TIMBER SUPPLY ANALYSIS

TREE FARM LICENSE 35
TIMBER SUPPLY ANALYSIS REPORT

DRAFT

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31 March, 2011

West Fraser Mills Ltd.
100 Mile House Woodlands
PO Box 97
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Attention: Mark Runge, RPF

Re: Draft Timber Supply Analysis Report for TFL 35 (Jamieson Creek)

Dear sir;

This draft report includes the results of the base case Patchworks runs for TFL 35 along with the alternative harvest flows and sensitivity runs for your consideration. Feedback and comments will be reviewed for incorporation into the final Timber Supply Analysis Report.

Yours truly,

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1 EXECUTIVE SUMMARY

This Timber Supply Analysis Report is intended to provide the Chief Forester with information to assist in the determination of the Annual Allowable Cut (AAC) for Tree Farm Licence 35 (TFL 35). Attached to this Report as Appendix I is the most up-to-date *Tree Farm Licence 35 Timber Supply Analysis Data Package.*

The timber supply analysis described in this document was carried out using Patchworks, over a planning horizon of 250 years (starting in 2010) with five year planning periods.

The base case tested in this timber supply analysis seeks to:

- prioritize harvesting in mount pine beetle (MPB) affected stands by using shelf life assumptions and minimum merchantability criteria;
- maximize the salvage of spruce bark beetle (BB) in the first five years; and
- maintain a non-declining flow in the existing healthy stands until harvest begins in regenerated stands, after which the harvest rate rises to its long-term average.

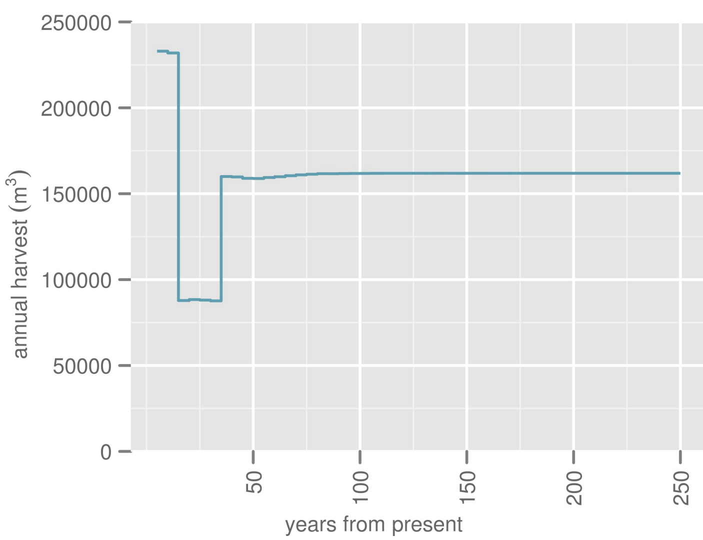

Figure 1.1: Base case harvest level

As can be seen in Figure 1.1, these goals produce a timber flow with three main characteristics:

1. a high harvest level of 232,500 m³/year driven by salvage objectives over the short term (years 5 – 10);
2. a resulting reduced harvest level of 88,000 m³/year in the medium term (years 15 – 30); and
3. a subsequent return to the the long term (years 35 – 250) average harvest level of 161,500 m³/year.

Two alternative harvest flows were evaluated: the first, minimizing the the mid-term fall-down seen in the base case; the second, maximizing the long term harvest level.

The base case was tested for its sensitivity to: reduced minimum harvest volumes for pine; changes in minimum harvest age; changes in existing stand yields; changes in regenerated stand yields; increasing stand regeneration delay; changing timber harvesting land base area; removal of VQO restrictions on mountain pine beetle-affected stands; and changes to green-up period. In all cases, the results of these tests showed no unexpected or catastrophic outcomes, supporting the stability of the base case.

2 INTRODUCTION

This Timber Supply Analysis Report has been prepared by TECO Natural Resource Group Ltd. (TECO; formerly Timberline) on behalf of West Fraser Mills Ltd. (West Fraser) in order to provide the Chief Forester with information to assist in the determination of an Annual Allowable Cut (AAC) for Tree Farm Licence 35 (TFL35).

Due to changes that have occurred subsequently in the legislation related to Management Plans, West Fraser will be submitting a new Management Plan that will accompany the final Timber Supply Analysis report. Also, the requirement for a new AAC determination remains in force, and this document is submitted to inform that decision.

Timber supply is the rate of timber availability for harvest over time. The methodology used to forecast this includes use of a forest-level simulation model, which predicts the development of a forest over a 250-year planning horizon. The model uses a description of initial forest conditions, expected patterns of growth, and a set of rules related to harvesting and regenerating the forest. In addition, management assumptions related to non-timber forest resources are included in the analysis process.

The annual allowable cut for TFL35 was established by the Chief Forester in 2001 at 125,600 m^3/year, based on a timber supply analysis and supporting documents provided by the TFL holder of the time, Weyerhaeuser Company Ltd. The 2003 McLure Fire and the mountain pine beetle (MPB) epidemic led Weyerhaeuser to apply for an AAC uplift in 2004. Based on the 2001 determination and the uplift submission, the Chief Forester established the new AAC at 325,600 m^3/year effective 1 March, 2004. This AAC increase was to facilitate increased harvesting to minimize losses due to the McLure fire and the MPB epidemic.

Since the 2004 AAC determination and the preparation of the Data Package, the tenure has been transferred from Weyerhaeuser to West Fraser Timber Company Ltd. No changes to the TFL boundary have occurred with this transfer. West Fraser has prepared this timber supply analysis to support a new determination of the AAC for TFL 35.

2.1 Implementation Recommendations

The 'Implementation' section of the 2004 AAC Rationale document focused on the need to harvest in fire damaged and beetle killed stands in order to minimize unnecessary losses.

The 'Implementation' section of the 2001 determination focused on the need to:

- re-examine the extent of the area with low site productivity that contributes to the timber harvesting land base (THLB);
- confirm or refine the estimates of site index for high elevation areas and for spruce generally;
- continue to document harvesting performance in marginally merchantable stands and within areas classified as terrain class IV;
- review estimates of road width and in-block disturbance;
- review the operational adjustment factors used to generate yield estimates for managed stands;

- improve the modelling of mixed species regeneration;
- work with MSRM and BCFS staff to complete delineation of old growth management areas; and
- document the area of riparian management zones and the basal area retained when harvesting in those zones.

2.2 Methodology

Timber supply analysis involves three main steps:

1. assembling data and preparing information about the land base;
2. using the data in a forest estate model to develop harvest forecasts and test the sensitivity of those forecasts to small changes in the input data and assumptions; and
3. interpreting and reporting the results.

The *Tree Farm License 35 Data Package* was the first document published in support of the current Timber Supply Review (TSR) process. It was submitted to the Ministry of Forests and Range (now Ministry of Forests, Lands and Natural Resource Operations - MFLNRO) and was also made available for a First Nations review over a period of two months. The Data Package was accepted by MFLNRO Forest Analysis Branch on 25 May, 2010 pending some minor changes to be made as an appendix to this document (see Appendix I).

The information provided in the Data Package has been used to define and model several timber supply scenarios. Those results are presented in this report. A base case scenario is described and the results are presented. The results of several sensitivity model runs are also summarized; these provide an indication of the stability of the base case harvest level forecast relative to the uncertainty inherent in the data and assumptions upon which it is based.

The Chief Forester will consider the timber supply Analysis Report and other sources of information in order to make a new AAC determination. This determination will be published by the MFLNRO in a report entitled *Tree Farm Licence 35 – Rationale for AAC Determination.*

3 DESCRIPTION OF THE AREA

TFL 35, also know as the Jamieson Creek TFL, is located approximately 28 kilometres north of the City of Kamloops.

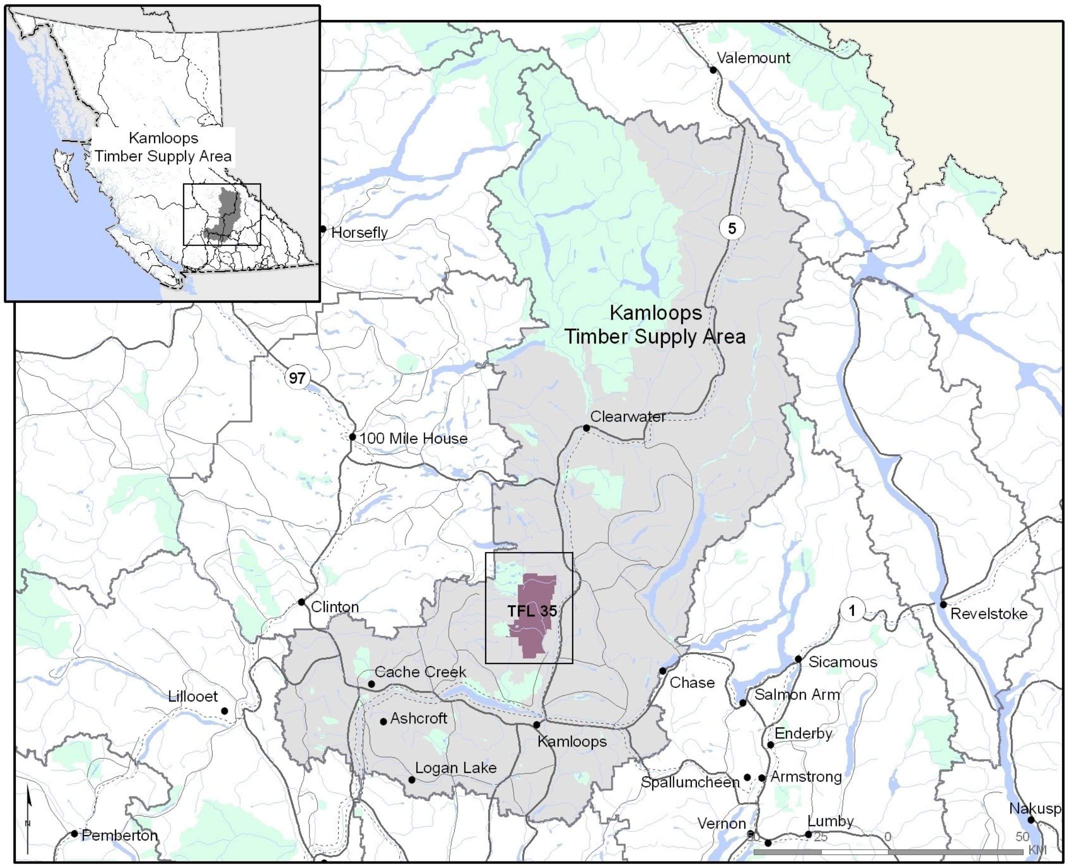

Figure 3.1: TFL 35 location

The TFL is surrounded by the Kamloops Timber Supply Area (TSA), located within the Skull Landscape Unit and bordered by the Bonaparte and Porcupine Meadows Provincial Parks.

