389,964	92,034	$43,098,340
76-80	30,214	$5,577,198	69,999	$41,999,323	100,212	$47,576,521
81-85	29,006	$5,042,081	79,064	$47,438,396	108,070	$52,480,477
86-90	27,125	$4,992,815	92,017	$55,210,447	119,143	$60,203,262
91-95	29,452	$5,282,839	97,423	$58,453,821	126,875	$63,736,660
96-100	27,847	$4,937,215	104,372	$62,623,042	132,219	$67,560,256

This scenario had no impact on the mid-term harvest level; however the harvest from year 56 and onwards was increased substantially. Between years 56 and 60 the harvest was increased by 1.09 million m^3 per year from the Base Case to 10,910,000 m^3 per year. Similarly between years 61 to 125 the harvest level was 1.51 million m^3 per year higher than that of the Base Case and from year 126 onwards it was 1.33 million m^3 per year above the Base Case level of 10,740,000 m^3 per year at 12,070,000 m^3 per year (Figure 71). Fertilizing these stands allows for their harvest to start 5 years earlier (year 66) than in the previous scenario (Figure 72). It also increases the volume of the stands, allowing for a higher long term harvest level.

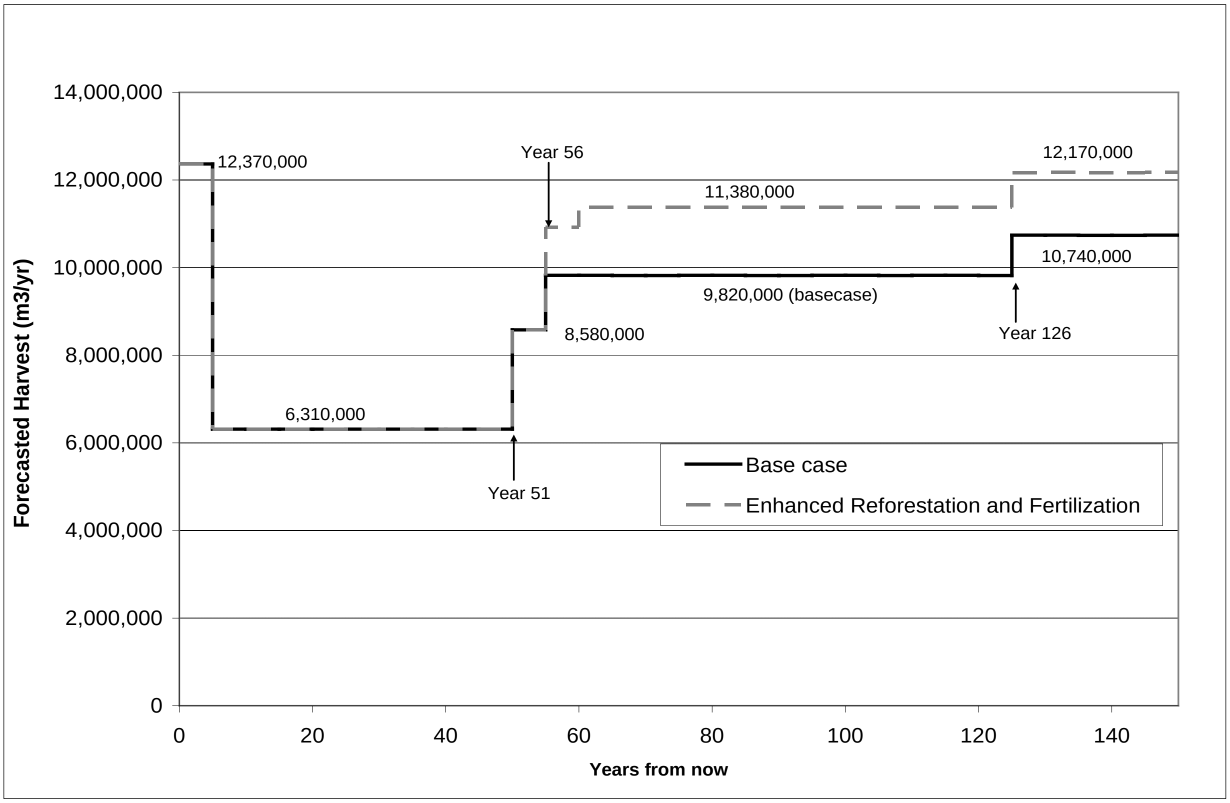


Figure 71: Harvest forecast; enhanced reforestation and fertilization

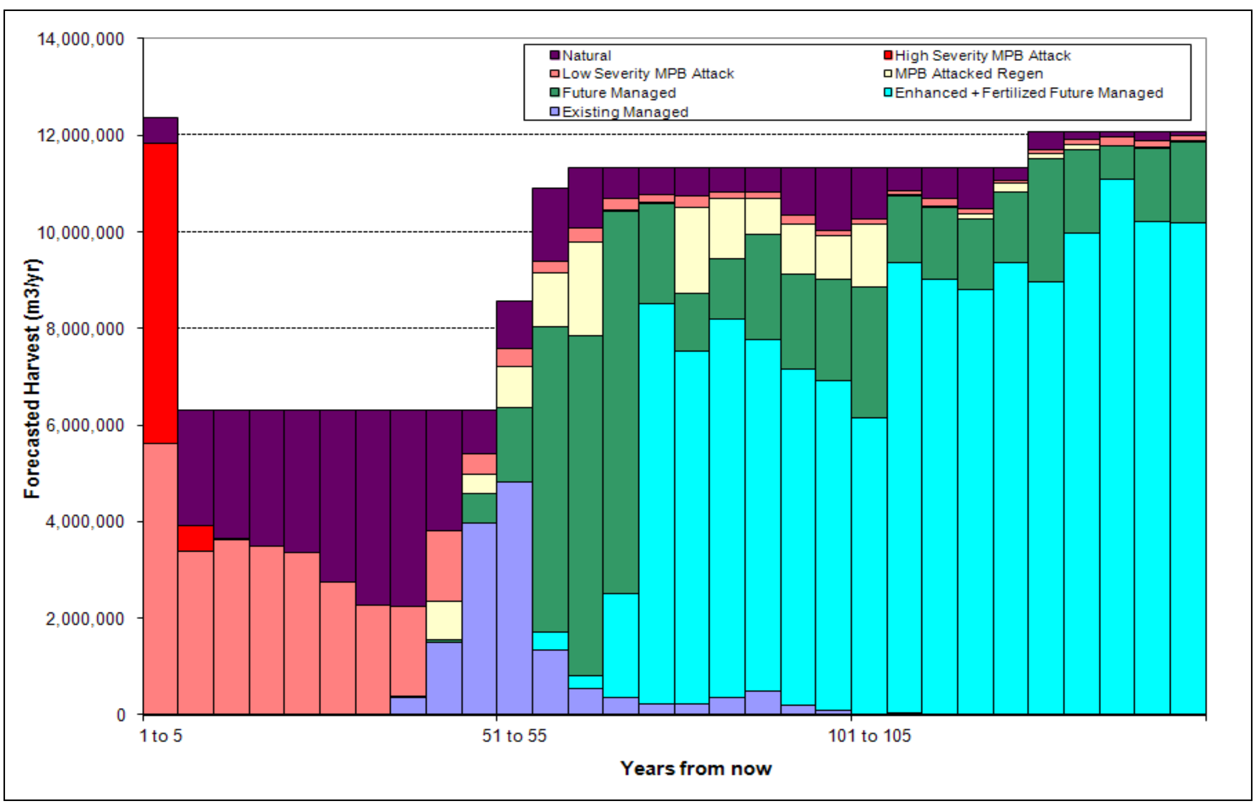


Figure 72: Harvest forecast by yield type; enhanced reforestation and fertilization

3.2.13 Comparison of Silviculture Scenarios

Table 27 provides an overview of the differences between the harvest levels of the silviculture scenarios and the base case. The harvest level differences presented are averages during the four periods (MPB uplift, midterm, step-up, and long-term) and have been rounded to the nearest 500m^3/yr.

In general, the fertilization scenarios provided an increase to the midterm harvest levels; however, this increase resulted in a decrease to the harvest between years 51 to 125. The benefits from the rehabilitation and enhanced reforestation scenarios appear too late in the planning horizon to make any impact to the midterm harvest level.

Table 27: Summary of average harvest levels for silviculture scenarios, compared to the base case

Silviculture Scenario	Average Harvest Difference from Base Case (m^3/yr)			
	MPB uplift (years 1 to 5)	midterm (years 6 to 50)	step-up (years 51 to 125)	long-term (years 125 to 150)
Rehabilitation	0	-30,500	643,500	-1,000
Rehabilitation and Fertilization	0	-35,500	718,500	-100,000
Fertilization of Young Natural	0	100,500	-60,500	0
Fertilization of Existing Managed	0	465,500	-136,500	-500
Fertilization of All Managed	0	1,165,000	-208,500	-500
Fertilization of All Managed and Young Natural	0	1,182,000	-182,500	-198,500
Enhanced Reforestation	0	0	23,500	197,000
Enhanced Reforestation and Fertilization	0	0	1,425,000	1,435,000

The average additional costs for each siliviculture scenario, above the base case, are shown in Table 28. While these costs are presented as averages spread out during the periods being reported on, the timing of the costs within the periods for some scenarios is not even. For example, in the fertilization of all managed stands scenario the costs in the step-up period all occur in years 51 to 55, though the average spread out during the entire step-up period is presented here.

Table 28: Summary of average costs for silviculture scenarios, compared to the base case

Silviculture Scenario	Average Additional Silviculture Costs ($/yr)			
	MPB uplift (years 1 to 5)	midterm (years 6 to 50)	step-up (years 51 to 125)	long-term (years 125 to 150)
Rehabilitation	$113,155,200	$0	$0	$0
Rehabilitation and Fertilization	$113,155,200	$11,303,988	$2,078,953	$0
Fertilization of Young Natural	$3,333,492	$1,263,749	$0	$0
Fertilization of Existing Managed	$15,040,092	$9,658,644	$0	$0
Fertilization of All Managed	$15,040,092	$28,943,038	$909,286	$0
Fertilization of All Managed and Young Natural	$18,373,583	$30,217,080	$909,286	$0
Enhanced Reforestation	$7,230,524	$2,945,909	$4,844,649	$5,316,153
Enhanced Reforestation and Fertilization	$7,230,524	$15,386,733	$49,489,565	N/A

3.3 Expanding the Economically Operable Land Base

In the land base classification, areas that never reached a minimum harvest volume, or were too far away, were not considered economic for harvest operations. In the rail portion of the Fort St James Resource District (mostly consisting of supply block A), the non-economic stands either did not meet the threshold volume of 246 m^3/ha or had a cycle time more than 3.9 hours from the nearest rail head.

While not considered a customary silviculture strategy, expanding infrastructure to facilitate harvesting, can also provide access for other treatments. Therefore, 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 the Fort St. James Resource District, therefore increasing the THLB. Areas within supply block A that met the minimum harvest volume for the rail area with current cycle times between 3.9 and 5 hours were switched from NHLB to THLB to simulate improved access. The increased THLB was 24,502 ha. The costs for this scenario are unknown and were not modeled.

Figure 73 illustrates the current age class distribution by leading species of the added THLB area in Supply Block A. Age class 8 and 9 balsam stands form the majority of the added area.

As expected the additional THLB allows for a higher mid-term harvest level; the harvest can be increased modestly by 2.5% from 6,310,000 m^3 per year to 6,470,000 m^3 per year (Figure 74). This increase is attributable to the older stands from Supply Block A filling the pinch point at around 45 years from now as shown in (Figure 75).

