TIMBER SUPPLY ANALYSIS REPORT

TIMBER SUPPLY REVIEW 2003/2004

ARROW TIMBER SUPPLY AREA

Prepared for:
The Arrow Forest Licence Group

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This document was prepared to support an allowable annual cut determination by British Columbia's chief forester. To learn more about this process please visit the following website:

http://www.for.gov.bc.ca/tsb/

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March 31, 2004

File: 4041005-1-1

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Reference: Arrow TSA 2003/2004 Analyses

Please accept this analysis report for the TSR 3 portion of the project.

It has been our pleasure working with you.

Yours truly,
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EXECUTIVE SUMMARY

A timber supply review process has been initiated for the Arrow Timber Supply Area. Timberline Forest Inventory Consultants Ltd., on behalf of the Arrow Forest Licence Group, is preparing timber supply information for the analysis. These reviews are conducted every five years and assist the B.C. Forest Service's Chief Forester in re-determining allowable annual cuts. For the Arrow Timber Supply Area, the Chief Forester will determine a new AAC by September 2004.

The key documents supporting AAC determination are a data package describing the inputs to the timber supply analysis, this timber supply analysis itself, and a socio-economic analysis. The data package and socio-economic analysis are appendices to this report.

The allowable annual cut for the Arrow TSA was set in 1983 at 619,000 m^3/yr and was maintained at that level in the 1995 Timber Supply Review No. 1 (TSR 1) AAC determination. Following TSR 1 the Forest Practices Code was implemented and the *Kootenay-Boundary Land Use Plan* was completed. The *Arrow TSA Rationale for AAC Determination* was published for TSR 2 in April of 2001. At that time the AAC was reduced by 11% to 550,000 m^3/yr.

This document presents the results of the timber supply analysis conducted in support of TSR 3. A base case analysis was prepared using the most current data sources and management assumptions based on current practice. These inputs are documented in the *Data Package* included as an appendix to this report. The base case initial maximum sustainable harvest level was determined to be 550,000 m^3/yr, which represents no change from the current AAC. This level then increases to a maximum long-term sustainable harvest level of 690,000 m^3/yr after 70 years.

A series of 32 sensitivity analyses were conducted to explore the risk associated with various sources of uncertainty in the modelling assumptions and data. The sensitivity analyses revealed that timber supply within the Arrow TSA continues to be limited by the age class gap in the existing age class distribution. Short-term timber supply is limited by the timber supply shortfall resulting from this gap in approximately 70 years. Any changes to the management assumptions or inventory information that help to fill the age class gap directly impact short-term timber supply.

The PEM and SIBEC sampling projects completed by the AFLG were implemented in this analysis with an impressive positive impact. The managed stand productivity increased greatly and the long-term harvest level jumped to the one of the highest levels predicted in a timber supply analysis for the Arrow TSA. The VRI completed by the AFLG and used in this analysis did not show any major changes in standing volume or productivity estimates for existing stands. However, there is the potential to change this result by completing the second phase of the VRI.

It was an improbable result to find that after so many changes in the data sources and assumptions used to model this analysis the initial base case harvest was the same as the current AAC. It was anticipated that the new data sources would have a positive pressure on the timber supply. However, it is important to consider all of the new modelling techniques and management objectives first implemented in this analysis with potentially downward pressures. The lack of change clearly indicates that the work of the AFLG to produce these new data sources has effectively mitigated the new downward pressures.

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Appendix III - Public Review Report

1.0 INTRODUCTION

Timberline Forest Inventory Consultants Ltd., on behalf of the Arrow Forest Licence Group (AFLG), is preparing timber supply information for the Provincial timber supply review (TSR). These reviews are conducted every five years and assist the B.C. Forest Service's Chief Forester in re-determining allowable annual cuts (AAC). For the Arrow Timber Supply Area (TSA), the Chief Forester will determine a new AAC by September 2004.

Under proposed defined forest area management (DFAM) legislation, the responsibility to conduct timber supply analysis within a TSA will be transferred to the licencees operating within the TSA. The DFAM legislation requires, to carry out this process, the formation of a DFAM group that includes the holders of replaceable forest licences, BC Timber Sales (BCTS), and other holders of agreements that meet the prescribed requirements.

The DFAM group will complete the steps leading up to, and including the delivery of, timber supply analyses as follows:

- Collecting data and preparation of an data package which summarizes the data assumptions - land base, growth and yield, forest management practices, statement of management strategies, and analysis methods - that will be used, and the critical issues that will be examined in the timber supply analysis;
- Providing for an initial public and First Nations review of the data package;
- Completing the timber supply analysis and report;
- Completing a socio-economic analysis; and
- Providing for public and First Nations review of the timber supply and socio-economic analyses.

After the completion of these steps, the analysis report is submitted to the Chief Forester. The AAC is then set by the Chief Forester using the analysis report as one of the many factors required as part of the determination process.

In the Arrow Timber Supply Area the DFAM group is represented by the five forest companies operating in the Arrow TSA portion of the Arrow Boundary Forest District of southern British Columbia, known collectively as the Arrow Forest Licence Group (AFLG). The AFLG was formed in 1998 when it entered into Innovative Forestry Practices Agreements (IFPA) with the Ministry of Forests under Section 59.1 of the British Columbia Forest Act. IFPAs are designed to test and pilot alternative and new approaches to forest resource management.

The third Timber Supply Review (TSR 3) process has been initiated for the Arrow TSA. Prior to this process, the AFLG had been working under the IFPA toward submitting an AAC uplift application under Section 59.1 of the Forest Act. Both projects were carried forward simultaneously under the title Arrow TSA 2003/2004 analyses. Both projects will share the same set of model data inputs and assumptions but have differing timber supply analysis objectives. Therefore, the two projects share the same data package but analysis results are presented in two different reports.

This analysis report documents the outcomes of the timber supply analysis performed for TSR 3.

1.1 DFAM PROCESS

Preparation for the Arrow TSA TSR 3 analysis began in May 2003. The first step under the DFAM process is the preparation of the data package. The data package is a technical document that acts as the foundation for the timber supply analysis. It provides a clear description of information sources, assumptions, issues, and any relevant data processing or adjustments related to the land base, growth and yield, and management objectives and practices used in the analysis.

The first draft of the data package was completed on October 17, 2003. It was submitted at this time to the MoF and was also made available for a public and First Nations review over a period of two months. Feedback was directly solicited from First Nations groups. The methodology used to carry out the public and First Nations review was documented and is provided in Appendix III. The feedback comments from the review process are also provided in this Appendix.

The *Data Package Timber Supply Review 2003/2004* was completed on March 4, 2004. The MoF accepted it for use on March 19, 2003. It is provided with this analysis report as Appendix II.

This analysis report is currently at the first draft stage. Under the DFAM process, the report, and the socio-economic report (Appendix I), must go through a second public and First Nations review period of two months. The review will span the period beginning April 7 through to June 5, 2004. After the review period, the feedback will documented with the feedback from the first review period. The analysis report will be adjusted to incorporate the feedback and finalized with MoF approval. The final analysis report will then be submitted to the chief forester as part of the TSR 3 decision process.

To facilitate the review process, an Internet web site dedicated to the 2003/2004 analyses was established at www.timberline.ca/arrowtsa. This draft analysis report, appendices, background documents, and maps were placed on this site. From this site they are freely available for download by individuals for review.

2.0 GENERAL DESCRIPTION OF LANDBASE AND TENURE

The Arrow Timber Supply Area is situated in southeastern British Columbia in the Southern Interior Forest Region. It is part of the Arrow Boundary Forest District and is administered from the MoF district office in Castlegar.

The total area of the TSA is approximately 605,600 hectares, of which 52% is non-productive or inoperable. Approximately 35% of the total TSA land base is considered available for harvesting under current management practices.

Figure 2.1 provides an overview map of the Arrow TSA (*Arrow Timber Supply Area Analysis Report*, April 2000).

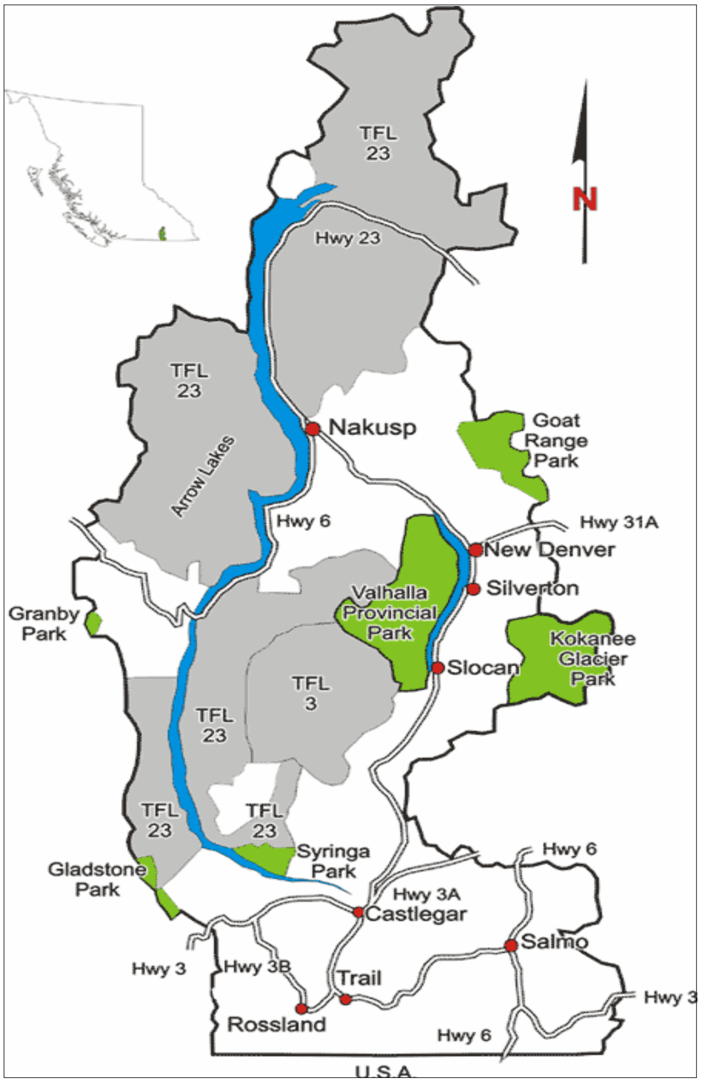

Figure 2.1. Overview of the Arrow TSA

3.0 TIMBER FLOW OBJECTIVES

The objective of the analysis is to determine the capacity of the land base to sustain a timber flow. The analysis goes beyond a simple calculation of capturing the growth potential of the land base. Many management objectives with overlapping and conflicting goals must be met. The maximum sustainable timber flow must ensure that these objectives are met while maximizing the growth potential of the land base.

A number of alternative harvest flows are possible, but for this analysis each harvest flow will attempt to closely follow the TSR 2 base case flow pattern. This will make it possible to clearly demonstrate any relative gains or losses over the TSR 2 levels.

The proposed harvest flows will also attempt to achieve a balance of the following timber flow objectives:

- Maintain or increase the initial harvest level of 550,000 cubic metres per year for as many decades as possible;
- Decrease the periodic harvest rate in acceptable steps (<=10%) when declines are required to meet all objectives associated with the various resources on the land base;
- Do not permit the mid-term harvest to fall below a level reflecting basic maintenance of the productive capacity of the IFPA (based on VDYP yield estimates); and
- Achieve a maximum even-flow long-term supply where the total inventory is stable.

4.0 LAND BASE INFORMATION

A complete description of the data sources and assumptions used as the basis for the Arrow TSA 2003/2004 analyses is contained in the *Arrow TSA 2003/2004 Data Package*. This document is included as part of this analysis report in Appendix II.

4.1 Land Base Classification

Many sources of data were used to compile information on the land base with the Arrow TSA. The main source of land base information was the vegetation resources inventory (VRI). This inventory replaced the forest cover data set used in TSR 2. Many of the attributes traditionally used during the land base classification process were no longer provided within the VRI. The transition from forest cover to VRI required some assumptions during the land base classification process that are documented in the *Data Package*.

The land base is first classified into four broad criteria:

- It is unproductive for forest management purposes;
- It is or will become inoperable under the assumptions of the analysis;
- It is unavailable for harvest for other reasons (*e.g.* wildlife habitat or recreation); or
- It is available for integrated use (including harvesting).

The results of the land base classification can be found in Table 3.1 of the *Data Package* and are summarized in Figure 4.1 and Figure 4.2.

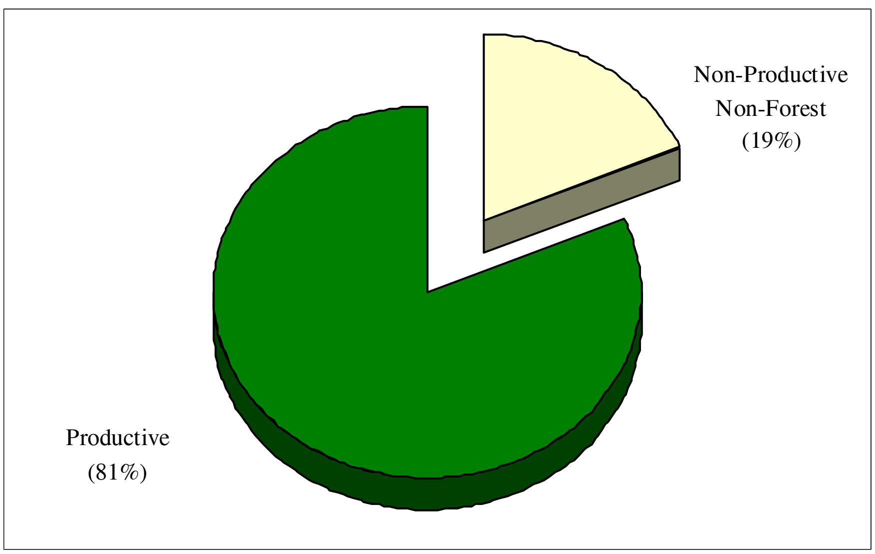

Figure 4.1. Productive and non-productive land base area

The timber harvesting land base (THLB) consists of all of the productive land expected to be available for harvest over the long-term. This land base is determined by reclassifying the total land base according to specified land base classification criteria.

The unharvestable component includes exclusions from the productive land such as inoperable area, low site removals, and deciduous leading stands. Figure 4.2 provides a break down of the land base reductions for the Arrow TSA.

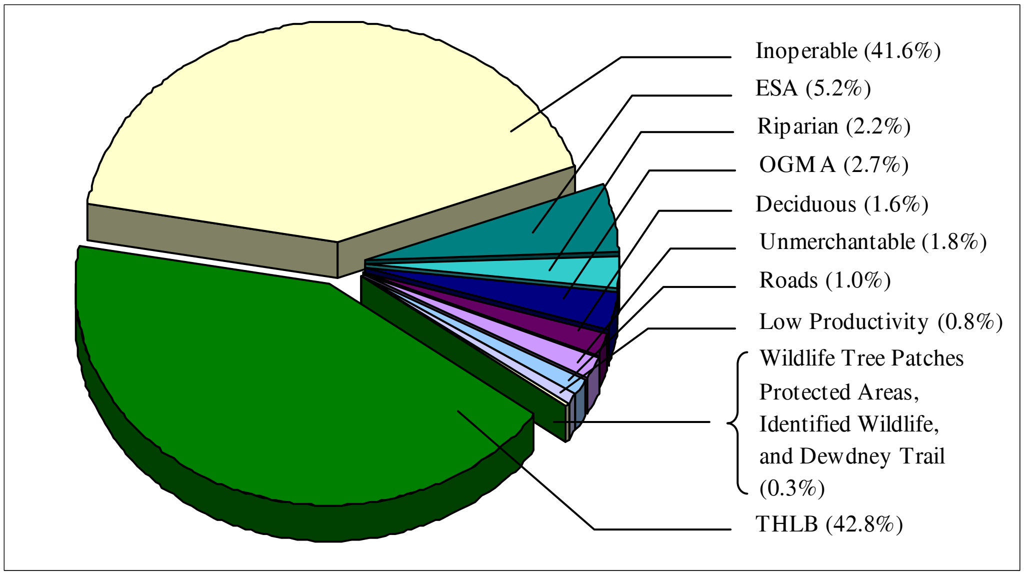

Figure 4.2. Distribution of productive area (493,267 ha)

4.2 FOREST INVENTORY

The productive forested area of the Arrow TSA is ecologically diverse. An ecological inventory using predictive ecosystem mapping (PEM) was recently completed by the AFLG. The PEM provides information on the range of biogeoclimatic ecological classification (BEC) units that occur within the TSA. The distribution of BEC units is shown by productive area in Figure 4.3. More information on BEC can be found in the publication Field Guide for Site Identification and Interpretation for the Nelson Forest Region (Braumandl, 1992).

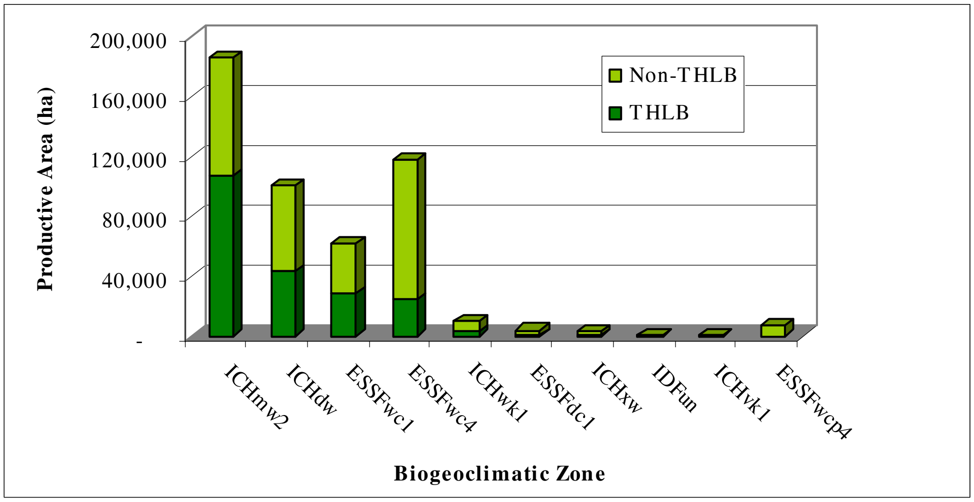

Figure 4.3. Biogeoclimatic zone productive area

Forest stands are generally categorized by leading species. The distribution of the productive area by leading species is shown in Figure 4.4.

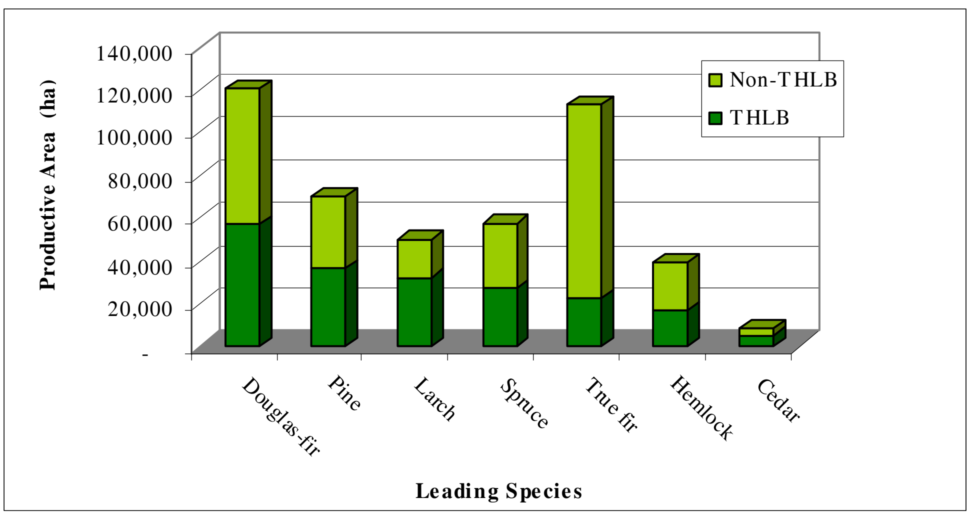

Figure 4.4. Leading species productive area

4.3 INVENTORY AGGREGATION

As part of the modelling process stands are aggregated for many purposes. They are grouped in order to represent areas designated for special management considerations and they are also aggregated to model stands with similar growth patterns.

4.3.1 Landscape Units

For planning purposes, the Arrow TSA has been subdivided into 33 landscape units. Specific management constraints are associated with the landscape units. Several of the resource management emphasis areas are also defined based on the landscape units.

4.3.2 Resource Emphasis Areas

The productive land base was assigned into resource emphasis areas (REA) to facilitate the modelling of management requirements. The major REA include:

- Polygonal-based visual quality objective (VQO) zones;
- Caribou management areas and ungulate winter range areas (UWR); and
- Community and domestic watershed areas (CWS).

The distribution of these areas is presented in Figure 4.5. These areas are difficult to summarize due to the overlap that occurs among the REA. Therefore, Figure 4.5 displays a grid summarizing the amount of overlap between every combination of REA. The total area in each REA can be found where the same REA heading from the two sides meet at the diagonal line down the center of the figure. The column titled "no other" indicates the amount of area under an REA that does not overlap with any other REA.

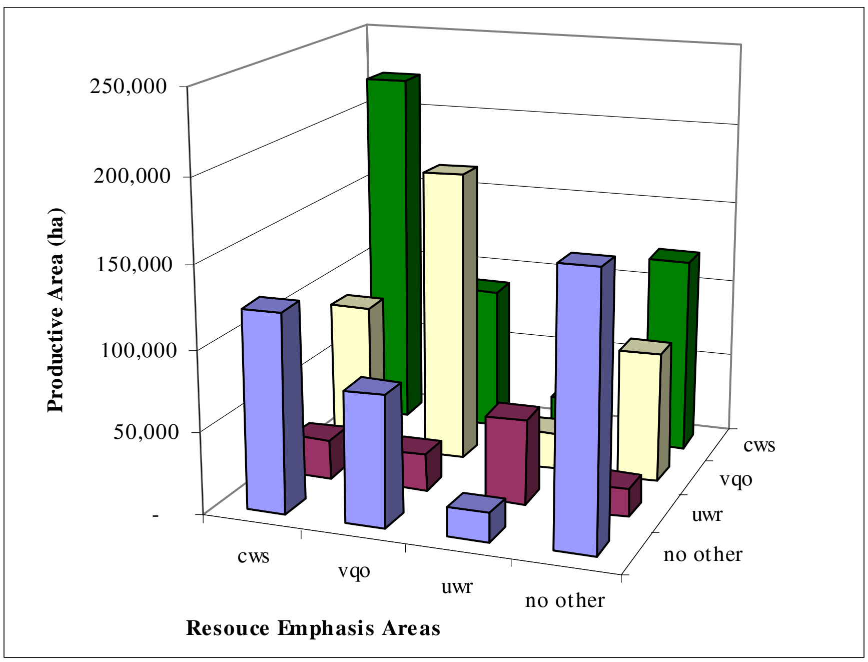

Figure 4.5. Distribution of resource emphasis areas

Figure 4.5 shows that watersheds cover the largest proportion of the land base. They also have the largest amount of area with no overlap with other management requirements. The ungulate management areas cover the smallest proportion of the land base. They also have a smaller disturbance requirement than the other REAs, so the impact of the ungulate management requirements is negligible. VQO zones have the most significant disturbance requirement followed by community watersheds. If an area is classified as both VQO and community watershed the VQO forest cover constraint will be the limiting factor in determining access to timber. Figure 4.6 shows the THLB and non-THLB area that falls within the VQO, watershed, and ungulate management REAs.

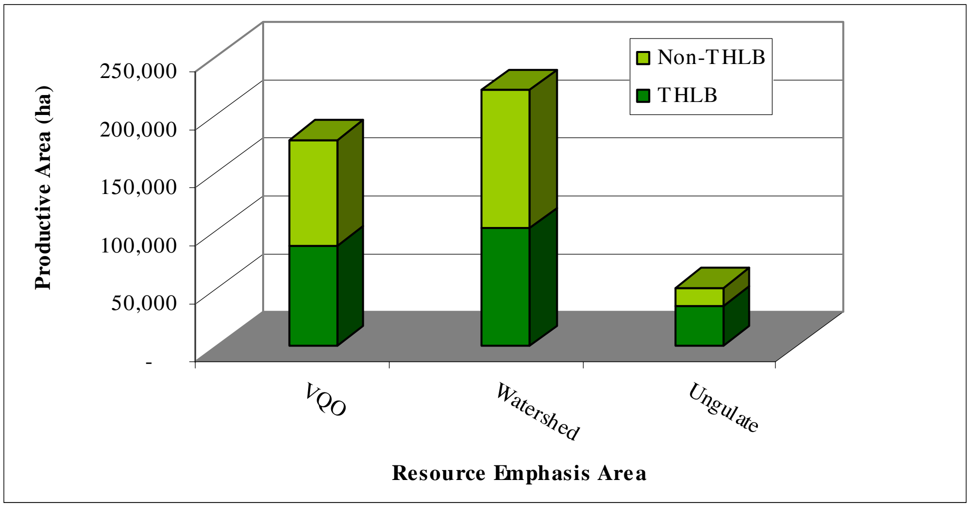

Figure 4.6. Resource emphasis area productive area

Seventy-two percent of the productive land base is classified as within at least one of three REAs. A large proportion of each REA is found in the non-THLB. This is relevant because the non-THLB can contribute to fulfilling the management requirements for each REA.

4.3.3 Analysis Units

The inventory was aggregated into analysis units to capture biological and productivity similarity for modelling purposes. In TSR 2, analysis units were formed based on similar species mix, productivity, and age group. For the 2003/2004 analyses, an ecologically based system for aggregating stands into analysis units was introduced. Stands were grouped based on their biogeoclimatic ecosystem classification (BEC) and leading species.

4.4 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 tracked over time through the use of yield projection tables. Yield tables are categorized into either natural stands or managed stands because of distinct growth pattern differences between the two types of stands. Natural and managed stands are differentiated based on stand age.