The total area of TFL 35 is 36,557 ha of which 32,447 ha contribute to the long-term timber harvesting land base.

Figure 3.1 shows the location of TFL 35 in relation to Kamloops and the surrounding area.

As can be seen in Figure 3.2, TFL 35 is located west of the North Thompson River, including portions of the Jamieson, Whitewood, Skull and Lanes Creek Watersheds. A small portion of the Tranquille Community Watershed touches the southwestern corner of the TFL.

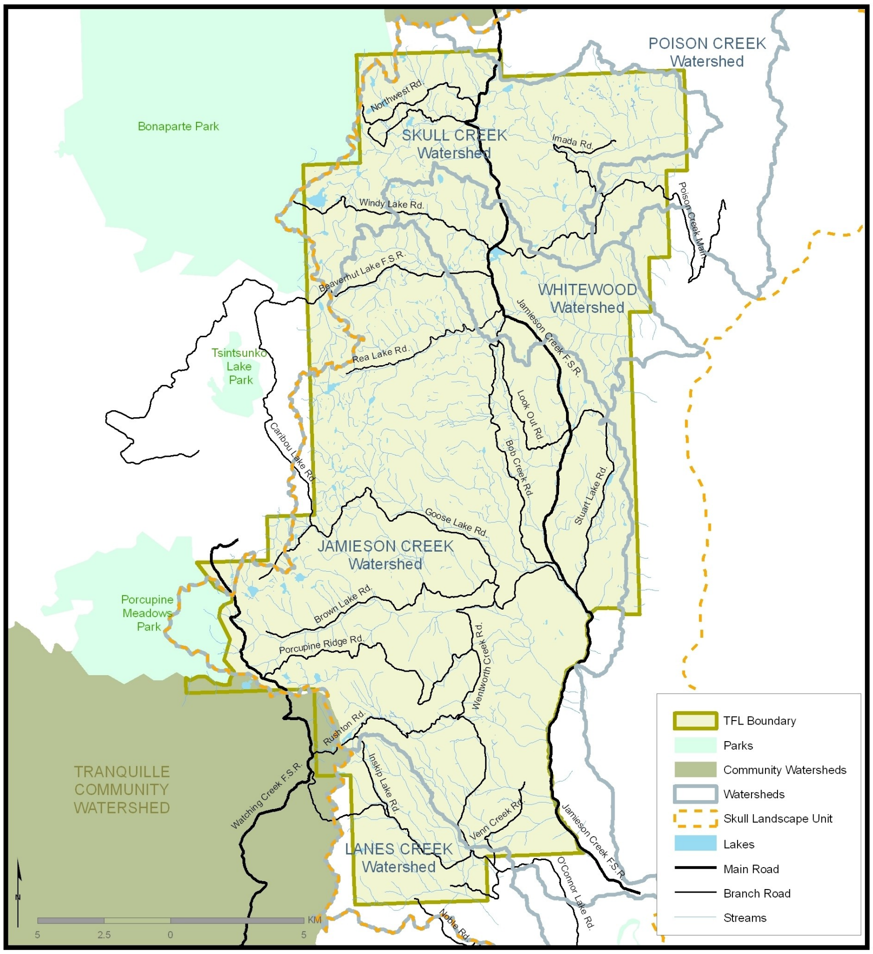

Figure 3.2: TFL 35 and related features

The topography is typical of the Interior Plateau, ranging from gently rolling, low relief terrain in the western part of the TFL and stream headwaters to deeply incised, steep-sided canyons along the middle to lower reaches of the major streams.

Elevations range from 360 meters at the confluence of Lanes Creek and the North Thompson River to about 1860 meters near Wentworth Lake at the headwaters of Wentworth Creek giving a range of relief of 1500 meters.

TFL 35 is represented by four biogeoclimatic zones with six subzones.

The Montane Spruce and the Engelmann Spruce/ Subalpine Fir zones dominate the land base with smaller amounts of Interior Cedar-Hemlock and Interior Douglas-fir.

The principal tree species on TFL 35 are Lodgepole Pine, Engelmann Spruce, Subalpine Fir and Douglas-fir.

4 INFORMATION PREPARATION

The following sections describe the information prepared for this timber supply analysis.

4.1 Land Base

The current timber harvesting land base (THLB) is 32,447 hectares of a total 36,557 hectares (88.8% THLB).

The THLB for MP #9 was originally established at 32,937 hectares of a total 36,563 hectares (90.0% THLB).

The 490 hectare decrease in the THLB is generally related to the designation of old growth management areas (OGMAs) and accounting for wildlife tree patches (WTPs), existing and future, which were presented in an alternative base case for MP #9. An additional 214 hectares of existing and future roads have been accounted for in this analysis.

The slight change of six hectares in total area is due to boundary changes related to the finalization of the Porcupine Meadows Park. The change occurred along the westernmost portion of TFL 35 and the southeastern portion of the park.

4.2 Timber Growth and Yield

Forest growth and yield refers to the prediction of the growth and development of individual stands over time.

Stand growth in terms of height, diameter, and volume is projected over time through the use of yield models. Yield tables are categorized into either natural stands or managed stands because of distinct growth pattern differences between the two types of stands.

Existing natural and managed stands are differentiated based on stand age. Stands with a projected age of greater than 47 years in 2010 (i.e. stands first harvested prior to 1963) are modelled as natural stands. The parameters used to define the yield table inputs were identified in the approved *TFL 35 Timber Supply Analysis Data Package*.

4.2.1 Natural stands

Natural stand yield tables were developed for the analysis units as described in the *Data Package*, Section 3.2. Inputs into the yield tables included inventory site index, species composition, stocking class, and crown closure. The yield tables were developed using the batch version of the MFLNRO model Variable Density Yield Prediction (VDYP), version 6.6d. Yield curves were generated for each stand in the inventory, and these curves were used to create a single yield curve for each analysis unit.

4.2.2 Managed stands

Managed stand yield tables were developed for the analysis units identified in the *Data Package*. Inputs included species composition and density from the inventory (compiled by analysis unit), silviculture regimes by era, potential site index (PSI) estimates and operational adjustment factors (OAFs) from the inventory. The yield tables were developed using the MFLNRO BatchTIPSY (version 4.1c) program for managed stands. Similar to the natural stand yield tables, a yield curve was generated for each managed stand in the inventory, and these curves were used to create a single yield curve for each analysis unit. These curves were reviewed and approved by Mario Di Lucca of MFLNRO, as advised in an e-mail of 28 September, 2010.

4.2.3 Minimum harvest ages

Minimum harvest age (MHA) is established for each analysis unit (AU). An AU is first harvestable when it meets all three of the following criteria:

- minimum volume per hectare of 150 m3/hectare;
- minimum average piece size of 0.2 m3/tree; and
- within 90% of maximum mean annual increment (MAI).

The MHAs that result from the application of these rules can be found in the revised *Data Package.*

4.2.4 Harvest system

Clear cut harvesting was assumed to be the predominant harvesting system.

4.2.5 Site productivity

The rate at which a stand grows is determined by the underlying site productivity, and the chosen stand management regime. The productivity of a stand is measured using a site index. PSI estimates from the TFL35 Site Index Adjustment project[1] are used as inputs for existing and future managed stands.

4.3 Management Practices

Modelling integrated resource management objectives is accomplished through the use of forest cover constraints, adjacency restrictions and cut block size limitations (spatial analysis only). Forest cover constraints are applied for the following:

- moose winter habitat;
- badger habitat area;
- mule deer winter range;
- Tranquille Community Watershed;
- visual quality objectives; and,
- 3 m Green-up (all management zones except for visuals).

A detailed explanation of how these constraints are modelled is provided in the *Data Package*, Section 5.

1 J.S.Thrower and Associates Ltd. *Site Index Adjustments Using BEC Classification on TFL 35*. February 2000. 20 pp.

5 ANALYSIS METHODS

This section describes the forest estate model used in this analysis, along with the harvest flow objectives and presentation of results.

5.1 Forest Estate Model

Timber supply analysis is conducted using the Patchworks spatial optimization model. Patchworks is a spatially explicit harvest scheduling optimization model developed by Spatial Planning Systems in Ontario. It is capable of developing spatially explicit harvest allocations that explore trade-offs between a broad range of conflicting management and harvest goals.

For this analysis, Patchworks is formulated to schedule blocks for harvested based on maximizing harvest volume over the long-term subject to meeting non-timber and other management objectives on the land base.

As such, there are no explicit harvest rules, other than minimum merchantability limits, applied to the model.

Patchworks has the ability to assess trade-offs through multiple account analysis. Targets are established with threshold values and incur a penalty when the model results fall outside the permissible threshold. The optimization process seeks out a solution that minimizes the overall penalties incurred. For the base case, the model is set up to ensure that none of the targets are violated except where exceptions are permitted for salvage harvesting. Allowing deviations from the targets for green-wood harvesting is assessed through sensitivity analysis.

Patchworks is approved for use in Timber Supply Review and Management Plan analysis by the MFLNRO Forest Analysis and Inventory Branch.

