Type II Forest Estate Analysis
in support of a
Incremental Silviculture Program
for the
Cranbrook Timber Supply Area

Prepared for:
Ministry of Forests
Cranbrook Forest District

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Executive Summary

This report describes a Type II forest estate analysis of alternative silviculture management regimes on the timber supply in the Cranbrook TSA. The analysis used the Forest Service Simulator (FSSIM) version 3.0, in conjunction with stand level models (VDYP and TIPSY) to quantify several management regimes that where described for the TSA in a Type I Silviculture Strategy. The analysis assumes static conditions with regard to timber and social values, and projects these values 250 years into the future.

The mid and long-term timber supply for the Cranbrook TSA is not secure. This analysis and a previous one completed for the AAC Determination, demonstrated that if current social values and operational practices remain unchanged, harvest levels must begin to drop in the next few decades. A mid-term harvest level is forecast to be roughly 18 percent below the current AAC. Alternatives to current silviculture practices were incorporated into a forest estate model, to quantify opportunities to improve timber supply. Improvements in timber quality and wildlife habitat were also considered as values that may be influenced by silviculture management regimes.

This analysis demonstrates that some management regimes provide substantial positive impacts, while others provide negative impacts. If all areas were treated according to the regimes described in this report, an annual investment of $3.7 million might be spent on incremental silviculture activities within the TSA. This investment would not increase the short-term harvest level, but it would greatly mitigate the fall-down scheduled to begin in 30 years. The investment would also provide funds for improvements to timber quality in the long-term and wildlife habitat restoration.

From among the regimes tested, a recommended silviculture program was developed and was submitted as a separate report. This program utilized the quantitative results from this analysis to budget a silviculture program that considered timber supply, timber quality, wildlife habitat, economic return, corporate philosophy and employment opportunity. With regard to all regimes tested, fertilization, sowing class A seed, and stand rehabilitation were shown to provide the greatest overall benefit to the TSA.

There are many inherent uncertainties when conducting an analysis that projects forest and management assumptions so far into the future. Although the best information available is used for this analysis, it is imperative that the principles that guide silviculture investment alternatives be re-visited periodically, as new information becomes available or old assumptions are re-evaluated.

Acknowledgements

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Assisting with the technical components of this project, the following individuals provided valuable contributions:

Bailey, Chris (Industrial Forestry Service Ltd.)
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The author extends thanks to these and all other people who contributed to the completion of this project.

CONTENTS

FIGURES

TABLES

APPENDIX

Type II Forest Estate Analysis for the Cranbrook TSA

1. Introduction

This report presents the results of a preliminary investigation into the quality and quantity of timber and wildlife habitat within the confines of the Cranbrook Timber Supply Area (The TSA). A Type II Forest Estate Analysis is typically a silviculture analysis that assesses opportunities to maintain or increase a forecast harvest level for a specified land base. Silviculture management regimes are also used to improve timber quality and/or wildlife habitat.

This analysis followed a standardized approach to the production of a Type II analysis as defined in the document Forest Level Analysis for Silviculture Investments *Draft 12 Ministry of Forests, July 21,1999.* The report utilized the forest estate analysis and modelling assumptions that were created for the Timber Supply Review (TSRII); and that culminated in the Cranbrook TSA Allowable Annual Cut (AAC) Determination on January 1, 2001. The current harvest level for the TSA has been shown to be unsustainable for the next 250 years. In the TSR and subsequent internal Ministry of Forests' analysis, the current AAC was shown to be sustainable for only a short period. This was followed by a fall to a mid-term harvest level below the current AAC and then a short rise to the long-term harvest level, after harvesting has shifted to managed stands. In this report the impact of alternative silviculture management regimes was examined to assess possibilities to improve the timber harvest flow, wildlife habitat, timber quantity and timber quality.

With respect to the goals of this report, perhaps the one most important point to stress is that this exercise is a work in progress. In analyzing the various inventories and developing management assumptions, we discover that there is much that we do not know and much for which operational precision in estimating mid and long-term impacts of management alternatives is lacking. Although the best information available is used in the analysis, it is the process of explicitly defining these uncertainties that has the potential to provide the greatest value to guiding resource managers towards future research endeavours.

1.1. Cranbrook TSA

The Cranbrook TSA is located in the southeastern portion of British Columbia and covers about 1.4 million hectares (Figure 1). Forest area within the TSA comprises roughly 805 thousand hectares, with about 774 thousand hectares (55 percent of the TSA) considered productive forest and managed by the B.C. Ministry of Forests. Both productive forest and non-productive forest (i.e., totalling 805,000 ha) were included in this analysis, as all of this area is subject to forest cover constraints. The timber harvesting land base (THLB) is 31 percent of the TSA. Stands within the THLB are eligible for harvesting when they are free from various forest cover and adjacency constraints. Table 1 summarizes the areas categorized within the TSA.

Table 1. Area Classifications within the TSA

Description	**Area (hectares)**	**Percent of TSA**
Cranbrook TSA Total Area	1,410,235	100
Forest Area (contributing to forest cover constraints)	805,735	57.1
Non-Productive Forest	31,483	2.2
Productive Forest	774,252	54.9
Current Timber Harvesting Land Base	431,109	30.6

Terrain is variable, consisting of rugged mountains, low foothills and many valley bottoms. Within this terrain, Lodgepole Pine, Douglas-Fir, Larch, Engelmann Spruce and Sub-Alpine Fir stands predominate. Yellow Pine, Western Hemlock, Western Red Cedar, White Bark Pine, cottonwood, birch and aspen occur in smaller amounts. The climate here is continental. The TSA has been classified using climate and biological diversity into six broadly homogeneous "biogeoclimatic" zones. These include the Engelmann Spruce Sub-Alpine Fir (ESSF) as the most predominant zone at 42 percent of the productive forest. Interior Cedar Hemlock (ICH) and Montane Spruce (MS) occur in lesser amounts at 15 percent and 23 percent respectively. Interior Douglas-Fir (IDF), Ponderosa Pine (PP) and Alpine Tundra (AT) comprise the remaining 20 percent.

Although the terrain is rugged, the majority (approximately 70 percent) of the Timber harvesting land base (THLB) exists on slopes less than 40 percent. Only about 8 percent of the THLB occurs at elevations above 1800 metres.

The TSA is part of the Nelson Forest Region and is administered through the Ministry of Forest's Cranbrook District Office. The current AAC for the TSA was set in January 2001 at 871,000 m^3. Of this total, 838,000 m^3 comes from the conventional timber harvesting land base. The remaining volume comes from problem forest types and the fire-maintained ecosystem restoration zone. The AAC partitioned 380 ha per year to problem forest types and 230 ha per year to the fire-maintained ecosystem restoration areas. These harvest partitions were not incorporated into this analysis.

Timber processing facilities that utilize the annual harvest include Tembec, Galloway Lumber Company, the McDonald Ranch and Sawmill and many smaller sawmills. The annual timber processing capacity of the existing processing facilities in the TSA is approximately 1.1 million m^3.

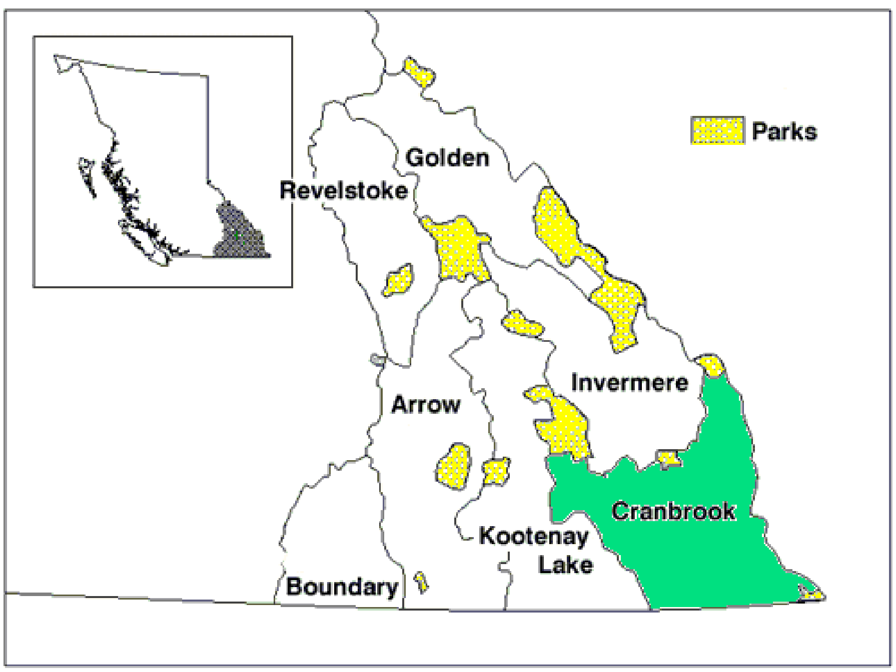

Figure 1 Location of the Cranbrook TSA within the Nelson Forest Region

2. Information Preparation

In any forest estate analysis, three categories of information are required to complete a harvest simulation that attempts to predict the future. An inventory is required of the attributes that you wish to manage and monitor. Growth assumptions are needed to predict changes to inventory attributes over time. Management assumptions are necessary to explicitly describe the human interaction with the forest estate.

2.1. Land Base and Forest Inventory

The land base and forest inventory for the TSA remains unchanged from the Timber Supply Review completed in 1999. The inventory is based upon 1988 aerial photography that has been interpreted and updated to 1996 for disturbances. In addition to standard timber information, several other inventories were incorporated into the data set describing the TSA. These include caribou habitat, ungulate winter range, community and domestic watersheds, visual landscape, recreation, slope and elevation, riparian reserves, biodiversity emphasis maps and the Kootenay/Boundary Land Use Plan resource management zones. All of these inventories are linked together using a geographic information system to provide a spatially explicit resultant database. In the process of using this database to define the timber harvesting land base, spatial integrity is lost. In particular, uncertainty about what specific stands would constitute problem forest types results in the application of various percent reductions to each stand meeting certain criteria.

The definition of the THLB in this analysis is changed slightly from that which was reported in the Timber Supply Review. This analysis utilizes a THLB definition that was developed by the MOF in support of the AAC Determination. Changes to wildlife habitat exclusions and areas not-sufficiently regenerated result in a reduction of the THLB by 8,000 hectares. A summary of these changes is described in the appended Data Package. Figure 2 illustrates the current age class distribution of the THLB by 10-year age classes. The figure also reveals that the TSA is disproportionably weighted to stands having a younger age. Of the total area within the THLB only 41 percent is currently considered of merchantable volume or diameter. Much of the area within the THLB is also constrained for non-forest values. Caribou and other ungulates, domestic watersheds, recreation and visually sensitive areas place constraints on the availability of this merchantable area. Figure 2 shows that only 6.7 percent of the THLB (or 3.8 percent of the productive forest land base) might be considered merchantable, reasonably unconstrained as defined under integrated resource management guidelines and have a low biodiversity emphasis.

Figure 2 also illustrates that the productive forest outside the THLB follows an age class distribution that is similar to the timber harvesting land base. Only 2.5 percent of the total forested land base exists in stands greater than 250 years of age.

An alternative view of the total forested land base is provided in Figure 3. Here we see that logging history has impacted approximately 8 percent of the TSA (5% of this is currently less than < 20 years of age). The portions of the graph defining mature forest and old growth were based upon the age and the BEC classifications in the biodiversity guidebook. The majority of the old growth exists in the ESSFdk and MSdk BEC subzones.

Figure 4 shows the distribution of area by leading species within the THLB. Lodgepole Pine stands cover the majority of the TSA at about 50 percent. Mixed-wood spruce balsam stands are secondary at 20 percent. Douglas-Fir, larch, yellow pine, hemlock and cedar add a degree of diversity and comprise the remaining 30 percent of the forest land base.

