Type 4 Silviculture Strategy

Draft Modelling and Analysis Report – Morice TSA

Version 1.2

Draft

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1 Introduction

1.1 Context

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.

1.2 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.
- Mountain pine beetle populations have moved from epidemic to endemic levels, and no additional large scale mortality will occur.

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 a formal TSR, differences exist. Most notable are several LRMP provisions which have not yet formally been passed into law by government. These were included in the Type 4 analysis, but would not be part of a TSR until such time that they become law. This was done to represent the intent of the legislation and provide a forward looking base case.

1.2.1 Shelf Life

Another significant difference is the way shelf life of the dead pine was modeled. The merchantability of beetle-killed wood remains an important uncertainty in timber supply analyses. In this analysis shelf life is defined as the time a stand remains economically viable for sawlog harvesting. The shelf life starts at the year of death; when cumulative kill reaches 50%. The status quo shelf life assumptions in most timber supply analyses to date have assumed 100% retention of merchantability for 15 years or some other period of time, after which the volume is no longer usable. This analysis assumes that a time period of 15 years is required from the average time of death until the stand becomes entirely unmerchantable. The merchantability is assumed to be 85% at the year of death and for the next 2 years and then declines in a linear fashion to 0 at year 15 as shown in Figure 1. This approach is consistent with other on-going Type

4 Silviculture Strategies. The shelf life for other product types could be longer; however, it is not modeled in this analysis.

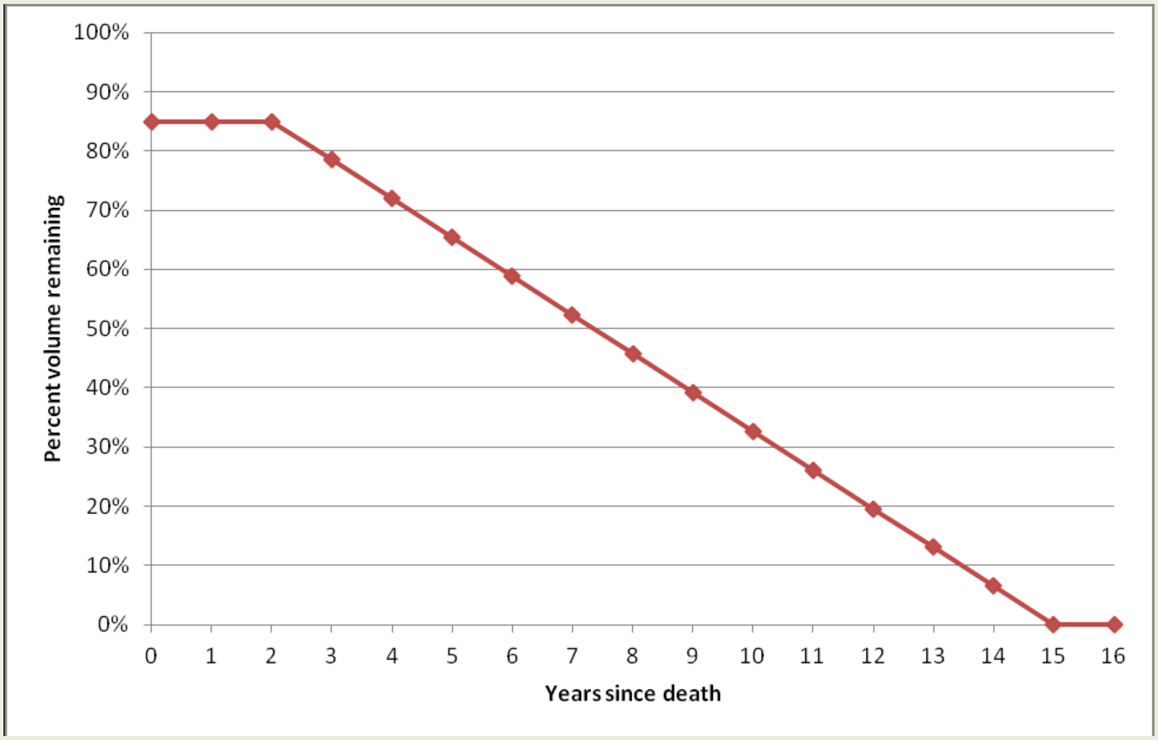

Figure 1: Shelf life for dead sawlogs

The impact of modeling shelf life as presented above has a significant impact on the modeled availability of dead pine. Figure 2 illustrates the impact of shelf life assumptions employed in this analysis on the remaining standing dead volume. The red bars represent the remaining volume of dead pine for each year of death with no shelf life applied, while the green bars show the estimated volumes as of 2013 using the presented shelf life assumptions. The blue bars represent predictions of dead volume in 2016 when applying shelf life. The same can be seen in Table 1. Note that as per the BCMPB data, the highest mortality in the Morice TSA occurred in 2007.

If no shelf life is assumed the available gross dead pine volume potentially available for harvesting would be approximately 27.8 million m^3. This is reduced to 17.5 million m^3 in 2013 and 11.6 million m^3 in 2016 when shelf life is applied.

The volumes presented are gross volumes. If the minimum volume of 150 m^3 per ha (minimum harvest criterion in this analysis) is required the volumes are further reduced, as presented in Figure 3 and Table 2.

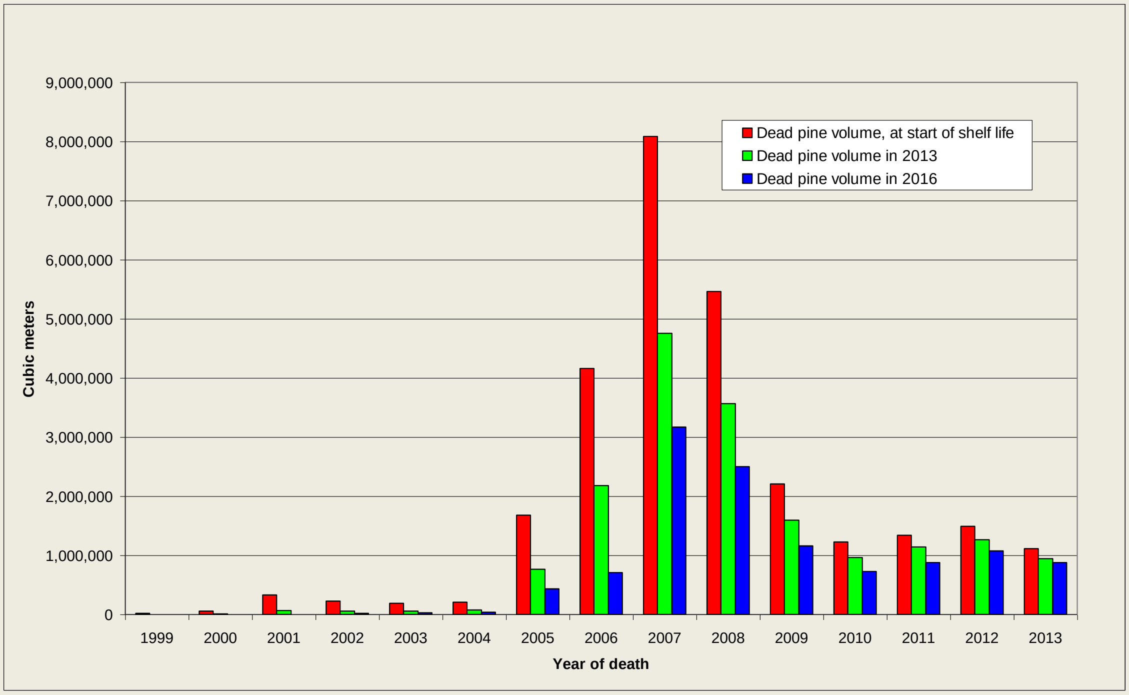

Figure 2: Impact of shelf life assumptions on remaining standing dead volume (THLB)

Table 1: Impact of shelf life assumptions on remaining standing dead volume (THLB)

Year of death	Years since death	Volume that died (remaining)	Years since death in 2016	2013 Volume (reduced by shelf life)	2016 Volume (reduced by shelf life)
1999	14	16,514	17	1,077	0
2000	13	59,011	16	7,707	0
2001	12	333,453	15	65,357	0
2002	11	221,817	14	57,983	14,462
2003	10	186,957	13	61,097	24,417
2004	9	203,685	12	79,885	39,922
2005	8	1,676,323	11	767,085	438,191
2006	7	4,160,515	10	2,175,949	711,100
2007	6	8,083,666	9	4,756,429	3,170,414
2008	5	5,459,052	8	3,569,128	2,498,062
2009	4	2,211,240	7	1,590,324	1,156,479
2010	3	1,230,192	6	965,209	723,845
2011	2	1,343,857	5	1,142,278	878,613
2012	1	1,489,117	4	1,265,749	1,070,973
2013	0	1,113,362	3	946,358	873,544
Total		27,788,761		17,451,616	11,600,022

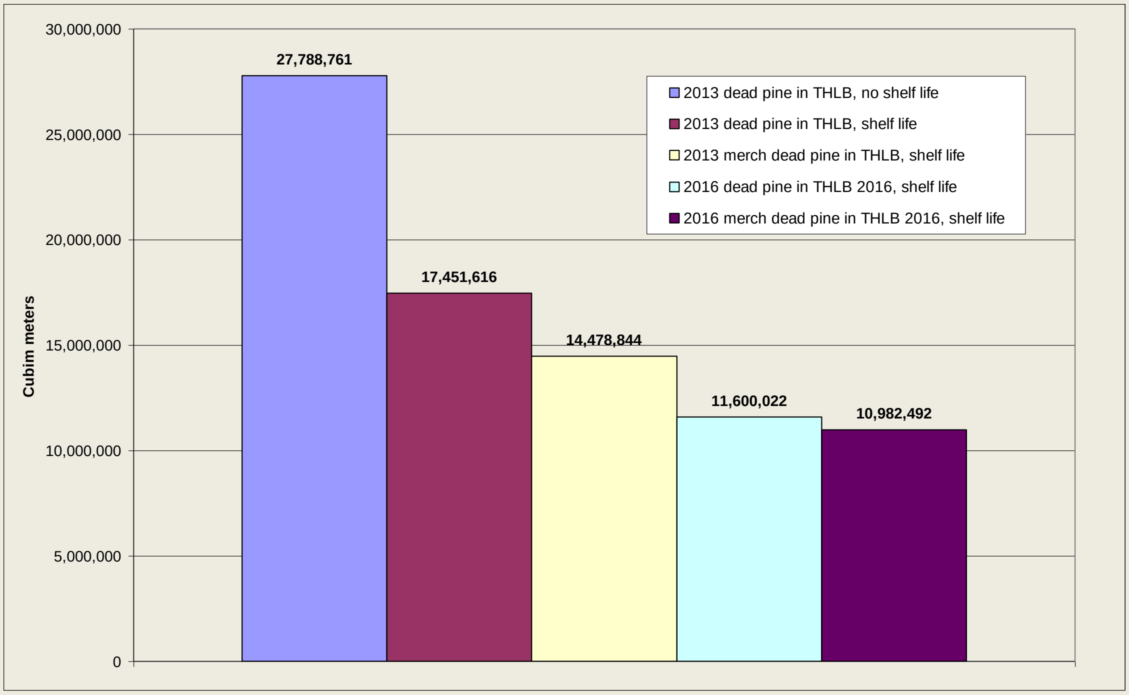

Figure 3: Impact of minimum merchantability and shelf life on dead pine volume

Table 2: Impact of minimum merchantability and shelf life on dead pine volume

Category	Standing volume
2013 dead pine in THLB, no shelf life	27,788,761
2013 dead pine in THLB, shelf life	17,451,616
2013 merchantable dead pine in THLB, shelf life	14,478,844
2016 dead pine in THLB, shelf life	11,600,022
2016 merchantable dead pine in THLB, shelf life	10,982,492

1.2.2 Harvest Priority

The harvest priority in the base case and other scenarios was set for the model to harvest as much dead pine as possible within the first 5 years as shown in Table 3.

Table 3: Harvest priority in the model

Class	Harvest Priority
Stands with more than 90% mortality	1
Stands with mortality between 71 and 90%	2
Stands with mortality between 51 and 70	3
Stands with mortality between 26 and 50	4
Stands with mortality less than 26 (includes non-pine stands)	No priority

1.2.3 Seral Stage of Un-Harvested Dead Pine Stands

In this analysis all un-harvested stands with more than 50% mortality were assumed to breakup and continued growing using the age of advanced 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.

2 Base Case

2.1 Model Output

2.1.1 Harvest Forecast

Figure 4 illustrates the base case harvest forecast. The initial harvest level of 2.165 million m^3 per year is maintained for 5 years. The mid term is predicted to drop to approximately 1.149 million m^3 per year then increase to 1.515 million at year 36. Another two steps are required until the long-term harvest level of 1.772 million m^3 is reached at year 170.

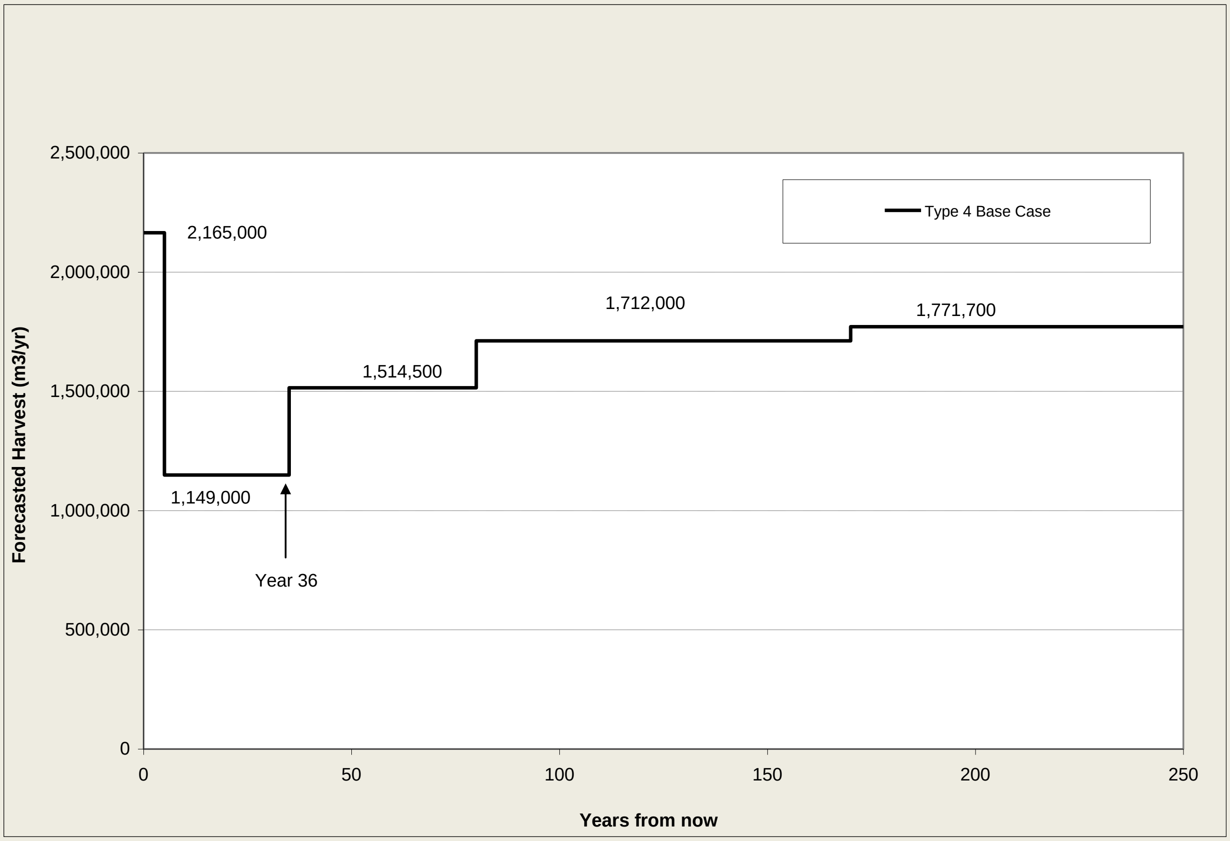

Figure 4: Base Case harvest forecast

Further investigation of the short-term harvest reveals that 884,403 m^3 of dead pine is predicted to be harvested annually during the first 5 years with the 5-year total of approximately 4.4 million m^3. Approximately similar volume of non-pine species (860,000 m^3 annually) is harvested to satisfy the target harvest level (Figure 5 and Table 4). Note that small amounts of dead pine are also harvested between years 6 and 10.

The predicted harvest of non-pine species during the first 5 years in the base case exceeds the maximum of 550,000 m^3 per year that the Chief Forester established in his AAC determination in 2008. The partition is discussed below under section 3.1.1.

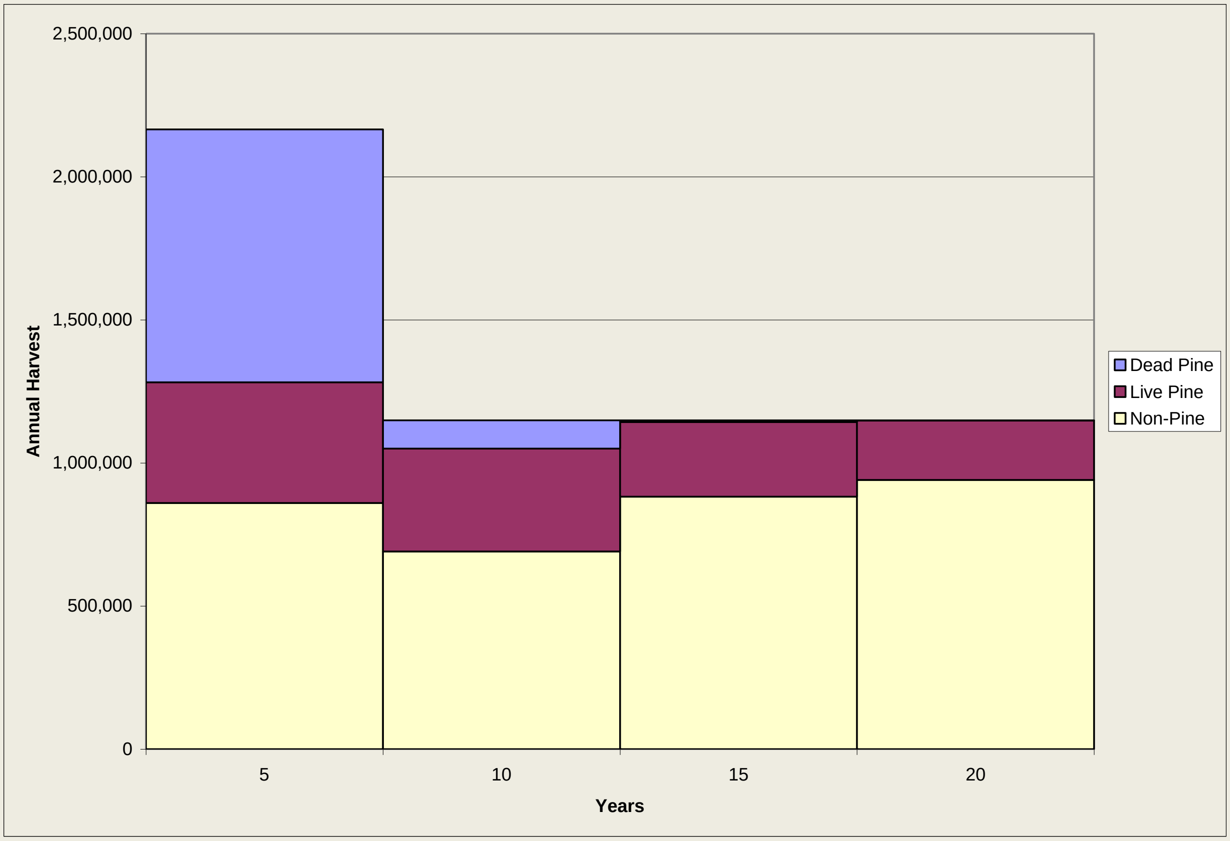

Figure 5: Base case; annual harvest by species group; 20 years

Table 4: Harvest forecast by species group; first 10 years, base case

Species Group	Annual Years 1 to 5	Total Years 1 to 5	Annual Years 6 to 10	Total Years 6 to 10
Dead Pine	883,403	4,417,013	99,192	495,961
Live Pine	421,744	2,108,721	359,437	1,797,183
Non Pine	860,316	4,301,580	690,637	3,453,183
Total	2,165,463	10,827,315	1,149,266	5,746,328

2.1.2 Un-Harvest Dead Pine Stands

In the base case approximately 49,000 ha of dead pine stands are predicted to remain un-harvested. While some of these stands do not get harvested due to biodiversity constraints, most of them remain in the landscape as a result of the decreasing merchantable volume due to shelf assumptions in the analysis. These stands are set to break up in the model and continue growing as younger stands. Figure 6 illustrates the spatial location of the stands that are predicted to remain in the landscape in the base case.

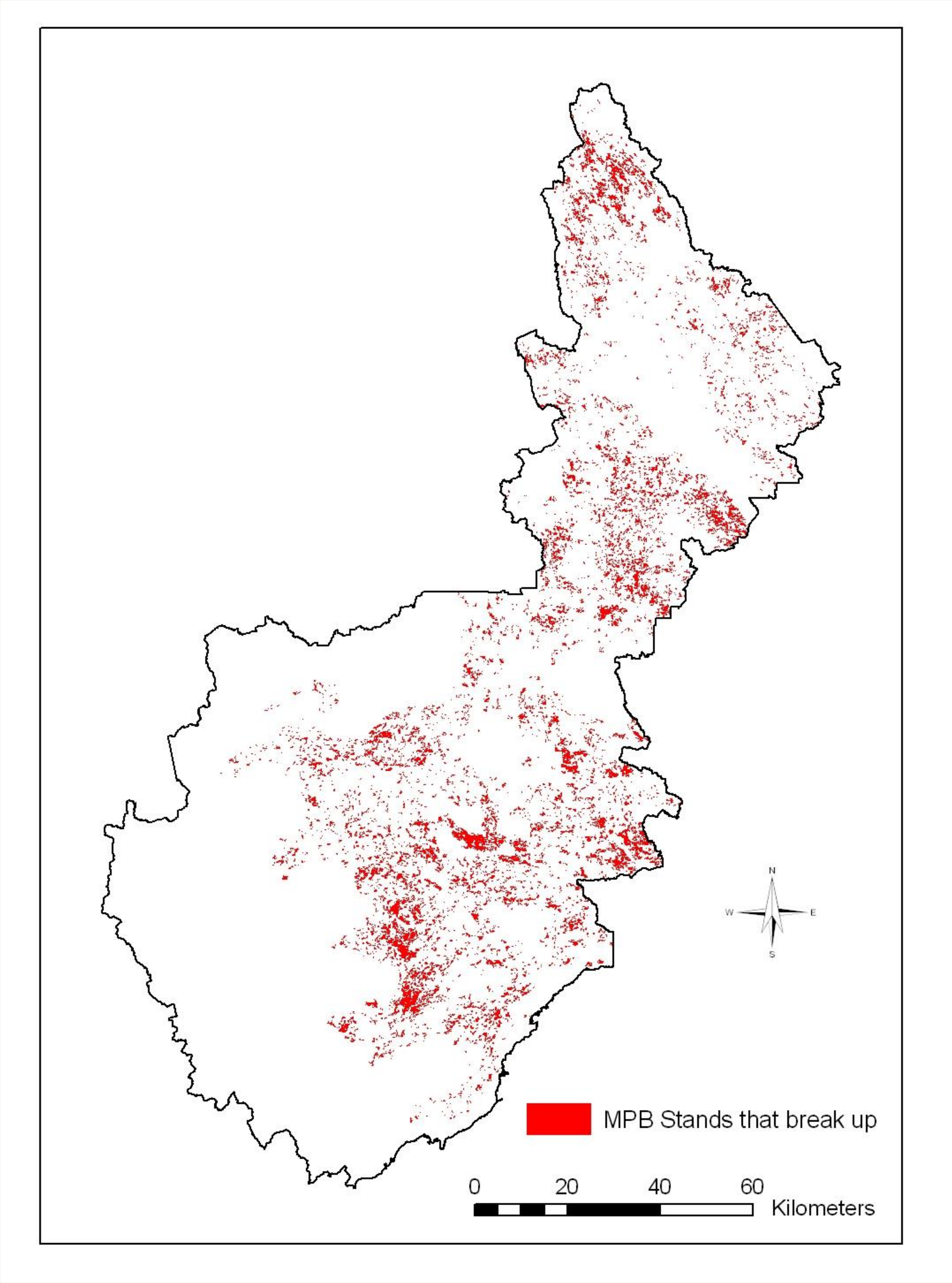

Figure 6: Dead pine stands that remain un-harvested in the base case

2.1.3 Growing Stock

Figure 7 and Figure 8 depict the predicted growing stock development for the base case. The stability of the growing stock in the long run is an indicator of sustainable harvest. The large merchantable growing stock in Figure 7 suggests that the lack of available growing stock does not constrain harvest in the Morice TSA. The harvest is constrained by seral stage objectives, which are discussed under section 2.2.