5.2 Timber Flow Objectives

The objective of the analysis is to determine the capacity of the TFL 35 land base to sustain a timber flow, and identify any risks to this flow resulting from uncertainty in the underlying assumptions.

The analysis goes beyond a simple calculation of capturing the growth potential of the land base. Many management objectives with overlapping and potentially conflicting goals must be met. The maximum sustainable timber flow must ensure that these objectives are met while capitalizing on the growth potential of the land base. Growing stock constraints are applied to the model to ensure that the harvest forecast is sustainable. The model has a planning horizon of 250 years (starting in 2010) with five year planning periods.

The base case seeks to:

- prioritize harvesting in mount pine beetle (MPB) affected stands by using shelf life assumptions and minimum merchantability criteria;
- maximize the salvage of spruce bark beetle (BB) in the first five years; and
- maintain a non-declining flow in the existing healthy stands until harvest begins in regenerated stands, after which the harvest rate rises to its long-term average.

These goals produce a timber flow with three main characteristics:

1. a high level of harvesting driven by salvage objectives over the short term (years 5 – 10);
2. a resulting reduced level of harvesting in the medium term (years 15 – 30); and
3. a subsequent return to the the long term (years 35 – 250) average.

In order to understand the trade-offs between these values and objectives, two alternate harvest flows have been assessed. These are:

1. minimize the mid-term fall-down level; and
2. maximize the long-term harvest level.

5.3 Presentation of Results

Analysis results are provided in both tabular and graphic format for all scenarios modelled.

The base case is presented in Section 6 and is described in detail. Harvest level and profiles, and growing stock forecasts are included. The relationship between the base case harvest level and other resource values is discussed.

The sensitivity analysis scenarios are presented in Section 7 and the annual harvest levels are provided with comparison to the base case harvest levels results.

Discussions and conclusions are presented in Section 8.

6 BASE CASE RESULTS

The base case scenario is designed to find the harvest level that can be achieved under the assumption that current management practices are continued into the future. It is based on current performance and so provides a reference timber supply forecast against which timber supply implications of different management assumptions may be measured. The base case is used as the baseline to assess risk associated with any of the assumptions in the sensitivity analysis.

6.1 Harvest Level and Growing Stock

As shown in Figure 6.1, the initial harvest rate has been set at 233,000 m³/year for the first five years, in order to target spruce bark beetle (BB) and mountain pine beetle (MPB), and 232,000 m³/year for the second five years, in order to target the remaining MPB, for an average of 232,500 m³/year.

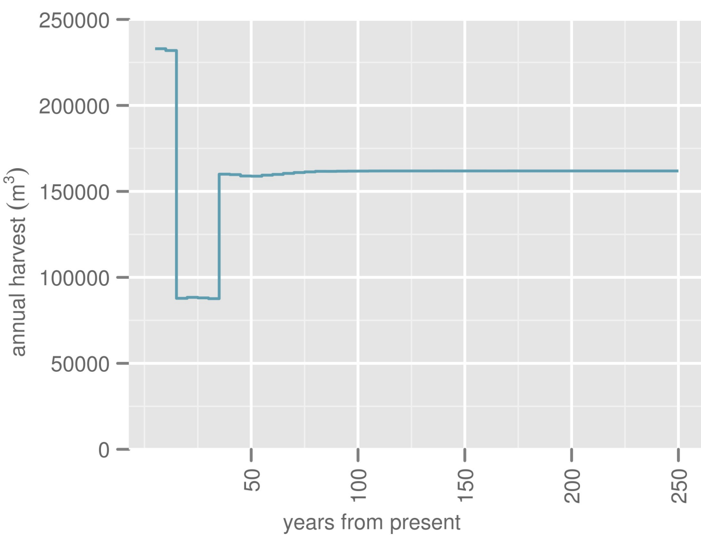

Figure 6.1: Base case harvest level

The medium-term harvest level for the remaining healthy stands was found to be 88,000 m³/year, which cannot be exceeded for years 15-30.

The long-term harvest level was found to be 161,500 m³/year, years 35-250. This level is similar to the long-term harvest level found in previous analyses, and just slightly below the managed stand long-run sustained yield (LRSY) of 167,255 m³/year.

In summary, the base case harvest level is characterized by three distinct periods:

4. a high harvest level of 232,500 m³/year driven by salvage objectives over the short term (years 5 – 10);
5. a resulting reduced harvest level of 88,000 m³/year in the medium term (years 15 – 30); and
6. a subsequent return to the the long term (years 35 – 250) average harvest level of 161,500 m³/year.

In order to ensure that proposed harvest levels are sustainable, several metrics in addition to harvest volume need to be assessed.

The first of these metrics is growing stock level. Figure 6.2 shows how total growing stock and growing stock older than minimum harvest age vary over the planning horizon as a result of the base case harvesting regime.

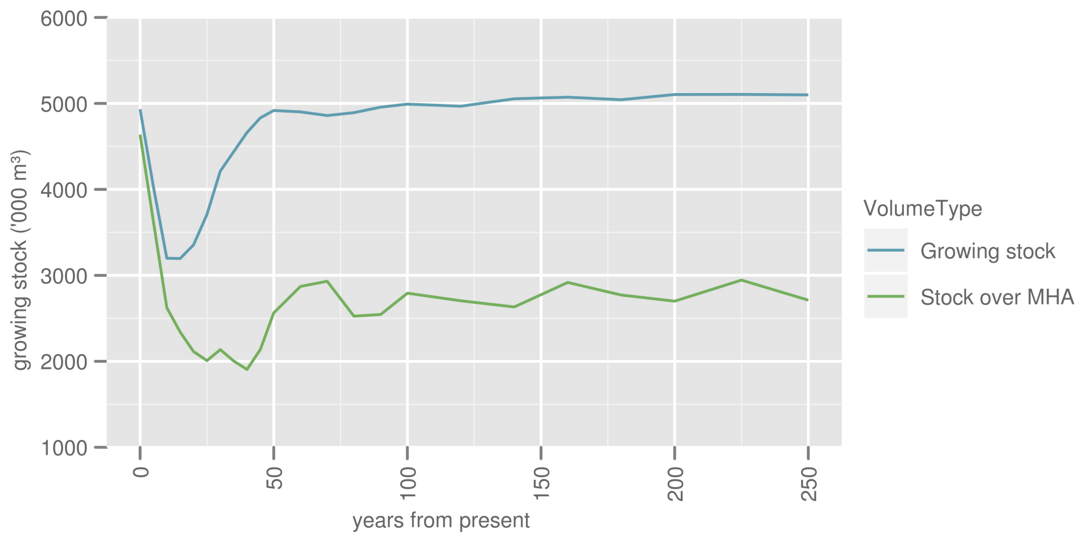

Figure 6.2: Base case growing stock levels

Total growing stock represents the sum of the net merchantable volumes of all stands in the THLB. Growing stock over MHA, which is lower, only includes the volume from stands that are above their minimum harvest age.

This graph shows that the pinch-point in timber supply occurs in years 10 - 15. After that, growing stock levels rebound. This is also the point at which the harvest level decreases to its minimum level.

Long term growing stock levels are stable, with operable and available volumes rising slightly over the planning horizon, starting at year 50.

6.2 Harvest Contribution from Existing and Future Stands

Figure 6.3 below shows the progression of harvesting through the four types of stands:

- existing MPB,
- existing SBB,
- existing natural/managed, and
- future.

Existing MPB and SBB are the mountain pine beetle and spruce bark beetle-damaged stands, respectively.

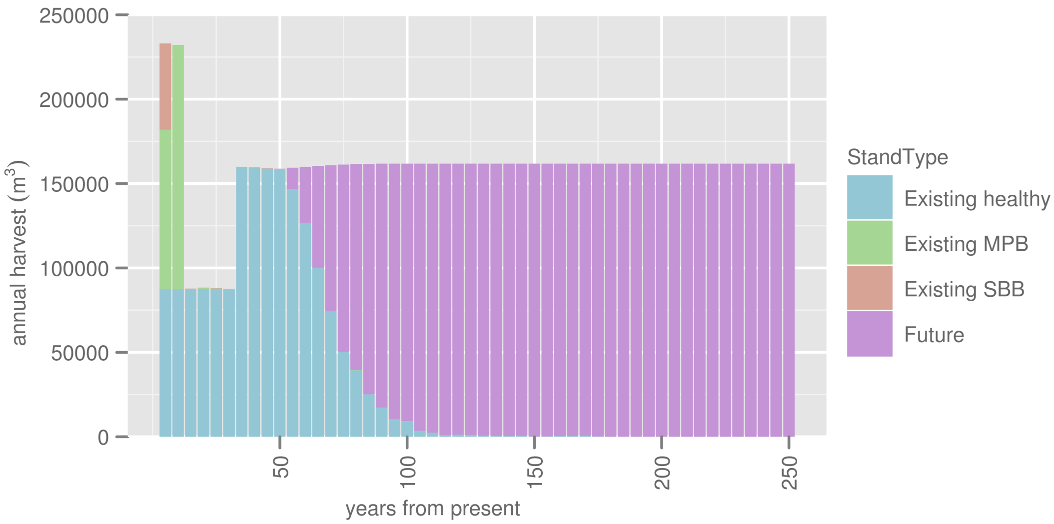

Figure 6.3: Harvest contribution from existing and future stands

Existing natural stands are comprised of old growth and second growth stands established prior to 1963; existing managed stands are those established since that time. Some existing stands – both natural and managed – are not harvested until late in the planning period either because they are needed to meet old seral requirements, or because they fall within very restrictive VQO constraints.

Trends in annual area harvested, average harvest age, and average harvested volume are also useful in attempting to understand the dynamics of the forest under the base case scenario.

A detailed inspection of the results of the base case run shows that over 95% of the BB affected stands are harvested in the first five years, and over 99% of the MPB affected stands are harvested in the first 10 years.

