

Type 2 Strategic Silviculture Analysis Report

Ministry of Forests
Vancouver Forest Region
Sunshine Coast Forest District

Type 2 Strategic Silviculture Analysis Report March 2001 (Revised March 2002)

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Type 2 Sunshine Coast TSA Silviculture Strategy Deviation Statement

District Comments

The attached Type 2 analysis for the Sunshine Coast TSA outlines a proposed incremental strategy that may not represent the most efficient and effective treatment programs for future incremental funding. This concern has been raised by both the Ministry of Forests as well as by some of the members of the forest industry. Unfortunately limited time and the lack of funding resources prevented further analysis to determine if these concerns are valid.

The primary issue surrounding the results of this report is that some of the operational constraints that face the Sunshine Coast TSA were not included in the model analysis due to the scope and budget of the project, and that it emphasized investing on medium and poor fir sites for some regimes. The district faces operational logistical constraints tied to water access throughout most of the operating areas that have not likely been adequately factored into the analysis. To some degree access difficulties have been taken into account in the treatment costs ranges associated with each analysis unit, however the analysis does not factor in the operational feasibility of running remote projects at minimum treatable sizes.

Generally, its felt that incremental investment in the TSA should focus on investing funds on treatments that improve the overall quality of the future timber supply while attempting to maintain harvest levels. Historically incremental treatments have focused on spacing and pruning medium and good Douglas-fir sites and where feasible fertilizing these areas upon stand recovery. Continuing with this philosophy at an annual budget of up to \$1.5 million will likely be a supported incremental silviculture strategy for the future.

Executive Summary

Introduction

This document presents an incremental silviculture strategy for the Sunshine Coast Timber Supply Area (TSA). 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 Sunshine Coast TSA. The only connection between the two is that any improvements resulting from the silviculture strategy may impact future AAC determinations.

Issues

Harvest Forecast

The current Timber Supply Review (TSR 2) analysis investigates two even-flow base case harvest forecasts. The first maintains the current AAC of 1,140,000 m³/year and the other increases the harvest level above the current AAC by 8% to 1,233,000 m³/year.

Land Base

The total area managed by the BC Forest Service has decreased by 19,312 hectares since TSR 1 in 1995. This decrease is primarily the result of the creation of new parks. The area within the timber harvesting landbase (THLB) remains the same as the addition of red alder areas to the THLB offsets the subtraction of areas for parks.

Age Class Structure

Approximately 11% of the THLB is currently in stands over 250 years old. The age class distribution in the THLB is well distributed between 0 and 100 years of age. In the longer-term, the non-contributing land base will be able to provide much of the area required to meet old-forest requirements.

Transition from Existing to Managed Stands

Harvest volumes for the first 80 years come exclusively from existing unmanaged stands. By decade 11, the harvest volume originates predominantly from managed stands.

Growing Sites

Old Growth Site Index (OGSI) adjustments were included in this analysis and were shown to improve harvest volumes by 7% over the higher of the two base case scenarios in the TSR 2 analysis.

Forest Cover Requirements

Forest cover constraints were modeled as per TSR 2.

Quality

Quality was not modeled in TSR 2. Objectives identified in Workshop #1 include quality objectives. The target for quality within the TSA was set to 10% premium logs by volume and a high proportion of the remainder of sawlog quality.

Old Forests

Approximately 11% of the THLB and over 42% of forested areas outside the THLB are occupied by stands over or near 250 years of age. Sensitivity analyses on the application of old growth requirements revealed no impact on harvest level.

Minimum Harvest Ages

Minimum harvest ages were calculated as in TSR 2. The timber supply is insensitive to a 10-year increase or decrease in minimum harvest age.

Estimates of Existing and Regenerated Stand Volumes

Existing stand volumes in the base case were adjusted based on the results of the Vegetation Resources Inventory project for the Sunshine Coast. Not applying the inventory adjustment would result in a 6% decrease in harvest level from the higher of the TSR 2 base cases to 1,157,789 m³/year.

A 10% decrease in regenerated stand volumes forces a 12% decrease in long-term harvest level beginning at decade 10. An increase in regenerated stand volumes of 10% results in an immediate increase in long-term harvest level of 8%.

Forest Health Issues

No epidemic forest health issues were identified for this analysis.

Issues Relating to Habitat and Non-timber Forest Resources

Approximately 2,800 hectares have been removed from the THLB to provide safe wintering areas for mountain goats.

Guidelines for Deviating from the Silviculture Strategy

Occasionally, it may be necessary to deviate from this silviculture strategy. The guidelines for deviating from the silviculture strategy are outlined in Chapter 14.

Management Objectives

The following management objectives were identified during Workshop #1:

- Increase timber diversity and quality.
- Increase timber volume.
- Make old growth attributes available sooner through silviculture.
- Make dense hemlock/fir/cedar stands productive for timber and habitat through silviculture.