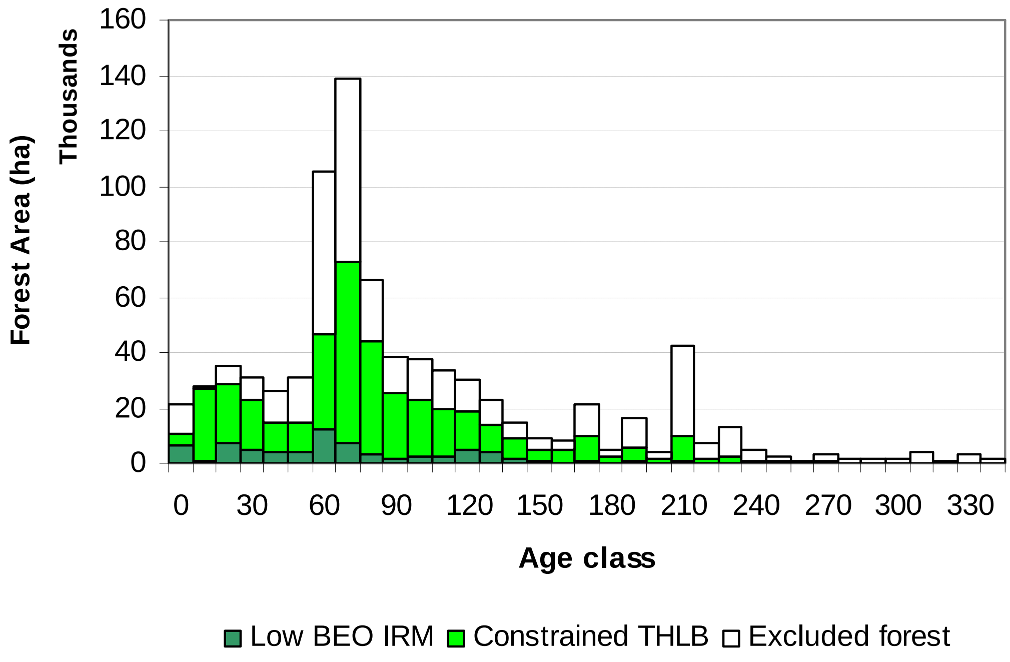

Figure 2 Current Forested Age Class Distribution

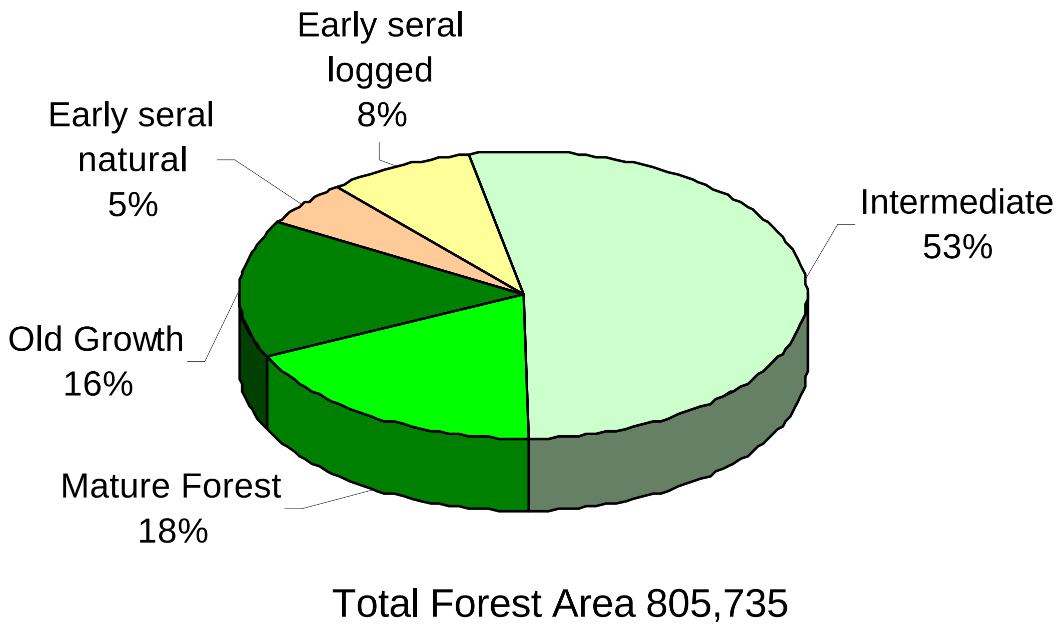

Figure 3 Seral Stage of the Total Forest Area

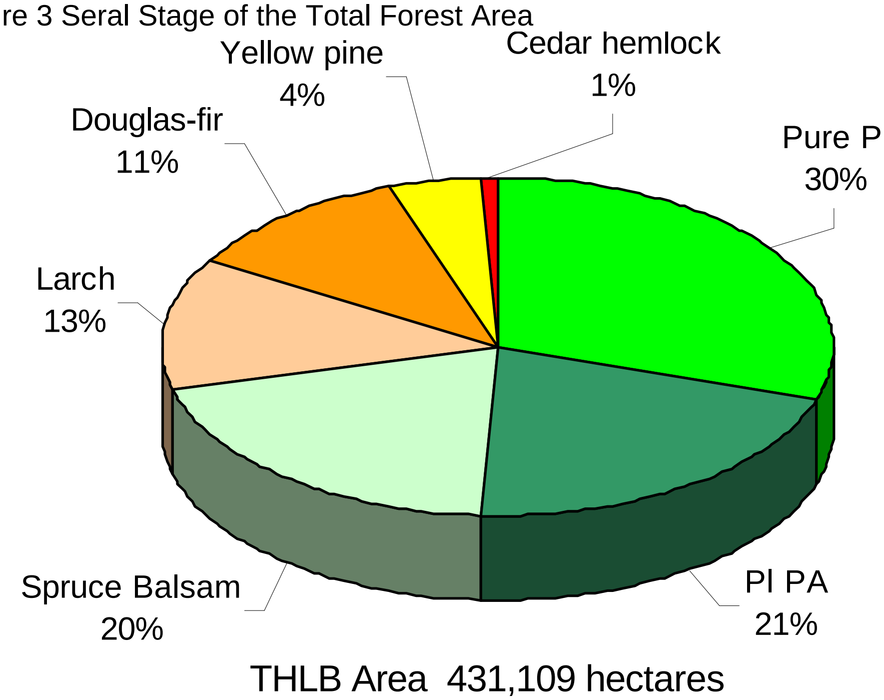

Figure 4 Proportion of THLB by dominant species

2.2. Timber Growth and Yield

Growth and yield in this analysis refers to the change in stand volume over time and the change in the average diameter and piece size per stem over time.

Stand growth and yield tables were allocated based upon silviculture history and silviculture management system. The MOF's Variable Density Yield Prediction (VDYP) model was used to predict the current volume and diameter and future growth of existing unmanaged stands. The Ministry's Table Interpolation Program for Stand Yields (TIPSY) model was used to determine the volume, diameter and piece sizes of future managed stands. Piece sizes for unmanaged stands were also predicted using the TIPSY model, with adjustments for stem diameter.

Site index assignments for unmanaged stands and managed stands utilized the VDYP program. VDYP assigns a site index using the predicted height a stand will achieve at 50 years of age.

Timber quality is the second growth and yield item that was predicted and tracked throughout the simulation period. Diameter at breast height (DBH) is a yield measure that can be reported for each analysis unit using both the VDYP model and the TIPSY model. Although this measure is not used to drive the selection of stands during a harvest simulation, the results of the simulation can be used to link a data set of diameters by age class. In addition to diameter, piece size is the log attribute of greatest interest to most sawmill managers. Estimated piece sizes were obtained for future managed stands using TIPSY stand and stock tables. These tables, specifically m^3/ha by diameter class and the corresponding m^3/tree by diameter class, were used to determine the proportion of volume harvested from each stand, by piece sizes ranging from less than 0.2 m^3/stem to greater than 0.8 m^3/stem.

Figure 5 illustrates the current diameter class distribution of stands within the THLB. The lack of smaller diameter stands between 14 and 18 cm is related to the age class distribution which showed that little area exists between 30-50 years of age.

The Type I Silviculture Strategy for the Cranbrook TSA indicated that logs greater than 32.5 cm were considered premium sawlogs and stems between 27.5 cm and 32.5 cm were standard sawlogs. Figure 5 shows that 34,500 hectares might meet the criteria for premium sawlog and 52,200 hectares, the criteria for standard sawlog.

Figure 6 shows the current estimated piece size distribution of stems existing in the THLB. Very generally, the larger the diameter and height, the greater is the piece size of the tree. Mature Lodgepole Pine 24 metres tall with a 20 cm DBH should produce a piece size of approximately 0.22 m^3. Whereas a 24 metre tall, 40 cm DBH tree in the same stand would produce 1.06 m^3. Table 2 provides an example of the correlation between various diameters and pieces sizes.

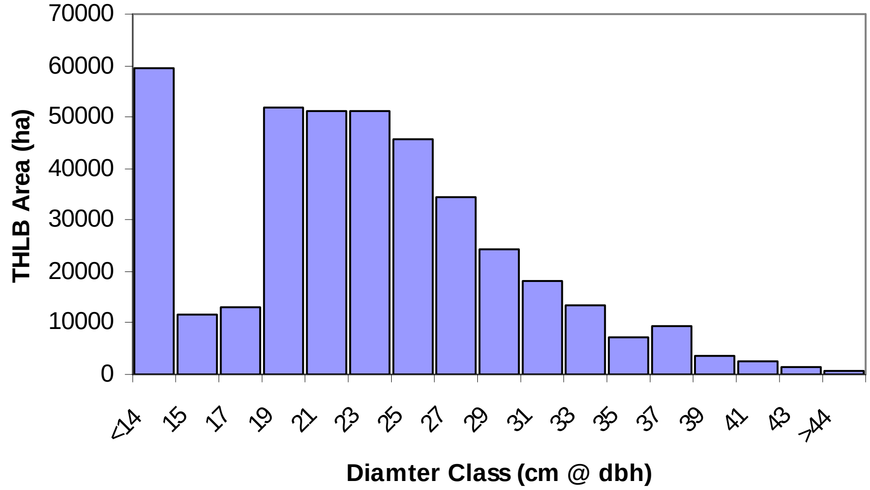

Figure 5 Diameter class distribution of stems within the THLB

Table 2. Example of DBH / Piece size correlation (24m tall Pine @ 80 years)

DBH class (cm)	15	20	25	30	35	40	45
Piece Size (m3/tree)	0.11	0.22	0.40	0.60	0.83	1.06	1.38

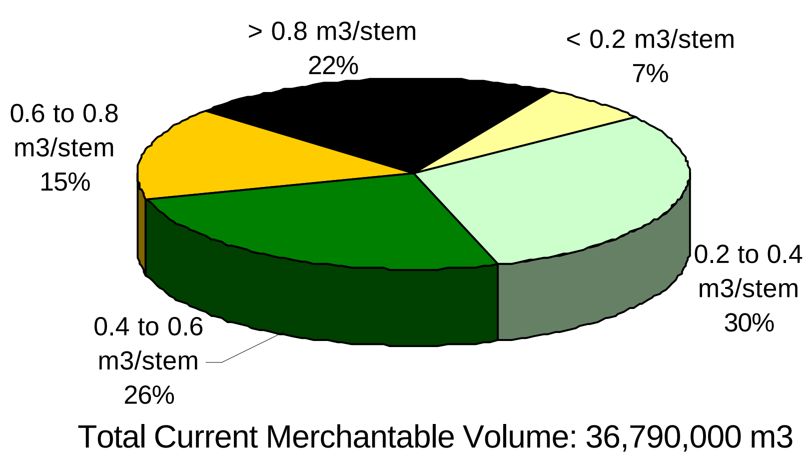

Figure 6 Piece size proportion of mature stands within the THLB

2.3. Management Practices

Management assumptions described in the Base Case harvest simulation represent as much as possible, current management practices across the TSA. Details on minimum harvest age, harvest priorities, regeneration assumptions and operational strategies in support of non-forest values are detailed in the appended Data Package. Table 5 in the Data Package provides a summary of the forest cover requirements applied to the forested land base. Forest cover requirements can be applied in several ways. For this TSA they are used as a surrogate for adjacency constraints, by restricting harvesting so it does not become too concentrated in any one area. They are also used to ensure that green up targets are met before new harvesting takes place.