6.3 Average Annual Harvest Area, Age and Volume

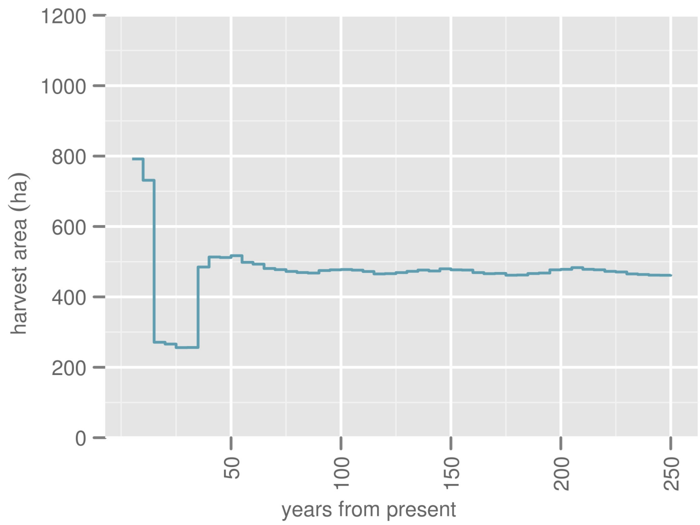

Figure 6.4: Average annual area harvested

The average annual area harvested is shown in Figure 6.4.

Annual area harvested dips from a high initial starting value of 800 hectares per year to 250 hectares per year by year 25, forced down by the limited available harvest volume.

Once the available growing stock recovers, the area harvested climbs back to 500 hectares per year by year 40, where it remains roughly stable with an average of 475 hectares per year until the end of the planning horizon.

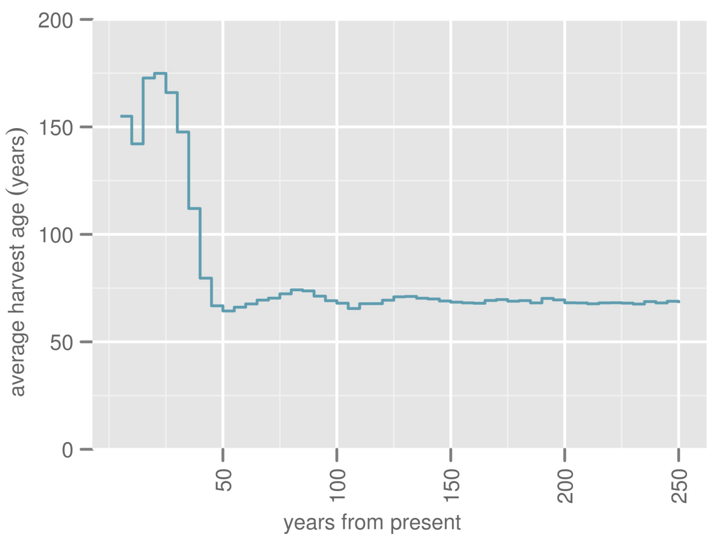

Figure 6.5: Average harvest age

As shown in Figure 6.5, over the first 10 years of the planning horizon, during the period when MPB and SBB stands are targeted, the average harvest age is 150 years.

Once the majority of the MPB and SBB stands are harvested, the average age climbs to 170 years old for 15 years, then drops rapidly to its long-term average of 70 years old in year 40 of the planning horizon as harvesting shifts into the managed stands.

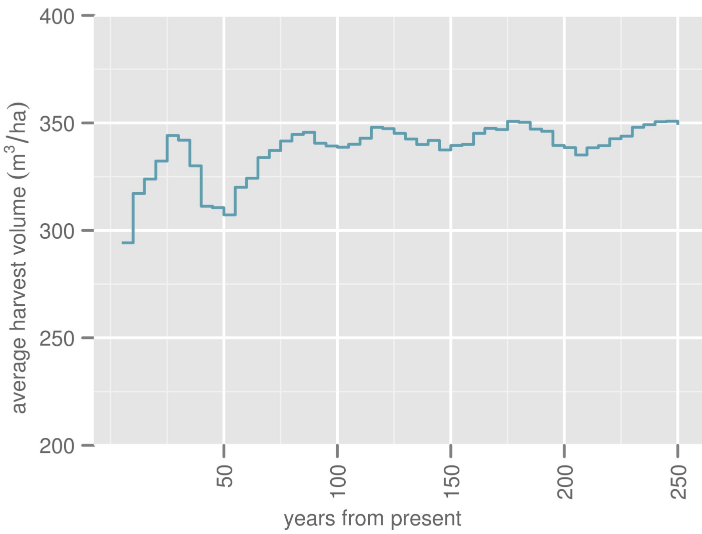

Figure 6.6: Average harvest volume

The average volume of harvested stands, as seen in Figure 6.6, begins at a low level of less than 300m³/ha in year 5 of the planning horizon, due to the salvage harvesting.

Average harvest volume then climbs steadily to 340m³/ha by year 25, dropping again over years 35 to 70, reaching a low of slightly more than 300m³/ha in year 50. This drop in average harvest volume coincides with the return of harvest level to the long-term average (Figure 6.1, page 10), and is offset by the slight peak seen in average annual harvest area seen in years 35 to 70 (Figure 6.4, page 13).

From year 75 onward, average annual harvest volume remains relatively steady around its long-term average of 340m³/ha.

6.4 Evolution of Age Class Distribution

The base case can be further assessed by reviewing the evolution of the age class distribution of the forest over the planning horizon, as shown in Figure 6.7 below.

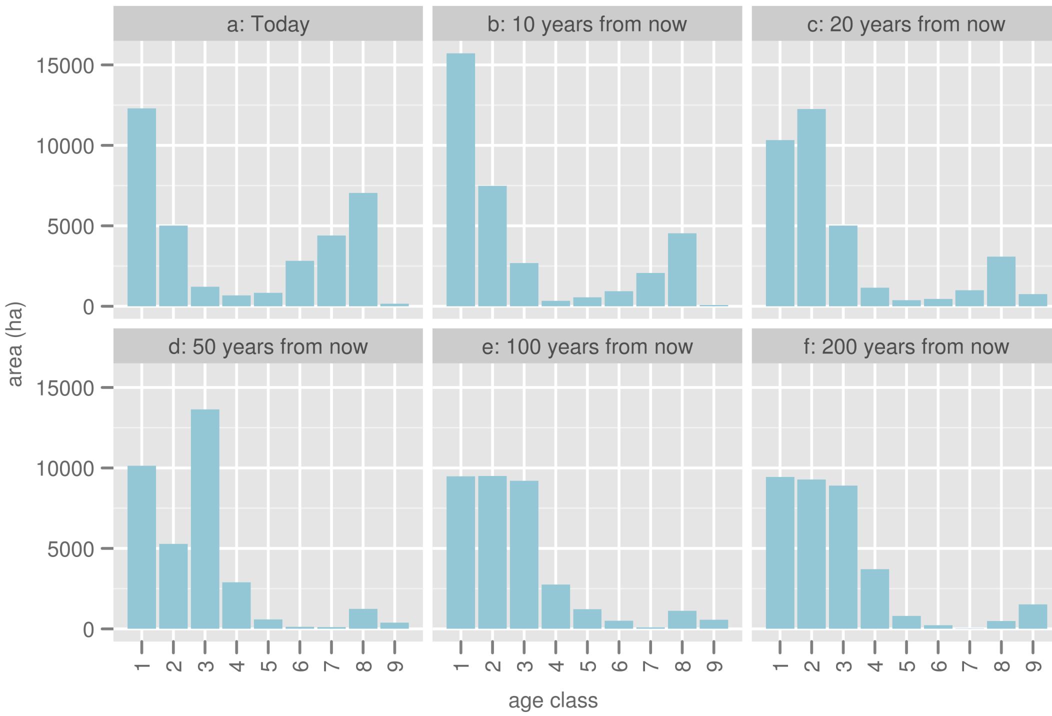

Figure 6.7: Age class distribution throughout the planning horizon

The current distribution ("Today") shows a bimodal distribution with peaks of 12,000 hectares in age class 1 (1-20 years) and 7,000 hectares in age class 8 (141-250 years).

After the first 10 years of harvesting at elevated levels to target the MPB and SBB stands, age class 1 area reaches its maximum of nearly 16,000 hectares.

By age 20, the results of the high harvesting levels in years 5 and 10 have moved into age class 2 (21-40 years).

Year 50 shows the forest evolving toward its long-term structure, fully evident in year 100 and year 200, where 80% of the forest land base is aged between 1 and 60 years old, and that 80% is evenly distributed between age classes 1, 2, and 3 (41-60 years).

This series of graphs can be compared to Figure 6.3 on page 12, which shows that the forest has been almost entirely converted to future stands by year 100 of the planning horizon.

6.5 Marginally Merchantable Stands Harvest Projection

Concerns in regards to harvest performance in marginally merchantable stands (MM stands) have been raised by the MFLNRO since the 2001 AAC determination. MM stands are defined as:

- non-pine leading stands >100 years old but <19.5 m height;
- pine-leading stands>80 years but <19.5 m height; and
- pine stands that have been disturbed or have low stocking and/or small trees.

Due to the MPB infestation and fire salvage since that time, harvesting efforts have been driven by salvage priorities. The MFLNRO Forest Analysis and Inventory Branch (FAIB) has requested that the projected harvesting in MM stnads be reported in the timber supply analysis. The results of this projection are summarized in Figure 6.8.

