Dunkley Lumber Ltd.

Tree Farm Licence 53
Strategic Silviculture Analysis
Analysis Report – Draft 2
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TFL #53 Strategic Silviculture Analysis
Analysis Report – Draft 2

Executive Summary

Introduction

This document presents an incremental silviculture strategy for Tree Farm Licence (TFL) #53 managed by Dunkley Lumber Ltd. The purpose of the strategy is to guide the application of available incremental silviculture funds toward the most efficient and effective treatment programs. The main focus of the strategy is incremental silviculture; however, some basic silviculture activities are addressed where appropriate.

The strategy is guided by the principles contained herein and by those of the *Incremental Silviculture Strategy for British Columbia*. These principles direct responsible stewardship of forest-dependent resources within the TSA.

This strategy should not be confused with the allowable annual cut (AAC) determination. The AAC is based on actual practice and current information at the time of the determination while this strategy is concerned with improving the future state of the forests within the TFL. The only connection between the two analyses is that any improvements resulting from the silviculture strategy may impact future AAC determinations. Future decisions regarding intensive silviculture should be tested in the timber supply analysis for Management Plan 4.

This analysis has presented many significant challenges, which is not surprising given that it is part of the first round of Type 2 strategies. Forecasting intensive silviculture activities at a forest level while considering multiple values and constraints is a complex undertaking. Biologically uncertain stand dynamic responses, long-term analysis horizons, different data sets and analysis rules between MP3 and this Type 2, effects of minimum harvest criteria on available volume and the harvest level are factors which have contributed to the complications and have challenged the understanding and interpretation of the analysis results. These issues should be considered for future analyses in the effort to improve the understanding of results and produce an enhanced silviculture strategy for TFL 53.

General Objective

The objective of the silviculture strategy for TFL #53 is to increase the harvest level within the TFL to 360,000 m^3/year (60% of mill capacity). None of the tested strategies met this objective. However, a program of fertilization with $1 million annual budget forecasted a future harvest level of 351,000 $m^{3/}$year. Backlog NSR rehabilitation and establishing a seed orchard for pine could increase the long-term harvest a further 2.5 - 3 %, which equals Dunkley's harvest target of 360 000m^3/year.

Scenarios

The pre-determined analysis scenarios form the basis of the analysis methodology. The first scenario performed is a benchmark to the Management Plan (MP) #3 timber supply review analysis. This Type 2 benchmark is not directly comparable to the TSR analysis due to different data and assumptions for the two analyses. The silviculture strategy base case is built in successive steps from this benchmark run and becomes the reference point against which the results of the subsequent incremental silviculture scenarios and ultimately the preferred scenario are evaluated.

Major Silviculture Strategies

Basic Silviculture

- Minimize the current NSR by quick planting after harvesting.

- Use mechanical site preparation, where needed, to create plantable spots and improve rooting conditions for the planted seedlings. Excavator piling is used to create plantable spots and mounding is used to warm soils and improve drainage.
- Use seed orchard stock for all spruce seeding requirements.
- Plant a higher component of pine where ecologically appropriate.
- Plant high densities (1,800 – 2,000 sph) to:
  - Provide high site occupancy and high potential for growing wood fibre;
  - Reduce risk of plantation failure;
  - Create opportunities for commercial thinning.
- Use effective and timely vegetation management to promote better survival and growth of seedlings. This includes impeded older plantations. Yield predictions in the stand level models TIPSY and TASS are based on unimpeded growth of seedlings. Effective vegetation management reduces the uncertainty inherent in predicting future yields.

Incremental Silviculture

The proposed incremental silviculture strategy for Dunkley Lumber consists of:

- Fertilization.
  - Considering the cost per m^3 for increased harvest level, approximately $0.25 million should be allocated to this regime annually. This budget level provides the lowest cost per m^3 harvest level increases of all three volume scenarios. Since there is a rather small land base available for road rehabilitation, the emphasis on modeling was focused on fertilization. Throughout the planning horizon the amount of area fertilized increases from the start of the period to 25 years where the area treated stabilizes. The fertilization regime is proposed for the entire 200 year planning horizon at a cost of $350/ha. Over the first 10 years, an average of 487 ha are fertilized annually at an average cost of $170,352/year or a total of $1,703,520.
- Road rehabilitation.
  - Road rehabilitation did not result in a significant increase in harvest level for TFL 53 since the equivalent area that is “added back” to the timber harvesting land base equals approximately 178 ha. This increase in the future timber harvesting land base is too small have an influence on harvest level. Nonetheless if this 178 ha is treated over 10 years it would equal approximately 18 ha/year treated at a cost of $52 650. While road rehabilitation does not have a significant impact on the harvest level, it does maintain Dunkley’s objective of maximizing the productivity of TFL 53.
- Backlog NSR rehabilitation.

- TFL 53 has approximately 800 ha of backlog NSR. It is likely that not all of this NSR can be rehabilitated because of high wildlife habitat values. It is recommended that 600 ha of backlog NSR is treated within the next 10 years (60 ha/year). The cost of treating NSR is estimated at $2,080/ha with the annual cost of approximately $124,800.

- Establishing a growth and yield monitoring system for managed stands.
  - Dunkley Lumber plans to commence a growth and yield monitoring program. This program will involve establishing random or systematic growth and yield monitoring plots throughout the population of managed stands. The extent and the costs of the required program have not yet been determined.

- Establishing a seed orchard to produce genetically improved pine seed.
  - Dunkley Lumber is proposing to set up a seed orchard for producing genetically improved pine seed. The total cost of the orchard is estimated at $275,000 - $300,000 over a 10 year period. Approximately 50% of the total cost will be incurred during the first 3 years. The remaining 50% of the cost will be expended during the remaining 7 years.

As a result of this strategy the harvest level for TFL 53 increases over the short, mid and long-term by 7.6%, 3.4% and 10.8% respectively. Harvest level increases can be realized starting in the 4^{th} decade up to 284,673 m^3/year and again in the 7^{th} decade to 307,657 m^3/year and finally to 329,500 m^3/year in the 19^{th} decade. While the silviculture scenarios were only analysed for 200 years, this harvest level was tested for 250 years to ensure it could be maintained.

For information purposes, when the relative harvest level increases experienced in the Type 2 analysis are applied to the MP3 Supplemental A2 scenario, the long-term harvest level could be increased to 382,260 m^3/year, which exceeds Dunkley's volume objective. There is no guarantee that this harvest level can be achieved and this should be tested further in the upcoming timber supply analysis for MP 4.

Short-term employment resulting from the proposed silviculture strategy would total 1,524 person days while mid and long-term employment from increased harvest provides a further 1660.6 person years of TFL jobs and 2154.2 person years of provincial jobs over the next 200 years.

The fertilization scenario that was used to develop the incremental silviculture strategy utilizes unproven treatment regimes. While the regimes do represent Dunkley's current approach to fertilization, the biological uncertainty of their responses should be cautioned. Therefore, the achievement of the harvest level responses provided in this report is equally uncertain. Only through localized monitoring of actual yield response and timber supply analysis can these silviculture forecasts be assessed. As knowledge of yield responses from the fertilization becomes available it should be incorporated into new analysis. As such, this report represents an origin for silviculture investment for TFL 53 to be expanded in the future.

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1 Introduction

The Ministry of Forests (MoF) is mandated by legislation to undertake the planning function related to the management of Crown forestland. As part of the service agreement between the MoF and Forest Renewal BC, the MoF is required to recommend conservation and stewardship investment opportunities in support of the strategic objectives identified in the "Forest Renewal BC Strategic Plan 1999-2003". The development of a "Forest Level Incremental Silviculture Strategy" was chosen as the way to accomplish these objectives. The silviculture strategy is intended to assist in optimizing the use of available incremental silviculture funding to meet timber supply quality, timber quantity, and forest habitat objectives. The silviculture strategy provides a link between broader resource objectives of higher-level planning to silviculture investment decision-making and on-the-ground project selection.

A Type 1 silviculture strategy identifies issues, objectives, and regimes for the management unit using existing information. The Management Plan process for Tree Farm Licence (TFL) 53 fulfills this function. Silviculture objectives and strategies are explored in timber supply analysis scenarios to assist in developing the silviculture program, including both basic and incremental silviculture, for the TFL. The Type 2 silviculture strategy compliments the Management Plan process. Type 2 includes in-depth forest-level modeling to develop incremental silviculture strategies. The key concept of the Type 2 project is that it is based on forest level objectives.

The objective for the TFL 53 Silviculture Strategy is to increase the harvest level within the TFL to 360,000 m^3/year (60% of mill capacity). Timber quality was not a priority objective. Dunkley Lumber Ltd. (Dunkley Lumber) operates with a severe shortage of secure fibre supply. As a consequence, management strategies focus on maximizing fibre production within the Provincial social and economic framework. Dunkley Lumber currently plants at high densities, which allows for silviculture intervention to improve quality, if objectives change to include this in the future. Although quality was not targeted in the analysis, the impact on quality will be investigated.

This analysis report is the second of two reports completed in fulfillment of the Type 2 Strategic Silviculture Analysis for TFL 53. The first report is the Information Package, a document that details the assumptions and methodology of the Type 2 analysis. The Information Package is attached to this report as Appendix 1.

Incremental silviculture treatments are part of a suite of forest management strategies and activities that together can influence the future condition of the forest, including quality and quantity of timber and habitat supply. The Silviculture Strategy, if implemented, will likely influence future allowable annual cut (AAC) determinations. Other than this potential future impact, the strategy is not linked to the Timber Supply Review (TSR) process.

2 Procedure

2.1 Project Procedure

In preparing the strategic silviculture analysis and strategy for TFL 53, the methodology is defined by a number of broad steps. These steps are:

1 Identify forest level timber supply and habitat issues by reviewing existing information. Summarize the issues by time frame (short-, mid-, and long-term).

2 By accessing local knowledge and analyzing existing information, identify possible solutions and treatment opportunities.

3 Clarify goals and objectives. This step takes provincial-level objectives and adapts them to the local situation.

4 Define potential strategies and treatment regimes. Local experience is needed to determine a viable initial set for consideration.

5 Conduct a stand-level analysis of the proposed treatment regimes to determine responses and, if possible, costs. These results are used as inputs to the forest-level analysis.

6 Conduct forest-level (TSA) analysis to evaluate strategies with respect to short-term, mid-term, and long-term timber and habitat supply and quality issues. The forest-level analysis provides a variety of output products so that the selection of an appropriate strategy could be based on future timber quality and quantity, habitat supply, and forest condition.

7 Select an appropriate strategy with suitable components for the short-, mid-, and long-term.

8 Define an annual incremental silviculture program spatially for the first ten years.

Workshop 1 was held on January 30, 2001 at the Prince George Forest Region office. Representatives of the Ministry of Forests (Prince George Forest Region and District), Dunkley Lumber and Forest Ecosystem Solutions Ltd. attended the workshop. The purpose of the workshop was to define issues, establish objectives, and define current treatment regimes from a local perspective. The workshop produced the following:

- Management issues to be considered;
- Management objectives to guide the analysis and resolve management issues;
- Potential strategies to meet objectives;
- Treatment regimes, rules and costs; and
- A list of analysis scenarios.

Stand level analysis consisted of preparing the growth and yield information needed for all analysis scenarios. The growth and yield model Variable Density Yield Predictor (VDYP) was used to generate yield curves for currently mature stands. The model Tabular Interpolation Program for Stand Yields for Windows (WinTIPSY) was used to generate yield curves for current immature and future managed stands. Using the Tree and Stand Simulator (TASS) model, Ken Polsson of the MoF Research Branch developed yield curves for the incremental silviculture treatment regimes.

The strategic forest-level (management unit) analysis was done using the ***FSOS*** model. ***FSOS*** analyzes forest systems in a spatial and temporal manner using both simulation and heuristic modeling techniques. Both approaches are used in this project: simulation for the benchmark scenario and no stand tending scenario and the heuristic to determine the preferred treatment schedules. ***FSOS*** combines the spatial data management capabilities of ARC/INFO GIS and MS Access with landscape analysis capability, simulation model flexibility, and professional experience.

In heuristic mode, the model uses a target-based approach, based on moving the forest estate towards a user-defined "desired future condition". The model operates by running a series of iterations. Treatments are allocated at each iteration, according to a set of basic rules (for example, specific treatments are restricted to stands of a certain species and age range). Penalties are applied for deviating from the user-defined resource condition and feedback mechanisms ensure progression towards a better solution (where further iterations do not result in an improved solution).

Using the heuristic approach, ***FSOS*** allows users to set targets that have tolerances associated with them. For example, an old age forest requirement for NDT 1 may be 9% of the forested land base must be >250 years old. We set this in the model by defining the NDT 1 layer, assigning the old age (251+) and target % for NDT 1 but also identify a % tolerance for the target. Therefore, by establishing 9% as the target and 5% as the allowing variation, 8.6 – 9.5% would be considered within the tolerance of the 9% target and a result within this range would not receive any penalty. This provides some flexibility for the algorithm to achieve the multitude of targets that are applied in any given scenario.

The objective function of the heuristic module is used to drive the solutions and is defined as the maximization equation below:

$$\mathbf{F = V/Vo - (w_1X /Xo + w_2Y/Yo + w_3Z/Zo + w_4S/So + w_5Q/Qo) + w_6P/Po}$$

Where:

F is the total objective function value;

V is the total timber production;

X is the total patch size distribution penalty;

Y is the total age class structure penalty;

Z is the total volume flow penalty;

S is the cut block size penalty;

Q is the silviculture budget penalty;

P is the profit;

Vo, Xo, Yo, Zo, So, Qo and Po are initial values (at iteration 1) of V, X, Y, Z, S, Q and P, respectively. V, X, Y, Z, S, Q and P are not directly comparable between each variable because they have different measuring units. To make them comparable, the objective function value at iteration N is the sum of the ratios between the values at iteration N and the initial values (at iteration 1), respectively. w_1, w_2, $w_{3,}$ w_4 w_5 and w_6 are weighted factors for each objective, respectively. The default values of w_1, w_2, w_3, w_4, w_5 and w_6 are 1. Penalties in the objective function are additive and if there are no objectives for a given value such as patch size or profit then they are excluded from the equation. This is how ***FSOS*** in heuristic mode utilizes penalty functions based on an area-weighted set of values to search for an improved solution.

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The fully spatial approach of ***FSOS*** allows maps to be produced for any period of time in the planning horizon showing the location of silviculture treatments. Charts and reports are also produced from ***FSOS*** output although no maps were required for this project.

A draft analysis report was prepared for discussion at a second meeting with the MoF and Dunkley. There were several complications with the initial draft of the analysis report that were discussed at this meeting which included the lack of harvest level response due to fertilization and road rehabilitation. These complications and their resolutions are discussed throughout this report.

Mr. Les Herring of the Ministry of Forests, Prince George Forest Region managed the overall project and Forest Renewal B.C provided funding.

2.2 Data Acquisition and Manipulation

Significant amounts of data were required for this process. Spatial Mapping Ltd provided the majority of the data with few exceptions. A detailed description of the data inputs and analysis assumptions is provided in Section 2.2 of the Information Package (Appendix 1).

2.3 Analysis Methodology

The complete description of the analysis methodology is provided in the Analysis Information Package. In short, the analysis included:

- A benchmark run that emulates the TFL 53 Timber Supply Analysis (TSA) for Management Plan # 3 results (Scenario 1);
- A no stand tending scenario which investigates the impact of past and future backlog treatments on the timber supply (Scenario 2);
- The Silviculture Strategy Base Case which includes no incremental silviculture treatments and serves as a baseline for all subsequent scenarios (Scenario 3);
- A road rehabilitation scenario investigating the opportunity to increase harvest flows through the rehabilitation of on-block roads (Scenario 4);
- A fertilization scenario investigating the opportunity to increase harvest flows using fertilization treatments (Scenario 5);
- A commercial thin scenario investigating the opportunity to increase harvest flows by using partial cutting in areas with visual quality objectives to remove volume while maintaining visual quality (Scenario 6);
- A set of volume impact scenarios to test the opportunities to increase harvest flows with the use of road rehabilitation and fertilization in combination at varying budget levels (Scenarios 7, 8, and 9)
- A preferred option built upon the results of the previous silviculture scenarios.

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3 Tree Farm Licence 53 Information

3.1 Description of the TFL

TFL 53 is located in the Prince George Forest District south of the community of Hixon and north of Ahbau Creek on the east side of Highway #97. The landscape of the area is characterized by rolling plateaus intersected by streams. Spruce and pine are the most common tree species, comprising approximately 80% of stands. Sub-alpine fir makes up about 15% of the forest cover and small components of Douglas-fir, aspen, birch, and cottonwood make up the remainder of stands.

Over 90% of the TFL is located within the Sub-Boreal Spruce (SBS) biogeoclimatic zone. The climate consists of cool, snowy winters and warm summers. The remainder of the TFL falls within the Engelmann Spruce Subapline Fir (ESSF) biogeoclimatic zone. The climate of this zone consists of long, cold winters and short, cool summers.

3.2 History of the AAC

The AAC for TFL 53 has consistently increased during each management plan period recognizing Dunkley's investment in forest management, data and increased productivity (Table 1).

Table 1: History of the allowable annual cut.

Year	AAC (m^3/year)
1989 – 1993	187,630
1994 – 1999	204,700
2000 +	239,500

3.3 Current Basic Silviculture Systems

The main silvicultural system used in TFL 53 is clearcut with reserves. A small amount of partial cutting is also used. Regeneration is generally achieved through planting.

3.4 Incremental Silviculture History

3.4.1 Genetically Improved Seed

Currently, genetically improved seed orchard seed is available only for spruce. The current program utilizes genetically improved spruce seed exclusively in the reforestation program.