Working Targets

Quantity: Increase the long-term timber supply by 8% without sacrificing long-term sustainability.

Quality: Manage regenerated stands to yield at least 10% premium logs by volume, with the majority of the remainder being of sawlog quality.

Premium Log:

Douglas-fir – clear, pruned minimum 5.2 metre log, 45+ cm dbh

Hemlock, Douglas-fir – 55+ cm dbh unpruned log

Cedar – 30+ cm dbh log over 15 metres, few knots

Sawlog:

Minimum average stand dbh of 30 cm, minimum stand volume of 350 m³/ha

Strategies

Response Time Frame	Strategy Description	Anticipated result
Short-Term	<ol style="list-style-type: none"> Expand the timber harvesting land base by: <ul style="list-style-type: none"> Deciduous stand conversion. Increase the volume of some existing stands through: <ul style="list-style-type: none"> Late rotation fertilization. 	<ol style="list-style-type: none"> As per TSR 2, short-, mid- and long-term timber supply is sensitive to changes in the size of THLB base. Stand conversion and eliminating backlog NSR amount to an increase in THLB area. Short-, mid- and long-term timber supply is somewhat sensitive to an increase in existing stand volumes. A 10% increase in stand volumes is anticipated to result in 2% increase in timber supply.
Mid-Term	<ol style="list-style-type: none"> Increase regenerated stand volumes as per the Long Term. Space and fertilize to set up stands for future CT. Increase the value of second growth stands by: <ul style="list-style-type: none"> Pruning, spacing and fertilization. 	<ol style="list-style-type: none"> Increased regenerated stand volumes have some impact on mid-term timber supply; however, the greatest impact is in the long term. Maintain options for CT. Bring some long-term volumes to the mid term. Mid-term value increase expected to be modest, as benefits will occur in the long term.
Long-Term	<ol style="list-style-type: none"> Increase regenerated stand volumes by: <ul style="list-style-type: none"> Using genetically improved seed; Fertilizing suitable regenerated stands; Increase the value of second growth stands by: <ul style="list-style-type: none"> Pruning, spacing and fertilization. 	<ol style="list-style-type: none"> This analysis assumes 10.01% gain for Fd, 8.25% gain for Cw and 8.22% gain for Hw using 2nd generation improved seed. <p>Assume a 9% long-term timber supply impact.</p> <p>Value increases expected in the long-term.</p>

Scenarios

The designed analysis scenarios form the basis of the analysis methodology. The first run performed is a base case scenario designed as a benchmark to the TSR 2 analysis. 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 runs and ultimately the proposed scenario are evaluated.

The incremental silviculture scenarios can be organized in two groups: one group, which investigates the opportunity for increases in volume flow through incremental silviculture, and the other, which investigates those opportunities to increase timber value. The results of the value- and volume-oriented scenarios were analyzed to create the proposed scenario, a run, which produces higher timber values while maintaining harvest levels. This was achieved by including both value and volume weightings in the optimization function of the forest estate model *FSOS*. This provides the model with incentives to maintain high harvest volumes and to schedule treatments, which improve piece size and overall value of the future timber supply.

Incremental Silviculture Strategy

- If funding is available, an annual budget of up to \$1.5 million - net of CT costs - is able to maintain a reasonable harvest level while providing larger piece sizes and value (proposed strategy).
- In the first decade, 8% of available funding (9% of area treated) should go to the combination treatment of spacing and fertilization; 20% (27% of area treated) should go to spacing and 6% (43% of area treated) to fertilization of already spaced stands. The remaining 66% should be invested in pruning treatments (spacing/pruning, spacing/fertilization/pruning).
- In the first decade, the recommended annual treatment areas are 26 ha of commercial thinning, 475 ha of fertilizing, 295 ha of spacing, 98 ha spacing/fertilizing, 38 ha of hectares spacing/pruning and 180 hectares of spacing/pruning/fertilizing.
- Local objectives were set to produce more clearwood over the planning horizon than resulted from this analysis. There should be flexibility to allocate more funds to pruning than this analysis indicates if it is deemed necessary to produce more clearwood to maintain future product options. Pruning should concentrate on lower cost productive fir sites.

Adopting an incremental silviculture strategy with an average annual budget level of \$1.5 million as per the proposed strategy could produce the following results:

- A significant increase in quadratic mean diameter over most of the planning horizon.

- An average increase of over \$10 per cubic meter in managed stand value over most of the planning horizon.
- An average of over 180,000 cubic meters, or an average of 1.4% of total harvest volume, of clear wood per decade beginning 50 years from now.
- 28 annual silviculture jobs over the next 10 years.

Incremental Silviculture Program

The following table illustrates the annual treatment areas for different treatments regimes, which comprise the incremental silviculture strategy for the next 100 years.