Mature and old growth targets do not restrict harvesting if more merchantable timber is currently available than is required to meet the 'mature' and/or 'old' seral stage target. If old growth targets are not met with the current age class structure, the 'next' oldest timber is placed into a reserve. Younger, merchantable timber outside this reserve is available for harvest, if it is not constrained by other overlapping forest cover requirements.

The forest cover requirements for caribou, watersheds, visually sensitive areas, recreation, ungulate winter range, IRM areas and the FMER closely follow the constraints that were applied in the Timber Supply Review (TSR) Base Case analysis. Forest cover constraints for landscape level biodiversity changed from the TSR Base Case where each landscape unit was assigned a generic 10% high, 45% low and 45% intermediate biodiversity emphasis objective. Biodiversity deployment from the Regional Landscape Unit Planning Strategy was used in this analysis.

The scheduling of stands for harvesting followed a "random" selection approach, rather than a harvest rule such as oldest first or relative oldest first. As a result, the most efficient harvest schedule was not carried out, leading to analysis results that are often difficult to logically justify.

2.4. Wildlife Quality and Quantity

Wildlife habitat and habitat values were not explicitly modelled in this analysis. To do so would require inventories such as Terrestrial Ecosystem Mapping (TEM) and wildlife habitat ratings tables for the critical species within the TSA. This information is not currently available for the Cranbrook TSA. In lieu of this, caribou and other ungulate management zones were delineated on maps and merged with the forest cover inventory. Forest cover constraints were imposed on this area in a generalized attempt to maintain a certain ‘mature and old’ forest structure that is suitable habitat for these species.

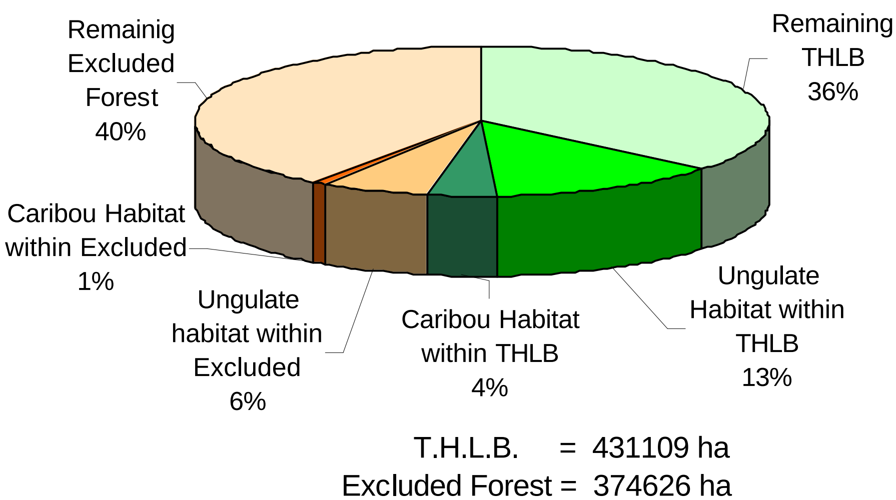

Figure 7 Defined Caribou and Ungulate habitat

Figure 7 shows the current amount of THLB and excluded forest constrained for caribou and other ungulates. In total 195,960 hectares are identified as area suitable for habitat.

Habitat for other critical species was addressed through a 1 percent reduction to the THLB from the area described in the TSRII Base Case. In addition to alpine forest, wildlife tree patches, riparian reserves, inoperable areas and other exclusions, this area nets down the productive forest land base to approximately 391,000 hectares.

2.5. Analysis Methods

The MOFs forest estate model FSSIM version 3.0 was used to simulate harvesting in forest stands over time. Changes to analysis assumptions were completed by changes to the input file structure in the FSSIM model. To measure the impact of alternative silviculture regimes, the growth and yield model (TIPSY) was used to incorporate silviculture management alternatives. The impact of these alternatives on timber quality was measured through lookup tables that took the results of the harvest simulation and reported out the effect on stand diameter and piece size.

Eleven scenarios were examined in this investigation. They have been grouped according to six general topics.

1. The Base Case analysis (1 scenario).
2. Measuring the impact of alternative amounts of pre-commercial thinning (2 scenarios).
3. Measuring the impact of alternative amounts of fertilization (3 scenarios).
4. Increasing the land base through stand rehabilitation (1 scenario).
5. Incorporating Class A seed (1 scenario).
6. Improving wildlife habitat (3 scenarios).

Each scenario measures small, singular changes to the Base Case, thereby allowing us to quantify individual management assumptions.

3. Base Case Results

Over the past 4 years, three Base Case harvest simulations have been completed for the Cranbrook TSA. Two of these were discussed at some length in the Type I Silviculture Strategy for this TSA. The first Base Case was reported in the Timber Supply Review produced by the MOF and released in 1999. A second "more realistic" Base Case was described in the AAC Determination for the Cranbrook TSA and was completed at the Chief Forester's request (also in 1999). The third and current Base Case is the one completed and reported in this document in support of a Preferred Silviculture Strategy.

The harvest flows described by all three Base Cases vary. The change from the TSR base case occurs primarily due to a reduction in the THLB. The change from the "more realistic" base case occurs due to a change in the old (intermediate BEO) seral target for the ESSF dk, from 250 years to 140 years. A comparison of these "alternative Base Cases" is provided in Figure 8.

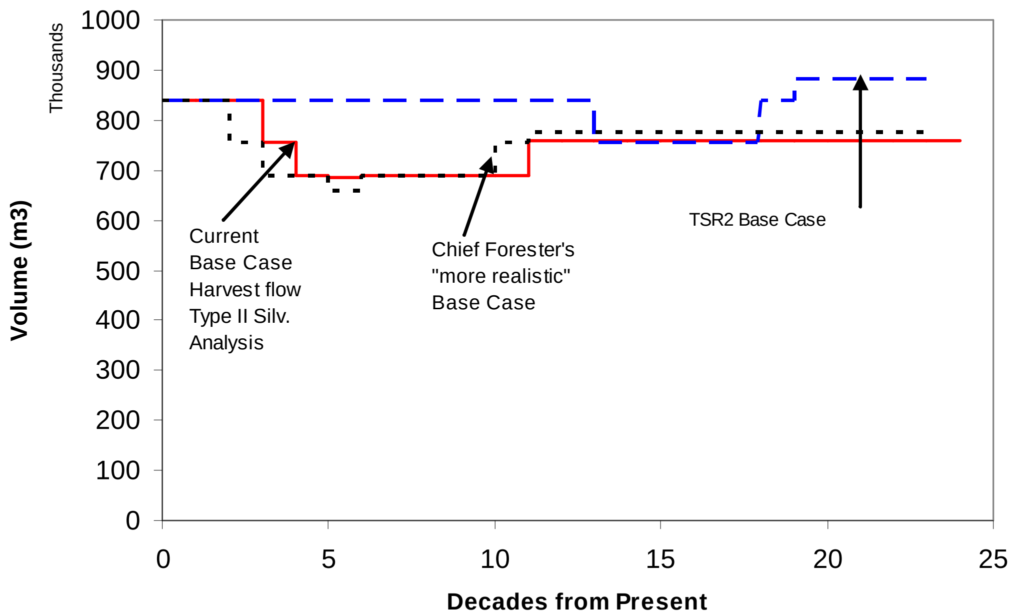

Figure 8 Comparison of previous Base Case results

The most significant difference between these Base Case results is the duration that the current conventional AAC can be maintained. The TSRII Base Case forecast that the current AAC could be maintained for the next 130 years. The more realistic Base Case suggested it could only be maintained for 20 years. The current Base Case predicts a 30 year rate of harvest at the current AAC before the harvest must begin to decline.

The following Section describes the results of the current base case harvest simulation completed for the Cranbrook TSA.

3.1. Base Case timber supply

The Base Case harvest flow as a result of this analysis is shown again in Figure 9. Here the current AAC of 838,000 m^3 can be sustained for 3 decades. This is followed by declines of 10 percent in period 4, eight percent in period 5 and a 1 percent dip in period 6. In period 12, the AAC is forecast to increase to a long-term sustainable harvest level of 759,000m^3/year.

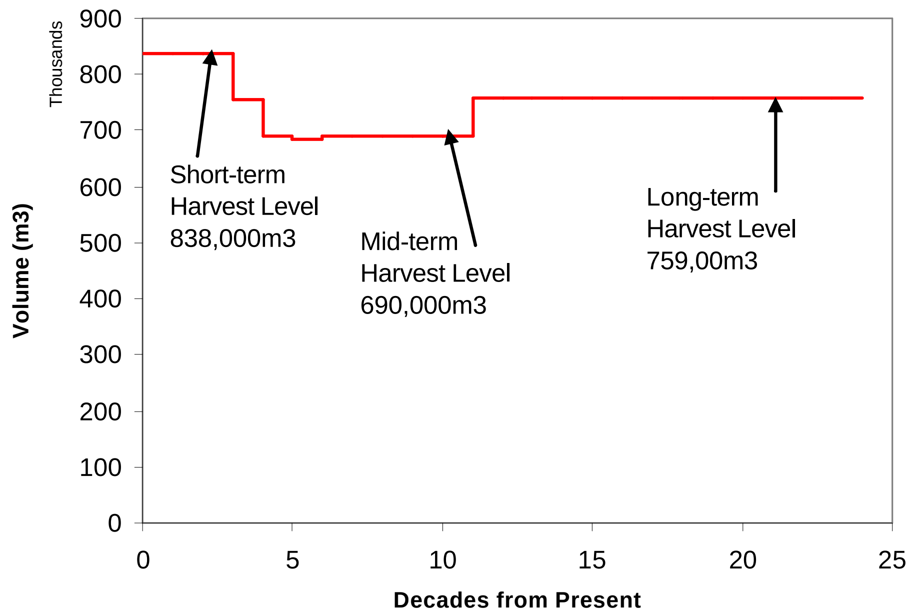

Figure 9 Base Case Harvest Forecast, Cranbrook TSA

For the current Base Case, Figure 10 illustrates that the TSA has a merchantable growing stock of 36.7 million m^3 and a total growing stock of 51.9 million m^3. In only 80 years, the merchantable growing stock reaches a relatively stable level of approximately 23 million m^3.

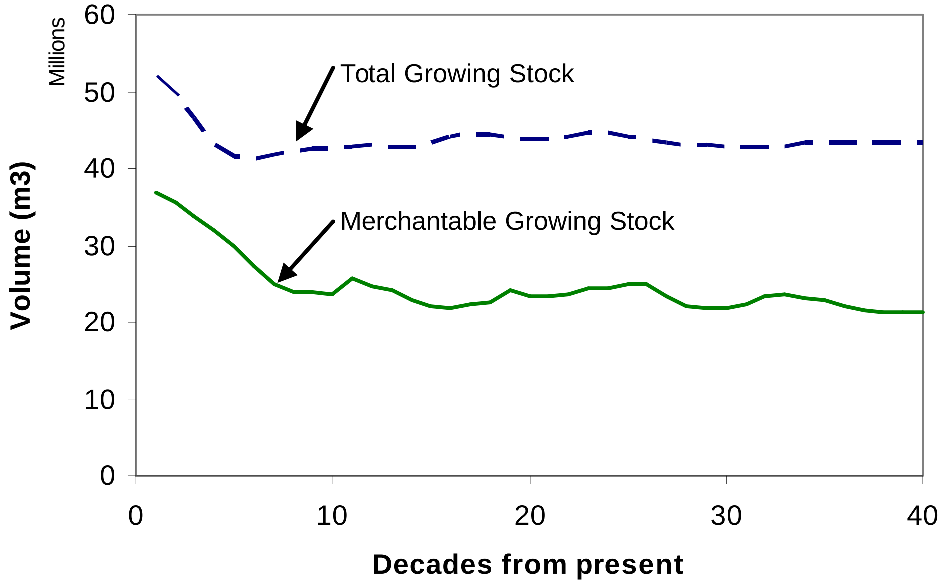

Figure 10 Forecast Growing Stock, Base Case Analysis, Cranbrook TSA

Timber harvesting and ageing of the forest changes the structural state of the forest over time. Structural state is defined in the biodiversity guidebook as early, mature and old. Criteria are based upon age and biogeoclimatic ecosystem classification (BEC). Seven subzones exist within the TSA which are grouped into four different interpretations of structural state. These subzones and corresponding seral classifications are shown in Table 3. Approximately 40 percent of the total forest area have old seral targets of 250 years; however, Figure 2 had previously illustrated that very few stands within the TSA were above this age. As a consequence, this is one of the greatest constraints on the short-term harvest level.