The remainder of seed for pine and Douglas –fir will come from natural stands until adequate supplies of seed orchard seed are available for these species. The production of seed orchard pine is a concern. Forecasts show that the opportunity for an adequate supply of improved pine seed is doubtful for the short and medium term based on existing capacity.

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3.4.2 Fertilization

Fertilization of a stand raises the productivity of the site and is the only presently recognized treatment for increasing total stand volume. In addition to increasing total volume, fertilization can also reduce the age at which a stand reaches harvestable size. Forest fertilization is felt to hold much potential for mitigating pinch points in the timber supply of TFL 53. Dunkley Lumber is currently co-operating with the MoF in a fertilization response trial on the TFL.

3.4.3 Commercial Thinning

Commercial thinning (CT) is a program where the thinning occurs when the trees being removed have commercial value. It is assumed that CT treatments are cost neutral in that expected revenue will cover the costs of treatments. Commercial thinning can capture stand mortality, concentrate growth on fewer stems, increase the merchantable proportion of a stand, and increase timber value. Commercial thinning has been used on a trial basis to manage visual quality in areas with visual quality constraints.

3.4.4 Backlog Reforestation

Significant areas of backlog reforestation have been undertaken in TFL 53. The majority of remaining backlog areas is concentrated in areas of high wildlife habitat value. In addition, much of the area is extremely difficult to treat given environmental factors such as geographic distribution and proximity of old watercourses in the area. As such, the heavy treatment regimes required to establish additional conifer cover in backlog areas may not always be the most desirable course of action given other resource values.

3.4.5 Historical Silviculture Budgets

Dunkley Lumber, through a multi year funding agreement re-invests approximately $500,000 of FRBC funds in the forests of TFL 53 annually. This funding level was used in the analysis as a baseline figure. Increased ($1,000,000) and decreased ($250,000) funding levels were also investigated.

3.5 Previous Silviculture Plans and Reports

Silviculture objectives and strategies have been addressed in Management Plan 3. The objectives of the silviculture program have been maintained on the TFL since the first management plan and are as follows:

- To obtain maximum timber harvest for TFL 53 within the land capability and economic and social limitations.
- To maintain and enhance productivity of the forest land base with a view to increasing allowable annual cuts.
- To restock and achieve free-to-grow status on all cutover lands to targeted stocking levels, with desired species and within a minimum time period to maximize fibre production.
- To restock all current and backlog NSR lands and maintain a “steady-state” silviculture program over time.
- To convert problem forest stands (excluded) into timber stands (contributing) with commercially acceptable species capable of maximizing yields.
- To enhance growth potential on the TFL by improving site occupancy through increased stocking levels and effective plantation maintenance.

The silviculture strategy for Management Plan 3 addresses both MoF funded obligations (backlog NSR) and basic silviculture (seed collection, silviculture prescriptions, site preparation, reforestation, assessments, and stand tending). Intensive silviculture is also addressed in regards to plantation enhancement (manual brushing and fertilization) and road rehabilitation.

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4 Identification of Issues

4.1 General Timber Supply Issues

General timber supply issues identified below are acquired from the MP3 timber supply analysis prepared by Industrial Forestry Service Ltd. with updated information from Dunkley Lumber. This information is presented for background purposes so that the reader understands the most recent timber supply dynamics for TFL 53. The Type 2 results presented in the report are based on different data and assumptions than in the timber supply analysis. The differences are documented further in Section 9.1.1 and relevant sections from the MP3 timber supply analysis are included in Appendix 2.

4.1.1 MP3 Harvest Forecasts

Figure 1 illustrates the MP3 base case and Supplemental A2 harvest forecasts. Representing current operational management (as of 1998), the base case scenario as generated in the MP3 timber supply analysis presents the harvest level result from existing management assumptions. The base case analysis exhibits harvest level benefits from significant improvement in data and information for TFL 53 such as site productivity, growth and yield and resource inventories. Supplemental A2 utilizes similar assumptions to the base case except for the relative oldest first harvest rule and splitting NDT 3 into 3 variant groups for biodiversity modeling. It is presented here, as it will be used for comparison to the Type 2 benchmark scenario.

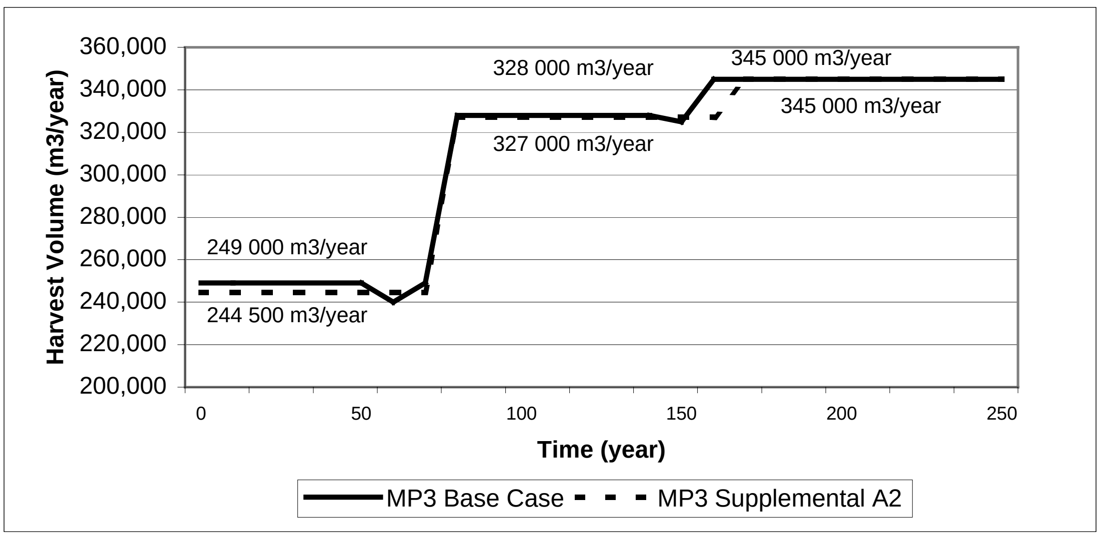

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Figure 1: TSA base case harvest forecast.

The initial harvest level for MP3 base case is 249,000 m^3/year, which is maintained for 50 years at which point there is a small dip of 3.6% in timber supply to 240,000 m^3/year in decade 6. This dip represents a pinch point for available timber supply based on current management assumptions. The harvest level is then able to increase back to 249,000 m^3/year for 10 years and then increase to a mid-term level of 328,000 m^3/year in the 7^{th} decade. At 150 years in the future there is a 1% dip in harvest level to 325,000 m^3/year for another 10 years. These small declines in harvest level represent pinch points where the amount of unconstrained growing stock gets very close to the operable growing stock. The timber flow increases again after this point back to 328,000 m^3/year for 10 years. At 160 years in the future, the timber supply increases to the long-term harvest level (LTHL) of 345,000 m^3/year where it is maintained throughout the rest of the planning horizon. The Supplemental A2 scenario presents a slightly different harvest level than the base case, in that the short-term harvest is lower (2%), there are no dips at decade 6 or 15, the mid-term harvest level is 1 000 m^3/year less and the transition to the long-term harvest level occurs 10 years later.

The following descriptions of assumptions refer to the base case scenario. The only differences that apply to the Supplemental A2 scenario is that the relative oldest first harvest rule is used and NDT 3 is split into 3 variant groups for biodiversity modeling.

4.1.2 Land Base

In the MP3 timber supply analysis the current timber harvesting land base was 70,142 ha and the future timber harvesting land base was 69,378 ha. This compares to the Type 2 current timber harvesting land base of 68,628 ha and 67,880 ha for the future timber harvesting land base. This difference in area between the MP3 and Type 2 is mostly caused by the difference in ESAs (Appendix 1).

Sensitivity analysis in the MP3 timber supply report showed that a 5% decrease in the size of the THLB forces a decline in short-term timber supply to 238,000 m^3/year for periods 1 to 5. In period 6, a 7.2 percent drop occurs. The long-term harvest level is also decreased by 5%.

Conversely, a 5% increase in the size of the THLB produces a short-term increase to a non-declining harvest level of 259,000 m^3/year. The long-term harvest level increases 5.2% to 363,000 m^3/year.

4.1.3 Age Class Structure

The age class distribution within the TFL is irregular; however, it does show a fairly even spread of area between mature and immature. Approximately 42% of the THLB is currently occupied by mature timber. Currently, little area is in "old" seral stage in NDT 1 and 2, which requires recruitment over time to achieve full biodiversity requirements. Under the base case scenario, TFL 53 begins to exhibit a more normal age class distribution in 50 years as existing mature forests become old age forests. One hundred years into the future most of the timber harvesting land base is in plantations with almost 80% of the timber harvesting land base less than 90 years old. The remaining natural forest is comprised of stands, which have been held for forest cover requirements or are in the non-timber harvesting land base. By year 200, TFL 53 exhibits a normal forest distribution with relatively equal areas in each age class. Stands are harvested very close to culmination, as most of older stands (>180 years) are outside of the timber harvesting land base.

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4.1.4 Transition from Existing Natural to Managed Stands

The transition from harvest of predominately natural stands to managed stands occurs near the 8 decade where an increase in harvest is forecast (Figure 1). After 160 years, a further increase is predicted when all existing natural stands, not reserved for old growth, will have been converted to managed plantations.

The transition point represents a key factor for the TFL Silviculture strategies. Dunkley's main objective is to ensure that actual managed stands produce at least as much volume as predicted by the yield curves, or to actually improve on those predicted volumes. Figure 1 also demonstrates that treatment responses on managed stands will not be realized until 70-80 years from present, although treatment of existing immature stands may result in earlier harvest level increases. This has implications for the Type 2 strategy; where monitoring the growth and yield of managed stands is important to ensure that the desired productivity is achieved.

4.1.5 Forest Cover Requirements

A variety of forest management zones and associated forest cover requirements occur within TFL 53. Detailed descriptions of the modeling assumptions and rules as applied in MP3 are provided in Appendix 2. The forest cover requirements as applied to the management zones in the Type 2 analysis are as follows:

- **Integrated Resource Management** – applies to 96% of the THLB. Maximum of 33% of the THLB within this zone can be less than 3 metres. The Type 2 analysis applies to 65,847.9 ha with a maximum rule of 33% of the THLB can be less than 3 metres (17 years).

- **Visual Quality Objectives** –

  - **Preservation** – applies to less than one tenth of one percent of the THLB. A maximum of 1% within this zone may be less than 5.4 metres in height. The Type 2 had 13.4 ha within the Preservation zone which received a maximum rule of 1% of this area may be less than 5.4 metres (20 years).

  - **Retention** – applies to less than one tenth of one percent of the THLB. A maximum of 5% of this zone may be less than 4.4 metres in height. In the Type 2, this area is approximately 41.7 ha and received a maximum rule of 5%, which may be less than 4.4 m (16 years).

  - **Partial Retention** – applies to 1.6% of the THLB. A maximum of 15% of this zone may be less than 4.6 metres in height. The Type 2 area in Partial Retention was 1269 ha which received a maximum rule of 15% of the area may be less than 4.6 m (16 years).

  - **Modification** – applies to 2.3% of the THLB. A maximum of 25% of this zone may be less than 4.6 metres in height. The Modification zone within the Type 2 analysis was 1853 ha which received a maximum disturbance rule of 23% of the area may be less than 4.6m (23 years).

  - **Maximum Modification** – applies to 0.1% of the THLB. A maximum of 33% of this zone may be less than 5.3 metres in height. The Maximum Modification zone within the Type 2 analysis was approximately 108 ha and received a maximum disturbance rule of 33% of the area, which may be less than 5.3 m (26 years).

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Visual quality objective rules were designed using a high Visual Absorption Capacity (VAC) rating. In the MP3 timber supply analysis a sensitivity analysis was performed to test the impact of calculating these targets using the mid-range VAC. As a result, short-term harvest levels were not very sensitive to this change. The base case harvest level could be maintained for 4 decades with a 5% decline to 236,000 m^3/year until period 8. At this point, the harvest level increases to 326,000 m^3/year. The harvest level was increased again to 344,000 m^3/year from period 17 on.

Several other sensitivity analyses were performed to test the impacts of variations in management for visual quality. These revealed slight sensitivity to changes in visual quality management. Most notably, one sensitivity analysis revealed that decreasing visually effective green up heights by 22% had a positive impact on short- and mid-term timber supply.

- **Wildlife Tree Patches** – WTP requirements represent 2% of the THLB. For the MP3 analysis a WTP layer was created which represents 4% of the THLB (double the requirement). This zone received a constraint, which specified that a maximum of 50% of the area might be less than 160 years. This same rule was applied in the Type 2 analysis.

4.1.6 Quality

Quality was not modeled in the MP 3 timber supply analysis or in the Type 2 project, as this is not a priority objective for Dunkley. The TFL silviculture regimes leave options open in the future to address quality, however. By increasing initial planting densities options exist to manage piece size through future commercial thinning. Increased initial density will also result in crown closure at an earlier age. This will speed up shading and shedding of branches on the lower stem. For information purposes, quality impacts of silviculture treatments designed to increase timber quantity for the preferred scenario will be investigated. The reports will be limited to examining the development of quadratic mean diameter over time.

4.1.7 Old Forests

Forest stands are assumed to gain attributes of old growth at an age of 250 years for NDT 2 areas and an age of 140 years for NDT 3 areas. While a significant portion of TFL is in NDT 2, very little forested area exists naturally over 250 years of age. This may reflect the transition nature of the TFL between NDT2 where old is defined as >250yrs and NDT3 where old is defined as >140yrs. Field analysis has determined that old characteristics develop in stands at 180 yrs of age in the NDT2 portion of the TFL.

In MP3 sensitivity analyses revealed a high degree of sensitivity based on old growth issues. Four sensitivity analyses were conducted in the TSA: one applying mature seral targets to the base case, one applying full low old seral targets immediately (no draw down), one applying low emphasis biodiversity throughout the land base with draw down, and one changing the age definition of old.

Without adjusting short-term harvest levels, the impacts of applying full old seral requirements resulted in a decrease in the harvest level of 29% in period 6 to 176,000 m^3/year. After this point, the timber in the non-contributing land base has aged enough to satisfy the old seral age targets and the remainder of the base case harvest flows remain unchanged.

Application of low biodiversity emphasis throughout the land base with 1/3 draw down resulted in an increase in the short-term harvest level of 3.2% above the base case level. Mid- and long-term harvest levels remained essentially the same as the increasing old growth requirement occurs at the same time that the non-contributing land base ages to old condition.

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A sensitivity analysis, which reduced the age definitions of old growth, was performed as these lower ages better reflect the occurrence of old growth characteristics recorded in the terrestrial ecosystem mapping project on the TFL. Decreasing the definition of old in NDT 1 and 2 to 180 years has a significant impact on harvest flow. In the short-term (decades 1-7), the harvest flow can be increased to 255,000 m^3/year (2.5% increase over the MP3 base case). In decade 8 the harvest level declines to 314,000 m^3/year and then increases again to 332,000 m^3/year in decades 9 through 16. After this point, the long-term harvest level of 345,000 m^3/year is achieved and maintained throughout the remainder of the planning horizon.

4.1.8 Minimum Harvest Ages

Minimum harvest ages are selected in order to ensure that the timber supply model selects only stands for harvest with sufficient merchantable volume and piece size. Sensitivity analysis indicated that increasing minimum harvest age results in an increase in the mid-term timber supply gap in period 6. The MP 3 base case scenario used the regional priority cutting age for existing unmanaged stands and culmination of mean annual increment for all managed stands. While the same criteria were used for the Type 2 analysis different harvest ages were modeled due to different yield curves and SI being used in the analysis (Section 8.4 of the information package Appendix 1). For the Type 2 volume impact scenarios, 90% of culmination of mean annual increment (CMAI) was used for minimum harvest age since there was no harvest level response from fertilization when full CMAI was used.

4.1.9 Estimates of Existing and Regenerated Stand Volumes

In MP3, harvest levels were found to be very sensitive to changes in natural stand yield estimates. A 10% increase in natural stand yields would allow a short-term, non-declining harvest level of 272,000 m^3/year, or slightly, more than a 9% increase. Conversely, a 10% decrease would result in a drop in the base case harvest level after 30 years, to 226,000 m^3/year with another drop to 205,000 m^3/year in decades 4, 5, and 7. In decade 6, another drop to 202,700 m^3/year occurs. The mid- and long-term harvest flows remain unchanged as managed stands make up the majority of harvest.

Variations in regenerated stand volumes affect the mid- and long-term, as these stands are largely unavailable for harvest until the fifth decade. Increasing managed stand yields by 10% has a slight upward impact on the harvest in period 6, while the mid- and long-term harvest levels are dramatically different. With a 10% increase in managed stand yields the harvest level can increase 8.5% to 356,000 m^3/year through periods 8 to 16. From decade 17 onwards, the harvest level increases to 376,000 m^3/year representing almost a 9% increase. Decreasing managed stand yields by 10% increases the period 6 shortfalls while the mid-term harvest level decreases almost 9% to 299,000 m^3/year and the long-term by 9% to 314,000 m^3/year.

4.1.10 Forest Health Issues

Dunkley Lumber has an aggressive and successful forest health program. As such, a minor volume reduction of 678 m^3/year is applied to the modeled harvest levels as an estimate of the unsalvageable volume lost to wind, fire, and insects. The same non-recoverable volume reduction was applied in the Type 2 analysis as well.

No epidemic forest health issues were modelled in this analysis. Mountain pine beetle and to a lesser extent spruce bark beetle do represent significant current issues and represent potential risk to TFL 53 given the sensitivity of the harvest forecast to natural stand yields. The allocation of funds through the FRBC program to address this issue is considered outside the scope of this report.