4.4.1 Natural Stands

Douglas-fir and spruce leading stands > 25 years and all other stands > 15 years were classified as natural stands. Natural stand yield tables (NSYT) were developed using the batch version of the Ministry of Forests (MoF) program *VDYP* (Version 6.6d).

4.4.2 Managed Stands

Douglas-fir and spruce leading stands 0 - 25 years and all other stands 0 - 15 years were classified as existing managed stands. Managed stand yield tables (MSYT) were developed using the MoF program *BatchTIPSY* (Version 3.0b). Separate MSYT were developed for all existing managed stands and future managed stands established following the harvest of existing stands. Genetic gain factors were included in the future MSYT.

4.4.3 Productivity

The rate at which a stand grows is a factor of the site productivity. The productivity of a stand is measured using a site index. Site index for natural stands was calculated from the VRI. Managed stand productivity was calculated using site index correlated to biogeoclimatic ecologic classification (SIBEC). Figure 4.7 shows the distribution of stand site index in 5 m classes for the THLB. The existing stand data represents the current distribution composed mostly of natural stands using the VRI site index. The future stands data represents the distribution in the far future when almost all of the stands in the THLB are managed and modelled using SIBEC.

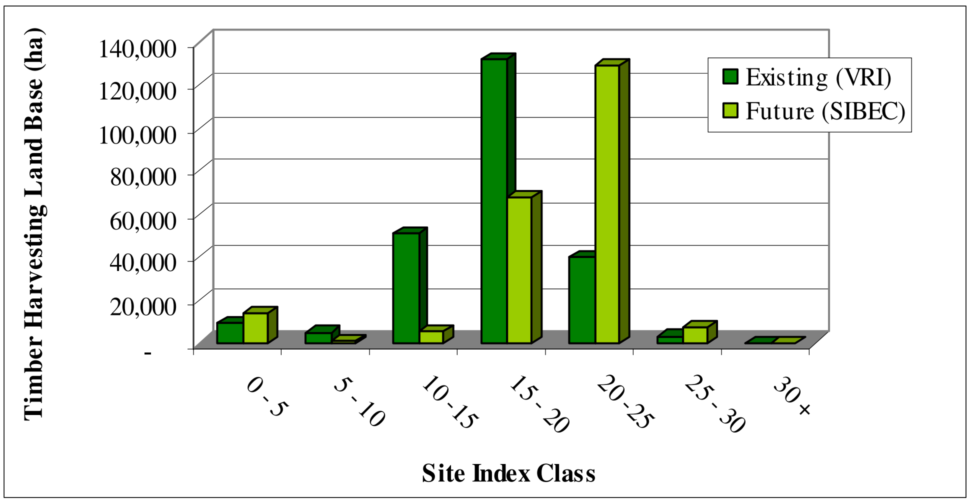

Figure 4.7. Site index distribution for existing and future stands

It is clear that the majority of the stands are in a higher site index class when stand productivity is based on SIBEC site index.

5.0 TIMBER SUPPLY ANALYSIS METHODS

Timberline's proprietary simulation model CASH6 (**C**ritical **A**nalysis by **S**imulation of **H**arvesting), Version 6.2l was used to develop spatial harvest schedules in the Arrow IFPA timber supply analysis. This model uses a spatial geographic approach to land base and inventory definition in order to adhere as closely as possible to the intent of forest cover requirements on harvesting. CASH6 can simulate the imposition of overlapping forest cover objectives on timber harvesting and resultant forest development.

These objectives are addressed by placing restrictions on the distribution of age classes, defining maximum or minimum limits on the amount of area in young and old age classes found in specified components of the forest. For the purposes of this analysis objectives are of two types:

1. Disturbance (green-up)
The disturbance category is defined as the total area below a specified green-up height or age. This disturbed area is to be maintained below a specified maximum percent. The effect is to ensure that at no time will harvesting cause the disturbed area to exceed this maximum percent. This category is typically used to model adjacency, visual, wildlife or hydrological green-up requirements in resource emphasis areas, and early seral stage requirements at the landscape unit level.

2. Retention (old growth)
The retention category is defined as the total area above a specified age. This retention area is to be maintained above a specified minimum percent. The effect is to ensure that at no time will harvesting cause the retention area to drop below this minimum percent. This category is typically used to model thermal cover and/or old growth requirements in wildlife management resource emphasis areas, and mature and old growth seral stage requirements at the landscape unit level.

The model projects the development of a forest, allowing the analyst to impose different harvesting and silviculture strategies on its development, in order to determine the impact of each strategy on long-term resource management objectives. CASH6 was used to determine harvest schedules that incorporate all integrated resource management considerations including spatial feasibility factors, for example, silviculture block green-up.

In these analyses, timber availability is forecasted in decadal time steps (periods). The main output from each analysis is a projection of the amount of future growing stock, given a set of growth and yield assumptions, and planned levels of harvest and silviculture activities. Growing stock is characterized in terms of operable volume (total volume on the timber harvesting land base), merchantable volume (operable volume above minimum harvest age), and available volume (maximum merchantable volume that could be harvested in a given decade without violating forest cover constraints).

A 250-year time horizon was employed in these analyses, to ensure that short and mid-term harvest targets do not compromise long-term growing stock stability. Also, modelled harvest levels included allowances for non-recoverable losses. Harvest figures reported here exclude this amount unless otherwise stated.

Over the next rotation it may be necessary to reduce harvest levels prior to achieving the long-term level. Unless otherwise stated in the timber supply forecasts that follow, the decadal rate of decline was limited to 10%, and the mid-term harvest level was not permitted to drop below a level reflecting the basic productive capacity of the land base. The long-term steady harvest level will always be slightly below the theoretical long-term level, attainable only if all stands are harvested at the age when mean annual increment (MAI) maximizes. This is due to the imposition of minimum harvest ages and forest cover requirements, which alter time of harvest.

5.1 INTERPRETING TIMBER AVAILABILITY

Harvest flow has traditionally been the primary indicator used to evaluate the timber supply impacts of various management scenarios. However the harvest flow for a given scenario does not necessarily reveal the complete timber supply picture. Another useful indicator is timber availability, which is the total volume of merchantable timber that could be harvested in any given period without violating any forest cover requirements. The profile of timber availability provides valuable insights into the timber supply dynamics of a given scenario. In general, the periods with the least amount of timber available control the resulting harvest flow.

Although a stand-alone timber availability profile can provide valuable information, they have greater utility when comparing management scenarios. When comparing different management scenarios using timber availability profiles, it is critical to use the same harvest request in both scenarios. In doing so the differences in the timber availability profiles can be entirely attributed to differences in the management assumptions and not clouded by differences in modelled harvest. In every case when two timber availability profiles are displayed on the same graph, the profiles are created using the same harvest flow request. Generally the harvest flow requested is the basecase harvest flow unless otherwise specified.
Figure 5.1 provides an example to demonstrate the interpretation of availability lines. The logical progression is as follows (numbers relate to labels in the figure):

1. Establish the base case harvest flow;
2. Determine timber availability associated with the base case;
3. Rerun the analysis with the assumption change but request the same harvest levels as the base case;
4. This yields the difference in availability due to the change in assumption (the change isolated from further complication associated with a change in harvest levels); and
5. Rerun the changed assumption but modify the harvest requests to determine the sustainable harvest flow.

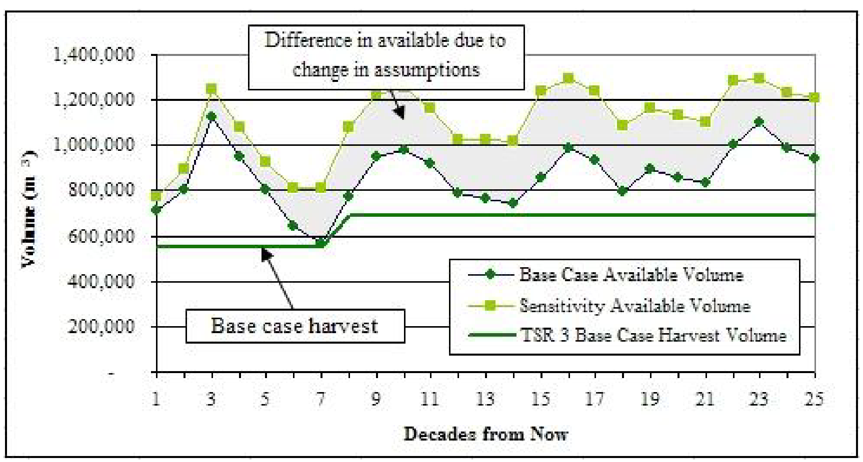

Figure 5.1. Interpretation of available volume graphs

6.0 TIMBER SUPPLY ANALYSIS

This section presents the base case harvest flow profile established through analysis of timber supply. In addition, sensitivity analyses that address the issues associated with a large degree of uncertainty are also presented. Thirty-one sensitivity issues were tested as listed in Table 6.1.

Table 6.1 Summary of sensitivity analyses

Issue	Sensitivity Levels to be Tested
Harvest flow	Establish a non-declining even flow (NDEF) Highest initial harvest level Oldest first harvest priority
Land base	Adjust timber harvesting land base by +/- 10%
Growth and yield	Adjust existing stand yields by +/- 3m Adjust managed stand yields by +/- 3m
Visual landscape	Adjust denudation percentages +/- 5% Do not group visual polygons
Green-up	Adjust green-up heights +/- 1.5m
Adjacency	Do not consider adjacency in harvest
Minimum harvest ages	Adjust minimum harvest ages +/- 10 years
Slocan Valley	Removed using contentious area definition Removed using contentious five landscape unit definition Limited harvest based on past practice
SIBEC	Site index assigned based on first PEM decile only Over and underestimation in SIBEC
West Kootenay ungulate winter range	Use new ungulate winter range mapping and management constraints
Disturbance of inoperable areas	Do not disturb areas outside of the THLB Disturbances do not contribute to VQO limits
Root rot	Adjust managed stand yields for root rot losses
Landscape biodiversity	Apply seral requirements in place of OGMAs
No Management Objectives	No adjacency, disturbance, or retention constraints
Spatial Analysis	No adjacency constraints Aspatial analysis

6.1 BASE CASE

The base case scenario represents the projected timber flows based on current practice with the best available information. It was built using the TSR 2 analysis inputs and assumptions as the foundation. New data and new management considerations were added when available and applicable. The many changes from TSR 2 are documented in the data package. Some of the major changes include:

- New vegetation resource inventory (VRI);
- New predictive ecosystem mapping (PEM);
- Improved site productivity estimated using site index correlated to ecosystems (SIBEC);
- Improved terrain stability mapping;
- Improved modelling of areas managed for visuals with localized visually effective green-up (VEG) heights;

- Implementation of old growth management areas (OGMA) refined by licencees in place of biodiversity management requirements;
- Use of tree improvement program seed;
- Improved methodologies for defining wildlife tree patch requirements;
- Updated conventional operability line;
- Disturbing the non-timber harvesting land base;
- Green-up of 2.5 m as indicated in higher level plan;
- Fully spatial for 20 years;
- One percent volume reductions for identified wildlife; and
- Inclusion of connectivity corridor with proportional representation

The timber supply flow pattern utilized in the base case was developed following the harvest flow objectives outlined in Section 3.0. The maximum sustainable timber flow for the TSR 3 base over a 250-year time horizon is presented in Figure 6.1 and Table 6.2. For comparison, the harvest flow values from the TSR 2 base case are also provided.

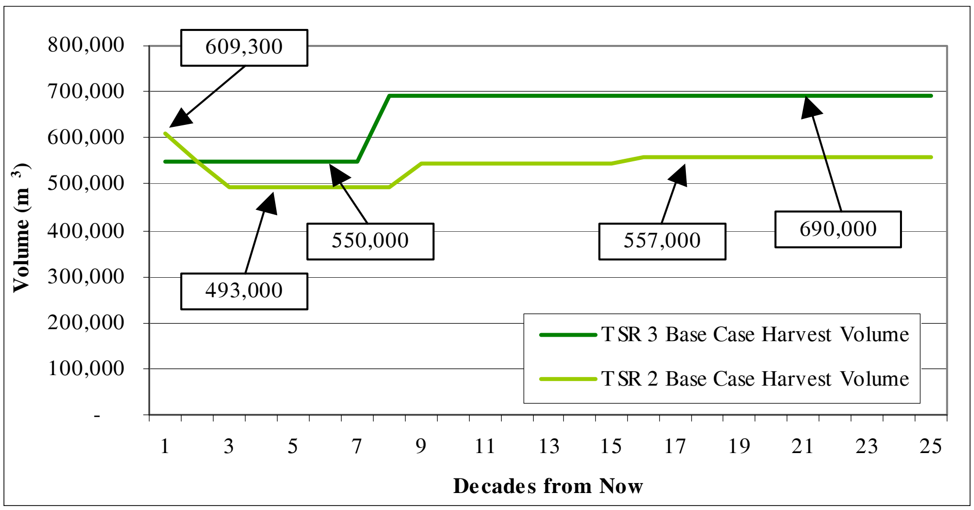

Figure 6.1. Base case harvest flow for TSR 3 and TSR 2

Table 6.2. Base case harvest flow for TSR 3 and TSR 2

Decade	TSR 2 Base Case	TSR 3 Base Case
1	609,300	550,000
2	548,400	550,000
3 - 7	493,500	550,000
8	493,500	690,000
9	544,000	690,000
10 - 15	544,000	690,000
16+	557,000	690,000

The TSR 3 base case harvest flow starts at the current AAC of 550,000 m^3/yr and maintains this level for seven decades. The TSR 2 base case started at a higher level, but then had to decrease quickly to a mid-term level below the current AAC. A higher initial harvest level for the TSR 3 base case was not selected because it would have required a compensating step down in the mid-term. Selecting a consistent harvest level through the short and mid-term meets the first timber supply objective "to maintain or increase the initial harvest level of 550,000 m^3/yr for as many decades as possible". Therefore, no further adjustments to short and mid-term harvest flow pattern were required.

Subsequent to the seventh decade, the harvest level increases dramatically to a long-term maximum sustainable harvest level of 690,000 m^3/yr. This long-term level is much higher than the TSR 2 long-term harvest level. The increase resulted from the implementation of SIBEC productivity estimates for managed stands which tend to be much higher than the productivity estimates calculated from inventory attributes.

The location of the timber supply shortages is most clearly demonstrated by studying the availability of merchantable volume that could be harvested in a given decade without violating forest cover constraints. Figure 6.2 displays the 250-year growing stock (inventory) profile including a line indicating the volume available for harvest at each decade.

The available volume is very limited in the first decade due to the spatial adjacency constraints which are applied during the first two decades. The significant increase in available volume in decade three is associated with the removal of the adjacency constraint. The growing stock then declines as the natural stands are harvested at a level that is greater than their natural rate of growth. This continues until a critical point at decade seven where the first of the regenerating stands become available for harvest. This transition from the harvest of natural stands to the harvest of managed stands is the most limiting point in the available harvest volume.

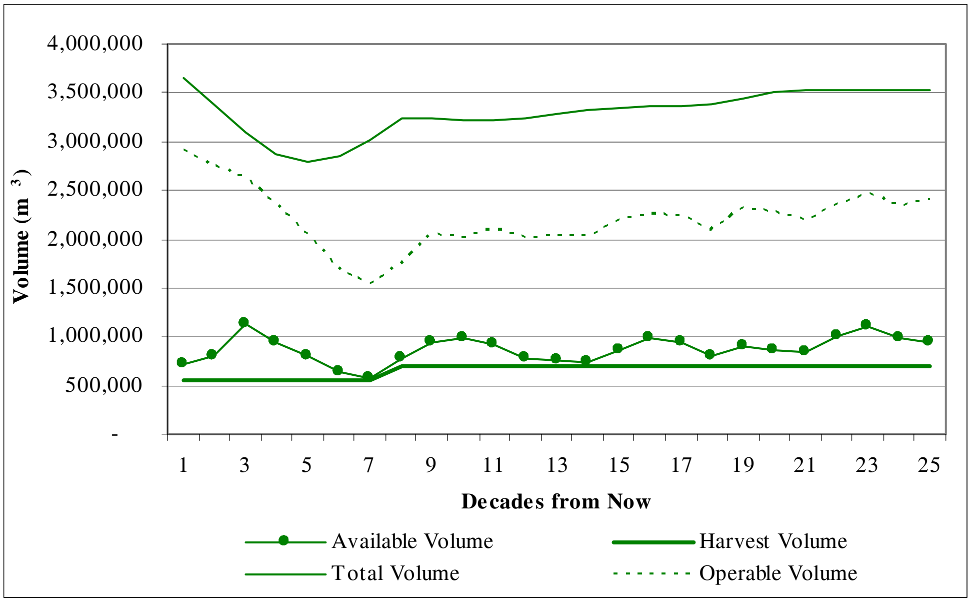

Figure 6.2. Base case growing stock profile

As more of the higher yielding managed stands reach minimum harvest age, Figure 6.2 shows the available volume increasing. There is a slight drop again around decade fourteen which appears to be an echo of the shortfall at decade seven occurring roughly one 80 year rotation period later. The long-term available volume eventually stabilizes at a level where management constraints, managed stand growth and harvest level are more or less balanced. There is a slight increase in growing stock at the end of the modelled time horizon. This was not captured in the harvest level because of the harvest flow objective to maintain a consistent long-term harvest level. The long-term harvest level selected was limited by the decrease in available volume around decade fourteen.

6.1.1 Harvest Trends

Figure 6.3 shows the sources of the base case timber harvest over the modelled time horizon. For the first six decades, the majority of the harvest comes from the existing natural stands. A small proportion of the harvest over this time comes from managed stands. At decade seven, the first major harvest from the regenerated managed stands begins. For the remainder of the modelled time horizon, the majority of the harvest is produced from managed stands through their subsequent rotations. Small harvests of natural stands occur late in the modelled time horizon as natural stands that were reserved from harvest to meet management objectives are freed through the recruitment of managed stands in their place.

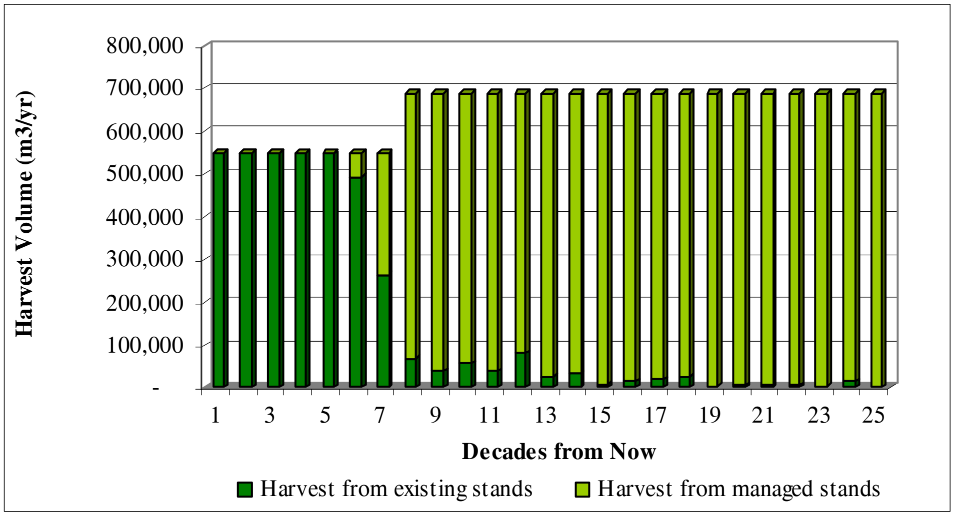

Figure 6.3. Base case timber supply sources

The following figures show the average harvested age, volume per hectare and area harvested per year in the base case scenario. Figure 6.4 shows a sudden shift in average harvest age starting at decade six. This occurs as the harvest shifts from the older natural stands to the regenerated managed stands. The managed stands tend to be harvested at approximately their minimum harvest age resulting in a much lower average harvest age.

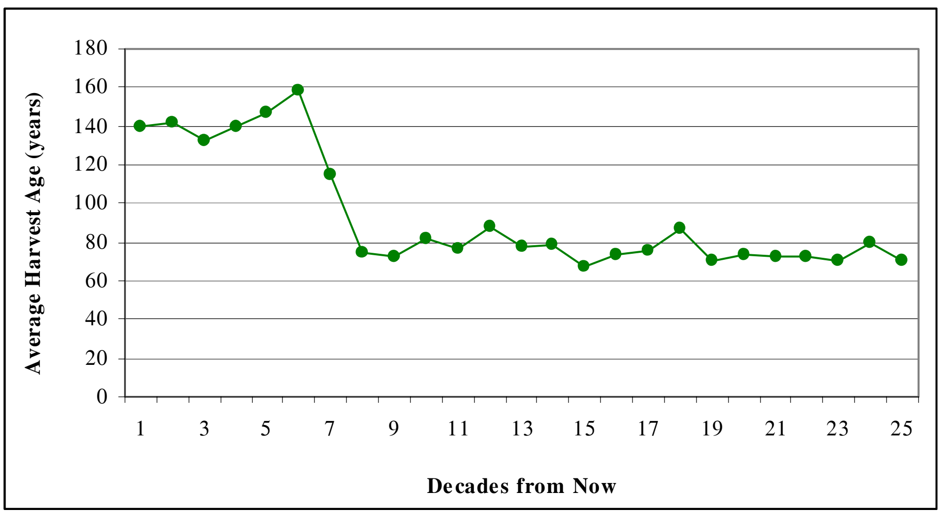

Figure 6.4. Base case average harvest age

Figure 6.5 shows that the average volume per hectare harvested increases over the modelled time horizon. Although the average harvested age drops during the shift to managed forest, the volume per hectare increases due to significantly higher managed stand yield expectations.

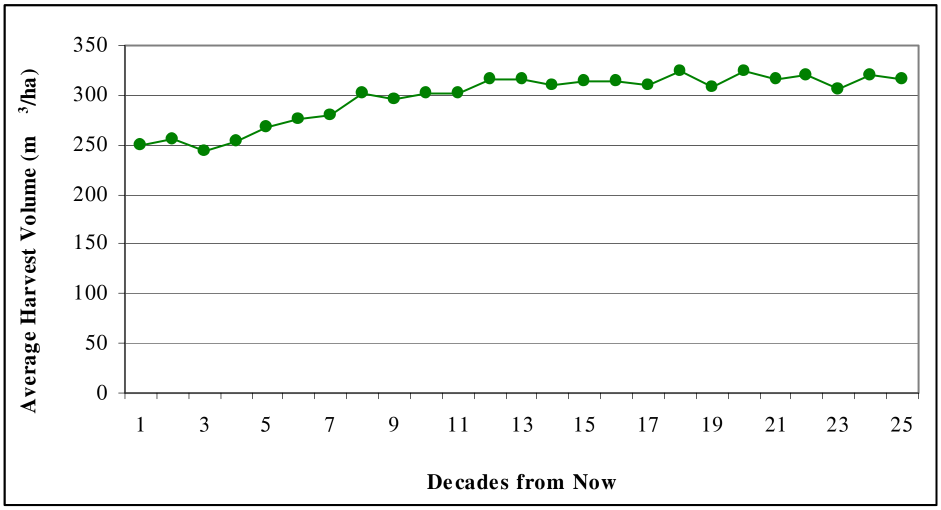

Figure 6.5. Base case average harvest volume per hectare

As the average harvest volume per hectare increases, it can be expected that a smaller harvest area would be required to produce the same harvest. Figure 6.6 displays this downward trend between decades three and seven. There is a sudden increase at decade eight that results from the step up in harvest volume that occurs at this point. Thereafter, the average harvest area remains relatively constant.

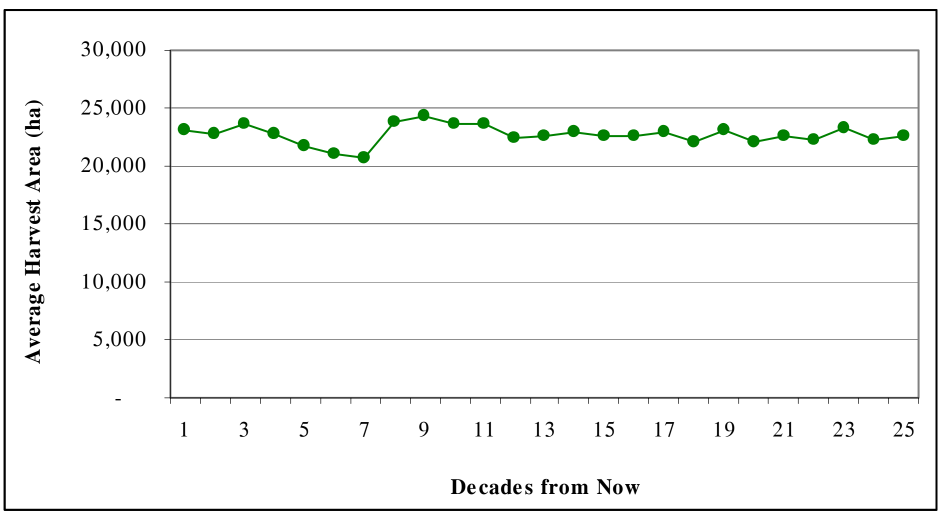

Figure 6.6. Base case average area harvested

6.1.2 Ageclass Distribution

Figure 6.7 through Figure 6.10 display the changes in forest structure over the modelled time horizon. Each figure reports on the productive area within the Arrow TSA divided into THLB and non-THLB. The stands are categorized into age classes. Age class 1 represents ages 0 - 10 years, age class 2 represents ages 11 - 20 years, *etc*. These classes continue through to age 350 years.