Decade	ct	ct fert	fert	space	space fert	space prune	space prune fert	Total
1	26	0	475	295	98	38	180	1112
2	57	0	752	348	533	27	87	1805
3	62	0	1339	366	463	28	68	2325
4	57	8	1773	325	505	27	72	2768
5	53	49	1941	394	518	32	52	3039
6	61	80	2198	407	504	24	49	3322
7	48	100	2121	459	446	32	53	3259
8	113	83	2110	428	475	32	51	3292
9	95	137	2004	432	479	23	65	3233
10	123	87	2030	427	474	42	52	3235

Incremental Silviculture Program, First Decade

The following table presents the annual treatment areas for the next 10 years with the treatments separated by analysis unit.

Analysis Unit	ct	fert	space	space fert	space prune	space prune fert	Total
Cedar good/medium			71				71
Fir good	3				8	6	18
Fir medium	11	155	3	13	30	173	386
Fir poor		320	47	85			452
HemBalSpruce good	11		61				73
HemBalSpruce medium			113				113
Grand Total	26	475	295	98	38	180	1112

- **Commercial Thinning:** Only 26 hectares per year are proposed for the whole decade.
- **Fertilization:** This treatment usually follows spacing or spacing/pruning treatments with 475 hectares per year being proposed over the first decade of the planning horizon. The proposed treatment area is divided between two Fir site types: Poor Fir sites receive 67% with the remaining 33% allocated to medium site Fir stands.
- **Spacing:** A total of 295 hectares of annual spacing treatments are proposed for the first decade. Medium HemBalSpruce sites receive approximately 38% of this treatment. Cedar good/medium has a 24% share.
- **Space/Fertilize:** A total of 98 hectares annually are proposed for the next ten years. The treatment area is allocated for poor site Fir (85%) and medium site Fir (15%).
- **Space/Prune:** Only good and medium site Fir stands are eligible for this treatment regime, which combines spacing and pruning. As both pruning lifts occur during one decade, this treatment includes spacing, pruning 1st lift and pruning 2nd lift. A total of 38 hectares annually are proposed during the first decade of the planning horizon (79% Fir medium, 21% Fir good).
- **Space/Prune/Fertilize:** Only good and medium site Fir stands are eligible for this treatment regime, which combines spacing, pruning and fertilization. As both pruning lifts occur during one decade, this treatment includes spacing, fertilization, pruning 1st lift and pruning 2nd lift. A total of 180 hectares annually are proposed during the first decade of the planning horizon (3% Fir good, 97% Fir medium).

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1 Introduction

Incremental silviculture has been practiced in the Sunshine Coast Timber Supply Area (TSA) for over 30 years. Historically, treatment decisions were based on stand-level factors such as species, age, access and related treatment rules.

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 for the Sunshine Coast TSA. 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 I project has been completed for the Sunshine Coast TSA. Type I projects are based exclusively on existing information, such as Timber Supply Reviews. The Type I project for the Sunshine Coast TSA has identified product objectives, working targets, and major silviculture strategies for the Sunshine Coast TSA.

This project, the Type II Analysis, is the next step in the process. This step uses timber supply analysis and computer modeling to provide additional insight into creating and implementing a Silviculture Strategy. The key concept is that the development of the Silviculture Strategy must be based on forest-level objectives.

The objectives of the Sunshine Coast TSA Silviculture Strategy are:

- To identify resource management and timber product objectives and priorities;
- To evaluate the interim silviculture strategies produced in the earlier project and develop additional strategies to meet the objectives through incremental silviculture treatments;
- To delineate and evaluate draft strategies in relation to timber quantity and quality, habitat supply and socio-economic issues using forest-level analysis;
- To identify stewardship investment opportunities for the Sunshine Coast TSA; and
- To present strategic and tactical-level analysis results in a manner that facilitates the development of an implementation program and budget.

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

In preparing the strategic silviculture analysis and strategy for the Sunshine Coast TSA, the methodology was defined by a number of broad steps.

2.1 Project Procedures

The general steps in developing the silviculture strategy 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. The number of potential strategies and treatment regimes is very large. Local experience is needed to narrow this down to 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 input 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 November 14th, 2000. The workshop was attended by representatives of the Ministry of Forests (Sunshine Coast Forest District and Vancouver Forest Region), Ministry of Environment, Lands, and Parks, Canfor, Interfor, Western Forest Products, Terminal Forest Products, and Forest Ecosystem Solutions Ltd. The

purpose of the workshop was to define issues, establish objectives, develop potential strategies and define current treatment regimes from a local perspective.