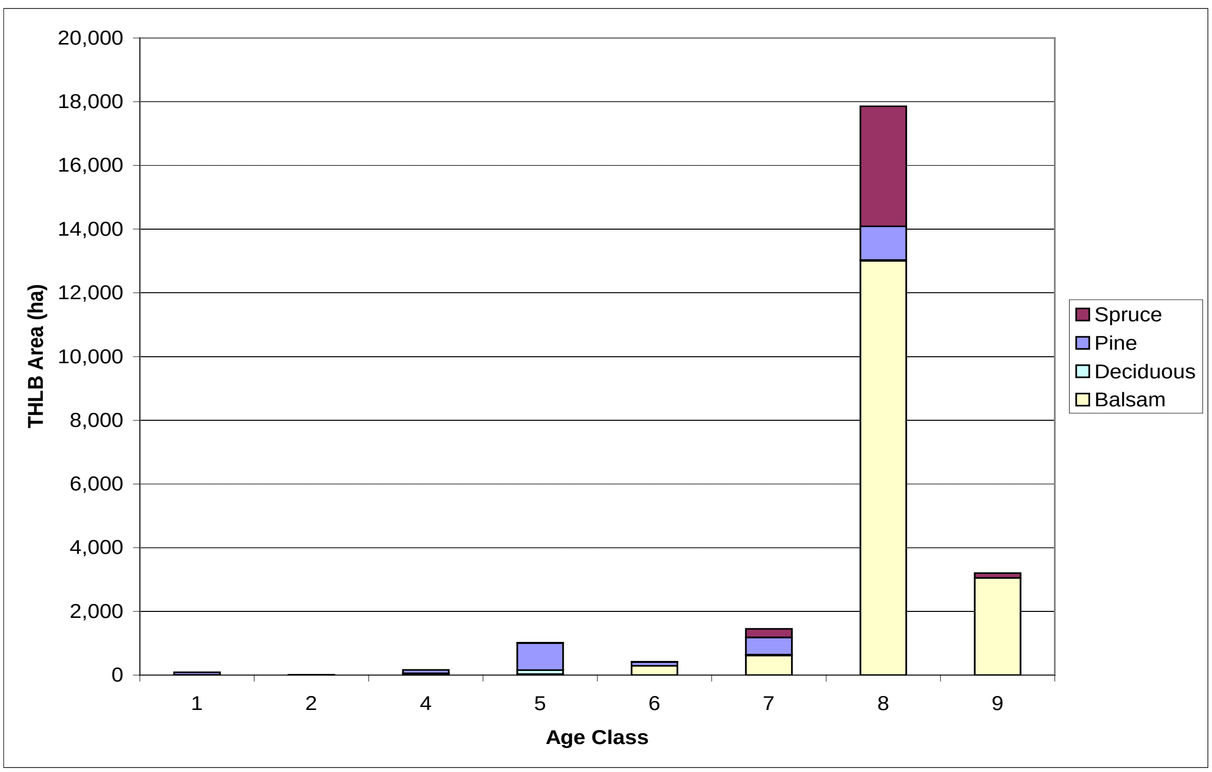


Figure 73: Additional THLB; age class distribution by leading species

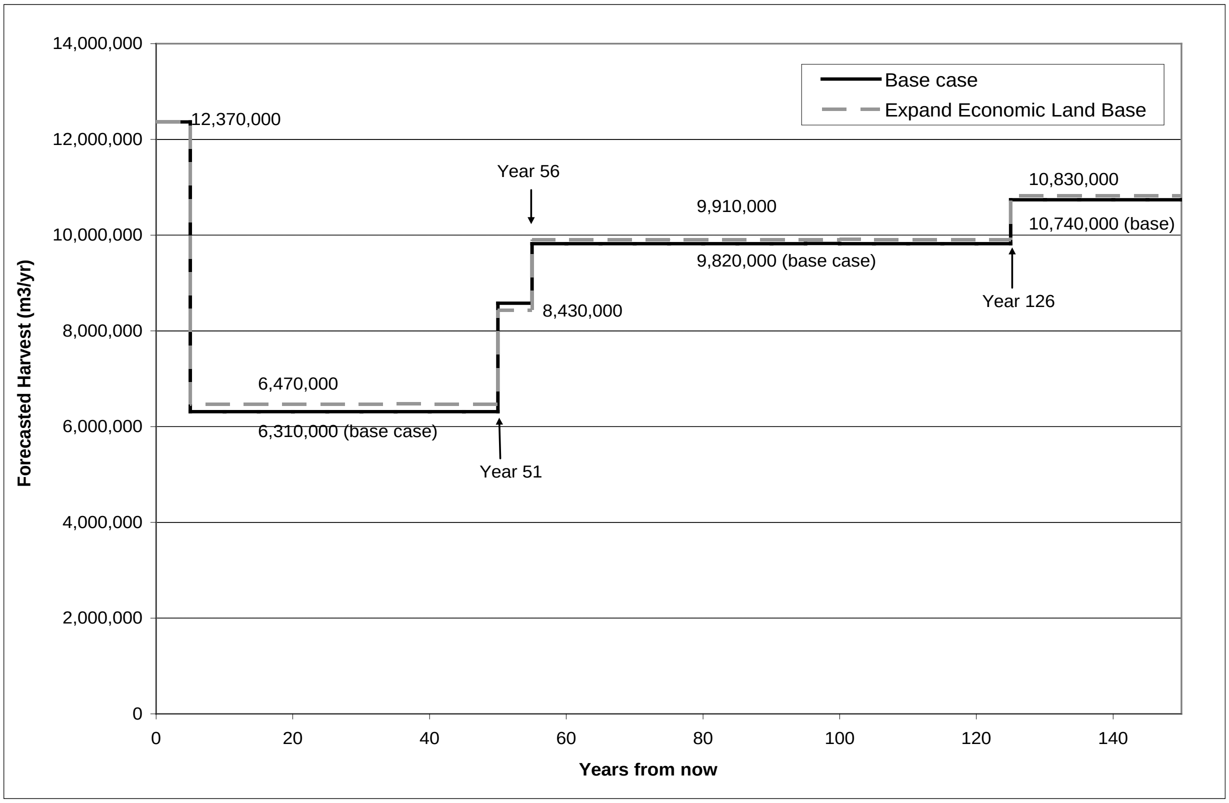


Figure 74: Harvest forecast; increasing the THLB by infrastructure improvement

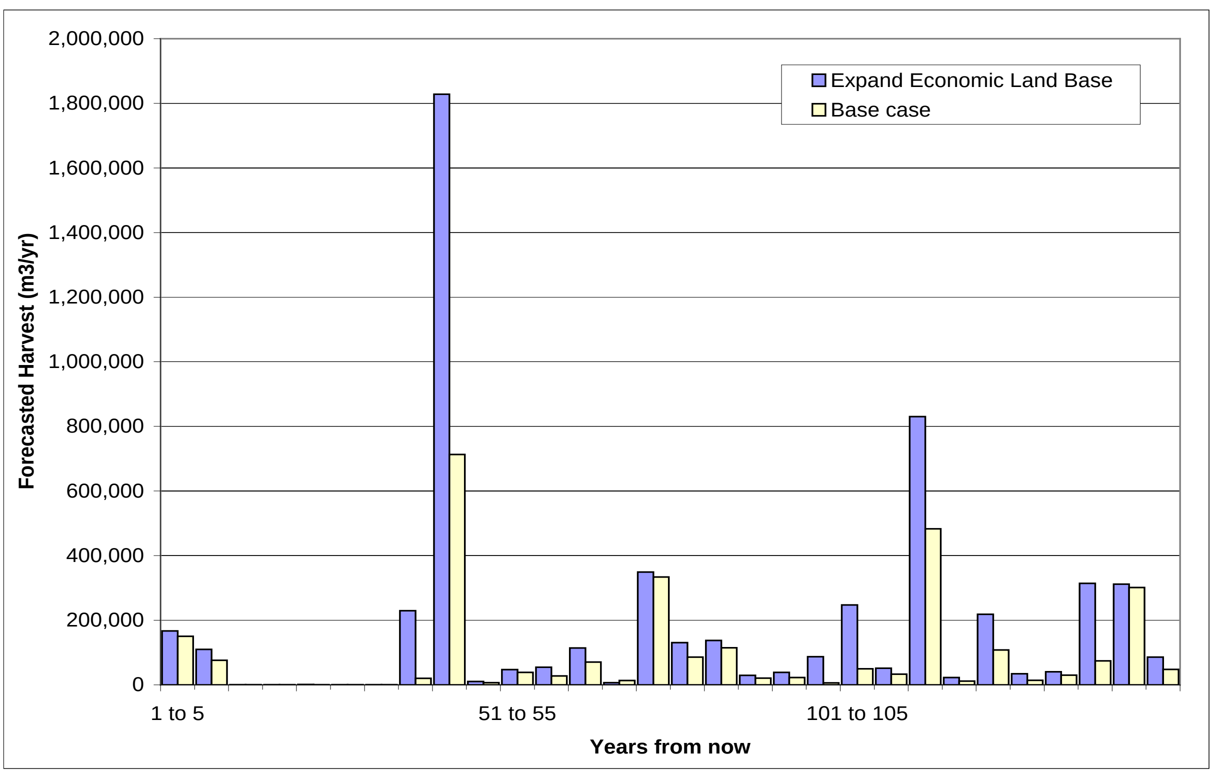


Figure 75: Harvest forecast from Supply Block A compared to the base case

4 Composite Scenarios

Two composite scenarios were constructed. For both scenarios the fertilization costs were adjusted to $500.00 per ha from the $600.00 used in the initial scenarios. The costs of rehabilitating dead pine stands were assumed to be $2,000 per ha as before.

The first scenario was designed by the Prince George TSA stakeholder group. It set an incremental silviculture target of 8,000 ha of fertilization per year for the next 10 years at the cost $4 million per year. Due to First Nations' concerns, no fertilization was recommended in Fort St. James for the first 5 years of the planning horizon.

The target for the rehabilitation of dead pine stands is a modest 200 ha per year at the cost of $400,000 annually. The stakeholder group felt that in spite of the large areas of dead pine stands that are not predicted to be harvested by conventional harvest operations (mostly sawlog), opportunities still exist for the biofuel industry to utilize this dead timber. For this reason the recommendation is to focus the limited rehabilitation efforts on younger stands, so as to not compromise the biofuel opportunities.

No targets were set for enhanced reforestation; the stakeholder group felt that while important and worth pursuing, increased planting densities should be pursued through policy direction with no further modelling. A sum of $600,000 annually was recommended for surveys and monitoring. This was not modeled in the scenarios below.

The annual budget cap was set at $4.4 million for the next 30 years. Treatments (and costs) take place beyond this time period due to the nature of fertilization treatments; the last fertilization treatment of some regimes occurs as late as 55 years into the future. Note that rehabilitation treatments were not extended beyond the first 20 years.

The second scenario increased the annual funding to $6.4 million and maintained this budget through 30 years.

Both scenarios were modeled using a combination of heuristics and time-step simulation techniques. Heuristics were used to help determine the stands for treatments, while time step simulation techniques were employed to determine the harvest forecast for the composite scenarios.

4.1 Composite Scenario 1

Using a $4.4 annual incremental silviculture budget resulted in a 3.5% increase in harvest between years 6 and 45 (Figure 76). The increase was more pronounced between years 46 and 50 at approximately 14.5%. The harvest increases in the near mid-term come at a cost: the step up to higher harvest levels is delayed compared to the base case. Between years 51 and 55 the harvest level is predicted to be 15.8% less than that of the base case, and from year 56 to 71, 3.3% less harvest is projected compared to the base case.

The treatment areas (ha) as modeled are shown in Table 29 and Table 30 shows the budget split by treatment. As only existing stands were fertilized, the fertilized area and expenditures decline over time and eventually go to 0 (not shown). The majority of the fertilization treatments are in the Prince George Resource District as shown in Table 31 while rehabilitation treatments are mostly located in Vanderhoof (Table 32).