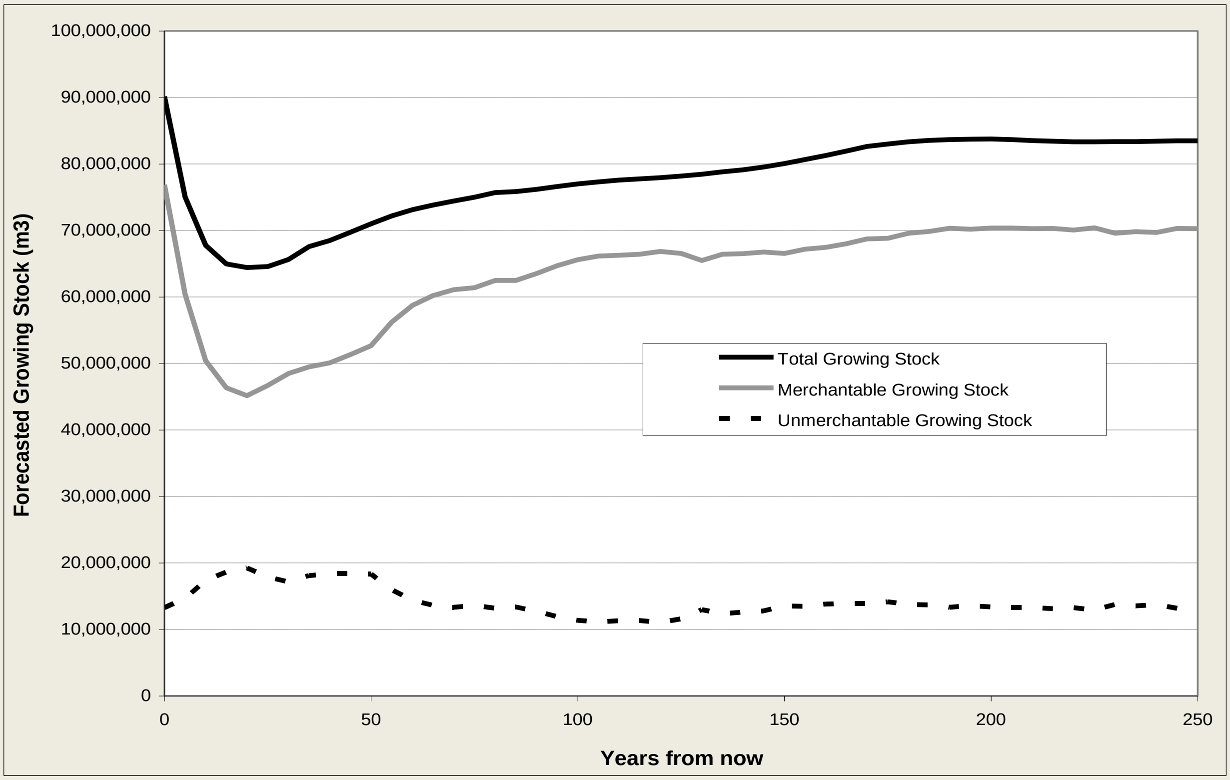

Figure 7: Predicted growing stock development: base case

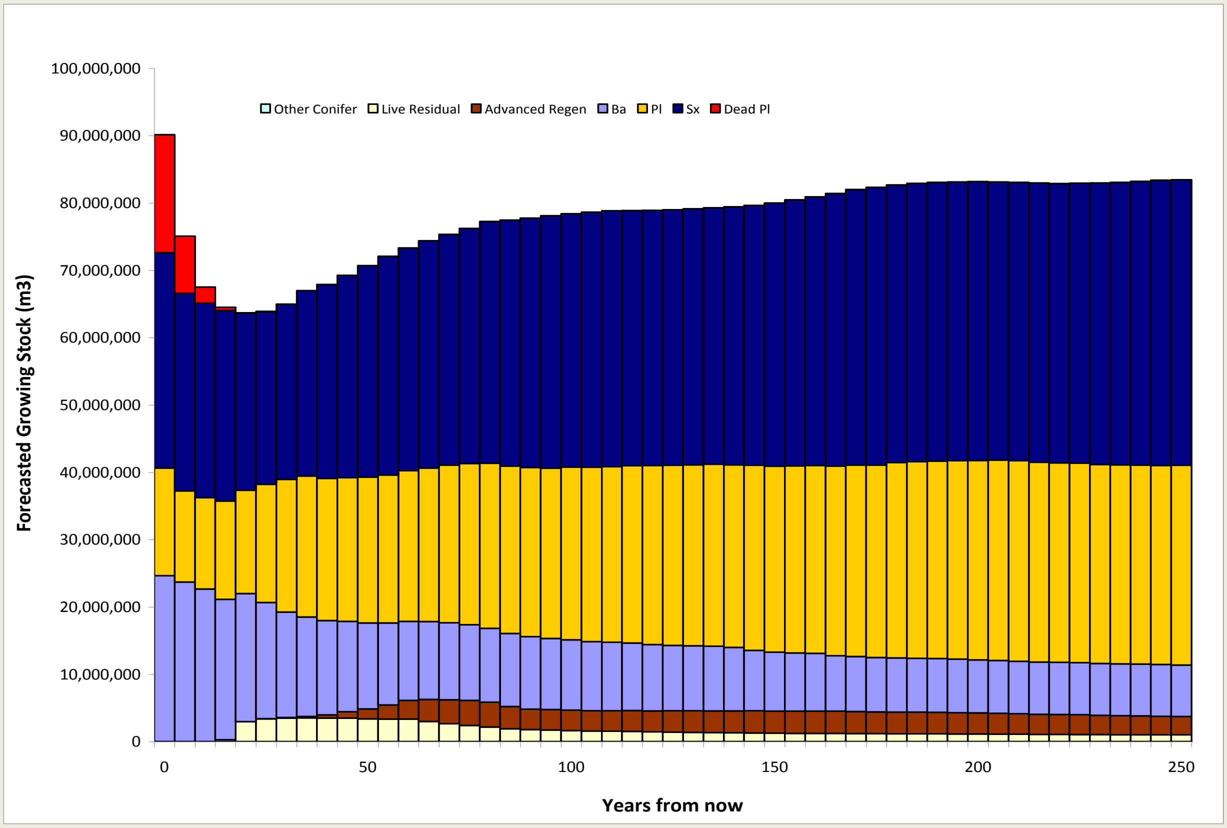

Figure 8: Predicted growing stock development by species: base case

2.1.4 Harvest by Forest Unit and Species

Figure 9 illustrates the harvest forecast by Forest Unit. The analysis output was divided into 6 classes (Forest Units): MPB severe attack (more than 50% of the stand killed), MPB mild attack (50% or less killed), natural (no MPB attack), existing managed stands, future managed stands and advanced regeneration.

The harvest of existing managed stands does not begin until year 26 and until that time the mid-term timber supply is dependent on the harvest of non-MPB attacked stands (called Natural) and those stands with mild attack.

Figure 10 illustrates the base case harvest forecasts by species. The harvest of dead pine occurs only during the first 5 years with the exception of a small amount between years 6 and 10. Note the small contribution of advanced regeneration and residual stands to the mid-term timber supply. Similarly, all of the volume in the first 5 years comes from MPB attacked stands 71% severe and 29% mild attack.

Both Figure 9and Figure 10 indicate that given the shelf life assumptions in the analysis the harvest level of 2.165 million m^3 annually may be too high as it results in the harvest of stands that are not currently at risk. Different initial harvest levels were tested through scenario analyses presented later in this document in section 3.1.

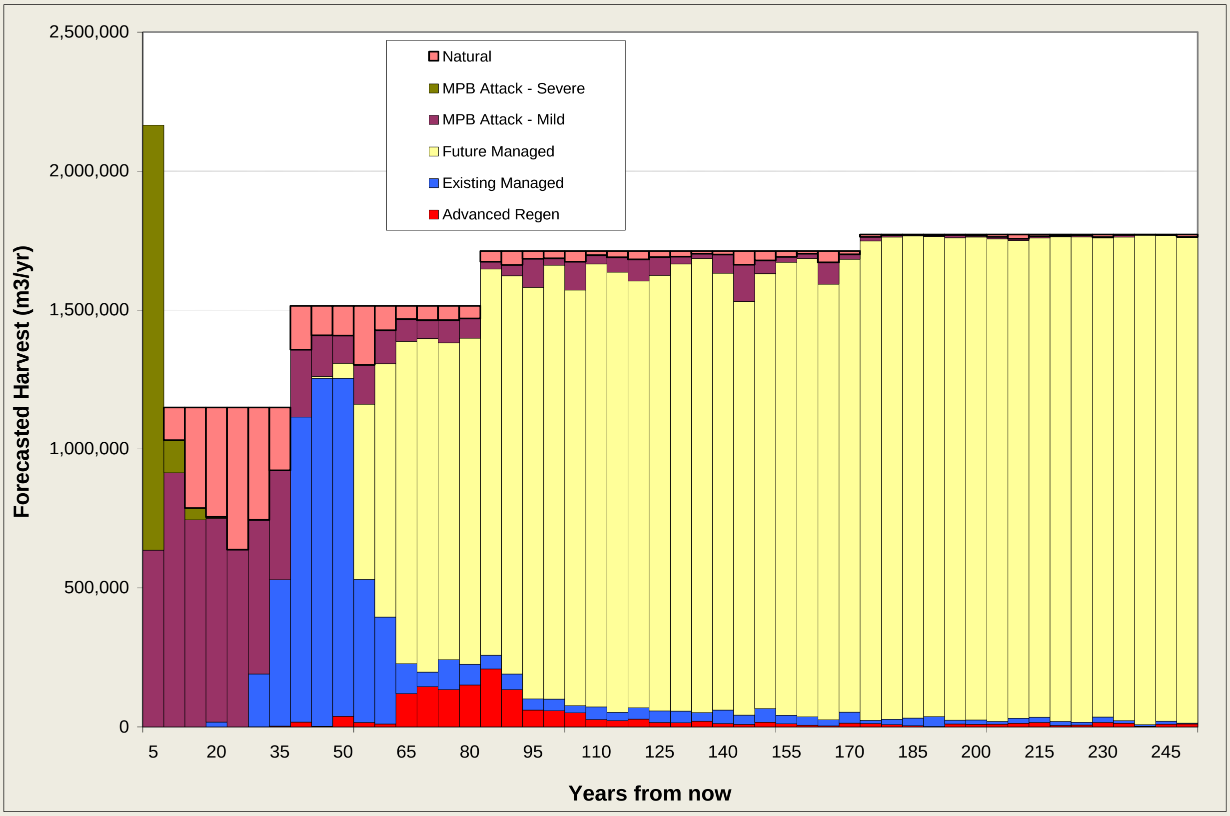

Figure 9: Harvest forecast by forest unit: base case

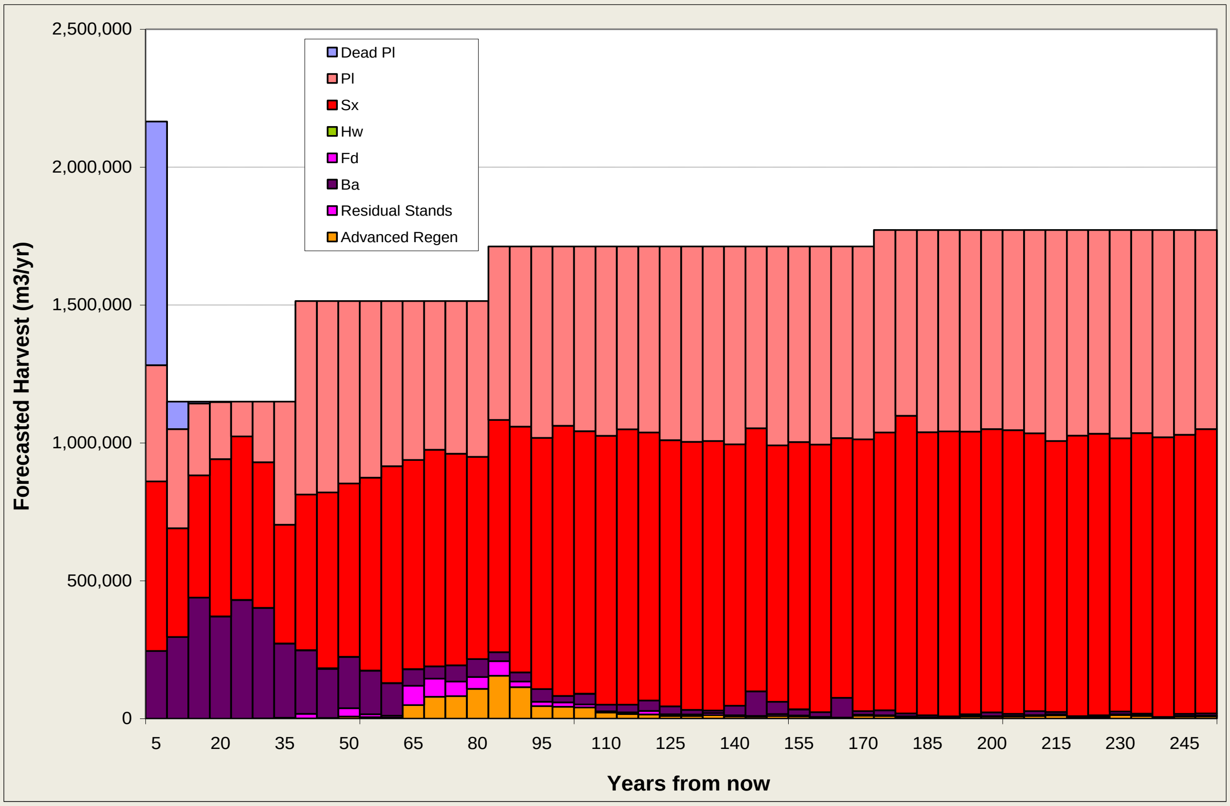

Figure 10: Harvest forecast by species: base case

2.1.5 Harvest Age, Volume and Area

The mid-term harvest is mostly dependent on the harvest of older, mainly age class 8 and 9 stands as illustrated in Figure 11. The managed stand harvest starting between years 26 and 30 consists of some age class 3 stands with the majority in age class 4. Over the long term most of the harvest is predicted to come from age class 4 stands. This is also depicted in Figure 12 showing the predicted average harvest age over time. In the long term the average harvest age settles at around 75 years.

Figure 13 shows the harvest by volume class. Note some small volumes in the short term depicting the on-going salvage. Some small volume stands (150 to 200 m^3) are harvested later on in the planning horizon; many of these stands are residual stands or advanced regeneration stands. The mid term is clearly dependent on older natural stands that are harvested at between 200 and 400 m^3 per ha. In the long run the predicted harvest volumes seem reasonable; mostly greater than 200 m^3 per ha. The same trends can be seen in Figure 14 depicting the predicted average harvest volume per ha. In the mid term the average harvest volume drops close to 250 m^3 per ha (years 30 and 55). Towards the end of the planning horizon, the average harvest volume increases and stabilizes at around 300 m^3 per ha.

Figure 15 illustrates the predicted annual harvest area over the planning horizon of 250 years. After the first 40 years the average harvest areas settles at around 6,000 ha per year.