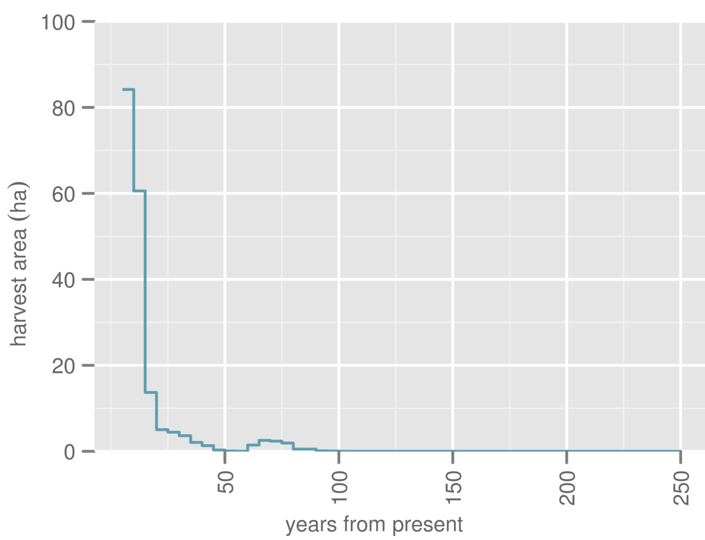

Figure 6.8: Average area harvested annually in marginally merchantable stands

Altogether, over 700 hectares of MM stands are harvested in the first 10 years of the harvest schedule, and a further 200 hectares in the next 130 years. From that point on, no further harvesting takes place in MM stands.

Evidently, the significant area of MM stand harvesting in the first 10 years is driven by the correlation between the pine-leading nature of many of the MM stands and the prioritization of MPB affected stands.

It is instructive to compare Figure 6.8 with Figure 6.4 on page 13, showing the total average annual area harvested.

6.6 Non-Merchantable Dead Wood Volume Projection

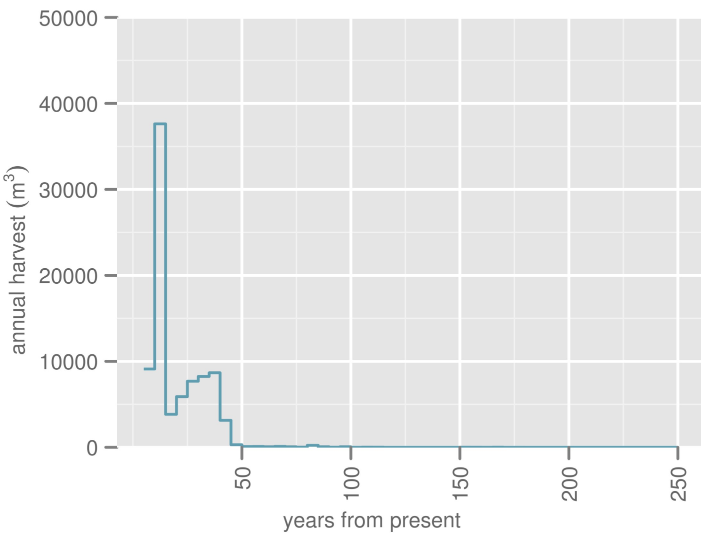

Figure 6.9: Non-merchantable dead wood volume projection

In order to compute the volumes of non-merchantable dead wood arising from the salvage harvesting of MPB stands, the formula applied to reduce the merchantable volumes in the base case was applied to determine the amount reduced, creating a parallel set of yield curves.

These "non-merchantable yield curves" were then applied to the harvest schedule generated by Patchworks to compute the non-merchantable dead wood harvest projection shown in Figure 6.9.

6.7 Alternative Harvest Flows

As seen in Figure 6.1 on page 10, base case harvest level is characterized by three distinct periods:

1. a high harvest level of 232,500 m³/year driven by salvage objectives over the short term (years 5 – 10);
2. a resulting reduced harvest level of 88,000 m³/year in the medium term (years 15 – 30); and
3. a subsequent return to the the long term (years 35 – 250) average harvest level of 161,500 m³/year.

In order to evaluate the stability of the timber supply to departures from this queueing rule, two alternative harvest rules were compared to the base case: "minimize mid-term fall-down" and "maximize long-term harvest level".

6.7.1 Minimize mid-term fall-down

The first alternative harvest rule to be tested minimized the mid-term fall-down, at the expense of the high initial starting level in the base case that was used to target the mountain pine beetle (MPB) and spruce bark beetle (BB) affected stands.

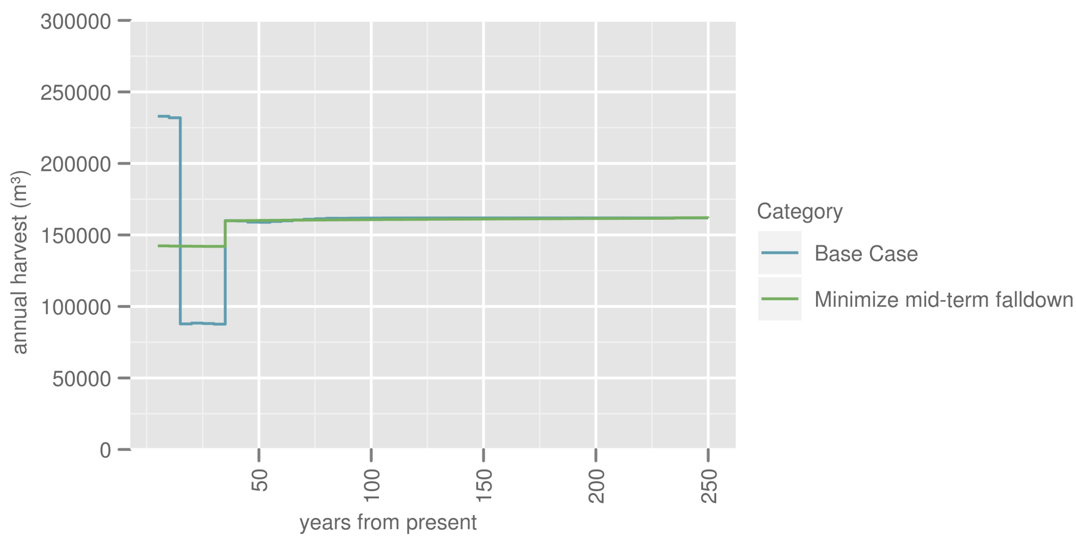

Figure 6.10: Alternative harvest rule 1: minimize mid-term fall-down

The results of this test can be seen in Figure 6.10 and Table 6.1. The long-term harvest level is not affected, but the short-term decreases and the medium-term increases to achieve a relatively steady-state flow from the present through year 30 of the plan.

Table 6.1: Alternative harvest rule 1: minimize mid-term fall-down

	Minimize mid-term fall-down	
	% change	Harvest level m^3/year
Years 5-10	-39%	142,300
Years 15-30	61%	142,000
Years 35-250	0%	161,000

6.7.2 Maximize long-term harvest level

The second alternative harvest rule to be tested maximized the long-term harvest level, once again at the expense of the high initial starting level in the base case, used to target the mountain pine beetle (MPB) and spruce bark beetle (BB) affected stands.

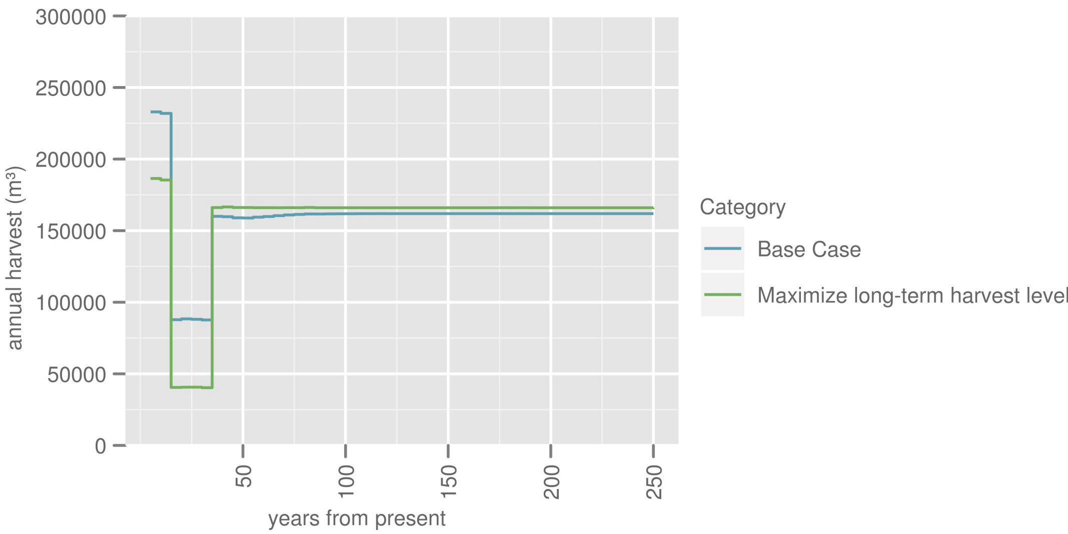

Figure 6.11: Alternative harvest rule 2: maximize long-term harvest level

The results of this test can be seen in Figure 6.11 and Table 6.2. The long-term harvest level rises marginally by 3% at the expense of a marked decrease in the short-term and medium-term harvest levels.

Table 6.2: Alternative harvest rule 2: maximize long-term harvest level

	Maximize long-term harvest level	
	% change	Harvest level m³/year
Years 5-10	-20%	185,900
Years 15-30	-54%	40,500
Years 35-250	3%	166,000

7 SENSITIVITY ANALYSIS

Sensitivity analysis provides a measure of the upper and lower bounds of the base case harvest forecast that reflects the uncertainty in the data and/or the management assumptions made in the base case. The magnitude of the increase and decrease in the sensitivity variable reflects the degree of uncertainty surrounding the assumption associated with that specific variable. Table 7.1 summarizes the sensitivity tests that have been performed for this analysis.

Table 7.1: Parameters tested in sensitivity analysis

Description & Objective	
Harvestability	
	Reduce pine minimum harvest volumes from 150m³/ha to 100 m³/ha for pine stands only.
	Reduce pine minimum harvest volumes from 150m³/ha to 100 m³/ha for all stands.
	Increase minimum harvest age by 10 years.
	Decrease minimum harvest age by 10 years.
Growth and yield uncertainty	
	Reduce existing stand yields by 10%.
	Increase existing stand yields by 10%.
	Reduce regenerated stand yields by 10%.
	Increase regenerated stand yields by 10%.
	Increase stand regeneration delay to two years.
Resource values	
	Increase THLB area by 5%.
	Decrease THLB area by 5%.
	Remove VQO restrictions on MPB-impacted stands.
	Increase green-up period by 10%.
	Decrease green-up period by 10%.