The workshop produced the following:

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

Stand-level analysis consisted of preparing growth and yield curves for various treatment regimes. 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 growth and yield models Tabular Interpolation Program for Stand Yields for Windows (WinTIPSY) and Variable Density Yield Predictor (VDYP) were also used to create yield curves needed for the analysis. VDYP was used for predicting growth of currently mature and older immature stands. WinTIPSY was used to predict growth of untreated managed stands and to provide understanding of stand-level dynamics in establishing modeling parameters.

The strategic forest-level (management unit) analysis was done using the **FSOS** model. The **FSOS** model analyzes forest systems in a spatial and temporal manner using both simulation and optimization techniques. Both approaches are used in this project, simulation for the base case and optimization to determine the proposed treatment schedules. The **FSOS** model combines the spatial data management capabilities of ARC/INFO GIS and MS Access with landscape optimization capability, simulation model flexibility, and professional experience.

In optimization mode, the model uses a results-oriented 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 for 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 near-optimal solution (where further iterations do not result in an improved solution).

The fully spatial approach of the **FSOS** model 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 output from the **FSOS** model.

A draft report was prepared for discussion at a second workshop. Reviewing the results of the preliminary results, workshop participants designed the proposed scenario and guided any further analysis.

Mr. Larry Sigurdson of the Ministry of Forests, Vancouver Forest Region, managed the overall project, and Forest Renewal B.C provided funding. The participation of

representatives from the following organizations at the workshops and in other aspects of this project is gratefully acknowledged:

- Ministry of Forests, Forest Practices Branch
- Ministry of Forests, Vancouver Forest Region
- Ministry of Forests, Sunshine Coast Forest District
- Ministry of Forests, Research Branch
- Ministry of Forests, Timber Supply Branch
- Ministry of Environment, Lands, and Parks
- Canfor
- Interfor
- Terminal Forest Products
- Western Forest Products

2.2 Data Acquisition and Manipulation

Significant amounts of data were acquired for this process. The primary sources of digital data were:

- TSR 2 resultant dataset, which includes the 1999 inventory update (FC1 and FIP) and other resource data layers that were utilized in TSR 2 in progress during this contract; and
- Integrated Silviculture Information System (ISIS) activity data.

2.3 Analysis Methodology

The specifics of the analysis methodology are presented in the Analysis Information Package. In short, the analyses included:

- A base case run that emulates the TSR 2 base case results (called the FESL base case);
- FESL base case with site index adjustments;
- Silviculture Strategy Base Case with site index adjustments and genetic improvements;
- Optimized Silviculture Strategy Base Case; same as previous run, except the optimization algorithms are applied instead of simulation;
- Timber Volume Optimization Runs: runs using different silviculture budgets to determine the impact on timber flow.
- Timber Value Optimization Runs: runs using different silviculture budgets to determine the impact on timber value.
- Proposed Option: an optimization run that combines volume and value objectives.

3 Sunshine Coast TSA Information

3.1 Description of the TSA

The Sunshine Coast TSA is situated in the Vancouver Forest Region. It is located north of Howe Sound up to the head of Bute Inlet covering approximately 1.1 million hectares.

The TSA is part of the Sunshine Coast Forest District. The forest district also includes Tree Farm License (TFL) 10 and part of TFL's 39 and 43.

The Sunshine Coast TSA is administered by the Sunshine Coast Forest District office in Powell River, and a field office in Sechelt.

Harvesting, silviculture, and the manufacture of wood, and pulp and paper products support forestry employment in the area. There is substantial movement of wood fibre across TSA boundaries.

The biogeoclimatic zones in the TSA are Coastal Douglas Fir (CDF), Coastal Western Hemlock (CWH) and Mountain Hemlock (MH). The forests of the Sunshine Coast TSA are home to a wide variety of wildlife, including large mammals, invertebrates, birds and extensive fish stocks.

Of the total TSA area (over 1.5 million hectares), only 427,594 hectares are productive Crown forest. Further reductions applied to the productive forest result in 223,806 hectares considered being available for timber harvesting (MoF, 2000).

Douglas-fir and Hemlock forests dominate the timber harvesting land base (THLB), covering about 44 and 29 percent of the area, respectively. True firs and cedar account for 13 percent of the area. The remaining 13 percent is comprised of red alder (4.9%) and other species.

3.2 History of the AAC

AAC	1986	1989	1993	TSR1
Conventional	1,429,580 m ³	1,429,580 m ³	1,100,000 M ³	1,045,000 M ³
Deciduous		16,000 m ³		95,000 m
Total	1,429,580 m ³	1,445,580 m ³	1,100,000 m ³	1,140,000 m

3.3 Current Basic Silviculture Systems

A variety of silviculture systems are used in the Sunshine Coast TSA including clearcutting, clearcut with reserves, and partial harvesting systems (MOF 2000). Regeneration is achieved predominantly through planting, although some natural regeneration also occurs on harvested areas.