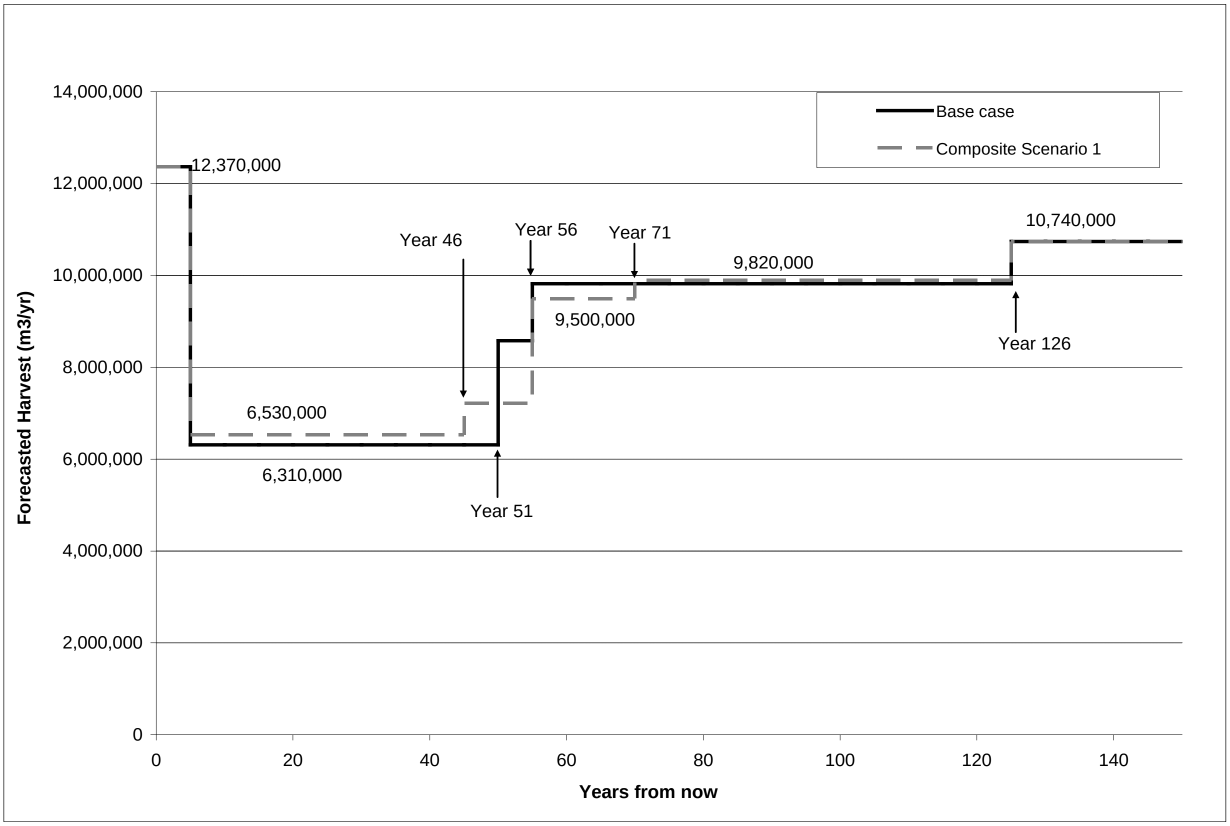


Figure 76: Composite Scenario 1 compared to the base case

Table 29: Annual treatment areas (ha); Composite Scenario 1

Year	Fertilize	Rehab	Total
1 to 5	8,000	200	8,200
6 to 10	8,000	200	8,200
11 to 15	8,000	200	8,200
16 to 20	8,332	200	8,532
21 to 25	8,001		8,001
26 to 30	8,000		8,000
31 to 35	6,121		6,121
36 to 40	6,207		6,207
41 to 45	1,681		1,681
46 to 50	517		517

Table 30: Annual budget split by treatment; Composite Scenario 1

Year	Fertilize	Rehab	Total
1 to 5	$4,000,000	$400,076	$4,400,076
6 to 10	$4,000,000	$400,041	$4,400,041
11 to 15	$4,000,000	$400,004	$4,400,004
16 to 20	$4,166,053	$400,012	$4,566,065
21 to 25	$4,000,251		$4,000,251
26 to 30	$4,000,000		$4,000,000
31 to 35	$3,060,522		$3,060,522
36 to 40	$3,103,571		$3,103,571
41 to 45	$840,343		$840,343
46 to 50	$258,440		$258,440

Table 31: Annual fertilization areas (ha) by Resource District, Composite Scenario 1

Year	DJA	DPG	DVA	Total
1 to 5	0	7,003	997	8,000
6 to 10	1,511	4,710	1,779	8,000
11 to 15	191	6,525	1,284	8,000
16 to 20	1,556	4,681	2,095	8,332
21 to 25	191	5,944	1,866	8,001
26 to 30	1,500	4,408	2,092	8,000
31 to 35	191	4,097	1,833	6,121
36 to 40	1,144	3,512	1,552	6,207
41 to 45	190	650	840	1,681
46 to 50	88	183	246	517

Table 32: Annual rehabilitation areas (ha) by Resource District, Composite Scenario 1

Year	DJA	DPG	DVA	Total
1 to 5	20.3	19.2	160.5	200.0
6 to 10	11.5	8.0	180.5	200.0
11 to 15	14.3	48.3	137.3	200.0
16 to 20	27.4	21.6	151.0	200.0

Figure 77 illustrates the harvest forecast by yield type for Composite Scenario 1. The harvest of fertilized stands starts in year 26 and contributes to the increased harvest. The harvest of rehabilitated dead pine stands is limited and contributes little to the harvest. Stands with remaining secondary structure and natural regeneration (MPB attacked regen) play a significant role in the late mid-term.

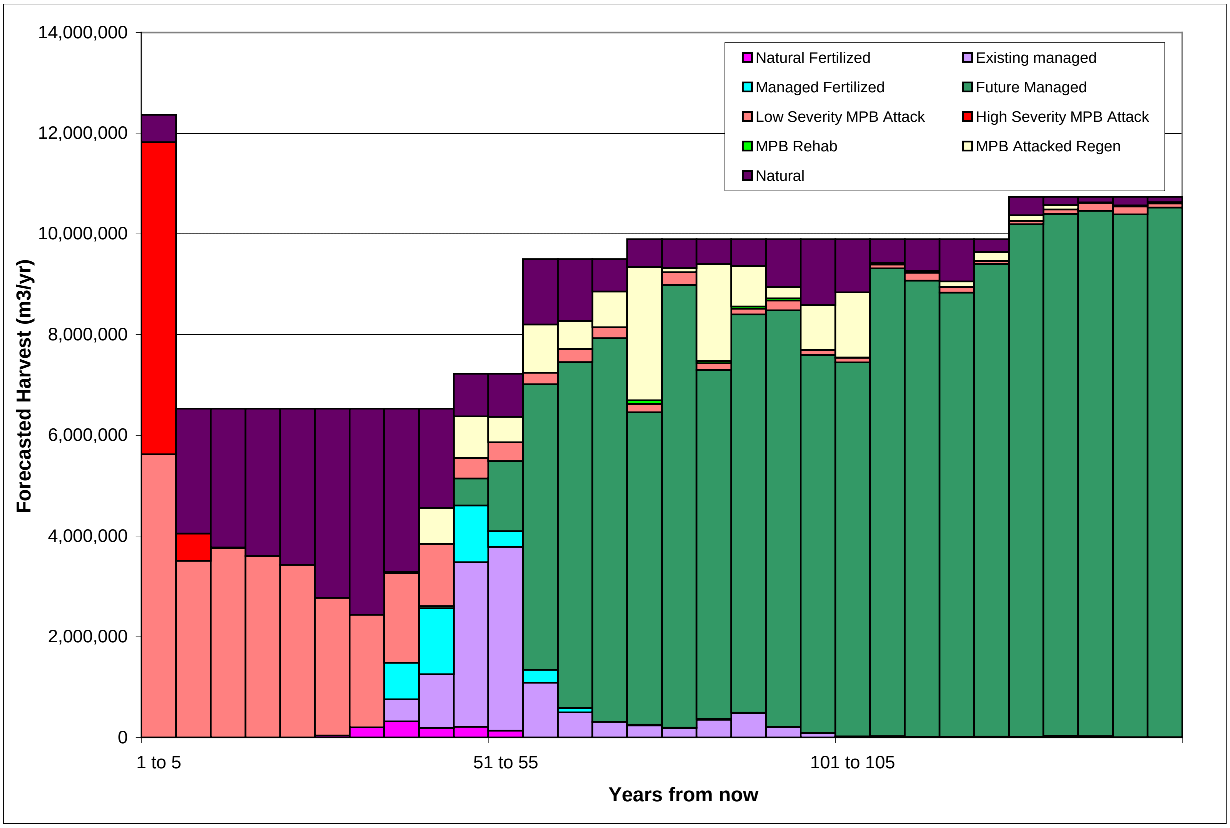


Figure 77: Harvest forecast by yield type; Composite Scenario 1

Figure 78 compares the predicted quadratic mean diameter of managed stands between the base case and Composite Scenario 1. In the base case graph, existing managed stands and future managed stands are combined. For Composite Scenario 1, two categories are identified: untreated managed stands and fertilized managed stands. The fertilized managed stands are predicted to have higher mean diameter at harvest than managed stands. The same results are also presented in Table 33.

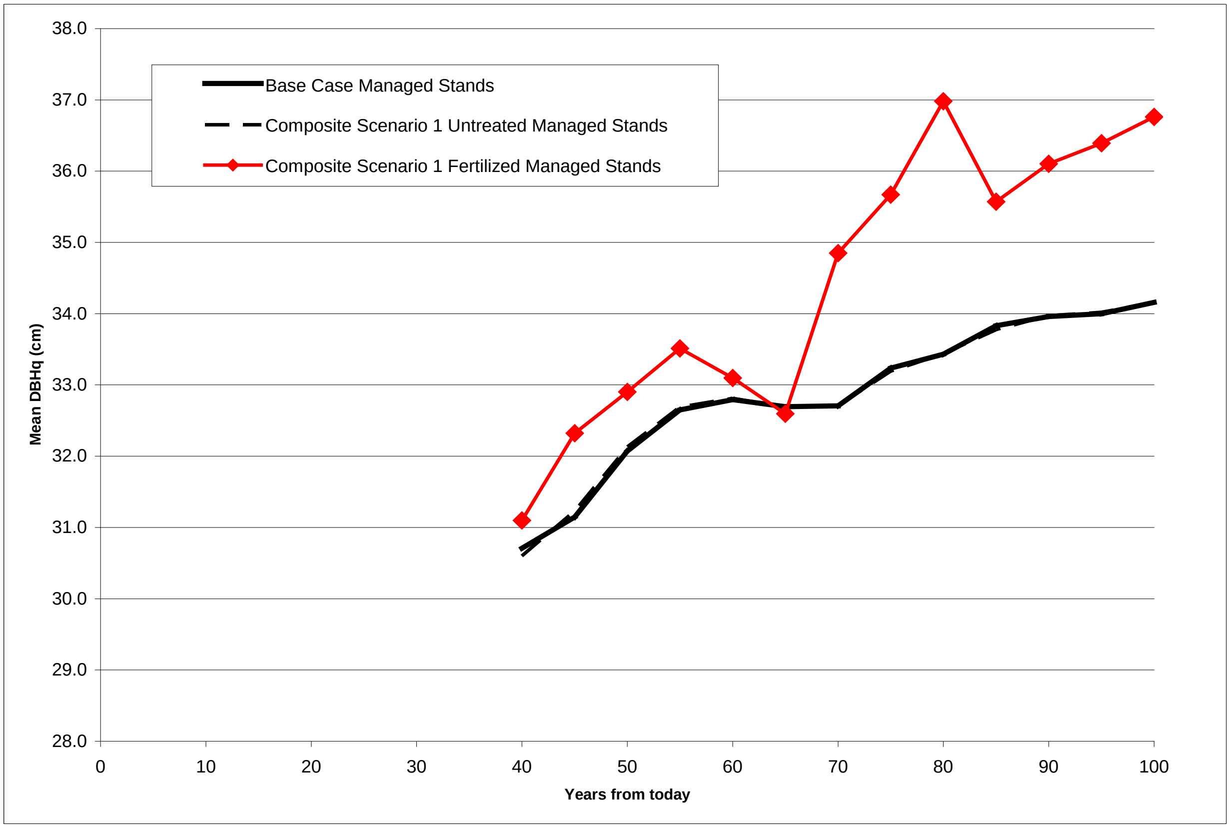


Figure 78: Predicted quadratic mean dbh, managed stand harvest; Composite Scenario 1