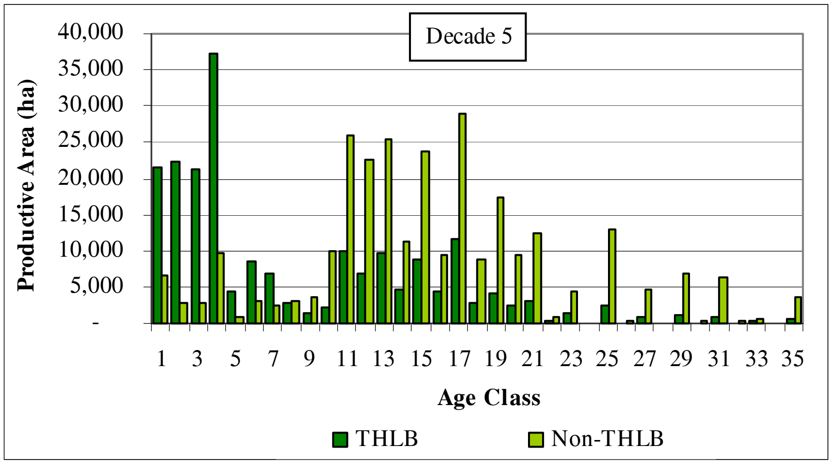

Figure 6.7. Base case age class distribution at decade 5

The age class distribution in Figure 6.7 shows some very important patterns that influence the short-term timber supply. The Arrow TSA currently has a very large age class gap resulting from the absence of stands several consecutive of age classes. By decade five, this gap has moved to the region between age class five and age class ten. At this point it becomes problematic because this is the range of ages at which stands are typically harvested. At decade five, it is possible to see that a shortfall is imminent as the regenerated stand area currently in age classes four and below are still several decades below their minimum harvest age. Harvesting of the natural stands in the older age classes helps to fill this gap but it eventually contributes to the shortfall at decade seven. The large spike in age class four represents the combination of the harvest from the first decade and all stands that returned to the land base within the first decade such as NSR and Timber Licences.

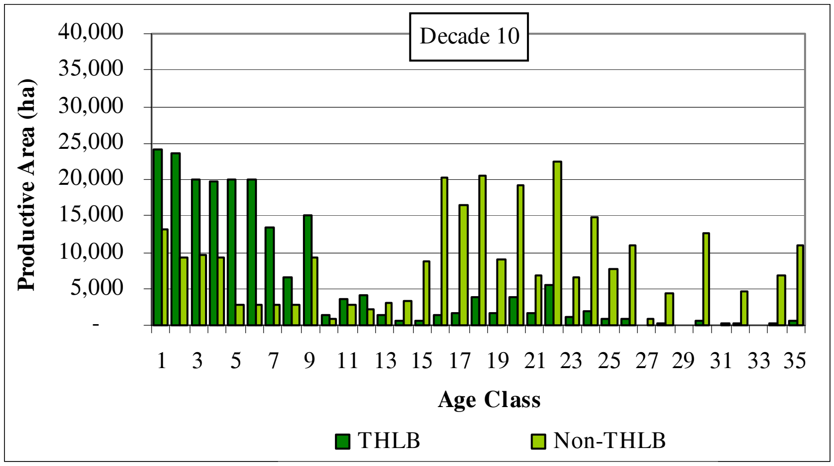

Figure 6.8. Base case age class distribution at decade 10

At decade ten, the harvest of managed stands is well underway. The steady supply of THLB in the younger age classes represents the rotation of managed stands. The impact of harvesting the older natural stands to fill the age class gap can be seen in the low levels of THLB in the older age classes. The implementation of modelling disturbances in the inoperable areas can be seen in relatively uniform occurrence of non-THLB in each of the younger age classes.

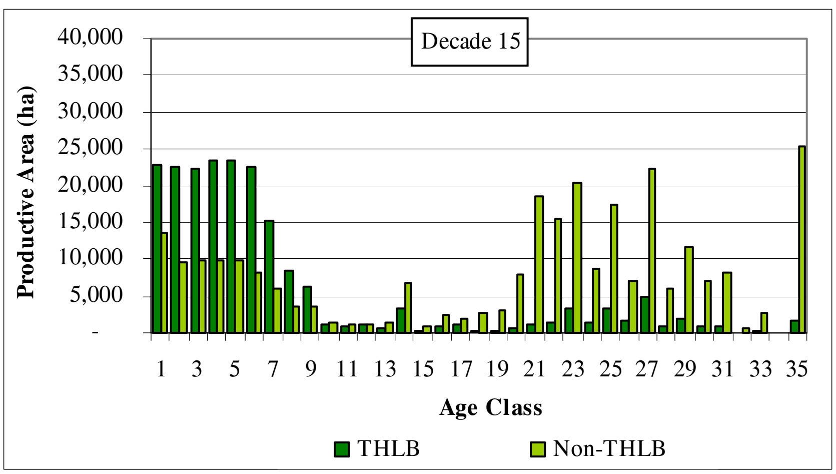

Figure 6.9. Base case age class distribution at decade 15

At decade 15, there is a reduced supply of THLB area in the age classes typically representing minimum harvest age. This is an echo from the shortfall at decade seven that is appears one rotation length later. The distribution of stands in the older age classes does not appear to have changed significantly except that it has shifted up five age classes. These stands represent the old stands reserved for management objectives such as habitat and biodiversity. The proportion of THLB in these stands is very small.

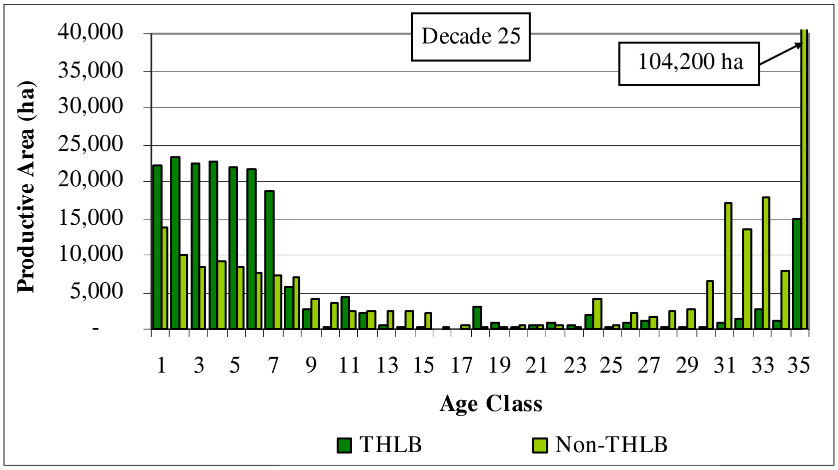

Figure 6.10. Base case age class distribution at decade 25

At the end of the modelled time horizon at decade 25 a large amount of the stand area has accumulated in the oldest age classes. It appears that modelling the disturbance of the inoperable areas has succeeded in distributing the non-THLB across the age classes. However, there is still a large gap in age classes 20 to 30 and an over abundance of area still accumulated in age class 35.

6.1.3 Long Run Sustainable Yield

The maximum sustainable harvest level is determined in part by the productive capacity of the harvestable land base. The theoretical productive capacity of the land base is measured in terms of the long-term sustainable yield (LRSY). This value is calculated from the culmination mean annual increment (MAI) of the stands within the THLB. The LRSY for both the existing natural stands and the future managed stands are shown calculated in Table 6.3 for the base case.

Table 6.3. Base case natural and managed forest LRSY

Description	Natural	Managed
THLB (including NSR) (ha)	210,275	210,275
- future roads + timber licences (ha)	- 11,570	- 11,570
= net long-term landbase (ha)	= 198,705	= 198,705
* average MAI (m^3/yr/ha) at culmination age	* 1.96	* 4.66
= theoretical gross long-term (m^3/yr)	= 389,177	= 926,918
- wildlife reductions (3.5%) (m^3/yr)	- 13,621	- 32,442
- non-recoverable losses (NRLs) (m^3/yr)	- 28,720	- 23,000
= theoretical net long-term (m^3/yr)	= 346,836	= 871,476

The theoretical net long-term sustainable yield for natural stands is approximately 350,000 m^3/yr. This is 37% less than the base case short-term harvest level of 550,000 m^3/yr. The difference indicates that the short-term harvest level is well above the productive capacity of the natural stands. This theoretical over harvest is done in anticipation that the harvest level will be sustained by the higher yields produced by the future managed stands. The average MAI in previous analyses based on the old forest cover inventory was calculated to be 2.43 m^3/yr/ha resulting in a theoretical gross long-term harvest level of 486,403 m^3/yr. This difference of approximately 100,000 m^3/yr indicates that the new VRI estimates of natural stand productivity are much lower than the original forest cover estimates.

The managed stand LRSY is approximately 870,000 m^3/yr. This is an astounding 2.5 times greater than the natural stand LRSY, providing a strong indication that natural stand productivity is underestimated. The managed stand LRSY is also 26% greater than the base case long-term harvest level of 690,000 m^3/yr. The difference indicates that the full productive capacity of the managed stands is not being captured. The loss of potential harvest can be attributed to the many management objectives that reserve stands from harvest in the long-term. The impact of these management objectives on timber supply will be explored in the following sensitivity analysis section.

Figure 6.11 presents the base case harvest flow along with the natural and managed stand LRSY.

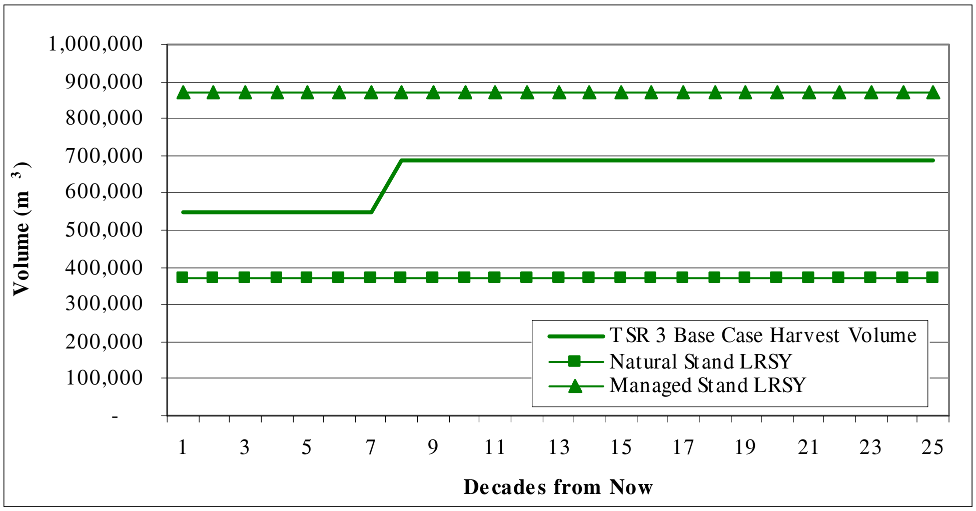

Figure 6.11. Base case harvest flow and LRSY

7.0 SENSITIVITY ANALYSIS

Sensitivity analysis provides a measure of the upper and lower bounds of the base case harvest forecast, reflecting the uncertainty inherent in assumptions made in the base case. The magnitude of the change in the sensitivity variables reflects the degree of uncertainty associated with each variable. By developing and testing a number of sensitivity issues, it is possible to determine which variables most affect results. This in turn facilitates the management decisions that must be made in the face of uncertainty.

To allow meaningful comparison of sensitivity analyses, they are performed using the base case and varying only the assumption being evaluated. All other assumptions remain unchanged.

In each analysis, the changes in timber availability were first assessed, using the base case harvest level, and imposing the alternative assumption to be tested. Available growing stock was determined for each decade by setting an infinite harvest target for that period, and imposing the base case harvest request for all other periods. This process is repeated for each period. In this way, the impact on availability of the alternative assumption through the entire analysis time frame was determined. Based on the changes in availability, a new harvest level was sought, adhering to the flow policy described earlier.
In adjusting the flow to reflect the alternate assumption, short-term harvest levels were altered first, followed by mid-term and finally long-term levels.

The sensitivity issues are listed in Table 6.1. The timber supply impacts are illustrated in Sections 7.1 through 7.13.

7.1 HARVEST FLOW

Many harvest pattern options are available. These sensitivities explore the impact of using patterns that do not follow the harvest flow objectives listed in Section 3.0.

7.1.1 Establish a Non-declining Even Flow

In the process of determining the maximum non-declining even flow harvest (NDEF) can help to identify the times at which the most constraining timber supply shortages occur. The maximum NDEF was found to be 550,000 m^3/yr which also happens to be the current AAC, and the short-term harvest level of the base case. The harvest level is limited by the shortfall at decade seven. The harvest pattern is shown in Figure 7.1.

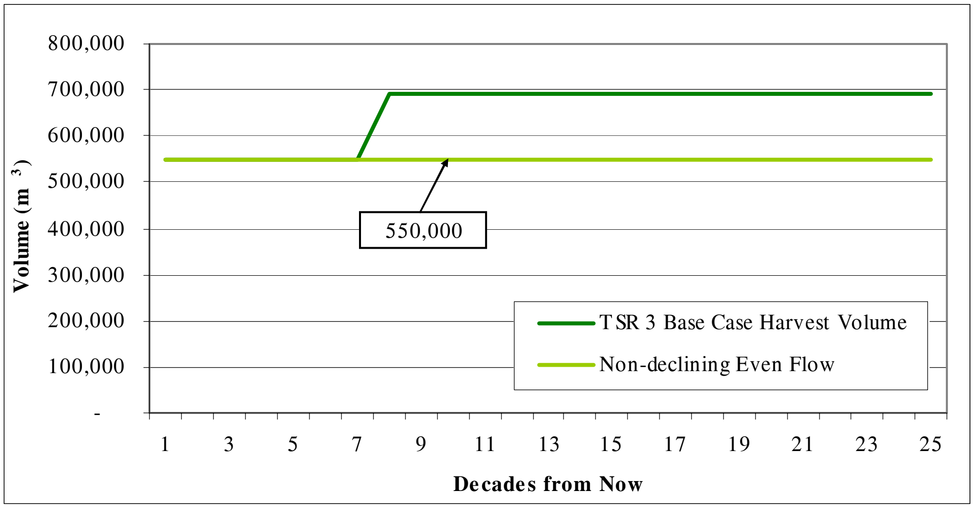

Figure 7.1. Non-declining even flow harvest level

It is clear that by not increasing the harvest flow after decade seven the yield from the managed stands is not captured. Since only the harvest request pattern changed in this sensitivity there was no change in the availability of volume. The available volume only changes when there is a change in the management assumptions. Therefore, no availability figure was generated for this sensitivity.

7.1.2 Highest Initial Harvest Level

The objective of this sensitivity was to identify the maximum initial harvest level. The sensitivity then also demonstrates the degree to which the increasing the initial harvest impacts the harvest level in the mid-term. The tradeoff required to balance an increase in initial harvest level can be seen in this extreme example. The results are shown in Figure 7.2.

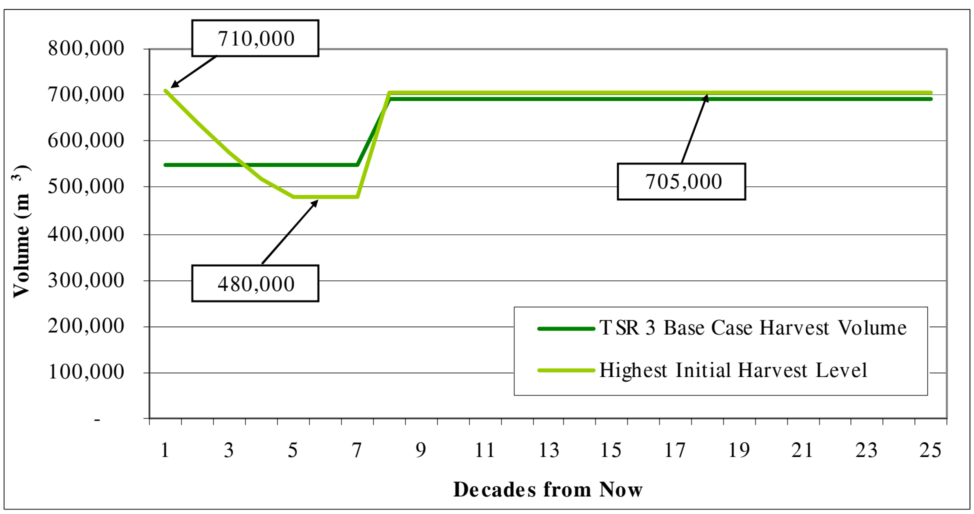

Figure 7.2. Highest initial harvest level harvest flow

The maximum initial harvest level was 710,000 m^3/yr. At this level, all of the available volume in decade one was harvested. Therefore it was necessary to immediately decrease the harvest level by 10% steps over the next four decades. The maximum sustainable mid-term harvest level was 480,000 m^3/yr. After decade seven, the managed stands provide enough volume to restore the harvest level to a level slightly higher than the base case long-term level (710,000 m^3/yr). This is likely the result of accelerated initial harvest. By harvesting more stands earlier, a greater proportion of stands regenerate to maturity sooner. These stands provides more harvest volume during the critical shortfalls that occur at the transition from the harvest of natural stands to the harvest of managed stands.

Since this sensitivity only required a change in harvest request pattern no availability figure was generated for this sensitivity.

7.1.3 Oldest First Harvest Priority

The base case was modelled using the relative oldest first harvest priority. In this sensitivity, the oldest stands were prioritized for harvest first. The change to this harvest priority resulted in decrease in the long-term maximum sustainable harvest level to 685,000 m3/yr. The results are shown in Figure 7.3.

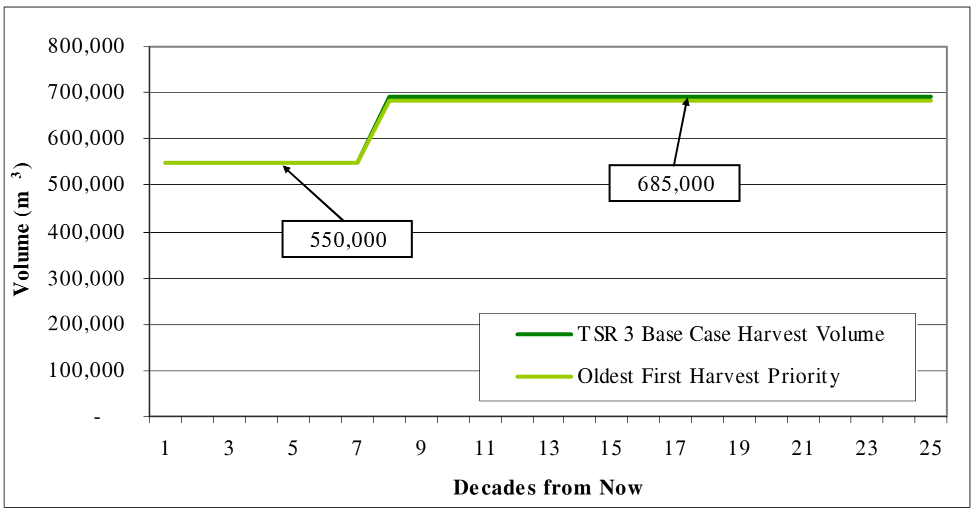

Figure 7.3. Oldest first harvest priority harvest flow

The change to the oldest first priority was anticipated to be a downward pressure. This is because the relative oldest first priority tends to select stands with lower minimum harvest ages. For example, if two stands are 250 years old, the stand with a minimum harvest age of 100 years is relatively older than the one with a minimum harvest age of 120. A higher harvest level is achieved because a lower minimum harvest age is often associated with higher productivity stands. Therefore, the relative oldest first harvest priority tends to harvest and grow high productivity stands while reserving lower productivity stands for meeting habitat and biodiversity objectives.

The results show almost no difference between the two harvest priority rules. This is likely because there is such a limited supply of timber in the short-term that similar stands are selected using either priority. In the long-term, there is more harvesting flexibility which allows for different harvesting priority options. The outcome of this can be seen in long-term harvest level difference. It can also be seen in the difference in available volume is shown in Figure 7.4.

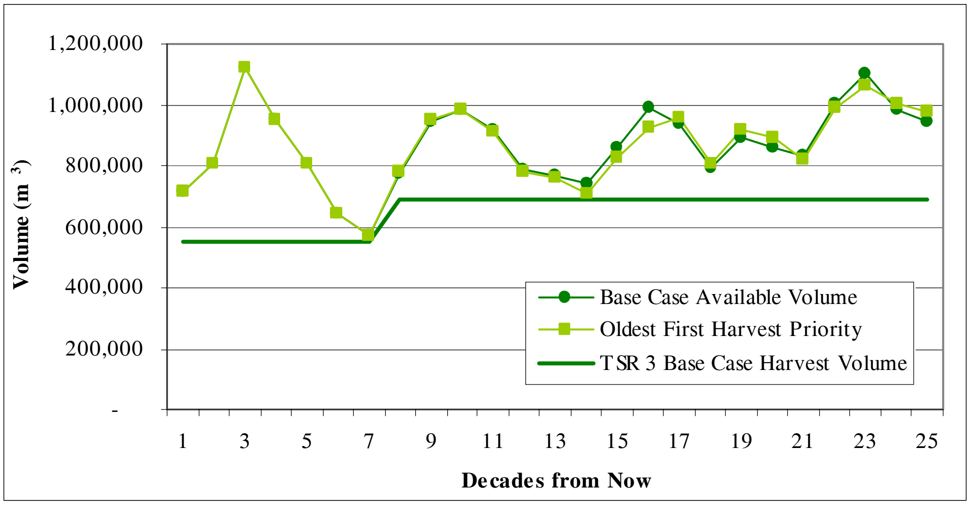

Figure 7.4. Oldest first harvest priority available volume

The decrease in available volume resulting from the oldest first harvest priority only becomes apparent past decade twelve. Since the most limiting point in the long-term around decade fourteen, the long-term harvest level was reduced.

7.2 LAND BASE

The timber supply modelling exercise assumes that the size of the THLB will remain constant over the modelled time horizon (expect for losses to future roads). With land use values changing over time, there is some uncertainty associated with this assumption. In these sensitivities, the size of the THLB was increased or decreased by 10% uniformly across all stands. There was a proportional shift in the non-THLB to compensate so that the total land base area remained constant.

7.2.1 Increase Timber Harvesting Land Base by 10%

Increasing the THLB by 10% resulted in dramatic increases in both the short and long-term maximum sustainable harvest levels. The short-term harvest level increased to 600,000 m^3/yr and the long-term increased to 750,000 m^3/yr. These both represent approximately 8% increases over the base case values. The differences are shown in Figure 7.5.

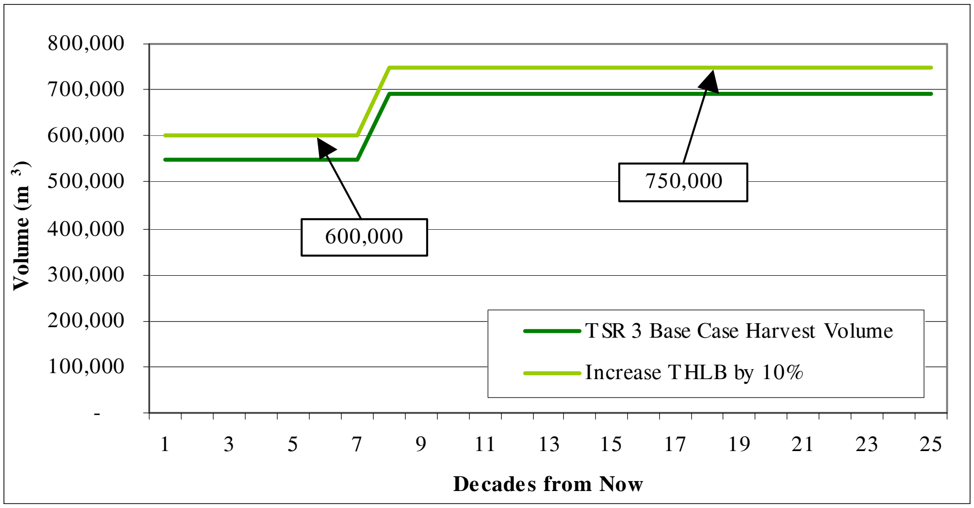

Figure 7.5. Increase timber harvesting land base by 10% harvest flow

It is interesting to note that a 10% shift in the land base did not result in a proportional 10% shift in the harvest levels. This indicates that other management objectives still limit harvest flexibility in such a way that the full harvesting potential of an increase in THLB area can not be utilized directly. This trend can be observed in the available volume levels shown in Figure 7.6.

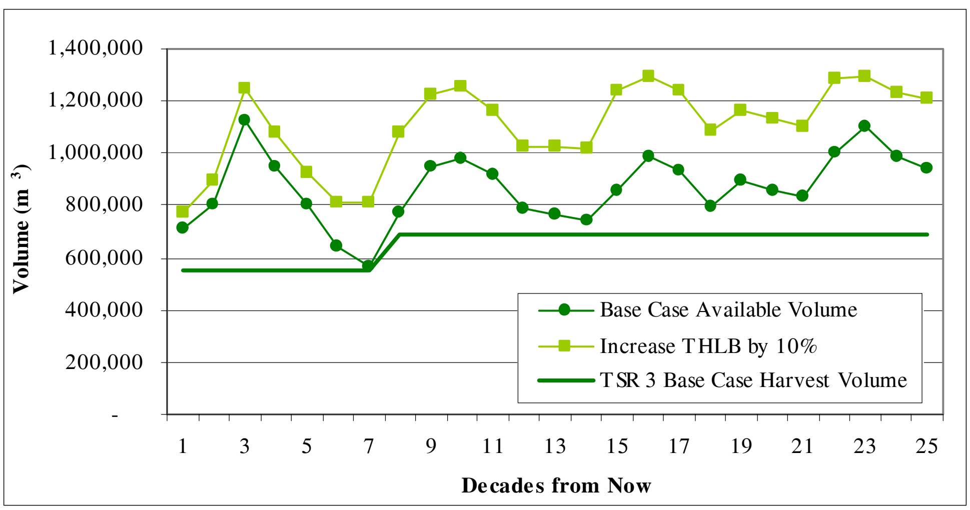

Figure 7.6. Increase timber harvesting land base by 10% available volume

7.2.2 Decrease Timber Harvesting Land Base by 10%

The decrease in the THLB resulted in an immediate impact on harvest levels. The initial harvest level could be maintained for one period and then had to be reduced by 10% to 495,000 m^3/yr. Only after decade seven could the harvest level be increased to a long-term level. The long-term level was also impacted and had to be reduced to 625,000 m^3/yr. These changes represent short and long-term decreases of 10% and 9% respectively. These impacts are shown in Figure 7.7.