3.4 Incremental Silviculture History

3.4.1 Genetically Improved Seed

Currently, about 50% of seedlings planted in the Sunshine Coast TSA are from genetically improved seed. This number is expected to increase to 75% within 10 years. The TSR 2 base case accounted for long-term volume gains anticipated from the use of genetically improved seed by applying a 2% gain for fir, cedar and hemlock managed stands in 75% of the cases. This resulted in an 1.5% upward adjustment in these yield curves (75% x 2% = 1.5%) (Craig Robinson, Pers. Comm. 2000)

3.4.2 Juvenile Spacing

Juvenile spacing is the removal of less-desirable trees within a juvenile stand to manage the density of the stand. This reduces competition for water, nutrients, and sunlight among the residual trees and the primary stand-level effect is to allow the stand to reach minimum harvest size sooner. Juvenile spacing can also manage species composition, address forest health issues, and meet biodiversity or wildlife objectives. Juvenile spacing began in the Sunshine Coast in 1971. Since then, approximately 15,000 hectares in total have been spaced. In the last 5 years, an average of 725 hectares per year of spacing has been done.

3.4.3 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. Aerial application of urea is the most common technique. Fertilization began in the TSA in 1979 and a total of 8000 hectares has been fertilized. Approximately 1000 hectares has been fertilized within the last 5 years.

3.4.4 Pruning

Pruning is the removal of branches from the bole of the tree with the purpose of creating clear lumber. Two treatments (lifts) of pruning are done, when the tree is from 12 to 18 years old. The rule is that pruning shall leave a length of crown that is not less than 50% of the total tree height. Pruning began in 1984 and since then a total of 2500 hectares has been pruned. Currently, about 360 hectares are pruned each year.

3.4.5 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 recovering. 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 undertaken on approximately 100 hectares within the last 5 years.

3.4.6 Backlog Reforestation

There is currently less than 200 hectares of backlog NSR. District staff is assessing treatment of these areas (MOF 1998).

3.4.7 Historical Silviculture Budgets

Year	Budget (\$ million)
1995-1996	1.2
1996-1997	1.4
1997-1998	0.78
1998-1999	3.3
1999-2000	2.5
2000-2001	1.6

3.5 Previous Silviculture Plans and Reports

Sunshine Coast Timber Supply Area - Incremental Silviculture Strategy (1998)

This project used existing information (mostly based on TSR I analysis from the 1995 Sunshine Coast TSA Timber Supply Analysis Report) to identify timber quantity and quality issues and opportunities. This is the "Type I" silviculture strategy project mentioned earlier in this report.

The recommended silviculture strategy was oriented towards mitigating the impact of cover constraints on the timber supply and increasing the mid and long term harvest level through fertilization and other silviculture regimes. Improving the quality of timber supply was also an important goal. A number of strategies were recommended to achieve the objectives, including the following:

- Achieve green-up 5 years earlier by reducing regeneration delay 2 years; planting large, second generation, improved stock; and fertilizing at the time of planting.
- Increase partial harvesting / commercial thinning regimes in VQO zones.
- Repeat fertilize approximately 4 000 ha of existing stands scheduled for harvest 20 to 80 years from now (300 ha/yr in spaced stands & 100 ha/yr in commercially thinned stands) to raise their volumes.
- Increase regenerated stand volumes 15% through a variety of silvicultural actions (tree improvement is critical to success).
- Brush 400 ha to maintain backlog plantations.
- 1st lift prune 400ha/yr to create knot-free timber in the lowest 3.0 m log.
- 2nd lift prune 250 ha/yr to create knot-free timber in the lowest 5.1 m log.
- Space 1200 ha/yr to obtain large dimension timber and prepare stands for fertilization and pruning.

TSR 1 sensitivity analyses were a significant factor when the above strategies, particularly the ones affecting volumes were designed. Timber supply in TSR 1 was sensitive to VQOs and green-up ages. The policies around these parameters have changed since TSR 1 and their impact on timber supply is now less restrictive.

4 Identification of Issues

4.1 General Timber Supply Issues

The following issues are related to timber quantity, timber quality, forest health, and/or habitat within the Sunshine Coast TSA. The following interpretations of the current timber supply conditions in the Sunshine Coast TSA were provided by Craig Robinson (MoF, Vancouver Forest Region) from the preliminary results in the course of the TSR 2 process, as well as through Workshop #1. The terms short-term, mid-term and long-term are used throughout and are defined as follows:

- Short-term - This refers to the next twenty years.
- Mid-term - This is the period from year 21 to year 100.
- Long-term – Over 100 years from now.

4.1.1 Harvest Forecast

TSR 2 investigates two base case scenarios: one where the current harvest level of 1,140,000 m³/year is maintained for 250 years and one where the harvest level is increased by 8% to 1,233,000 m³/year over the same planning horizon. The impacts of this increase are investigated through comparisons of several parameters between scenarios.