Tracking the age class distribution within each of these subzones enables us to create a profile of the structural state of the forest over time. This is illustrated in Figure 11. Here we see the amount of mature and old forest increase, from approximately 30 percent of the land base to 50 percent over time. Much of this increase is due to the assumption that the forests of the TSA will age to perpetuity. Although many may find this assumption illogical, it demonstrates how the non-THLB land base ages over time and eventually reduces the seral constraints on the THLB in the long-term. A more logical approach might be to factor in catastrophic events into the harvest simulation. This is done to some extent through the reduction of the gross possible harvest level by 77,000m^3/year for non-recoverable losses. However, this is a volume not an area loss.

Table 3 Biogeoclimatic sub zone/ variant

BEC	**Mature minimum age (years)**	**Old minimum age (years)**	**Total Forest Area (ha)**
ESSF dk	120	140	264,179
ESSF wm	120	250	105,341
ICH mk1	100	140	40,196
ICH mw2/mw1	100	250	56,083
IDF dm2	100	250	41,614
MS dk	100	140	186,734
PP dh2	100	250	13,000
AT / ESSF (parkland)	100	250	98,588
Total forest area contributing to forest cover constraints			805,735

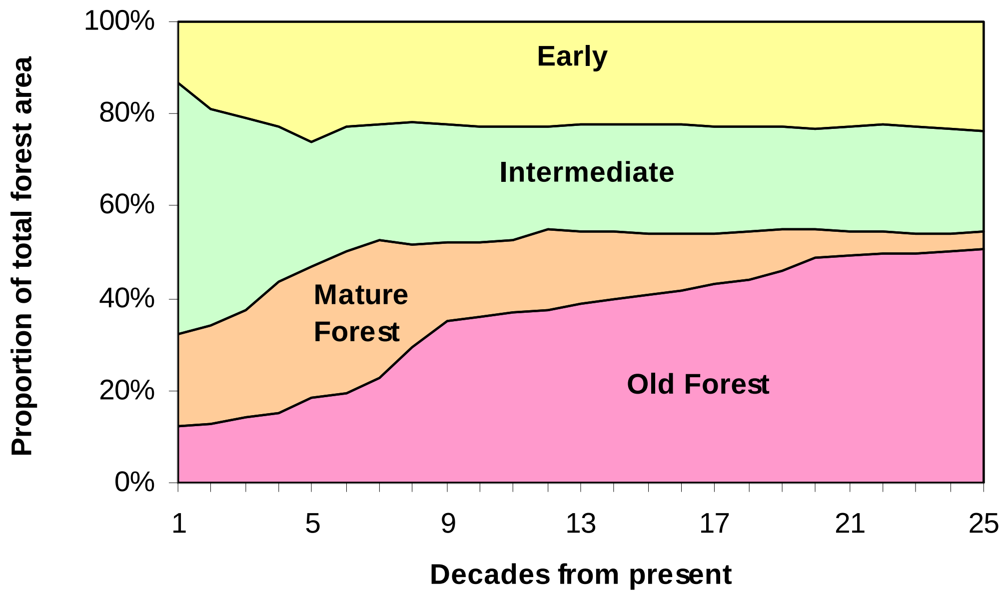

Figure 11 Change in structural stage

3.2. Base Case timber quality

The Type I Silviculture Strategy for the Cranbrook TSA indicated that log diameter provided a measure of timber quality. Diameters greater than 32.5 cm DBH were considered premium sawlogs and diameters between 27.5 and 32.5 cm were considered average sawlogs. This assumed a “sawlog” economy where size is a surrogate for quality.

To assess timber quality, the approach used in this analysis involved tracking the average diameter and piece size of stands harvested over time. Both of these stand attributes are very subjective with respect to forest inventory information (i.e., the degree of confidence in the estimates for any one stand are likely quite variable, since little or no auditing has been done to verify the estimates used). Therefore, prior to analyzing these results it is important to place in perspective the change in the average harvested stand age over time and the time when stands are converted from natural unmanaged stands to managed stands through harvesting. These results are shown in Figures 12 and 13.

Over time, stands are very gradually harvested at a younger age. This would suggest that the diameters should decrease and the amount of knots found in stems would increase due to the managed stand densities and greater live crowns. Over the long-term, the average age of stems harvested across the TFL decreases by about 50 years. At the ages indicated and densities managed, natural pruning will become less evident in many stands.

Figure 13 illustrates the time period when harvesting shifts move away from natural stands towards managed stands. This transition begins to occur 50 years from present and by period 9, 75 percent of the harvest is from managed stands. By the 13th decade, approximately 97% of the harvest is supported by managed forest. The remaining 2 to 5 percent harvest from natural stands comes primarily from old growth existing in visually sensitive areas with retention as a VQO. These stands (approx. 24,000 ha) are harvested on a 500-year extended rotation.

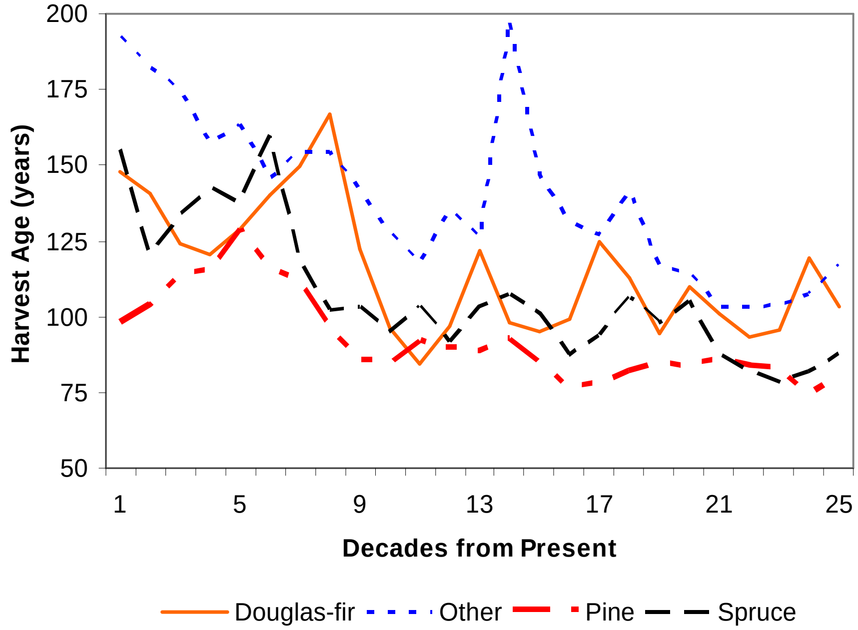

Figure 12 Average harvest age by leading species over time

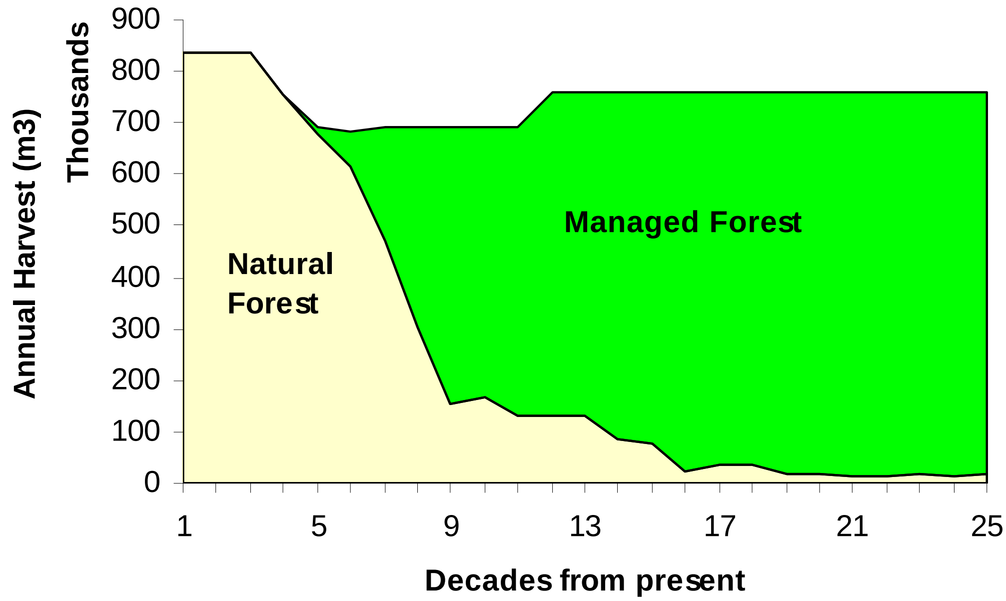

Figure 13 Conversion from harvesting natural stands to managed stands

It is indicated in the appended data package, that diameter is an output available for both managed and unmanaged stands using the TIPSY and VDYP models. Piece size however, is an output that is only currently available for managed stands using the TIPSY model. Piece sizes (i.e., stand stock tables) for existing unmanaged stands are not available. The change in diameter for each analysis unit, at each age class, was used to adjust managed stand piece size proportions and make them applicable to the corresponding unmanaged stand. Although the absolute values shown in the following graphs may differ somewhat from what is actually achieved operationally, it is the trend in the change in piece sizes that is of importance.

In light of the trends shown in Figures 12 and 13, the development revealed in Figure 14 for diameter over time, and Figure 15, piece size over time, offer some interesting observations. As expected, average diameter will decrease. The current average diameter harvested is estimated for natural stands at 27 cm dbh. This remains relatively constant over the next 70 years before a drop to a long-term average harvest diameter of 21 cm. This observation is supported by Figure 15, which illustrates the proportion of harvest volume that falls into 5 piece size categories. Initially, about 37 percent of the TSA's harvest provides piece sizes greater then 0.6 m^3/tree. At about period 7, the availability of larger piece sizes begins to decline as harvesting comes increasingly from managed stands of timber. The smaller future piece sizes occur primarily as a result of a lower harvest age and reduced percentage of old growth.