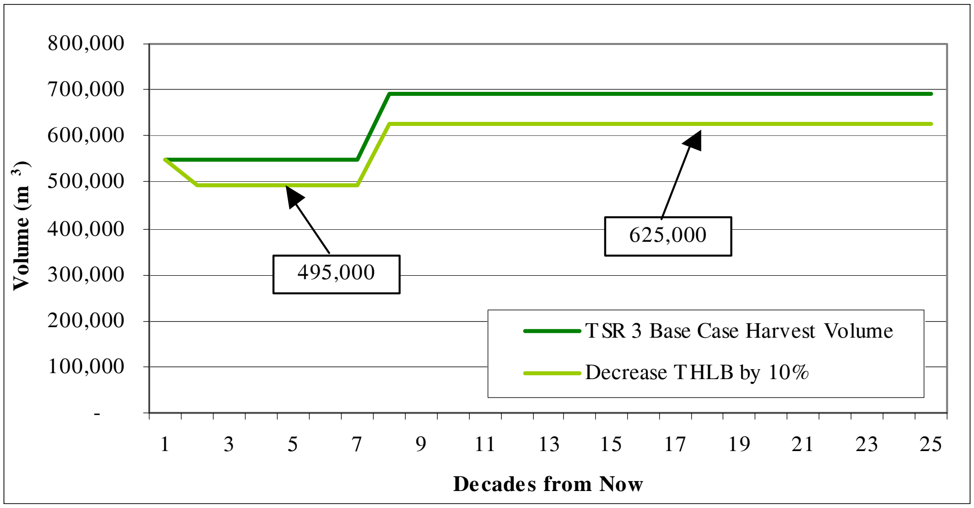

Figure 7.7. Decrease timber harvesting land base by 10% harvest flow

Unlike the increase in THLB sensitivity, the decrease in THLB resulted in an almost proportionate decreases in harvest levels. This is not unusual as a decrease in the THLB reduces the harvesting flexibility and would be anticipated to have compounding effects with other management objectives that could potentially result in impacts greater than the proportion of the decrease. The impact on available volume is shown in Figure 7.8.

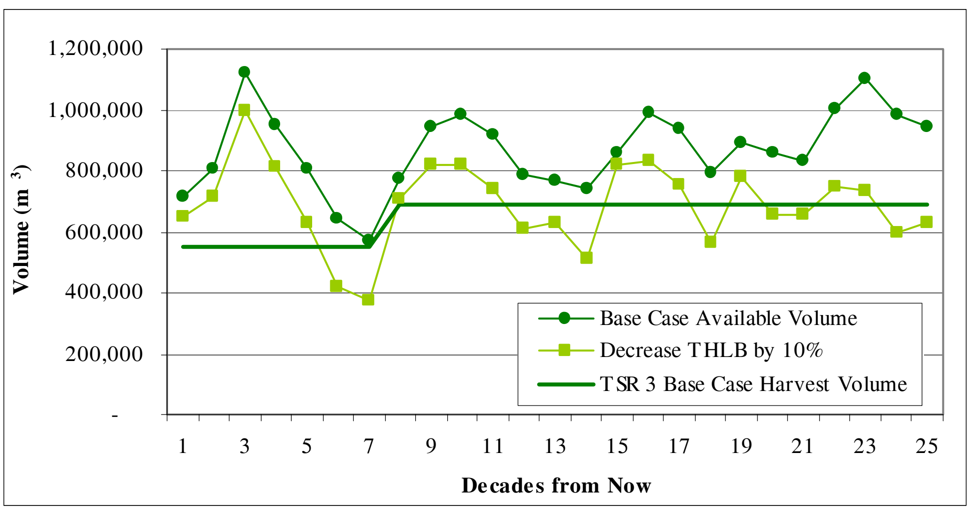

Figure 7.8. Decrease timber harvesting land base by 10% available volume

7.3 GROWTH AND YIELD

In TSR 2, the uncertainty around the productivity estimates was explored by adjusting the model yields by 10%. This gave a relative estimation of the impact. In the course of completing the TSR 3 data package, the accuracy of the site index productivity estimates was investigated using data from the inventory audit. The investigation compared the ground sample measured site index to the managed stand site index values generated using SIBEC. It revealed that the site index of managed stands was likely overestimated by approximately 1.5 meters. The investigation also compared the ground sample site index values to the natural stand site index values calculated from the VRI. It revealed that the site index of natural stands was likely underestimated by approximately four meters.

Therefore, in order to explore the uncertainty around these results, it was decided that the growth and yield sensitivities would be adjusted with direct site index shifts. An adjustment of three meters was selected as an interval that would give an approximation of the impact on timber supply if the productivity investigation results are confirmed.

A site index shift of three meters is a major change in terms of site index. Therefore, the sensitivity adjustments resulted in some dramatic shifts in the harvest levels that made the impacts difficult to interpret. However, it is important to consider that this scale of the shift is potentially close to reality.

7.3.1 Increase Natural Stand Site Index by 3m

A change to natural stand yields will impact the short-term harvest level since the initial harvest all comes from the natural stands. The three meter increase resulted in a dramatic increase of 120,000 m^3/yr in the short-term harvest level to 670,000 m^3/yr. The dramatic change in the initial harvest level had very little repercussion on the long-term harvest level which only increased by 10,000 m^3/yr to 700,000 m^3/yr. These changes are shown in Figure 7.9.

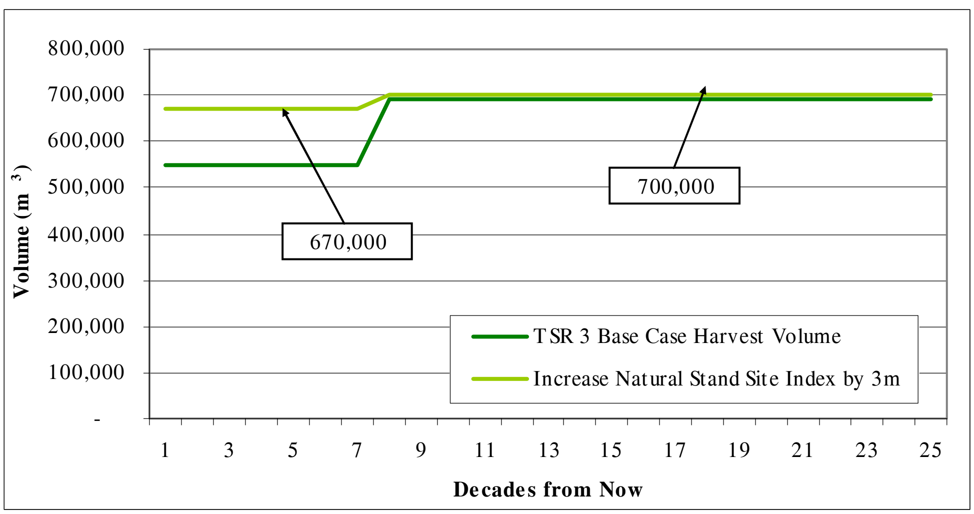

Figure 7.9. Increase natural stand site index by 3m harvest flow

The increase in natural stand yields almost completely filled the difference between the short-term and long-term (*i.e.* natural stand and managed stand) harvest levels. However, the transition at decade seven still remains as the factor defining the harvest flow pattern.

Minimum harvest ages were calculated based on yield curve characteristics. Therefore, changes to the site productivity resulted in changes to the minimum harvest ages. The increased site index values lowered the minimum harvest ages for the natural stands which increases harvest option flexibility. The higher flexibility likely helped the harvest flow to pass the decade seven shortfall at a higher harvest level. The impact of minimum harvest age on timber supply is explored in more detail in Section 7.6. The resulting changes in available volume can be seen in Figure 7.10.

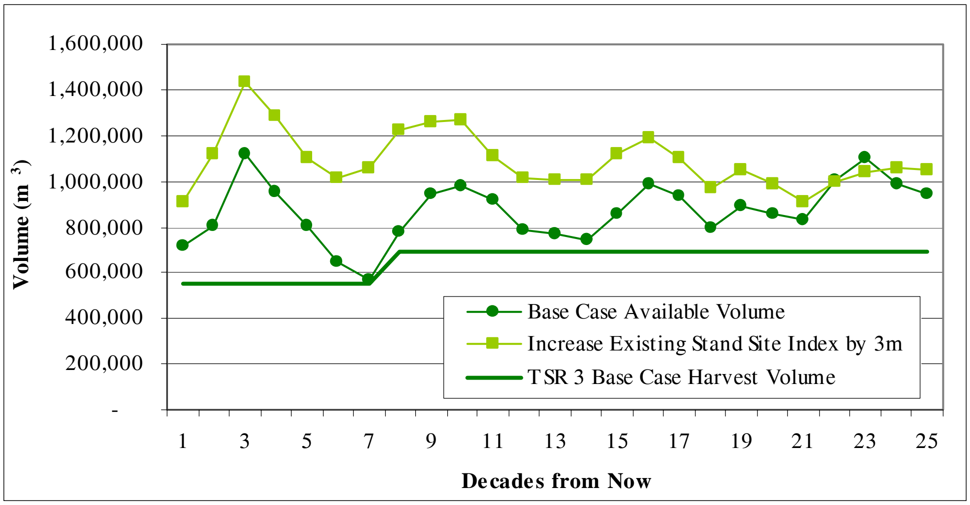

Figure 7.10. Increase natural stand site index by 3m available volume

7.3.2 Decrease Natural Stand Site Index by 3m

After observing the dramatic impact of increasing the natural stand yields by three meters, the large impact of decreasing the yields for the same stands by three meters was not surprising. This was the only sensitivity where the current AAC harvest level could not be achieved for the first harvest period. The decrease in yields resulted in an immediate drop to 475,000 m^3/yr. This was followed by a further 10% drop to 430,000 m^3/yr for the remainder of the mid-term. As was seen in the previous sensitivity, the major change in the natural harvest level had very little impact on the long-term harvest level which was slightly reduced to 680,000 m^3/yr. These levels are shown in Figure 7.11.

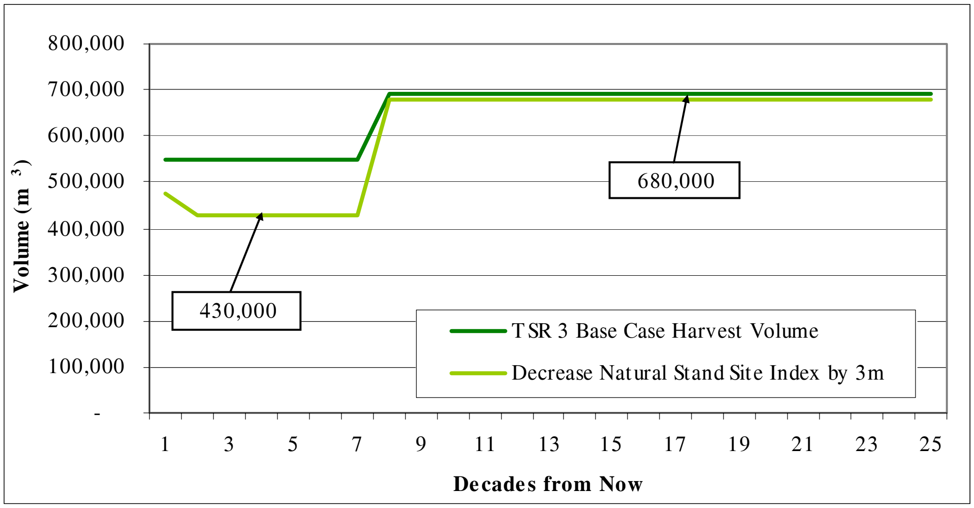

Figure 7.11. Decrease natural stand site index by 3m harvest flow

Although three meters is a large adjustment, the extreme response to both increase and decrease of the natural stand site index adjustment indicates that the short-term harvest level is very sensitive to stand yields. This is because the short-term harvest level is higher than the productive capacity of the natural stands. The natural stand volume is being rapidly depleted over the short-term until the higher yielding managed stands are old enough to contribute to the harvest and compensate for the over-harvest. By decreasing the productive capacity of the natural stands, the already scarce volume available is further depleted. This resulted in the large decrease in the maximum harvest level that can be sustained through the short-term. The impact of lower site index values on the minimum harvest ages likely also contributed to the decrease. The decreased stand productivity resulted in lower minimum harvest ages which reduce harvest flexibility. The drop in available volume is shown in Figure 7.12.

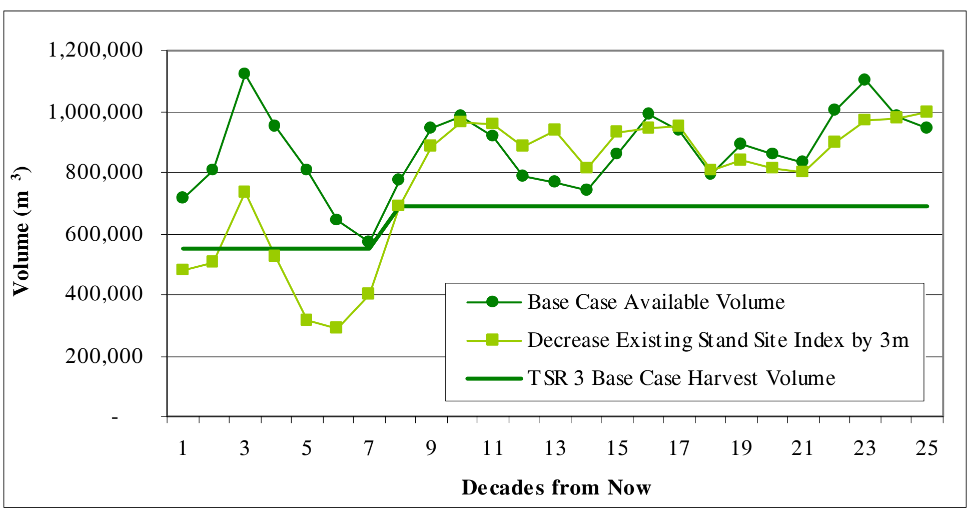

Figure 7.12. Decrease natural stand site index by 3m available volume

7.3.3 Increase Managed Stand Site Index by 3m

The managed stand site index values increased from previous analyses through the shift to SIBEC based estimates. Therefore, it is not likely that a further increase in site index may occur. This sensitivity was included as a parallel to the following decreased managed stand site index sensitivity for contrast. An adjustment to the managed stand productivity was anticipated to have an impact on the long-term. But the analysis of the base case revealed that managed stands are making a contribution to the harvest level starting from period six (Figure 6.3). Therefore, it was not surprising to observe an increase in the short-term harvest level to 650,000 m^3/yr. As expected, long-term as increased to 845,000 m^3/yr. These levels are shown in Figure 7.13.

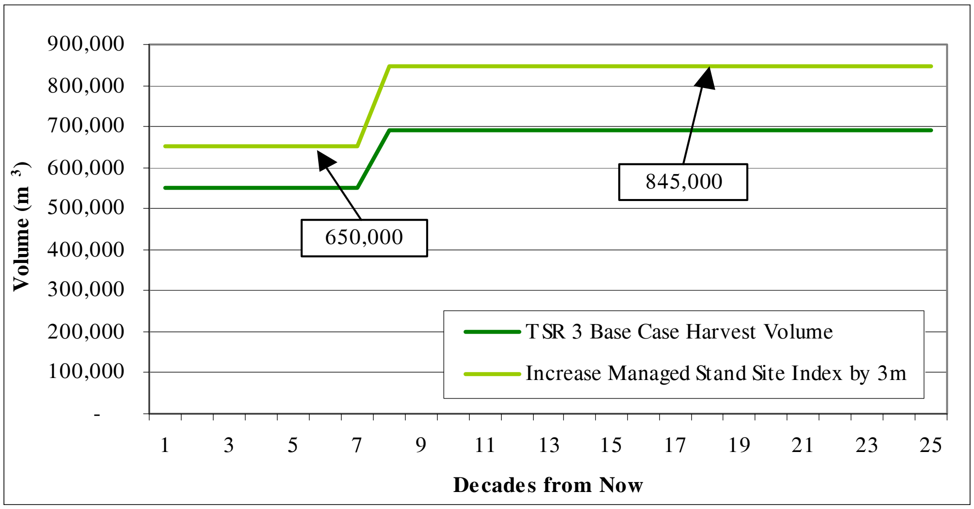

Figure 7.13. Increase managed stand site index by 3m harvest flow

The short-term harvest level increased by 100,000 m^3/yr and the long-term increased by over 150,000 m^3/yr. These impressive increases further demonstrate the sensitivity of the harvest flow to productivity, but it is still important to remember that three meters is a large adjustment factor. The increased contribution from managed stands helped to pass the shortfall at decade seven. The increased site index also caused the minimum harvest ages to be decreased for managed stands. The impact of changes in managed stand productivity on minimum harvest ages should also be considered. The increased site index values resulted in lower harvest ages which increase harvest flexibility. The flexibility likely made it easier for the harvest flow to pass the shortfall at decade seven at a higher harvest level. The increased availability through this period can be seen in Figure 7.14.

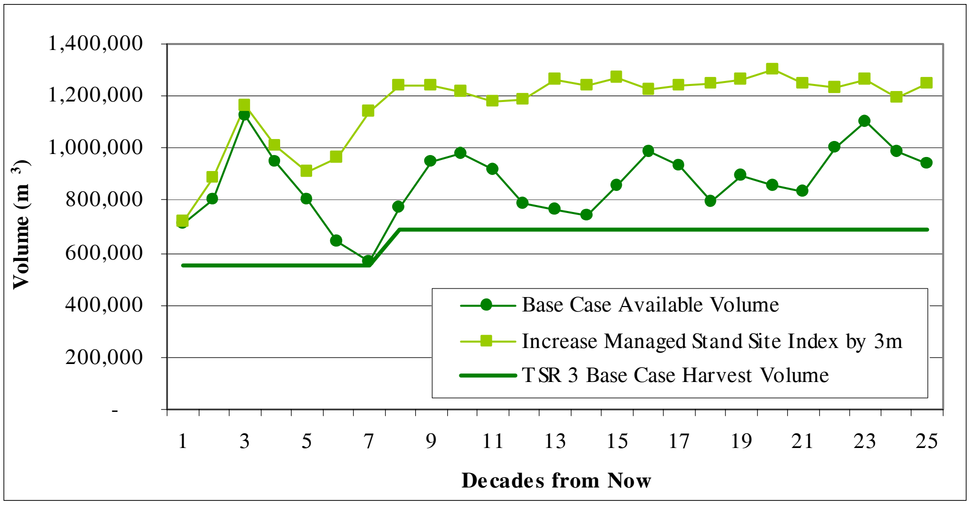

Figure 7.14. Increase managed stand site index by 3m available volume

7.3.4 Decrease Managed Stand Site Index by 3m

Decreasing the managed stands site index resulted in a drop in the short-term harvest level immediately after the first decade. The short-term harvest level dropped by a 10% step in period two and then dropped to 460,000 m^3/yr for the remainder of the short-term. The transition point from natural to managed stands was delayed by the reduction in the growth potential of the managed stands. The step up in harvest level could only occur at decade nine. Even then, the maximum sustainable long-term harvest level was 525,000 m^3/yr. The harvest levels are shown in Figure 7.15.

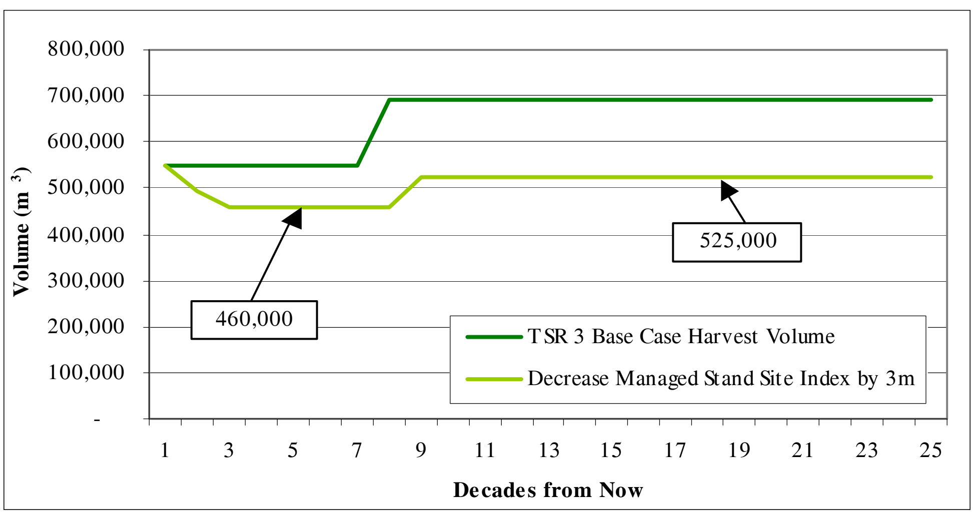

Figure 7.15. Decrease managed stand site index by 3m harvest flow

The immediate impact on the short-term harvest level indicates how much the managed stands contribute to the short-term harvest. The delay in the transition to managed stand harvest is not surprising because the decreased productivity resulted in higher minimum harvest ages. Therefore, it took longer for the regenerating stands to reach the age at which they were able to contribute to the timber supply. The drop in the long-term harvest level was dramatic as it decreased to a level below the current AAC. This is likely simply due to reduced yields as can be seen in the available volume shown in Figure 7.16.

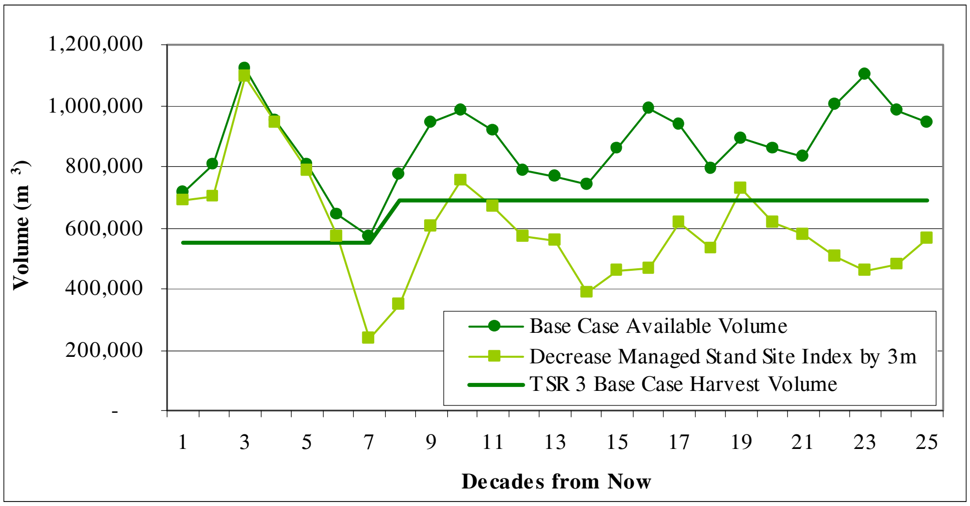

Figure 7.16. Decrease managed stand site index by 3m available volume

7.4 VISUAL LANDSCAPE

In Section 4.3.2 it was shown that management for visual resources is conducted across a large proportion of the Arrow TSA. In previous analyses this management objective has proven to have a large influence on the timber supply. The uncertainty surround the management of visual resources was explored in three sensitivities. The first two studied the impact adjusting the maximum disturbance percentages allowed in the visual resource emphasis areas. The third explored the impact that grouping similar visual polygons together had on timber supply.

7.4.1 Increase Disturbance Percentages by 5%

The amount of disturbed area is limited in visual resource emphasis zones. This objective is maintained by placing a limit on the total area that is currently below green up height. The area limit was set as a percentage of the visual polygon area. The percentage was determined based on the visual quality objective of the polygon. These percentages ranged from 25% for modification to 5% for retention. This objective tends to limit timber supply because stands that would otherwise be harvestable are restricted from harvest while other stands within the same visual polygon are below green-up height

In this sensitivity the percentages were each increased by 5%. This had an upward pressure on timber supply since a greater proportion of the land base could be below green-up height. This increased the number of stands available for harvest and allowed for greater harvest flexibility. The short-term harvest level was increased to 585,000 m^3/yr and the long-term harvest level increased to 730,000 m^3/yr. These harvest levels are shown in Figure 7.17.

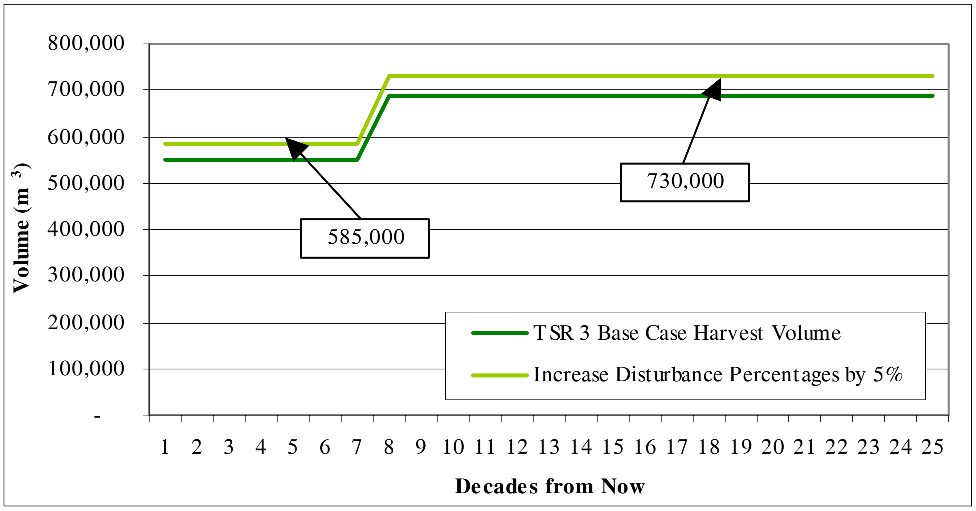

Figure 7.17. Increase disturbance percentages by 5% harvest flow

This sensitivity had an impact on both the long-term and the short-term harvest levels. The short-term was affected because it is limited by the age class gap that causes the shortfall at decade seven. Adjusting the disturbance percentages provided some flexibility to pass this point with a slightly higher harvest level. Once past the shortfall, it can be seen that the disturbance percentages play a large role in determining the maximum long-term sustainable harvest level. This difference can be seen in the available volumes in Figure 7.18.