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4.1.11 Issues Relating to Habitat and Non-timber Forest Resources

Wildlife habitat values are modeled through the constraints applied for biodiversity, adjacency, IRM, riparian, and wildlife tree patch modeling. No reductions or management zones were required to manage for the habitat of any particular species as the coarse filter approach represents current management for TFL 53. Similar constraints were applied in the Type 2 analysis as in the MP3 timber supply analysis.

5 Timber Supply Concerns and Analysis Objectives

5.1 Summary of Timber Supply Issues

5.1.1 Short-term

The short-term timber supply is sensitive to:

- Increases and decreases in the size of the timber harvesting land base,
- Reducing visually effective green-up heights,
- Changing the application of biodiversity constraints (specifically applying low biodiversity emphasis with draw down and reducing age definition of old forest), and
- Changes in natural stand volumes.

5.1.2 Mid-term

The mid-term timber supply is sensitive to:

- Increases and decreases in the size of the timber harvesting land base,
- Calculating VQO targets using mid-range visual absorption capacity ratings,
- Reducing visually effective green-up heights,
- Changing the application of biodiversity constraints (specifically applying mature seral targets and reducing age definition of old forests),
- Increasing minimum harvest ages,
- Increases and decreases in natural stand volumes, and
- Increases and decreases in managed stand volumes.

5.1.3 Long-term

The long-term timber supply is sensitive to:

- Increases and decreases in the size of the timber harvesting land base,
- Changing the application of biodiversity constraints (specifically applying mature seral targets), and
- Increases and decreases in managed stand volumes.

5.2 Timber Supply Concerns

The mid-term timber shortfall (occurring at period 6 in the TSA) is the most prominent timber supply concern for TFL 53. Two intervention strategies can address this timber supply pinch point. The first is to maintain or improve the yield from natural stands over predicted volumes through treatments such as fertilization. This will in effect bank timber until it is needed in period 6.

Managed stands from the 1970s and 80s also become available for harvest in period 6. Again, strategies to achieve or exceed the predicted volumes are relevant. Treatments to bring other stands to a merchantable state earlier can also impact period 6.

5.3 Higher Level Objectives

Incremental silviculture strategies must be developed in accordance with higher-level provincial goals and objectives.

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5.3.1 Provincial Goals

Government's goals are (MoF, 1999):

- Sustainable Use
- Community Stability
- Strong Forest Sector

5.3.2 Provincial Objectives

The provincial objectives are based on the following guiding principles:

- Minimize risk and maintain options.
- BC's forests are important from the local to global levels and should be managed in this context.
- Each generation has a moral obligation to preserve the province's forest resources for future generations.

The Provincial Incremental Silviculture Strategy specifies a working target of increasing volume and maintaining or enhancing future premium wood quality supplies. More specific objectives are to:

1. Minimize interim reduction in timber supply so that the allowable annual cut is not less than 65 million cubic meters;
2. Increase timber supply over the mid-term to a long-term level of 75 million m^3; and
3. Maintain the production of premium quality logs at or above 10% of total harvest. (MOF, 1999c).

5.4 Local Objectives and Opportunities

5.4.1 Objectives

Dunkley's main objective for the TFL 53 Silviculture Strategy is to increase the harvest level within the TFL to 360,000 m^3/year (60% of mill capacity).

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6 Potential Strategies

6.1 Potential Strategies by Response Timeframe

Strategies describe how the identified objectives will be achieved. The strategies in this section are considered potential strategies until their effectiveness is proven by management unit analysis. General strategies have been identified at the provincial level and include the following:

- Increase use of alternative silvicultural systems, particularly commercial thinning,
- Reduce green-up ages,
- Increase regenerated stand volumes by 20%,
- Eliminate NSR,
- Substantially increase fertilization program on suitable stands,
- Accelerate the tree improvement program,
- Institute a void-management program to ensure stand voids do not exceed 10%, and
- Intensify forest health management to reduce losses to insects and disease.

Table 2 below provides a list of potential strategies for meeting the local objective of increasing harvest flow to 60% of mill capacity by response time frame.

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Table 2: Potential strategies by response timeframe.

Response Time Frame	Strategy Description	Anticipated result
Short-Term	1. Expand the timber harvesting land base by: • Eliminating backlog NSR • Rehabilitating roads. 2. Reduce visually effective green-up height through fertilization. 3. Improving natural stand yields by reducing endemic losses. 4. Improving natural stand yields by late rotation fertilization.	1. As per TSA, short-, mid- and long-term timber supply is sensitive to changes in the size of THLB. Eliminating backlog NSR and road rehabilitation amount to an increase of in THLB area. 2. As per TSA, short-term timber supply may be sensitive to decreases in visually effective green-up heights. As a surrogate, reducing time to achieve green-up height may similarly increase short-term volumes. 3. May increase short-term volumes. Difficult to predict. 4.May increase short-term volumes if stands are not too old for response.
Mid-Term	1. Improving natural stand yields by reducing endemic losses 2. Increase regenerated stand volumes by: ▪ Using genetically improved seed; ▪ Fertilizing suitable regenerated stands; ▪ Rehabilitating roads. ▪ Improving supply of seed orchard pine. 3. Use commercial thinning in VQO areas to remove volume while maintaining visual quality.	1. May increase short-term volumes. Difficult to predict. 2. ▪ This analysis assumes 18% improvement for Spruce seedlings ▪ Increased regenerated stand volumes have some impact on mid-term timber supply; however, the greatest impact is in the long term. ▪ Small Increase in the mid and long term. ▪ Potential impact significant. 3. Maintain options for CT. Bring some long-term volumes to the mid-term.
Long-Term	1. Increase regenerated stand volumes by: ▪ Using genetically improved seed; ▪ Fertilizing suitable regenerated stands; ▪ Rehabilitating roads. ▪ Improving supply of seed orchard pine.	1. ▪ This analysis assumes 18% improvement for Spruce seedlings ▪ Increased regenerated stand volumes have some impact on mid-term timber supply; however, the greatest impact is in the long term. ▪ Small Increase in the mid and long term. ▪ Potential impact significant.

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6.2 Stand Treatments

Table 3 describes the qualified impacts of basic and intensive silviculture on selected stand attributes.

Table 3: Impacts of silviculture on selected stand attributes

Treatment	Reduced Min Harvest Age	Increased Yield	Increase Ave DBH	Improved Quality
Basic Silviculture	+		+	+
Spacing	+	+-	+	+
Pruning				+
CT	+	+-	+	
Fertilization	+	+	+	
Tree Improvement	+	+	+	+

(Adapted from G. Weetman, SIBC, 1982)

6.3 Treatment Regimes

Table 4 illustrates the treatment regimes that were considered in the Type 2 analysis for TFL 53. These regimes were developed during the initial workshop with the MoF and Dunkley Lumber Ltd.

Table 4: Treatment regimes.

AU	Treatment Options		
	Fert.	CT	Do Not Treat
101 Fir		✔	✔
102 Balsam Good		✔	✔
103 Balsam Medium		✔	✔
104 Balsam Poor		✔	✔
105 Balsam IU		✔	✔
106 Spruce Good	✔	✔	✔
107 Spruce Medium	✔	✔	✔
108 Spruce Poor	✔	✔	✔
109 Spruce/Pine Good	✔	✔	✔
110 Spruce/Pine Medium	✔	✔	✔
111 Spruce/Pine Poor	✔	✔	✔
112 Spruce/Decid Good		✔	✔
113 Spruce/Decid Medium/Good		✔	✔
114 Pine Good	✔	✔	✔
115 Pine Medium/Poor	✔	✔	✔
116 Pine/Spruce Good	✔	✔	✔
117 Pine/Spruce MediumPoor	✔	✔	✔
118 Pine/Decid Good		✔	✔
119 Pine/Decid Medium/Poor		✔	✔
120 Aspen Conifer		✔	✔

[1] Parameters for Treatments:
Fert – every 6 years after dominance (4.5 metres) to harvest
CT – only in VQO zones

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All fertilization treatments were for managed stands. Late rotation fertilization was not tested through modelling because there is significant uncertainty associated with the growth and yield response to this treatment.

6.4 Stand Level Treatment Responses

Figures 2 and 3 below illustrate the volume growth response on a spruce and lodgepole pine (Pl) good site to commercial thinning and fertilization treatments, respectively. The curves also illustrate the differences between the TIPSY and TASS models when no treatment is forecasted. As shown in Figure 2 and 3, TIPSY produces much higher volumes than TASS for the same stand types. This difference is part of the cause for the differences between the Type 2 benchmark scenario and the SS base case scenario (Section 9.1.3). Another factor, which causes uncertainty for future harvest levels, is that the no treatment TIPSY curves and the fertilization TASS curves are very similar.

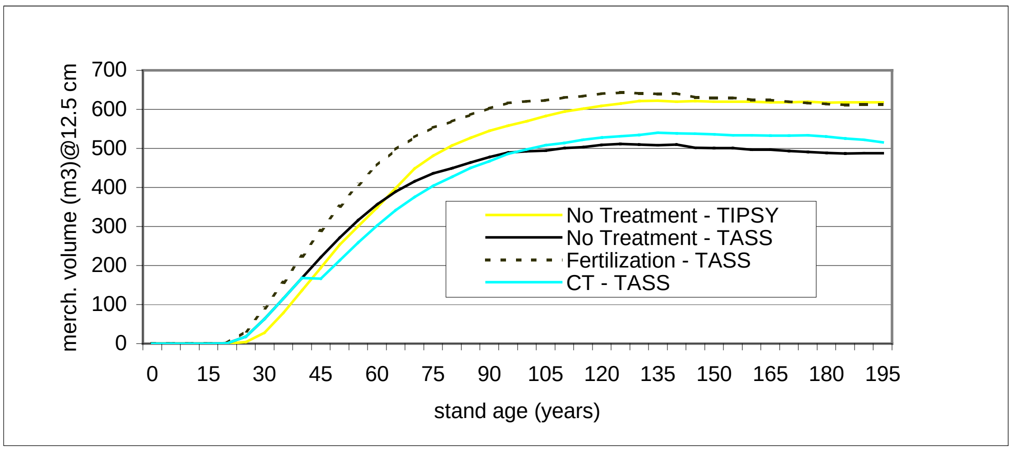

Figure 2: Fertilizer and CT volume growth response, Sw good site.

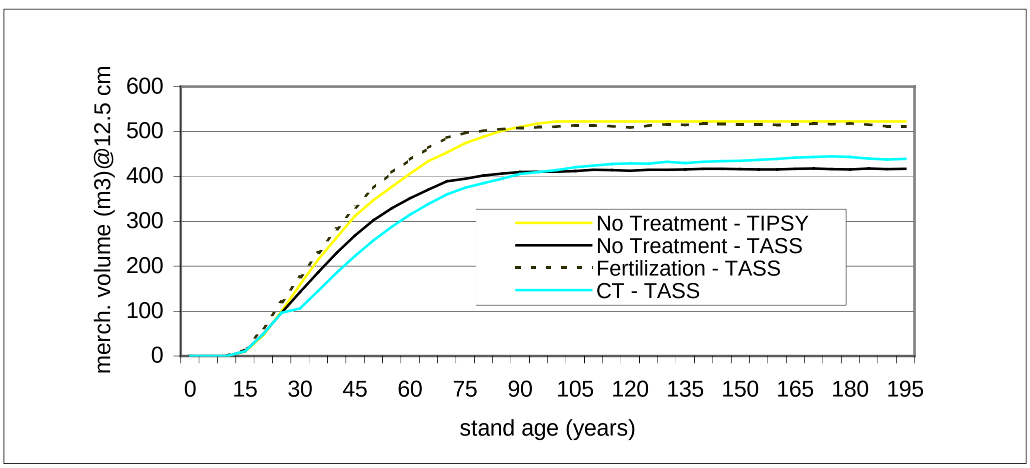

Figure 3: Fertilizer and CT volume growth response and comparison between TASS and TIPSY, Pl good site.

A complete summary of analysis units and treatment responses has been included in the Type 2 information package (Appendix 1).

7 Stand Level Analysis

Both the MoF and forest industry have researched a number of stand-level silviculture treatments to determine the most effective treatments, multiple treatment regimes and rules that are applicable to different stand types and forest ecosystems. The rules, which would include treatment timing, intensity and other factors, have led to standardized procedures and predictable responses for each treatment.

The use of computer modeling provides yield curves based on the research results. The Tree and Stand Simulator (TASS) is a computer model that simulates the growth of individual trees and stands. It was developed by the Research Branch of the Ministry of Forests to assess the effects of silviculture treatments and environmental factors on stand growth and yield. Analysis of incremental silviculture strategies generally involved generating custom TASS yield tables for individual treatment regimes. Ken Polsson from the Ministry of Forests Research Branch generated the curves for this analysis. TASS provided yield curves for each aggregate unit.

TASS is a single species, even-aged stand model; therefore, the curves generated for this analysis included these assumptions. Output from TASS includes: yield information, stand volume, mean piece size by grade, stand height, diameters, and piece size distributions by stand age. VDYP is the computer model used to generate yields for unmanaged mature or older immature stands. The output from VDYP is limited to height, diameter, volume and MAI.

Readers should be aware that there are volume differences between TASS and TIPSY. Therefore, a given stand type with identical stand attributes (species, site index, etc.) will produce different volume trends for TASS and TIPSY. The cause of the differences depends on the issues being modeled.

TASS runs provide the source data for TIPSY. These TASS runs set the top height value equivalent to the site height of the stand, regardless of initial density (site height is the height from the site index equation used for any given age). If this were not done, then top height would be lower (for a common age) for lower initial planting densities. This was done for TIPSY because TIPSY is primarily used for timber supply analyses, where existing stand conditions are used as input.

The TASS runs that were prepared for this Type 2 analysis did not establish stand top height equivalent to site height and all stands were considered fully stocked. Since genetic gain and fertilization can affect height growth, and if top height were used it would have counteracted the responses from these treatments.

In comparing a TASS Fdi curve against a similar TIPSY curve, at 28m height, the difference in volume is approximately 20 m3/ha. Other reasons for the differences between TASS and TIPSY are caused by the fact that most of the TIPSY database is from TASS as calibrated in 1992. Since then, TASS has had many bug fixes and minor changes over the years. The changes have been insignificant, but vary the volumes between the models +/- a few percent. More significant is that TIPSY has a limited set of tables, and it interpolates between them to get stand densities and output ages, and scales by height to get tables for different site indexes. As a result, TASS and TIPSY are almost always different, though in a sense, both are correct. For more information regarding specific differences between TASS and TIPSY readers are encouraged to contact Ken Polsson at (250) 387-6948.

There is no guarantee that the stands that are selected for silviculture treatment are harvested in the future. Only those stands that meet the harvest criteria and are not required to meet a forest cover target are eligible for harvest. Through the heuristic approach the model will know which stands will contribute the most volume in the future. Also any stand that is fertilized and not harvested will remain on the fertilized curve until harvest. Once a stand is placed on a treatment curve it cannot be removed unless it is eligible for another treatment or can be harvested. Treatments cannot be skipped once the stand is assigned to a fertilization curve.

8 Forest Level Analysis

8.1 Assumptions

The assumptions and data used in the Type 2 analysis are different than in the MP3 timber supply analysis. Section 4.1 of this report describes the assumptions of the MP3 timber supply analysis and the base case harvest level scenario. Further description of the Type 2 analysis assumptions and data is documented in the information package and included in Appendix 1 of this report.

Further assumptions regarding the Type 2 analysis are:

- Success of results will not be limited by funding availability, source, or ability to deliver the program;
- Status quo timber harvesting land base will be applied except where noted;
- Forest Practices Code will be applied;
- Ministry timber supply concepts and harvest flow controls will be utilized;
- The analysis will originate with the current AAC and utilization standards;
- Precision for objectives will be applied as follows:
  - Silviculture investment not to exceed maximum budget level by more than 10%; and
  - +/- 5% tolerance around age-class targets specified in TSA for optimization.
- Treatment costs were taken from recent experience in TFL 53 and are listed in the information package (Appendix 1).

8.2 Working Targets

Dunkley's volume target for TFL 53 is to increase the long-term harvest level to 360,000 m^3/year (60% of mill capacity). This increase in harvestable volume will allow Dunkley to maintain desired employment and revenue levels.

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8.3 Analysis Scenarios

The scenarios to be tested in the Type 2 project are provided in Table 5. The title and scenario number provide a reference for each scenario. In the title column the type of model algorithm is described in brackets. The scenario description explains the scenario intent. Further information is provided in the descriptions following this table.

Table 5: Analysis scenarios.

Scenario	Title	Scenario Description
1	Benchmark (simulation)	▪ Recreation of MP3 supplemental analysis run A.2. ▪ Includes genetic improvement for spruce from 1998 on.
2	Backlog NSR Restocking (simulation)	▪ Compares to Scenario 1. ▪ Uses regeneration delay to reflect impacts of not undertaking past and future treatment of backlog NSR.
3	Silviculture Strategy Base Case (simulation)	▪ Serves as starting point for all subsequent silviculture strategy runs. ▪ TASS curves replace TIPSY curves from Scenario 1. ▪ Low biodiversity emphasis applied in TFL. ▪ Otherwise follows Scenario 1 assumptions.
4	Road Rehabilitation (heuristic)	▪ Compares to Scenario 3. ▪ $500,000 annual budget. ▪ Investigates opportunity to increase harvest flows through expenditures on road rehabilitation.
5	Fertilization (heuristic)	▪ Compares to Scenario 3. ▪ $500,000 annual budget. ▪ Investigates opportunity to increase harvest flows through expenditures on fertilization.
6	Commercial Thin (heuristic)	▪ Compares to Scenario 3. ▪ Commercial thinning modeled as cost recovering (i.e. no budget). ▪ Investigates opportunity to increase harvest flows through commercial thinning in VQO zones.
7	Volume Impact (heuristic)	▪ Compares to Scenario 3. ▪ Annual budget levels: - $250,000 - $500,000 - $1,000,000 ▪ Investigates opportunity to increase harvest flows by use of combined road rehabilitation and fertilization.
8	Preferred (heuristic)	▪ Compares to Scenario 3. ▪ Budget level and treatment options are selected based on review of analysis results of Scenarios 3 – 7.