Table 33: Predicted quadratic mean dbh, managed stand harvest; Composite Scenario 1

Year	Base Case		Composite Scenario 1			
	Managed Stands		Managed Stands		Fertilized Stands	
	Harvest/yr	Mean DBHq	Harvest/yr	Mean DBHq	Harvest/yr	Mean DBHq
36-40	355,688	30.7	436,596	30.6	728,573	31.1
41-45	1,545,519	31.1	1,112,326	31.2	1,307,713	32.3
46-50	4,570,313	32.1	3,798,670	32.1	1,128,558	32.9
51-55	6,364,994	32.6	5,041,193	32.7	308,711	33.5
56-60	7,550,923	32.8	6,759,127	32.8	253,394	33.1
61-65	7,610,528	32.7	7,366,331	32.7	86,349	32.6
66-70	8,191,785	32.7	7,927,385	32.7	2,160	34.8
71-75	6,089,674	33.2	6,442,104	33.2	16,193	35.7
76-80	8,909,406	33.4	8,981,149	33.4	3,322	37.0
81-85	7,534,353	33.8	7,283,782	33.8	14,077	35.6
86-90	8,281,012	34.0	8,394,142	34.0	6,927	36.1
91-95	8,230,794	34.0	8,473,322	34.0	8,866	36.4
96-100	7,528,416	34.2	7,595,289	34.2	1,121	36.8

Table 34 presents the fertilization schedule by district, leading species and current stand age for the first 10 years. Figure 79, Figure 80 and Figure 81 illustrate the fertilization schedule for the first 10 years spatially in the Prince George, Vanderhoof and Fort St. James Natural Resource Districts. Note that no fertilization is scheduled in Fort St James until year 6 of the planning horizon.

Table 34: Fertilization; annual areas (ha) by resource district, leading species and age; Composite Scenario 1

Resource District	Years	Current Stand Age 1 to 15		Current Stand Age 16 to 25		Current Stand Age 26 to 60		Total
		Pine	Spruce	Pine	Spruce	Douglas-Fir	Spruce	
DPG	1 – 5			1,703	1,725	212	3,362	7,003
DVA	1 – 5			932		12	53	997
DPG	6 – 10	462	245	1,887	1,080	77	958	4,710
DVA	6 – 10	668		1,061		1	48	1,779
DJA	6 – 10	166	3	1,130	39	11	163	1,511

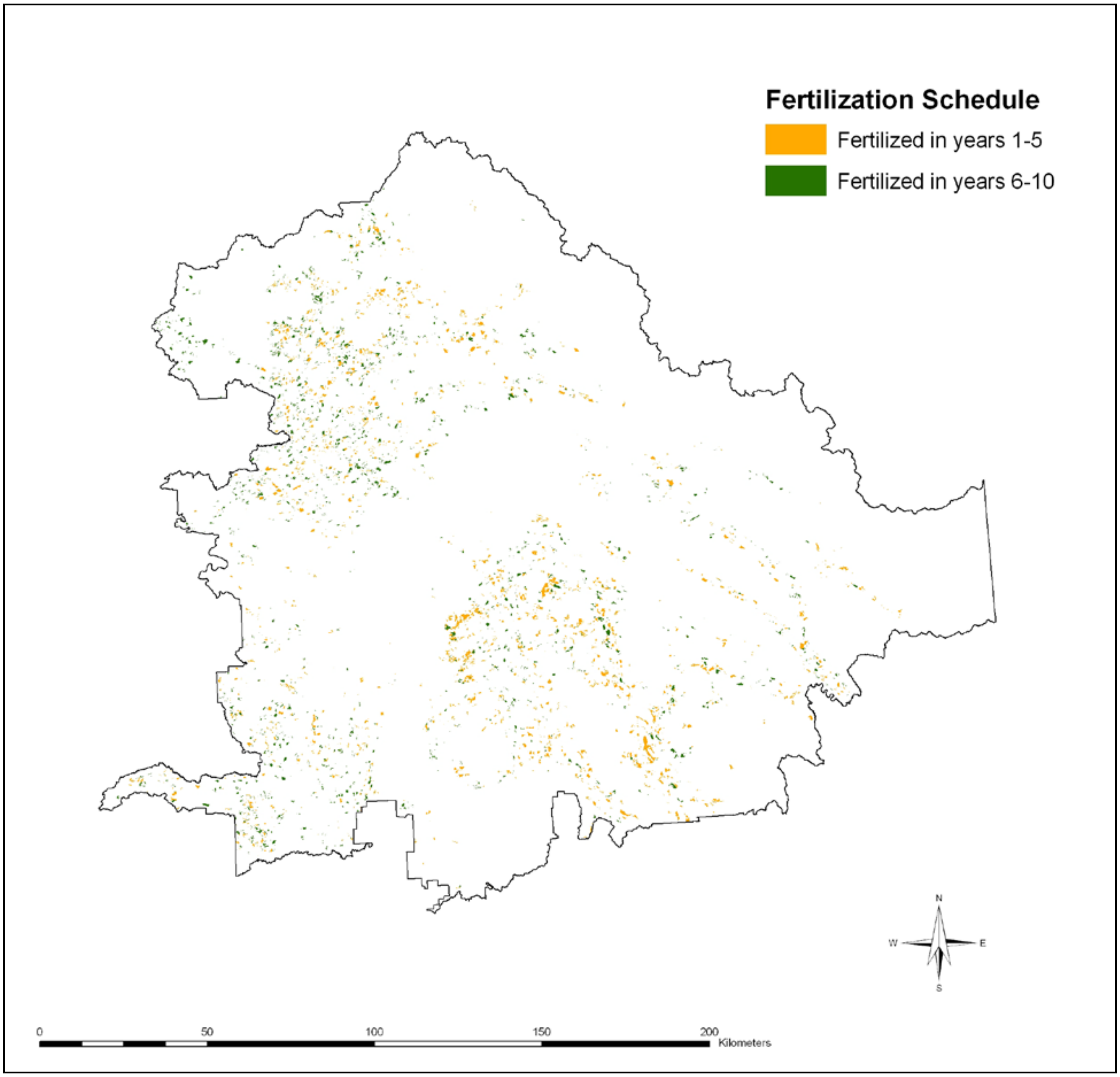


Figure 79: Stands fertilized in the model years 1 to 10, Prince George; Composite scenarios 1

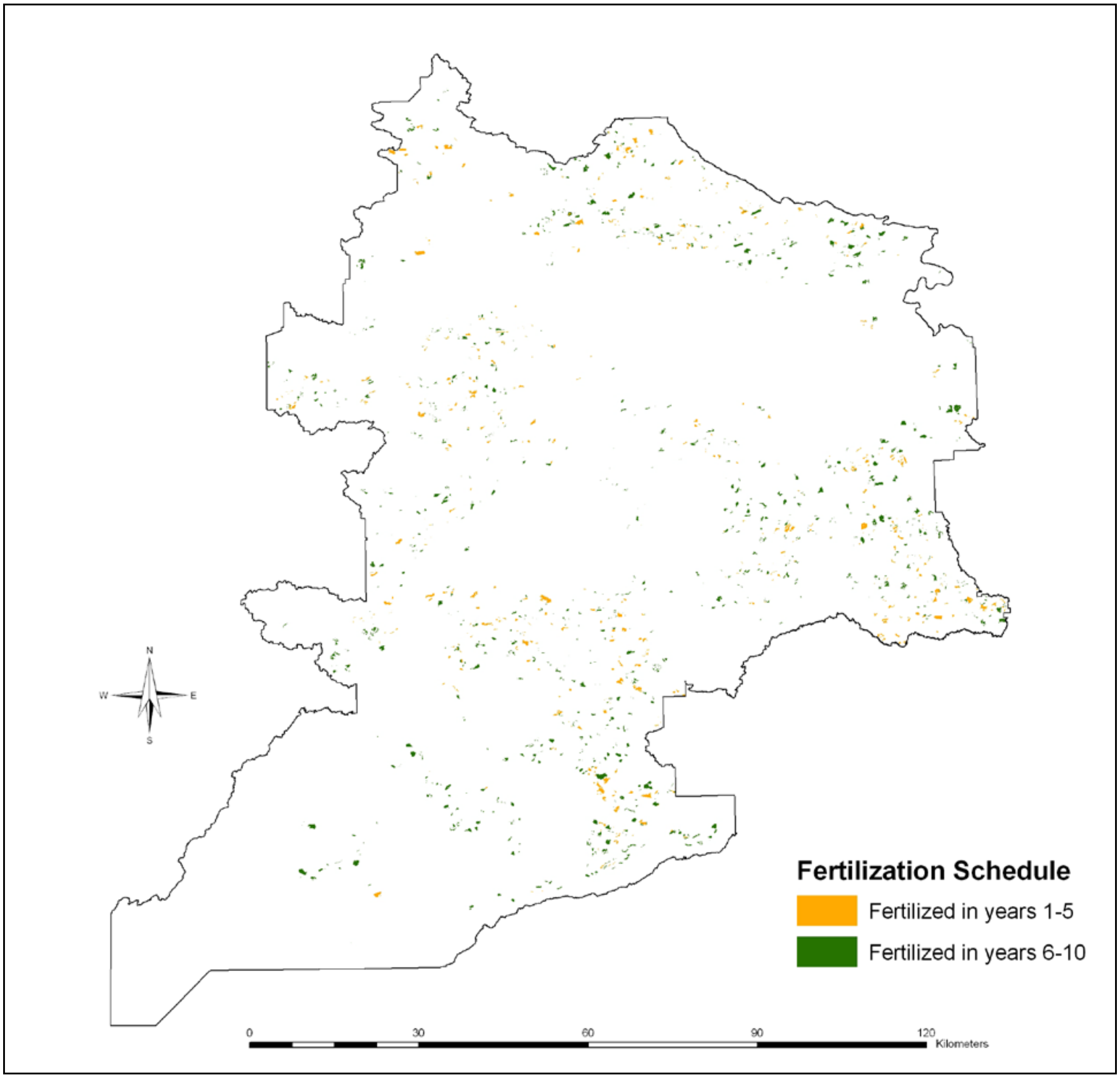


Figure 80: Stands fertilized in the model years 1 to 10, Vanderhoof; Composite scenarios 1