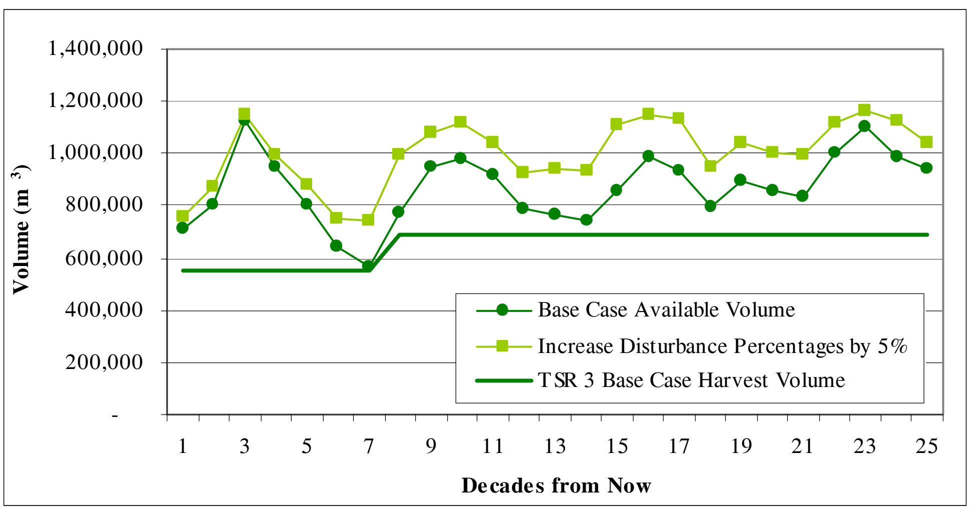

Figure 7.18. Increase disturbance percentages by 5% available volume

7.4.2 Decrease Disturbance Percentages by 5%

If increasing the disturbance percentages resulted in more stands available for harvest and greater harvest flexibility, then it can be anticipated that decreasing the percentages would result in a more restricted timber supply. This sensitivity revealed that decreasing the disturbance percentages had an impact on both the short and long-term harvest levels. The initial harvest level could only be maintained for one decade before it was necessary to drop the harvest level by 10% to 495,000 m^3/yr for the mid-term. The maximum sustainable harvest level in the long-term was decreased to 635,000 m^3/yr. The harvest levels are shown in Figure 7.19.

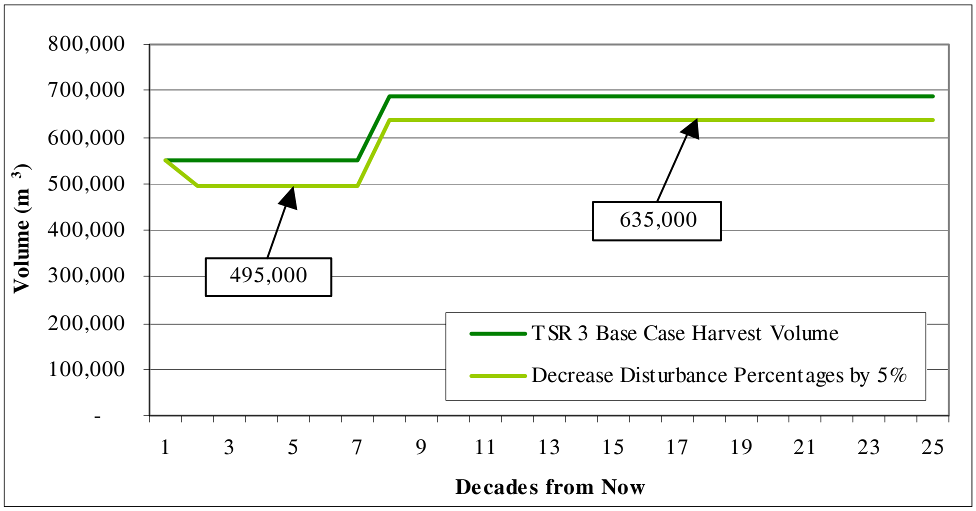

Figure 7.19. Decrease disturbance percentages by 5% harvest flow

The increase in disturbance percentages did not significantly ease the factors limiting the short-term harvest level. However, decreasing the disturbance percentages appears to have compounded with the other downward pressures resulting in a large decrease. The land base is so tightly constrained that any downward pressure will affect the harvest level. As was discussed above, it appears that the management of visual resources is one of the more influential factors on the long-term harvest level. This was further confirmed by the decrease observed in the maximum sustainable long-term harvest level that was almost proportional to the increase seen in the previous sensitivity. The change in available volume is shown in Figure 7.20.

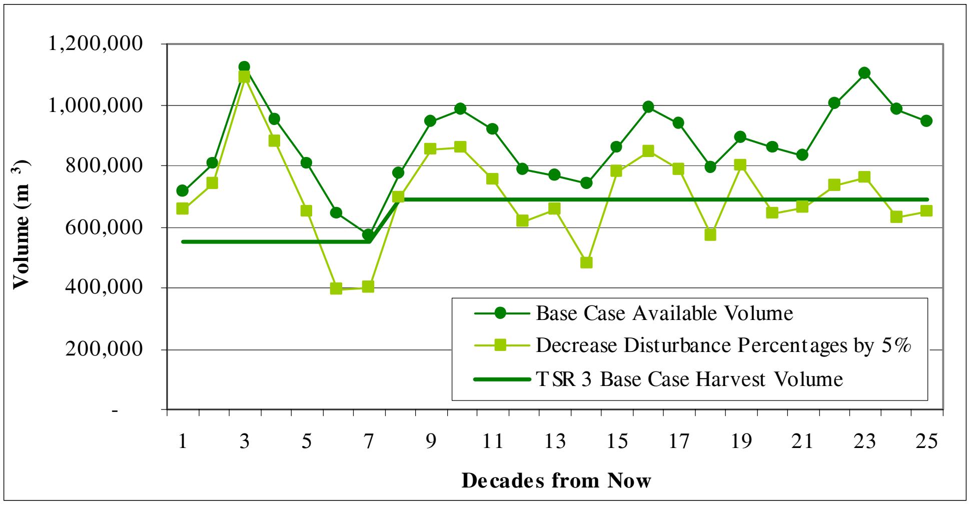

Figure 7.20. Decrease disturbance percentages by 5% available volume

7.4.3 Visual Polygons Not Grouped

An investigation of the visual resource mapping revealed that many of the visual polygons shared the same visual quality objective as an adjacent polygon. For input to the base case, an exercise was undertaken to group these similar polygons. By combining polygons, the harvest flexibility was increased because the same objective could be met through contributions from stands over a larger area.

In this sensitivity, the visual polygon groupings were not utilized. This resulted in almost no impact on the short-term harvest level. A small drop to 520,000 m^3/yr was required to pass the shortfall at decade seven. The impact on the long-term was also very small requiring only a 5,000 m^3/yr decrease to 685,000 m^3/yr. These differences are shown in Figure 7.21.

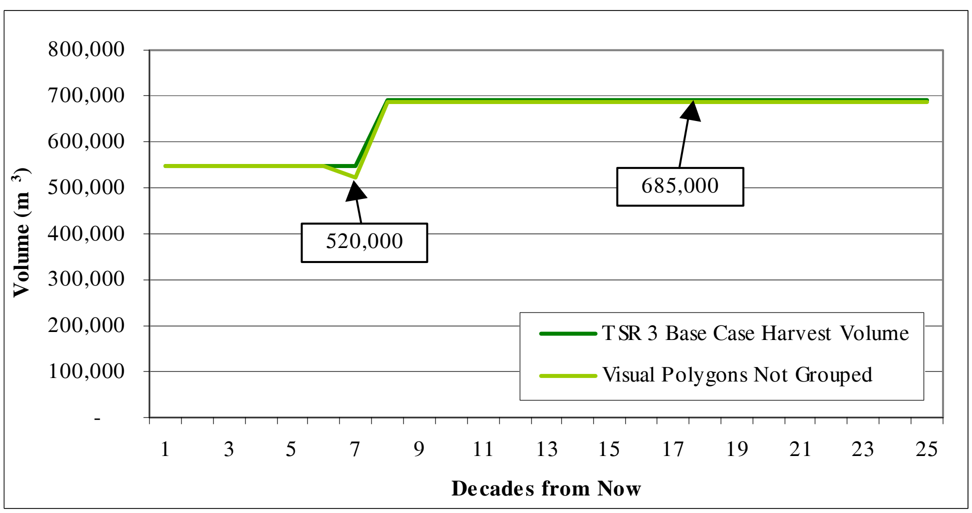

Figure 7.21. Visual polygons not grouped harvest flow

The impact of not using the visual polygon groupings demonstrates the relative gains provided by grouping the polygons. If the polygon groupings were not used the impact on the base case would be small. This demonstrates that the risk associated with using this methodology is minor. The differences in the available volume shown in Figure 7.22 are difficult to discern.

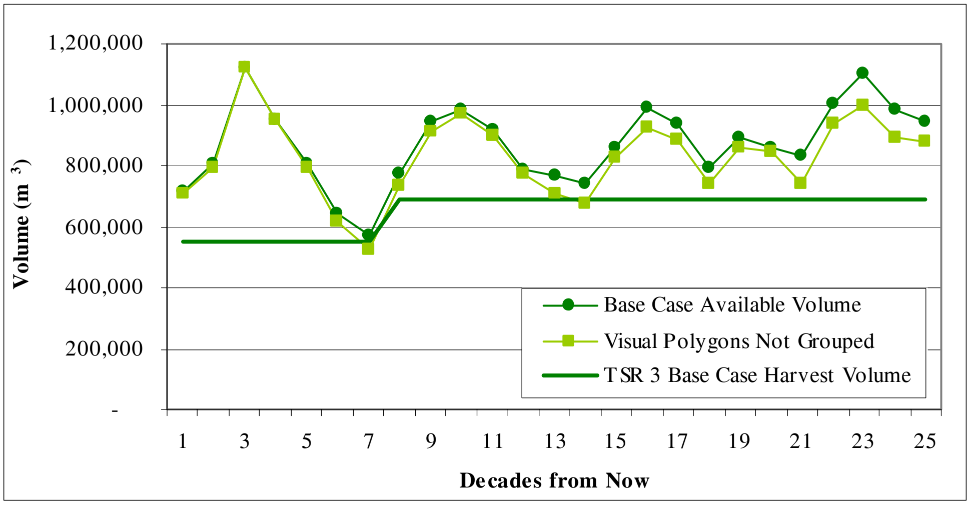

Figure 7.22. Visual polygons not grouped available volume

7.5 GREEN-UP

Green-up refers to the point at which a stand reaches full establishment and the stand area is no longer considered to be disturbed. Green-up is usually measured through stand height. A modelling exercise was undertaken in this analysis to determine visually effective green-up (VEG) heights for all stands within the THLB. This sensitivity investigates the risk associated with the uncertainty that the VEG heights may be overestimated or underestimated.

Green-up is one of the two variables used to manage stands for visual management objectives. A maximum disturbance percentage is placed on stands within a visual polygon. Until a recently harvested stands reaches its green-up height, it is still considered to be disturbed and contributes towards the disturbance area total. This prevents the potential harvest of other stands in the visual polygon.

7.5.1 Increase Green-up Heights 1.5 m

In this sensitivity the green-up heights were all increased by 1.5 m in the visual management areas. This resulted in a downward pressure because it requires a longer time for the stand to grow to the higher green-up height. Meanwhile the stand is still considered to be disturbed and restricts the potential harvest of other stands in the same visual polygon because of the maximum disturbance percentage constraints. The downward pressure was not immediately apparent in the short-term. The initial harvest level could be maintained for five decades before an approximately 10% drop to 500,000 m^3/yr was required for two decades to pass the shortfall at decade seven. The impact on the long-term was a decrease to 675,000 m^3/yr. The harvest flows are shown in Figure 7.23.

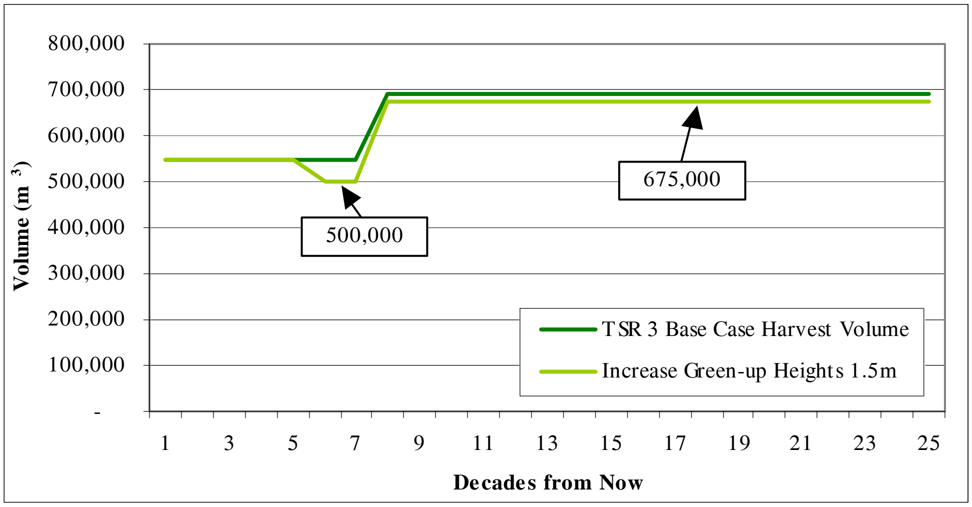

Figure 7.23. Increase green-up heights 1.5 m harvest flow

Since green-up works in conjunction with the disturbance limits used to manage visual resources, this sensitivity shares the same impact on the timber supply. Increasing the green-up height limits the availability of stands for harvest and reduces harvesting flexibility. Green-up likely also plays a large role in determining the maximum sustainable long-term harvest level as was seen in the disturbance percentage sensitivities. The impact of the green-up sensitivity appears to be less only because of the scale of the adjustment selected during the development of the analyses. The impact of the selected adjustment on available volume is shown in Figure 7.24.

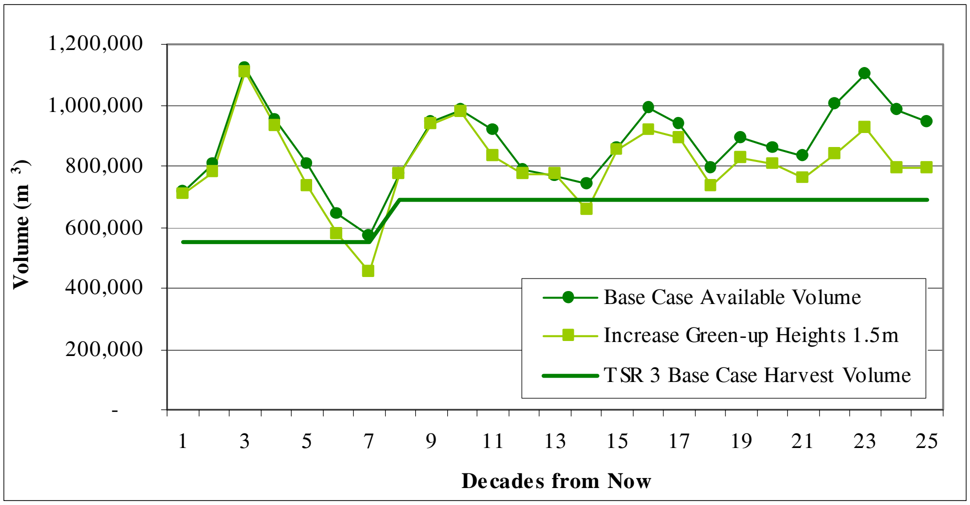

Figure 7.24. Increase green-up heights 1.5 m available volume

The available volume follows a similar pattern to the impact of adjusting the disturbance percentages on available volume.

7.5.2 Decrease Green-up Heights 1.5 m

In this sensitivity, the decrease in green-up height in the visual management areas resulted in an upward pressure on timber supply. By allowing the stands to achieve green-up at a lower height, more stands were available for harvest and harvest flexibility was increased. The short-term harvest level increased to 570,000 m^3/yr and the long-term harvest level increased to 715,000 m^3/yr. These levels are shown in Figure 7.25.

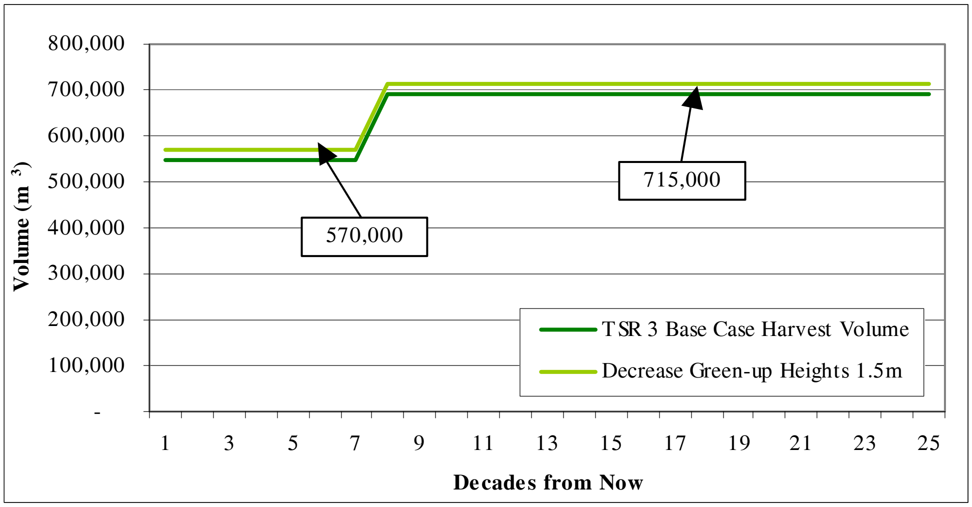

Figure 7.25. Decrease green-up heights 1.5 m harvest flow

The impact on the short-term harvest level was the same as the impact of increasing the disturbance percentages showing that both adjustments have a limited ability to ease the limits on the short-term harvest. Again, the impact on the long-term is less than the increased disturbance percentage sensitivity but this is likely due to the smaller scale of the adjustment used in this sensitivity. However, the shift in the long-term harvest level was proportionally much larger than compared to the downward shift observed in the increased green-up sensitivity. This difference can be seen by comparing the available volume shown in Figure 7.26 with that of the previous sensitivity (Figure 7.24).

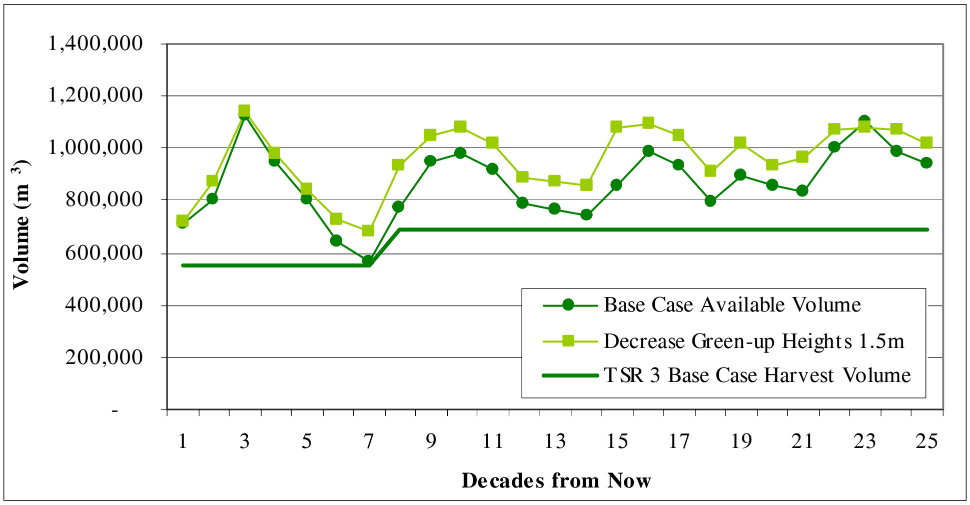

Figure 7.26. Decrease green-up heights 1.5 m available volume

7.6 Minimum Harvest Ages

The minimum harvest ages were set to the age at which a stand reaches 95% of its culmination mean annual increment. Adjusting the minimum harvest ages often results in complicated trends. By lowering the minimum harvest age, the regenerating stands are made available for harvest sooner which increases modelling flexibility. However, if the stands are harvested sooner, it is done at the cost of volume because the stands have not reached their optimal volume accumulation potential. Since the minimum harvest age is set at 95% of the culmination mean annual increment (CMAI), the efficient growth that occurs before CMAI is reached is lost.

7.6.1 Increase Minimum Harvest Ages 10 Years

The timber supply appears to be very sensitive to adjustments in minimum harvest age. Increasing the minimum harvest ages by 10 years resulted in an almost immediate decrease in the short-term timber supply. The initial harvest level could only be maintained for two decades before a 10% drop to 495,000 m^3/yr was required for the remainder of the mid-term. Atypical of the other sensitivity analyses, the shortfall usually found at decade seven was still limiting harvest levels at decade eight in this sensitivity analysis. Therefore, the mid-term harvest level of 495,000 m^3/yr was maintained through decade eight and the harvest level was increased to the long-term level at decade nine.

The complicated nature of adjusting the minimum harvest ages is demonstrated through the impact on the long-term timber supply. Although increasing the minimum harvest age had a downward pressure on the short-term, it resulted in a positive pressure on the long-term harvest level. The long-term maximum sustainable harvest level was 700,000 m^3/yr and is shown in Figure 7.27.

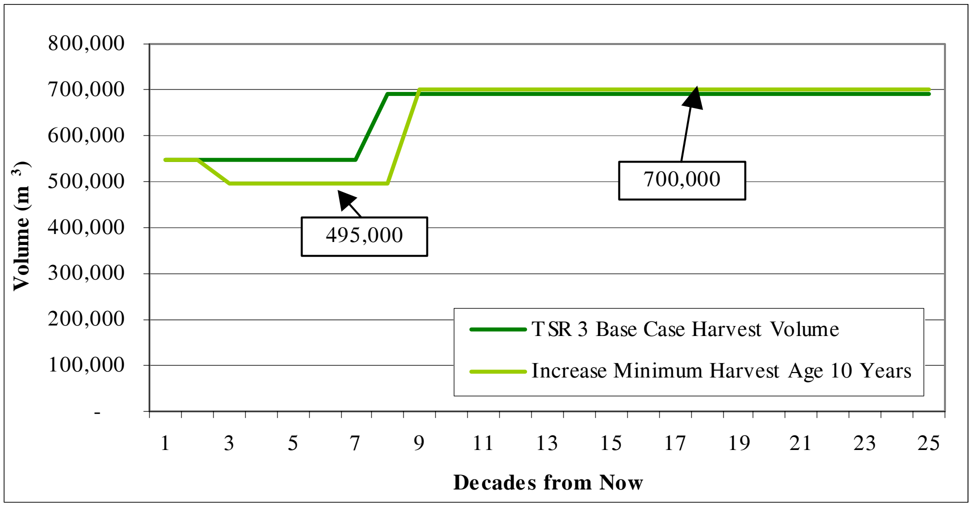

Figure 7.27. Increase minimum harvest ages 10 years harvest flow

These contrary results in the short and long-term are the result of the tradeoff between harvest flexibility and increased harvest volumes. The impact on the short-term was anticipated because the higher minimum harvest age resulted in a delay in access to the managed stands. This proved to be detrimental to the short-term harvest because yield from the managed stands is urgently needed to fill the shortfall at decade seven. This delay in access to managed stands even resulted in a delay in the transition of the short-term harvest level to the long-term harvest level by one decade.

An interesting result was the increase in the long-term harvest level. This is likely due to the fact that the adjusted constraint prevents the model from harvesting stands as early as possible. This is evidently not detrimental to the harvest flow and allows the stands reach their full growth potential. The result is better management of potential growth and a high harvest level. This can be seen in the available volume shown in Figure 7.28.

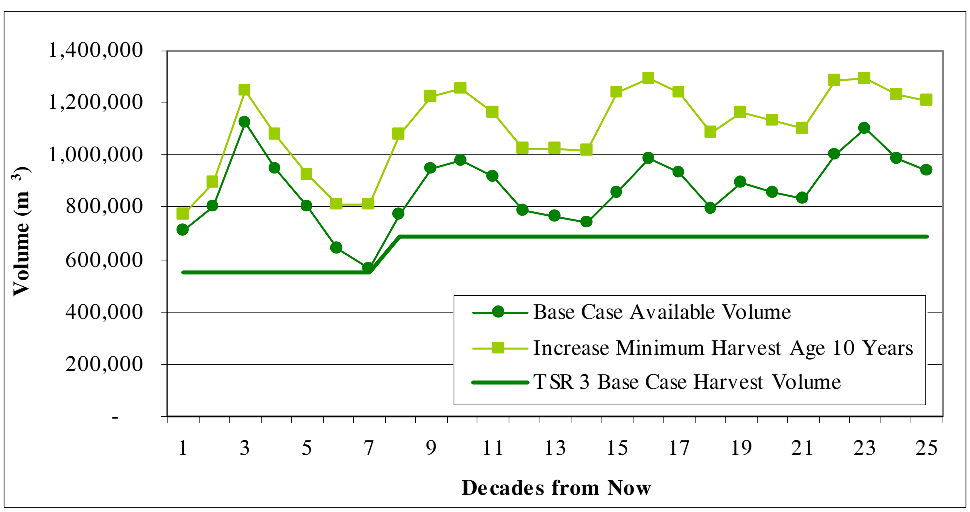

Figure 7.28. Increase minimum harvest ages 10 years available volume

7.6.2 Decrease Minimum Harvest Ages 10 Years

The decrease in the minimum harvest age appears to have been beneficial in the short-term. The short-term harvest level increased to 595,000 m^3/yr. However, similar to the increased minimum harvest age sensitivity, the impact of the long-term was the opposite. The long-term harvest level was reduced to 635,000 m^3/yr. These levels are shown in Figure 7.29.