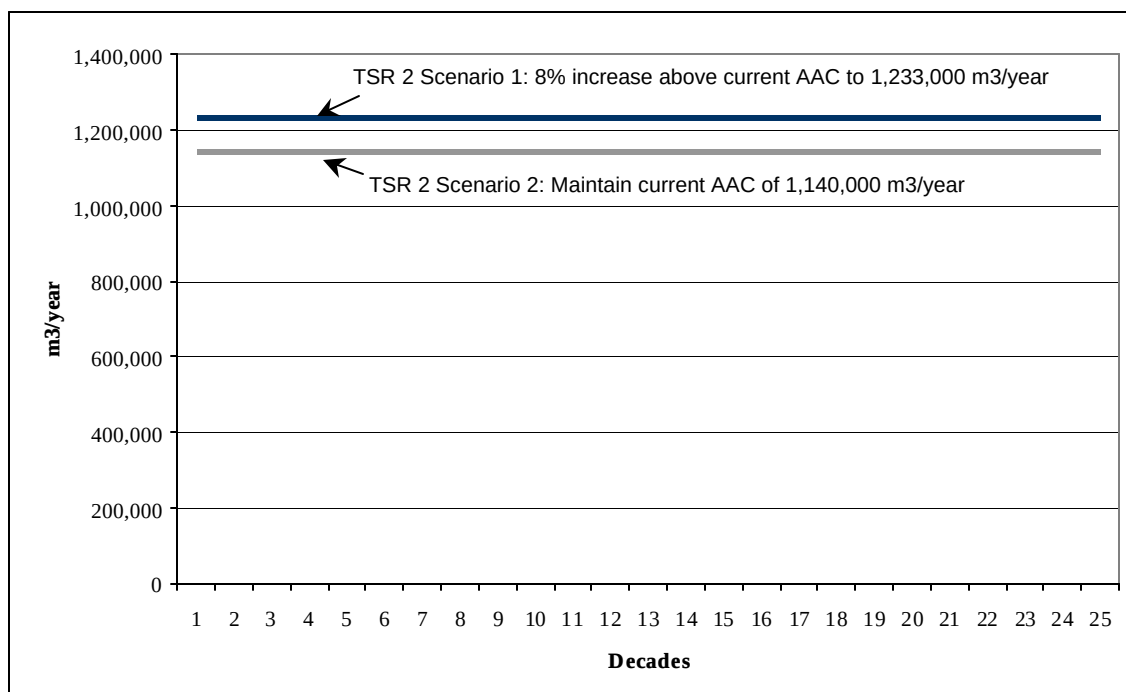


Figure 1 – TSR 2 harvest forecasts

4.1.2 Land Base

Since TSR 1 (1995), the total area managed by the Forest Service has decreased by 19,312 hectares, primarily due to the creation of parks and changes in the order of netdown procedures. THLB area remains the same as in TSR I, as the addition of red alder areas to the THLB offsets the subtraction of areas for parks.

Decreasing the timber harvesting land base by 10% forces the harvest flow to decrease by 10% following decade 4, with a long-term harvest flow of 1,108,000 m³/year (11% below the base case) being reached at decade 5.

Increasing the size of the THLB by 10% allows a 10% increase in the harvest level to 1,353,000 m³/year.

4.1.3 Age Class Structure

Approximately 11% of the THLB is currently in stands over 250 years old. The age class distribution in the THLB is well distributed between 0 and 100 year of age. In the

longer-term, the non-contributing land base will be able to provide much of the area required to meet old-forest requirements.

4.1.4 Transition from Existing to Managed Stands

For the first 8 decades, harvest volume comes exclusively from existing stands. During decades 9 and 10, dependence on regenerated stands increases rapidly and by decade 11 the harvest is projected to come predominantly from managed stands.

4.1.5 Growing Sites

Site productivity estimates for old stands may be inaccurate as tree heights do not reflect actual productivity and it is very difficult to determine ages of old trees accurately. In a sensitivity analysis, applying Old Growth Site Index (OGSI) adjustments as per the appropriate study results (*Site index adjustments for old-growth stands based on paired plots* (Nussbaum 1998) or *Site index adjustments for old-growth stands based on veteran trees* (Nigh 1998)) resulted in a 7% increase in timber supply over scenario 1 to 1,318,000 m³/year.

4.1.6 Forest Cover Requirements

The following forest management zones occur in the Sunshine Coast TSA:

- Integrated resource management - applies to 50% of the THLB. The base case has a requirement that a maximum of 33% of the THLB within a landscape unit be less than 3m in height. This requirement is intended to model Forest Practices Code adjacency and green-up requirements.
- Visual Quality Objectives (VQO's):
 - Modification VQO - applies to 7.5% of the THLB. A maximum of 25% of the VQO area within a landscape unit < 5m in height.
 - Partial retention VQO - applies to 39% of the THLB. A maximum of 15% of the VQO area within a landscape unit < 5m in height.
 - Retention VQO - applies to 3% of the THLB. A maximum of 5% of the VQO area within a landscape unit < 5m in height.
 - Preservation VQO - applies to 0.2% of the THLB. A maximum of 1% of the VQO area within a landscape unit < 5m in height.