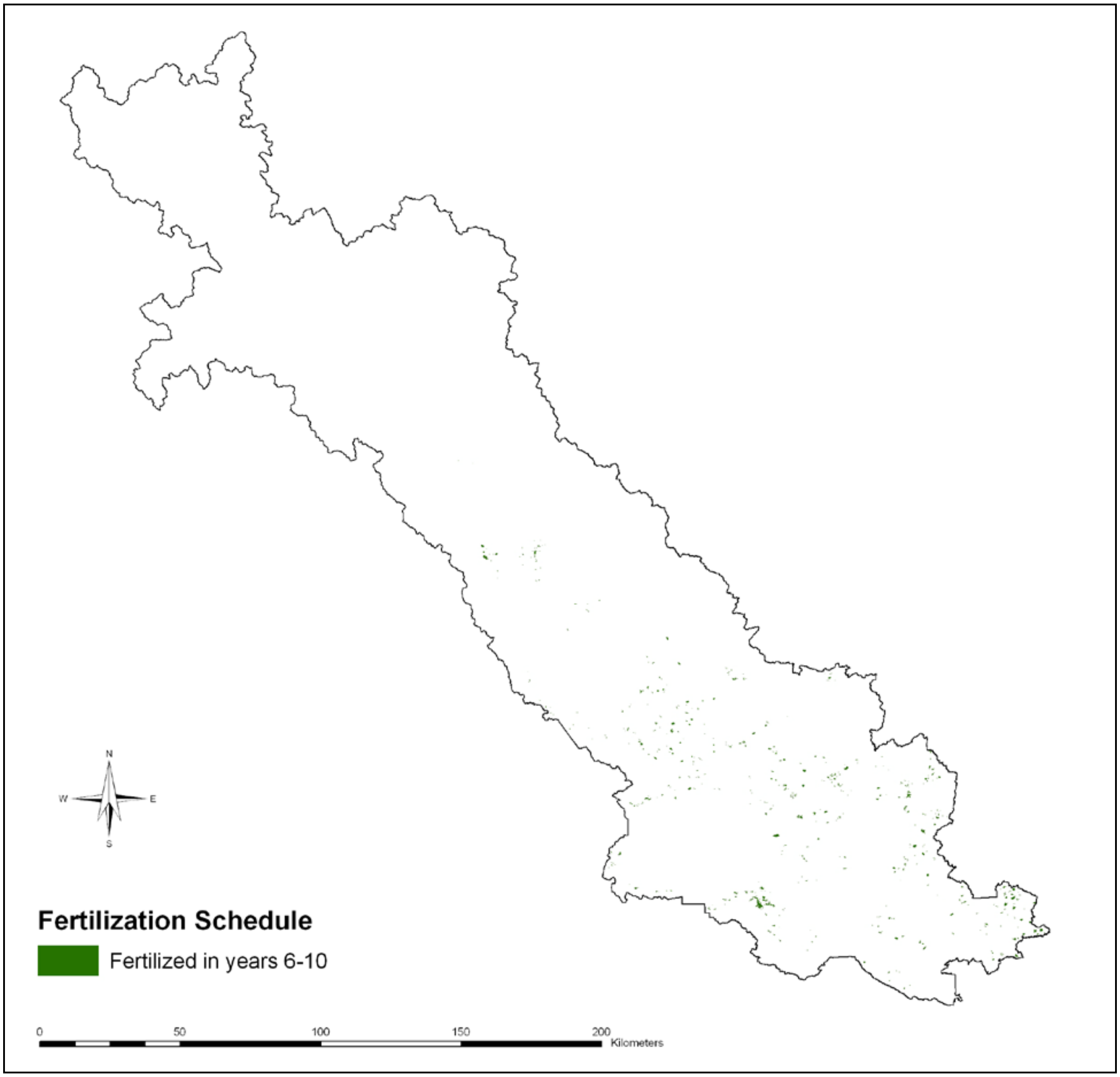


Figure 81: Stands fertilized in the model years 1 to 10, Fort St. James; Composite scenarios 1

4.2 Composite Scenario 2

This scenario increased the incremental silviculture budget to $6.4 million annually. This budget level resulted in a 5.9% increase in harvest between years 6 and 45 (Figure 82). The increase was larger between years 46 and 50 at approximately 9.2%. The harvest increases in the near mid-term reduce the harvest level more between years 51 and 55 than Composite Scenario 1; the harvest level is predicted to be 19.6% less than that of the base case, and from year 56 to 71, 4.3% less harvest is projected compared to the base case.

The treatment areas (ha) as modeled are shown in Table 35 and Table 36 shows the budget split by treatment. As in the previous scenario the majority of the fertilization treatments are in the Prince George Resource District as shown in Table 37 while rehabilitation treatments are mostly located in Vanderhoof (Table 38).

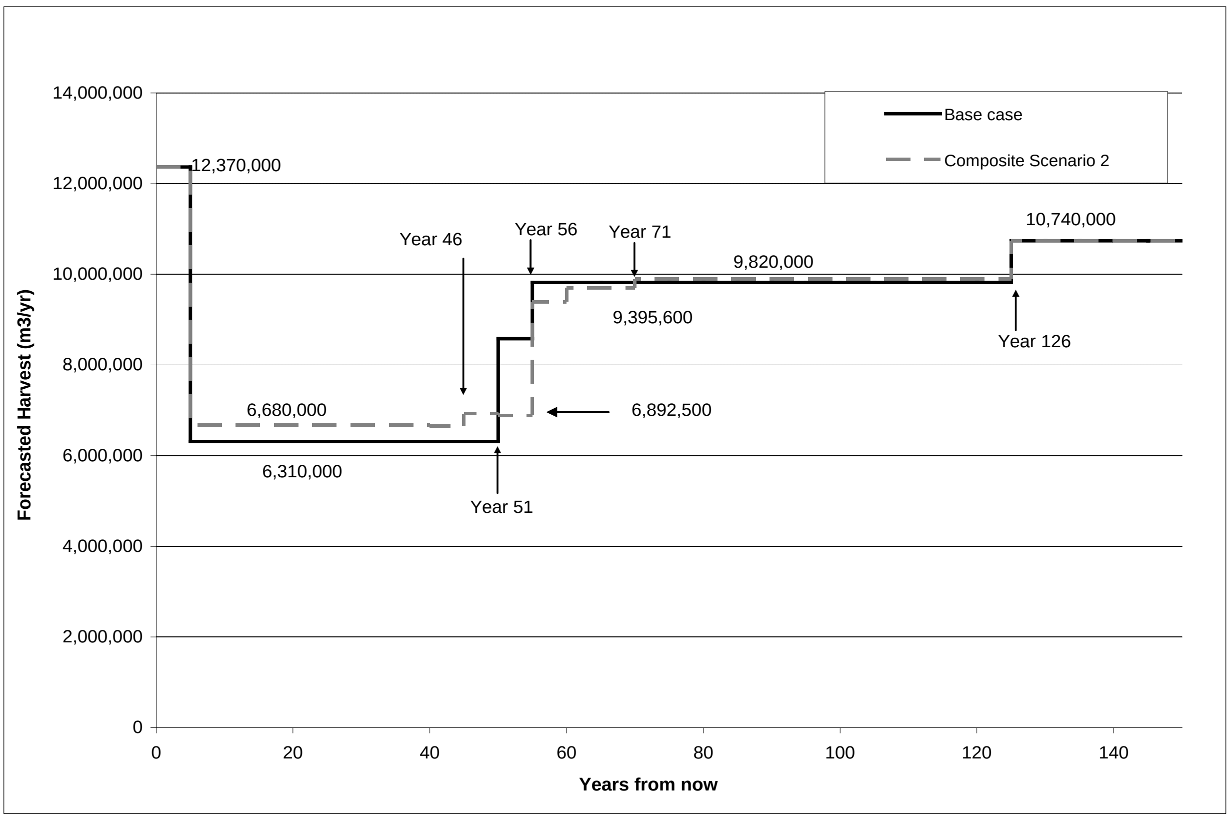


Figure 82: Composite Scenario 2 compared to the base case

Table 35: Annual treatment areas (ha); Composite Scenario 2

Year	Fertilize	Rehab	Total
1 to 5	12,000	392	12,392
6 to 10	12,000	392	12,392
11 to 15	12,000	387	12,387
16 to 20	12,386	390	12,776
21 to 25	12,001		12,001
26 to 30	12,000		12,000
31 to 35	9,184		9,184
36 to 40	9,368		9,368
41 to 45	1,851		1,851
46 to 50	585		585

Table 36: Annual budget split by treatment; Composite Scenario 2

Year	Fertilize	Rehab	Total
1 to 5	$6,000,000	$784,495	$6,784,495
6 to 10	$6,000,000	$783,436	$6,783,437
11 to 15	$6,000,000	$773,524	$6,773,524
16 to 20	$6,192,989	$779,818	$6,972,807
21 to 25	$6,000,593		$6,000,593
26 to 30	$6,000,000		$6,000,000
31 to 35	$4,591,937		$4,591,937
36 to 40	$4,684,107		$4,684,107
41 to 45	$925,426		$925,426
46 to 50	$292,527		$292,527

Table 37: Annual fertilization areas (ha) by Resource District, Composite Scenario 2

Year	DJA	DPG	DVA	Total
1 to 5	0	10,264	1,736	12,000
6 to 10	2,380	7,033	2,587	12,000
11 to 15	127	9,782	2,091	12,000
16 to 20	2,443	7,105	2,839	12,386
21 to 25	127	9,053	2,820	12,001
26 to 30	2,398	6,770	2,832	12,000
31 to 35	127	6,279	2,777	9,184
36 to 40	1,811	5,510	2,047	9,368
41 to 45	125	663	1,063	1,851
46 to 50	105	286	194	585

Table 38: Annual rehabilitation areas (ha) by Resource District, Composite Scenario 2

Year	DJA	DPG	DVA	Total
1 to 5	18.5	33.2	340.5	392.2
6 to 10	34.7	25.4	331.6	391.7
11 to 15	43.5	40.0	303.2	386.8
16 to 20	38.0	53.4	298.6	389.9

Figure 83 illustrates the harvest forecast by yield type for Composite Scenario 2. As in the previous scenario the harvest of fertilized stands starts in year 26 and contributes to the increased mid-term harvest. The harvest of rehabilitated dead pine contributes little to the harvest due to the small areas rehabilitated. Stands with remaining secondary structure and natural regeneration (MPB attacked regen) play a significant role in the late mid-term as in the previous scenario.

Figure 84 compares the predicted quadratic mean diameter of managed stands between the base case and Composite Scenario 2. As in Composite Scenario 2 the fertilized stands show higher mean diameters at harvest. The same results are also presented in Table 39.