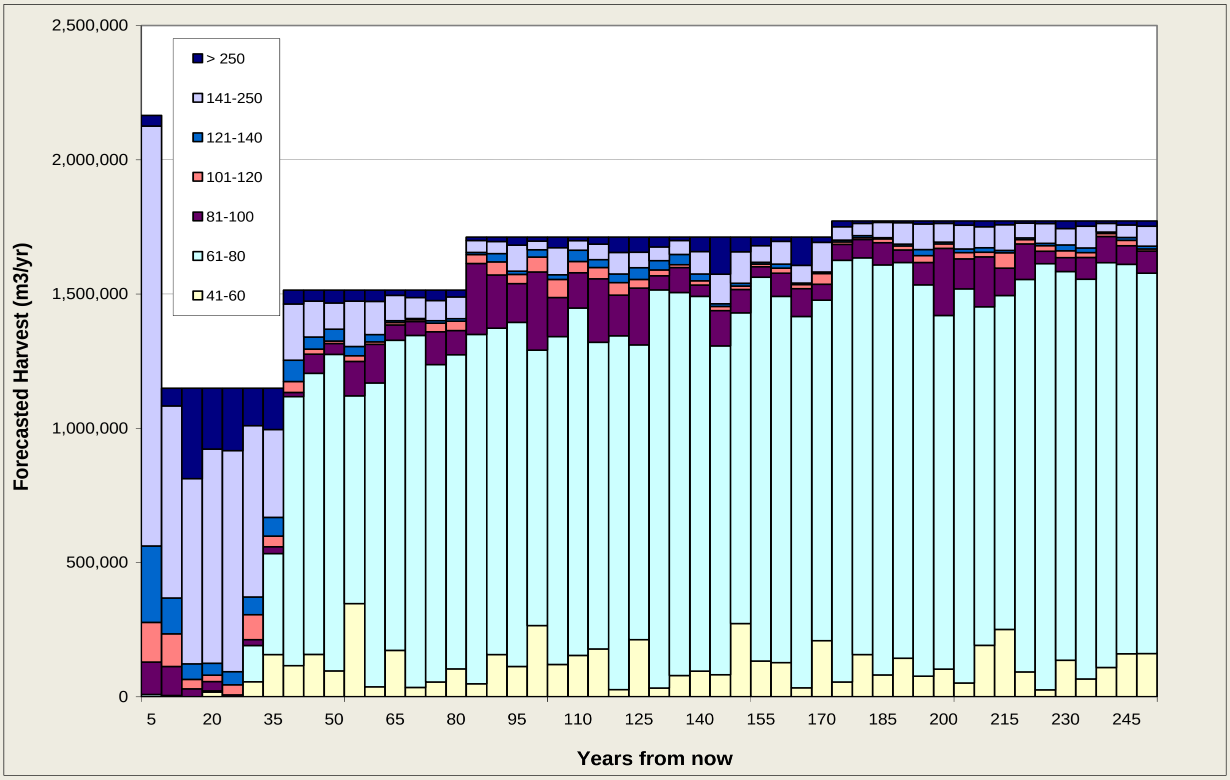

Figure 11: Harvest forecast by age class: base case

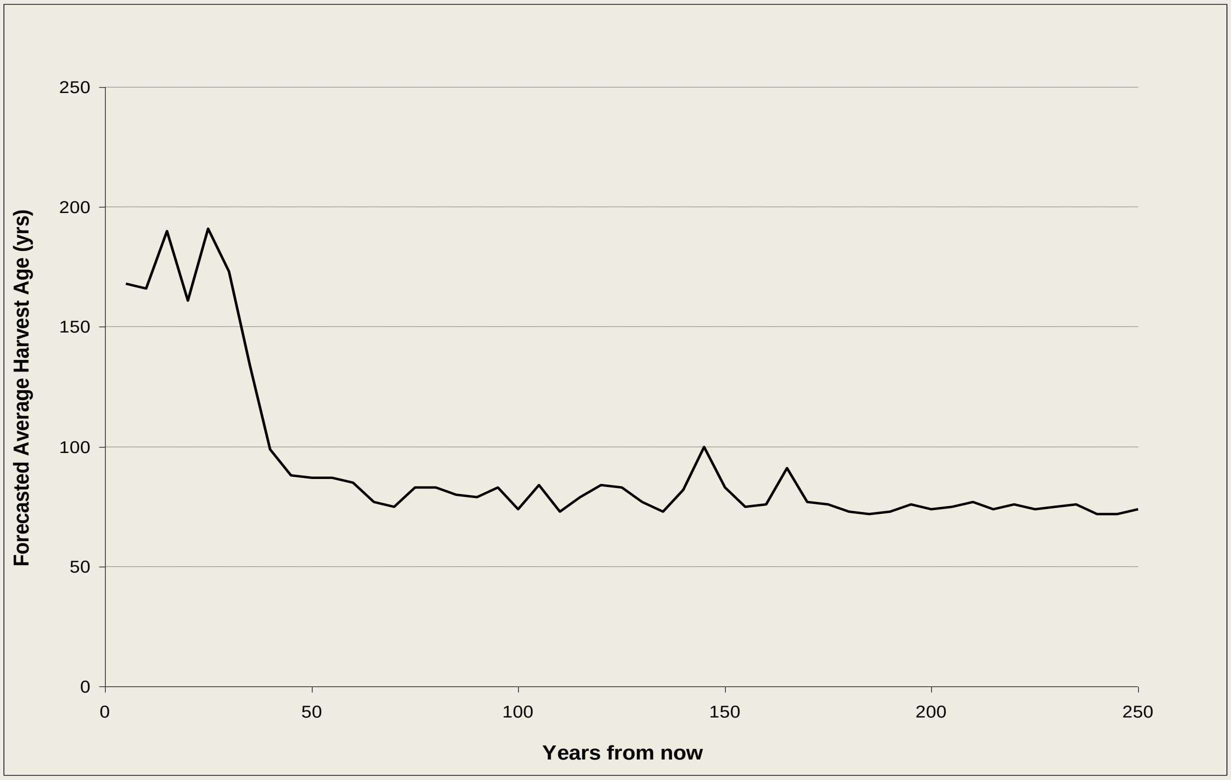

Figure 12: Average harvest age; base case

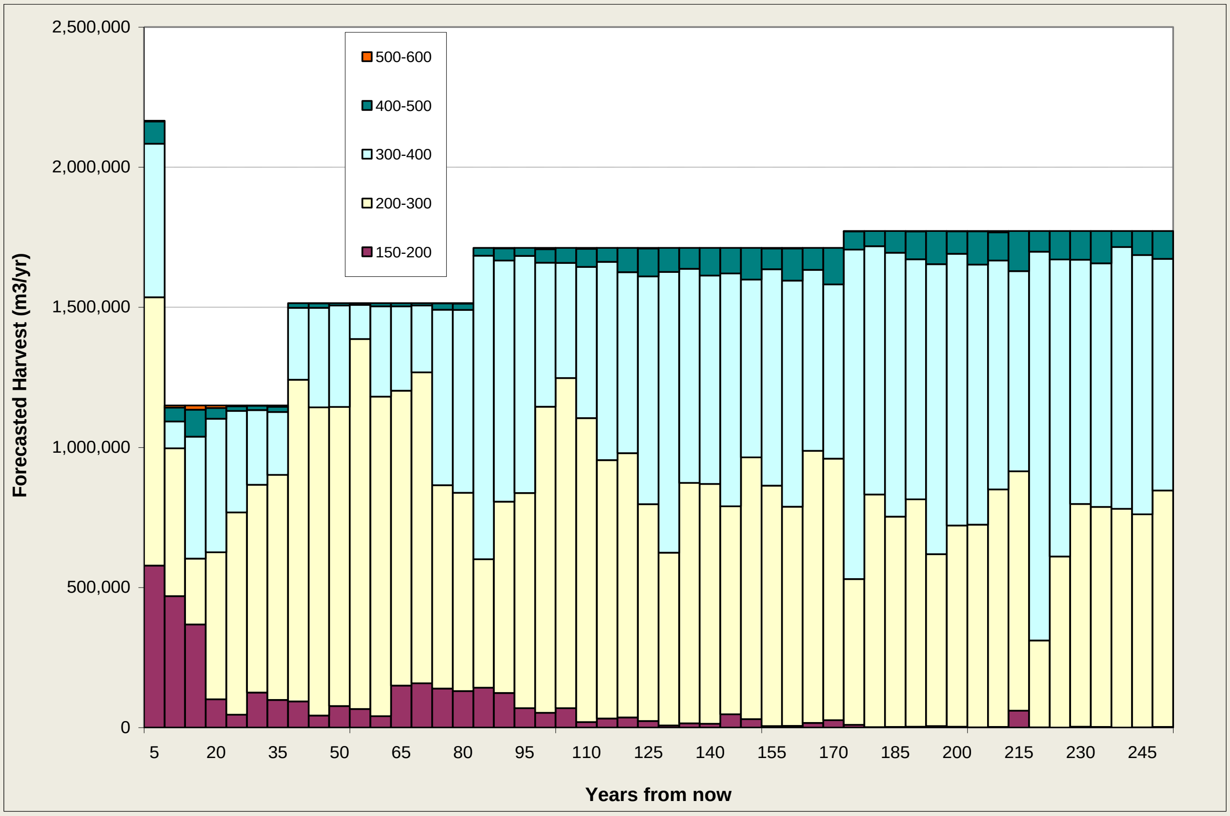

Figure 13: Harvest forecast by volume class: base case

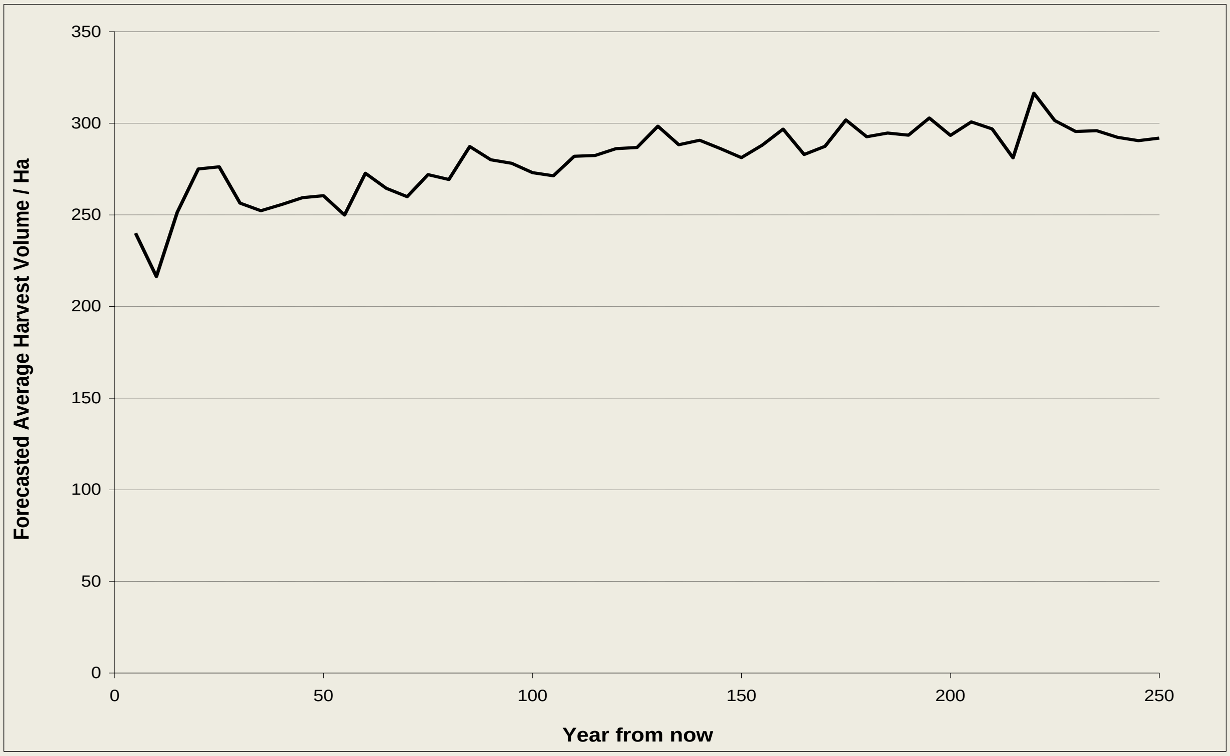

Figure 14: Average harvest volume per ha; base case

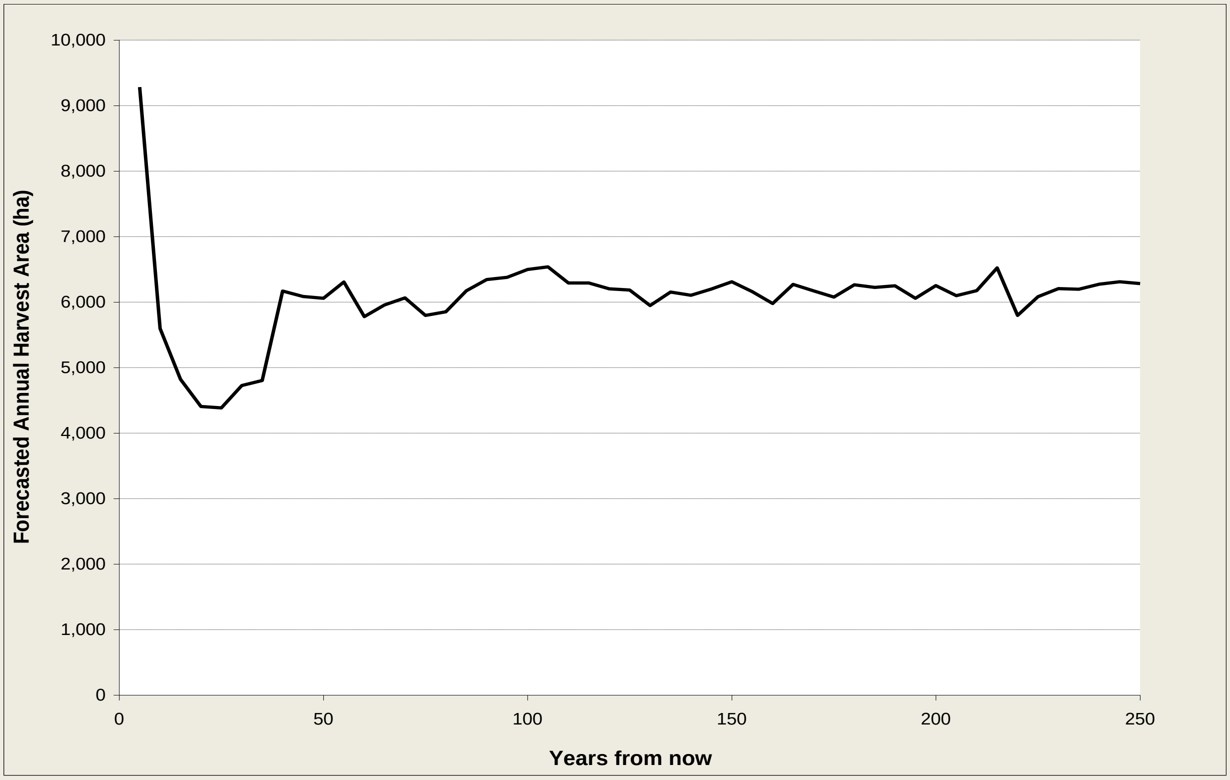

Figure 15: Average annual harvest area; base case

2.1.6 Age Class Distribution

Figure 16 and Figure 17 illustrate the predicted development of age classes in the Morice TSA over a period of 250 years. The high harvest level in the short term consists mostly of age class 8 stands which can be seen as a reduction in the area represented by this age class in year 20. The area of age class 1 increases correspondingly. Reduction in the area of older age classes within the NHLB is caused by modeled succession.

In the course of time the age class distribution remains unbalanced; age class 1 area decreases after the first 50 years and remains relatively constant after that. Age classes 2, 3, 8 and 9 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 under section 2.1.5. 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 for biodiversity 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.

Building fire probability modelling and fire risk in the analysis would provide direction to management decisions and suggest treatments that could lessen this risk.

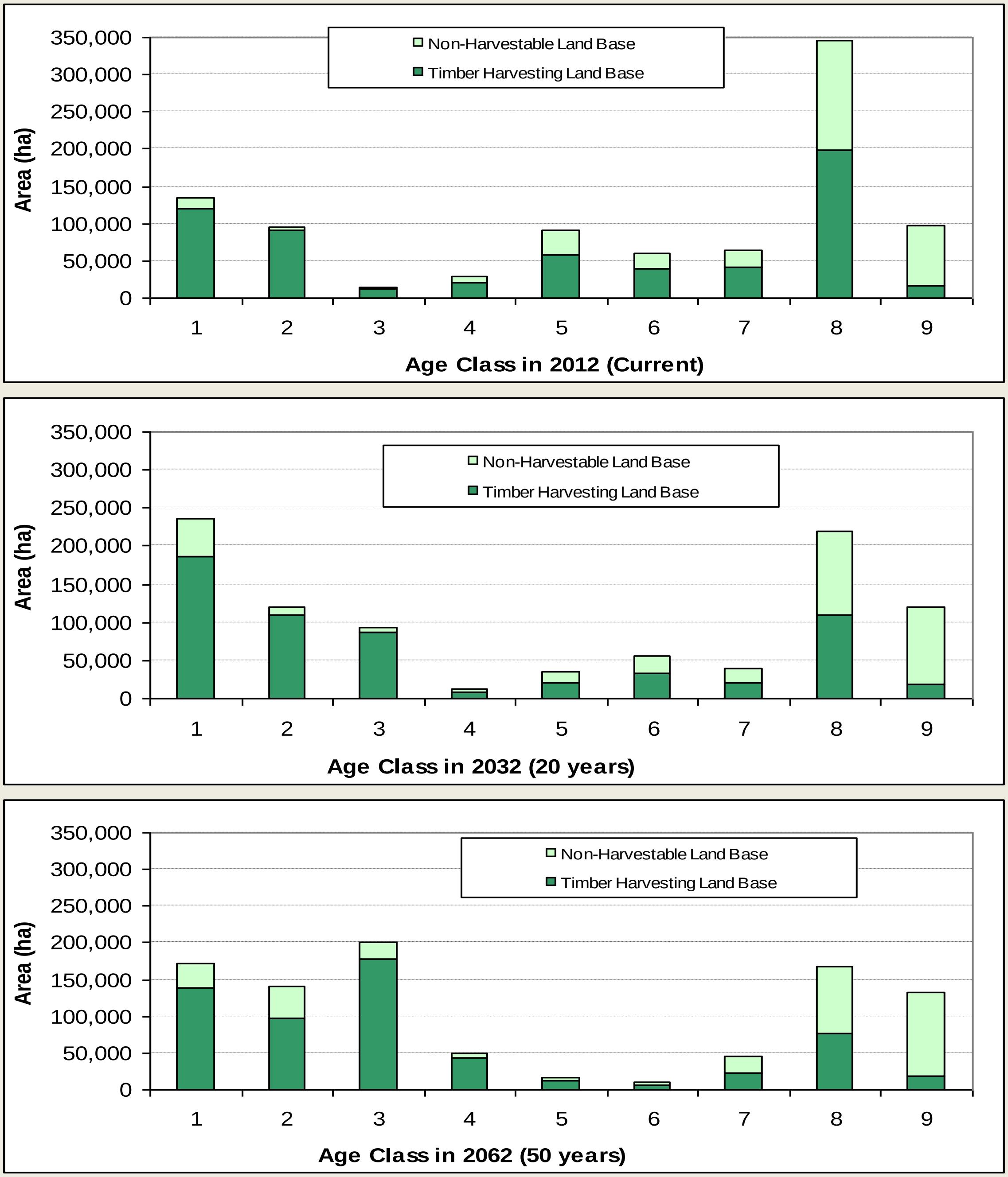

Figure 16: Age class distributions: current, 20 years and 50 years

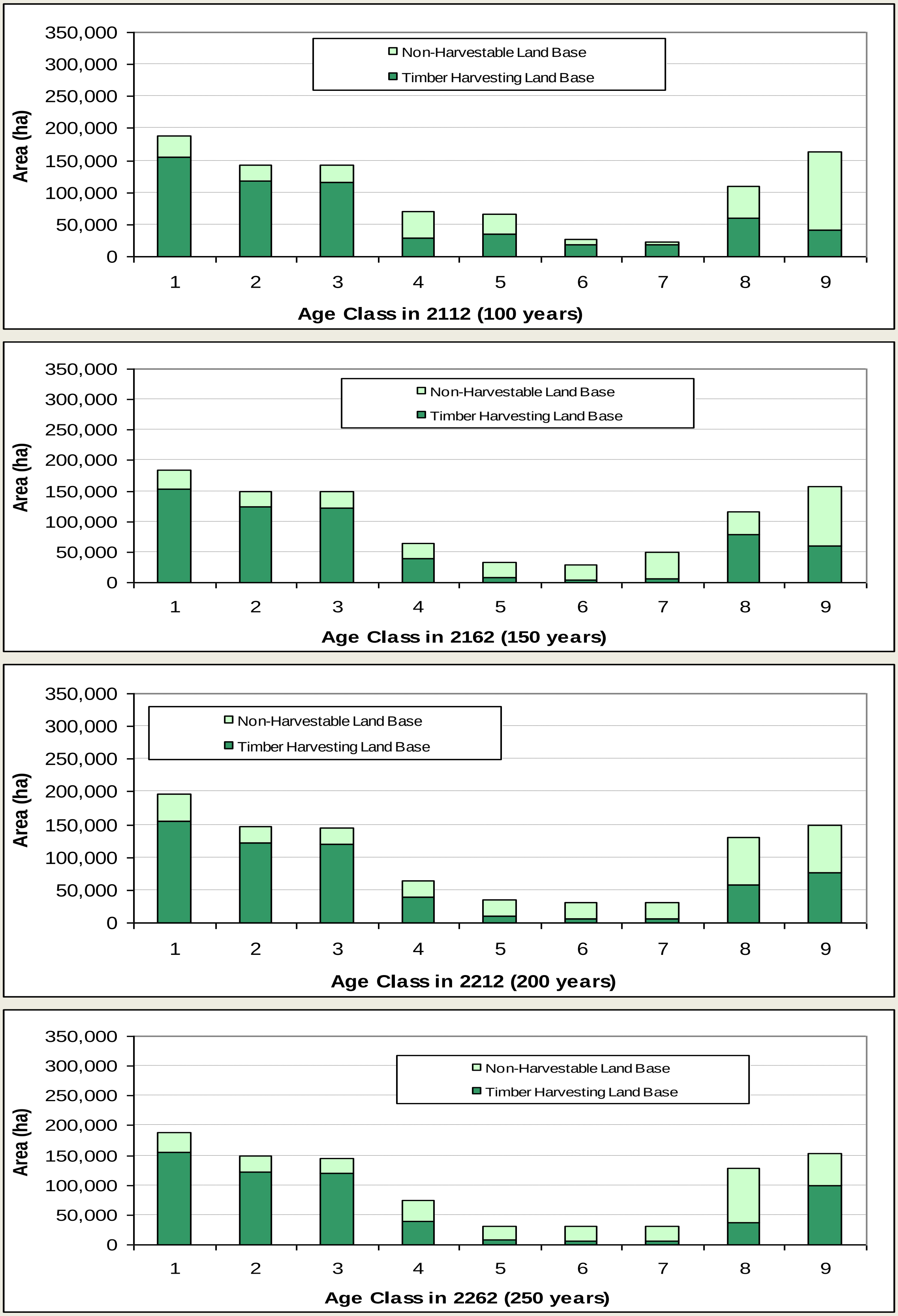

Figure 17: Age class distributions: 100,150 year, 200 years and 250 years

2.2 Biodiversity and Non-Timber Values

2.2.1 Caribou Habitat

2.2.1.1 Telkwa Caribou Habitat

The Telkwa Caribou no harvest areas in draft WHA 6-333 were removed in the THLB netdown process. The rest of this WHA was modeled by setting constraints for the amount of early and mature seral stages. Early seral stage was defined as younger than 40 years while mature seral stage included all stands older than 80. The seral stage targets are shown in Table 5.

Table 5: Seral stage targets for Telkwa Caribou WHA

BEC Subzone	Maximum of Forest in Early Seral Stage	Early Seral Stage Age	Minimum of Forest in Mature Seral Stage	Mature Seral Stage Age	CFLB Area (ha)	THLB Area (ha)
ESSF	28%	<40	60%	>80	19,564	5,435
SBSdk	39%	<40	45%	>80	7,334	4,737
SBSmc	28%	<40	60%	>80	51,182	37,662

The seral stage objectives, particularly within the SBS mc, subzone constrains timber supply significantly. This productive subzone contains a large area of THLB (37,662 ha) within the available portion of the WHA. Timber supply is constrained because the stands older than 80 years of age must be maintained for habitat or cannot be harvested due to the maximum early seral stage limit. The achievement of habitat targets is shown for the caribou WHA SBS mc subzone in Figure 18 and Figure 19. The mature seral stage remains somewhat below the target in Figure 19 due to natural disturbance in the NHLB.

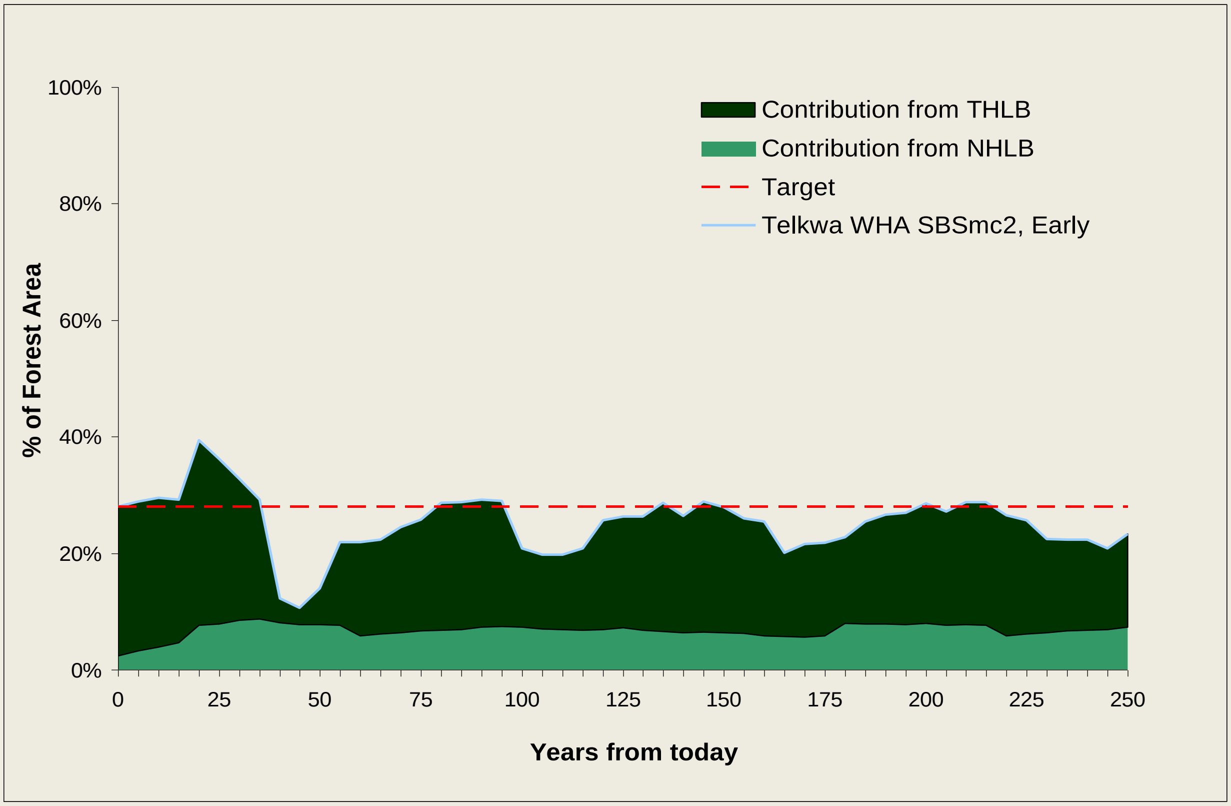

Figure 18: Telkwa WHA SBSmc2; achieved early seral, maximum target, constraining

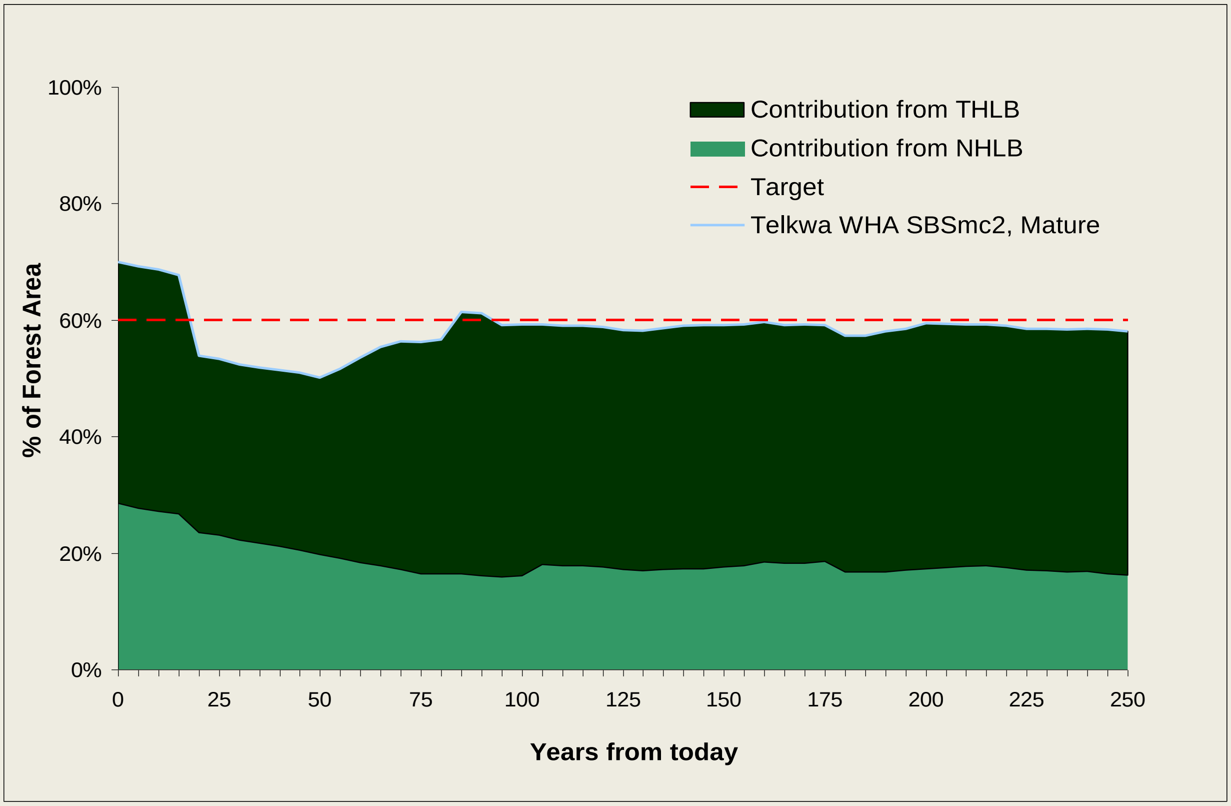

Figure 19: Telkwa WHA SBSmc2; achieved mature seral, minimum target, constraining

2.2.1.2 Takla Caribou Medium Habitat

The Takla Caribou high value habitat areas were removed in the THLB netdown. The medium value habitat was modeled in such a way that no more than 30% of the forest can be harvested every 80 years. The impact of this constraint on the harvest is small due to the small area involved; there are a total of 1,238 ha of CFLB in the medium habitat area. Of this only 440 ha is classified as THLB.