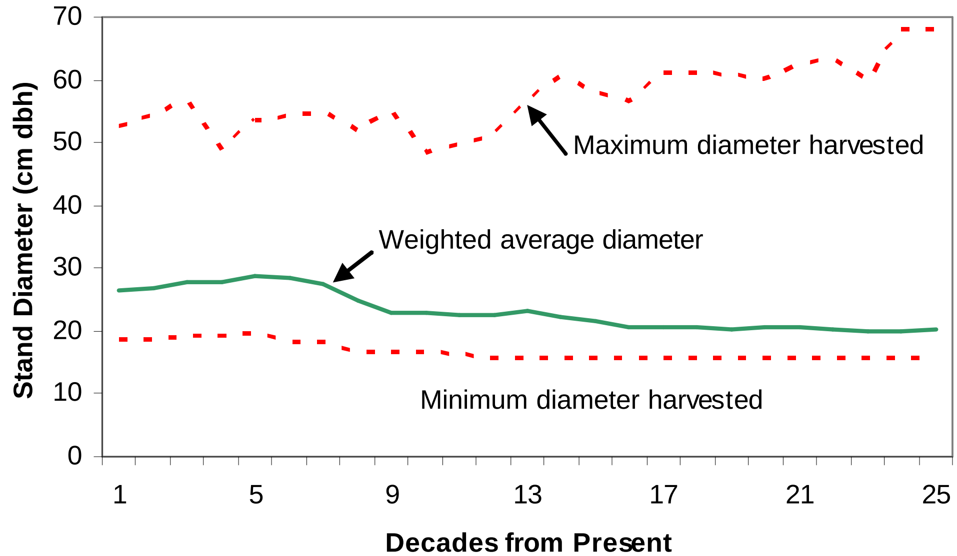

Figure 14 Weighted average diameter and range of diameters harvested

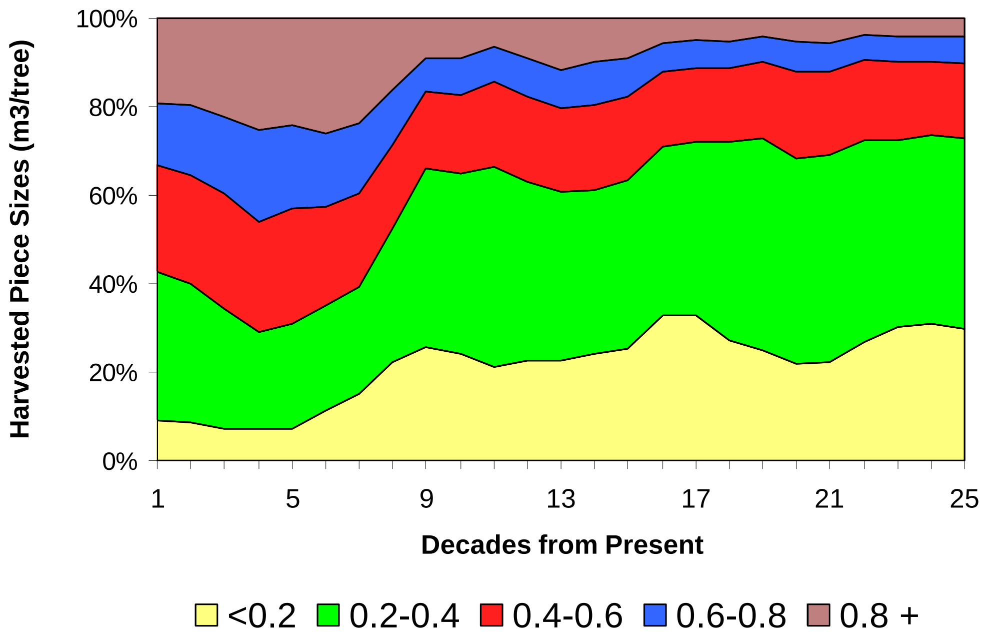

Figure 15 Forecasted piece sizes harvested

3.3. Base Case habitat quality

Habitat management zones within the Cranbrook TSA have been spatially identified for caribou and other ungulates. To maintain or improve the forest habitat for these species, forest cover constraints and green up constraints have been applied to harvesting operations in these areas. As well, these areas are subject to biodiversity objectives that were defined by the Regional Landscape Unit Planning Strategy.

Figure 16 shows the harvest level for the TSA and the proportion that comes from the Caribou and other ungulate management zones. An average of 380,000 m^3 or 1200 hectares is harvested from these areas annually.

As a result of harvesting in these wildlife zones, the structural state of the forest also changes. Figures 17 and 18 illustrate this change over a 250-year planning horizon.

Figure 17 shows that Caribou habitat covers approximately 45,000 hectares. Initially about 10,000 hectares (22%) are greater than 140 years. Over time, this increases to about 33 percent of the Caribou zone, however, the majority of the stands have aged to beyond 250 years.

Figure 18 illustrates the change in age classes across habitat delineated for other ungulates. Here the results are more significant with respect to an increase in the amount of older stands. This wildlife zone covers over 150,000 hectares; however only 12 percent of the area is currently represented by older forests over 140 years of age. By period 9 these older forests have increased to 44 percent of the wildlife zone.

Old growth is generally considered to be good quality ungulate habitat. Constraints on harvesting have been imposed to increase the quantity of wildlife habitat. Thus both of these graphs suggest that quantity and quality of ungulate habitat will increase considerably over the next 50 to 100 years.

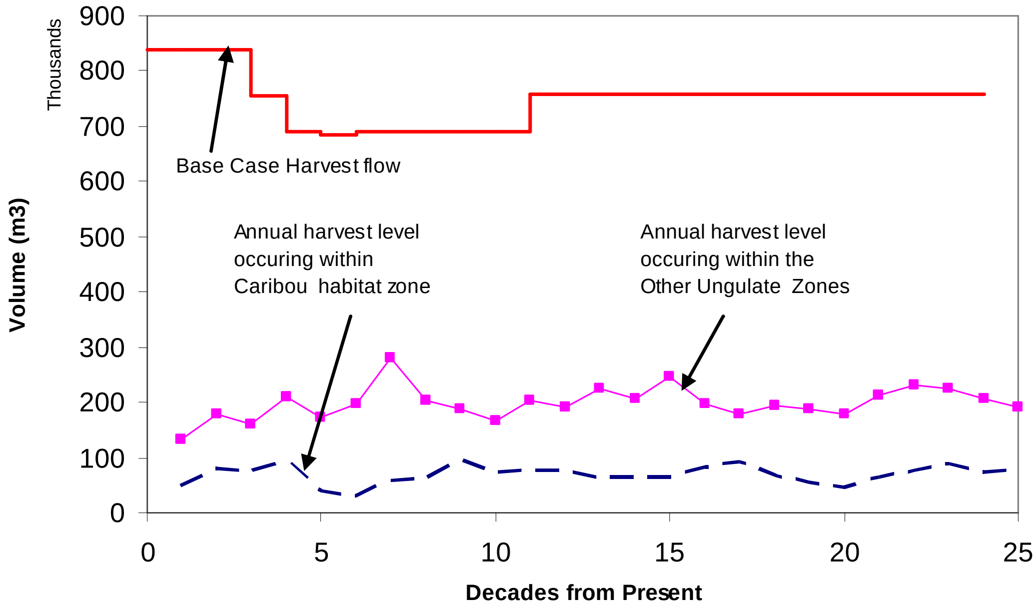

Figure 16 Harvest forecast from Caribou and ungulate habitat areas

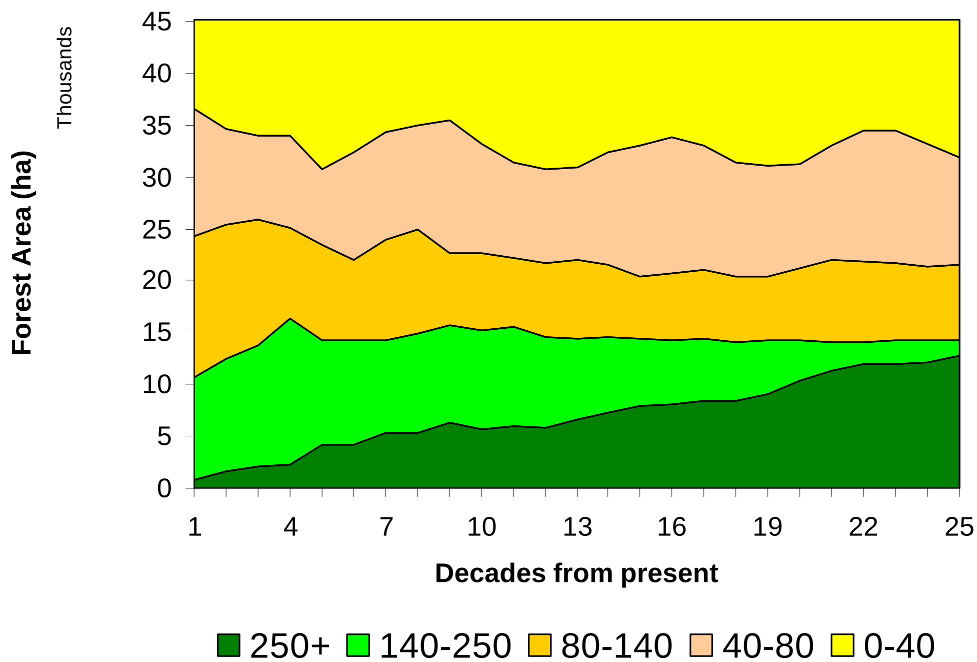

Figure 17 Caribou habitat age class distribution over time

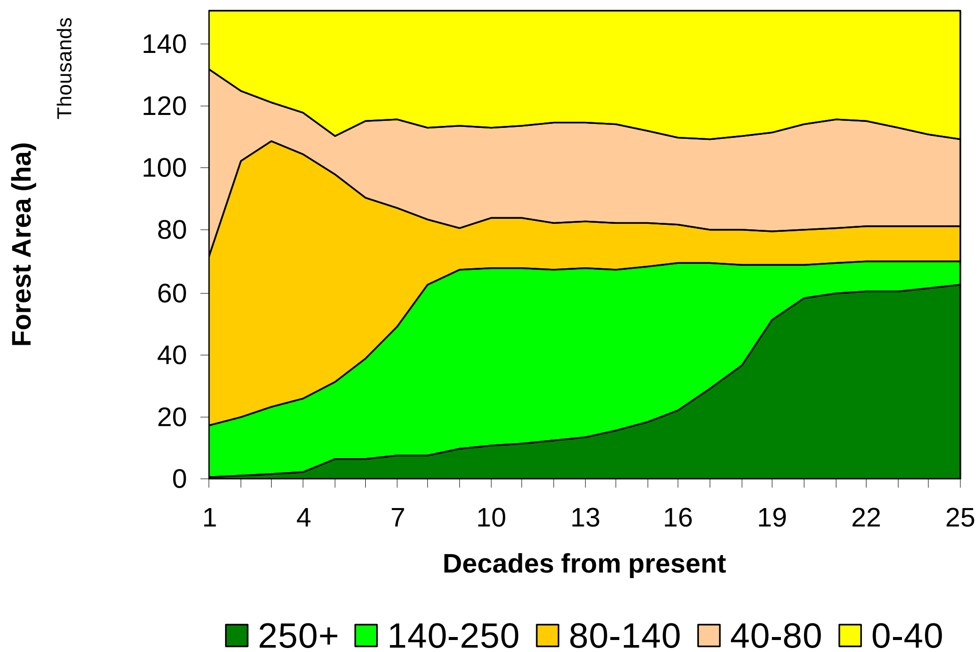

Figure 18 “Other Ungulate” habitat age class distribution over time

4. Scenario Results

The following section describes the results of the various sensitivity scenarios investigated for the TSA. Some of the scenarios focused on improving timber supply; others, quality or habitat. In all scenarios the forecast harvest level is identified. Additional information is only provided on those components of the Base Case for which a measurable impact was observed.

4.1. Pre-commercial thinning

The silviculture management assumptions used in the Base Case for this report did not have pre-commercial thinning applied to the natural component of managed stands. In contrast, two scenarios investigated different levels of pre-commercial thinning (PCT) across the TSA. One scenario measured the impact of a program that incorporated PCT to the natural component of all managed stands (i.e., approx. 1500ha/year PCT to a target spacing of 1200 to 1600 stems per hectare (sph)). A second scenario reduced the amount of PCT to approximately 1000ha/year.

Figure 19 shows the results of pre-commercial thinning with respect to the Base Case harvest flow. There is almost no change in the short or mid-term as a result of either of these silviculture strategies. In period 10, a PCT program of 1000ha/year permits a rise to the long-term harvest level one decade sooner. This will also increase the long-term harvest level 0.7 percent to 764,700m^3/year. A slightly more intensive program, whereby almost all stands are PCT, should result in a long-term harvest increase of 1 percent (8100 m^3) to 767,400m^3/year.

The impact of the full PCT strategy on timber quality is shown in Figures 20 and 21. As expected, no change will occur from harvesting existing unmanaged stands. As we saw in Figure 13 a gradual impact will only be realized after harvesting begins to come from existing and future managed stands. In Figure 20 we see that the average diameter of stands harvested after Period 8 will increase slightly over the Base Case. The average relative change in diameter is a 1.4 cm DBH gain from period 12 on.