The harvest forecast is insensitive to both a 5 year increase and decrease in visually effective green-up age.

- Community Watersheds – 26 Community Watersheds have been identified within the Sunshine Coast TSA. These areas have been restricted to 10% of the productive forest area eligible for harvest in a 10-year period.
- Islands – Islands represent 6% of the THLB. A maximum of 25% of the THLB may be less than 3 metres in height.

- Aerial Harvest Areas – These areas comprise 4% of the THLB. A maximum of 33% of the THLB may be under 3 metres in height.
- Community Interface – These areas represent 13% of the THLB. A maximum of 25% of the THLB may be under 3 metres.

4.1.7 Quality

Quality was not modeled in TSR 2. Quality objectives were identified in Workshop #1.

4.1.8 Old Forests

Approximately 11% of the THLB is occupied by stands greater than 250 years of age and over 42% of the non-contributing land base is at or near 250 year of age. Forest cover requirements for old growth assume that forests develop old growth characteristics at an age of 250. Old growth targets were applied by weighted average of the lower, medium, and higher biodiversity emphasis option (BEO) targets for the area. In addition, the calculation of the weighted averages allowed for a 2/3 reduction of the old seral requirements in low BEO landscape units. Sensitivity analyses on the application of old growth requirements revealed no impact on harvest level.

4.1.9 Minimum Harvest Ages

Minimum harvest ages are chosen in order to ensure that the timber supply model selects only stands for harvest with sufficient merchantable volume and piece size. The timber supply is insensitive to a 10-year increase or decrease in minimum harvest age.

4.1.10 Estimates of Existing and Regenerated Stand Volumes

Existing stand volumes in the base case were adjusted based on the results of the Vegetation Resources Inventory project for the Sunshine Coast. The result was an average increase in volume of 16% for Douglas-fir and 10% for Hemlock. Not applying the inventory adjustment would result in a 6% decrease in harvest level from Scenario 1 to 1,157,789 m³/year.

A 10% decrease in regenerated stand volumes forces a 12% decrease in long-term harvest level beginning at decade 10. An increase in regenerated stand volumes of 10% results in an immediate increase in long-term harvest level of 8%.

4.1.11 Forest Health Issues

No epidemic forest health issues were identified for this analysis. A volume reduction of 12,211 m³/year is applied to estimate the unsalvageable volume lost to wind, fire, disease, mammals, and insects.

4.1.12 Issues Relating to Habitat and Non-timber Forest Resources

- Goat Winter Range – Approximately 2,800 hectares have been excluded from the THLB to provide safe wintering areas for mountain goats.

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:

- Increasing the size of the THLB,
- Changes managed stand yields,
- Reducing existing stand volumes by not applying the inventory adjustment, and
- Applying Old Growth Site Index adjustments.

5.1.2 Mid- and Long-term

The mid-term timber supply is sensitive to:

- Increasing the size of the THLB,
- Reducing the size of the THLB,
- Increasing managed stand yields,
- Reducing managed stand yields,
- Reducing existing stand volumes by not applying the inventory adjustment,
- Applying Old Growth Site Index adjustments, and
- Reducing allowable visual disturbance.

5.2 Timber Supply Concerns

The timber supply within the Sunshine Coast TSA appears to be quite robust. Preliminary results of TSR 2 indicate that the landbase can support a harvest level above the current AAC. As the AAC determination depends not only on this harvest forecast but also on an analysis of risk and other social considerations, there may or may not be a change in the AAC for the Sunshine Coast.

5.3 Higher Level Objectives

This incremental silviculture strategy is based on higher level provincial goals and objectives, which are as follows:

5.3.1 Provincial Goals

Government's goals are (MoF, 1999):

- Sustainable Use
- Community Stability
- Strong Forest Sector

5.3.1.1 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 m³; and
3. Maintain the production of premium quality logs at or above 10% of total harvest. (MOF, 1999c)

5.3.2 Regional Objectives

- Ensure a long-term sustainable harvest, which approximates the current harvest value and volume levels and that, produces a diversified mix of products necessary to create and maintain sustainable forest employment.
- Balance treatments that enhance growth and yield such as fertilizing, spacing and forest health activities with those that increase the value of the wood such as pruning.
- Utilize incremental silviculture treatments to contribute to sustainable management of non-timber values at the landscape level.