2.2.2 Landscape Level Biodiversity

The Morice LRMP defines high biodiversity emphasis areas (HBEA) and area specific management areas (ASM) while the Draft Ministerial Order (MoAL, 2010) provides targets for old, old and mature, and early seral stages for HBEAs and for the general forest area (GFA). Most of the seral stage targets constrain timber supply significantly. Table 6 shows a broad classification of landscape units and BEC variants based on their level of constraint on the timber supply in the base case. Those units with early seral targets were generally most constraining.

Table 6: Ranking of BEC units: constraint on timber supply

Description	Area	Rank
Nanika River ESSFmc HBEA	12	Not constraining
Nanika River SBSmc2 HBEA	1,477	Constraining
Morice River SBSmc2 (Above) HBEA	2,822	Constraining
Morice River SBSdk HBEA	7,210	Constraining
Morice River SBSmc2 HBEA	6,357	Constraining
Nadina/Owen ESSFmc ASM	1,006	Constraining
Nadina/Owen SBSdk ASM	3,368	Constraining
Nadina/Owen SBSmc2 ASM	6,263	Constraining
Grease Trail ESSFmv3 ASM	78	Not constraining
Grease Trail SBSmc2 ASM	1,615	Constraining
Nadina River SBSdk ASM	2,472	Constraining
Nadina River SBSmc2 ASM	2,127	Constraining
Le Talh Giz ESSFmc ASM	548	Not constraining
Le Talh Giz SBSmc2 ASM	3,214	Constraining
Friday Lakes ESSFmv3 HBEA	42	Constraining
Friday Lakes SBSmc2 HBEA	7,299	Constraining
Morrison Lake SBSmc2 HBEA	5,821	Constraining
Thautil / Gosnell ESSFmc HBEA	11,304	Constraining
Thautil / Gosnell ESSFmk HBEA	1,064	Constraining
Thautil / Gosnell SBSmc2 HBEA	18,842	Moderately constraining
Buck ESSFmc	18,005	Not constraining
Buck SBSdk	8,444	Not constraining
Buck SBSmc2	20,206	Constraining
Burnie ESSFmk	11,742	Constraining
Fulton ESSFmc	10,709	Constraining
Fulton SBSmc2	65,741	Constraining
Gosnel ESSFmc	5,898	Not constraining
Gosnel ESSFmk	2,198	Constraining
Gosnel SBSmc2	6,447	Not constraining
Granisle ESSFmc	1,645	Not constraining
Granisle SBSmc2	11,106	Not constraining
Houston - Tommy ESSFmc	11,590	Not constraining
Houston - Tommy SBSdk	2,254	Not constraining
Houston - Tommy SBSmc2	20,595	Not constraining
Kidprice ESSFmc	12,143	Constraining
Kidprice ESSFmk	12,465	Constraining
Kidprice SBSmc2	40,895	Constraining
Morice Lake CWHws2	7,589	Constraining
Morice Lake ESSFmc	1,686	Not constraining
Morice Lake ESSFmk	8,770	Constraining
Morice Lake SBSmc2	3,008	Constraining
Morrison ESSFmc	2,146	Constraining
Morrison ESSFmv3	4,013	Constraining

Description	Area	Rank
Morrison SBSmc2	48,558	Constraining
Nadina ESSFmc	22,975	Not constraining
Nadina SBSdk	9,849	Moderately constraining
Nadina SBSmc2	49,527	Constraining
Nanika CWHws2	2,273	Constraining
Nanika ESSFmk	5,440	Constraining
Nanika MHmm2	28	Not constraining
North Babine ESSFmv3	4,732	Not constraining
North Babine SBSdk	240	Not constraining
North Babine SBSmc2	33,084	Not constraining
Owen ESSFmc	5,708	Constraining
Owen SBSdk	5,083	Not constraining
Owen SBSmc2	13,973	Constraining
Parrott ESSFmc	3,513	Constraining
Parrott SBSdk	12,674	Not Constraining
Parrott SBSmc2	22,357	Constraining
Sibola CWHws2	6,139	Constraining
Sibola ESSFmc	3	Not constraining
Sibola ESSFmk	5,149	Constraining
Sibola MHmm2	593	Constraining
Sibola SBSmc2	1,703	Not constraining
Tahtsa ESSFmc	12,396	Constraining
Tahtsa ESSFmk	29	Not constraining
Tahtsa SBSdk	1,343	Constraining
Tahtsa SBSmc2	42,456	Constraining
Thautil ESSFmc	12,756	Not constraining
Thautil SBSmc2	6,442	Not constraining
Tochcha - Natowite ESSFmv3	13,914	Constraining
Tochcha - Natowite SBSmc2	22,461	Constraining
Tochcha - Natowite SBSwk3	34,253	Constraining
Topley ESSFmc	7,500	Not constraining
Topley SBSmc2	19,920	Not constraining
Triotsa CWHws2	1,756	Constraining
Triotsa ESSFmc	239	Not constraining
Triotsa ESSFmk	12,660	Constraining
Triotsa MHmm2	461	Not constraining
Triotsa SBSmc2	1,298	Constraining
Valley ESSFmc	18,672	Not constraining
Valley SBSdk	21,827	Not constraining
Valley SBSmc2	35,358	Not constraining
Whitesail ESSFmc	6,356	Not constraining
Whitesail ESSFmk	504	Constraining
Whitesail SBSdk	280	Constraining
Whitesail SBSmc2	26,315	Not Constraining

The following figures provide examples of seral stage targets and how they were met in the base case for the two largest landscape unit/bec variant combinations in the TSA: Fulton SBS mc2 and Nadina SBS mc2. These areas are large and also contain large areas of THLB. Early seral stage was defined as stands younger than 40 years. Mature and late seral stage included stands between the ages of 101 and 140, while the age for late seral stage was set at 141 and older (Table 7).

Table 7: Areas and targets for Fulton and Nadina SBS mc2

LU/BEC	Forest Area (ha)	THLB Area (ha)	Early Seral Stage Target (Max % of forest)	Mature and Late Seral Stage Target (Min % of forest)	Late Seral Stage Target (Min % of forest
Fulton SBS mc2	65,741	54,415	48%	20%	17%
Nadina SBS mc2	49,527	40,688	48%	20%	17%

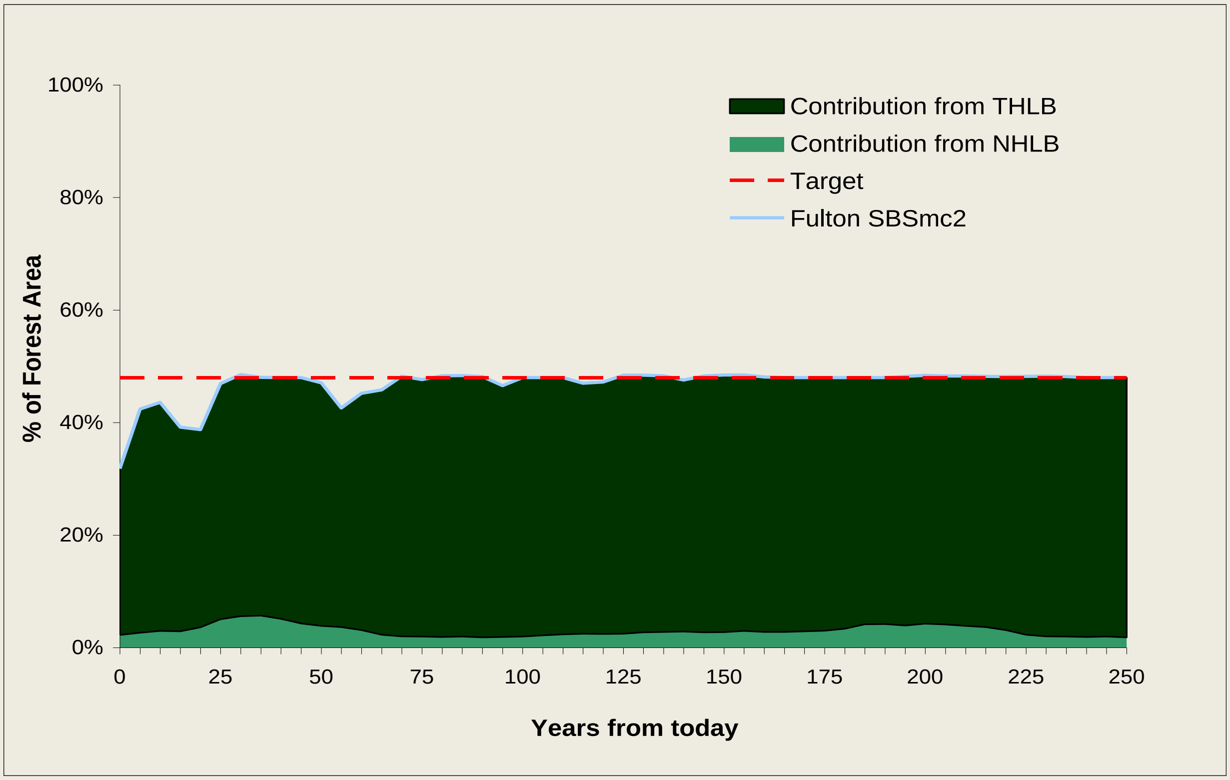

Figure 20: Fulton SBS mc2, achievement of early seral stage in the base case, max target

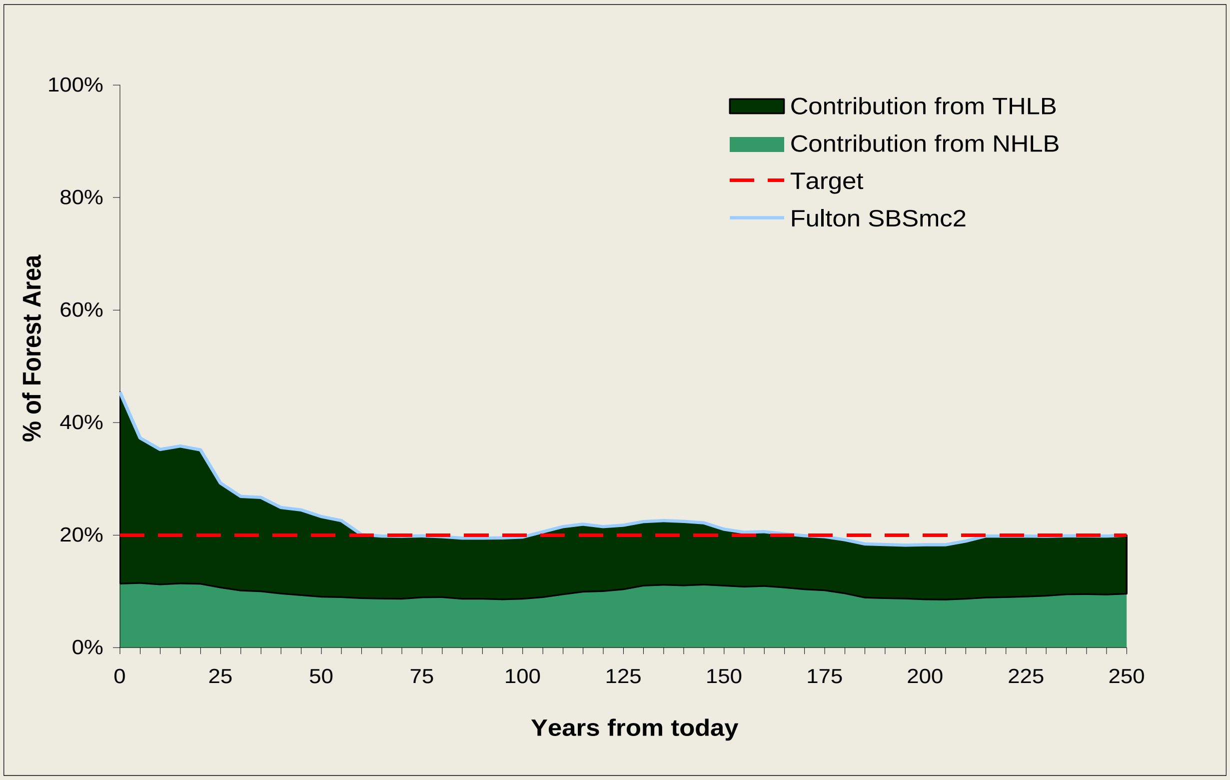

Figure 21: Fulton SBS mc2, achievement of mature and late seral stage in the base case, min target

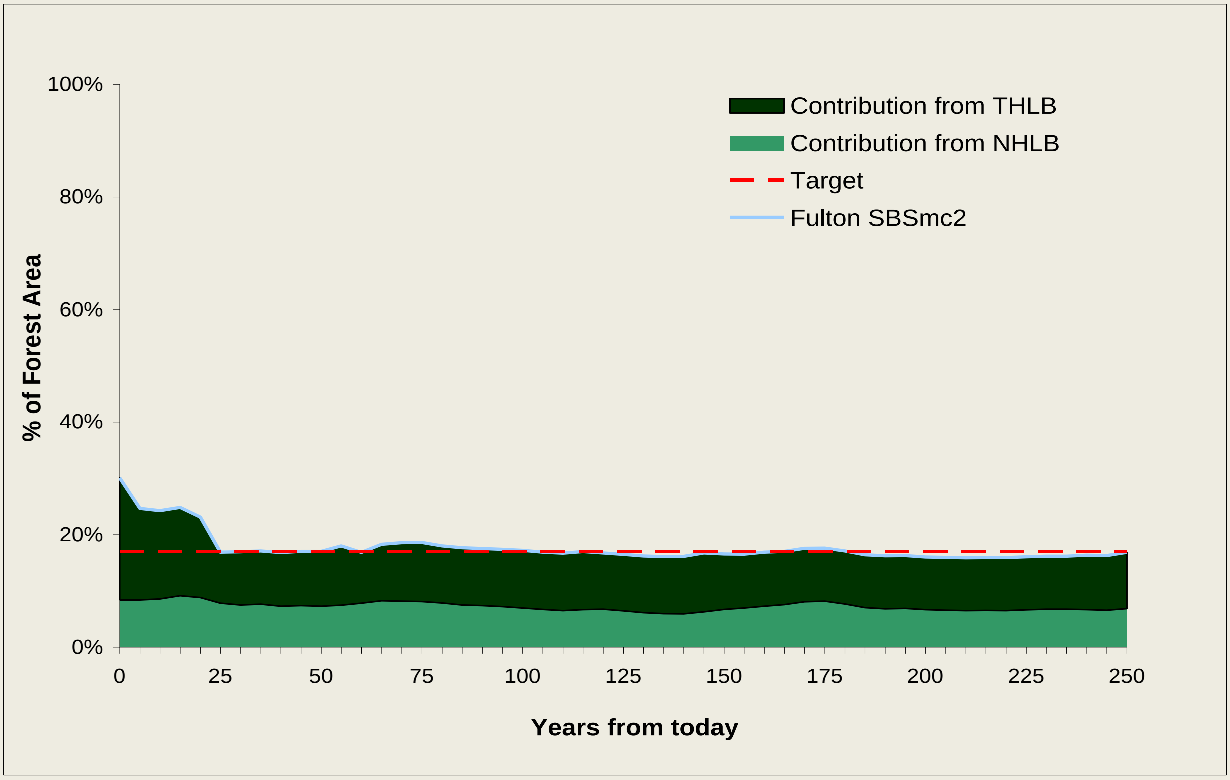

Figure 22: Fulton SBS mc2, achievement of late seral stage in the base case, min target

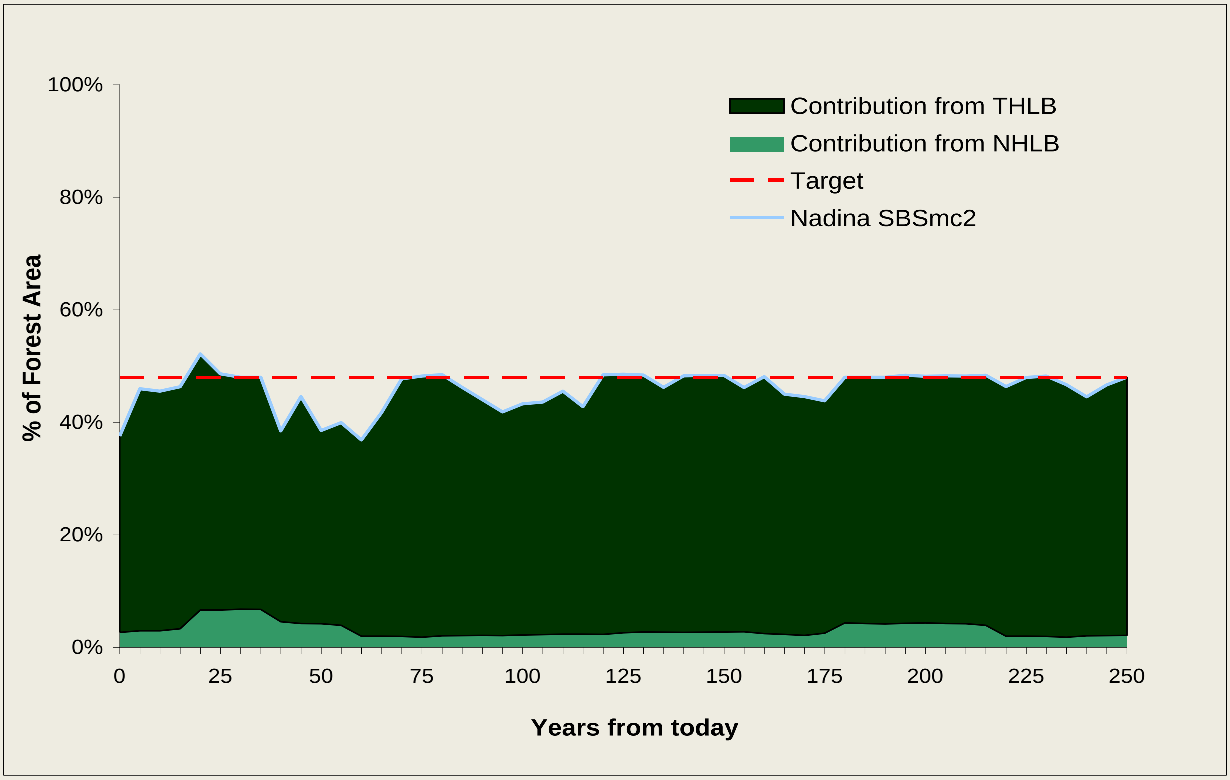

Figure 23: Nadina SBS mc2, achievement of early seral stage in the base case, max target

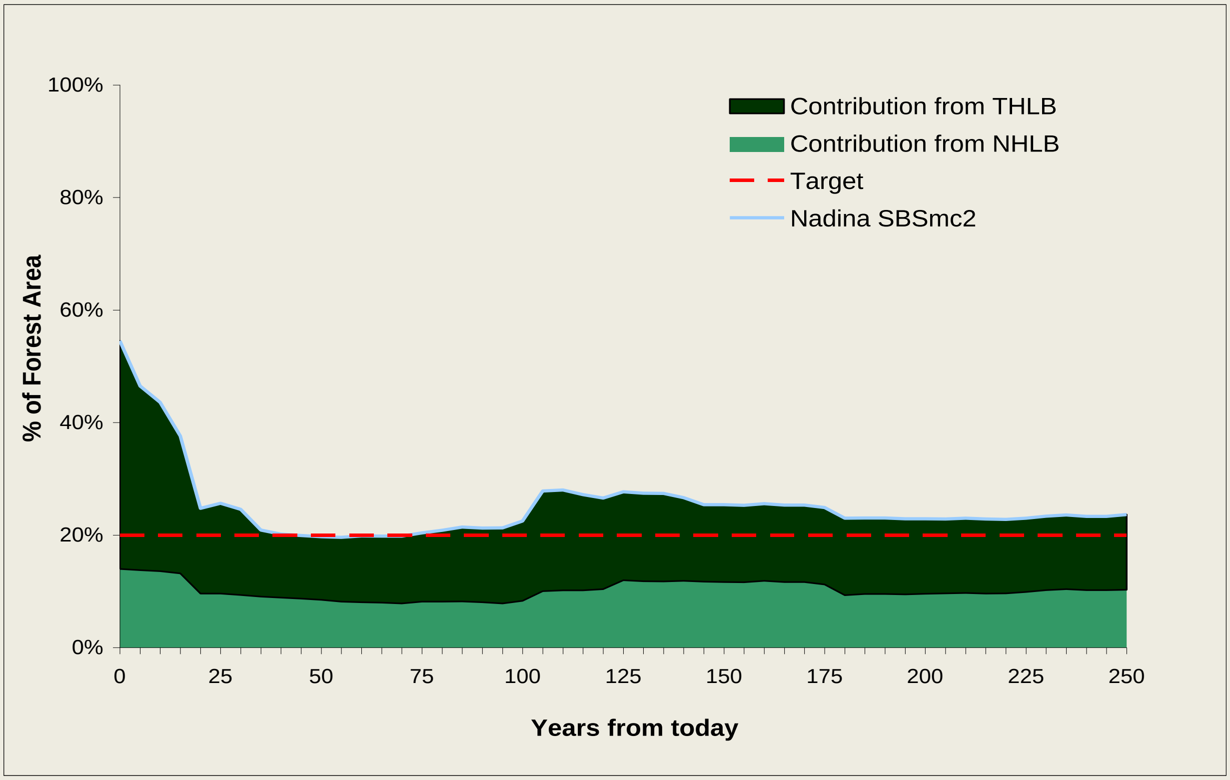

Figure 24: Nadina SBS mc2, achievement of mature and late seral stage in the base case, min target

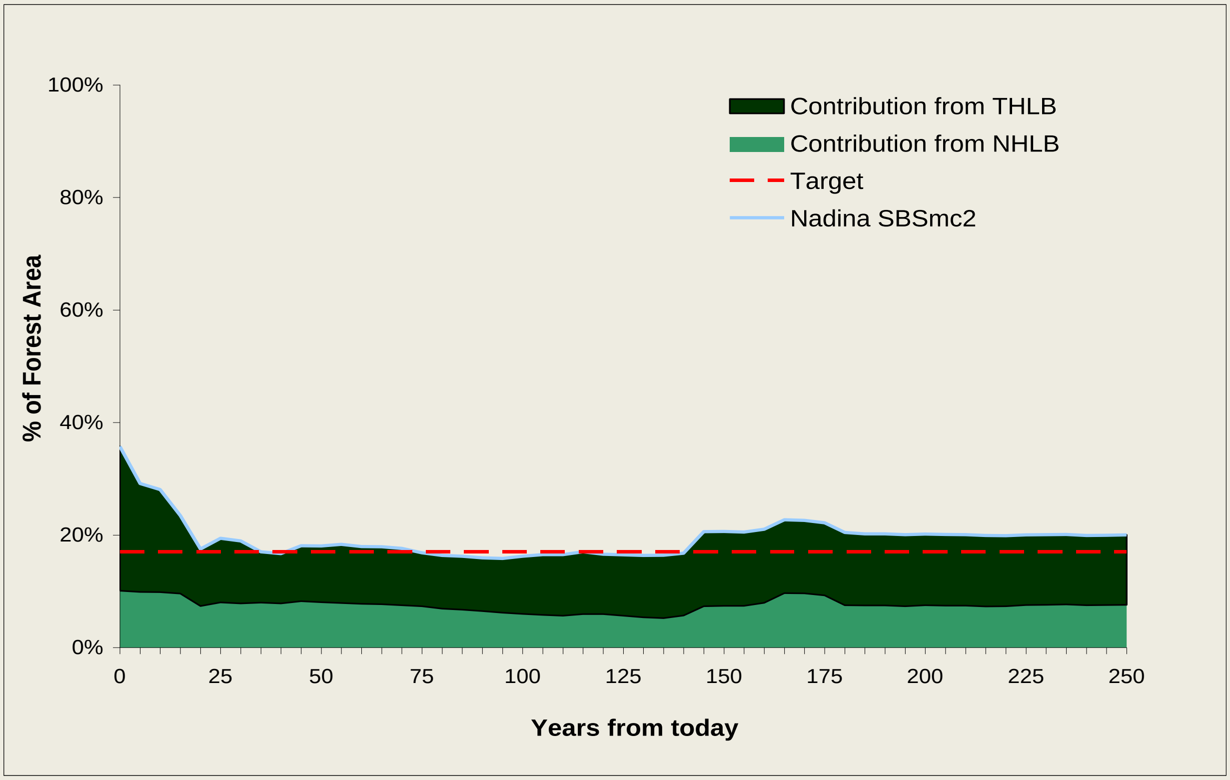

Figure 25: Nadina SBS mc2, achievement of late seral stage in the base case, min target

2.2.3 Green-Up

As a surrogate for cutblock adjacency, a green-up target was applied to the THLB. A maximum of 25% of the THLB was allowed to be less than 3 m in height throughout the planning horizon. This limit was applied by landscape unit in all non-scenic areas (no VQO's). Figure 26 illustrates the achievement of the green-up target in the Fulton landscape unit where the area of THLB outside of visual polygons is 57,557 ha. At times the green-up target constrains harvest as indicated in Figure 26.