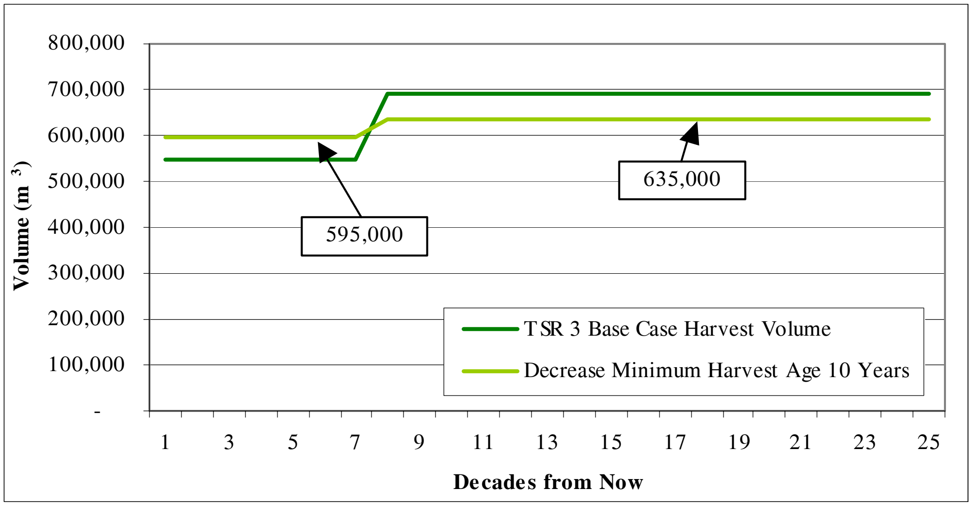

Figure 7.29. Decrease minimum harvest ages 10 years harvest flow

It was anticipated that lowering the minimum harvest age would aid the short-term harvest level because it would make the regenerating managed stands available for harvest sooner. This helped to fill the shortfall at the crucial transition from the harvest of natural stands to managed stands at decade seven. The degree of the impact on the long-term was again interesting. It is likely that the model utilized the option to harvest the managed stands as early as possible in the long-term. This resulted in lost growth potential and lower harvest yields. The available volume is shown in Figure 7.30.

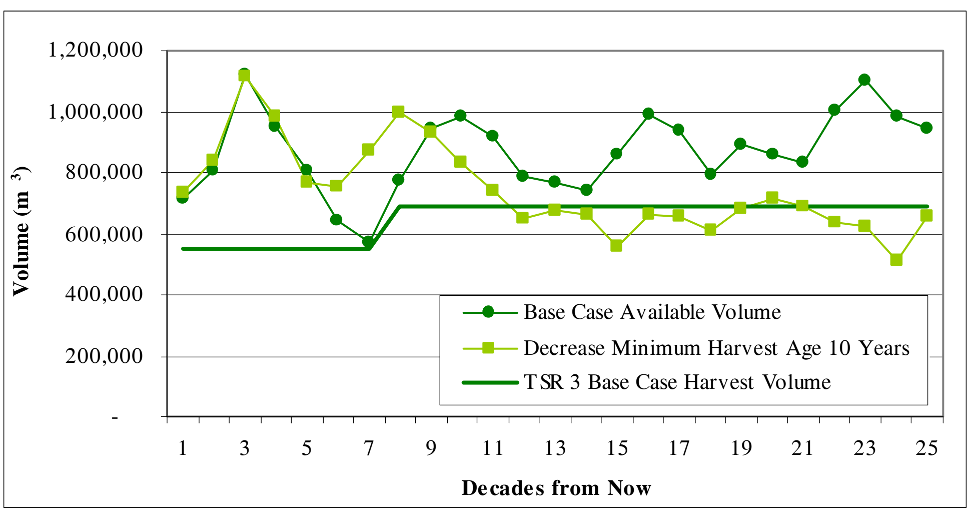

Figure 7.30. Decrease minimum harvest ages 10 years available volume

7.7 SLOCAN VALLEY

In the base case, the Slocan Valley was managed with no specific additional management objectives. However, there is still a large amount of uncertainty surrounding the management of this area. The following sensitivity analyses were performed to assess the risk associated with this uncertainty.

7.7.1 Slocan Valley Removed Using Contentious Area Definition

The contribution of the Slocan Valley to the base case was assessed by removing it from the harvestable land base. In this sensitivity analysis, the Slocan Valley was defined using the contentious area definition. This is a refined definition of the contentious area that only includes the valley bottom and visually sensitive face slopes encompassing 9,495 ha. Removing the Slocan Valley using this definition resulted in a mid-term decrease in harvest level to 505,000 m^3/yr after maintaining the initial harvest level for four decades. The long-term harvest level decreased to 670,000 m^3/yr.

An alternate harvest flow was developed with a non-declining short-term harvest level of 525,000 m^3/yr. The 25,000 m^3/yr difference between this harvest level and the base case harvest level can be used as an approximation of the contribution to the harvest flow made by the Slocan Valley contentious area. The harvest levels are shown in Figure 7.31.

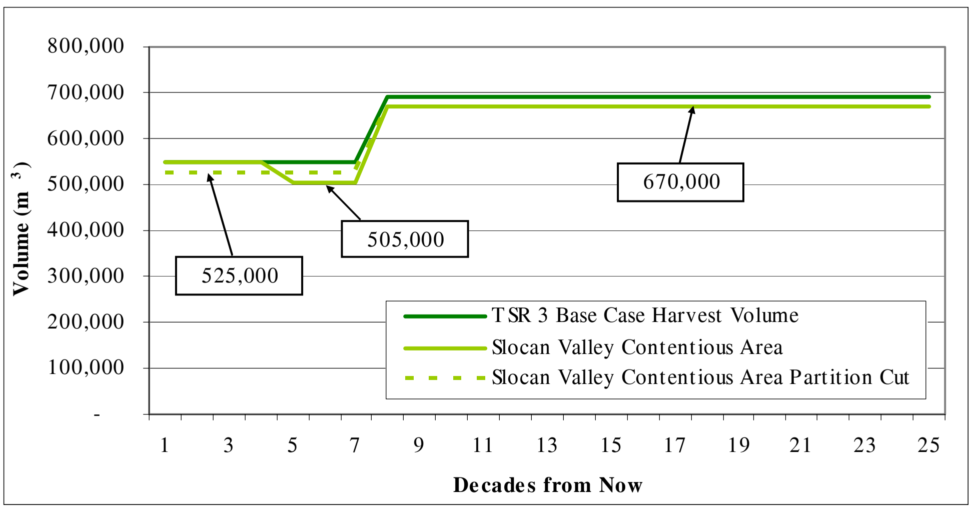

Figure 7.31. Slocan Valley removed using contentious area definition harvest flow

The 25,000 m^3/yr decrease in harvest resulting from the removal of the contentious area represents approximately 4.5% of the harvest. This is a proportional impact considering that the 9,495 ha within the contentious area represents approximately 4.5% of the THLB. The available volume is shown in Figure 7.32.

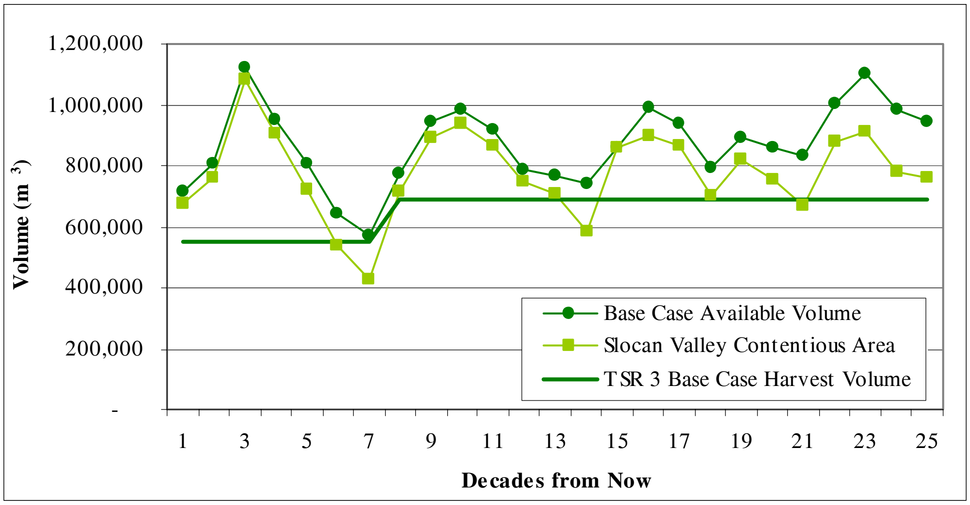

Figure 7.32. Slocan Valley removed using contentious area definition

The process of refining the definition of the Slocan Valley was evidently done in such a way that protected social values while still maintaining a relatively stable timber supply. However, the contentious area definition is still being refined at the time of this analysis and it is still not certain if it meets all of the social values associated with the Slocan Valley.

7.7.2 Slocan Valley Removed Using Five Landscape Unit Definition

The five landscape unit definition of the Slocan Valley encompasses a much broader area. It includes all of the area within the Hills, Idaho, Lemon, Pedro, and Perry landscape units encompassing a total of 36,047 ha. The contribution made by these landscape units was assessed by removing them from the harvestable land base. This had a dramatic impact on the short-term harvest level. The initial harvest level could only be maintained for one decade and the harvest level had to be dropped in two 10% steps over the next two decades. The mid-term harvest level was 430,000 m^3/yr. The long-term harvest level was also decreased by 100,000 m^3/yr to 590,000 m^3/yr.

An alternate harvest flow was developed with a non-declining short-term harvest level at 455,000 m^3/yr. The 95,000 m^3/yr difference between this harvest level and the base case harvest level can be used as an approximation of the contribution to the harvest flow made by the Slocan Valley five landscape units. The 95,000 m^3/yr decrease in harvest resulting from the removal of the five landscape units represents approximately 17.3% of the harvest. This is a reasonably proportional impact considering that the 36,047 ha within the five landscape units represents approximately 17.1% of the THLB. The harvest levels are shown in Figure 7.33.

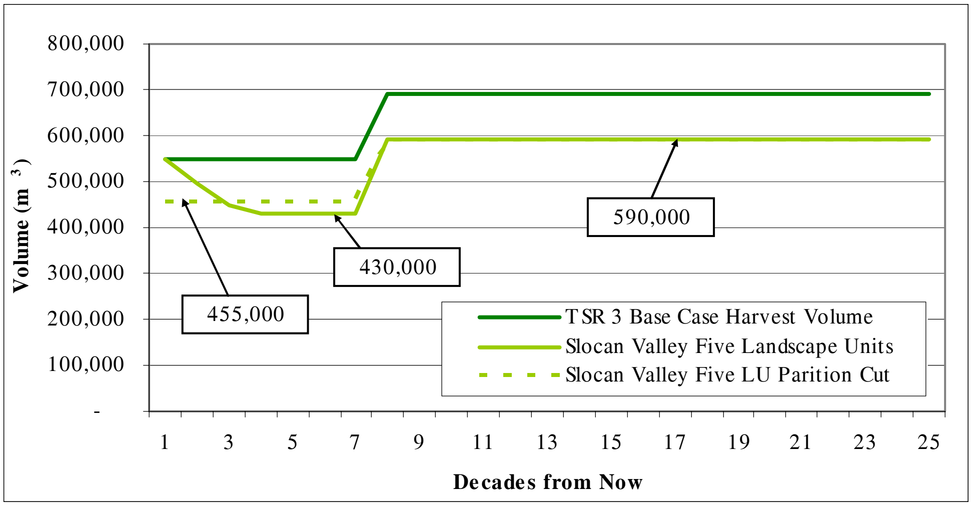

Figure 7.33. Slocan Valley removed using five landscape unit definition harvest flow

It appears that the five landscape units include parts of the land base that make an essential contribution to base case harvest level. This is a very broad definition of the Slocan Valley covering a much larger area and makes no attempt to balance the social values within the valley with timber harvest values. This sensitivity demonstrates that if management objectives are set using an overly broad definition, it can have excessive impact on timber harvesting levels. Therefore, there is high risk associated with the uncertainty that access to the Slocan Valley may restricted using this broad definition. The available volume is shown in Figure 7.34.

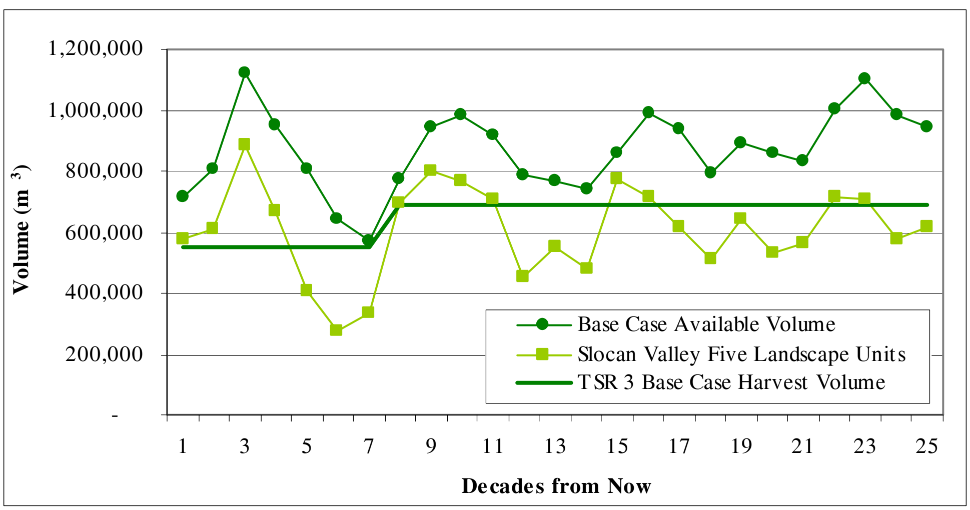

Figure 7.34. Slocan Valley removed using five landscape unit definition available volume

7.7.3 Limited Harvest in the Slocan Valley Based on Past Practice

A summary of the yearly harvest from the Slocan Valley based on the contentious area definition over the last ten years was compiled for this analysis. The average harvest was found to be approximately 59,000 m^3/yr. This value was used as a limit on the harvest contribution from the Slocan Valley in this sensitivity. The contentious area definition was used to identify the Slocan Valley. The results indicate that placing a limit on the Slocan Valley had no impact on either the short or long-term harvest levels. This lack of impact is shown in Figure 7.35.

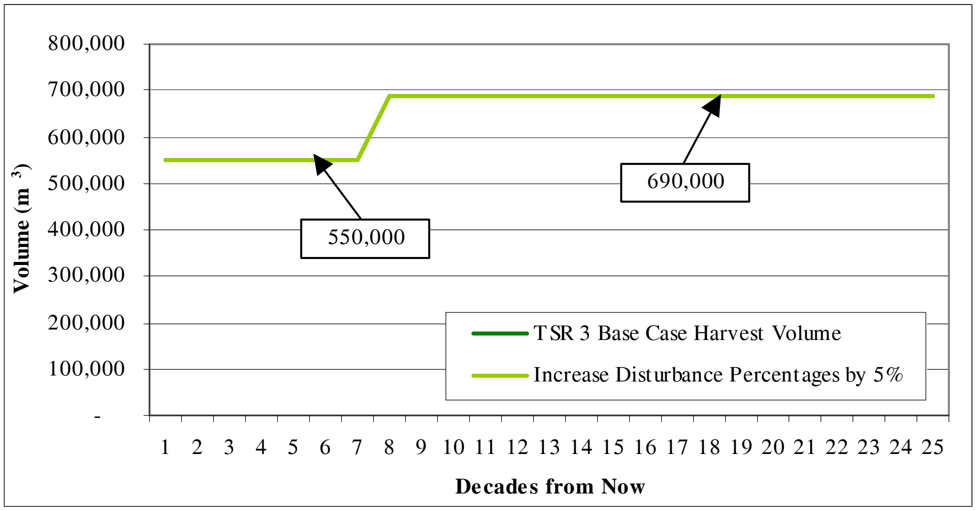

Figure 7.35. Limited harvest in the Slocan Valley based on past practice harvest flow

By studying the base case model outputs, it was determined that the harvest from the Slocan Valley never exceeds 36,000 m^3/yr in the base case over the entire modelled time horizon. Therefore, placing a limit of 59,000 m^3/yr on the harvest had no impact. Since there was no change in the harvest flow, the volume available would not change from the base case levels. Therefore, no available volume figure is presented.

7.8 SIBEC

When compared to previous analyses, the implementation of SIBEC productivity estimates produced the greatest impact on timber supply. The growth and yield sensitivities have shown that managed stand productivity influences the timber supply across the entire modelled time horizon. There is some uncertainty associated with the use of SIBEC in this analysis. The investigation of the accuracy of the productivity estimates using data from the inventory audit revealed that managed stand productivity may be overestimated. There were also some caveats provided with the acceptance of the PEM for use in this analysis to derive the SIBEC values. These were discussed in the data package (Section 5.1) and lead to the creation of the following sensitivities.

7.8.1 SIBEC Site Index Assigned Based on PEM First Decile Only

Within the discussion on the acceptance of the PEM in the data package, one of the concerns expressed was that the averaging of the PEM site series deciles was resulting in unnecessary variation. In order to assess the risk associated with this uncertainty, this sensitivity explores the impact of assigning the managed stand site index values using SIBEC values based on the first decile site series only.

The Base Case analysis units were formed by aggregating stands based on the BEC site series and leading species combination of each stand. In the base case, SIBEC values were calculated for each site series decile and then averaged for the stand. The stand site index values were then averaged for an analysis unit. For this sensitivity, the managed stand analysis units were simply assigned the SIBEC site index value for the BEC site series and leading species combination used to identify the analysis unit.

Using this approach to assigning SIBEC site index had an impact on timber supply levels. The short-term harvest level increased to 555,000 m^3/yr and the long-term level increased to 720,000 m^3/yr. These levels are shown in Figure 7.36.

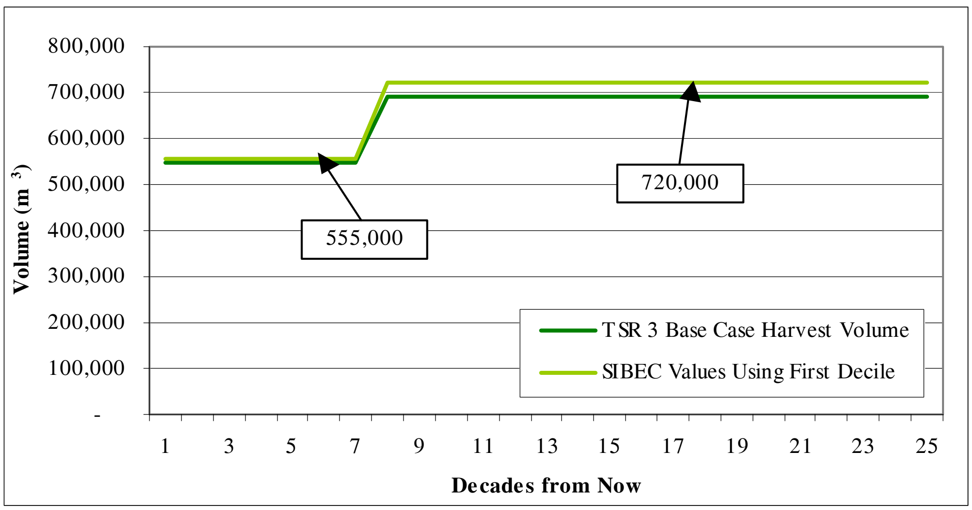

Figure 7.36. SIBEC site index assigned based on first PEM decile only harvest flow

The results indicate that there is a degree of risk in using an over simplified approach to assigning site index values. It is likely that the second and third decile for many stands differs greatly from the first and had a significant impact on the site index for the stand. Since the sensitivity showed an impact, it can be assumed that the decile information in the PEM is not simply unnecessary variation and should be investigated further. The available volume is shown in Figure 7.37.

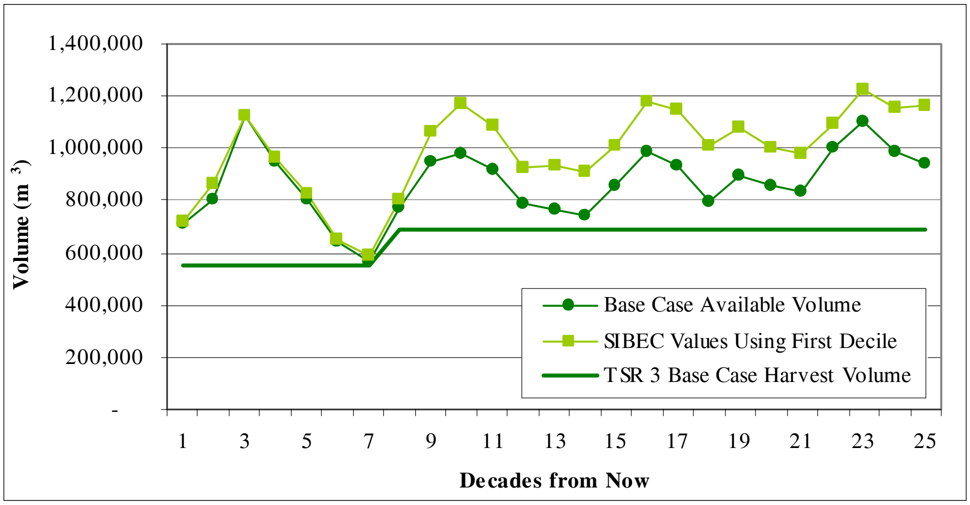

Figure 7.37. SIBEC site index assigned based on first PEM decile only available volume

7.8.2 Overestimation and Underestimation in SIBEC

Within the discussion on the acceptance of the PEM in the data package, another concern expressed that several of the BEC site series were either overestimated or underestimated. In order to assess the risk associated with this uncertainty, all analysis units within the BEC site series listed were adjusted by one meter in site index. This was done to approximate the effect that correcting these over and underestimations may have on timber supply.

These adjustments proved to have almost no impact on the timber supply. The short-term harvest level remained the same and the long-term level increased by 5,000 m^3/yr to 695,000 m^3/yr. This slight change is shown in Figure 7.38.

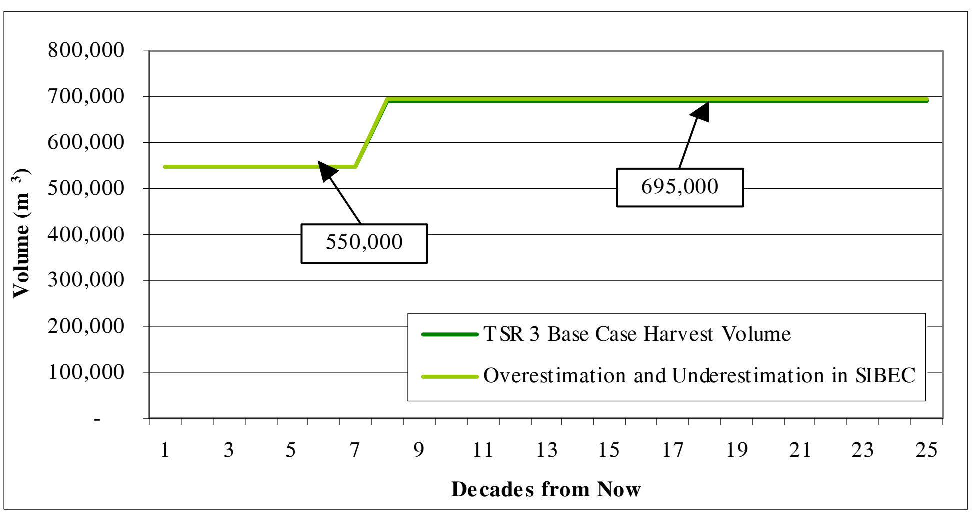

Figure 7.38. Overestimation and underestimation in SIBEC harvest flow

The lack of impact is a surprising result. The analysis units listed comprise a large portion of the THLB and an adjustment of one meter in site index is relatively large. However, it appears that the combination of the areas affected and the ratio of upward and downward corrections balanced out to have a negligible impact. The lack of impact can be seen in the available volume in Figure 7.39.