Piece sizes also increase as a result of pre-commercial thinning. Figure 21 and 22 illustrate the relative change in piece size in comparison to the Base Case at periods 10, 15 and 20. The largest degree of change occurs in the smaller piece sizes at period 20. Here, a large shift from piece sizes less than 0.2 m^3/tree, is made into the piece size category of 0.2 to 0.6m^3/tree. Very little change occurs relative to sizes greater than 0.8m^3/tree.

The change in minimum cutting age as a result of PCT is negligible. This is primarily due to the method used to determine cutting age in the Base Case. The Base Case assessed minimum cutting age using a combination of volume, minimum diameter and economic culmination. The slight change in volume and diameter as a result of thinning often had a small impact on the minimum cutting age criteria. However, given that the simulation model operates on periods of 10 years, a significant change in yield or diameter would need to occur to warrant a change to the minimum cutting age.

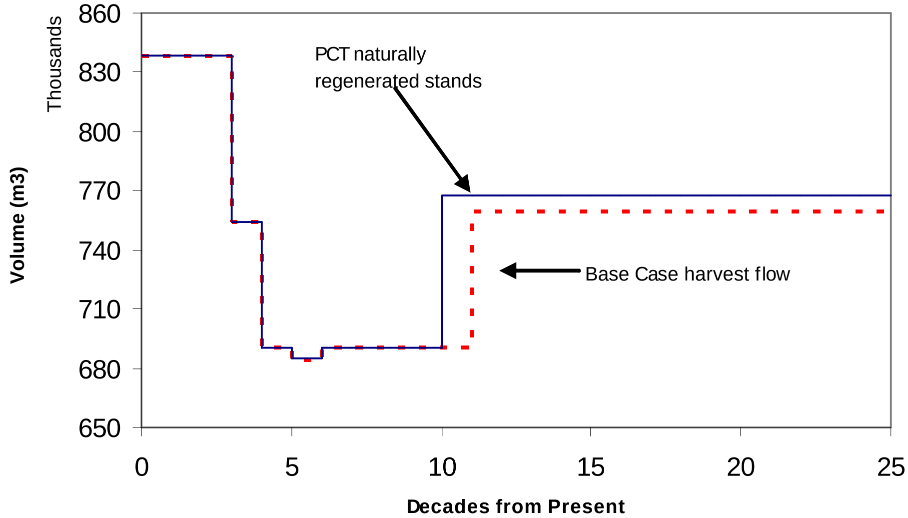

Figure 19 Impact of Pre-commercial thinning

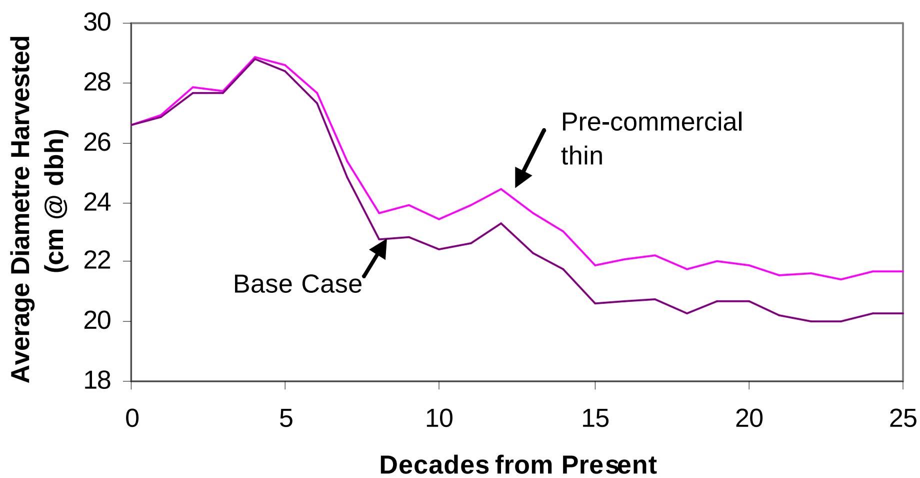

Figure 20 Average diameter harvested – PCT

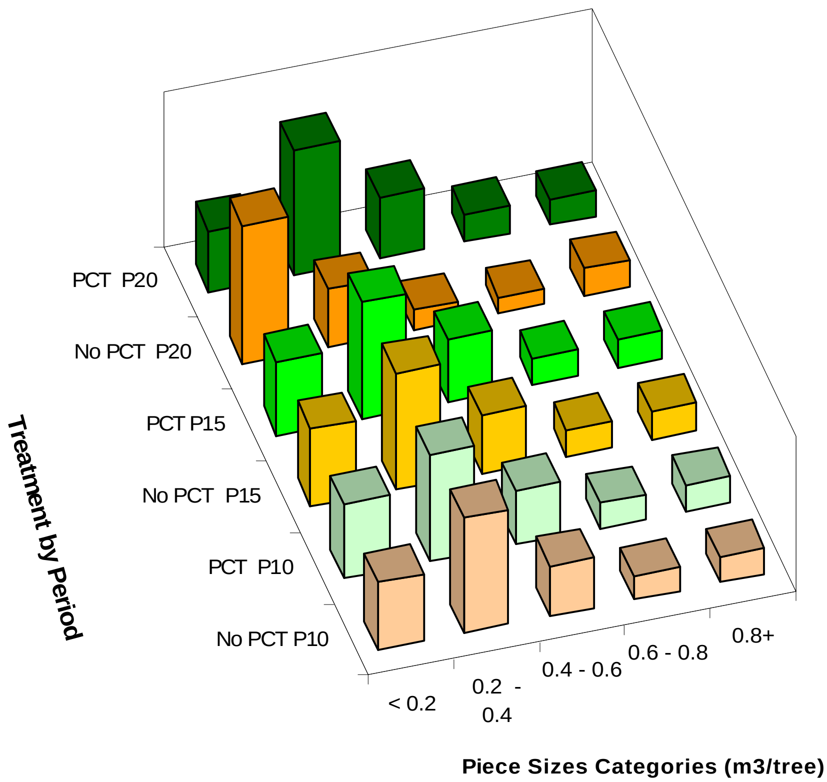

Figure 21 Change in Piece Size, PCT vs. No PCT in Periods 10, 15 & 20

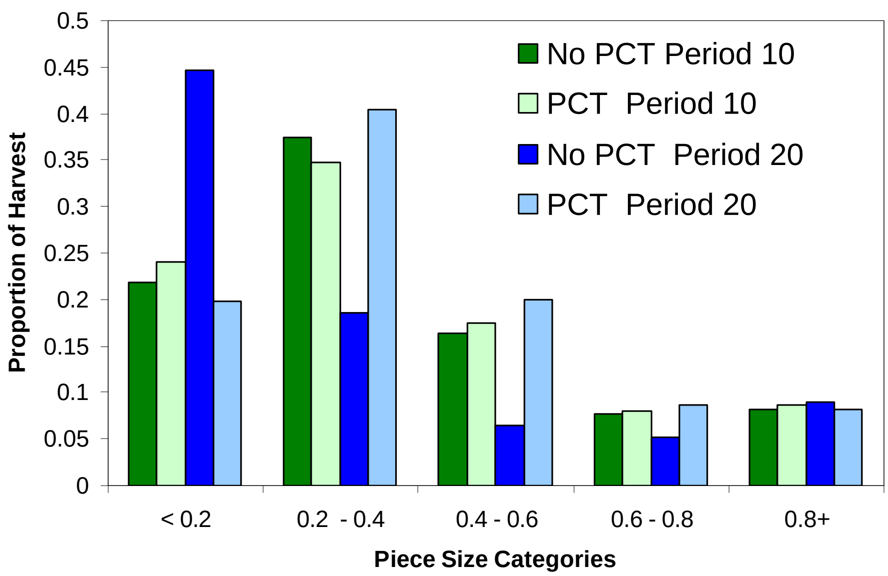

Figure 22 Change in Piece Size, Periods 10 and 20

4.2. Fertilizing Spaced Managed Stands

Two scenarios tested the impact of fertilizing spaced, managed stands. Existing managed Lodgepole Pine (Pl) or Pl-Douglas-Fir mixed-wood stands, located in integrated resource management (IRM) areas having a low or intermediate biodiversity emphasis option (BEO), were spaced and fertilized when they reached an initial age of 35 years. The initial intention of these two scenarios was to fertilize at a rate of 1,700 ha/year and 2,500ha/year. The TSA inventory does not have sufficient managed area of appropriate age within the IRM zone to undertake this fertilization schedule. At a rate of approximately 500 ha per year for 31 years, a total of 18,300 hectares were fertilized. Figure 23 shows the operational fertilization schedule that was modelled in these two scenarios.

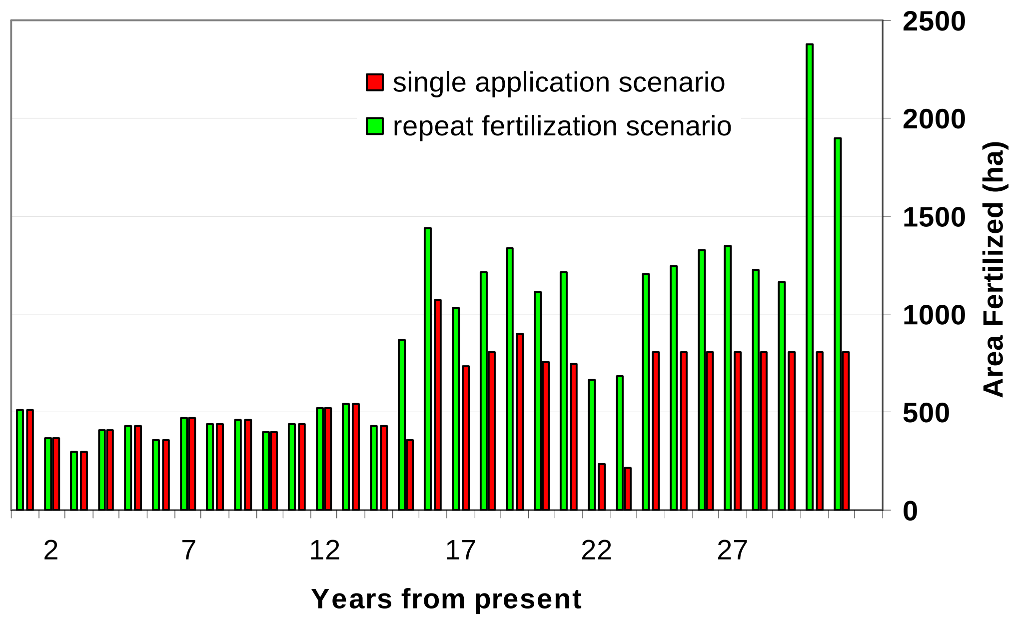

Figure 23 Operational schedule of fertilization applications

In the first scenario, the TIPSY model predicted that fertilization would result in both a 15 m^3/ha gain by 80 years and a small reduction in the minimum cutting age for these stands.

The second scenario mimicked the first, but scheduled three repeat applications of fertilizer. For a similar total area of 18,300 hectares, treatments were planned to occur at 35 years, 50 year and 65 years.[1] The minimum harvest ages for these stands dropped 10 years. A volume gain of approximately 15m^3/ha was forecast with each application. This provided a total, additional volume increase at harvest of approximately 45m^3/ha.

The results from both of these scenarios are shown in Figure 24. The most significant impact is that fertilization results in the ability to maintain the current short-term harvest level for another 10 years. This is possible because of the additional managed stand volume that comes available in Period 5. More managed volume in period 5 allows us to shift some of the unmanaged volume and harvest it at an earlier age. However, this is not without cost. The shift towards more short-term volume results in slightly less volume available throughout the mid-term and significantly less volume available in the latter part of the mid-term harvest flow. The long-term impact of fertilization was insignificant.

The results of a 3 time repeat application of fertilizer is not much different from a one time application. Although the yields achieved from these stands at harvest age is significantly greater (45m^3/ha), the total volume is insufficient to prolong the current harvest level for more than 1 decade beyond the Base Case. Repeat fertilization has a positive effect on the mid-term harvest. With repeat applications we see a small increase (0.8%) in the mid-term to 720,800m^3/year. Again, the cost of this increase is a two decade delay in reaching the sustainable long-term harvest level.