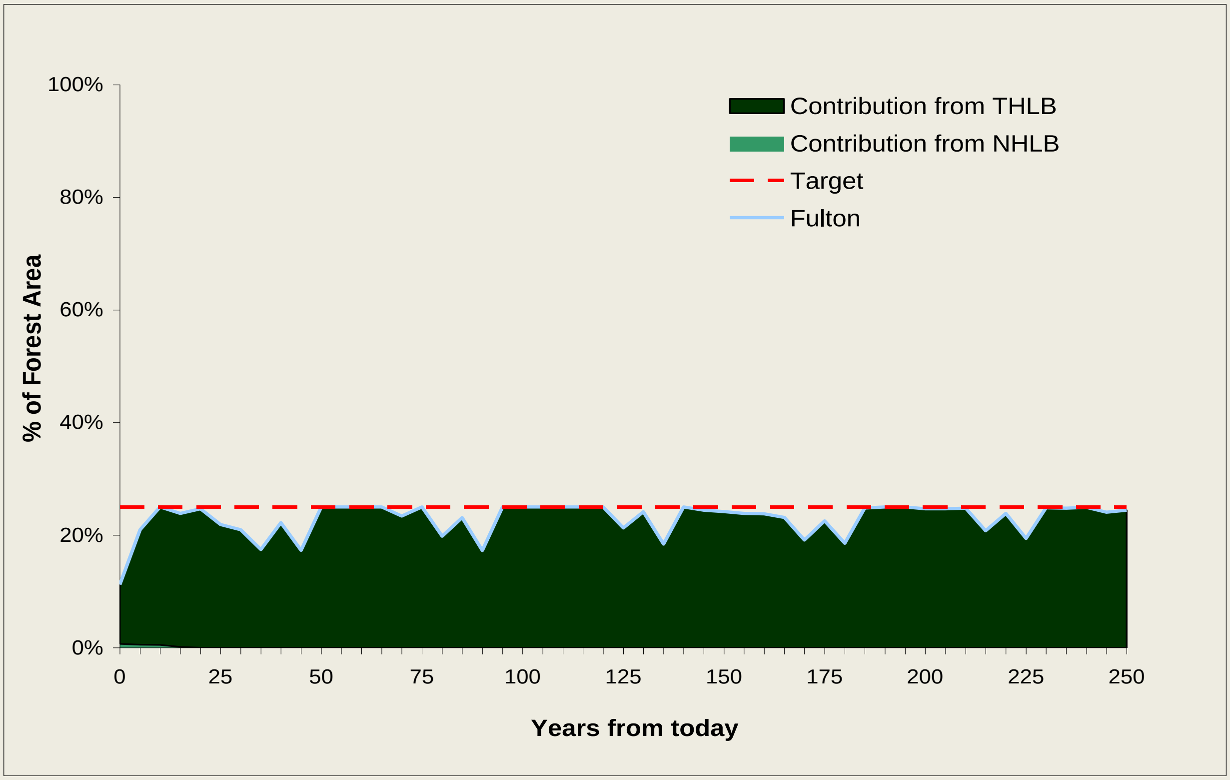

Figure 26: Fulton landscape unit; achievement of green-up, max target

2.2.4 Visual Quality Objectives

Visually effective green-up (VEG) heights were used in conjunction with plan-to-perspective methodology to model the protection of visual values. Visual quality objectives were found to be somewhat constraining on the timber supply at the beginning of the planning horizon due to a combination of harvest and stand break-up.

3 Scenarios

Several scenarios were completed to test the impact of harvest scheduling and silviculture treatments on the timber supply.

3.1 Harvest Scheduling Scenarios

3.1.1 Limiting the Harvest of Non-Pine Species

The Chief Forester established a partition for the harvest of non-pine species in his AAC determination in 2008 limiting the harvest of non-pine species to a maximum of 550,000 m^3 per year. This scenario enforced that partition in the timber supply model and did not allow the harvest of non-pine species to exceed 550,000 m^3 during the first 5 years.

The shelf life assumptions used in the base case analysis render large areas of pine forest un-merchantable before harvesting can occur. For this reason large live pine volume and non-pine volume need to be harvested to meet the current AAC, as illustrated above in the base case. Figure 27 illustrates the harvest forecast for this scenario. The mid term harvest level can be increased to 1.206 million m^3 and maintained until year 36 when it can be increased to 1.515 million m^3 as in the base case. The modest mid-term increase comes at a cost: this scenario results in a reduced total harvest over the first 35 years of about 1,500,000 m^3 (average of 43,000 m^3 per year). The long-term harvest level is approximately 1% less than that of the base case.

The moderate increase in the mid-term harvest is made possible by concentrating the harvest on severely attacked pine stands as shown in Figure 28.

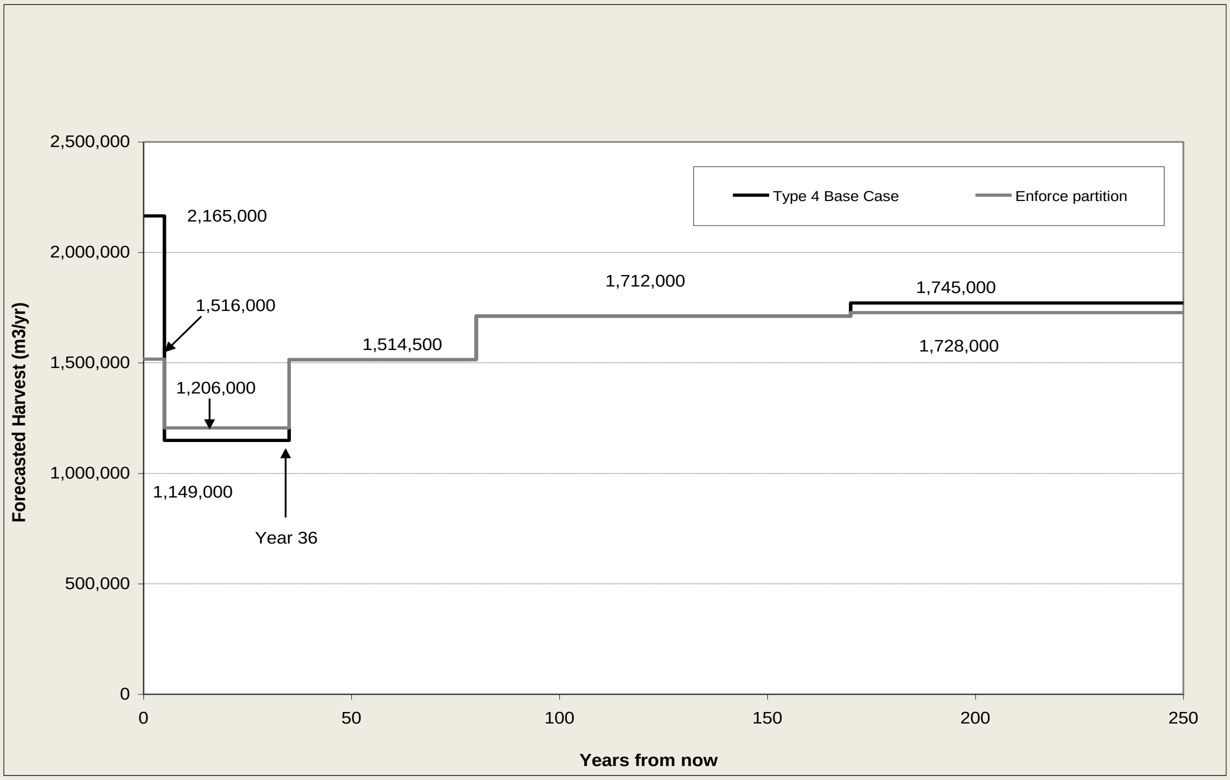

Figure 27: Harvest forecast; non-pine species harvest limited

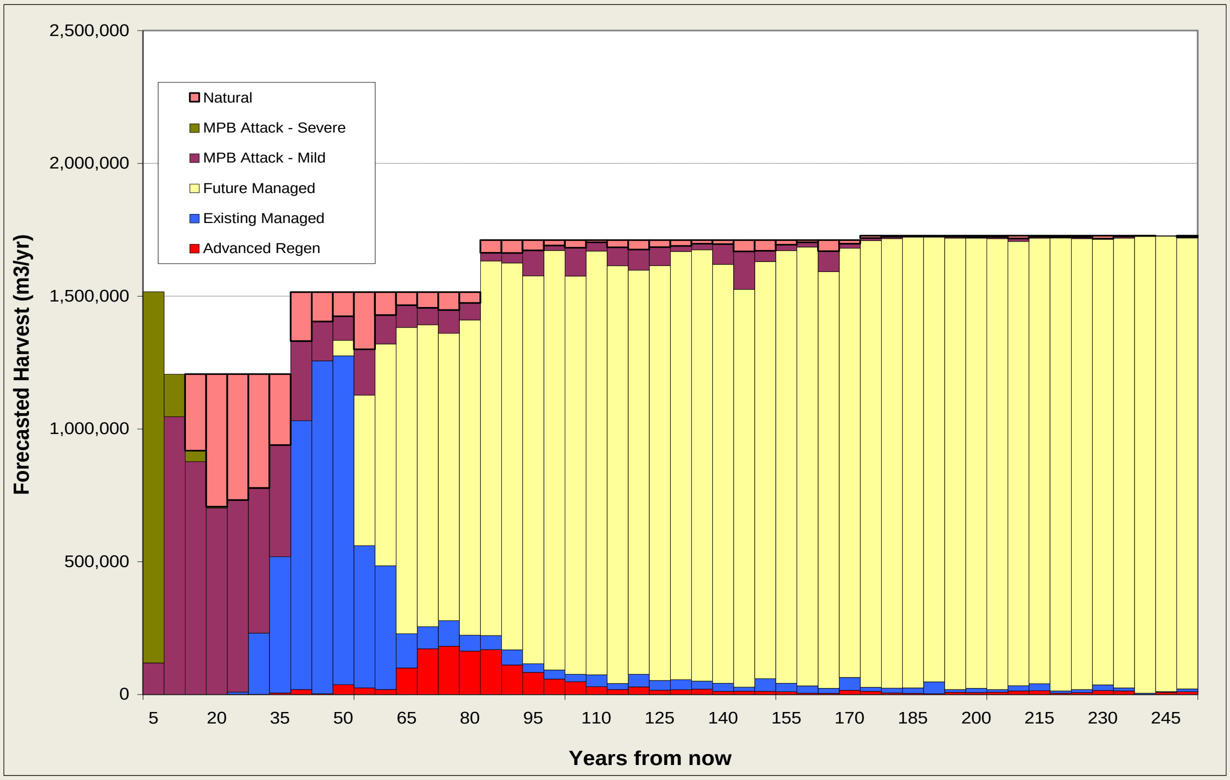

Figure 28: Harvest by forest unit; non-pine species harvest limited

Less dead pine is harvested during the first 5 years (-18%), however, this reduction comes mostly from less severely attacked pine stands, as 50,000 ha of non-merchantable dead pine stands are predicted to remain un-harvested, only 1,000 ha more than in the base case. The annual harvest of non-pine species is estimated at 539,604 in the first 5 years (Table 8). The non-pine species harvest is also shown in Figure 29.

Table 8: Harvest forecast by species group; first 10 years; non-pine species harvest limited

Species Group	Annual Years 1 to 5	Total Years 1 to 5	Annual Years 6 to 10	Total Years 6 to 10
Dead Pine	721,491	3,607,456	147,342	736,708
Live Pine	255,292	1,276,462	391,085	1,955,426
Non Pine	539,604	2,698,018	667,764	3,338,818
Total	**1,516,387**	**7,581,935**	**1,206,191**	**6,030,953**

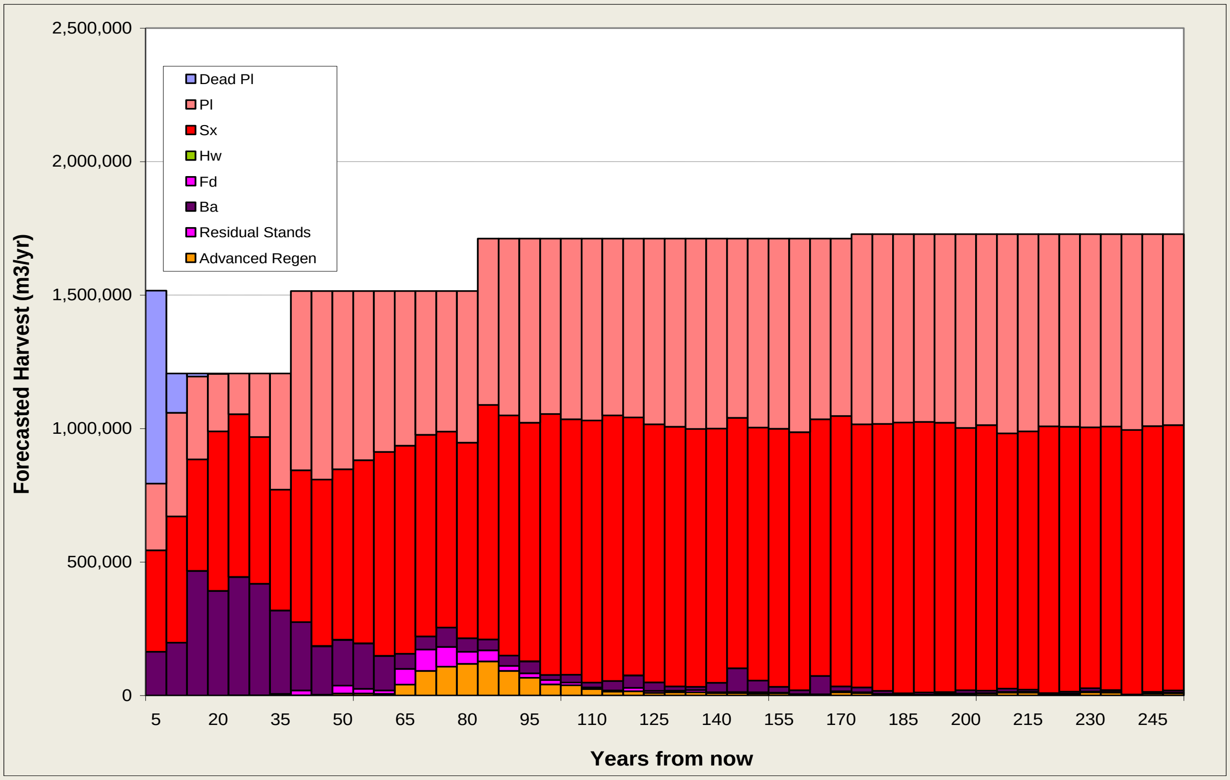

Figure 29: Harvest by species; non-pine species harvest limited

3.1.2 Maximize Mid-Term Harvest Level

This scenario attempted to maximize the mid-term harvest level. The result is presented in Figure 30. The mid-term harvest level of 1.220 million m^3 was maintained between years 6 and 35. This is 6% higher than that of the base case. Over the first 35 years this scenario resulted in a reduced total harvest of about 2,000,000 m^3 (average of 58,000 m^3 per year). Note that the harvest level from year 36 on had to be reduced by approximately 1% from the base case in this scenario.

Less dead pine was harvested than in the base case (Table 9); however, 96% of the harvest is predicted to come from severely attacked pine stands during the first 5 years (Figure 31).

Approximately 51,600 ha of dead pine leading stands are not harvested within the first 20 years mostly because their volume per ha falls below the limit of 150 m^3 per ha before the harvest in the model occurs.

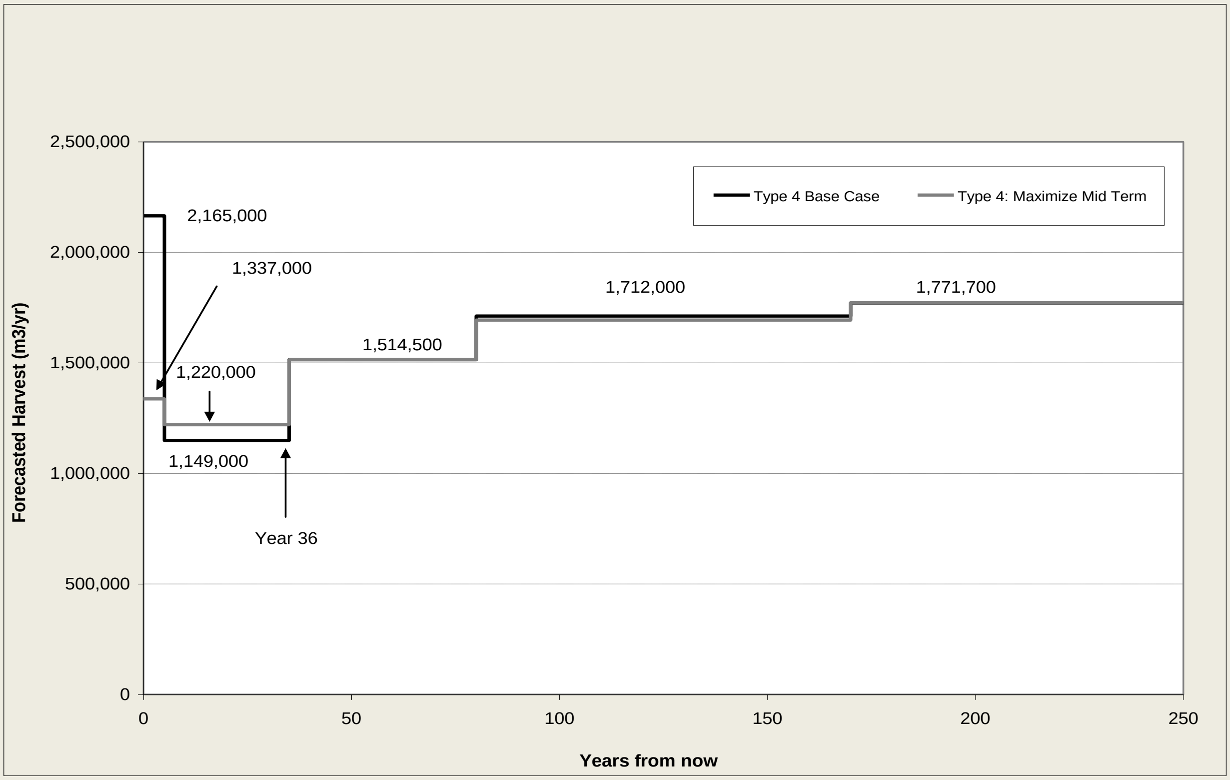

Figure 30: Harvest forecast; maximize mid term

Table 9: Harvest forecast by species group; maximize mid term

Species Group	Annual Years 1 to 5	Total Years 1 to 5	Annual Years 6 to 10	Total Years 6 to 10
Dead Pine	665,444	3,327,222	161,263	806,315
Live Pine	193,198	965,988	415,535	2,077,675
Non Pine	478,512	2,392,560	643,191	3,215,956
Total	**1,337,154**	**6,685,770**	**1,219,989**	**6,099,946**

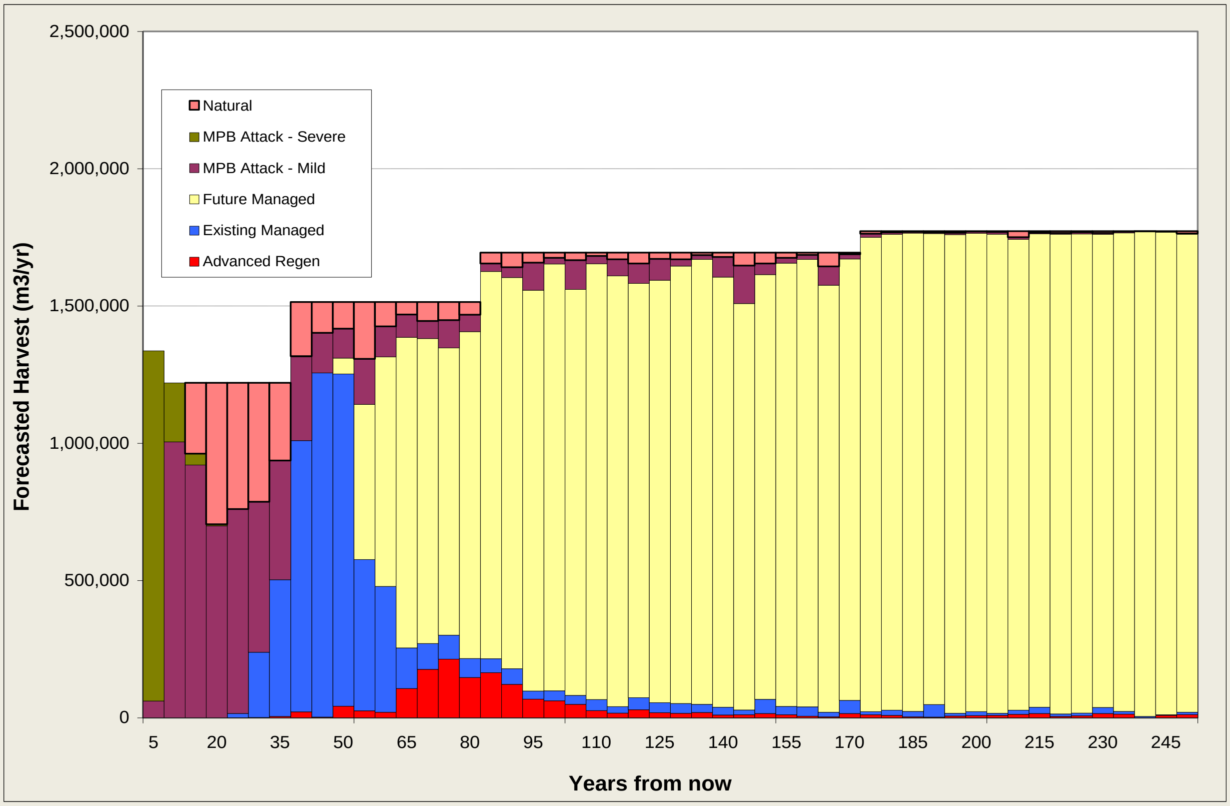

Figure 31: Harvest by forest unit; maximize mid term

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 Morice TSA (Figure 32). In the base case approximately 49,000 ha of dead pine stands were not harvested; these stands remain in the landscape as a potential fire hazard. In addition these stands that are not expected to naturally restock quickly which will be a drag on the timber supply for years to come. The rehabilitation of these stands will reduce the fire hazard and likely increase the timber supply in the late mid term and the early long term.