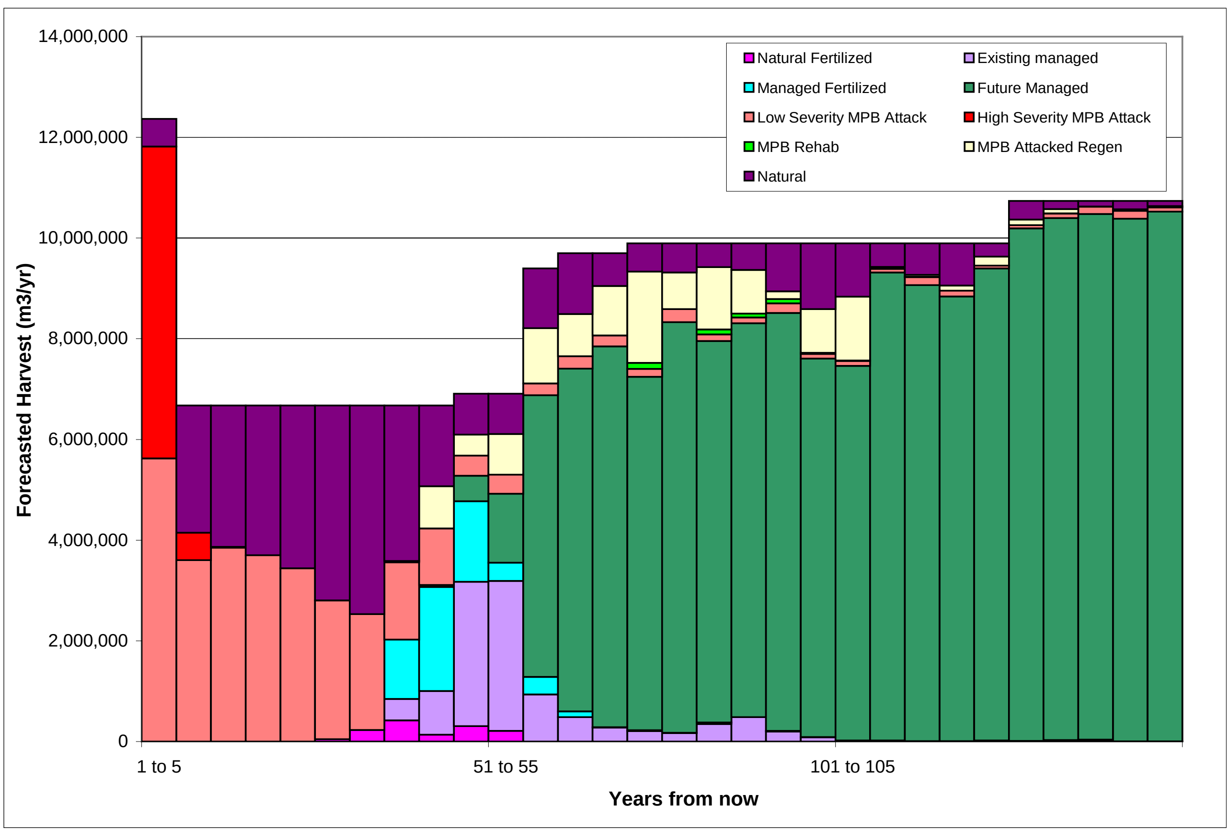


Figure 83: Harvest forecast by forest unit; Composite Scenario 2

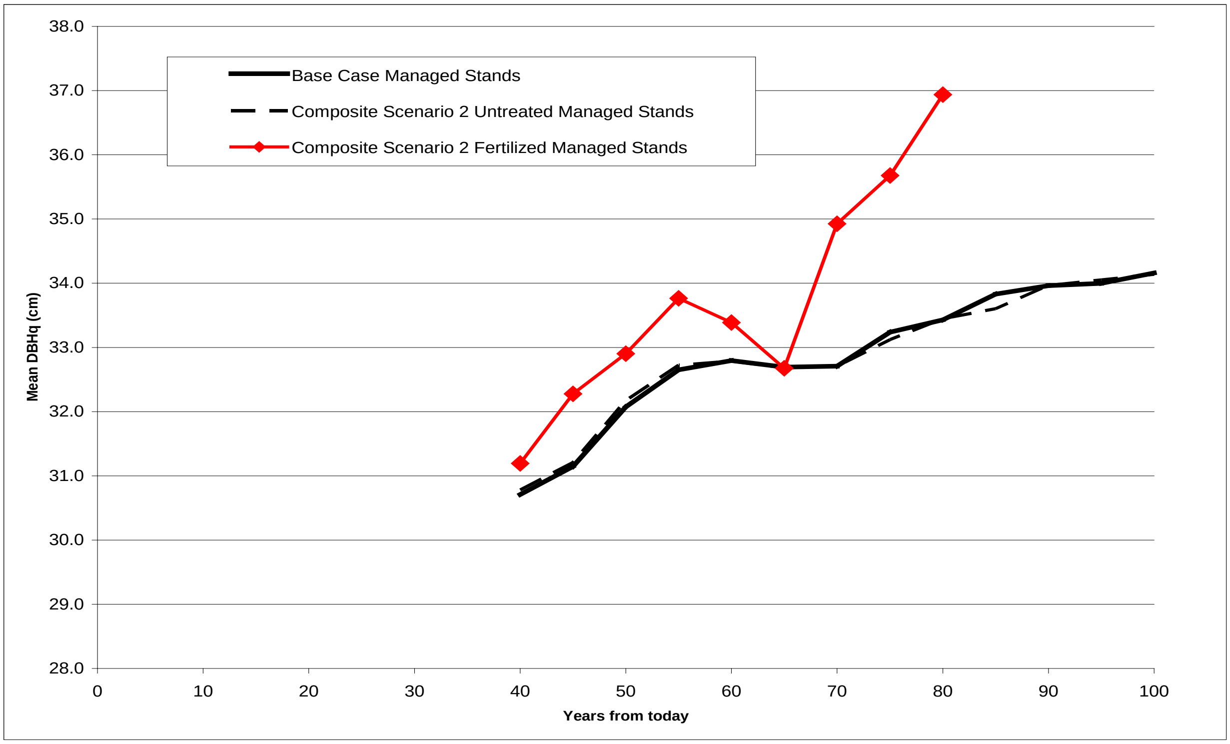


Figure 84: Predicted quadratic mean dbh, managed stand harvest; Composite Scenario 2

Table 39: Predicted quadratic mean dbh, managed stand harvest; Composite Scenario 2

Year	Base Case		Composite Scenario 2			
	Managed Stands		Managed Stands		Fertilized Stands	
	Harvest/yr	Mean DBHq	Harvest/yr	Mean DBHq	Harvest/yr	Mean DBHq
36-40	355,688	30.7	424,036	30.8	948,023	31.2
41-45	1,545,519	31.1	907,025	31.2	695,830	32.3
46-50	4,570,313	32.1	3,373,355	32.2	821,017	32.9
51-55	6,364,994	32.6	4,345,526	32.7	577,325	33.8
56-60	7,550,923	32.8	6,524,792	32.8	671,380	33.4
61-65	7,610,528	32.7	7,289,710	32.7	273,503	32.7
66-70	8,191,785	32.7	7,843,494	32.7	148,635	34.9
71-75	6,089,674	33.2	7,223,248	33.1	35,933	35.7
76-80	8,909,406	33.4	8,321,073	33.4	10,424	36.9
81-85	7,534,353	33.8	7,927,628	33.6	0	
86-90	8,281,012	34.0	8,305,761	34.0	0	
91-95	8,230,794	34.0	8,499,323	34.1	0	
96-100	7,528,416	34.2	7,601,222	34.1	0	

Table 40 presents the fertilization schedule by district, leading species and current stand age for the first 10 years. Figure 79, Figure 80 and Figure 81 illustrate the fertilization schedule for the first 10 years spatially in the Prince George, Vanderhoof and Fort St. James Natural Resource Districts.

Table 40: Fertilization; annual areas (ha) by resource district, leading species and age; Composite Scenario 2

Resource District	Years	Current Stand Age 1 to 15		Current Stand Age 16 to 25		Current Stand Age 26 to 60		Total
		Pine	Spruce	Pine	Spruce	Douglas-Fir	Spruce	
DPG	1 – 5			2,668	2,929	240	4,428	10,264
DVA	1 – 5			1,657		12	67	1,736
DPG	6 – 10	706	425	2,977	1,662	82	1,182	7,033
DVA	6 – 10	948		1,597		5	37	2,587
DJA	6 – 10	267	3	1,872	16	9	214	2,380

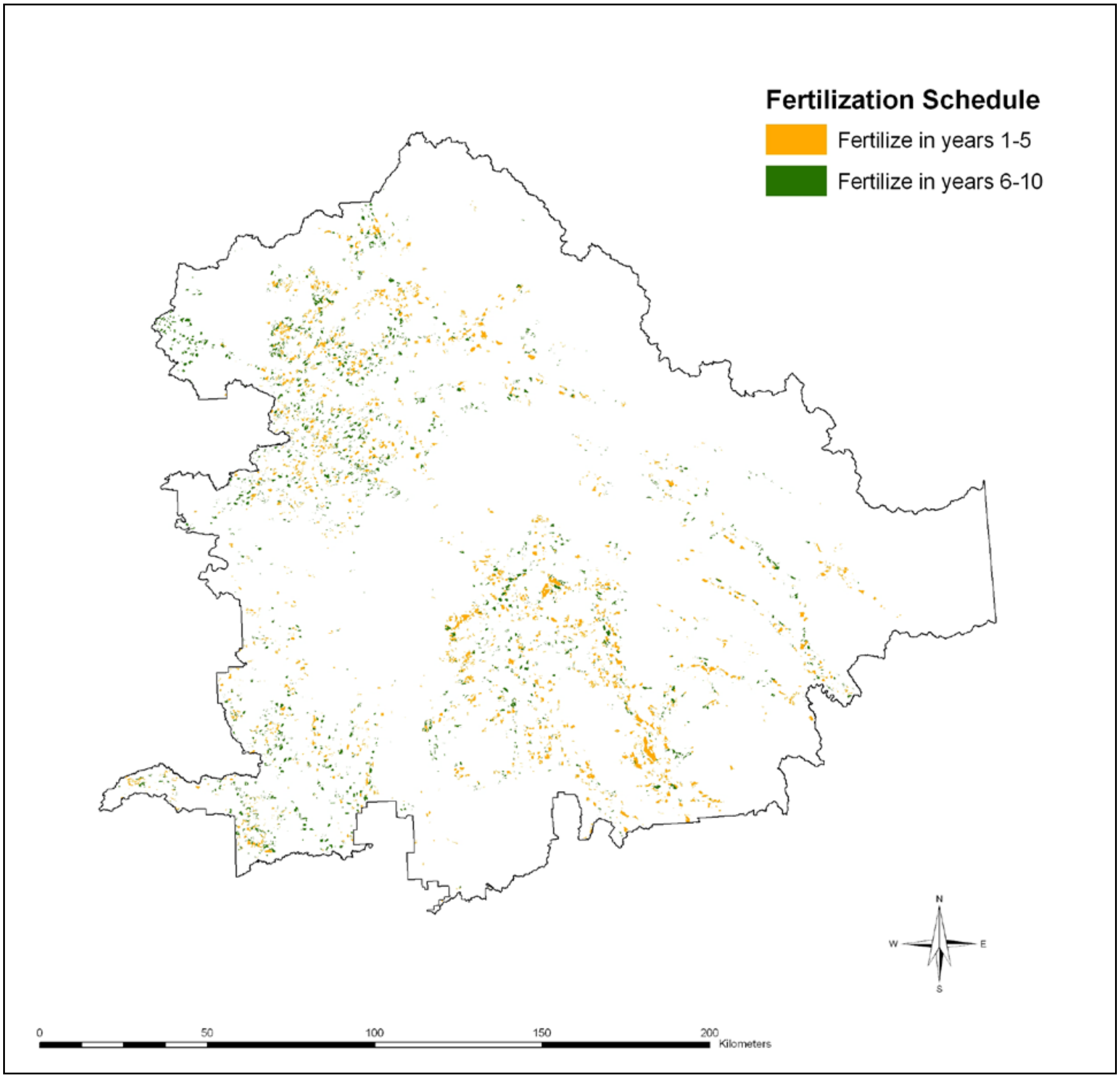


Figure 85: Stands fertilized in the model years 1 to 10, Prince George; Composite scenario 2