Figure 25 illustrates the area harvested from fertilized stands each period. Repeat fertilization resulted in the total 18,300 hectares being harvesting at a slightly faster rate. In both cases, all of the fertilized stands have been harvested by period 13.

[1] TIPSY is not calibrated to provide results for repeat fertilization. Therefore each yield table was calibrated by factoring a 1x application at varying ages and adjusted accordingly.

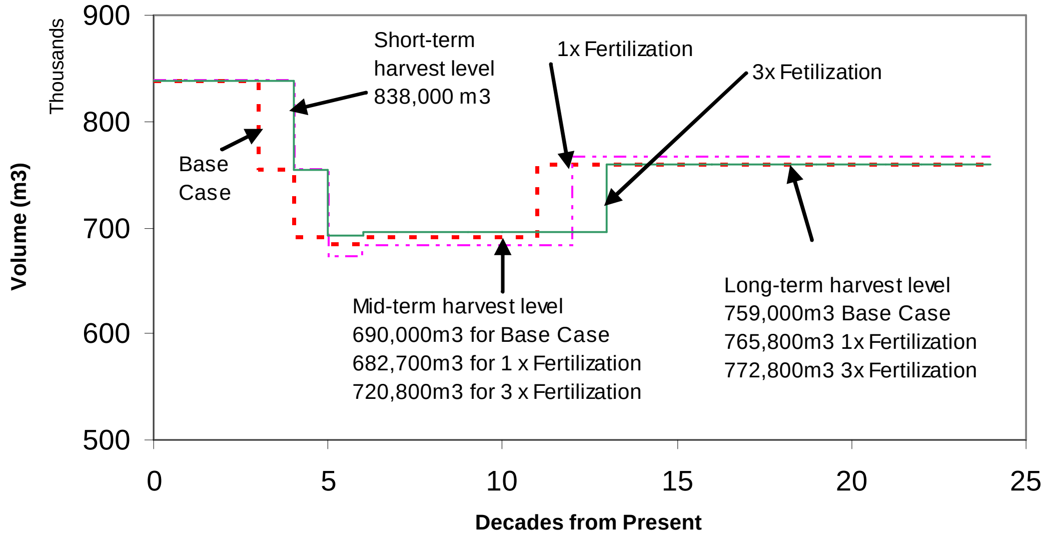

Figure 24 Impact of fertilization on the harvest flow

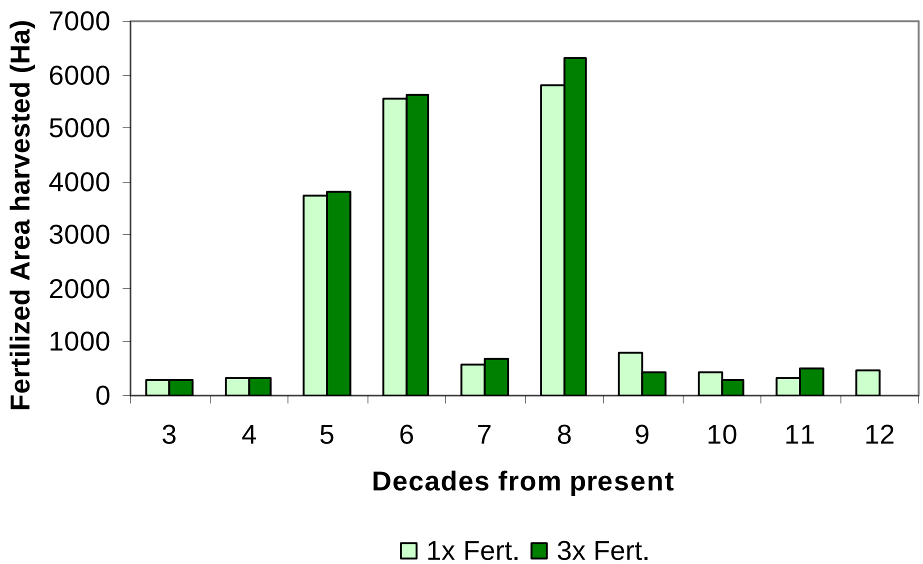

Figure 25 Scheduling fertilized stands for harvest

4.3. Late fertilization existing unmanaged stands

With insufficient area in existing managed stands to warrant an extensive spacing-fertilization program, older unmanaged stands were identified as candidates for late fertilization. Good and medium site pine and larch stands in low and intermediate BEO IRM areas were selected for late fertilization15 years prior to harvest. Fertilization was carried out at a rate of 1,700ha/year for the next 10 years. It was assumed that fertilization would result in a 15m^3/ha increase in yield at harvest age. If the stand was not harvested within 35 years of the treatment, the yield gain was lost. A priority was placed on these stands, to ensure they were harvested at or near their minimum cutting age.

In this scenario, 93 percent of the stands selected for late fertilization were harvested in periods 2, 3 and 4. The harvest flow as a result of late fertilization is shown in Figure 26. Late fertilization allowed us to maintain the current harvest level. Prolonging the forecast fall-down into period 4 was not possible. However, the degree of fall in period 4 was considerably reduced. The mid-term harvest flow result is a 5.9 percent increase above the Base Case, to 730,800m^3/year. However, this increased volume in the mid-term causes the long-term rise to be delayed by 5 periods.

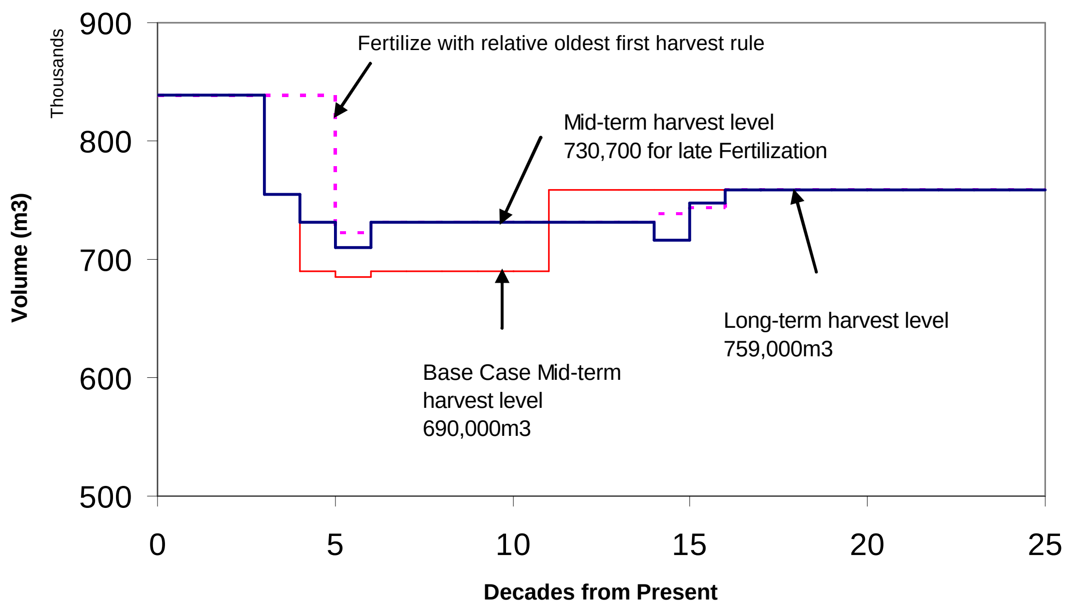

Figure 26 Harvest flow from late fertilization of natural stands

The result from this scenario and the scenario investigating spaced managed stands are difficult to analyze, since the results are somewhat unexpected. Fertilization of stands 15 years prior to harvesting did not result in an improvement in the short-term; whereas fertilization of young managed stands did. This is due in large part to the random selection of stands scheduled for harvesting in the simulation model. Different selections can result in dramatically different harvest flows. In all the fertilization scenarios, a priority was placed on harvesting the fertilized stands as soon as they are eligible for harvesting. The resultant selection of other stands is thereafter very different from the Base Case. An analysis of the impact of fertilization would be better addressed through a harvest schedule under defined guidelines, such as relative oldest stands first. If this harvest rule was used in the late fertilization scenario, the current harvest flow can be maintained for 6 decades. However, the relative improvement over the Base case was not tested.

4.4. Stand Rehabilitation

This scenario was developed in an effort to reduce the mid-term fall down and improve the long-term harvest flow. Stands currently excluded from the THLB, older than 60 years and located within IRM, low BEO areas, were selected for stand rehabilitation. A total of 500 hectares per year were rehabilitated and added back to the THLB over the next 25 years. It was assumed that the rehabilitation process would net $75m^3$/ha of merchantable volume. The area would then be regenerated to managed stands yielding 250-300 m^3/ha in the long-term. The resultant net increase in the THLB was 12,500 hectares.

Figure 27 shows the impact of this strategy as compared to the Base Case harvest flow. The initial harvest level follows the Base Case to the end of Period 4. In period 5, there is a 4 percent decline to the mid-term harvest level (with a 1 percent dip in period 6). The mid-term harvest level stabilizes 9 percent above the mid-term for the Base Case. Similarly, the long-term harvest level, which is achieved in period 17, is 1.8 percent above the Base Case.

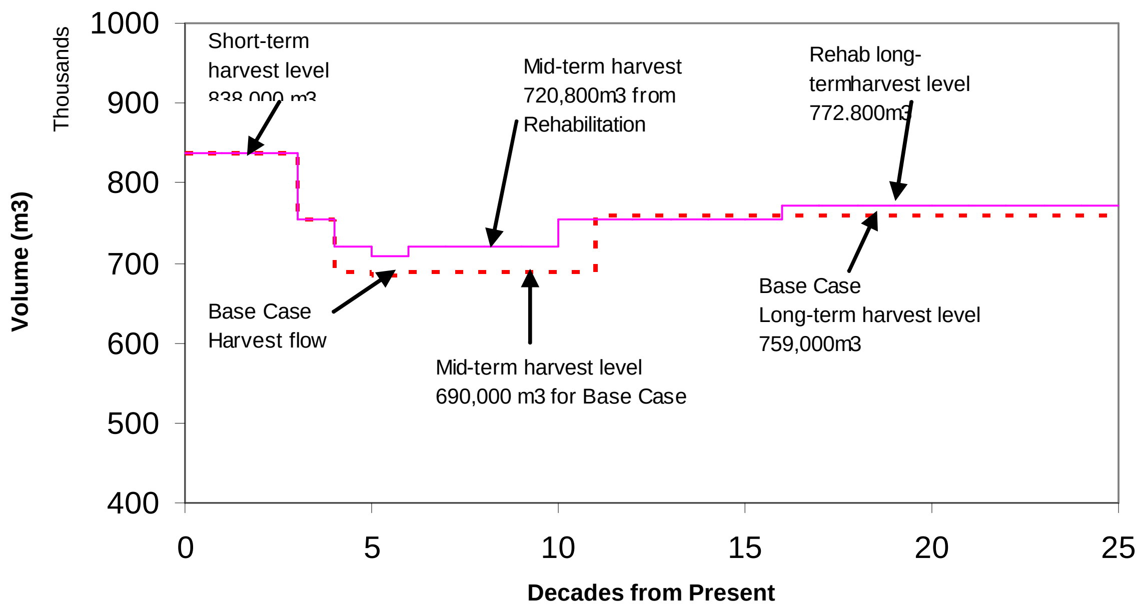

Figure 27 Harvest flow resulting from stand rehabilitation

4.5. Class A Seed

Seedlings produced from Class A seed will likely be available for many parts of the TSA in the very near future. Class A seed should result in reduced free growing and adjacency constraints and long-term improvements in timber quality and pest resistance. A significant improvement in stand yield is also forecast, if these trees are harvested near their economic culmination age. Stands harvested considerably after economic culmination will see a diminishing gain in yield over wild seed.

Figure 28 shows the impact of Class A seed on the mid and long-term harvest levels. There is no impact in the short-term, as timber availability is constrained more by old seral targets than by green up. At period 7 the harvest level can increase 5.8 percent over the Base Case, due solely to the increase in yield from Class A planted seedlings. The long-term will see less of an increase at 5.5 percent.