As seen in Figure 6.1 on page 10, base case harvest level is characterized by three distinct periods:

1. a high harvest level of 232,500 m³/year driven by salvage objectives over the short term (years 5 – 10);
2. a resulting reduced harvest level of 88,000 m³/year in the medium term (years 15 – 30); and
3. a subsequent return to the the long term (years 35 – 250) average harvest level of 161,500 m³/year.

Averages from the sensitivity runs are compared to these averages in this section.

7.1 Harvestability

There is uncertainty around the appropriate minimum harvest volumes, in particular for stands that suffer merchantable volume loss as a result of epidemic insect infestations. Mature stands may drop below the minimum harvest volume of 150 m³/ha due to mountain pine beetle (MPB) attack when the shelf-life assumptions are applied. Also, the earliest point at which second growth stands become available is largely determined by the lowest stand volumes that can be economically harvested.

7.1.1 Reduce pine minimum harvest volumes

The base case used a minimum harvest volume of 150 m³/ha. Two sensitivity runs were completed to test the impacts of reducing the minimum harvest volume per hectare in the pine components of the land base. The first reduced the minimum harvest volume to 100 m³/ha in pine stands only; the second reduced the minimum harvest volume to 100 m³/ha in all stands.

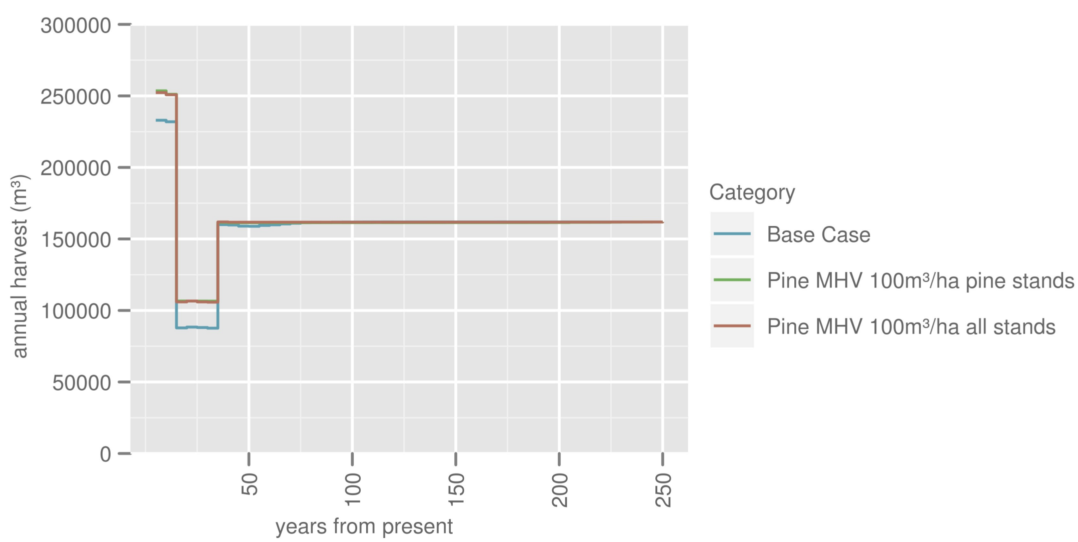

Figure 7.1: Effects on harvest schedule: reduced pine minimum harvest volumes

The results of these two runs are compared to the base case in Figure 7.1 and Table 7.2.

In summary, both runs demonstrate increased harvest level in the short term, years 5-30, but no significant change over the long term, years 35-250.

The effect of lowering pine MHV for all stands provides no significant additional harvest capacity as compared to lowering pine MHV in pine stands only.

Table 7.2: Effects on harvest schedule: reduced pine minimum harvest volumes

	Pine MHV lowered to 100m³/ha in pine-leading stands only		Pine MHV lowered to 100m³/ha in all stands	
	% change	Harvest level m³/year	% change	Harvest level m³/year
Years 5-10	9%	252,300	8%	251,600
Years 15-30	21%	106,600	21%	106,100
Years 35-250	0%	161,500	0%	161,800

7.1.2 Minimum harvest age

The base case uses a minimum harvest volume (MHV) of 150 m³/ha and an average piece size of 0.2 m³/tree to define the minimum harvest age for regenerating stands. Stands are not considered harvestable in the base case until this threshold is reached. This is not a "rotation age" *per se*, but rather the earliest age at which the stand would be available for harvest.

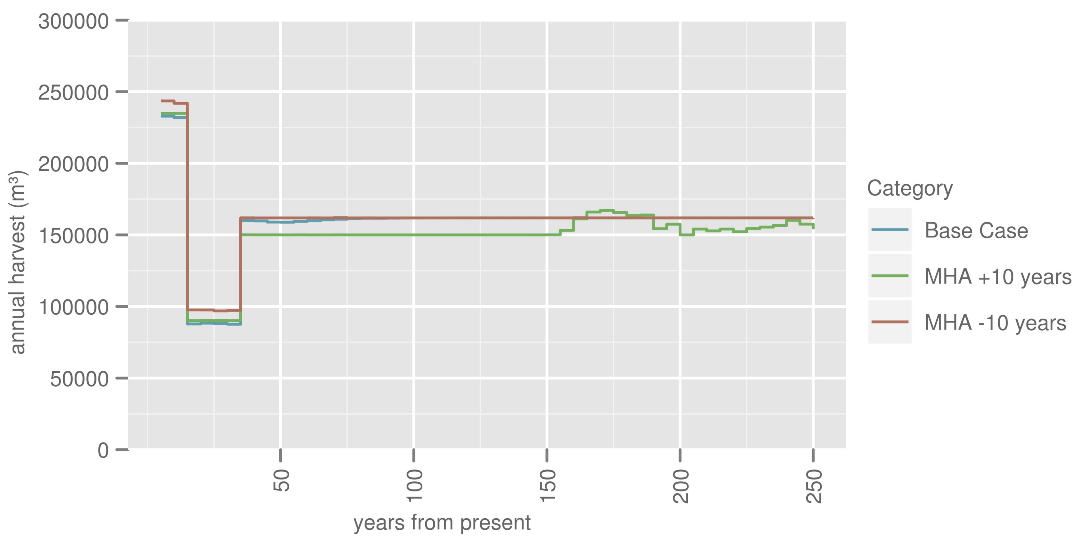

Figure 7.2: Effects on harvest schedule: changing minimum harvest age

In order to determine the sensitivity of the base case to changes in this threshold minimum harvest age (MHA), two runs were undertaken, with the MHA increased and decreased by 10 years, respectively establishing lower and upper limits of harvest level on the basis of changes to MHA.

The results of these two runs are compared to the base case in Figure 7.2 and Table 7.3.

In summary, a decrease in MHA by 10 years permits an increase in harvest level over the short term, years 5-30, and no significant increase in the long term, years 35-250.

Conversely, an increase in MHA by 10 years requires a significant decrease in the long term. This is to be expected, as this causes some (but not all) future managed stands to be retained past the age at which MAI would be maximized. However, the short term harvest level is unaffected and mid-term harvest level actually rises slightly under this scenario. This counter-intuitive outcome is likely due to the reduced harvest pressure in the long term allowing a resequencing of the harvest schedule that frees up stands in constrained areas for harvest in the mid-term

Table 7.3: Effects on harvest schedule: changing minimum harvest age

	MHA reduced by 10 years		MHA increased by 10 years	
	% change	Harvest level m^3/year	% change	Harvest level m^3/year
Years 5-10	4%	242,800	1%	234,900
Years 15-30	11%	97,300	3%	90,200
Years 35-250	0%	161,900	-5%	153,500

7.2 Growth and Yield Uncertainty

Estimates of stand yield form the core of a timber supply analysis. Stand yield forecasts for this analysis were developed using VDYP and TIPSY. These yields, for existing and future stands, are subject to uncertainties that arise from inventory inputs, changing silvicultural practices, uncertain site productivity and the limitations of the individual models.

Five runs were made to test the sensitivity of the base case harvest level to changes in existing stand yield, changes in regenerated stand yield, and increases in regeneration delay.

7.2.1 Existing stand yield

Uncertainty in existing stand yields are tested by two runs: the first, where existing yields are decreased by 10%, and the second, where they are increased by 10%.

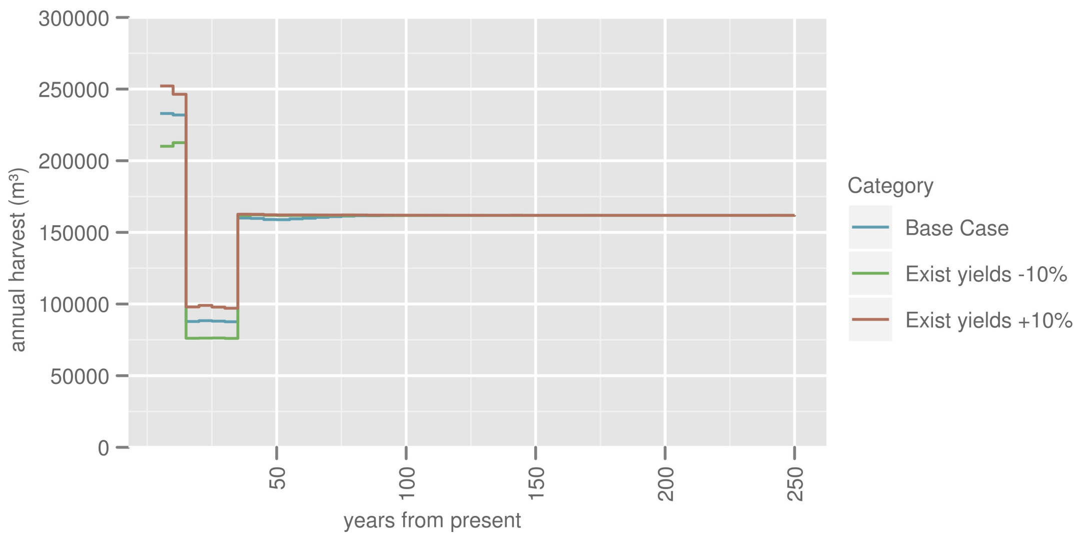

Figure 7.3: Effects on harvest schedule: changing existing stand yields

The results of these two runs are compared to the base case in Figure 7.3 and Table 7.4.