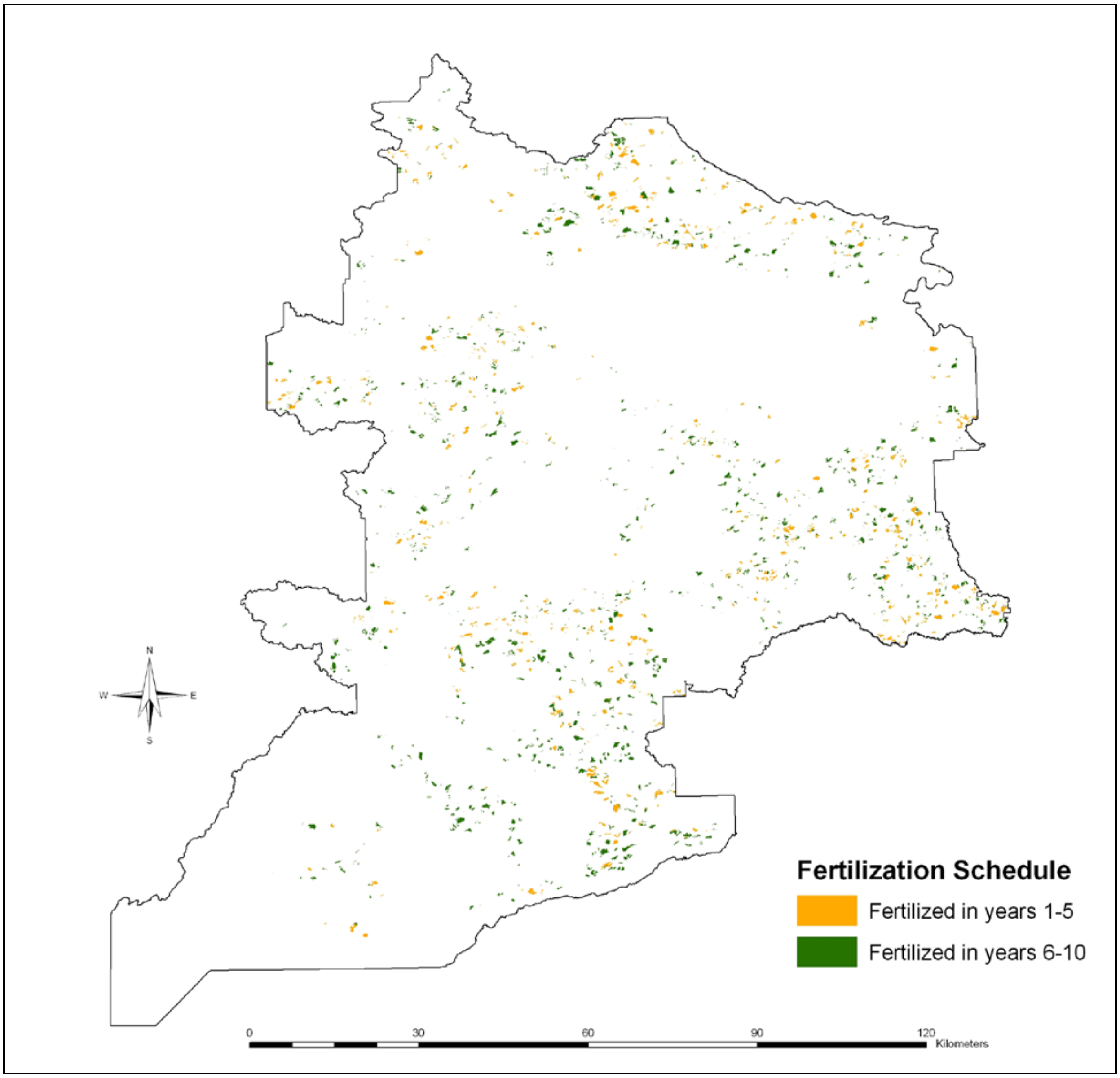


Figure 86: Stands fertilized in the model years 1 to 10, Vanderhoof; Composite scenario 2

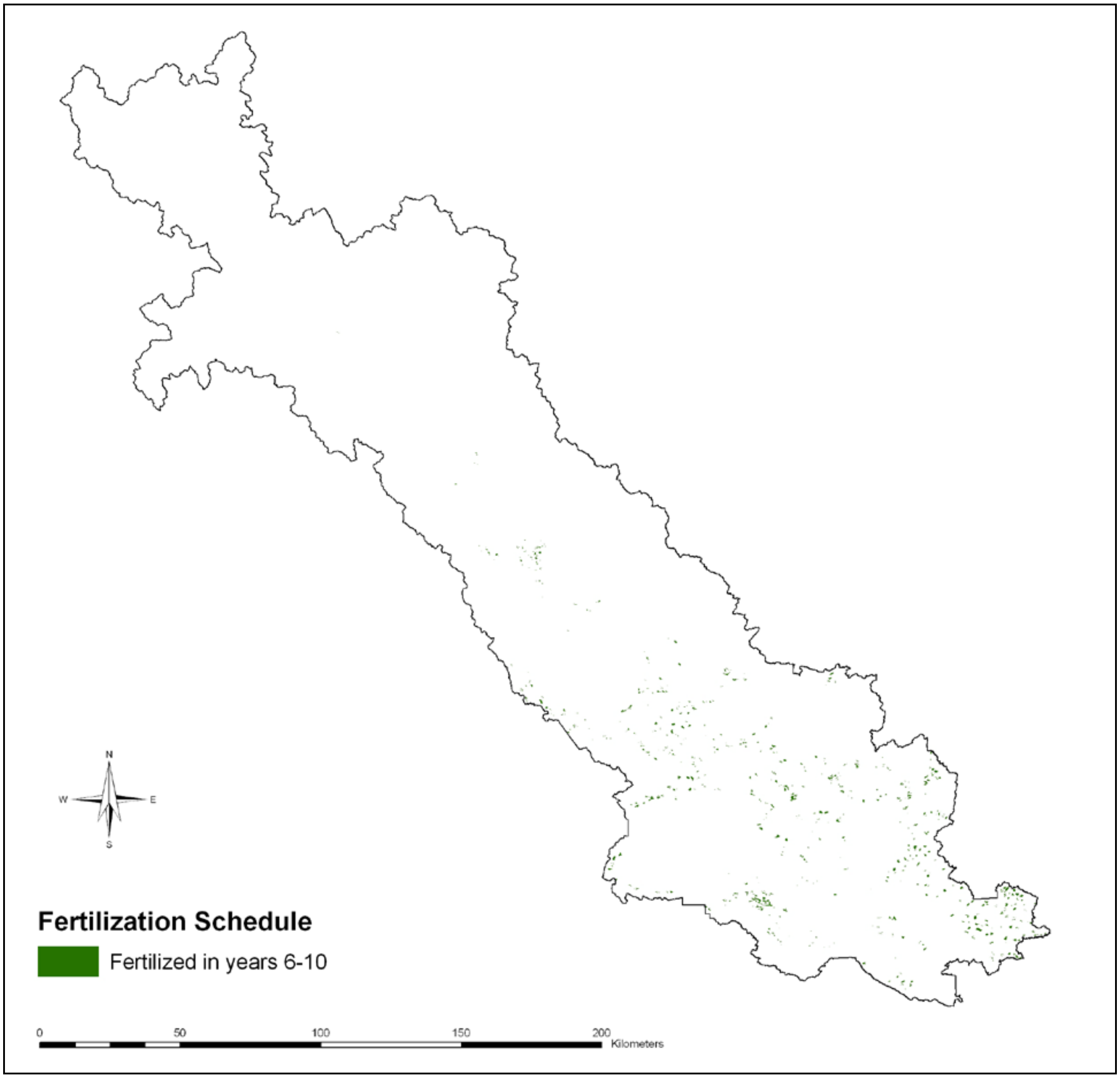


Figure 87: Stands fertilized in the model years 1 to 10, Fort St. James; Composite scenario 2

4.3 Economic Considerations

The following section provides a brief summary of the stand and forest-level economic impacts of the modelled scenarios. A net present value (NPV) approach was used to compare the present day value of expected future revenues against the present day costs incurred to achieve those revenues. Both analyses use broad-based, simplistic assumptions and methodologies, and the results are provided for context only relative to the estimated yield impacts of the scenarios. A 2% discount rate and a base net economic benefit to the government of $\$25/m^3$ for any incremental volume realized were assumed.

4.3.1 Stand Level

The following assumptions were applied to the different scenarios;

- Rehabilitation
  - Net treatment costs of $2,000/ha assuming knockdown, site preparation and reforestation with applicable assumed future stand criteria. The base analysis assumed that no merchantable timber will be recovered. A sensitivity analysis testing the economic impacts of recovering some merchantable volume was modeled by reducing the net treatment costs to $1,500/ha.
  - New stands are reforested according to the future managed stand assumptions.
  - Harvest of the new stands was assumed to be at 60 years from treatment and would generate revenue of $6,375/ha (255 m^3 /ha at $25/ m^3)
- Fertilization
  - For each application the cost is $500/ha.
  - Fertilization responses are from TIPSY
  - Existing young natural spruce and (Douglas fir)-leading stands 26 to 55 years old are treated three times (10, 20 and 30 years before harvest), twice (10 and 20 years before harvest) or once(10 years before harvest). TIPSY was used to model the estimated average stand in the population. The TIPSY inputs used were; Sw80% (SI=20m), Bl20%, initial planted density of 1200sph with a 3 year regeneration and normal OAFs. The treatment responses are;
    - Starting 10 years before harvest (1 treatment at 55 years); increased revenue is $250 (10 m^3/ha treatment response times $25/ m^3)
    - Starting 20 years before harvest (2 treatments; at 45 and 55 years); increased revenue is $525 (21 m^3/ha treatment response times $25/ m^3)
    - Starting 30 years before harvest (3 treatments; at 35, 45 and 55 years); increased revenue is $700 (28 m^3/ha treatment response times $25/ m^3)
  - Existing and future managed, 16 to 25 and 0 to 15 years old respectively and enhanced future pine and spruce-leading stands are treated three or four times at ages 25, 35, 45 and (55) years (40, 30, 20 and 10 years respectively before harvest) with the following treatment responses;
    - Starting 30 years before harvest (3 treatments; at 35, 45 and 55 years); increased revenue is $825 (33 m^3/ha treatment response times $25/ m^3)
    - Starting 40 years before harvest (4 treatments; at 25, 35, 45 and 55 years); increased revenue is $1,050 (42 m^3/ha treatment response times $25/ m^3)

  In a sensitivity analysis for the enhanced future stands the assumed economic benefit is increased by 25% from $25 to $32.25/$m^3$ to simulate the impacts of quality improvement. It is assumed that the incremental volumes in these stands are of higher quality logs.

- Enhanced Reforestation
    - The incremental planting cost varies from about $170 to $184/ha to increase planting densities by about 300 to 325 sph to about 1700 sph which results in an increased revenue of $875 to 250 (7 to 10 m^3/ha treatment response times $25/ m^3);

      A sensitivity analysis was completed to estimate the impact of higher quality logs; the net economic benefit is increased by 25% from $25 to $32.25/$m^3$ for stands with increased planting densities to simulate the impacts of quality improvement.

Table 41 shows the NPV's calculated for various treatments using the above assumptions. Based on stand-level financial analysis the only favourable treatment is rehabilitation, assuming that total costs can be kept around $1500 per hectare or below. The second best treatment is enhanced reforestation with a net loss of about $106 to $122 per hectare. All of the fertilization regimes led to significant negative NPV's mostly due to the small volume responses.

Table 41: Stand-level NPVs for selected treatments

Treatment	Population/Assumptions	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Fertilization	Existing Natural Sw(Fdi) leading stands 26 to 55 yr old	$(295)	$(557)		
	Existing (16-25 yrs), future (0 to 15 yrs and future) and increased density future stands			$(791)	$(1,047)
	Increased Density Future Stands, Assume Higher Quality			$(659)	$(909)
Rehabilitation of Dead Pine Stands	Net Cost = $2,000/ha	$(57)			
	Net Cost = $1,500/ha	$443			
Increased Planting Densities	Quality as Per Future Stands	$(122)			
	Assume Higher Quality	$(106)			

4.3.2 Forest Level

A simplified forest level economic analysis was completed by establishing a net present value for all scenarios. This was done by summing up all the discounted incremental revenues from increased harvest and subtracting the discounted treatment costs from these revenues. The calculation was carried out over a period of 150 years. The discount rate was set at 2% and the assumed net economic benefit to the government for any incremental volume realized was set to $\$25/m^3$.

None of the scenarios produced a positive NPV at the forest level (Table 42). In many scenarios, the increased mid-term volumes required a decreased harvest later in the planning horizon compared to the base case; this contributed turning some of the scenario net present values negative.

Composite Scenario 2 had the highest NPV at $(3) million and can be considered the most attractive of all the modeled scenarios. Figure 88 illustrates the forest level discounted net values (discounted incremental revenues – discounted treatment costs) for the two composite scenarios over the period of 150 years.