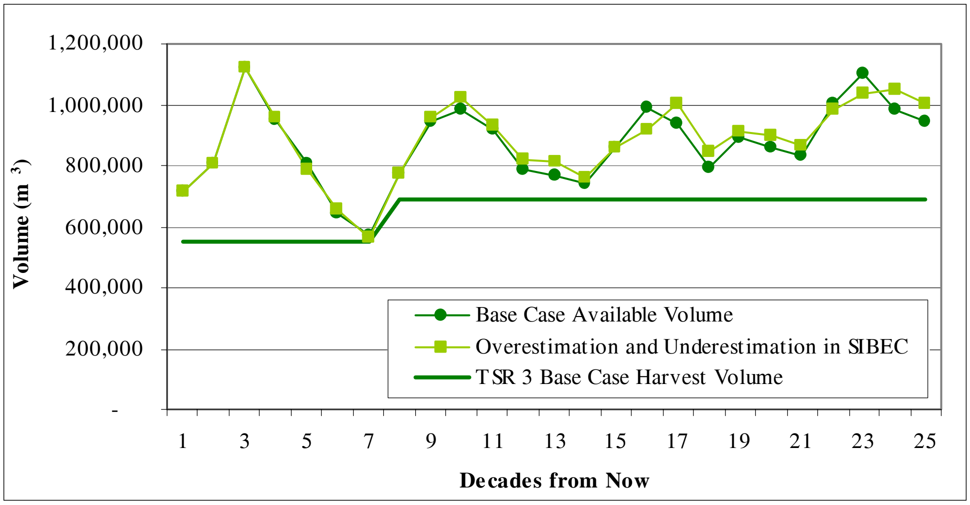

Figure 7.39. Overestimation and ynderestimation in SIBEC available volume

7.9 West Kootenay Ungulate Winter Range

New mapping of the UWR in the Arrow TSA and a new set of management objectives were available for this analysis. However, since they are not yet approved as current practice, they were not implemented in the base case. This sensitivity was performed in order to evaluate the impact that these new management practices will have on timber supply if or when they are implemented.

The new UWR had an almost immediate impact on the short-term harvest level. The initial harvest level could only be maintained for one decade before having to drop by 10% and remaining at 495,000 m^3/yr for the remainder of the mid-term. The long-term harvest level also decreased to 635,000 m^3/yr. These results are shown in Figure 7.40.

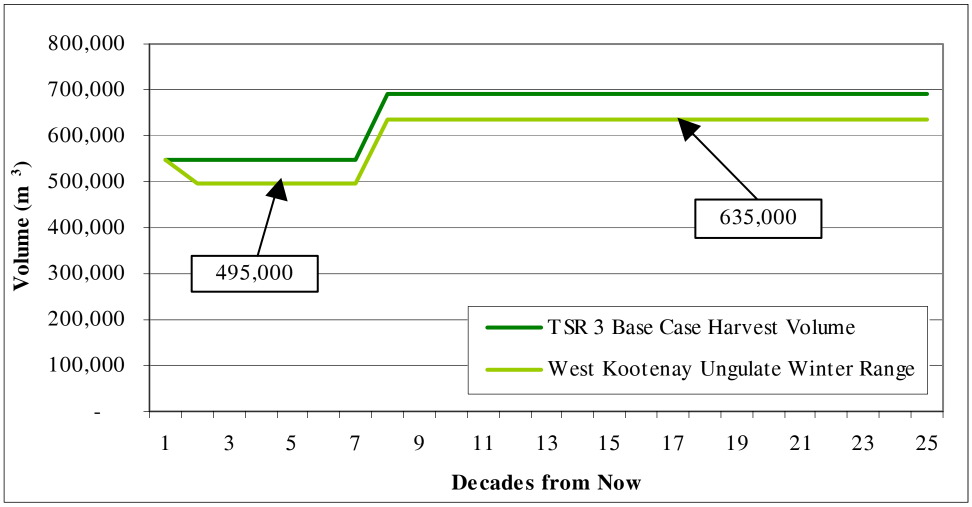

Figure 7.40. West Kootenay ungulate winter range harvest flow

An impact of this scale is interesting because the existing UWR management zones used in the Base Case comprise a small portion of the land base and have a small impact on timber supply. The West Kootenay UWR covers approximately 5,000 ha more of the THLB (26,500 ha) than the original UWR mapping (21,500 ha). It is difficult to compare the differences in retention requirements because the West Kootenay UWR requirements vary by target species and BEC subzone. The disturbance requirements are roughly equivalent. The results indicate that the increase in affected THLB area and higher average retention requirements resulted in a major downward pressure to timber supply. This is due to the fact that the short-term harvest relies heavily on the harvest of older natural stands to pass the age class gap that causes the shortfall at decade seven. The new regulations more strictly reserve these older stands for habitat values reducing the available volume through this period. The available volume is shown in Figure 7.41.

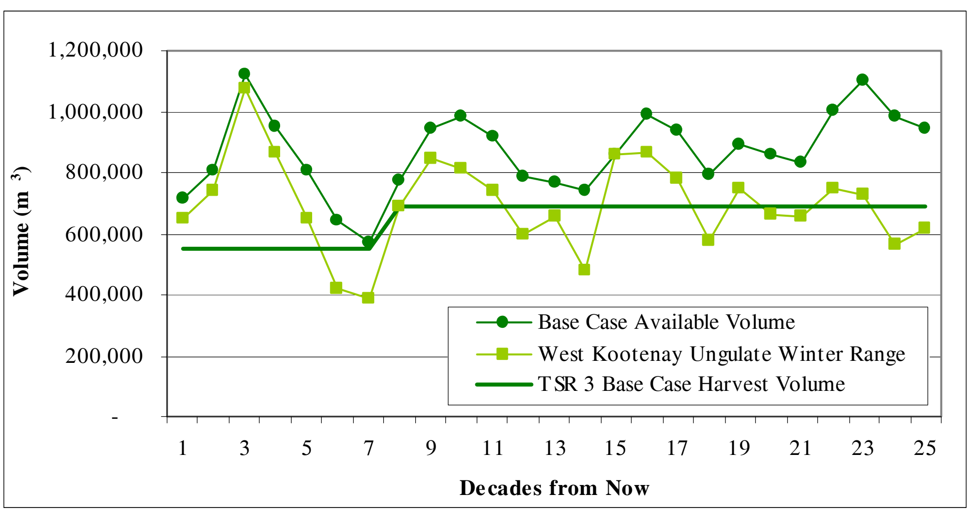

Figure 7.41. West Kootenay ungulate winter range available volume

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7.10 DISTURBANCE OF INOPERABLE AREAS

A new modelling technique implemented in this analysis was the disturbance of inoperable areas. This technique was used to simulate the natural disturbances that occur in forests over time. This reduces the typical modelling trend of accumulating all of the inoperable land base in the oldest age classes by the end of the modelled time horizon. It was anticipated that increasing the total area disturbed at each period would have a downward pressure on timber supply. The naturally disturbed areas would no longer be available to contribute as old forest to meet biodiversity and wildlife habitat values. The naturally disturbed stands were also deemed to contribute to the disturbance limits set for the management of visual resources. When added to disturbance from harvesting this would make the limits more restrictive to timber supply.

7.10.1 Do Not Disturb Areas Outside of the THLB

The impact of implementing the disturbance of inoperable areas was investigated through the removal of the technique in this sensitivity analysis. Inoperable areas outside of the THLB were modelled as continuously aging as they have been in all previous analyses. The results showed a slight increase in the short-term harvest level to 555,000 m^3/yr. The impact on the long-term harvest level was larger with an increase to 705,000 m^3/yr. These results are shown in Figure 7.42.

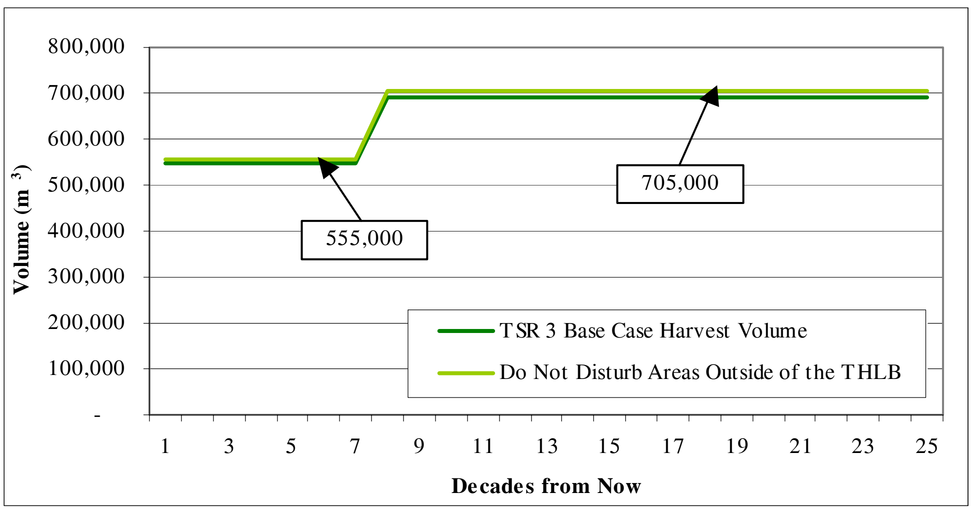

Figure 7.42. Do not disturb areas outside of the THLB harvest flow

The difference between the base case harvest levels and the sensitivity harvest levels can be attributed to modelling the disturbance of the inoperable. The small impact in the short term indicates that the immediate risk associated with implementing this modelling technique is small. The changes in available volume are shown in Figure 7.43.

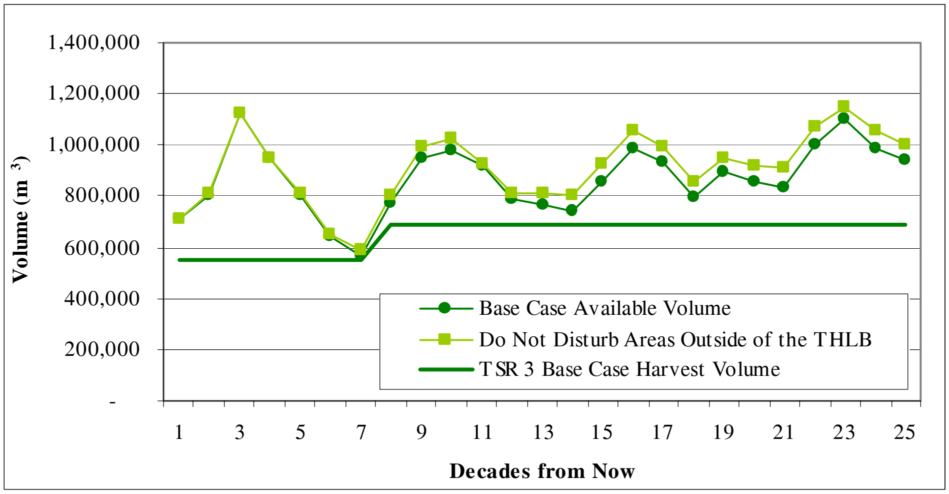

Figure 7.43. Do not disturb areas outside of the THLB available volume

7.10.2 Disturbances Do Not Contribute to VQO Disturbance Limits

The decision to consider the areas naturally disturbed as contributing to the visual management disturbance limits was debated during the development of the data package. In the end it was determined that natural disturbances in the Arrow TSA are historically large enough in area to be a visual consideration. In order to investigate the impact that the disturbance of the inoperable areas has on the disturbance limits, this sensitivity was run with the disturbance limits modified to not account for natural disturbances.

The results from this sensitivity showed the same impact on the short-term as the complete removal of the disturbing the inoperable technique. The short-term harvest level increased slightly to 555,000 m^3/yr. The impact on the long-term was less with an increase to only 700,000 m^3/yr. The results are shown in Figure 7.44.

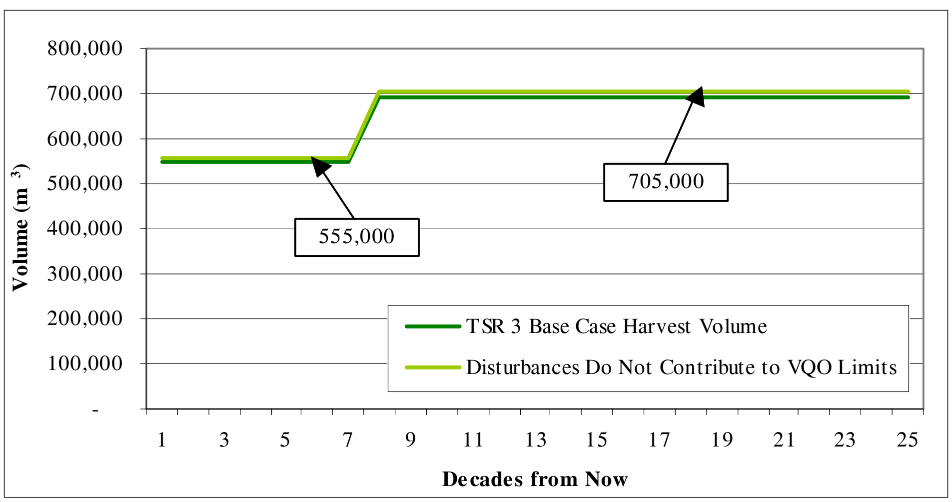

Figure 7.44. Disturbances do not contribute to VQO disturbance limits harvest flow

The same results in the short-term indicate that impact from the disturbance of the inoperable areas is derived purely from its contribution to the visual resource disturbance limits. This makes sense since at this point in the model scenario, there is still a large amount of old natural stands available to meet the retention requirements. In the long-term, removing the contribution to the disturbance limits increased the volume available for harvest. However, it did not increase as much as when disturbing the inoperable was not used. The difference can then be attributed to loss of old stand providing retention values through the disturbances. When an old stand in the inoperable is disturbed and reset to age zero, THLB stands may be reserved to meet the retention requirements in its place. The available volume is shown in Figure 7.45.

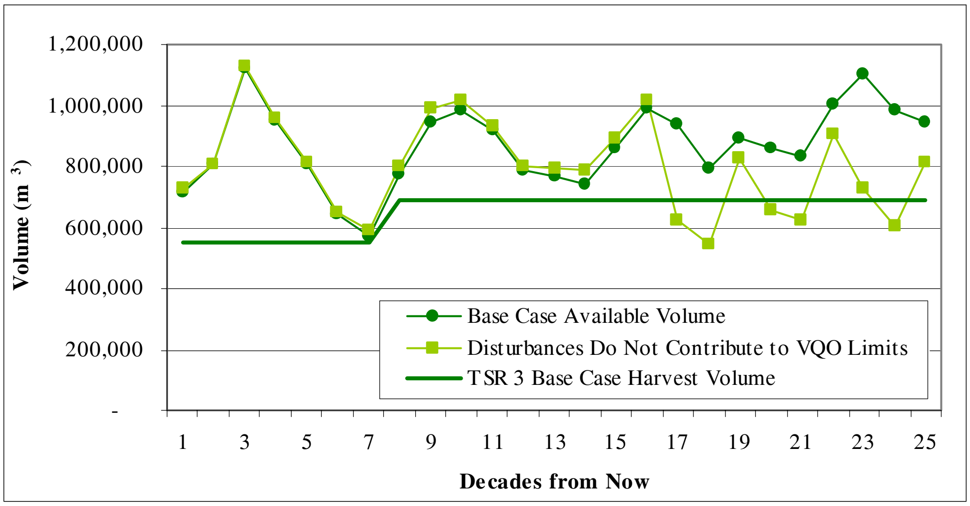

Figure 7.45. Disturbances do not contribute to VQO disturbance limits available volume

7.11 Root Rot

There is concern that the impact of root rot is underestimated within the Arrow TSA. A project to estimate the extent and impact of *Armillaria* was conducted concurrently by Stearns-Smith & Associates, Forestry Consultants. Operational adjustment factors (OAF) were developed in this report to reduce yield estimates to reflect losses resulting from root rot. The OAF values were developed to represent a combination of infection severity levels that would represent the distribution of the infection levels across the Arrow TSA. Three OAF values were provided to run three scenarios that reflect a high, medium and low distribution of infection. The resulting volume loss for the three scenarios was: 42% for low; 46% for medium; and 50% for high. These losses were applied to managed stand yields for stands in the ICH containing Douglas-fir.

7.11.1 Low Severity

A low severity extent of infection was modelled first. Since the *Armillaria* is only modelled in managed stands, the impact on the short-term harvest level was minimal. In order to avoid a shortfall at decade seven the harvest level had to be reduced to 545,000 m^3/yr. As it was expected, the largest impact of the *Armillaria* can be seen in the long-term harvest of the managed stands. The low severity infection level resulted in long-term maximum sustainable harvest level of 645,000 m^3/yr. This is shown in Figure 7.46.

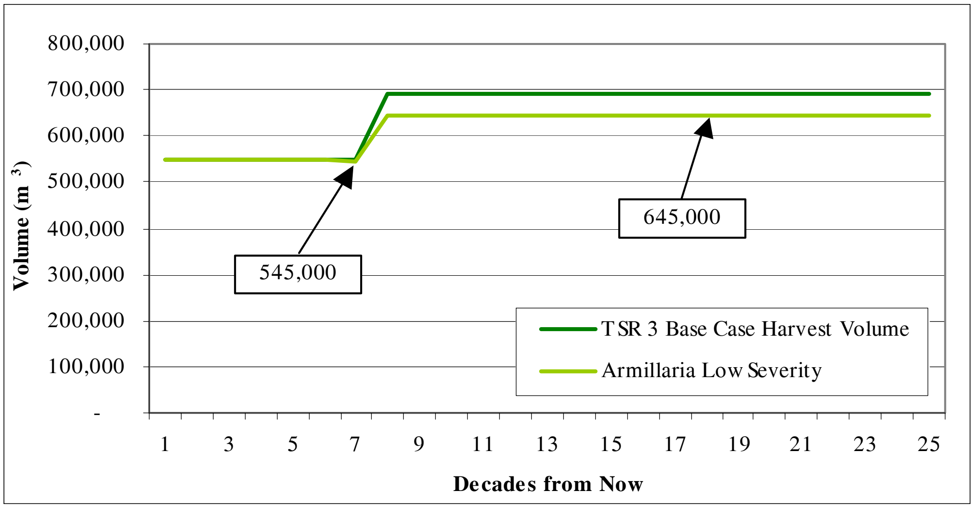

Figure 7.46. *Armillaria* low severity harvest flow

The reduction in the harvest level at decade seven results from the impact of *Armillaria* on the initial regenerating managed stands. The reduction in growth results in less volume being available when it is most needed at this transition period. The difference in available volume is evident in Figure 7.47.

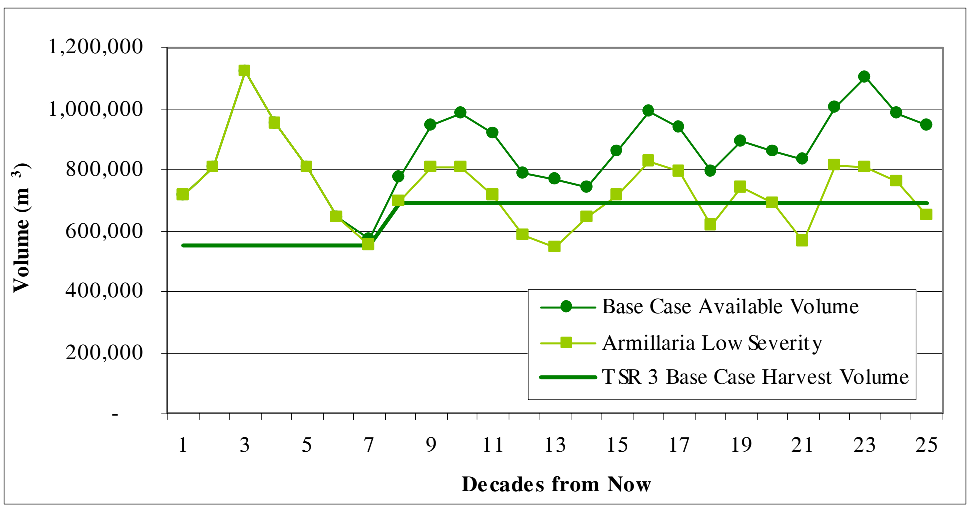

Figure 7.47. *Armillaria* low severity available volume

7.11.2 Medium Severity

The medium severity extent of infection did not differ much from the low severity sensitivity. A slightly lower step down to 540,000 m^3/yr was required to pass the shortfall at decade seven. The medium severity also caused a further slight decrease in the long-term harvest level to 640,000 m^3/yr. The harvest levels are shown in Figure 7.48.

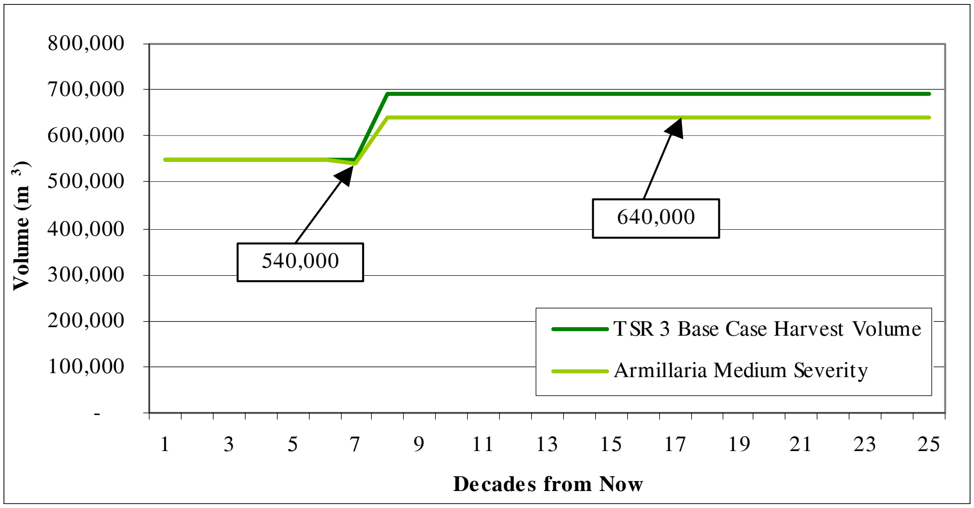

Figure 7.48. *Armillaria* medium severity harvest flow

Figure 7.49 shows that the impact of the *Armillaria* on the available volume does not vary much from that shown for the low severity.

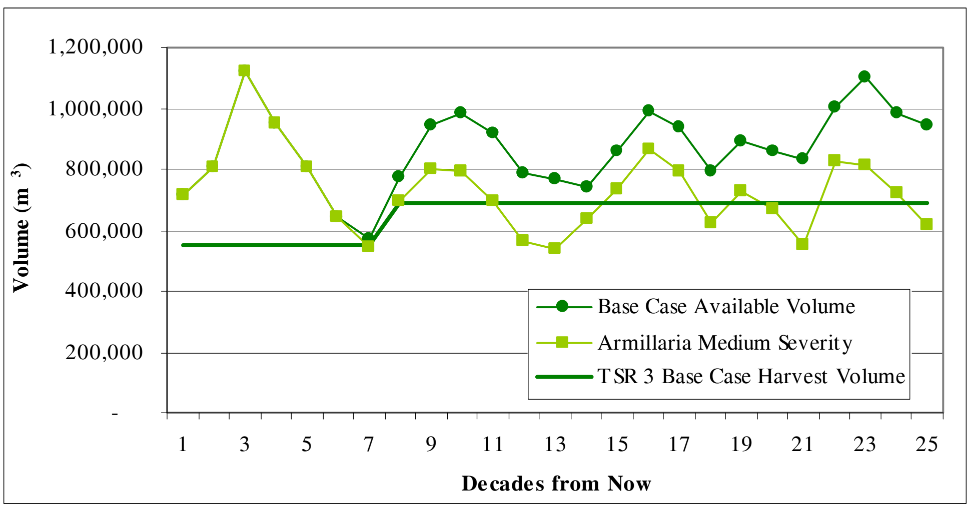

Figure 7.49. *Armillaria* medium severity available volume

7.11.3 High Severity

The modelling of a high severity rate of infection did not impact the short-term harvest level any more than the medium severity level. A reduction to 540,000 m^3/yr was also sufficient to pass the transition at decade seven. The long-term maximum harvest sustainable harvest level did experience an impact and was further reduced to 635,000 m^3/yr. The harvest levels are shown in Figure 7.50.

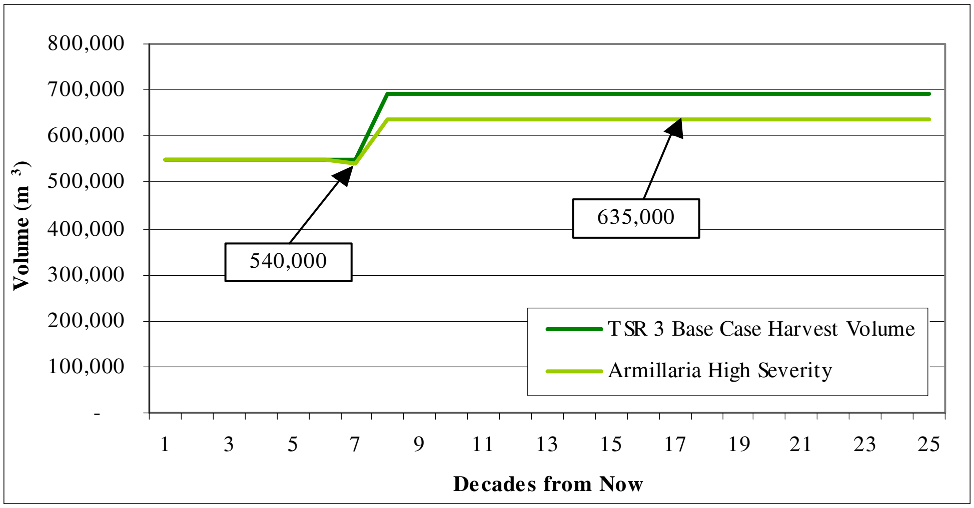

Figure 7.50. *Armillaria* high severity harvest flow

No significant differences in the available volume for the high severity infection level can be seen in Figure 7.51 when compared to the other infection level sensitivities.