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8.3.1 Benchmark (Scenario 1)

This scenario uses Dunkley's MP3 Supplemental A2 (base case) assumptions and serves as a benchmark between the Type 2 analysis and the timber supply analysis. Re-creating the TSA base case makes it possible to evaluate the model's performance as well as monitor differences between this analysis and the TSA.

The benchmark includes some genetic improvement as in the MP3 Supplemental A2. Between 1982 and 1997, approximately 20% of seedlings planted were from improved seed and Dunkley Lumber intends to use improved seed for all spruce reforestation in the year 2000 and beyond. Therefore, the expected genetic worth of 18% was applied to TIPSY yield volumes for spruce beginning in 1998 to reflect past and future use of genetically improved stock.

The MP3 timber supply analysis base case applied landscape biodiversity forest cover constraints at the NDT level and the supplemental analyses A2 was performed to test the application of these constraints at the BEC variant level. It was decided that this analysis should follow the latter method. Dunkley Lumber conducted several supplemental analyses runs. Supplemental analysis run A.1 modeled biodiversity at the BEC variant level using an oldest-first harvest rule while run A.2 modeled biodiversity similarly but with a relative-oldest-first harvest rule. ***FSOS*** employs the latter harvest rule and, as such, **Scenario 1 is a recreation of supplemental TSA analysis run A.2.** Further description of Dunkley supplemental analyses A2 is provided in Appendix 2.

8.3.2 Backlog NSR Restocking (Scenario 2)

This scenario investigates the impact that past and future stand tending has had on the current forest condition, specifically what harvest volumes would be if past and future backlog treatments had not been undertaken. Several analysis runs tested this by adjusting the volumes of the treated stands by increasing the length of regeneration delay. Guidance for the selection of regeneration delays came from the Ministry of Forest, Forest Practices Brach report *Worksheets for Assessing Backlog Treatment Costs Relative to Expected Gains* (May, 2001).

8.3.3 Silviculture Strategy Base Case (Scenario 3)

This scenario uses assumptions as per the benchmark (Scenario 1) with two exceptions. First, TASS curves replace TIPSY curves for managed stands. Second, low biodiversity emphasis is applied to all three NDT groups by BEC variant as opposed to the 45/45/10 split between low, intermediate, and high in the benchmark. This change reflects the draft biodiversity emphasis designation for TFL 53. The silviculture strategy base case (SS base case) includes no incremental silviculture treatments and serves as the basis for all subsequent incremental silviculture scenarios (Scenarios 4 – 10).

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8.3.4 Road Rehabilitation (Scenario 4)

This scenario explores the impact of road rehabilitation within the TFL as intended through Dunkley Lumber's access management plan. When this scenario was developed, the entire silviculture budget of $500,000 was available for on-block road rehabilitation where available. As the access management plan was not available spatially at the time of this analysis, the rehabilitation of on-block roads was modeled non-spatially; that is, as a percent addition to the productive capacity of the land base rather than the addition of specific geographic areas.

Based on the land base net down procedure described in Table 2 of the information package (Appendix 1) a reduction of 1.09% was applied to every polygon in the THLB to account for future road reductions. Based on an analysis by Dunkley, 0.26% was assumed to represent on-block roads. Therefore, all future managed stands were considered eligible for the road rehabilitation treatment, which would increase the managed stand yield curve volumes by 0.26%. This allowed the model to choose whether to do the road rehabilitation treatment or not. The cost of road rehabilitation including site preparation and planting is $2 925/ha. The area to be treated or effectively "added back" to the future timber harvesting land base is 178 ha (current THLB = 68 627.9 x 0.26% in block road deduction).

8.3.5 Fertilization (Scenario 5)

This scenario explores the opportunity for fertilization treatments to increase timber volumes. A budget of $500,000 is available for fertilization of stands in appropriate analysis units. Fertilization treatments are applied to selected stands every 6 years after seedling dominance, which is assumed to occur at a height of 4.5 metres. All existing immature stands were considered eligible for treatment and as such some of them will be taller than 4.5 metres when fertilization treatments are initiated. The same fertilization curve is used whether the fertilization initiates at 4.5 metres or higher. Stands taller than 4.5 metres would receive less fertilization treatments and in reality would likely exhibit less yield increase than stands that had been fertilized starting at 4.5 metres.

The TASS curves that were generated include fertilization treatment (volume) response information for pine but not for spruce. As such, fertilization response in spruce was modeled as a 25% volume increment gain in the period following treatment. This response was developed based on information provided by Rob Brockley of the Kalamalka Research Station. Fertilization treatments in pine assumed application of 200 kg/ha Nitrogen plus 50 kg/ha Sulphur; for spruce 200 kg/ha Nitrogen.

8.3.6 Commercial Thin (Scenario 6)

This run explores the possibility of increasing the harvest level by using commercial thinning in areas with constraints for visual quality. Commercial thinning can be used to obtain harvest volume while maintaining adequate tree cover to fulfill visual quality objectives. For the purposes of this analysis commercial thinning is modeled as having zero net cost.

The commercial thinning treatment is a single removal of 30% of basal area 20 years before minimum harvest age with a 12.5 cm minimum diameter limit. Within TASS, the treatment progresses in three steps. First, all trees below 12.5 cm diameter are excluded from possible removal. Second, the remaining trees are ordered by basal area from smallest to largest. Finally, trees are removed from this eligible group beginning with the tree of smallest diameter until the target 30% is removed.

8.3.7 Volume Impact Scenarios (Scenarios 7, 8 and 9)

This set of runs investigates the opportunity for increasing the harvest level through road rehabilitation and fertilization treatments. Scenarios 7, 8, and 9 have available silviculture budgets of $250,000, $500,000, and $1,000,000, respectively. The model can choose to spend the budget on road rehabilitation, fertilization, or any combination of the two treatments to produce volume gains.

8.3.8 Preferred Scenario (Scenario 10)

The preferred scenario will be developed from the results of the incremental silviculture scenarios (Scenarios 4 – 9) as they compare to the SS base case (Scenario 3) will be used to design this preferred scenario. Effective treatments and budget levels will be selected based on the outcomes of the Scenarios 4 – 9.

9 Results

9.1 Base Scenarios (Scenarios 1 – 3)

9.1.1 Benchmark (Scenario 1)

Figure 4 illustrates the Type 2 benchmark run harvest flow compared to the MP3 supplemental analysis run A2. Scenario A2 provides a more logical comparison to the Type 2 benchmark since it includes the modeling of biodiversity using 10/45/45 and dividing NDT 3 into 3 variant groups. A2 also includes modeling using the relative oldest first harvest rule which is the rule that is used in ***FSOS***, where stands are selected for harvest based on the greatest difference between their current age and the minimum harvest age. Supplemental analysis A2 and the MP3 base case are described in Section 4.1.1. The most significant difference between the two scenarios is that the harvest level dips in decade 6 and 15 are eliminated.

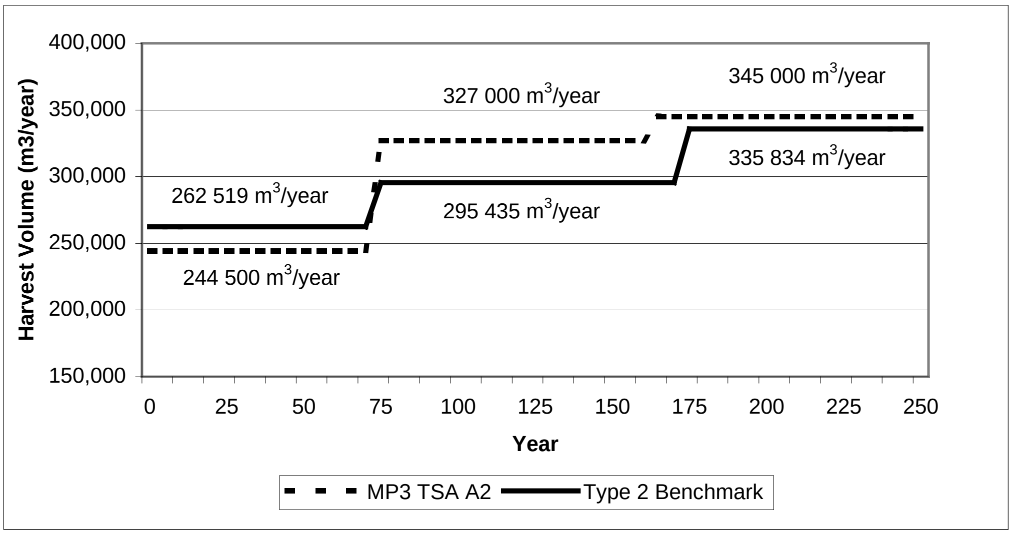

Figure 4: Harvest forecasts: TSA supplemental analysis run A2 and Type 2 benchmark run.

Table 6 provides the net harvest results for the MP3 A2 and the Type 2 benchmark scenarios. Several model runs were completed to develop the Type 2 Benchmark scenario with a harvest level that was as similar as possible to the MP3 Supplemental A2 scenario. In the development of the Type 2 Benchmark harvest level, we were able to increase the short-term harvest level above the MP3 Supplemental A2 level without any impact in our mid and long-term results. Therefore, the lower mid-term harvest level exhibited by the benchmark scenario is not a result of the increased short-term harvest. This was confirmed by running the Benchmark scenario short-term harvest at both the TSR A2 supplemental level (244,500m^3/year) and the increased harvest (262,519m^3/year). The increased initial harvest level produced no declines in the mid and long-term harvest levels. The operable growing stock charts for both scenarios (Figure 5) supports the increased short-term harvest level.

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Table 6: Summary of net harvest for the MP3 TSA A2 and Type 2 Benchmark scenarios.

Time Period	MP 3 TSA A2 (m^3/year)	Type 2 Benchmark (m^3/year)	% Difference
Short-term	244 500	262 519	+7.4
Mid-term	327 000	295 435	-10.7
Long-term	345 000	335 834	-2.7

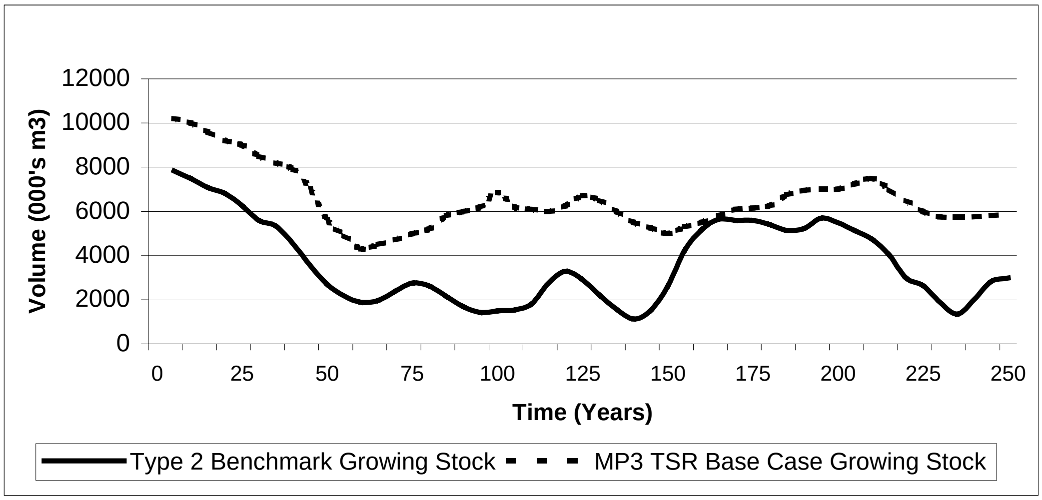

Figure 5: Operable Growing Stock: TSA Base Case and Type 2 benchmark scenarios.

The operable growing stock (volume above minimum harvest age) for the Type 2 benchmark scenario is approximately 20% below the MP3 TSR base case scenario and maintains a similar reduced trend throughout the first 70 years. The operable growing stock for MP3 A2 scenario is not presented here, as it was not available from the timber supply analysis report, however it is expected to be similar to the base case and therefore appropriate for comparison purposes. There are however, comparable pinch points in the Type 2 operable growing stock, which represents reduced volume availability and timing as in the MP3 base case.

In comparing the Type 2 benchmark to the MP3 Supplemental A2 results, there are numerous discrepancies between the 2 scenarios, which contribute to the harvest level differences. The following lists those discrepancies:

- The modelling algorithms are different between the MP3 and Type 2 analysis. The Type 2 analysis uses ***FSOS*** rather than FSSIM. This is not thought to cause significant differences as ***FSOS*** has been compared to FSSIM in the past with similar results, but could account for minor differences;
- The timber harvesting land base for the Type 2 benchmark scenario is 2% smaller than that of the MP3 timber supply analysis or approximately 1500 ha. This area difference could result in upwards of 2.2 – 2.3 % of the mid and long-term harvest level differences;
- The VQO zones have changed since the MP3 timber supply analysis. This likely caused most of the short-term differences in the harvest level. The Type 2 THLB area in VQOs were typically less than the MP3 (except for maximum modification) and the years required to reach visual effective green up were also lower in the preservation, retention, and partial retention VQOs which would result in increased available volume;

- Old seral targets were modeled differently than the MP3 timber supply analysis. Some short-term targets were more relaxed in the Type 2 benchmark scenario, while some mid-term old growth targets were more restrictive than in MP3 timber supply analysis. Again, these differences would result in higher short-term and lower mid- and long-term harvest level in the Type 2 benchmark as compared to MP3 Scenario A2;
- Analysis unit areas and their average site indices were different between the MP3 timber supply analysis and Type 2 (Appendix 1 - information package Table 17). The most significant differences were in the immature and future managed stands where the MP3 SI's were higher than the Type 2. For example, AU 8 (Spruce Poor) has 1200 ha more in the TSR than in the Type 2 and average site index for future managed stands in the TSR is 19 as compared to 12.4 in the Type 2. Also, AU 17 (Pine/Spruce Med/Poor) has 1260 ha more in the TSR than in the Type 2 and the average site index for future managed stands in the TSR is 20.2 compared to 14 in the Type 2.
- In parts of the TFL, terrain stability classes were used in this analysis rather than ESAs. In the Type 2, 500 ha and 1300 ha net area were removed for terrain stability class IV and V respectively. In MP3 there were 600 ha of ES1 removed. This increased reduction contributes to the timber harvesting land base differences.

For more information regarding the differences in the assumptions between the MP3 Supplemental A2 and Type 2 benchmark scenarios the net down tables, analysis unit and site index comparisons, and forest cover requirements are provided in Appendix 2.

9.1.2 Backlog NSR Restocking (Scenario 2)

This scenario tested the impact of past and future restocking of backlog areas on the harvest level of TFL 53. This was modeled by varying regeneration lag periods in the analysis on the treated backlog areas and comparing the results with the benchmark. The Ministry of Forest, Forest Practices Branch report *Worksheets for Assessing Backlog Treatment Costs Relative to Expected Gains* (May, 2001) was provided to Forest Ecosystem Solutions Ltd. by Les Herring. This report provides regeneration lag estimates for lodgepole pine and interior spruce stands based on understory vegetation type. As stand-specific information regarding understory vegetation was not available, the range of regeneration lags provided in the report was tested (5, 10, 15 and 30 years). In modeling the regeneration lag scenarios, the backlog areas were regenerated to managed stand yield curves following the delay (5, 10, 15, and 30 years). Following second rotation harvests these stands were then assigned a normal regeneration delay of one year.

Figure 5 illustrates the impact of regeneration lag periods of 5 and 30 years on the benchmark harvest level. Generally, the harvest level impact is concentrated in the short-term (over the first 8 decades) where modest harvest level decreases occur as compared to the benchmark scenario. The 5 year regeneration lag scenario results in approximately a 2% reduction in the short-term harvest level to 257,187 m^3/year while the 30 year regeneration lag results in a 6.8% reduction from the benchmark level to 254,011 m^3/year. Both scenarios result in a later transition to the mid-term harvest level at year 85 instead of 75 as in the benchmark scenario. There are slight variations in the mid-term harvest levels between the benchmark, 5 and 30 year regeneration lag scenarios at 295,435, 298,032, and 297,346 m^3/year, respectively. The long-term harvest level remains similar for each scenario at 335,834, 338,032 and 337,501 m^3/year for the benchmark, 5 and 30 year regeneration lag scenarios.

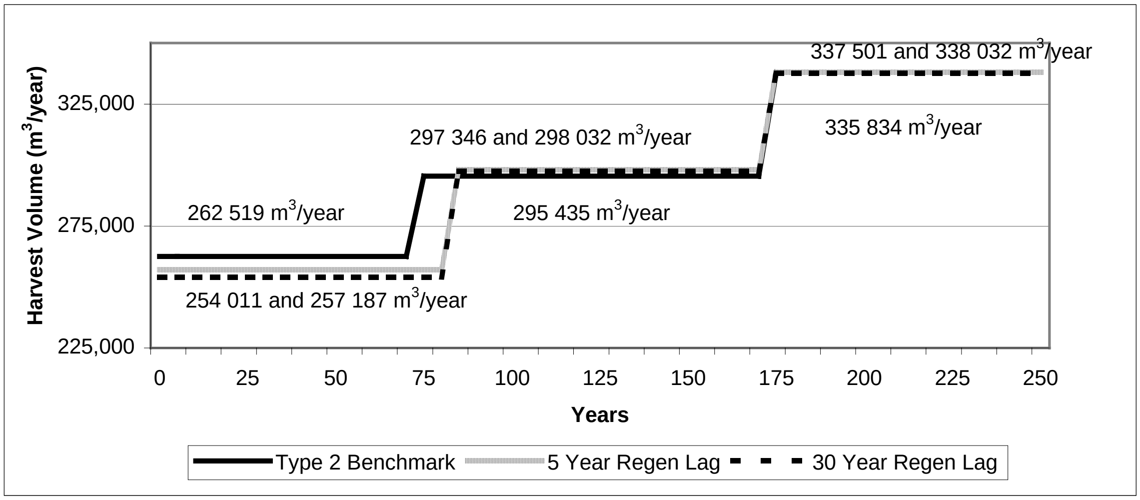

Figure 5: Harvest forecasts: Benchmark and no stand tending (5 and 30 year regeneration lag) scenarios.