Class A seed is conservatively estimated to produce yield increases of from 9 percent to 25 percent at culmination age. The long-term harvest level did not increase by this proportion largely due to the influence of natural regeneration. Undoubtedly, both the mid and long-term harvest levels could increase substantially higher, if less reliance was placed upon natural regeneration and more on planted stock produced from Class A seed. [2]

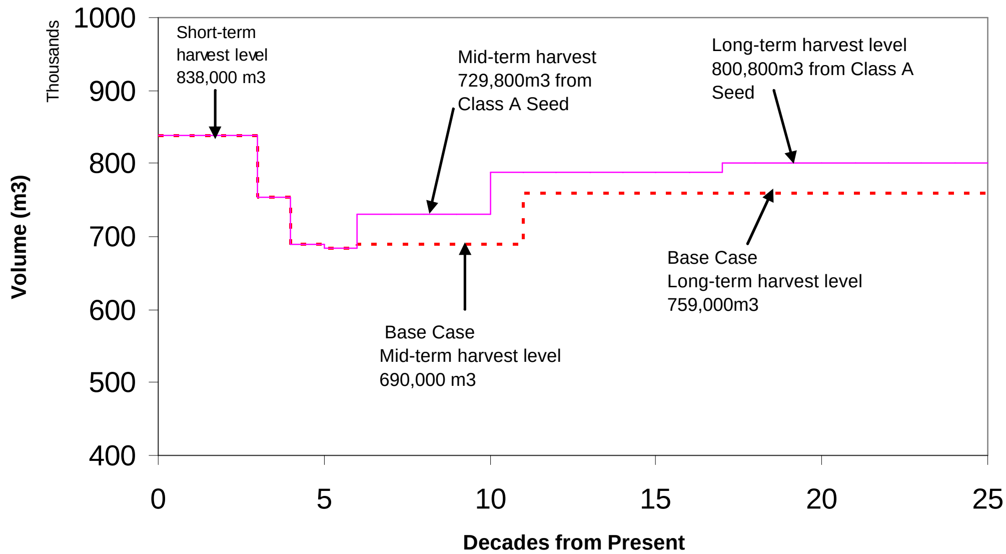

Figure 28 Harvest flow resulting from Class A Seed

[2] The assumptions incorporated throughout this analysis assumed that approx. 40% of harvested areas regenerate naturally.

4.6. Wildlife Strategies

Three scenarios investigated the potential for improving wildlife habitat using silviculture management strategies. The strategies involved:

1. Clumpy planting of pine in low biodiversity emphasis areas of Natural Disturbance Type 4 (NDT 4).

2. Increasing the voids (Additional 5% OAF) in planted stands on drier sites in the MSdk and ESSFdk (NDT3)

3. Applying full old seral constraints in period 1, rather than factoring them in over 14 periods.

The results from each of these scenarios are illustrated in Figure 29. To varying degrees all have a negative impact on timber supply. There is no apparent impact on timber quality. The affect on wildlife habitat quality is currently unquantifiable.

The application of full old seral constraints has a very large negative impact on short and mid-term timber availability. This occurs because a significant portion of the productive forest land base does not have sufficient area to meet these targets. This is especially true for the areas having "old" targets greater than 250 years. If we were to assume that the non-THLB land base is representative of the natural, undisturbed state of the forest, we would expect this area to have a reasonable distribution of stands over 250 years of age. This is not the case in the Cranbrook TSA. This might suggest that some of the definitions of appropriate seral distribution proportions in the Forest Practices Code biodiversity "*guidelines"* are inappropriate for this TSA.

Application of full old seral targets will result in the maintenance of the current harvest level for only 2 decades. This is followed by two declines of 10 percent per decade and a 12 percent drop to 611,200m^3 in the fifth decade. The mid-term harvest level is reached in the sixth decade and from here on the harvest flow matches the Base Case.

Increasing managed stand voids by 5 percent on drier sites within NDT 3, had very little impact on the overall harvest flow. Approximately 230,000 hectares meets these criteria in the THLB. Since leaving voids will not impact the harvest level until these stands are suitable for re-harvesting, the short and mid-term harvest levels remain unchanged. In the long term the harvest level decreases 2.2 percent to 741,800m^3/year.

Clumpy planting was also tested for application in the low biodiversity emphasis, NDT 4 integrated resource management (IRM) areas. Approximately 40,000 ha in the THLB meet these criteria. This is a relatively small area of the THLB and as such, measurable effects in the short, mid and long-term were negligible. Although clumpy planting is forecast to reduce planted stand yields by a much as 20 percent, some of this loss is offset by ingress from natural regeneration. The majority of the managed stand yield tables incorporated a component of natural regeneration in the development of the final yield assumption. Thus, total effect on yield was often slightly less (i.e., 10-15%).

Although increases in stand diameter of 1 to 3 cm dbh by age 100 were forecast as a result of clumpy planting, these gains were also offset by the natural regeneration component of the yield table. The overall area affected by clumpy planting was insufficient to result in a change in long-term diameter or harvest flow for the TSA as a whole.

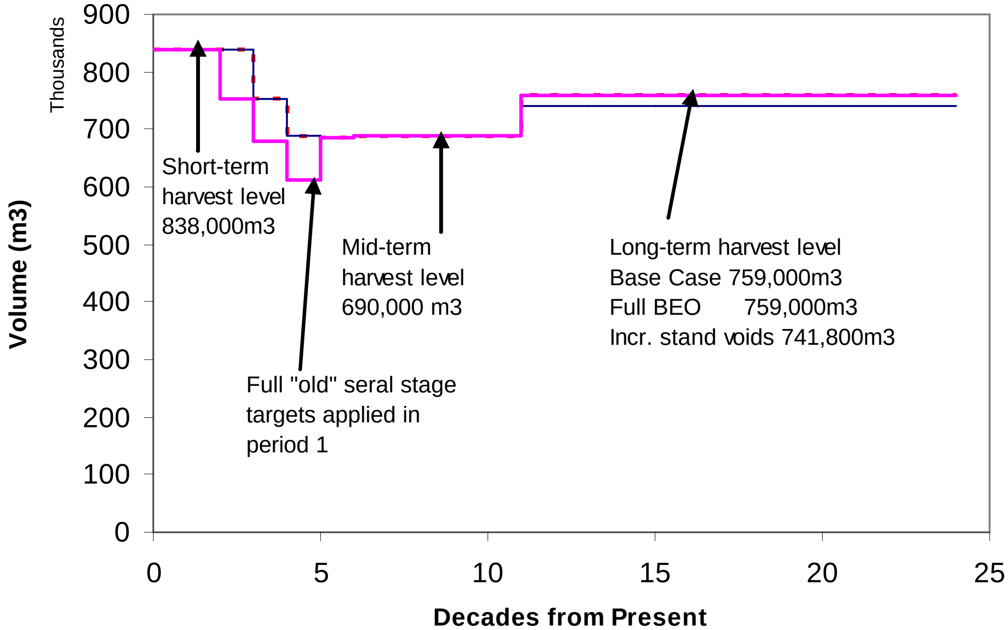

Figure 29 Harvest flows from wildlife strategies

5. Working Targets

Timber supply harvest simulations are a useful tool for measuring the aggregate effect of different silviculture alternatives. Stand level management tools are also helpful when used in conjunction with forest level simulations, to focus management decisions towards the most appropriate operational management regime.

The previous sections of this report provided a quantitative analysis of several silviculture alternatives. However the results described here are limited by the assumption that current conditions (i.e., market demand, species utilization, forest cover constraints) remain static in the long-term. Therefore when dealing with very long planning horizons, a decision on where best to invest time and labour should weigh not only the quantitative results of this report, but also consider qualitative aspects of the industry such as economic return, licensee preference, social impacts and politics.

Timber supply, timber quality and habitat supply were the objectives of the qualitative analysis. Economic return, short and long-term employment and corporate philosophy (as conveyed by past and current licensee management initiatives) were not explicitly analyzed in this report, but the impact of alternative management strategies can be estimated using professional judgement. All of these conditions form the basis for the ranking system developed and shown in Table 4. Each treatment regime was assigned a measure of high (H), moderate (M), low (L) or negative (N/A) for having relative merit with respect to decision influences. The assignment of "N/A" suggests the regime has a negative impact on the decision category. Each measure was then awarded a numerical value as follows: H=3, M=2, L=1, N/A=0. A total value for each treatment regime is calculated by summing across the categories.

This ranking system assumes equal priority on all selected influences. Different users may wish to assign different weights to each category or assign different values to each cell in the table.

Table 4 Weighting Treatment Regimes

Regime Description	Timber				Wildlife	Economic	Employment		Current	Aggregate Ranking
	Short Term Supply	Medium Term Supply	Long Term Supply	Long-term Quality	Habitat	Return	Short Term	Long Term	Activity Focus	
Base Case (no spacing)	L	L	L	L	L	L	L	L	L	9
Space 1000 ha/yr	L	M	L	M	L	N/A	M	M	H	14
Space 1300 ha/yr	L	M	L	M	L	N/A	M	M	M	13
Space/fertilize 1 application	M	L	L	M	L	H	M	L	L	14
Space/Fertilize 3 applications	M	M	L	M	L	M	M	M	L	15
Late Fertilization of natural stands	L	H	L	L	L	M	H	L	L	14
Stand rehabilitation	L	H	M	L	M	M	H	M	L	17
Plant Class A Seed	L	H	H	H	L	M	L	L	M	17
Increase stand Voids	L	L	N/A	L	M	L	L	L	L	9
Clumpy Planting	L	L	L	M	M	L	L	L	M	12
Apply Full Old BEO	N/A	N/A	L	N/A	M	L	L	L	L	7

N/A = 0, L= 1, M = 2, H = 3

The three treatment regimes with the highest aggregate scores are, sowing Class A seed, stand rehabilitation, and repeat fertilization of spaced stands. A second tier of management regimes, single application fertilization, late fertilization, pre-commercial thinning and clumpy planting received aggregate ranks slightly above the Base Case value of “9”. Thus if funding is available, these regimes could also be considered in a preferred management program. The two remaining regimes, full low BEO and increasing voids, provided response rankings sufficiently low as to discount further consideration.

The development of a rational investment strategy involves estimating the quantity of forest that might be in an appropriate condition to benefit from each treatment regime. Table 5 summarizes information provided in the Type I Silviculture Strategy for the TSA.

Table 5 Silviculture Investment Costs

Silviculture Treatment	Candidate Area (ha/year)	Regime Cost ($/ha)	Investment Opportunity Cost ($/yr)	Maximum Regimes Cost ($/year)
Space 1000 ha/yr	1000	500	500,000	n/a
Space 1300 ha/yr	1300	500	650,000	650,000
Fertilize 1 application	500	528	264,000	n/a
Fertilize 3 applications	500	528	264,000	264,000
Late Fertilization	1700	528	897,600	897,600
Stand rehabilitation	500	2000	1,000,000	1,000,000
Plant Class A Seed	1500	70	105,000	105,000
Increase Stand Voids	2000	300	600,000	600,000
Clumpy Planting	550	300	165,000	165,000
Apply Full Old BEO	n/a	n/a	0	0
Total Cost				3,681,600

The present incremental silviculture program for the TSA is estimated at approximately $700,000/ year. If all of the treatments indicated in Table 4 were implemented on all sites modelled in this analysis, the cost would be 5 times the current budget.

Incorporation of the results of this analysis into a preferred management program is provided under a separate cover. The report is entitled a “Preferred Silviculture Program Report for the Cranbrook TSA.”

6. References

Type 1 Silviculture Strategy for the Cranbrook TSA, version 1.3 March 31, 2002.

Type 1 Silviculture Strategy for the Cranbrook TSA, version 1.2 September 8, 1999.

Cranbrook Timber Supply Analysis Report, Ministry of Forests, 1999

Cranbrook Timber Supply Analysis Report Data Package, Ministry of Forests, 1999

Cranbrook Timber Supply Area Rationale for the Allowable Annual Cut Determination, MOF, January 1, 2001.