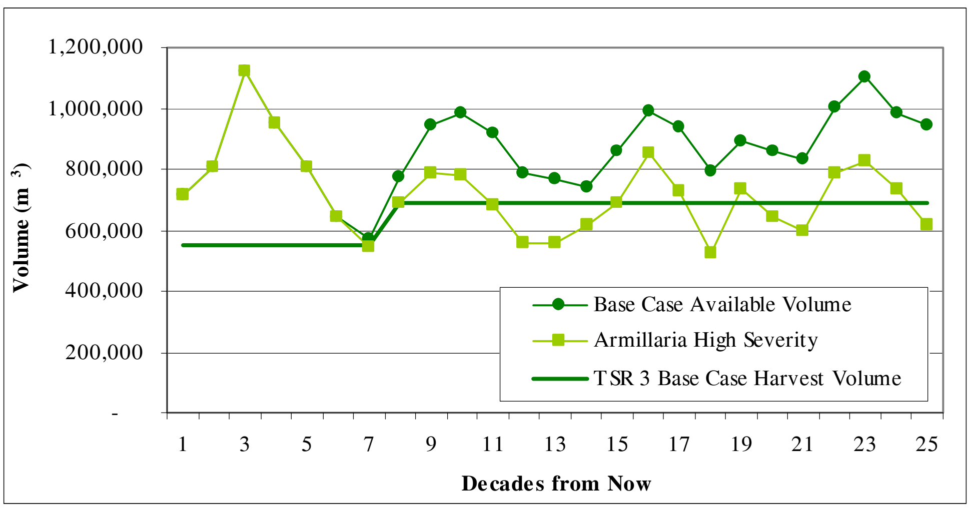

Figure 7.51. *Armillaria* high severity available volume

Since all three *Armillaria* sensitivity analyses have approximately the same level of volume loss regardless of severity (42% to 50%) and only impact about 21% of the land base, the impacts at the landscape unit level are fairly similar.

7.12 LANDSCAPE BIODIVERSITY

This analysis introduced the use of old growth management areas (OGMA) that were removed from the THLB to preserve landscape level biodiversity values. In previous analyses, a series of old and mature retention requirements were applied across the productive land base to meet the biodiversity management objectives. The impact of switching from using broad retention policies to complete area removals on the timber supply was uncertain. This sensitivity investigated the impact by returning the OGMA to the THLB and the original biodiversity retention policies were implemented.

In practice, the old biodiversity requirements in low biodiversity emphasis areas are being implemented over three rotations through a one-third drawdown. The full biodiversity impacts were modelled in this analysis in order compare the impacts of the OGMA fairly over the entire modelled time horizon.

This sensitivity resulted in no change in the initial harvest level for four decades. At this point the mid-term harvest level was decreased to 505,000 m^3/yr. In the long-term there was no impact on the harvest level. These results are shown in Figure 7.52.

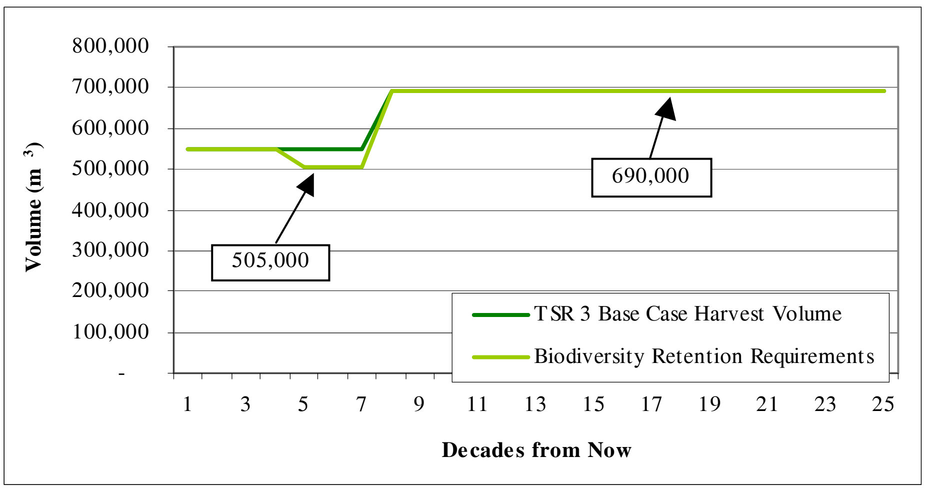

Figure 7.52. Biodiversity managed with retention requirements harvest flow

The results indicate that the change to using OGMA for landscape level biodiversity management had a positive pressure on the timber supply. Although it was a small decrease in the mid-term, using the retention policies would sacrifice potential harvest. Plus, the OGMA can be directed towards protecting specific areas. This more closely reflects actual practice of reserving areas from harvest. The use of retention policies was an over simplified method of modelling the potential impact that reserving sections of the land base may have on timber supply. The volume available is shown in Figure 7.53.

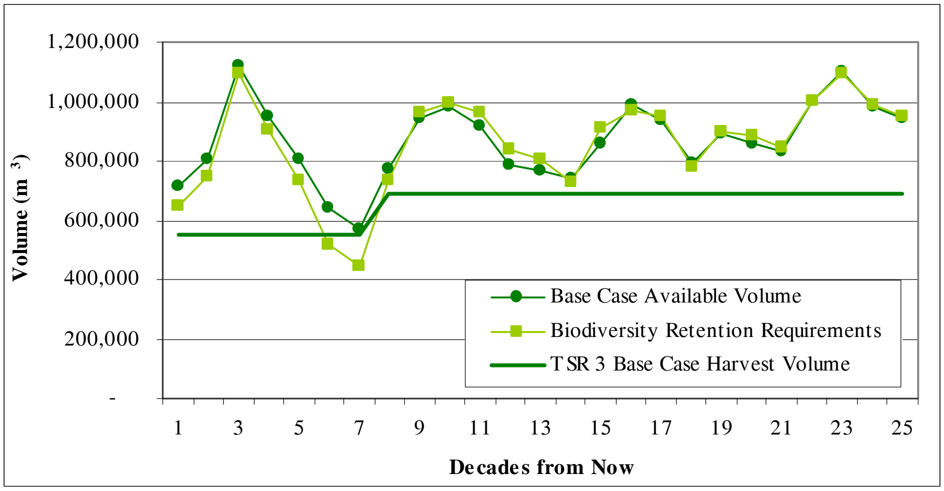

Figure 7.53. Biodiversity managed with retention requirements available volume

7.13 No Management Objectives

The calculation of the LRSY for the base case revealed that the theoretic productive capacity of the THLB is approximately 370,000 m^3/yr for natural stands and 870,000 m^3/yr for managed stands. The base case harvest level in the short-term is higher than the natural stand LRSY and the harvest level in the long-term is well below the managed stand LRSY. Previous analyses have shown that the short-term harvest level is able to exceed the natural stand LRSY because of the large existing volume as well as contributions from existing and future managed stands. This sensitivity attempts to explore why the long-term harvest level is well below the managed stand LRSY.

This sensitivity was performed by running the base case analysis with no adjacency, disturbance, or retention management policies. The result is a harvest pattern that is not limited by management objectives. The short-term harvest level increased to 665,000 m^3/yr and the long-term harvest level increased to 825,000 m^3/yr. These changes represent an approximate 20% increase in both the short and long-term harvest levels. The differences are shown in Figure 7.54.

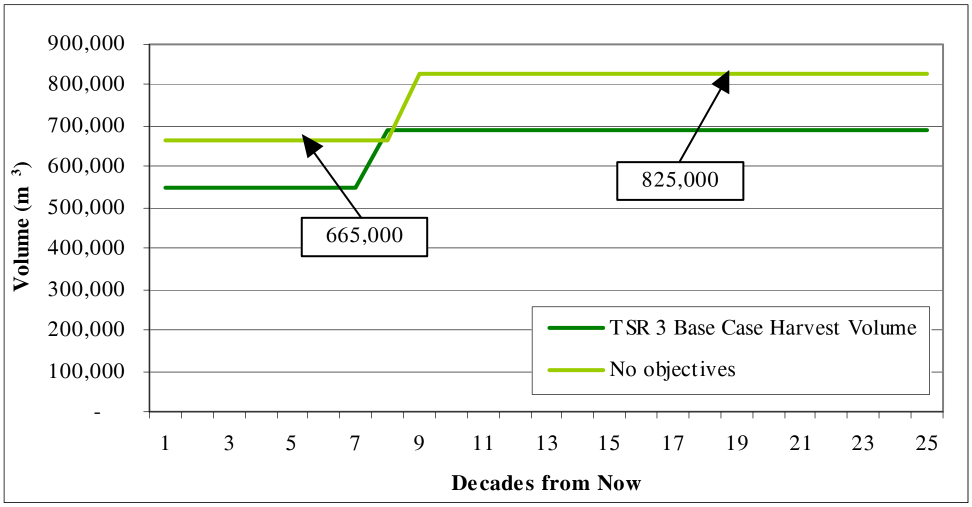

Figure 7.54. No management objectives harvest flow

The long-term harvest level is 135,000 m^3/yr higher than the base case long-term harvest level. This indicates that the potential harvest of 135,000 m^3/yr is restricted in order to meet all of the management objectives within the Arrow TSA. The long-term harvest level falls 45,000 m^3/yr short of the managed stand LRSY. The remainder can be attributed to a large extent to the choice of minimum harvest age. The LRSY is calculated under the assumption that stands are harvested at CMAI. In the Arrow TSA analyses, the minimum harvest ages were set at 95% of CMAI. This choice increases harvesting flexibility through a younger minimum harvest age but sacrifices potential volume growth. This lost volume can account for the majority of the difference observed. The impressive difference in available volume is shown in Figure 7.55.

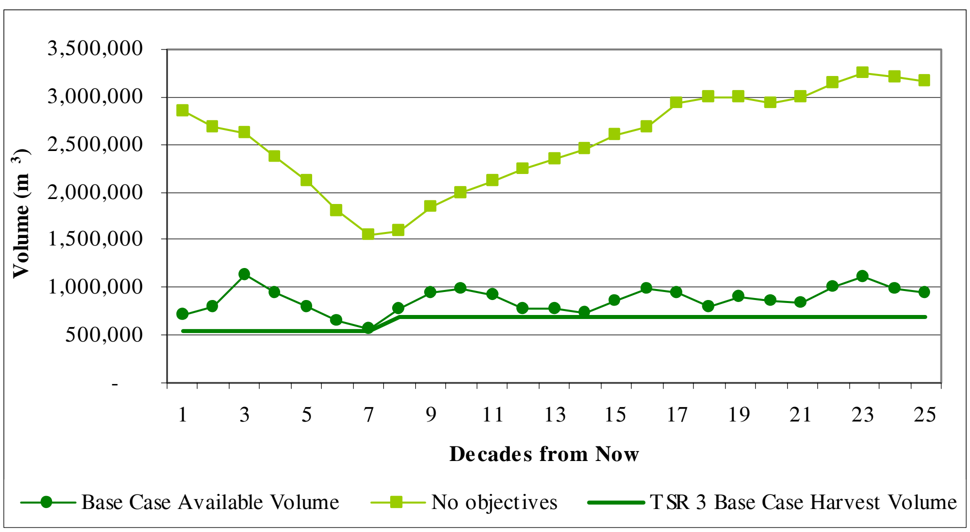

Figure 7.55. No management objectives available volume

7.14 SPATIAL ANALYSIS

The timber supply model was implemented using fully spatial analysis for two decades in the base case analysis. While the model is operating in spatial mode, the model checks that all polygons adjacent to a potentially harvestable stand are at least 2.5 m in height before it can be harvested. This models the impact that neighbouring stand adjacency regulations have on timber supply. Removing adjacency regulations is not the same as conducting an aspatial analysis since treatment units (blocking) are still used to regulate the spatial distribution of harvest across the land base.

7.14.1 Do Not Use Adjacency

Removing the adjacency constraint resulted in an increase in timber supply levels because more potentially harvestable stands were available when the status of neighbouring stands no longer had to be considered. The impacts were very small resulting in a 5,000 m^3/yr increase in both the short and long-term harvest levels (555,000 m^3/yr and 695,000 m^3/yr). This impact is shown in Figure 7.56.

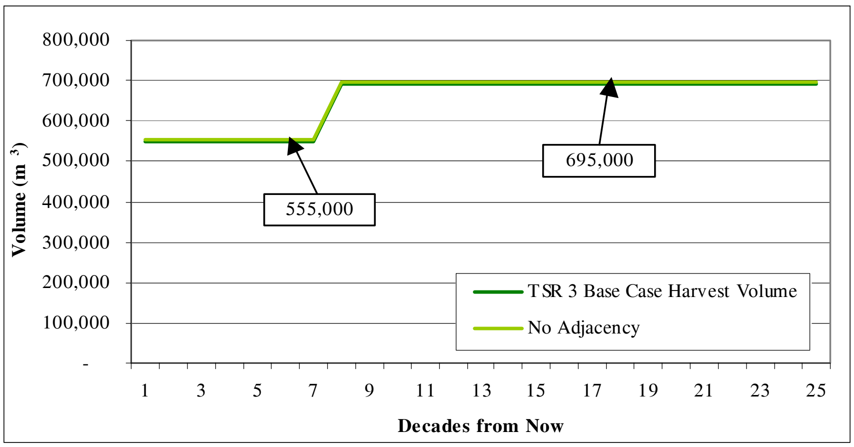

Figure 7.56. No adjacency harvest flow

These results indicate that the cost of modelling adjacency to timber supply is small. This is likely due to the tight timber supply situation. Although the impact is small, there is probably quite a different harvest sequence spatially. The available volume in Figure 7.57 reveals more clearly the impact of the changes in harvest pattern.

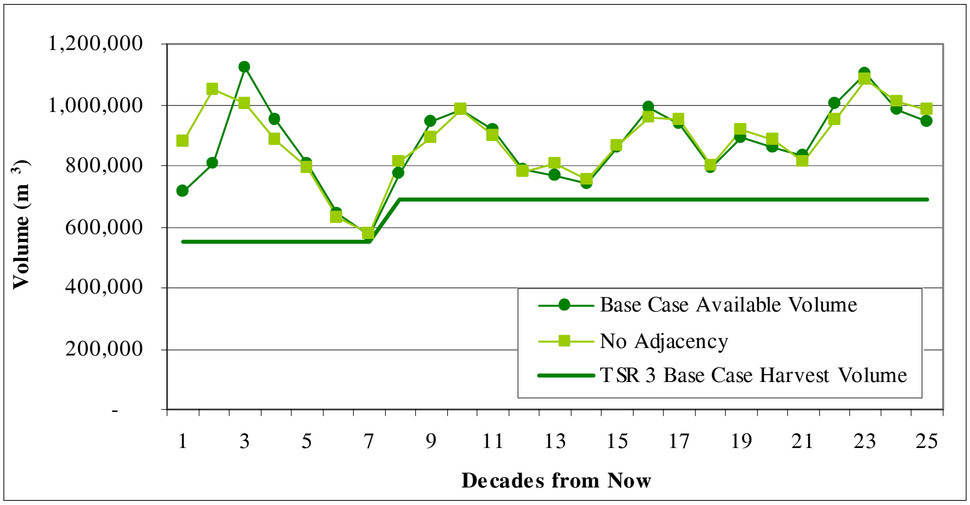

Figure 7.57. No adjacency available volume

Not using adjacency increases the available volume in the first two decades. However, by decade three when adjacency regulations were removed in the base case, the reserved base case volume is made available and jumps to a higher level than the sensitivity. By decade five, the available volumes are equal and therefore have no impact of the limiting shortfall at decade seven.

7.14.2 Aspatial Analysis

In order to investigate the full impact of using a spatial analysis, an aspatial analysis was completed for contrast. The timer supply model CASH can be operated in a non-spatial model. In this mode treatment units (blocking) are not employed. Treatment units are groupings of stands of similar composition that approximate harvest blocks. When treatment units are not used stands can be harvested regardless of size or location. This sensitivity was run with all other management objectives held constant (except for adjacency).

Running the analysis spatially resulted in an increase in the short-term to 570,000 m^3/yr and an increase in the long-term to 730,000 m^3/yr. These increases are shown in Figure 7.58.

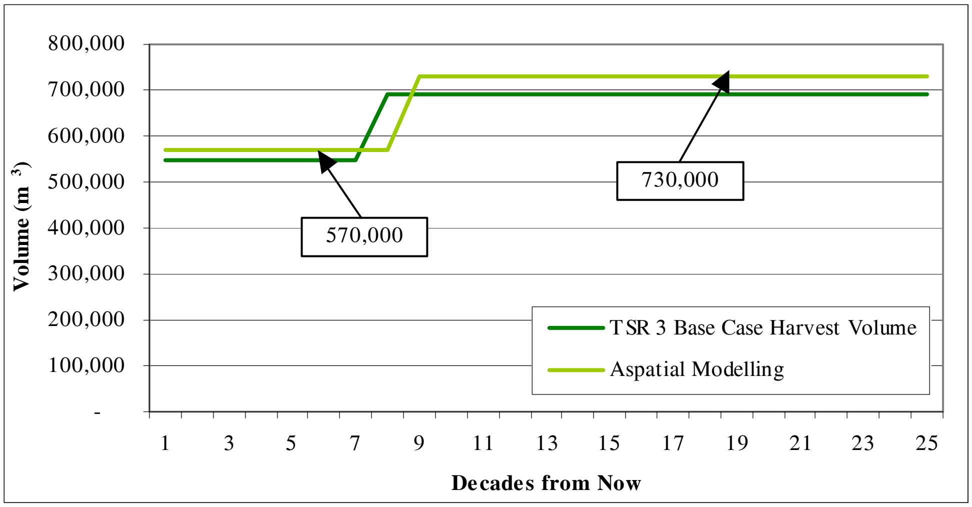

Figure 7.58. Aspatial analysis harvest flow

The removal of the adjacency and treatment units increases the harvest flexibility. The model is able to harvest any stand that is not limited by management objectives. Small slivers of land, frequently less than one hectare can be selected from across the land base to make up the total harvest for a year. The flexibility allows for an increased timber flow, but is a questionable representation of operational reality.

8.0 DISCUSSION OF RESULTS

The analyses have revealed many interesting results and have provided great insight into the processes that influence timber supply in the Arrow TSA. This section will explore some of the more significant results that had a particular impact on the determination of the base case.

8.1 RESOURCE EMPHASIS AREAS

The management objectives modelled in this analysis have gone through many changes since the TSR 2 analyses. In fact, the number of management objectives and the extent of the land base affected has even changed since the most recent analyses performed for the Arrow IFPA. It was surprising to see how the amount of area that does not fall into any of the main three resource emphasis areas has increased from the previous analyses. It would be assumed that an increase in THLB outside of the most heavily constraining management areas would be an upward pressure on timber supply. However, the results did not show a proportional impact.

The lack of impact resulting from this shift in resource emphasis areas is likely due to the fact that the major limit on timber supply within the Arrow TSA has traditionally not been management objectives. Every analysis performed since and including TSR 2 shows that timber supply is limited by a unique age class distribution. The Arrow TSA has a distinct age class gap resulting from pre-1900 fires purposely ignited for mineral exploration. This age class gap causes a very problematic shortfall in timber supply approximately 70 years into the future.

The results of the sensitivity analyses all show that timber supply in the time between the present and the shortfall in 70 years is only sensitive to changes that either increase or decrease volume in the age class gap. This is why sensitivities such as changing green-up heights or not using adjacency that do not influence the short-term volume produced very little or no impact. Therefore, it can be assumed that a shift in the resource emphasis areas resulting in a smaller area under management constraints such as these will have a limited impact.

8.2 INVENTORY AND PRODUCTIVITY

It was clear that the one change since TSR 2 that resulted in the largest impact on the timber supply was the implementation of ecologically based productivity estimates. The combined benefits from the PEM and the SIBEC localization projects completed by the AFLG were realized in this analysis. The impact on the managed stand yields was impressive. The contrast between the natural stand productivity and managed stand productivity was clearly shown in the LRSY values for each. The managed stand LRSY was found to be 2.5 times greater than the natural stands LRSY.

A concern was expressed that these two values should not reasonably be so far apart. The inventory information for this analysis came from the VRI also recently completed by the AFLG. An audit of the VRI was conducted prior to the analyses. A comparison with ground sample data revealed that the natural stand productivity is likely to be significantly underestimated while the managed stand productivity is slightly overestimated. Therefore, it is likely that a more accurate LRSY value for each lies somewhere between the two.

The impact of the SIBEC productivity estimates on timber supply is clear. The base case long-term harvest level is one of the highest ever predicted for the Arrow TSA. The sensitivity analyses also revealed that the short-term timber supply relies heavily on the increased yields from the existing managed stands. The higher productivity also allows the future managed stands to be harvested sooner. This helps to fill the age class gap that is limiting the short-term harvest level of the base case.

The poor audit results from the VRI were disappointing because it was anticipated that the new VRI would have corrected the natural stand productivity estimates with an upward adjustment. However, only the first phase of the VRI process has been completed to date. The first phase relies only on photo interpretation for inventory data. Therefore, results are not likely to vary greatly from the previous forest cover inventory also derived through photo interpretation. The second phase of a VRI involves ground sampling for data that are used to adjust the phase one attributes. The audit report suggested that if the second phase is completed, it is likely to correct the underestimation observed with an upward adjustment.

8.3 SENSITIVITY ANALYSES

The sensitivity analyses did not reveal any dramatic new trends or relationships. An attempt was made to discuss the result from each sensitivity when presenting the results in the previous section. As discussed above, the impact from each sensitivity was typically proportional to its influence on the volume available in the age class gap. The long-term harvest levels were mostly influenced by sensitivities that increased harvesting option flexibility. The results of all 32 sensitivity analyses are presented in Table 8.1. The short-term column shows the initial harvest level; the mid-term column shows the harvest level required to pass the shortfall; and the long-term column shows the stable long-term harvest level. Changes from the base case values are highlighted in green for increases and yellow for decreases. This allows for a quick evaluation of the results.

Table 8.1. Summary of sensitivity analyses results

Sensitivity	Short-Term	Mid-Term	Long-Term
Base Case	550,000	550,000	690,000
Non-Declining Even Flow	550,000	550,000	550,000
Highest Initial Harvest Level	710,000	480,000	705,000
Oldest First Harvest Priority	550,000	550,000	685,000
Increase Timber Harvesting Land Base by 10%	600,000	600,000	750,000
Decrease Timber Harvesting Land Base by 10%	550,000	495,000	625,000
Increase Existing Stand Site Index by 3m	670,000	670,000	700,000
Decrease Existing Stand Site Index by 3m	475,000	430,000	680,000
Increase Managed Stand Site Index by 3m	650,000	650,000	845,000
Decrease Managed Stand Site Index by 3m	550,000	460,000	525,000
Increase Disturbance Percentages by 5%	585,000	585,000	730,000
Decrease Disturbance Percentages by 5%	550,000	495,000	635,000
Visual Polygons Not Grouped	550,000	550,000	685,000
Increase Green-up Heights 1.5 m	550,000	550,000	675,000
Decrease Green-up Heights 1.5 m	570,000	570,000	715,000
Increase Minimum Harvest Ages 10 Years	550,000	495,000	700,000
Decrease Minimum Harvest Ages 10 Years	595,000	595,000	635,000
Slocan Valley Removed Using Contentious Area Definition	550,000	505,000	670,000
Slocan Valley Removed Using Five Landscape Unit Definition	550,000	430,000	590,000
Limited Harvest in the Slocan Valley Based on Past Practice	550,000	550,000	690,000
SIBEC Site Index Assigned Based on First PEM Decile Only	555,000	555,000	720,000
Overestimation and Underestimation in SIBEC	550,000	550,000	695,000
West Kootenay Ungulate Winter Range	550,000	495,000	635,000
Do Not Disturb Areas Outside of the THLB	555,000	555,000	705,000
Disturbances Do Not Contribute to VQO Disturbance Limits	555,000	555,000	705,000
Root Rot Low Severity	550,000	545,000	645,000
Root Rot Medium Severity	550,000	540,000	640,000
Root Rot High Severity	550,000	540,000	635,000
Landscape biodiversity (No OGMA)	550,000	505,000	690,000
No Management Objectives	665,000	665,000	825,000
Do Not Use Adjacency	555,000	555,000	695,000
Aspatial Analysis	570,000	570,000	730,000

The low sensitivity of the base case to changes involving the management of the visual objectives was interesting. In previous analyses, the management of visual resources had proven to be an influential factor on timber supply. The use of individual VEG heights calculated for each polygon was a new technique implemented in this analysis. An area weighted average summary of VEG heights was higher than the one height used in previous analyses. This was anticipated to have a downward influence on timber supply. It was also anticipated that the contributions made by the disturbance of the inoperable areas to the visual quality disturbance limits would also produce a large downward pressure. It is unclear why these impacts were not observed. Perhaps the improved growth of the managed stands through the use of SIBEC allowed stand to meet visual requirements faster mitigating these impacts.

The disturbance of inoperable areas was a new modelling technique implemented in this analysis. The sensitivity analysis revealed that the impact on timber supply was small. However, it was interesting to see a much more realistic distribution of both THLB and non-THLB across all age classes in the diagnostics of the base case. This technique is a step toward more ecologically accurate modelling.

The DFAM guideline provided for the option to conduct the timber supply analysis aspatially. In order to explore the impact of conducting the analysis aspatially, an additional sensitivity was added. The upward pressure on timber supply was quite large. However, this technique does not reflect operational reality. Therefore, not using spatial information would be considered a backward step from accurate modelling.

8.4 CONCLUSIONS

Timber supply within the Arrow TSA continues to be limited by the age class gap in the existing age class distribution. Short-term timber supply is limited by the timber supply shortfall resulting from this gap in approximately 70 years. Any changes to the management assumptions or inventory information that help to fill the age class gap directly impact short-term timber supply.

The PEM and SIBEC sampling projects completed by the AFLG were implemented in this analysis with an impressive positive impact. The managed stand productivity increased greatly and the long-term harvest level jumped to the one of the highest levels predicted in a timber supply analysis for the Arrow TSA. The VRI completed by the AFLG and used in this analysis did not show any major changes in standing volume or productivity estimates for existing stands. However, there is the potential to change this result with by completing the second phase of the VRI.

It was an improbable result to find that after so many changes in the data sources and assumptions used to model this analysis the initial base case harvest was the same as the current AAC. It was anticipated that the new data sources would have a positive pressure on the timber supply. However, it is important to consider all of the new modelling techniques and management objectives first implemented in this analysis with potentially downward pressures. The lack of change clearly indicates that the work of the AFLG to produce these new data sources has effectively mitigated the new downward pressures.

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