There are limited opportunities to increase the growth and yield of natural stands in the Morice TSA. Most of the mid term harvest comes from age class 8 stands, which are too old for incremental silviculture treatments (fertilization); however, some opportunities remain in stands that are currently between 40 and 60 years old.

The harvest of existing managed stands starts in the base case between years 26 and 30. From year 31 on 50% or more of the harvest is predicted to come from existing and future managed stands. There are uncertainties associated with the health and quality of these stands. Therefore the assumptions used in the base case to model these stands are also subject to uncertainty and risk. One of the top priorities for the Morice TSA stakeholders is an assessment of the managed stands that will dominate the harvest between years 26 to 50.

Increasing the growth and yield of healthy, good quality, existing managed stands that are currently between 11 and 40 years old may allow for higher mid-term harvest level or an earlier shift to higher level of harvest.

Improving basic reforestation to enhance resiliency and quality was rated high as an action item with the Morice TSA stakeholder group. This strategy is expected to impact mostly the long term timber supply and value generated from harvesting.

Figure 32: Base case; mid term silviculture opportunities

3.2.2 Scenario Approach

The bookend approach was adopted in the following scenarios. 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 and operational knowledge 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 Morice TSA. All the silviculture scenarios were run for the period of 150 years.

3.2.3 Rehabilitation of Dead Pine Stands

In the base case approximately 49,000 ha of dead pine stands had deteriorated below the analysis merchantability criteria and were not harvested. These stands were netted down by removing areas in the timber supply model were assumed to have high density of advanced regeneration and low levels of overstory. Visually constrained areas were also removed from the candidate population. This left a treatment population of 15,795 ha. These stands were assumed to be treated within the first 5 years at the cost of $2,000 per ha (total cost of $31.6 million over 5 years or $6.3 million annually. The theoretical spatial locations of the treated stands are shown in Figure 33.

Rehabilitation of dead pine stands had no impact on the near mid-term timber supply. The harvest level could be increased at year 36 by 3.4 % to 1,566,000 m^3 per year as depicted in Figure 34. Figure 35 illustrates the predicted growing stock of this scenario compared to the base case; the increased harvest from year 36 on reduces the growing stock at first. It later recovers and remains above the base case level.

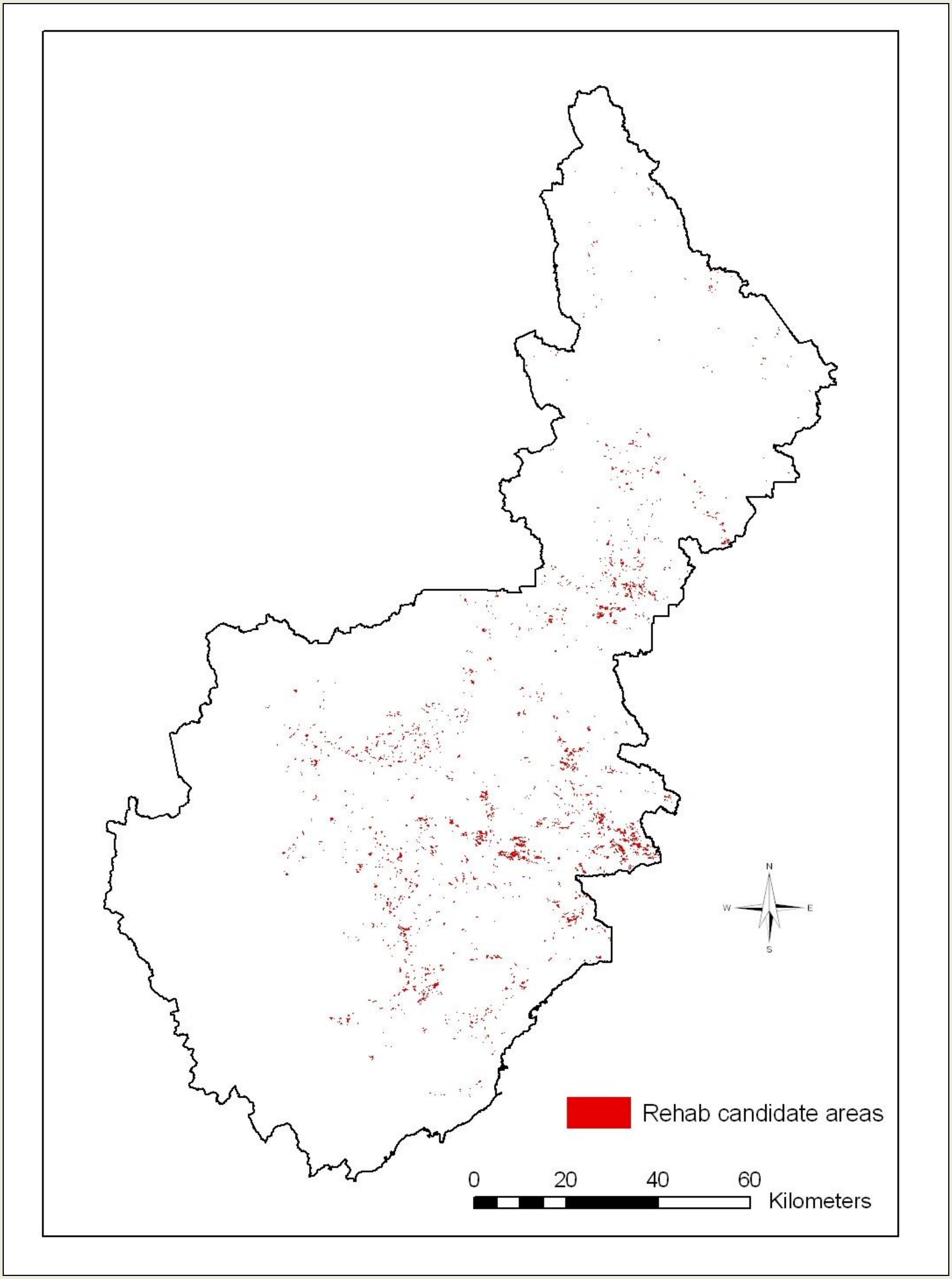

Figure 33: Stands rehabilitated in the model

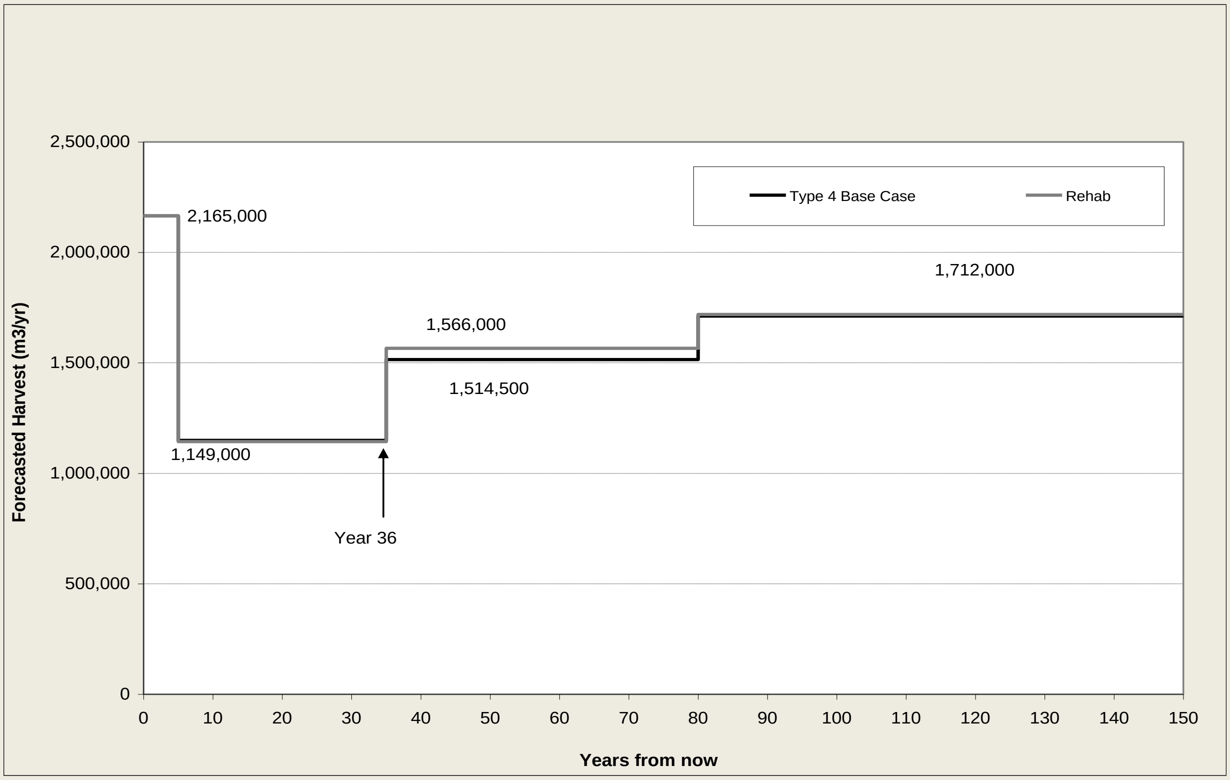

Figure 34: Impact of rehabilitating 15,795 ha of dead pine stands

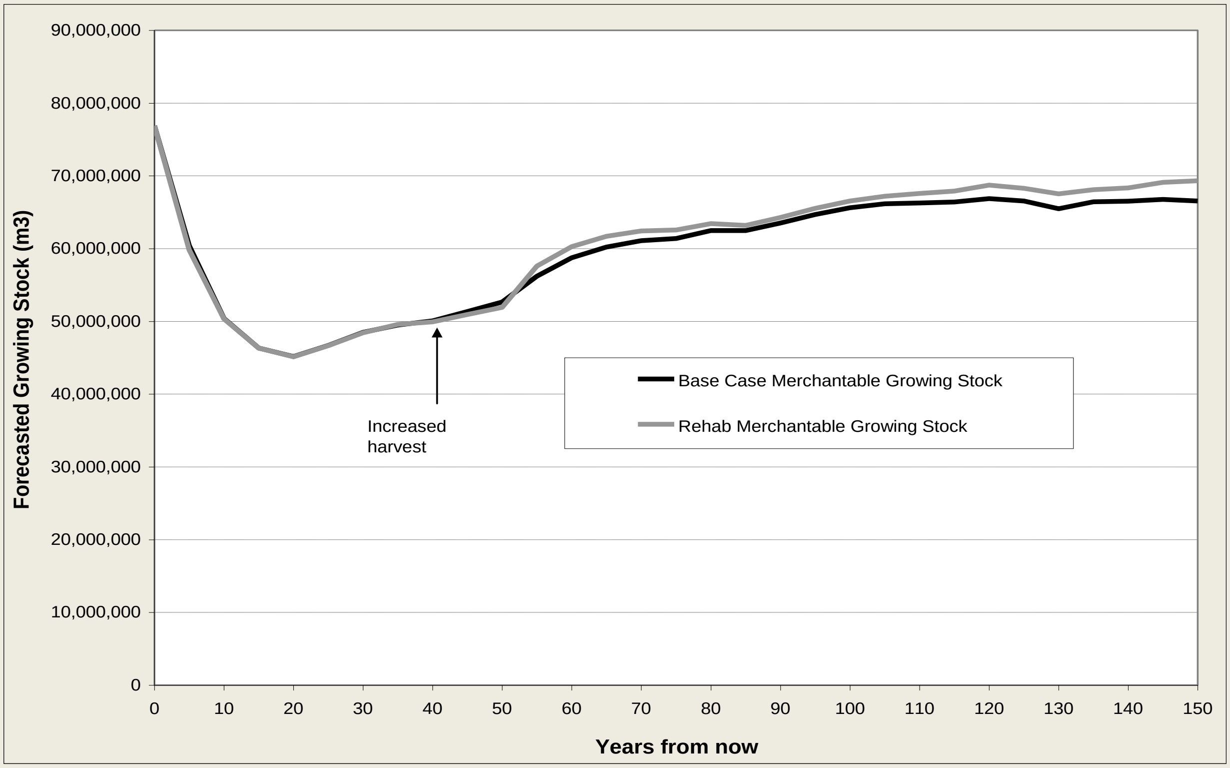

Figure 35: Merchantable growing stock; rehabilitating 15,795 ha of dead pine stands

3.2.4 Rehabilitation of Dead Pine Stands Combined with Fertilization

This scenario tested the timber supply impact of fertilizing all suitable rehabilitated stands at ages 25, 35, 45 and 55. The candidate population consisted of 15,336 ha of rehabilitated stands. The fertilization in the model started at year 26 and ended at year 60. Note that most of the stands are harvested before the last fertilization treatment at year 55. Table 10 depicts the fertilized areas over time and related fertilization costs for this scenario. These stands were also assumed to be rehabilitated within the first 5 years at the cost of $2,000 per ha (total cost of $31.6 million over 5 years or $6.3 million annually).

Table 10: Fertilized rehabilitation areas and costs

Years from now	Treated Area, Annual (ha)	Annual Cost
26 to 30	3,067	$1,840,260
31 to 35	0	$0
36 to 40	3,067	$1,840,260
41 to 45	0	$0
46 to 50	3,016	$1,809,409
51 to 55	0	$0
56 to 60	720	$432,248

As with rehabilitation alone, the harvest level could not be increased from the base case until year 36. The increase was modest at 3.7% between years 36 and 80 (up to 1,571,000 m^3 per year). The fertilization treatment provided only a nominal improvement in timber supply.

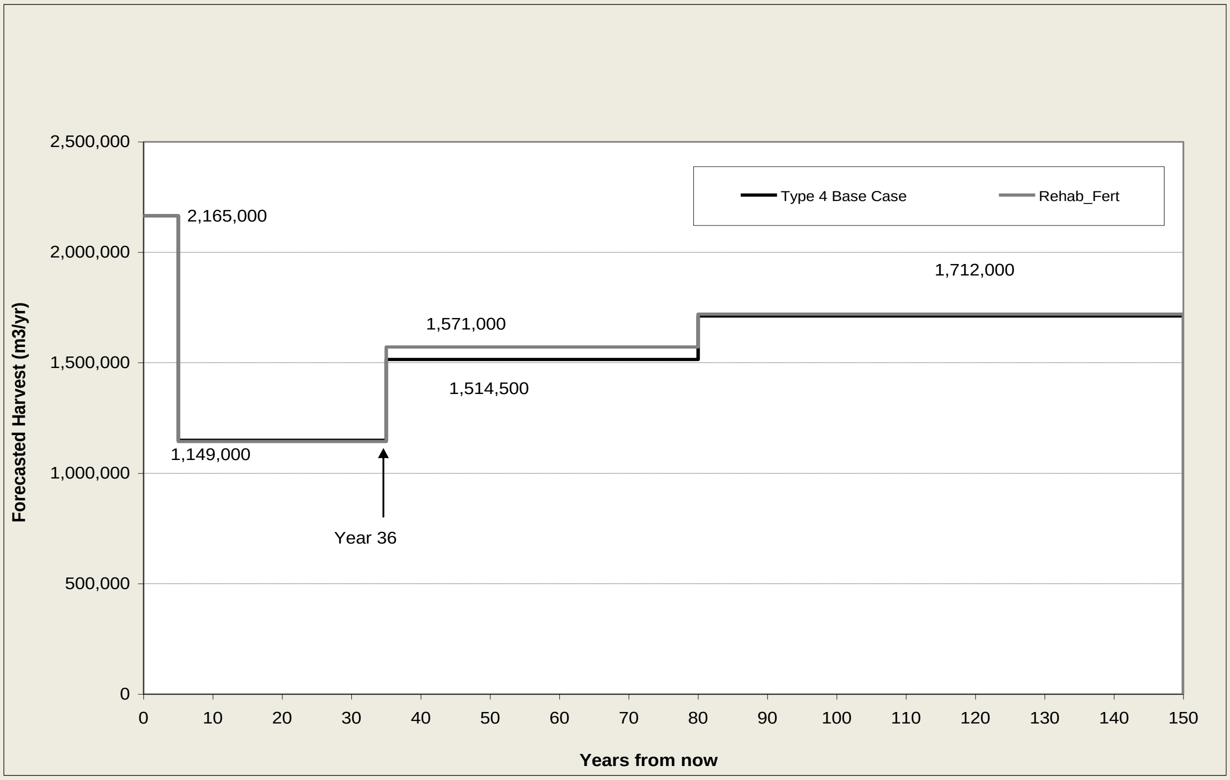

Figure 36: Impact of rehabilitating fertilizing currently dead pine stands

3.2.5 Fertilization of Existing Natural and Managed Stands

This scenario tested the impact of fertilizing existing stands. The candidate stands were natural good and medium spruce leading stands currently between 40 and 80 years of age, and good and medium existing managed stands of spruce and pine between 1 and 40 years of age.

Only 3,060 ha of stands older than 40 years of age were included in the candidate population. The regime for these stands consisted of one fertilization treatment.

The balance of the target population consisted of 163,276 ha of existing managed stands (age between 1 and 40). These stands were set to be fertilized up to 4 times depending on their current age. The fertilization was set to happen at years 25, 35, 45 and 55. No areas within WHAs or VQO PR were fertilized. The candidate “bookend” population of 11 to 40 year-old stands is illustrated in Figure 37.

Table 11 shows the fertilized areas and costs in this scenario for the first 50 years. Table 12 presents the same by leading species and BEC for the first 10 years. Figure 38 illustrates the fertilization schedule for the first 10 years spatially.

Table 11: Fertilization of existing stands, areas and costs

Years from now	Treated Area, Annual (ha)	Annual Cost
1 to 5	8,885	$5,330,750
6 to 10	11,288	$6,772,822
11 to 15	11,842	$7,104,905
16 to 20	14,961	$8,976,700
21 to 25	16,372	$9,822,912
26 to 30	12,966	$7,779,816
31 to 35	12,537	$7,522,151
36 to 40	6,986	$4,191,765
41 to 45	8,948	$5,368,732
46 to 50	3,849	$2,309,604

Table 12: Fertilization of existing stands by species and BEC; years 1 to 10, annual areas and costs

Years	Pine Managed		Spruce Managed		Spruce Natural	Total Area (ha)	Annual Cost ($)
	SBSdk	SBSmc2	SBSdk	SBSmc2	n/a		
1 to 5	1,211	4,905	112	2,298	358	8,885	$5,330,750
6 to 10	1,250	6,729	347	2,778	185	11,288	$6,772,822