Table 42: Net present values; silviculture scenarios compared to the base case

Scenario	NPV ($ Million)
Rehabilitation of Dead Pine Stands	$(348)
Rehabilitation of Dead Pine Stands with Fertilization	$(558)
Fertilization, Young Natural Stands	$(17)
Fertilization, Existing Managed Stands	$(62)
Fertilization, All Managed Stands	$(77)
Fertilization, All Managed Stands and Young Natural Stands	$(112)
Enhanced Reforestation	$(176)
Enhanced Reforestation with Fertilization	$(436)
Composite Scenario 1	$(15)
Composite Scenario 2	$(3)

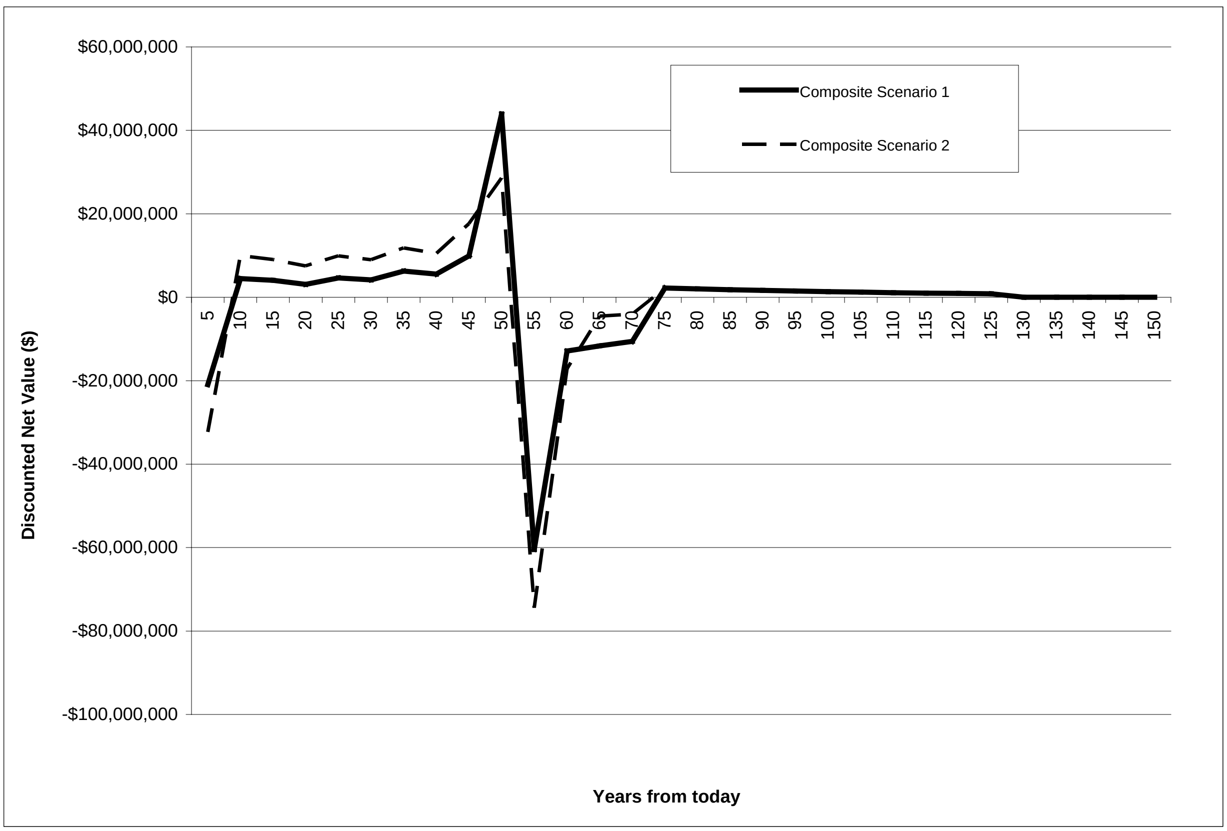


Figure 88: Discounted net values; composite strategies

5 Discussion

The growing stock losses to the MPB are predicted to reduce the mid-term timber supply in the Prince George TSA significantly. The estimates for this reduction vary; in this analysis the mid-term harvest level was predicted to decrease to approximately 6.3 million m^3 per year between years 6 and 50. The mid-term harvest forecast in the latest TSR by MFLNRO used different analysis assumptions and predicted a lower harvest level - between 4 and 6 million m^3 per year - depending on the scenario.

Harvesting (salvaging) all MPB attacked pine stands and immediately reforesting them would benefit future timber supply and reduce fire risk. However, many of the attacked and killed pine stands may not get salvaged due to low volume recovery and long haul distances. This analysis estimated that up to 436,000 ha of dead pine stands might remain in the landscape. The stakeholders in the Prince George TSA suggest that opportunities still exist for the biofuel industry to utilize this dead timber. For this reason, their recommendation is to focus any rehabilitation efforts on younger stands with little or no merchantable volume, so as to not compromise the future biofuel opportunities.

There likely is an adequate supply of timber in the Prince George 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.

The mid-term timber supply is dependent on the assumption that substantial harvest must occur in the Fort St. James Resource District 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 limited by the Prince George TSA Biodiversity Order as well.

The learning scenarios employed a bookend approach; the timber supply impacts were tested by treating all theoretically available areas in the forest estate model regardless of access, financial feasibility or actual condition of the treated stands. This was expected to generate the maximum theoretical treatment impacts.

Two composite scenarios were constructed based on stakeholder feedback. These scenarios attempted to reflect realistic and idealistic budget levels and treatment schedules for the TSA. The first composite scenario assumed an annual budget of $4.4 million, while the second one had a budget of $6.4 million per year.

Both composite scenarios allocated silviculture funding between 2 treatment options: fertilization and rehabilitation of dead pine stands. The approximate budget allocations were developed at a workshop in Prince George with the Prince George TSA stakeholder group. No targets were set for enhanced reforestation; the stakeholder group felt that while important and worth pursuing, increased planting densities should be pursued through policy direction.

Using a $4.4 million annual incremental silviculture budget resulted in a 3.5% increase in harvest between years 6 and 45. The increase was more pronounced between years 46 and 50 at approximately 14.5%. The harvest increases in the near mid-term come at a cost: the step up to higher harvest levels is delayed compared to the base case. Between years 51 and 55 the harvest level is predicted to be 15.8% less than that of the base case, and from year 56 to 71, 3.3% less harvest is projected compared to the base case.

A second scenario increased the incremental silviculture budget to $6.4 million annually. This budget level resulted in a 5.9% increase in harvest between years 6 and 45. The increase was larger between years 46 and 50 at approximately 9.2%. The harvest increases in the near mid-term reduce the harvest by 19.6% between years 51 and 55, and from year 56 to 71, 4.3% less harvest is projected compared to the base case.

Based on stand-level financial analysis the only favourable treatment is rehabilitation, assuming that total costs can be kept around $1500 per hectare or below. The second best treatment is enhanced reforestation with a net loss of about $106 to $122 per hectare. All of the fertilization regimes led to significant negative NPV's mostly due to the small volume responses.

A simplified forest level economic analysis was completed by establishing a net present value for all scenarios. None of the scenarios produced a positive NPV at the forest level. In many scenarios, the increased mid-term volumes required a decreased harvest later in the planning horizon compared to the base case; this contributed to turning some of the scenario net present values negative.

The modelling results are always subject to uncertainty and should be treated with caution. The following should be noted:

- Models cannot assess risk appropriately. For this reason, factors such as fire risk reduction that comes as a side benefit of rehabilitating dead pine stands are not considered by the timber supply model. Another case in point is the option of increased planting densities. In this TSA the growth and yield differences between the base case assumptions and the higher density stands are not significant; higher densities provide no obvious timber supply benefits in the model results. However, the decision to include this silviculture treatment as an option in the analysis has more to do with building resilient forests and reducing the overall risk of pests and diseases than it has with theoretical improvement in growth and yield.
- Shelf life assumptions of beetle killed timber have a significant impact on the modeled availability of dead pine. If the dead timber decays slower than expected, more harvest will be available in the mid-term. It is likely that the impact of incremental silviculture would be improved as well, because the effect of seral stage constraints on the timber supply would also be eased. The opposite is true, should the shelf life be shorter than modeled.
- This analysis assumed natural regeneration in many of the dead pine stands. It is not known what the growth and yield of this regeneration is and where it exists.
- The current management direction is to use secondary structure where it is adequate. It is not known what the growth and yield of secondary structure is or where it exists.
- In this analysis approximately 436,000 ha of dead pine stands are predicted to remain unharvested. While some of these stands did not get harvested due to biodiversity constraints in the forest estate model, most of them are predicted to remain in the landscape as a result of the decreasing merchantable volume due to shelf assumptions in the analysis. This estimate is subject to uncertainty, as are the spatial locations of these stands.

  The modeled locations of these stands for rehabilitation treatments are theoretical; operational planning is required to identify true candidate stands.

- Approximately 650,000 ha of the THLB in the Prince George TSA consist of stands younger than 26 years old. The harvest of these existing managed stands begins at year 36 and continues throughout the mid-term. The growth and yield of these stands is subject to uncertainty; anecdotal evidence suggests that these stands may not be growing as per their modeled yield tables. Studies have found evidence of pests and diseases that may impact the growth rates of these stands.

- The candidate population for fertilization in this analysis consisted of 664,000 ha of existing stands (managed and young natural stands, age between 1 and 60). Fertilization schedules suggested by the analysis are theoretical and have limited practical value; the condition of candidate stands must be known before fertilization treatments are initiated.
- The forest level NPVs are driven by costs, discount rate, time, and the expected incremental harvest volume and the value of this volume. Changes in analysis assumptions, such as seral stage targets, that increase gains through incremental silviculture have a significant impact on the forest level NPV.

6 References

British Columbia Ministry of Forests. 2001. Prince George Timber Supply Area Analysis Report.

British Columbia Ministry of Forests. 2002. Prince George Timber Supply Area: Rationale for Allowable Annual Cut (AAC) Determination.

British Columbia Ministry of Forests. 2004. Prince George Timber Supply Area: Rationale for Allowable Annual Cut (AAC) Determination.

British Columbia Ministry of Forests and Range, 2008. Prince George Timber Supply Area Timber Supply Review Data Package.

British Columbia Ministry of Forests, Lands, and Natural Resource Operations, Forest Analysis and Inventory Branch, 2011a. Prince George Timber Supply Area Technical Record for the Analysis that Supported the January 11, 2011 AAC Determination.

British Columbia Ministry of Forests, Lands, and Natural Resource Operations, Forest Analysis and Inventory Branch, 2011b. Prince George Timber Supply Area. Mid-Term Mitigation Timber Supply Analysis, Confidential Draft.

British Columbia Ministry of Sustainable Resource Management. 2004. Order Establishing Landscape Biodiversity Objectives for the Prince George Timber Supply Area.

Canadian Forest Products Ltd, Prince George, BC. 2006. Site Index Adjustment for the Prince George and Fort St. James Forest Districts. Craig Farnden R.P.F.Consulting Forester Vancouver, B.C.

Forest Ecosystem Solutions Ltd. 2008. Type 2 Silviculture Strategy, Prince George TSA.

Forest Ecosystem Solutions Ltd., 2013. Type 4 Silviculture Strategy Data Package – Prince George Timber Supply Area.

Forsite Consultants Ltd.. 2004. Landscape Objectives Working Group Prince George TSA Natural Disturbance Unit Analysis: Final Report

Slocan Forest Products, Plateau Division, 2004. Site index adjustment for the Vanderhoof IFPA. Craig Farnden R.P.F.Consulting Forester Vancouver, B.C.

Timberline Forest Inventory Consultants Ltd. 2003. Strategic Harvest and Investment Planning (SHIP) Timber Supply Analysis Data Package. Vanderhoof Forest District IFPA

Timberline Forest Inventory Consultants Ltd. 2004. Strategic Harvest and Investment Planning (SHIP) Timber Supply Analysis Report. Vanderhoof Forest District IFPA