The harvest level impacts due to variations in the regeneration lag are rather small due to the modest area in backlog condition (past and current) that was treated. Past and current backlog areas totalled 6 349 ha, which amounts to approximately 9% of the THLB.

9.1.3 Silviculture Strategy Base Case (Scenario 3)

Figure 6 illustrates the SS base case scenario harvest level with the Type 2 benchmark and the MP3 Supplemental A2. The silviculture strategy base case harvest level is similar to the benchmark throughout the planning horizon until year 175 where the benchmark scenario increases to 335 834m^3/year, which is 11.6% higher than the SS +base case level of 297 424 m^3/year.

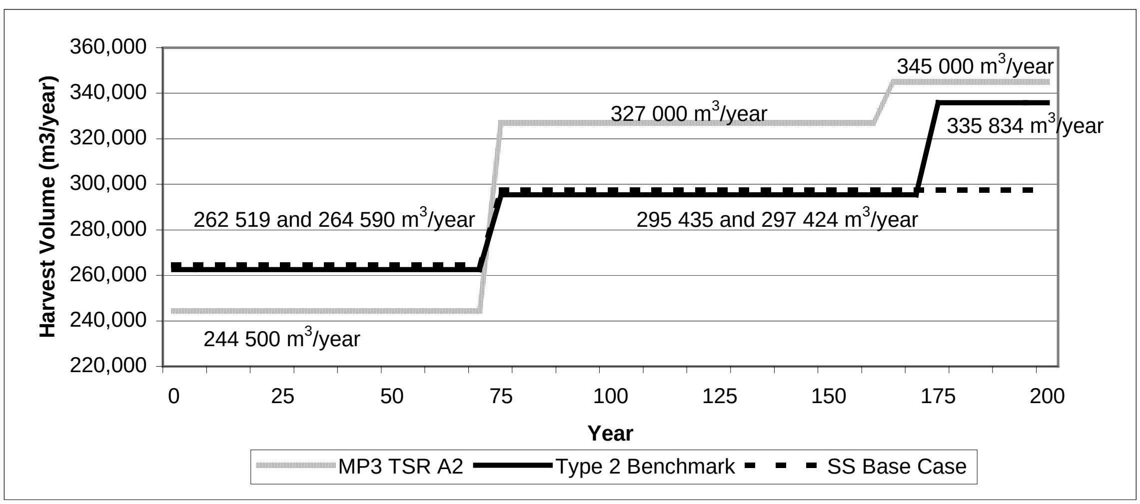

Figure 6: Harvest forecasts: TSA supplemental analysis run A.2, benchmark, and silviculture strategy base case.

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The variances in harvest level between the Type 2 benchmark and SS base case scenarios are a result of different analysis assumptions, model algorithms, and rule sets. Table 7 provides a summary of the assumptions used for each scenario. As discussed in Section 7, TASS and TIPSY will not produce identical modelling results because of the inherent differences in the two stand level yield models (Ken Polsson, Pers. Comm.). In addition, genetic gain was applied using the algorithm in TASS for the TASS yields, which produces less than the direct 18% linear impact as applied to the TIPSY yields. Biodiversity was also modeled as low emphasis versus the 10/45/45 requirement.

Table 7: Summary of analysis assumptions for key scenarios

Scenario	Model/Algorithm	THLB Area (current/future)	Biodiversity emphasis rules	Managed Curves
MP3 TSR A2	FSSIM - simulation	70 142/69 378	10/45/45	TIPSY
Type 2 Benchmark	FSOS - simulation	68 628/67 880	10/45/45	TIPSY
SS base case	FSOS - simulation	68 628/67 880	Low	TASS

Operable growing stock for the SS base case scenario is compared with the Type 2 benchmark scenario in Figure 7.

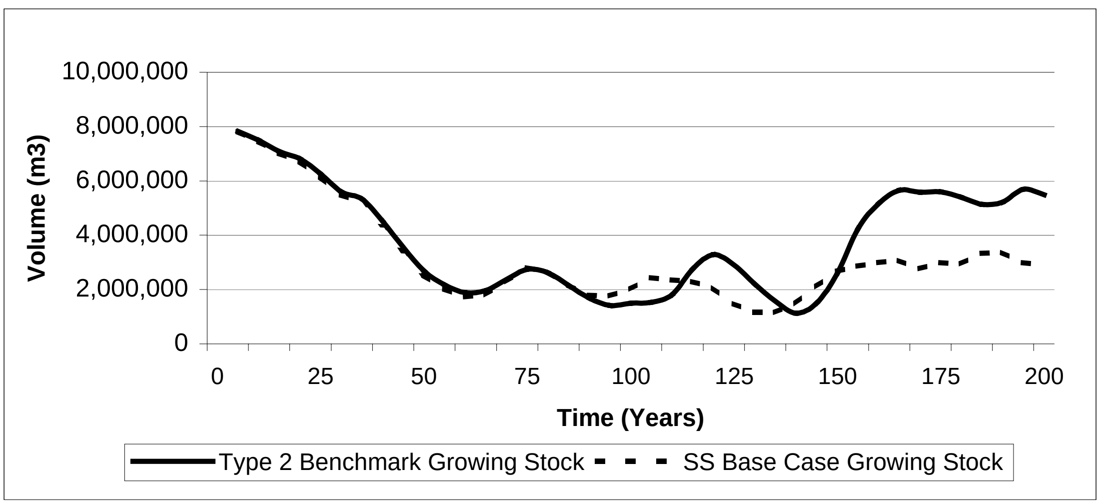

Figure 7: Operable growing stock: Type 2 Benchmark and SS base case Scenarios.

The operable growing stock for the Type 2 benchmark and SS base case scenario follow a similar trend throughout the planning horizon until the 15th decade. At this point the Type 2 benchmark scenario exhibits an increasing growing stock as compared to the SS base case. The excess operable growing stock supports the slightly higher harvest level as illustrated in Figure 6 but cannot be transferred to any further increases in the long-term harvest level as several available volume pinch points (year 100 and 140) will result in harvest level failures. Furthermore, attempts at increasing the long-term harvest level also resulted in harvest level declines around 300 years.

Figure 8 illustrates the harvest contribution for the SS base case harvest from existing natural and managed stands. There is a relatively abrupt transition that principally starts during decade 8 and by decade 9, managed stands comprise approximately 80% of the total harvest from TFL 53.

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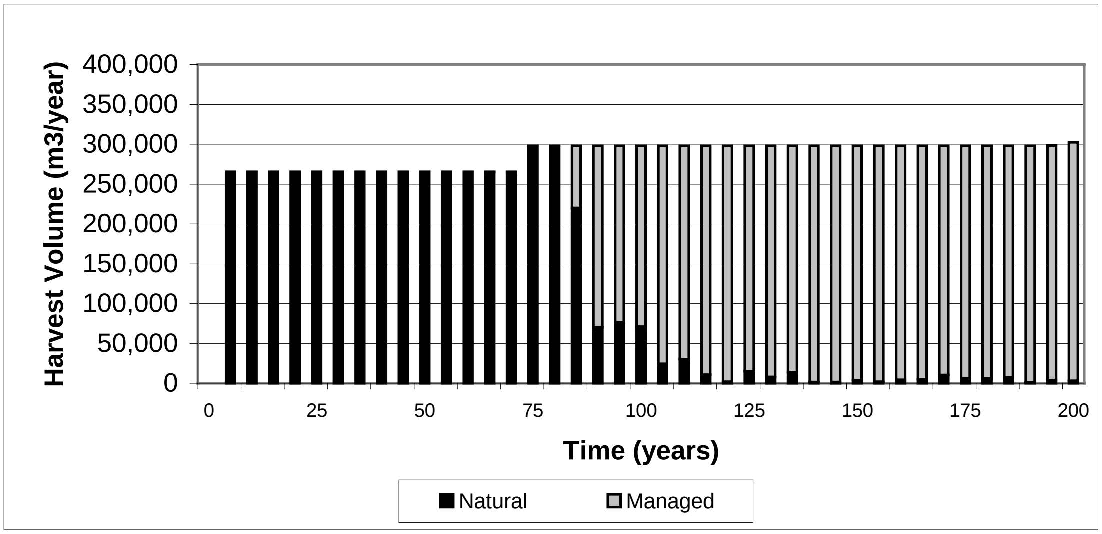

Figure 8: SS base case transition from natural stands to managed stands.

Figure 9 illustrates the average age, volume and net area harvested for the SS base case scenario. The average harvest age exhibits a decline in the future, as managed stands comprise more of the harvest level for TFL 53 going from a maximum of 210 years in the first decade to 76 years in the 6th decade. By decade 8, approximately 80% of the harvest level is concentrated in managed stands, which are eligible for harvest at 90% of culmination age. From decade 8 onwards the average harvest age fluctuates around 85 years old. The periodic increases in the harvest age reflect the increased availability of old stands when forest cover requirements have been satisfied.

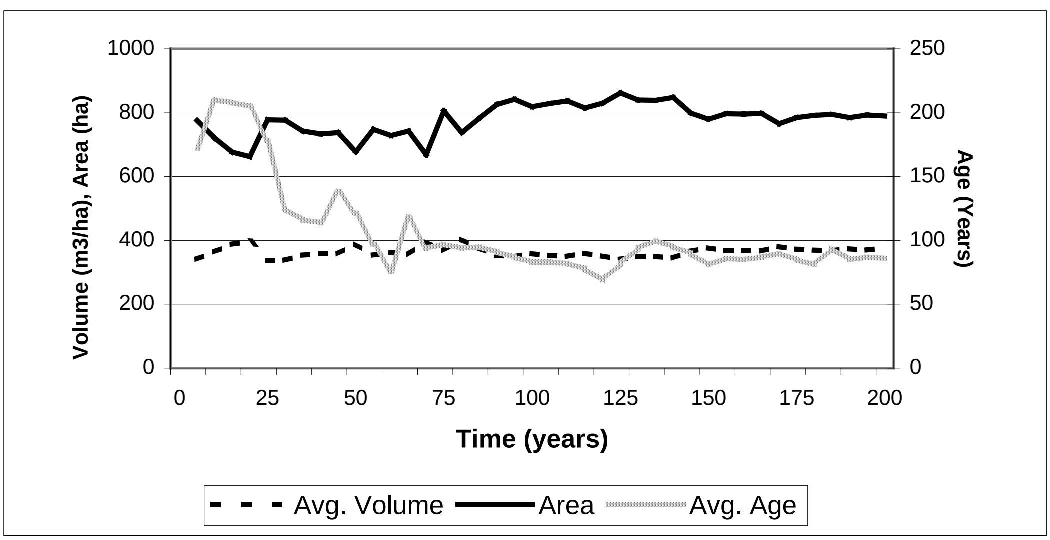

Figure 9: Average harvest age, average harvest volume and net area harvested – SS base case scenario.

The average harvest volume and net area harvested for the SS base case scenario is also reported in Figure 9. Over the entire planning horizon the average volume harvested remains rather constant fluctuating around 360 m^3/ha. Over the first 80 years the net area harvested averages around 730 ha/year. Following the transition to managed stand harvest; the average net area harvested over the remainder of the planning horizon increases to slightly more than 800 ha/year. Dunkley currently harvests approximately 550 ha/year.

9.2 Road Rehabilitation (Scenario 4)

Modeling of road rehabilitation was attempted by increasing the yields of future managed stands by 0.26%. This approach was selected, as no spatial road rehabilitation plan was available for this analysis. The cost of treatment was applied based on the area of the future managed stands. This assumption inflated both the area and cost for the road rehabilitation treatment and as such did not allow for appropriate modeling of this scenario. In reviewing the opportunity for road rehabilitation, there is currently a very small area available for treatment. Since only in-block roads were eligible for rehabilitation treatment, the area of these roads represents 0.26% of the total future roads reduction (1.09% of the current timber harvesting land base). If 100% productivity is assumed then the effective reduction for future roads is 0.83%. Therefore, with a current THLB of 68 628 ha, the equivalent area of in-block roads treated and converted to productive forestland would be 178 ha. Assuming 100% productivity, the impact on timber supply would be equivalent to approximately 890 m^3/year.

The road rehabilitation treatment is summarized in Table 8 using the assumption that 10 ha/decade will be treated. This regime is proposed for analysis purposes and provides flexibility for Dunkley to implement operationally. Unfortunately, this approach does not allow the comparison of road rehabilitation with other intensive treatments, but again since it is a relatively small area and volume impact it will not significantly affect the scheduling of fertilization.

Table 8: Road rehabilitation scenario

Years	Area Treated	Treatment Expenditures	Estimated Volume Impacts (based on 5m^3/ha/year)
Every decade between now and the end of the planning horizon	10 ha/decade	$29 250/decade	890 m^3/year starting after the transition in decade 7.

9.3 Fertilization (Scenario 5)

In the fertilization scenario, a budget of $0.5 million was tested for fertilization of stands in eligible analysis units (Table 4). In the first draft analyses, very minor harvest level responses were achieved from the fertilization scenarios. Following significant testing of this phenomenon, the use of culmination age as minimum harvest criteria prevented the realization of any harvest level gains from fertilization as the harvest rule eliminated any flexibility for increased harvest with such high minimum ages. Once the minimum harvest ages were reduced to 90% of culmination, the harvest ages decreased significantly (some up to 30 years) allowing for further flexibility and harvest level increases. Therefore, for the fertilization scenarios the minimum harvest ages were adjusted to 90% culmination age.

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As Figure 10 illustrates, the $0.5 million fertilization scenario results in approximately a 12% increase in the harvest level to 297 094 m^3/year in the 4th decade over the SS base case. In the 7th decade, the harvest level can be increased again up to 308 993 m^3/year while the SS base case maintains 297 424 m^3/year representing an increase of approximately 4%. There is a final increase in the harvest level in the 18th decade up to 341 753 m^3/year which represents a 15% increase over the SS base case harvest.

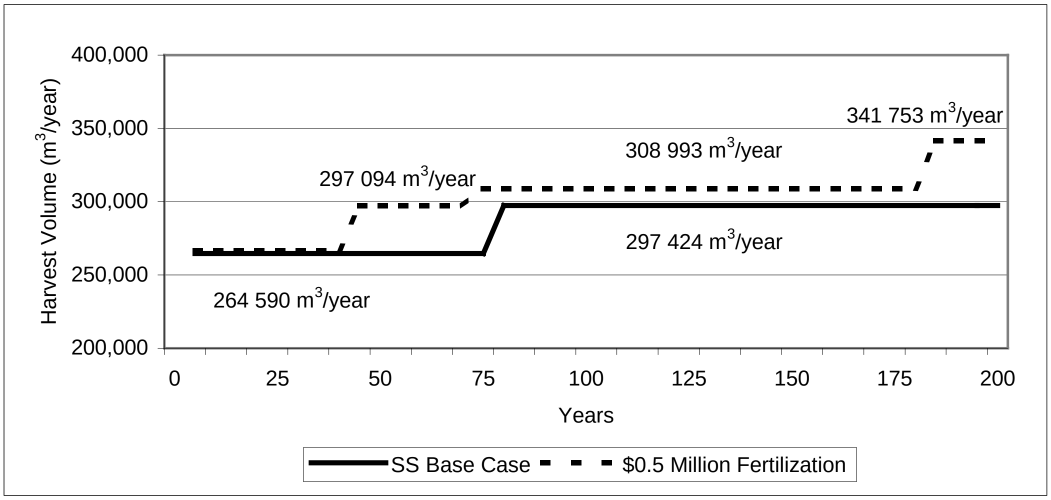

Figure 10: Harvest forecasts: SS base case and fertilization scenario ($0.5 million budget).

Table 9 illustrates the annual treated areas and expenditures for the $0.5 million fertilization scenario for the first hundred years. It takes 30 years until a consistent treatment level of approximately 1,500 ha per year of fertilization is achieved which is then maintained throughout the remainder of the planning horizon. Over the first 3 decades the majority of fertilization treatments are concentrated within the existing immature stands and over this period of time stands that are harvested in the short-term will have reached the height requirement for treatment eligibility. Within the last several years, Dunkley has fertilized approximately 500 ha/year, which is very similar to the forecasted treatment in the first period (Table 9).

Table 9: Annual treated area and expenditure, fertilization scenario ($0.5 million budget).

Period	Area Treated Annually (ha)	Annual Expenditures ($)
5	573.2	$200,616
10	902.8	$315,971
15	1191.9	$417,149
20	1299.4	$454,798
25	1393.9	$487,879
30	1484.6	$519,603
35	1567.8	$548,740
40	1555.2	$544,314
45	1571.3	$549,963
50	1570.7	$549,757
55	1571.4	$549,986
60	1571.3	$549,966
65	1571.4	$549,989

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70	1571.4	$549,993
75	1527.6	$534,661
80	1542.4	$539,854
85	1517.6	$531,163
90	1571.2	$549,912
95	1522.6	$532,903
100	1571.3	$549,959

Figure 11 illustrates graphically the annual fertilization treatments over the first 100 years. The fertilization of existing immature stands which comprises the majority of treatments over the first 2 decades allow for the significant increase in harvest level in 40 years.