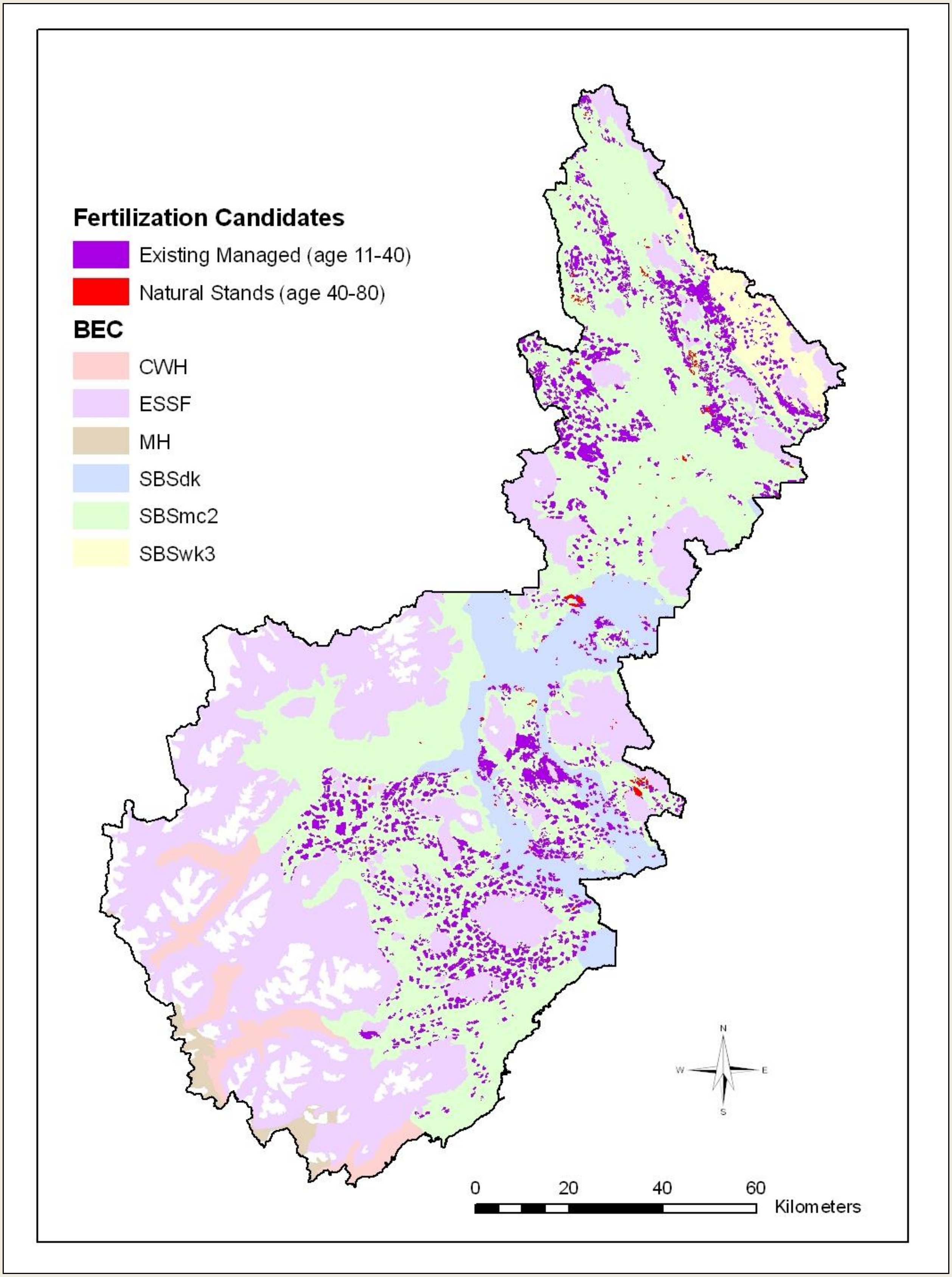

Figure 37: Fertilization candidate areas

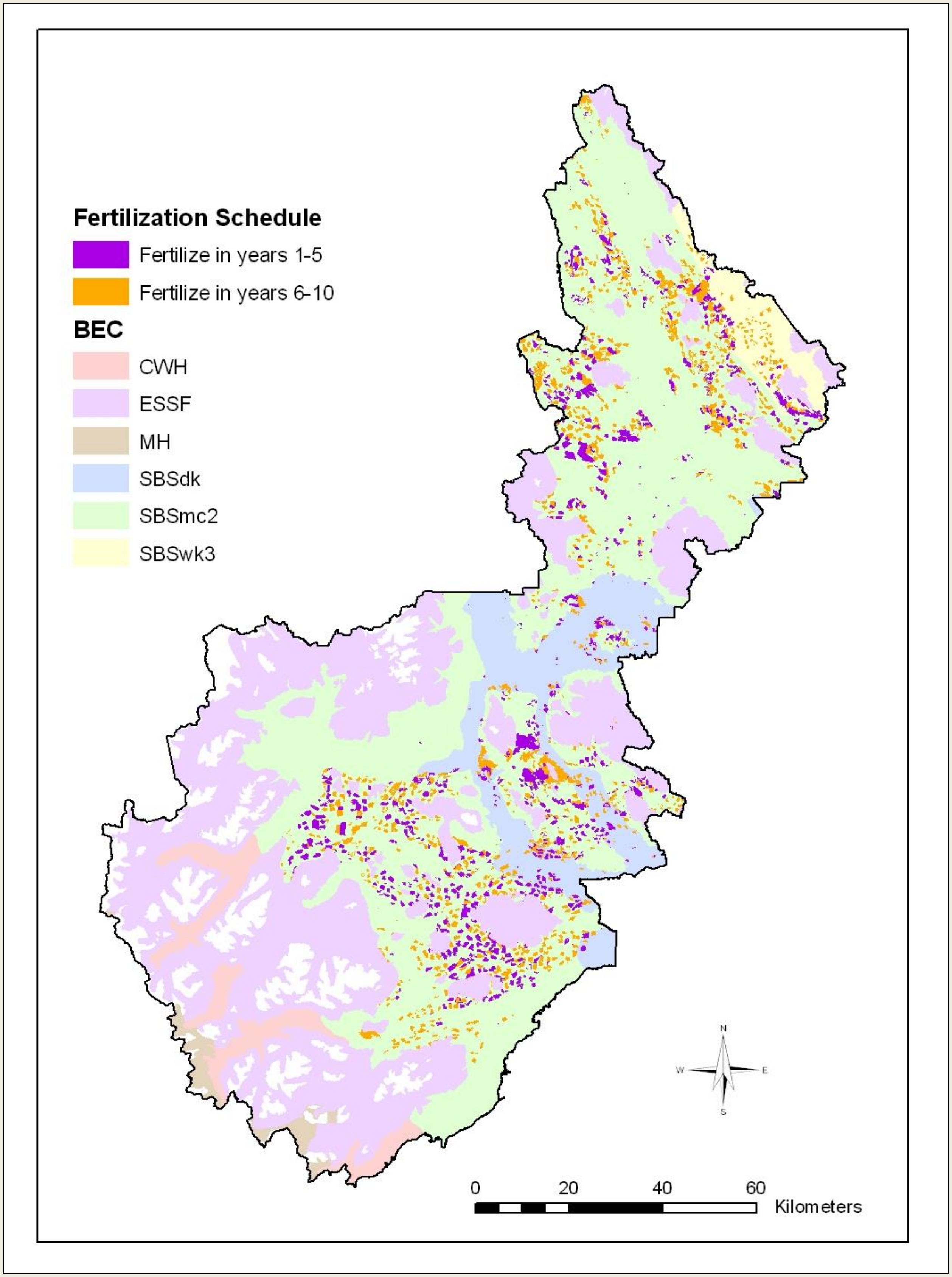

Figure 38: Stands fertilized in the model years 1 to 10

Fertilization increased the mid-term timber supply modestly by 4% to 1,194,400 m^3 per year between years 26 and 35. The increase was more significant starting at year 36 (10%) when the harvest was increased to 1,656,500 m^3 per year; however between years 81 and 110 the base case harvest level had to be reduced somewhat in this scenario.

The merchantable growing stock in this scenario is significantly higher between years 11 and 75 than that of the base case as depicted in Figure 40. This creates an impression that a much higher harvest level should be available starting at year 11. However, further investigation reveals that a higher harvest level is not possible due to early seral stage and late seral stage objectives as modeled for the Morice TSA in this analysis.

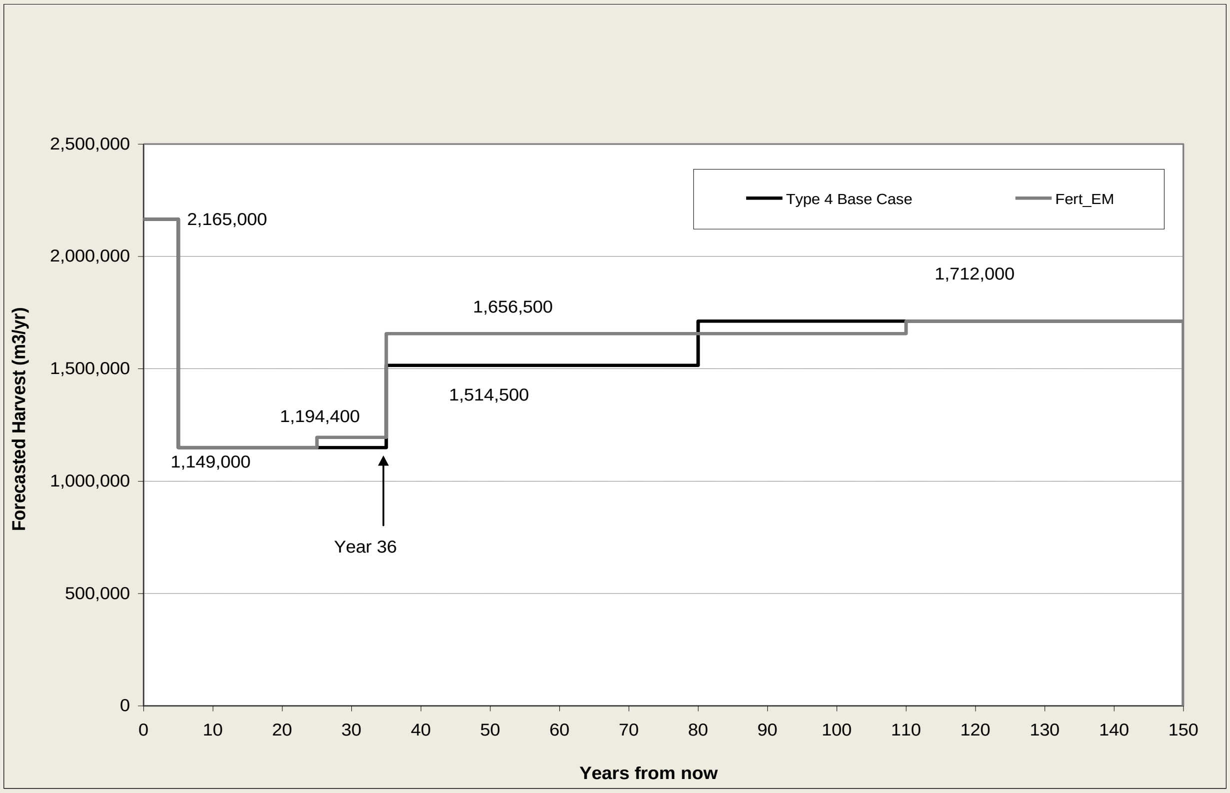

Figure 39: The impact of fertilizing existing (mostly managed) stands, 163,000 ha target population

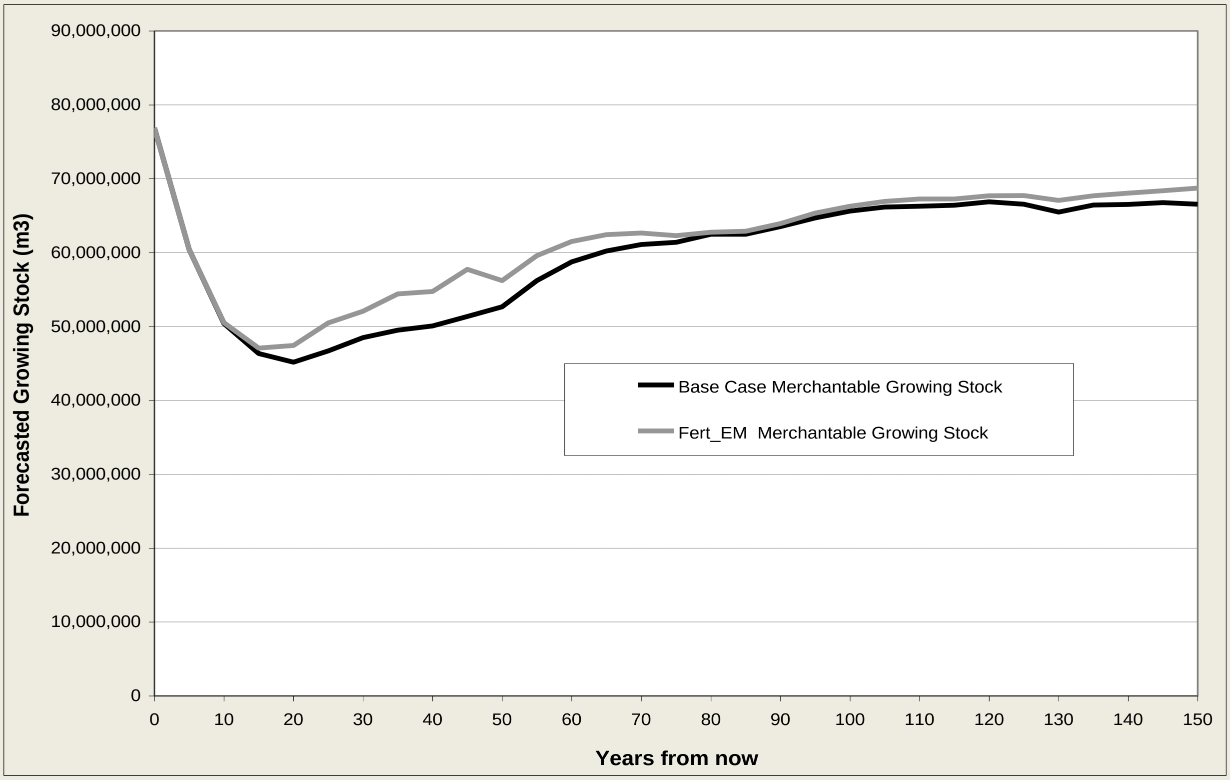

Figure 40: Merchantable growing stock; fertilizing existing stands

3.2.6 Fertilization of Existing Natural, Managed and Future Stands

This scenario incorporated all the fertilization from the previous scenario and the fertilization of all suitable future managed stands. Table 13 shows the fertilized areas and related costs in this scenario.

Table 13: Fertilization of existing and future managed stands, areas and costs

Years from now	Treated Area, Annual (ha)	Annual Cost
1 to 5	8,885	$5,330,750
6 to 10	11,280	$6,768,019
11 to 15	11,842	$7,104,905
16 to 20	14,922	$8,953,049
21 to 25	16,356	$9,813,466
26 to 30	20,256	$12,153,545
31 to 35	16,835	$10,100,781
36 to 40	17,711	$10,626,379
41 to 45	15,866	$9,519,539
46 to 50	17,388	$10,432,953

As in the previous scenario, fertilization increased the mid-term timber supply modestly this time by 5% to 1,203,400 m^3 per year between years 26 and 35 (Figure 41). The increase between years 36 and 80 was notable at 13% (1,712,000 m^3 per year). From year 81 on, the harvest forecast at 1,854,000 m^3 per year is 8.3% higher than that of the base case.

Figure 42 illustrates the merchantable growing stock for this scenario. Significantly more merchantable growing stock is available than in the base case; however, as in the previous scenario this increased growing stock cannot be harvest due to seral stage distribution objectives.

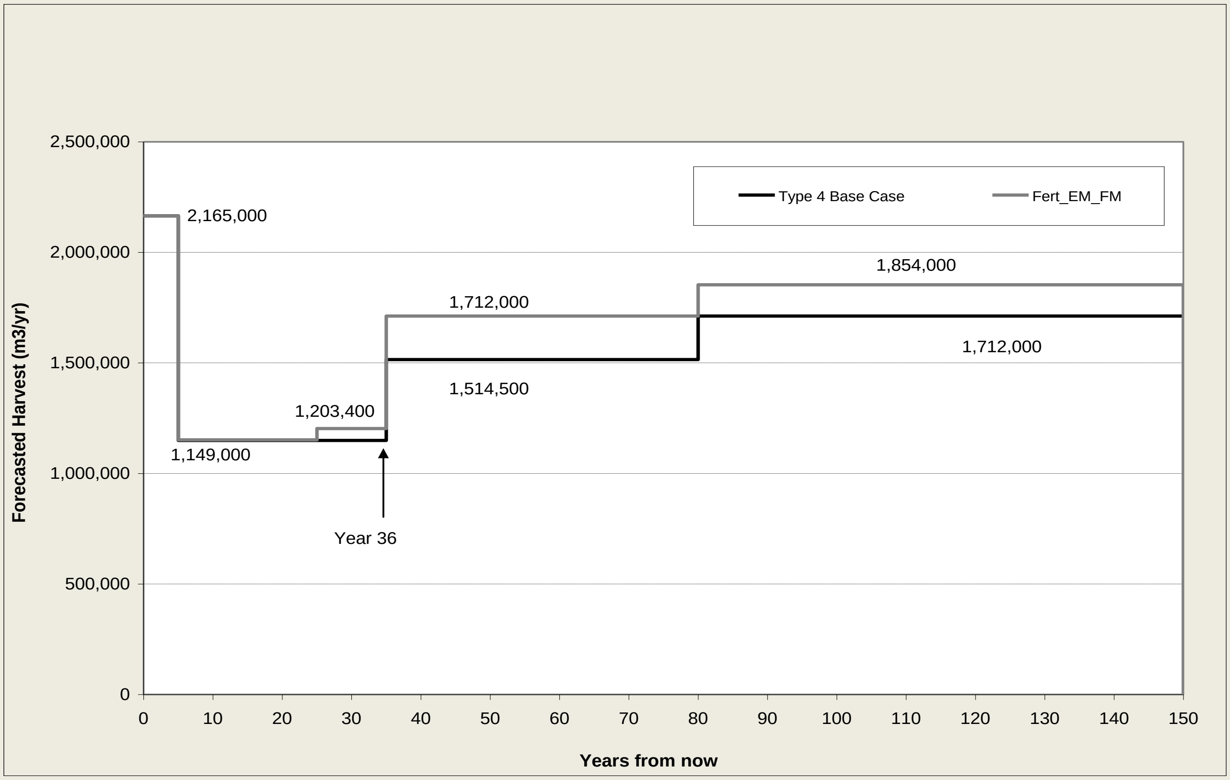

Figure 41: The impact of fertilizing existing stands and future stands

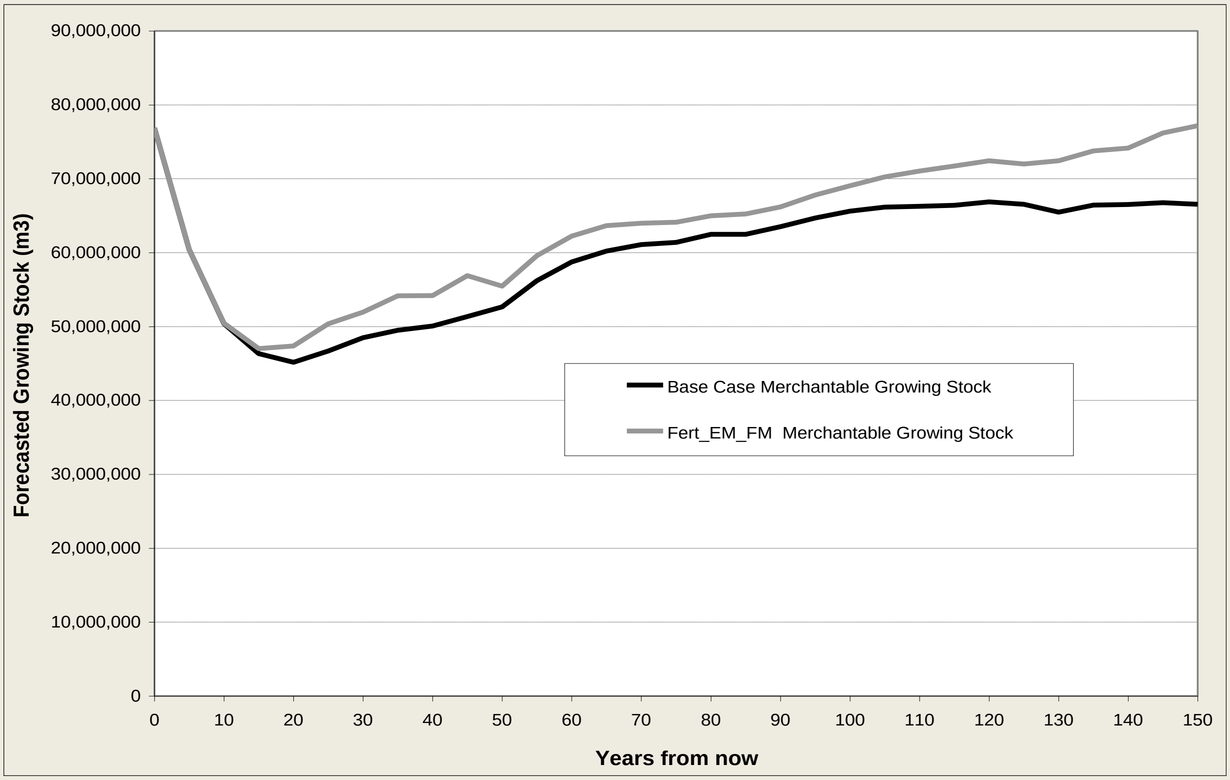

Figure 42: Merchantable growing stock; fertilizing existing stands and future stands

3.2.7 Enhanced Basic Silviculture; Increased Planting Densities

This scenario investigated the impact of increasing planting densities to 1,700 from 1,400 for all future stands. Table 14 below shows the treated areas and estimated incremental costs. The timber supply impact of increased planting densities was modest at around 4% and started only at year 61 (Figure 43). While the timber supply impact is small, the denser stands are expected to be more resilient against pests and diseases, be more valuable and be more viable for future silviculture treatments.

Table 14: Increased planting densities, areas and costs

Years from now	Treated Area, Annual (ha)	Annual Cost (Increase)
1 to 5	7,287	$1,246,076
6 to 10	4,195	$717,402
11 to 15	3,392	$580,065
16 to 20	2,794	$477,768
21 to 25	2,967	$507,299
26 to 30	3,029	$517,985
31 to 35	3,920	$670,286
36 to 40	5,514	$942,902
41 to 45	5,292	$904,885
46 to 50	4,962	$848,492

Table 15: Increased planting densities by BEC; years 1 to 10

Years	SBSdk	SBSmc2	Annual Area (ha)	Annual Cost ($)
1 to 5	921	6,366	7,287	$1,246,076
6 to 10	524	3,671	4,195	$717,402

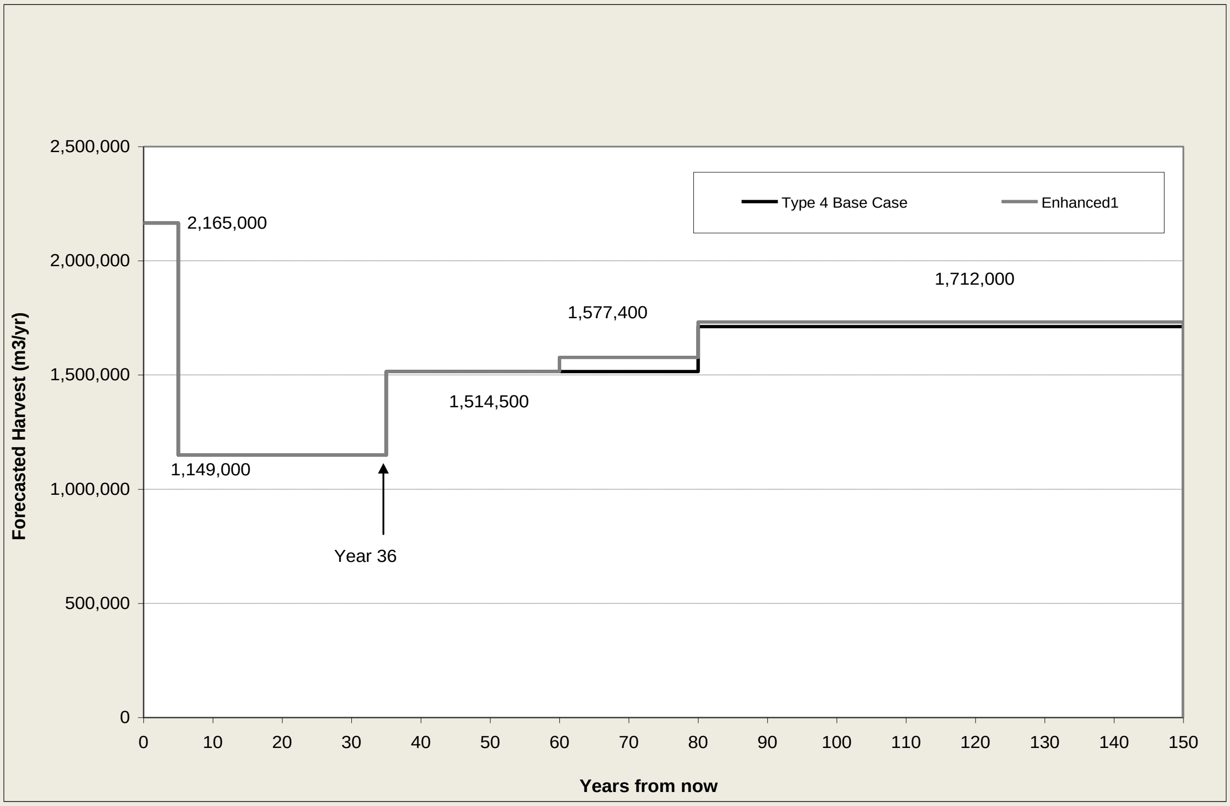

Figure 43: Impact of increased planting densities

3.2.8 Enhanced Basic Silviculture; Increased Planting Densities and Altered Species Composition

This scenario increased planting densities and changed the species composition of future stands; more spruce was planted instead of pine. Table 16 shows the treated areas and estimated incremental costs. The timber supply impact was negligible (Figure 44). The expected benefits of planting more spruce were not realized likely because most of the future stands get harvested relatively young between ages 61 and 80.