In summary, an increase in existing stand yields by 10% permits a significant increase in harvest level over the short term, years 5-30, and no significant increase in the long term, years 35-250.

Conversely, a decrease in existing stand yields by 10% requires a significant decrease in short-term harvest levels, but no significant decrease in the long term.

Table 7.4: Effects on harvest schedule: changing existing stand yields

	Existing stand yields increased by 10%		Existing stand yields reduced by 10%	
	% change	Harvest level m^3/year	% change	Harvest level m^3/year
Years 5-10	7%	249,300	-9%	211,300
Years 15-30	11%	98,000	-13%	76,100
Years 35-250	0%	162,000	0%	161,800

7.2.2 Regenerated stand yield

Similar to the tests applied to existing stands yield values, uncertainty in regenerated stand yields are tested by two runs: the first, where existing yields are decreased by 10%, and the second, where they are increased by 10%.

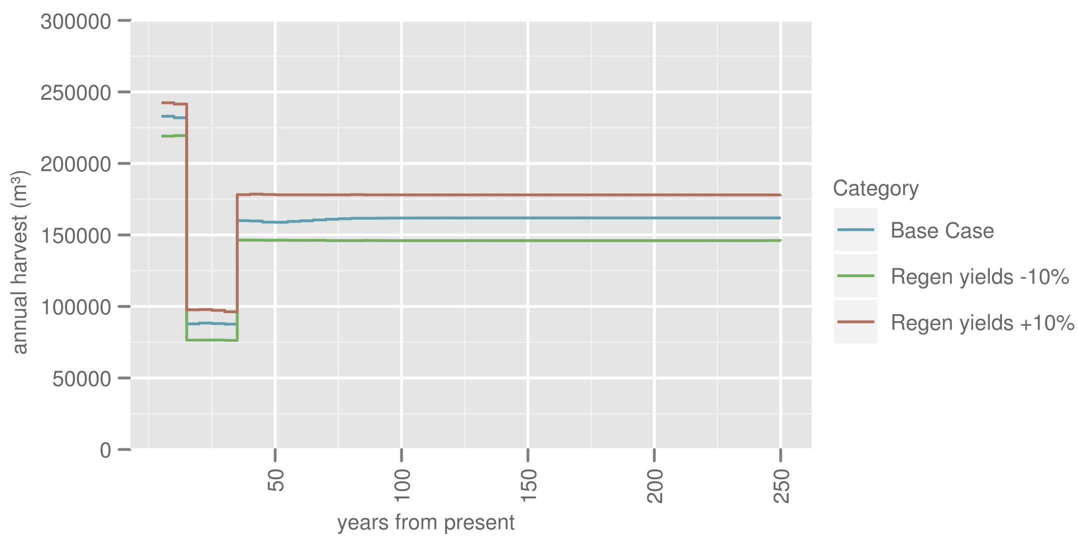

Figure 7.4: Effects on harvest schedule: changing regenerated stand yields

The results of these two runs are compared to the base case in Figure 7.4 and Table 7.5.

In summary, an increase in regenerated stand yields by 10% permits a significant increase in harvest level over all time periods, as the higher regenerated stand yields permit more aggressive harvesting of existing stands.

Conversely, a decrease in regenerated stand yields by 10% requires a significant decrease over all time periods, since reducing regenerated stand yields forces a lower harvesting rate on existing stands.

Table 7.5: Effects on harvest schedule: changing regenerated stand yields

	Regenerated stand yields increased by 10%		Regenerated stand yields reduced by 10%	
	% change	Harvest level m^3/year	% change	Harvest level m^3/year
Years 5-10	4%	241,900	-6%	219,300
Years 15-30	11%	97,300	-13%	76,400
Years 35-250	10%	178,000	-10%	146,100

7.2.3 Regeneration delay

Regeneration delay is defined as the time it takes to re-establish a stocked stand once harvesting has been completed. A regeneration delay of one year has been used in the base case as current practice reflects prompt site preparation and planting. This test evaluates the impact of changing that regeneration delay to two years.

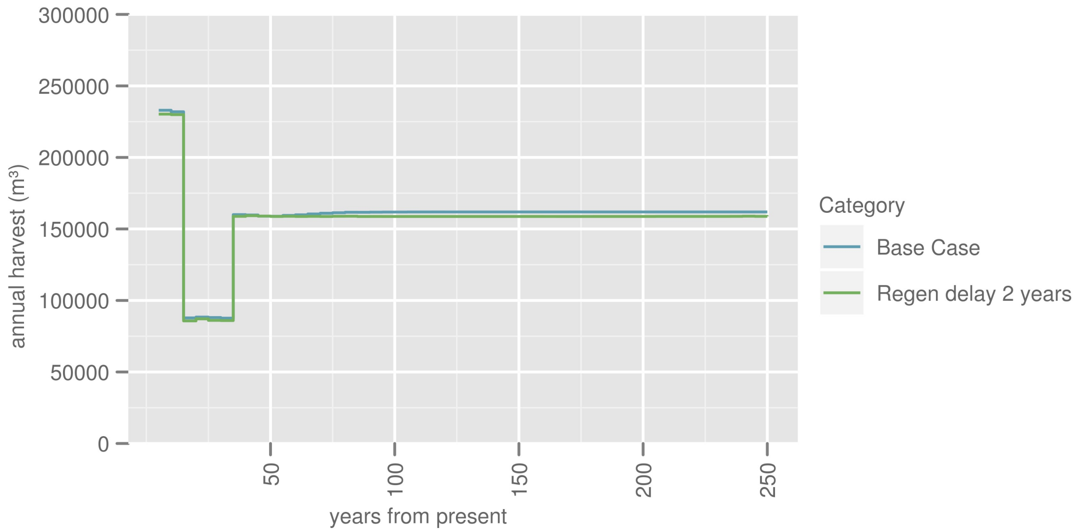

Figure 7.5: Effects on harvest schedule: changing stand regeneration delay, to 2 years

The results of this run are compared to the base case in Figure 7.5 and Table 7.6.

An increase in regeneration delay to two years requires a slight decrease in the short-term harvest level and a modest decrease in the medium-term and long-term harvest levels.

Table 7.6: Effects on harvest schedule: doubling stand regeneration delay, to 2 years

	Regeneration delay increased by 2 years	
	% change	Harvest level m³/year
Years 5-10	-1%	230,100
Years 15-30	-2%	86,200
Years 35-250	-2%	158,800

7.3 Resource Values

Disturbance limits have been established for several resource values. Sensitivity tests have been performed on the size of the timber harvesting land base (THLB), visual quality objectives (VQOs) and green-up period.

7.3.1 Timber harvesting land base (THLB)

The actual size of the timber harvesting land base (THLB) is generally a source of uncertainty. The size of the land base that could be harvested at any point in time varies with market conditions and with evolving objectives for non-timber resource values.

The THLB determination in the data package was based on the best available resource information; if underlying inventories, management assumptions or log prices change, the size of the THLB will be affected.

To gauge the potential impact of land base changes on timber supply, two runs have been carried out, where the THLB has been increased and decreased by 5% respectively.

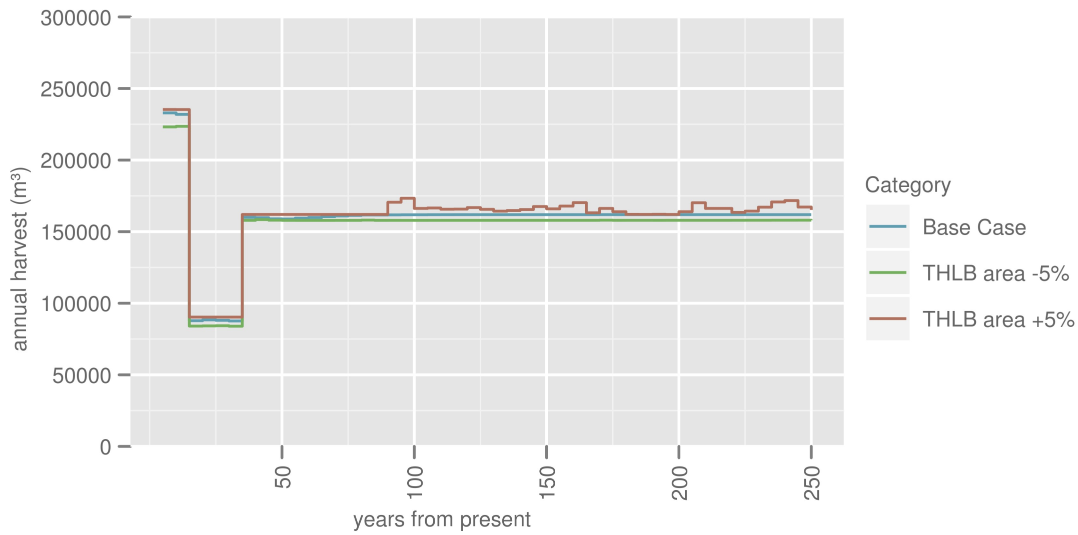

Figure 7.6: Effects on harvest schedule: changing THLB area

The results of these two runs are compared to the base case in Figure 7.6 and Table 7.7.

In summary, an increase in THLB area of 5% permits a significant increase in harvest level over the short and medium term, 5 – 30 years, and a modest increase over the long term, 35 – 250 years.