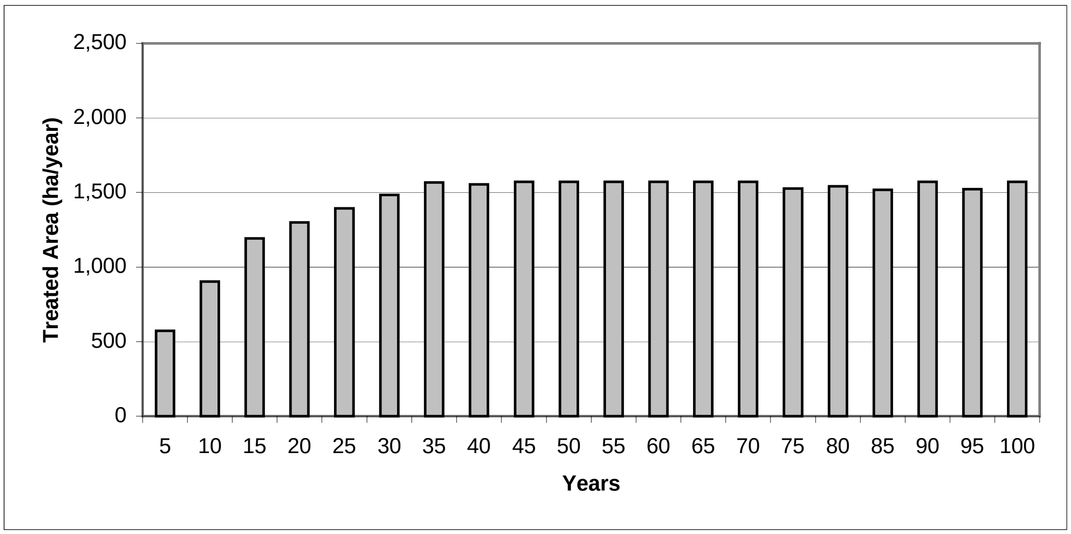

Figure 11: Annual treated area, fertilization run ($0.5 million budget).

9.4 Commercial Thin (Scenario 6)

Commercial thinning in visually sensitive areas had no measurable harvest level effects. Only 480 ha were commercially thinned throughout the planning horizon of 200 years. The average annual commercial thinning area was 12 ha. Since CT is assumed to be cost recovering and there are no measurable harvest level impacts, the results are not presented here.

9.5 Volume Impact Scenarios (Scenarios 7, 8 and 9)

As the road rehabilitation exhibited very little harvest level impacts, only fertilization was modeled in the volume impact scenarios. Scenarios 7, 8, and 9 test the harvest level impacts for silviculture expenditures for fertilization of $0.25, $0.5, and $1 million, respectively. The $0.5 million is the same as scenario 5 in section 9.3.

Figure 12 illustrates the achieved harvest levels for each volume impact scenario. In all three fertilization scenarios, the respective harvest levels follow similar increasing patterns throughout the planning horizon. As illustrated in Figure 10 with the $0.5 million fertilization scenario, there are distinct increases in the harvest level increases in the 4th, 7th and 17th – 19th decades. The increase in the 4th decade is attributable to the increased productivity of existing immature stands that are fertilized over the first 3 decades (Table 10). The harvest level increase in the 7th decade results from the harvest transition to future managed stands, which also achieve an increased productivity from fertilization treatments from decade 4 onwards. The late increase to the long-term harvest level likely results from the increasing accumulation of merchantable growing stock due to constrained areas such as wildlife tree patches and visually sensitive areas and the increased yield as a result of fertilization.

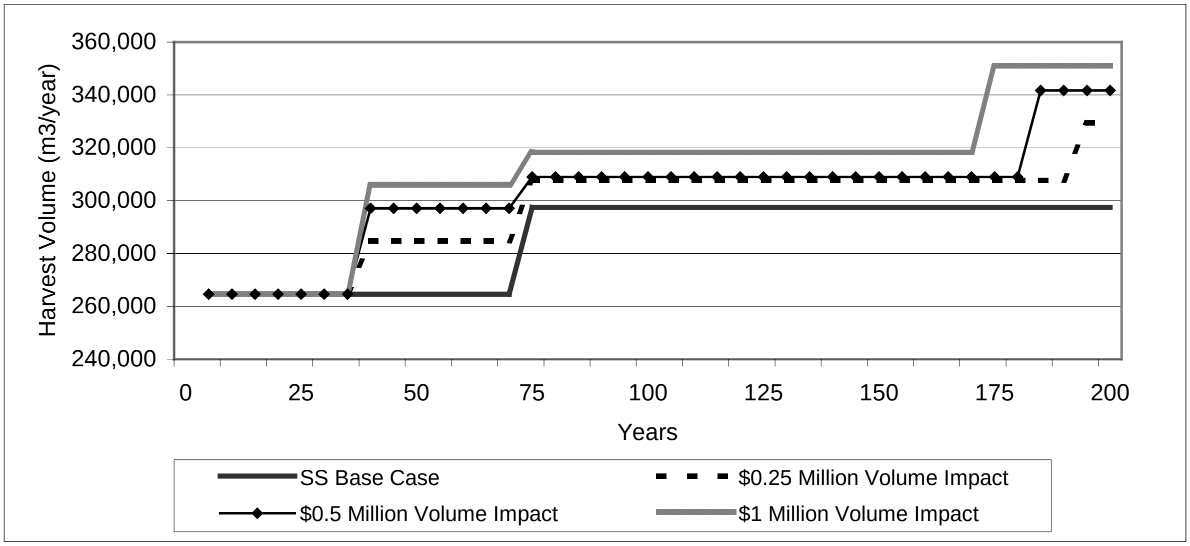

Figure 12: Harvest forecast, SS base case and volume impact scenarios ($0.25, $0.5, and $1.0 million budgets)

Table 10 describes the resulting harvest levels for each volume impact scenario.

Table 10: Harvest level impacts from fertilization.

Period (5 yrs)	SS base case volume (m^3/year)	$0.25 million volume ($m^3$/year)	$0.25 million % increase	$0.5 million volume ($m^3$/year)	$0.5 million % increase	$1 million volume ($m^3$/year	$1 million % increase
1-7	264 590	264 589	n/a	264 597	n/a	264 640	n/a
8-14	264 590	284 673	7.6	297 094	12.3	306 005	15.7
15-34	297 424	307 657	3.4	308 993	3.9	318 280	7.0
35-36	297 424	307 657	3.4	308 993	3.9	351 077	18.0
37-38	297 424	307 657	3.4	341 753	14.9	351 077	18.0
39-40	297 424	329 500	10.8	341 753	14.9	351 077	18.0

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The $0.5 million budget analysis results are summarized in Section 9.3. As illustrated in Table 10, over the first 3 decades the harvest level is similar for all scenarios. Starting in the 4th decade, harvest levels begin to increase as a result of fertilization as shown in the $0.25 million scenario, where the harvest level of 284,673 m^3/year represents almost an 8% over the SS base case. This harvest level is maintained until the 7th decade where there is an increase to 307,657 m^3/year, which represents a 3.4% increase over, the SS base case. In the 19th decade the harvest level can be increased further to 329,000 m^3/year. The $1 million scenario shows the largest increases in harvest levels starting in the 4th decade with an increase of 41,000 m^3/year or approximately 16% over the SS base case. This

increase is maintained for 35 years when there is another increase in the harvest of almost 7% to 318,280 m^3/year. In the 17th decade the harvest level can be increased almost 32,797 m^3 to 351,077 m^3/year which is an increase of almost 18% over the SS base case. Overall, fertilization provides opportunities for significant volume gains for TFL 53 over the planning horizon. Figure 13 illustrates the area of fertilization treatments for each budget level.

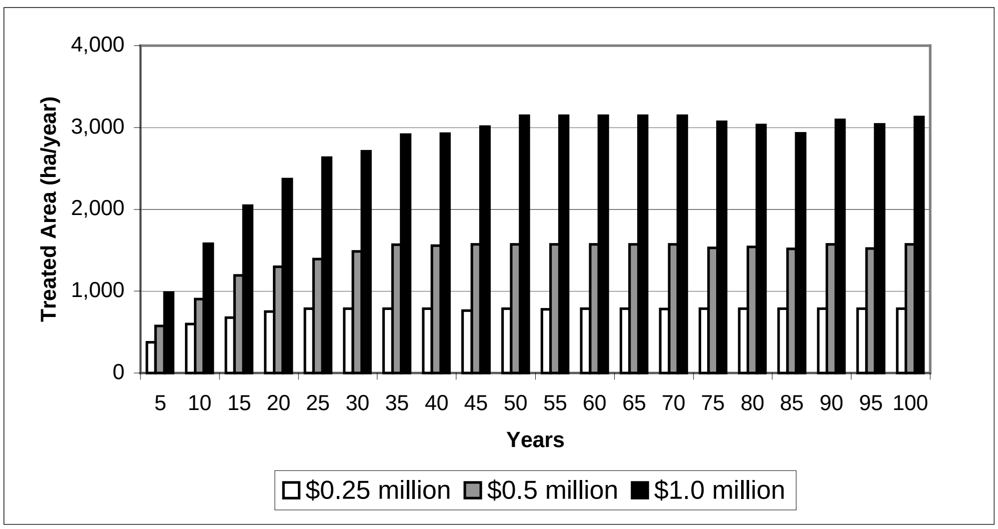

Figure 13: Annual areas treated, all budgets volume impact scenario.

As shown in Figure 13, there is a gradual implementation of fertilization treatments in each of the 3 budget scenarios. By the 3rd decade, the fertilization treatments reach a relatively stable level and are maintained throughout the remainder of the planning horizon. At the beginning of the planning horizon, only the existing managed immature stands are eligible for fertilization treatments as future managed stands are not available for treatment until they attain 4.5 m in height or for approximately 20 years.

With an assumed cost of $350/ha for fertilization, the maximum area treated would be approximately 715 ha, 1,430 ha, and 2,860 ha for the $0.25, $0.5 and $1 million scenarios, respectively. There is also a 10% tolerance on the budget expenditure, which would consider any solution that is within 10% of the total budget as meeting the budget target. Table 11 illustrates the area treated and expenditures for the volume impact fertilization scenarios (7, 8, 9) for the first 100 years of the planning horizon. For each scenario the budget target is achieved at different periods in the planning horizon. For the $0.25 million scenario, the budget target is essentially achieved in 15 years with an expenditure of $236,399. The $0.5 million scenario budget target is achieved in 20 years and the $1 million budget within 25 years with $454,798 and $920,000 respectively. By the 3rd decade, a relatively constant level of fertilization treatments are achieved for all scenarios and maintained throughout the next 70 years. The increasing quantity of fertilization treatments over the first 3 decades results from the short-term treatments within the existing immature stands and the onset of future managed stands available for treatment in 20 years once the regenerated stands reach a height of 4.5 metres.

In the first 15-25 years the total budget available is not spent for each of the volume scenarios but as the budget level increases so does the number of treatments and expenditures. This is likely caused by the relative harvest level gains that are achieved as compared to the budget level available. With lower budget levels, the model attempts to spend the money available where there are the largest yield benefits and conserves the balance.

As budget levels increase, and more potential treatable areas become available, the model will spend more money. The budget is first spent on those stands, which yield the largest benefits and then as more budget is available on the balance on stands where yield benefits are not as dramatic. This may result in the potential to fertilize more stands in the short-term than forecasted by the model.

Table 11: Annual area treated and expenditure for $0.25, $0.5 and $1 million volume impact scenarios.

Period	*$0.25 million*		*$0.5 million*		*$1 million*	
	Area (ha)	*$*	*Area (ha)*	*$*	*Area (ha)*	*$*
1	376.7	$131,846	573.2	$200,616	983.0	$344,045
2	596.7	$208,858	902.8	$315,971	1578.3	$552,394
3	**675.4**	**$236,399**	1191.9	$417,149	2044.4	$715,532
4	749.1	$262,186	**1299.4**	**$454,798**	2369.6	$829,360
5	785.7	$274,995	1393.9	$487,879	**2629.7**	**$920,400**
6	785.4	$274,898	1484.6	$519,603	2710.3	$948,616
7	**785.7**	**$274,998**	**1567.8**	**$548,740**	**2913.1**	**$1,019,584**
8	784.6	$274,614	1555.2	$544,314	2923.7	$1,023,290
9	760.8	$266,283	1571.3	$549,963	3011.4	$1,053,999
10	785.7	$274,998	1570.7	$549,757	3142.9	$1,099,999
11	777.6	$272,157	1571.4	$549,986	3142.9	$1,099,999
12	785.7	$274,987	1571.3	$549,966	3142.6	$1,099,901
13	785.7	$274,994	1571.4	$549,989	3142.9	$1,099,997
14	783.4	$274,201	1571.4	$549,993	3142.9	$1,099,998
15	785.5	$274,910	1527.6	$534,661	3067.7	$1,073,680
16	785.7	$274,998	1542.4	$539,854	3031.2	$1,060,928
17	785.7	$274,980	1517.6	$531,163	2929.0	$1,025,157
18	785.7	$274,979	1571.2	$549,912	3092.5	$1,082,368
19	785.6	$274,970	1522.6	$532,903	3038.8	$1,063,579
20	785.6	$274,969	1571.3	$549,959	3128.2	$1,094,854
Avg.	**747**	**$261,311**	**1432**	**$501,359**	**2758**	**$965,384**

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Figure 14 illustrates the operable or merchantable growing stock (volume above minimum harvest age) for the volume impact scenarios at each budget level. The operable growing stock represents the total volume that is above the minimum harvest age. Throughout the planning horizon there is a significant amount of operable growing stock in TFL 53. All scenarios exhibit an initial growing stock of approximately 8 million m^3 and in comparison to the SS base case scenario, the volume impact scenarios, maintain much higher volumes as a result of the increased stand yields from fertilization. The excess growing stock in the volume scenarios results from fertilized stands being held for forest cover requirements but not being eligible for harvest. Operationally more volume may be available as Dunkley would likely fertilize those stands that will not be required for forest cover constraints such as within wildlife tree patches, VQOs or in old growth management areas.

There is a slight decline of the operable growing stock at the end of the planning horizon that can be attributed to the increased harvest levels illustrated in Figure 12. These results are maintained as slight growing stock increases and decreases are common throughout the planning horizon as can be seen in both the Type 2 and MP3 analysis results. Also, the ending operable growing stock continues to remain near or above 4 million m^3 for all scenarios and when investigated to 250 years does not result in significant declines and can be maintained at similar levels.

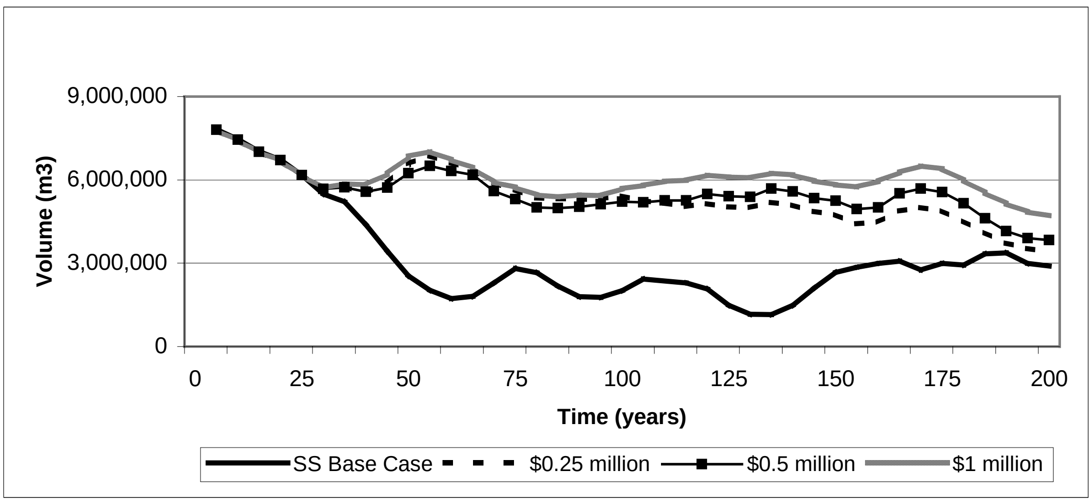

Figure 14: Operable growing stock, all budgets volume impact scenario.

Figure 15 illustrates the net area harvested for each budget level for the volume impact scenarios. There are no noticeable differences in the average area harvested for each of the budget scenarios. The net area harvested annually increases from 750 ha/year in the short-term to approximately 950 ha/year at the end of the planning horizon as a result of the increased harvest levels that are proposed in the future.

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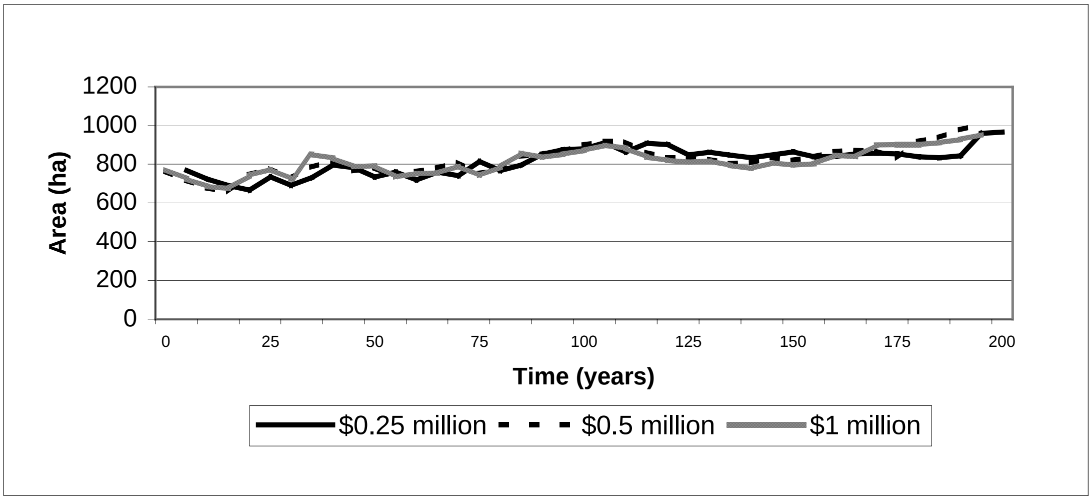

Figure 15: Net annual harvest, all fertilization scenarios.