Table 16: Increased planting densities and altered species composition, areas and costs

Years from now	Treated Area, Annual (ha)	Annual Cost (Increase)
1 to 5	7,287	$1,246,076
6 to 10	4,210	$719,923
11 to 15	3,361	$574,681
16 to 20	2,869	$490,528
21 to 25	2,908	$497,253
26 to 30	2,936	$502,034
31 to 35	3,866	$661,010
36 to 40	5,530	$945,610
41 to 45	5,264	$900,062
46 to 50	5,023	$858,922

Table 17: Increased planting densities and altered sp composition by BEC; years 1 to 10

Years	SBSdk	SBSmc2	Annual Area (ha)	Annual Cost ($)
1 to 5	921	6,366	7,287	$1,246,076
6 to 10	524	3,686	4,210	$719,923

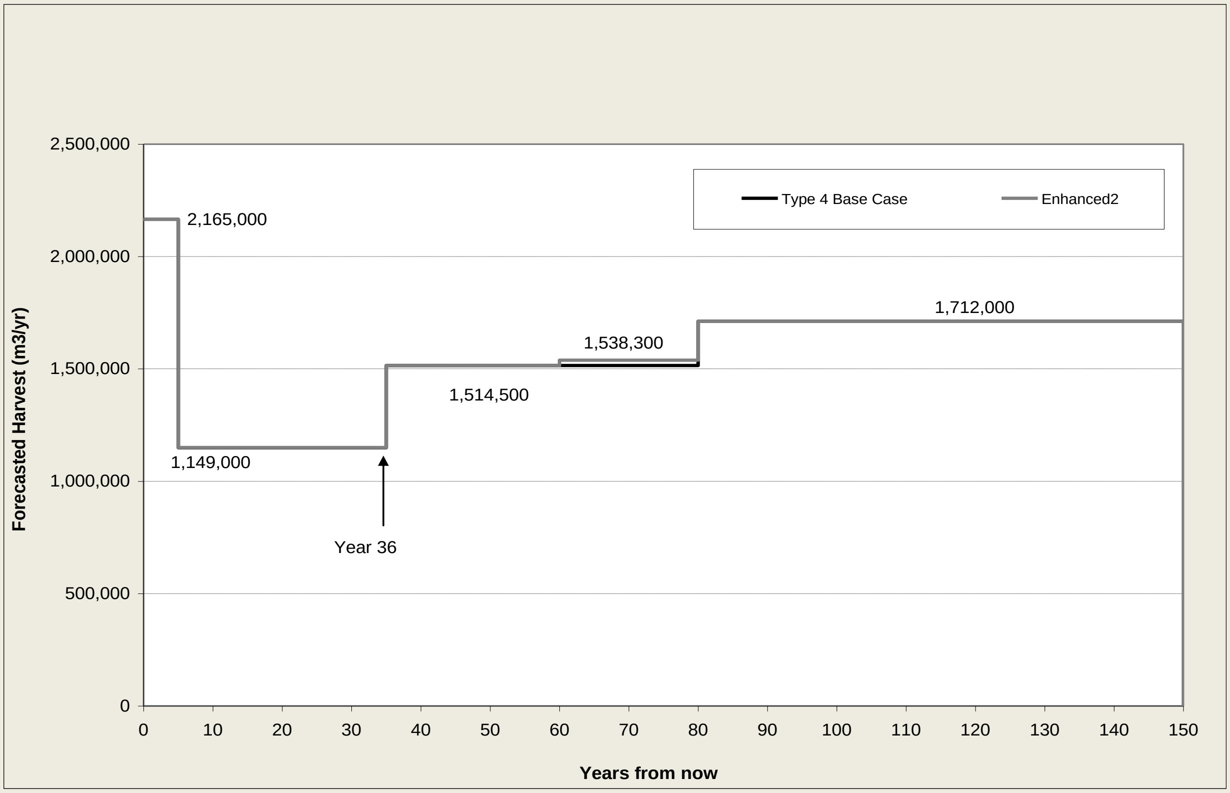

Figure 44: Impact of increased planting densities and altered species composition

3.2.9 Enhanced Basic Silviculture; Increased Planting Densities and Fertilization of Future Stands

This scenario combined increased planting densities with the fertilization of all suitable future stands. The future stands were fertilized at ages 25, 35, 45 and 55. The predicted treatment areas and costs are outlined in Table 18.

Figure 45 illustrates the harvest forecast for this scenario. The harvest level in this scenario was 6% higher than that of the base case starting at year 36 (1,606,450 m^3 per year). From year 81 on the harvest could be increased by almost 12% to 1,911,400 m^3 per year.

Table 18: Increased planting densities and fertilization of future stands, areas and costs

Years from now	Planting Density		Fertilization		Total Annual Cost
	Treated Area, Annual (ha)	Annual Cost (Increase)	Treated Area Annual (ha)	Annual Cost	
1 to 5	7,287	$1,246,076	0	$0	$1,246,076
6 to 10	4,195	$717,402	0	$0	$717,402
11 to 15	3,392	$580,065	0	$0	$580,065
16 to 20	2,794	$477,768	0	$0	$477,768
21 to 25	2,967	$507,299	0	$0	$507,299
26 to 30	3,029	$517,985	7,287	$4,372,196	$4,890,180
31 to 35	3,920	$670,286	4,195	$2,517,201	$3,187,487
36 to 40	5,890	$1,007,177	10,679	$6,407,511	$7,414,688
41 to 45	5,320	$909,759	6,989	$4,193,579	$5,103,338
46 to 50	5,398	$923,077	13,646	$8,187,507	$9,110,584

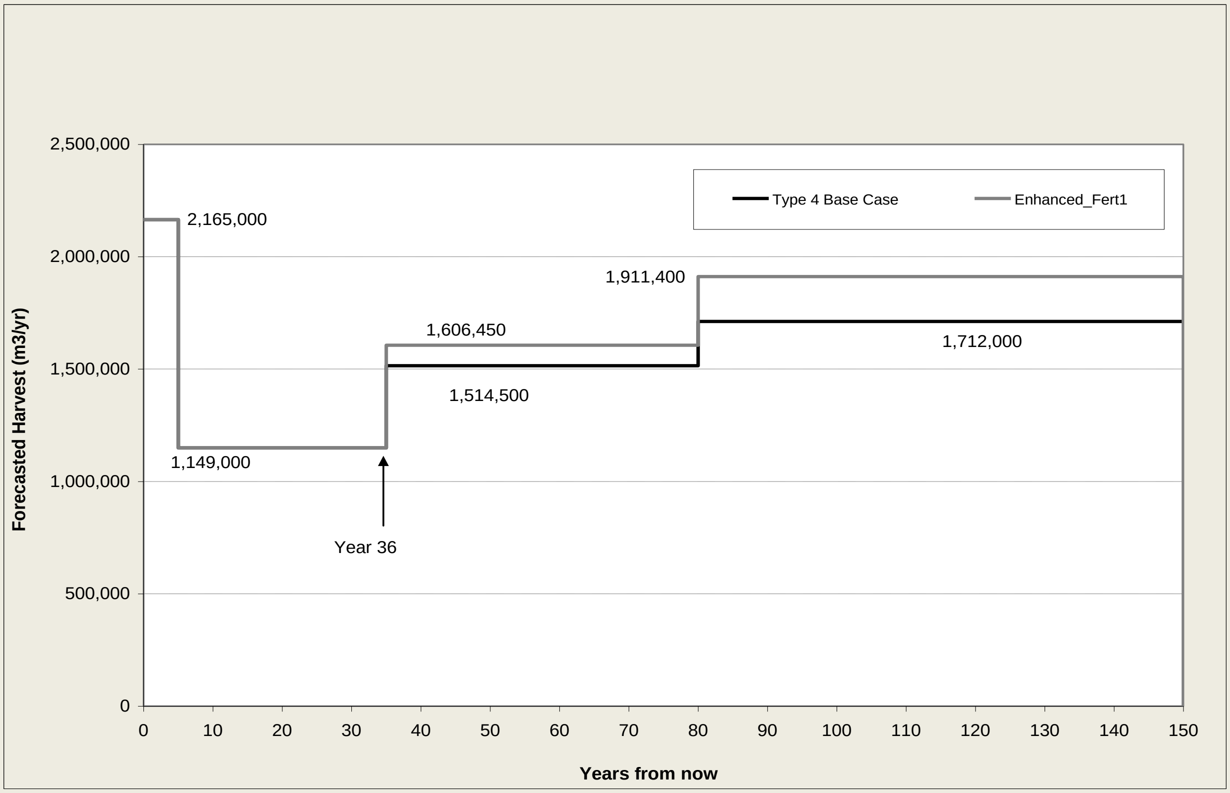

Figure 45: Impact of increased planting densities and fertilization of future stands

3.2.10 Enhanced Basic Silviculture; Increased Planting Densities, Altered Species Composition and Fertilization of Future Stands

This scenario combined increased planting densities and altered species composition with the fertilization of all suitable future stands. The future stands were fertilized at ages 25, 35, 45 and 55. The predicted treatment areas and costs are outlined in Table 19.

Figure 46 illustrates the harvest forecast for this scenario. The harvest increase was similar to that of the previous scenario; a somewhat more moderate response took place at year 36 (5% compared to the base case), whereas the harvest level was higher than in the previous scenario from year 81 on (over 13% compare to the base case).

Table 19: Increased planting densities and fertilization of future stands, areas and costs

Years from now	Planting Density		Fertilization		Total Annual Cost
	Treated Area, Annual (ha)	Annual Cost (Increase)	Treated Area Annual (ha)	Annual Cost	
1 to 5	7,287	$1,246,076	0	$0	$1,246,076
6 to 10	4,195	$717,402	0	$0	$717,402
11 to 15	3,392	$580,065	0	$0	$580,065
16 to 20	2,804	$479,503	0	$0	$479,503
21 to 25	2,954	$505,080	0	$0	$505,080
26 to 30	3,032	$518,527	7,287	$4,372,196	$4,890,722
31 to 35	3,919	$670,067	4,195	$2,517,201	$3,187,268
36 to 40	5,809	$993,275	10,679	$6,407,511	$7,400,786
41 to 45	5,352	$915,162	6,999	$4,199,668	$5,114,829
46 to 50	5,270	$901,232	13,633	$8,179,723	$9,080,954

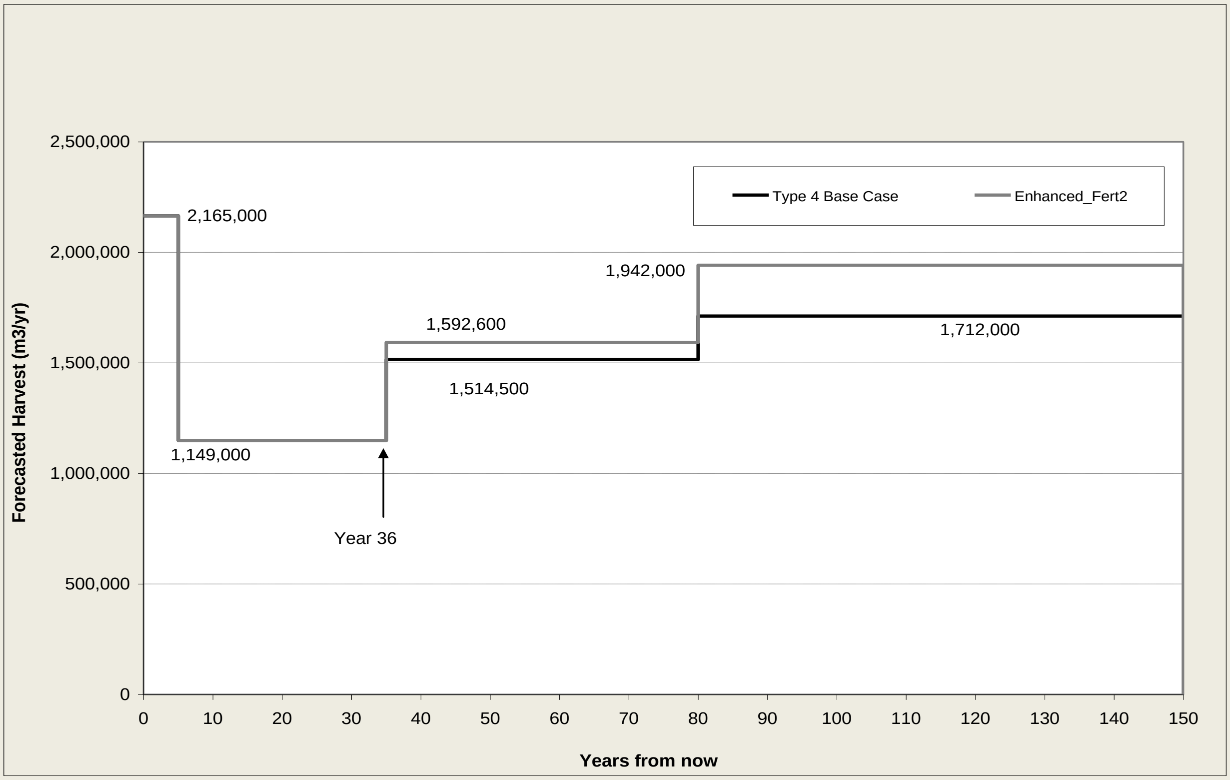

Figure 46: Impact of increased planting densities, altered species composition and fertilization of future stands

3.2.11 Enhanced Basic Silviculture; Increased Planting Densities and Fertilization of Existing and Future Stands

This scenario combined increased planting densities with the fertilization of all suitable existing and future stands. Existing stands between 41 and 80 years old were fertilized once. The existing managed stands and future stands were fertilized at ages 25, 35, 45 and 55. The predicted treatment areas and costs are outlined in Table 20.

Figure 47 illustrates the harvest forecast for this scenario. Fertilization of existing stands allows for a 6.7% increase in the harvest at year 26 compared to the base case. Ten years later at year 36 the harvest is predicted to be 13.3% higher than that of the base case. The trend is similar and at year 81 the harvest can be increased to 1,940,800 m^3 per year which is similarly 13.3% higher than that of the base case.

Table 20: Increased planting densities and fertilization of future stands, areas and costs

Years from now	Planting Density		Fertilization		Total Annual Cost
	Treated Area, Annual (ha)	Annual Cost (Increase)	Treated Area Annual (ha)	Annual Cost	
1 to 5	7,287	$1,246,076	8,885	$5,330,750	$6,576,826
6 to 10	4,234	$724,097	11,280	$6,768,019	$7,492,116
11 to 15	3,404	$582,007	11,842	$7,104,905	$7,686,912
16 to 20	2,818	$481,801	14,934	$8,960,560	$9,442,362
21 to 25	2,985	$510,403	16,356	$9,813,466	$10,323,869
26 to 30	3,296	$563,689	20,256	$12,153,545	$12,717,234
31 to 35	3,837	$656,189	16,827	$10,096,494	$10,752,683
36 to 40	5,666	$968,949	17,675	$10,604,980	$11,573,930
41 to 45	5,585	$955,048	15,820	$9,491,801	$10,446,849
46 to 50	5,108	$873,535	17,341	$10,404,854	$11,278,389

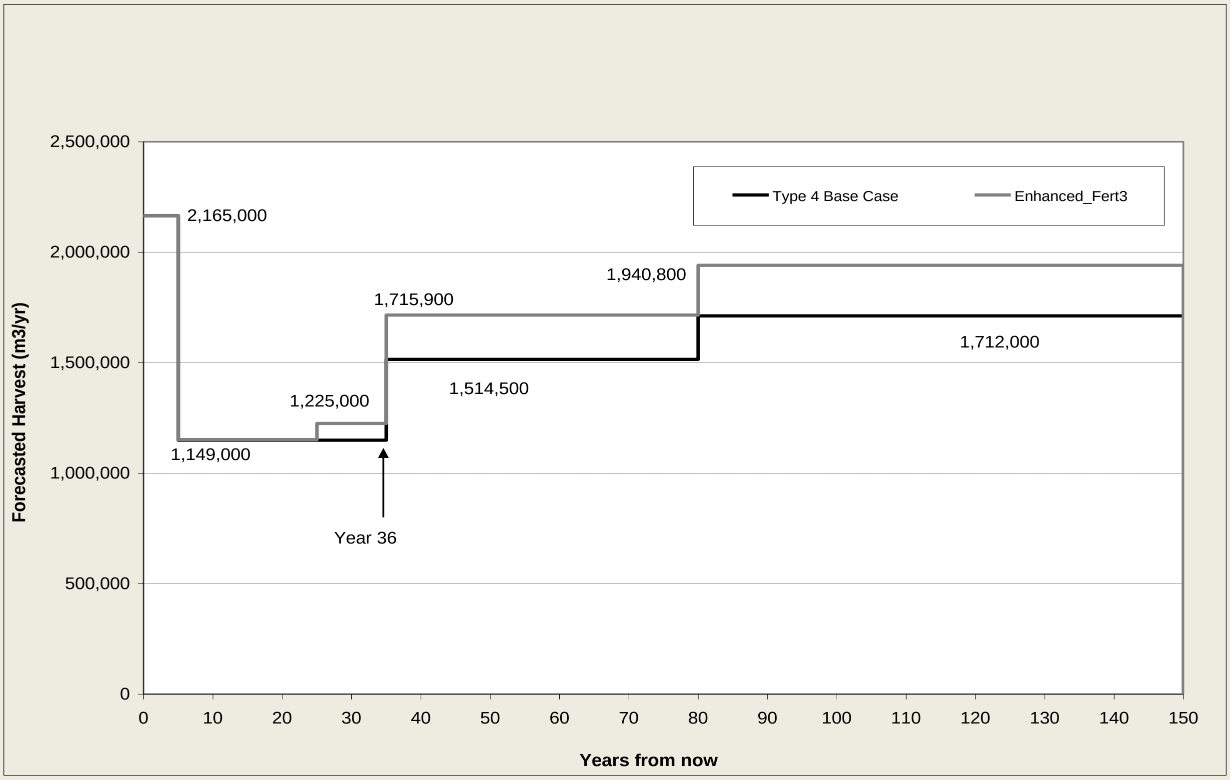

Figure 47: Impact of increased planting densities and fertilization of existing and future stands

3.2.12 Enhanced Basic Silviculture; Increased Planting Densities, Altered Species Composition and Fertilization of Existing and Future Stands

This scenario combined increased planting densities and altered the species composition with the fertilization of all suitable existing and future stands. Existing stands between 41 and 80 years old were fertilized once. The existing managed stands and future stands were fertilized at ages 25, 35, 45 and 55. The predicted treatment areas and costs are outlined in Table 21.

Figure 48 illustrates the harvest forecast for this scenario. The harvest was increased to 1,204,800 m^3 per year at year 26, 4.9% compared to the base case. Between years 36 and 80 he harvest is predicted to be 12.2% higher than that of the base case at 1,699,000 m^3 per year and between years 81 and 150 this scenario reached a harvest level of 1,980,800, 15.7% higher than that of the base case.

Table 21: Increased planting densities, altered species composition and fertilization of future stands, areas and costs

Years from now	Planting Density		Fertilization		Total Annual Cost
	Treated Area, Annual (ha)	Annual Cost (Increase)	Treated Area Annual (ha)	Annual Cost	
1 to 5	7,287	$1,246,076	8,885	$5,330,750	$6,576,826
6 to 10	4,234	$724,097	11,280	$6,768,019	$7,492,116
11 to 15	3,404	$582,007	11,842	$7,104,905	$7,686,912
16 to 20	2,826	$483,265	14,922	$8,953,049	$9,436,314
21 to 25	2,966	$507,203	16,356	$9,813,466	$10,320,669
26 to 30	3,215	$549,701	20,256	$12,153,545	$12,703,245
31 to 35	3,832	$655,220	16,833	$10,099,662	$10,754,882
36 to 40	5,604	$958,299	17,716	$10,629,828	$11,588,127
41 to 45	5,483	$937,598	15,928	$9,556,935	$10,494,534
46 to 50	5,132	$877,527	17,372	$10,423,203	$11,300,730

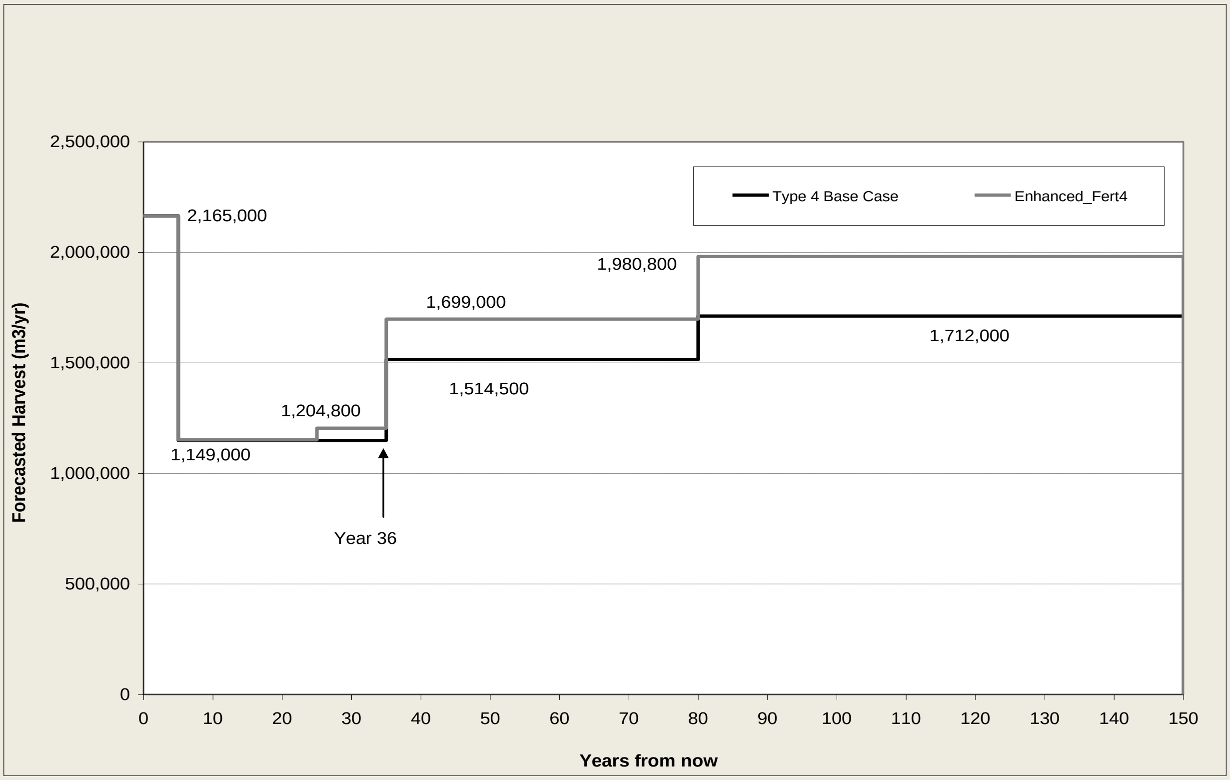

Figure 48: Impact of increased planting densities, altered species composition and fertilization of existing and future stands

3.2.13 Scenario Summary

Table 22 provides a summary of treatment impacts compared to the base case.

Table 22: Scenario summary; treatment impact compared to the base case

Years from Now	Base Case Harvest Level	Increase or Decrease from Base Case											
		Non-Pine Partition	Maximize Mid Term	Rehab Dead Pine	Rehab Dead Pine & Fertilize	Fertilize Existing Stands	Fertilize Existing and Future Stands	Increase Planting Densities	Increase Planting Densities, Alter Species Comp	Increase Planting Densities, Fertilize Future Stands	Increase Planting Densities, Alter Species Comp, Fertilize future Stands	Increase Planting Densities, Fertilize Existing and Future Stands	Increase Planting Densities, Alter Species Comp, Fertilize Existing and Future Stands
1 to 5	2,165,000	**-30.0%**	**-38.2%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
6 to 25	1,149,000	**5.0%**	**6.2%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
26 to 35	1,149,000	**5.0%**	**6.2%**	0.0%	0.0%	**4.0%**	**4.7%**	0.0%	0.0%	0.0%	0.0%	**6.6%**	**4.9%**
36 to 60	1,514,500	0.0%	0.0%	**3.4%**	**3.7%**	**9.4%**	**13.0%**	0.0%	0.0%	**6.1%**	**5.2%**	**13.3%**	**12.2%**
61 to 80	1,514,500	0.0%	0.0%	**3.4%**	**3.7%**	**9.4%**	**13.0%**	**4.2%**	**1.6%**	**6.1%**	**5.2%**	**13.3%**	**12.2%**
81 to 110	1,712,000	0.0%	0.0%	0.0%	0.0%	**-3.2%**	**8.3%**	0.0%	0.0%	**11.6%**	**13.4%**	**13.4%**	**15.7%**
111 to 150	1,712,000	0.0%	0.0%	0.0%	0.0%	0.0%	**8.3%**	0.0%	0.0%	**11.6%**	**13.4%**	**13.4%**	**15.7%**

4 Preferred Scenario

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