Conversely, a decrease in THLB area of 5% requires a significant decrease in the short and medium term, and a modest decrease over the long term. The decrease is less than might be expected as the area removed from the THLB is added to the productive non-contributing land base, so that the total area of the TFL remains unchanged, and the increase in non-contributing area is available to meet other resource objectives thereby reducing the pressure on the THLB.

Table 7.7: Effects on harvest schedule: changing the THLB area

	THLB area increased by 5%		THLB area reduced by 5%	
	% change	Harvest level m^3/year	% change	Harvest level m^3/year
Years 5-10	1%	235,300	-4%	223,400
Years 15-30	3%	90,300	-4%	84,100
Years 35-250	2%	165,200	-2%	157,900

7.3.2 Remove VQO restrictions on MPB-impacted stands

The rate of harvesting in visually sensitive areas is controlled so that viewscapes are not excessively impacted. The base case constrains forest cover such that the area less than three metres in tree height is less than the maximum percent alteration as per values defined in Table 18 of the Data Package.

This run tests the sensitivity of the base case to removing these VQO restrictions on stands to be salvaged due to MPB infestation.

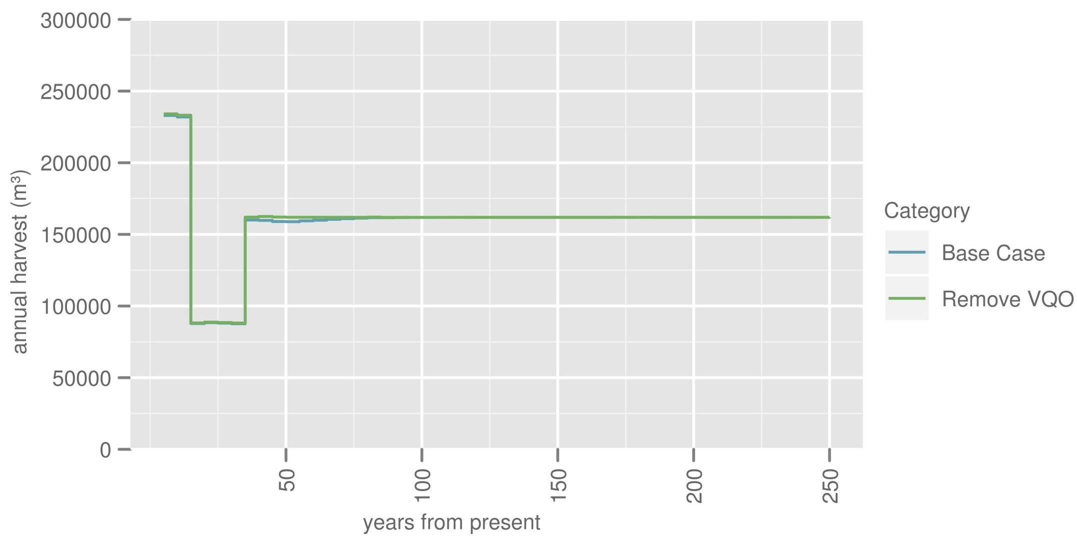

Figure 7.7: Effects on harvest schedule: removing VQO restrictions on MPB-impacted stands

The results of this run are compared to the base case in Figure 7.7 and Table 7.8.

In summary, removal of VQO restrictions permits a slight increase in harvest level over the short and medium term, years 5 – 30, and no significant change over the long term, years 35 – 250.

Table 7.8: Effects on harvest schedule: removing VQO restrictions on MPB-impacted stands

	Removal of VQO restrictions on MPB-impacted stands	
	% change	Harvest level m³/year
Years 5-10	1%	233,600
Years 15-30	1%	88,400
Years 35-250	0%	161,900

7.3.3 Green-up period

In areas that are not subject to visual quality management, disturbance constraints have been applied as a proxy for adjacency. No more than 33% of the landscape can be less than three metres in tree height (green-up height). This constraint applies to the THLB only.

Two runs were carried out to test the sensitivity of the base case to changes in the green-up period, by increasing and decreasing the green-up period by 10% respectively.

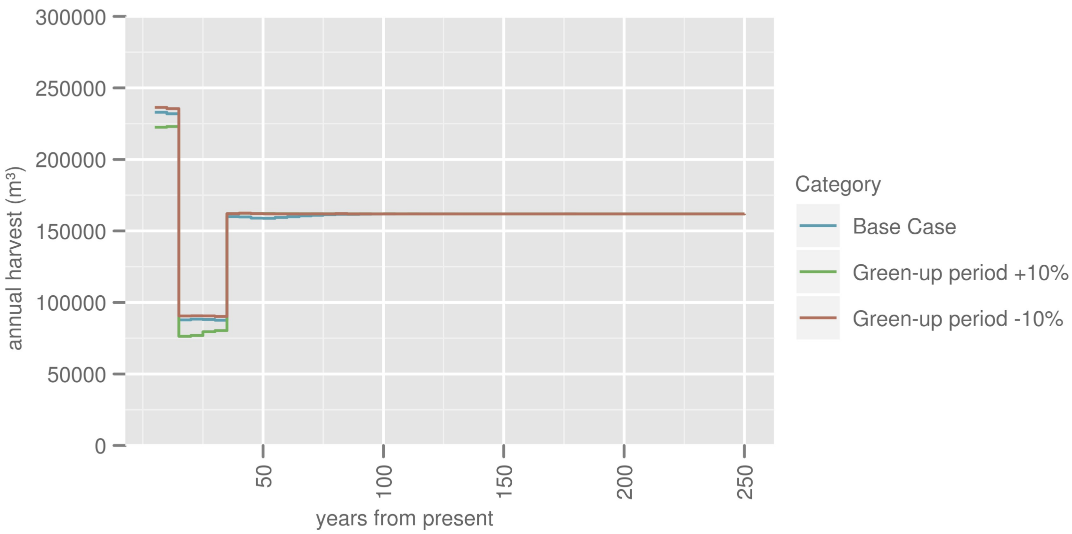

Figure 7.8: Effects on harvest schedule: changing green-up period

The results of these two runs are compared to the base case in Figure 7.8 and Table 7.9.

In summary, a decrease in green-up period of 10% permits a modest increase in harvest level over the short and medium term, 5 – 30 years, and no increase over the long term, 35 – 250 years.

Conversely, an increase in green-up period of 10% requires a modest decrease in harvest level over the short term, 5 – 10 years, a significant decrease over the medium term, 15-30 years, and no decrease over the long term.

Table 7.9: Effects on harvest schedule: changing green-up period

	Green-up period increased by 10%		Green-up period reduced by 10%	
	% change	Harvest level m³/year	% change	Harvest level m³/year
Years 5-10	2%	236,000	-4%	222,800
Years 15-30	3%	90,500	-11%	78,300
Years 35-250	0%	161,900	0%	161,900

8 DISCUSSION AND CONCLUSIONS

The analysis described in this report were developed to provide input into the process of determining the AAC for TFL35.

In doing so, a timber supply harvest rate was sought to quickly deal with the mountain pine beetle (MPB)- and spruce bark beetle (BB)–affected stands, which are almost completely harvested by the end of year 10 of the plan.

Rapid harvesting of these stands produces a mid-term “trough” in the timber supply, in years 15 – 30, followed by a return to a steady-state harvest level close to long-term sustainable yield, in years 35 – 250.

Two other alternative harvest rules were evaluated:

1. “*minimize mid-term fall-down*”, that is the “trough” described above, created by the aggressive harvesting of MPB- and BB-affected stands. In this alternative, a reduced harvest rate in the short term, years 5 – 10, permitted an increased harvest rate in the medium term, years 15 – 30, essentially lengthening the time taken to harvest the MPB- and BB-affected stands; and
2. “*maximize the long-term harvest level*”, which delivers a 3% increase in the long-term average harvest rate.

The base case was further tested with respect to its sensitivity to changes in:

1. reduce minimum harvest volume (MHV) for pine;
2. minimum harvest age;
3. existing stand yields;
4. regenerated stand yields;
5. regeneration delay;
6. visual quality objectives (VQO) constraints on MPB-affected stands; and
7. green-up period.

The results are summarized in Table 8.1.

Table 8.1: Comparison of results of analysis

Description	Short-term Impact (5-10 years)		Medium-term Impact (15-30 years)		Long-term Impact (35-250 years)	
	%	m³/year	%	m³/year	%	m³/year
Base case		232,500		88,000		161,500
Alternative harvest flows						
Minimize mid-term falldown	-39%	142,300	61%	142,000	0%	161,000
Maximize long-term harvest level	-20%	185,900	-54%	40,500	3%	166,000
Harvestability						
Reduce pine MHV from 150 m³/ha to 100 m³/ha for pine stands only.	9%	252,300	21%	106,600	0%	161,600
Reduce pine MHV from 150 m³/ha to 100 m³/ha for all stands.	8%	251,600	21%	106,100	0%	161,800
Increase MHA by 10 years.	1%	234,900	3%	90,200	-5%	153,500
Decrease MHA by 10 years.	4%	242,800	11%	97,300	0%	161,900
Growth and yield uncertainty						
Reduce existing stand yields by 10%.	-9%	211,300	-13%	76,100	0%	161,800
Increase existing stand yields by 10%.	7%	249,000	11%	98,000	0%	162,000
Reduce regenerated stand yields by 10%.	-6%	219,300	-13%	76,400	-10%	146,000
Increase regenerated stand yields by 10%.	4%	241,900	11%	97,200	10%	178,000
Set stand regeneration delay to two years.	4%	241,200	9%	96,100	-7%	150,300
Resource values						
Decrease THLB area by 5%.	-4%	223,400	-4%	84,100	-2%	157,900
Increase THLB area by 5%.	1%	235,300	3%	90,300	2%	165,200
Remove VQO restrictions on MPB-impacted stands.	1%	233,600	1%	88,400	0%	161,900
Increase green-up period by 10%.	-4%	222,800	-11%	78,300	0%	161,900
Decrease green-up period by 10%.	2%	236,000	3%	90,500	0%	161,900

APPENDIX I DATA PACKAGE