Figure 16 illustrates a similar average harvest age for all budgets in the impact scenarios. The average age of stands harvested over the planning horizon displays a predominant decrease from 200 years at the start of the planning horizon to 90 years at the 10th decade. Starting in the 13th decade, the average harvest age throughout the rest of the planning horizon is approximately 75 years.

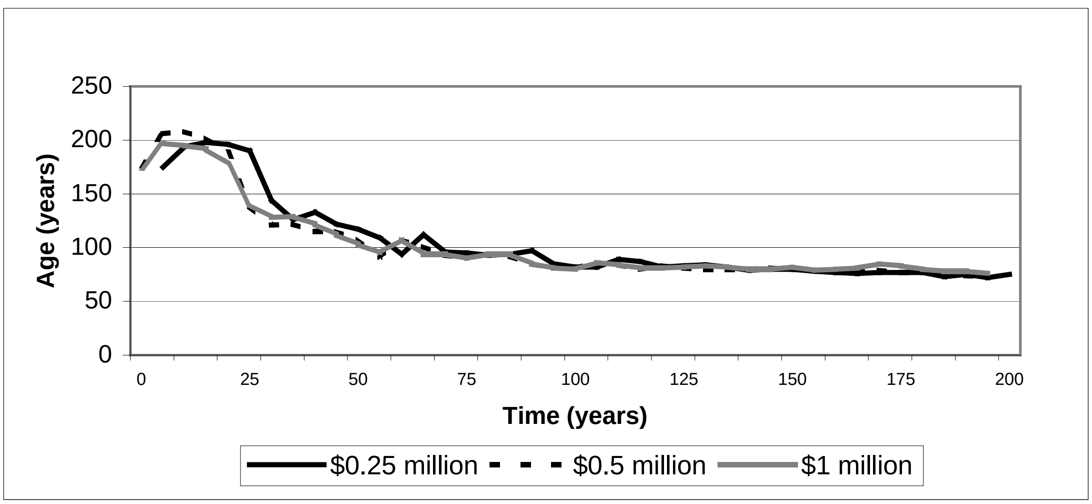

Figure 16: Average harvest age all budgets, volume impact scenarios.

Figure 17 illustrates the average volume harvested for all budgets in the impact scenarios. Over the first 50 years there are no distinct differences between the 3 budget levels. Starting in the 6th decade there is a noticeable difference in the average volume harvested as some of the fertilized immature stands will be harvested. The difference in average harvest volume becomes more pronounced later in the planning horizon as more of the harvest is composed of future managed stands, which have been fertilized. As expected, the $1 million scenario produces the highest average volume harvested, with the $0.5 million scenario producing the next highest and the $0.25 million budget the lowest. From year 90 throughout the planning horizon the average harvest volume for the $0.25, $0.5 and $1 million scenarios is 346 m^3/ha, 358 m^3/ha, and 378 m^3/ha respectively.

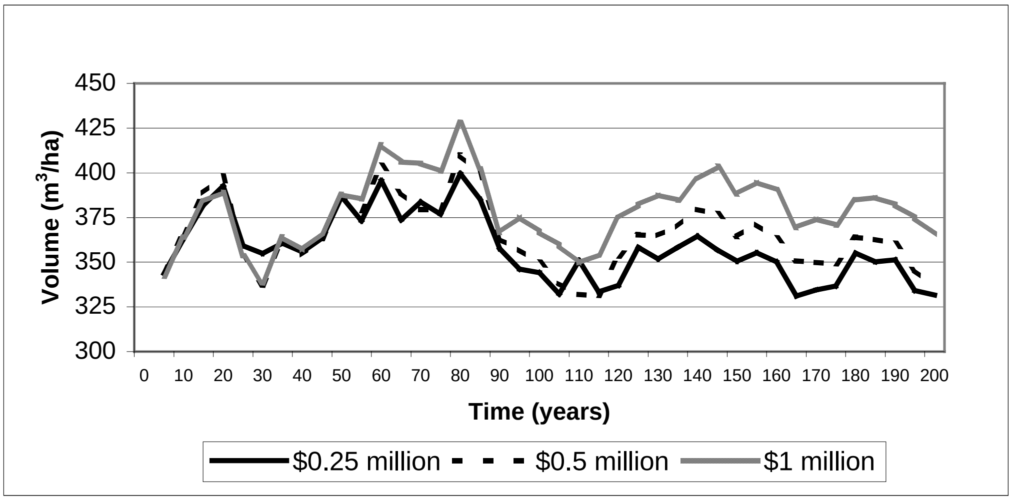

Figure 17: Average harvest volume all budgets, volume impact scenarios.

9.6 Preferred Scenario

9.6.1 Discussion

Dunkley Lumber maintains an aggressive silviculture strategy as stated in their Management Plan # 3. By following the strategy identified in the management plan, Dunkley Lumber is addressing the core silviculture issues well and there are limited opportunities to enhance the quality and quantity of timber supply in the short term, as this analysis indicates. Each of the scenarios tested, show an opportunity to increase the harvest level within 40 years if a fertilization program is implemented.

Dunkley Lumber is committed to eliminating the backlog NSR within the TFL. This will convert currently unproductive areas to productive areas, essentially having the same impact as road rehabilitation. While this regime did not show significant increases in the TFL harvest level, it is still important for Dunkley to maintain maximum productivity.

The basis of Dunkley Lumber's silviculture strategy is to use high establishment densities to enhance quality and prevent the need for fill-in planting in case of partial plantation failures. All plantations are assessed and tended to meet free growing within the time specified in silviculture prescriptions. Brushing and spacing of plantations are important in managed stands to meet the managed stand yield predictions that drive the future timber supply in the TFL.

One way to improve the reliability of yield predictions is to monitor the growth and yield of the managed stands. A share of the silviculture budget should be allocated for tracking the performance of these stands in the future.

Pine leading stands form approximately 25% of the existing timber harvesting land base within the TFL. This percentage will increase as some existing balsam and spruce stands will be converted to pine stands as well. Currently, there is no genetically improved pine seed available. As stands established with genetically improved planting stock can produce significantly higher yields, a seed orchard section should be established for the production of genetically improved pine seed.

9.6.2 General

The development of a preferred scenario incorporates information and results from the previous scenarios in a sequential process to present a solution that satisfies multiple emphases. This option represents an attempt to balance the benefits identified in the previous scenarios.

No new analyses were performed. Rather, the preferred scenario combines one of the tested scenarios with additional components that reflect Dunkley Lumber's commitment to forest stewardship.

As presented in the volume impact strategy scenarios (Section 9.5), the assessment of different budget levels indicated that all investment levels produced higher mid and long-term harvest volumes compared to the SS base case harvest level. There are potential volume increases starting in the 3rd decade varying between approximately 8 and 16% for the fertilization scenarios. The $1 million fertilization scenario allowed for an increased long-term harvest at 175 years while it took 195 years for the $0.25 million combination scenario. This late increase of the harvest level is a result of existing pinch points for timber availability due to constraints and a build up of merchantable volume over the mid-term. Any attempts at increasing to the long-term harvest level earlier in the planning horizon resulted in mid-term harvest level failure. The influence of the pinch points on the harvest level would likely be alleviated if the height growth effect from fertilization were considered in the analysis as height based forest cover constraints would in reality be alleviated from these treatments.

The slight decline of the operable growing stock at the end of the planning horizon does not cause significant concern as minor increases and decreases are common throughout the planning horizon. Also, the ending operable growing stock continues to remain near or above 4 million m^3 for all scenarios and when investigated out to 250 years can be maintained at this level.

9.6.3 Cost Benefit Comparison

In order to assess the harvest level increases compared to the investment in fertilization treatments, a simple cost benefit assessment was completed. This assessment provides a comparison that will assist in the determination of the preferred scenario. Table 12 illustrates an average cost benefit for the fertilization scenarios based on the increases in the harvest level as compared to the SS base case scenario. This assessment does not incorporate any discounting. A more detailed cost benefit assessment is provided in Appendix 3.

Table 12: Cost benefit assessment, all volume impact scenarios.

	SS Base Total Volume	$0.25 million Total Cost	$0.25 million Total Volume	$0.25 million $/m3 increase	$0.5 million Cost	$0.5 million Total Volume	$0.5 million $/m3 increase	$1 million Total Cost	$1 million Total Volume	$1 million $/m3 increase
200 Yr Total	11,437,284.2	$10,706,725.0	11,887,594.6	$23.8	$20,964,938.6	12,096,699.2	$31.8	$41,096,334.5	12,466,580.5	$39.9
200 Yr Avg.	285,932.1	$267,668.1	297,189.9	$22.9	$524,123.5	302,417.5	$36.5	$1,027,408.4	311,664.5	$40.7

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Table 12 illustrates the total and average volume harvested, cost of fertilization treatments and cost per m3 increase for each fertilization scenario over 200 years. Based on the analysis results, the $0.25 million fertilization scenario has the lowest cost per m^3 increase, which over the entire planning horizon averages $22.9/$m^3$ increase. Similarly, the cost per m^3 increase based on the total harvest and total cost of fertilization for the $0.25 million scenario is $23.8/$m^3$. The $0.5 and $1 million fertilization scenarios range between $31.8 and $36.5/$m^3$ and $39.9 and $40.7/$m^3$, respectively.

The road rehabilitation treatment was left out of this cost benefit assessment, as the overall cost and volume response were relatively insignificant.

9.6.4 Proposed Silviculture Strategy

The following section describes the proposed silviculture strategy for TFL 53. While this analysis does not deal specifically with basic silviculture it is important to emphasize that a solid overall silviculture strategy is a prerequisite for any incremental strategy to be successful.

9.6.4.1. Basic Silviculture

The basic silviculture activities for Dunkley Lumber include (TFL 53, Management Plan #3):

- Minimize the current NSR by quick planting after harvesting. Over the past couple of years Dunkley Lumber has been able to reduce their regeneration delay down to 11 months.
- Use mechanical site preparation, where needed, to create plantable spots and improve rooting conditions for the planted seedlings. Excavator piling is used to create plantable spots and mounding is used to warm soils and improve drainage.
- Use seed orchard stock for all spruce seeding requirements.
- Plant a higher component of pine where ecologically appropriate.
- Plant high densities (1,800 – 2,000 sph) to:
    - Provide high site occupancy and high potential for growing wood fibre;
    - Reduce risk of plantation failure;
    - Create opportunities for commercial thinning.
- Use effective and timely vegetation management to promote better survival and growth of seedlings. This includes impeded older plantations. Yield predictions in the stand level models TIPSY and TASS are based on unimpeded growth of seedlings. Effective vegetation management reduces the uncertainty inherent in predicting future yields.

9.6.4.2. Incremental Silviculture

The proposed incremental silviculture strategy for Dunkley Lumber consists of:

- Fertilization and a minor program of road rehabilitation.

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- Backlog NSR rehabilitation.
- Establishing a growth and yield monitoring system for managed stands.
- Establishing a seed orchard to produce genetically improved pine seed.

9.6.4.3. Fertilization and Road Rehabilitation

Fertilization and road rehabilitation treatments comprise the treatment regimes for the incremental silviculture strategy for TFL 53. Approximately $0.25 million should be allocated to this regime annually. Fertilization dominates the treatments during the first twenty years as illustrated in Table 13.

Table 13: Annual Treatments

Year	Fertilize (ha)	Rehabilitate Road (ha)	Total Treatments (ha)
1-5	377	1	378
6-10	597	1	598
11-15	675	1	676
16-20	749	1	750

During the first 20 years, almost 11 990 ha are treated by fertilization and only 20 ha for road rehabilitation. This averages approximately 600 ha of fertilization annually for the first 20 years and 1 ha of road rehabilitation annually for the same period. About 377 ha of fertilization is proposed annually for the first 5 years and by the second period (year 6-10) the annual treatments equal the 20 year average. The fertilization treatment area increases over the first 20 years and stabilizes in the 4th period (16-20) and continues at 785 ha for the remainder of the planning horizon.

Over the first 20 years of the planning horizon, most fertilization is proposed on good Sw sites, which receives approximately 45% of the annual treatments (Table 14). SwPl medium receives approximately 23% of the annual treatments and PlSw good 13%. The remaining 20% is distributed throughout the other stand types.

Table 14 illustrates how site types divide the proposed fertilization in the short term, over the next 20 years.

Table 14: Fertilization by Site Types

Year	Sw good (%)	Sw medium (%)	Sw poor (%)	SwPl good (%)	SwPl medium (%)	SwPl poor (%)	Pl good (%)	Pl med/poor (%)	Total (%)
1-5	47	2	1	4	30	1	5	0	100
6-10	39	7	1	3	24	1	5	1	100
11-15	42	9	1	2	22	1	5	1	100
16-20	53	8	2	3	18	1	3	1	100

9.6.4.4. Backlog NSR Rehabilitation

TFL 53 has approximately 800 ha of backlog NSR. It is likely that not all of this NSR can be rehabilitated because of high wildlife habitat values. For this analysis, it is assumed that 600 ha of backlog NSR is treated within the next 10 years (60 ha/year). The annual cost of treating NSR is estimated at $2,550/ha with the annual cost of approximately $153,000.

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9.6.4.5. Growth and Yield Monitoring Program for Managed Stands

BC Ministry of Forests Growth and Yield Monitoring Task Force defines growth and yield monitoring as: *The process of comparing the actual growth and yield of a forest or a stand to the predicted or expected growth and yield for that forest or stand.* Dunkley Lumber plans to commence a growth and yield monitoring program. This program will involve establishing random or systematic growth and yield monitoring plots throughout the population of managed stands.

The extent and the costs of the required program have not yet been determined but should be considered as funding becomes available.

9.6.4.6. Establish a Seed Orchard to Produce Genetically Improved Pine Seed.

Dunkley Lumber has committed to set up a seed orchard for producing genetically improved pine seed for their TFL. The orchard will be established and managed by Vernon Seed Orchard Company. The total cost of the orchard is estimated at $275,000 - $300,000 over a 10 year period. Approximately 50% of the total cost will be incurred during the first 3 years for orchard site preparation and establishment. The remaining 50% of the cost will be expended during the remaining 7 years.

It will take at least 10 years until the first genetically improved pine seed is available from the seed orchard.

9.7 Anticipated Silviculture Strategy Outcomes

9.7.1 Harvest Flow

Figure 18 compares the short, mid and long-term harvest level for the SS base case, and the $0.25 million fertilization scenario. As described in Section 9.3, the $0.25 million fertilization scenario is predicted to produce approximately a 7.6% higher harvest level starting in decade 3 at 284,673 m^3/year and a further increase to 307,657 m^3/year which is a 3.4% increase and finally in the 19th decade an increase of 10.8% or 329,500 m^3/year.

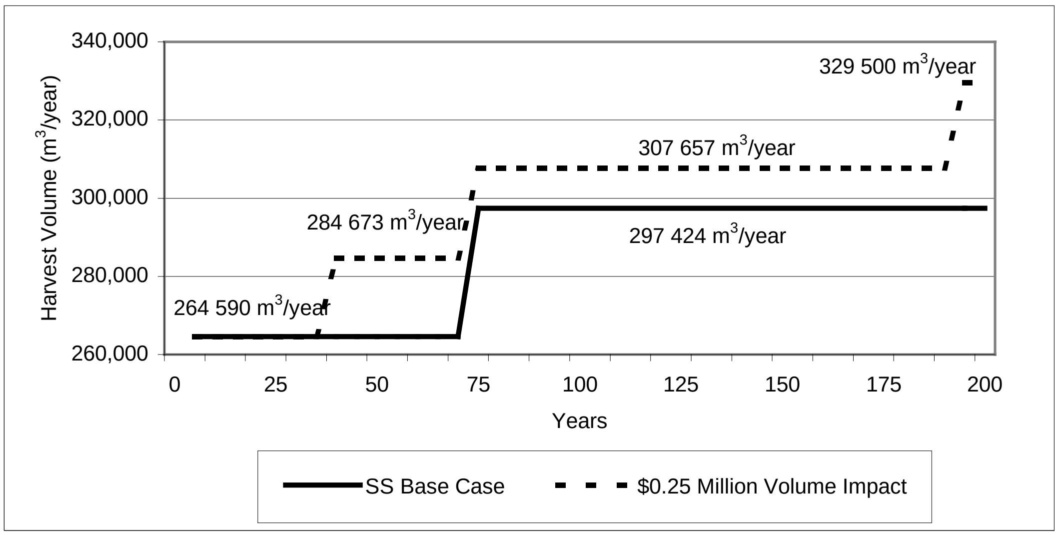

Figure 18: Fertilization regime for the proposed silviculture strategy, $0.25 million vs. SS base case

Rehabilitating 600 ha of backlog NSR would add less than 1% to the land base likely increasing the long-term harvest level by similar magnitude.

The impact of the genetically improved pine seed will be gradual. Alvin Yanchuk from the Ministry of Forests' Research Branch estimates that the pine volume gain at age 60 is approximately 8%. If all the planted pine in the TFL is eventually from orchard seed and if we assume that 30% of the total future managed volume comes from pine stands the long-term impact on harvest level could be around 2.5%.

9.7.2 Diameter

The predicted quadratic mean diameter of the $0.25 million fertilization scenario was compared to the SS base case for various stand types in TFL 53. There were no noticeable mean diameter differences between the two scenarios. This should be expected since only fertilization treatments are were modeled and no diameter based harvest rules were applied.

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9.7.3 Incremental Silviculture Program Costs and Benefits

Table 15 contains the area treated by each activity and year while Table 16 contains the expenditure by activity and year, based on the unit costs. Table 17 contains the silviculture employment benefits associated with the program. The cost and employment assumptions used in creating the tables were as follows:

- Only incremental silviculture was considered.
- Establishment of the seed orchard was not considered.
- Establishment of growth and yield monitoring program was not considered.
- Site preparation costs for road rehabilitation = $2,045 per hectare, 0.2 man-days.
- Site preparation costs for backlog NSR rehabilitation = $1,200 per hectare, 0.1 man-days.
- Planting costs = $880 per hectare, 1.5 man-days.
- Fertilization costs = $350 per hectare, 0.1 man-days.

Table 15: Area (ha) treated by activity and year

	Road Rehabilitation		Backlog NSR Rehabilitation			
Year	**Site Preparation**	**Planting**	**Site Preparation**	**Planting**	**Fertilization**	**Total**
1	1	1	60	60	377	499
2	1	1	60	60	377	499
3	1	1	60	60	377	499
4	1	1	60	60	377	499
5	1	1	60	60	377	499
Subtotal	**5**	**5**	**300**	**300**	**1885**	**2495**
Yr. 6-10	5	5	300	300	2985	3595
Total	**10**	**10**	**600**	**600**	**4870**	**6090**

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Table 16: Expenditure by activity and year

Year	Road Rehabilitation		Backlog NSR Rehabilitation		Fertilization	Total
	Site Preparation	Planting	Site Preparation	Planting		
1	$2,045	$880	$72,000	$52,800	$131,950	$259,675
2	$2,045	$880	$72,000	$52,800	$131,950	$259,675
3	$2,045	$880	$72,000	$52,800	$131,950	$259,675
4	$2,045	$880	$72,000	$52,800	$131,950	$259,675
5	$2,045	$880	$72,000	$52,800	$131,950	$259,675
Subtotal	**$10,225**	**$4,400**	**$360,000**	**$264,000**	**$659,750**	**$1,298,375**
Yr. 6-10	$10,225	$4,400	$360,000	$264,000	$1,044,750	$1,683,375
Total	**$20,450**	**$8,800**	**$720,000**	**$528,000**	**$1,704,500**	**$2,981,750**

Table 17: Short-term employment benefits (person-days) by activity and year

Year	Road Rehabilitation		Backlog NSR Rehabilitation		Fertilization	Total
	Site Preparation	Planting	Site Preparation	Planting		
1	0.2	1.5	12	90	37.7	141.4
2	0.2	1.5	12	90	37.7	141.4
3	0.2	1.5	12	90	37.7	141.4
4	0.2	1.5	12	90	37.7	141.4
5	0.2	1.5	12	90	37.7	141.4
Subtotal	**1**	**7.5**	**60**	**450**	**188.5**	**707**
Yr. 6-10	1	7.5	60	450	298.5	817
Total	**2**	**15**	**120**	**900**	**487**	**1,524**

In the immediate short-term, incremental silviculture creates direct jobs associated with the labour required for operational silviculture treatments. The mid and long-term employment opportunities would result from the projected changes in the harvest level. Table 18 illustrates the long-term jobs created by the proposed silviculture strategy based on the increase in harvest over the SS base case. Employment multipliers were extracted from the TSR Socio-Economic Analysis report for the Quesnel TSA by the Economics and Trade Branch of the Ministry of Forests. A similar relationship between employment in the Quesnel TSA and employment in TFL 53 and provincial employment was assumed.

Table 18: Long-term Total Employment for the Incremental Silviculture Strategy ($0.25 million)

Period (5 years)	Harvest Increment ('000)	Incremental Local Jobs	Incremental Provincial Jobs
1-7	n/a	n/a	n/a
8-14	700	518	672
15-38	1,224	905.8	1,175
39-40	320	236.8	307.2
Total	2,244	1,660.6	2,154.2

[a]**Multipliers as per Quesnel TSA TSR, TSA 0.74, Province 0.96 per 1,000 m^3 of AAC**

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As can be seen from Table 18, there is an apparent net gain of jobs from the proposed silviculture strategy compared to the SS base case. Over the first 35 years there are no job benefits since there is no increase in the harvest level between the SS base case and the $0.25 million fertilization scenario. Over the remaining 165 years of the planning horizon, there is the potential for significant employment creation as a result of the harvest level increases from the silviculture strategy. Between year 36 and 70, the total harvest level increase over that period of time is 700,000 m^3, which results in an additional 518 local jobs and 672 provincial jobs from harvest for TFL 53. Total local and provincial employment amounts to 1,660 and 2,154 person years of employment respectively over the entire planning horizon. Incorporating genetic gain for pine would likely increase the long-term employment by 2.5%. The potential to produce higher quality timber may result in value-added job opportunities that have not been assessed in this analysis.

There is no direct relationship between the proposed silviculture strategy and SS base case harvest levels with the official timber supply analysis of the TFL and the subsequent employment. The purpose of the employment comparison is to show relative employment changes as a result of silviculture investment. The only direct relationship between harvest levels and employment in the TFL is based on the actual AAC determination and actual harvest levels.

9.8 Comparison to MP3 Timber Supply Analysis

The differences between MP3 base case, supplemental A2 and the Type 2 benchmark and SS base case scenarios are documented throughout this report. As such there is no direct comparison between the Type 2 results and the timber supply analysis. For information purposes only, if the relative increases experienced in this Type 2 analysis for the $0.25 million scenario were applied to the MP3 Supplemental A2 scenario, the resulting harvest level would appear as illustrated in Figure 19.

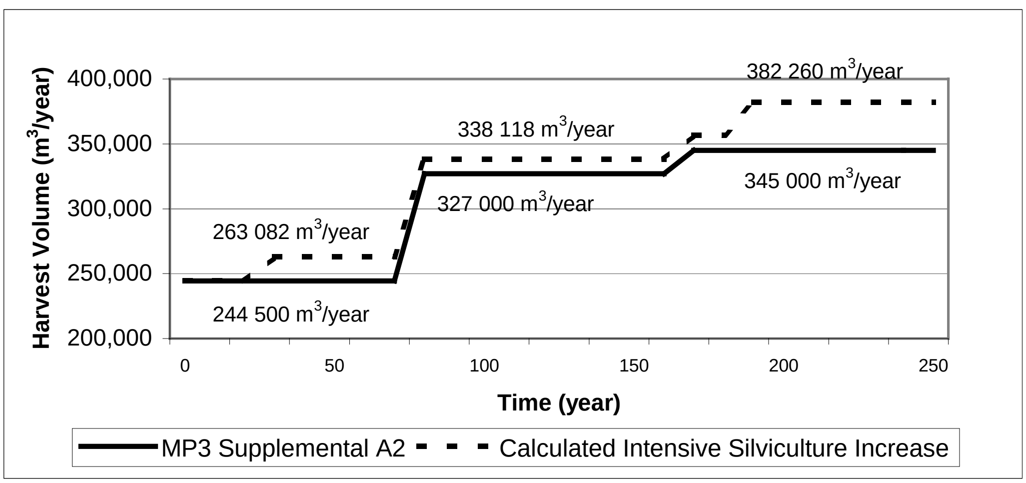

Figure 19: MP3 Supplemental and relative harvest level increase from Type 2 analysis.

Assuming that similar harvest level increases would occur, the harvest level could be increased in the 3rd decade to 263 802 m^3/year, a mid-term increase to 338 118 m^3/year in the 8th decade and the long-term harvest level to 382 260 m^3/year in the 19th decade. This assumption should be tested in MP 4 to assess the effect of intensive silviculture with the updated timber supply analysis base case.

10 Summary

The objective of this analysis was to assess the impact of silviculture investment and corresponding various treatment regimes on harvest volume at the forest level for TFL 53. This is a difficult task for several reasons:

- The range of possible budget levels and silviculture regimes can be large;
- Little work of this nature has been done in the past. As a result, it is difficult to define the exact scope and objectives of the analyses.
- There is often the expectation that analysis results are linear, i.e., increase in silviculture budget results in a similar increase in some parameter; of value, volume, dbh etc. This may not be the case.
- Heuristic type models work well when trying to balance different competing objectives, such as volume, value and non-forest values. However, the results of these models may be difficult to interpret; sensitivity analyses are not usually possible to test the impact of any particular variable. The analysis results may be acceptable, even desirable, yet the causal relationships may remain unknown.

This analysis used simulation and heuristic modeling techniques. The ***FSOS*** model through the heuristic technique was used to investigate forest level solutions considering a multitude of values including annual harvest and non-forest resources (old seral targets, visually sensitive areas, watersheds) while expending the desired budget in incremental silviculture. Different weights were applied to these analysis variables to derive the solution.

The Type 2 analysis used different data and analysis assumptions from the MP3 timber supply analysis. In order to quantify these differences, a benchmark scenario was completed using as similar assumptions as possible. The discrepancy in harvest levels was caused by a combination of analysis differences. A different timber harvesting land base contributed to lower mid and long-term harvest levels in the Type 2 analysis due mainly to different reductions for terrain stability. Changes in VQO areas and years to visual effective green up likely increased the short-term harvest level as these rules were less constraining. Old seral targets were modeled differently with some short-term targets being more relaxed in the Type 2 and mid-term requirements being more restrictive. Finally, the analysis unit areas and average site indices were different with some of the immature and future managed stands in MP3 being significantly higher and having more area. This would result in significantly more volume available for harvest in the MP3 analysis than in the Type 2.

The SS base case for the Type 2 provides a starting point for comparison with subsequent silviculture scenarios. TASS curves were used in the SS base case and subsequent scenarios to model intensive silviculture treatment regimes and TIPSY was used for both MP3 and the Type 2 benchmark. Slight differences in the harvest level for the SS base case and Type 2 benchmark were caused by the use of TASS curves, a different model algorithm, and the application of a different emphasis for biodiversity. For most of the planning horizon the harvest levels are the same except the Type 2 benchmark exhibits an increase in 150 years to a higher long-term harvest level.

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The road rehabilitation scenarios exhibited very little effect on the overall harvest level, as the effective area treated is only 0.83% of the THLB or 178 ha. Also, the commercial thinning scenario exhibited insignificant harvest level effects as only 480 ha were treated over the entire planning horizon. Therefore, only fertilization scenarios were investigated under the different budget levels of $0.25, $0.5 and $1 million. The road rehabilitation and commercial thinning treatments can be implemented to maintain maximum productivity for TFL 53, but won't contribute to significant increases in the future harvest level.

Each of the fertilization scenarios exhibited significant increases in the harvest levels. Overall, the $1million scenario resulted in the highest achievable harvest level over the entire planning horizon and the $0.25 million the lowest. In a relative comparison of the respective harvest levels, the $0.5 million scenario was not significantly different than the $0.25 million scenario. The average annual harvest level over the entire planning horizon for the $0.25, $0.5 and $1 million scenarios was 297,190, 301,985 and 311,665 m^3/year respectively.

Average area treated for each of the fertilization scenarios increases for each of the budget level increments, with the $1 million scenario treating the most area and the $0.25 million scenario the least. Over the first 100 years an average of 747, 1432 and 2758 ha is treated for the $0.25, $0.5 and $1 million scenarios. It takes 30 years for each scenario to reach a relatively stable treatment level, which is then maintained throughout the rest of the planning horizon. For each of the scenarios, the fertilization treatments illustrate a noticeable increase in the average harvest volume (m^3/ha).

The preferred silviculture strategy is designed from the results of the scenario analysis and results interpretations and discussions with Dunkley Lumber Ltd. In order to consider cost of treatment and effective harvest level benefits a simple cost comparison illustrated that the cost per m^3 increase varied from $22.90-$23.80 for the $0.25 million scenario to $31.80-$36.50 for the $0.5 million scenario and $39.90-$40.70 for the $1 million scenario. As such, the $0.25 million scenario was selected as the most desirable investment level based on the lowest cost per m^3 volume increase of the fertilization scenarios.

The fertilization scenario that was used to develop the incremental silviculture strategy utilizes unproven treatment regimes and while the regimes do represent Dunkley's current approach to fertilization, the biological uncertainty of their responses should be cautioned. Therefore, the achievement of the harvest level responses provided in this report is equally uncertain. Only through localized monitoring of actual yield response and timber supply analysis can the forecasts be evaluated. As knowledge of yield responses from the fertilization becomes available it should be incorporated into new analysis. As such, this report represents an origin for silviculture investment for TFL 53 to be built upon in the future.

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11 Conclusions

The intent of this report is to provide strategic direction for an incremental silviculture program for TFL 53, while considering current forest management objectives and the potential to increase harvest volume and value. Workshop participants identified local objectives during the first workshop. A scenario planning analysis approach was developed to provide a sequential process for analyzing the potential influences of different incremental silviculture strategies.

The main objective for the TFL 53 Silviculture Strategy is to increase the harvest level within the TFL to 360,000 m^3/year (60% of mill capacity). The forest level analysis in this report showed that different combinations of incremental silviculture were able to increase the long-term harvest level from the silviculture strategy base case by 18% up to 351,077 m^3/year in the long-term under the $1 million scenario. However, the $0.25 million scenario, which was selected as the preferred fertilization level, achieved 329,500 m^3/year at the end of the planning horizon. It is important to note that the tested scenarios did not incorporate genetic gain for pine. As Dunkley Lumber hopes to establish a seed orchard for pine, it is likely that the long-term harvest level will benefit from this and get closer to the target of 360,000 m^3/year.

Interestingly, when the relative increases experienced in the $0.25 million scenario were applied to the MP3 Supplemental A2 scenario from the timber supply analysis, the long-term harvest level exceeds the targeted 360,000 m^3/year. There is no assurance that these increases are achievable and they should be confirmed through the next timber supply analysis especially since the TIPSY no treatment curves which were used in MP3 and the TASS fertilization curves exhibit similar volume trends.

The long-term harvest projections are sensitive to changes in future managed stand volumes. The results presented are valid only if the actual yields of future managed stands follow the predicted TASS yields. If they don’t, future harvest levels may be higher or lower depending whether yields have been under or over-estimated. Dunkley Lumber’s plan to commence a growth and yield monitoring program will address this uncertainty.

11.1 Recommendations

It is important to emphasize that the proposed incremental silviculture strategy is only one of potentially many desirable approaches that Dunkley Lumber can follow. Different assumptions in the modeling would likely produce slightly differing results and different emphases in general management direction would favour a different set of regimes. Also, this analysis cannot factor in less concrete but important goals, such as, maintaining options for the future. For this reason, rather than taking one solution as the direction for incremental silviculture, we recommend consideration of the trends, such as:

- Aggressive, well-managed basic silviculture program is the basis for an incremental silviculture strategy.
- An annual budget level of $260,000 is appropriate to rehabilitate most of the backlog NSR in the first five years ($125,000/year for 5 years) and increase the short, mid and long-term harvest level by 7.6%, 3.4% and 10.8% if the balance of the budget ($135,000) is expended on fertilization and a minor component of road rehabilitation. This fertilization intensity should also reduce the uncertainty of future harvest levels for TFL 53 and provide some further assurance that the forecasted harvest levels in the MP3 timber supply analysis are achieved.
- In the next 5 year period funding for fertilization is forecasted to increase from $130,000 to $208,900/year. The budget for backlog NSR is expected to remain at $125,000/year.

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- In the first decade, 57% of the annual funding should go to fertilization, 42% to NSR rehabilitation and the rest (1%) to road rehabilitation.

- For the next 10 years, the recommended annual treatment areas are 1 ha of road rehabilitation, 60 ha of NSR rehabilitation and 377 ha (1^{st} period) – 597 ha (2^{nd} period) of fertilization.

- Growth and yield monitoring program should be established. FIA funding should be sought for this program.

- A seed orchard for producing genetically improved pine stock will be established. The total cost of the orchard is estimated at $275,000 - $300,000 over a 10 year period. Approximately 50% of the total cost will be incurred during the first 3 years. The remaining 50% of the cost will be expended during the remaining 7 years. FIA funding should be sought for this program. If all of these activities were undertaken (NSR backlog, road rehabilitation, fertilization, growth and yield monitoring and seed orchard establishment) annual budgets could reach $750 000 over a ten year period.

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12 Recommendations for future analyses and research

The results presented in this report are largely dependent on the analysis assumptions and inputs. More research and analyses are required to improve the reliability of the forest estate modelling. The following are some areas that require further investigation:

- Site indices significantly impact the results of any forest estate model. There is uncertainty throughout the province regarding the accuracy of site indices used in timber supply and other forest level analyses. Although Dunkley already has ecosystem based productivity estimates for TFL 53, work should continue to locally correct site indices.

- There is uncertainty whether the stand level model, TASS adequately represents different stand types and treatment regimes. Investment decisions may depend greatly on the responses that TASS exhibits for different treatment regimes. It is important for this stand level modelling work to continue. As new models are developed or existing models updated, they should be incorporated into these types of analyses.

- It is important to determine whether the operational adjustment factors for managed stands used in these analyses are reasonable.

- Creating old growth conditions through silviculture in areas that do not contribute to timber harvesting may allow harvesting of old growth timber somewhere else. Investing in these kinds of silviculture activities can be attractive as the benefits can be received immediately, rather than several years from now. However, in many areas of the province there are no agreed upon definitions for old growth other than age. Research is needed in this area of silviculture to identify were specific definitions of old growth. This information must then be incorporated into stand dynamics information so that it can be modeled over time.

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Appendix 1 – Type 2 Information Package

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