5.4 Local Objectives and Opportunities

5.4.1 Objectives

The following objectives were identified during Workshop #1:

- Increase timber diversity and quality.
- Increase timber volume.
- Make old growth attributes available sooner through silviculture.
- Make dense hemlock/fir/cedar stands productive for timber and habitat through silviculture.

6 Potential Strategies

6.1 Potential Strategies by Response Timeframe

Strategies describe how the 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%;
- Intensify forest health management to reduce losses to insects and disease; and
- More hardwood forest management.

Table 1 – Potential strategies by response time frame

Response Time Frame	Strategy Description	Anticipated result
Short-Term	1. Expand the timber harvesting land base by: <ul style="list-style-type: none"> • Deciduous stand conversion. 2. Increase the volume of some existing stands through: <ul style="list-style-type: none"> • Late rotation fertilization. 	1. As per TSR 2, short-, mid- and long-term timber supply is sensitive to changes in the size of THLB base. Stand conversion and eliminating backlog NSR amount to an increase of in THLB area. 2. Short-, mid- and long-term timber supply is somewhat sensitive to an increase in existing stand volumes. A 10% increase in stand volumes is anticipated to result in 2% increase in timber supply.
Mid-Term	1. Increase regenerated stand volumes as per the Long Term. 2. Space and fertilize to set up stands for future CT. 3. Increase the value of second growth stands by: <ul style="list-style-type: none"> • Pruning, spacing and fertilization. 	1. Increased regenerated stand volumes have some impact on mid-term timber supply; however, the greatest impact is in the long term. 2. Maintain options for CT. Bring some long-term volumes to the mid term. 3. Mid-term value increase expected to be modest, as benefits will occur in the long term.
Long-Term	1. Increase regenerated stand volumes by: <ul style="list-style-type: none"> • Using genetically improved seed; • Fertilizing suitable regenerated stands; 2. Increase the value of second growth stands by: <ul style="list-style-type: none"> • Pruning, spacing and fertilization. 	1. This analysis assumes 10.01% gain for Fd, 8.25% gain for Cw and 8.22% gain for Hw using 2 nd generation improved seed. Assume a 9% long-term timber supply impact. Value increases expected in the long-term.

6.2 Stand Treatments

Table 2 describes the impacts of silviculture on selected stand attributes.

Table 2 – 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

The following treatment regimes were developed during Workshop #1.

Table 3 – Treatment regimes

AU	Regen Delay	OAF1	OAF2	Plant/ Natural %	TSR 2		Silviculture Strategy Options ¹							
					Density	Space	Initial Density	Space	Space Fert	Space Fert Ct	CT	Space Prune	Space Prune fert	Do Not Treat
101 Fir – good	2	15	12	100/0	1200	700	2200	✓	✓	✓	✓	✓	✓	✓
102 Fir – medium	2	15	12	100/0	1200	700	2400	✓	✓	✓	✓	✓	✓	✓
103 Fir – poor	2	15	5	100/0	1200		2600	✓	✓					✓
104 Cedar – good/medium	2	15	5	90/10	1200	700	2500	✓						✓
105 Cedar – poor	2	15	5	60/40	1200		2200							✓
106 Hem/Bal/Spruce – good	2	15	5	70/30	1200	700	4500	✓			✓			✓
107 Hem/Bal/Spruce – medium	2	15	5	60/40	1200		4500	✓						✓
108 Hem/Bal/Spruce – poor	2	15	5	50/50	1200		4200							✓
109 Pine	2	15	5	0/100	1200	700	-							✓
110 Alder	2	15	5	100	1600	900	-							✓
121 Fir – good XM (CWHxm1, xm2)	2	15	12.5	100/0	1200	700	2200	✓	✓	✓	✓	✓	✓	✓
122 Fir – medium XM (CWHxm1, xm2)	2	15	12.5	100/0	1200	700	2400	✓	✓	✓	✓	✓	✓	✓
141 Fir – good Shelt (Shelterwood)	2	15	12	100/0	1200	700	2200	✓	✓	✓	✓	✓	✓	✓
151 Fir – medium Shelt (Shelterwood)	2	15	12	100/0	1200	700	2400	✓	✓	✓	✓	✓	✓	✓
161 Fir – good Shelt XM	2	15	12.5	100/0	1200	700	2200	✓	✓	✓	✓	✓	✓	✓
171 Fir – medium Shelt XM	2	15	12.5	100/0	1200	700	2400	✓	✓	✓	✓	✓	✓	✓

¹ Parameters for Treatments:

- Space – 700 stems/ha at 12 years
- Prune – 1st lift 12 years (3.1 m), 2nd lift 18 years (5.6 m)
- CT - 40 to 70 years, 300 sph @ 30 cm quad mean DBH – 20 year delay to MHA
- Fert (aerial) – 15, 25, 35, 45, 55 years

6.4 Stand Level Treatment Responses

Figure 2 illustrates an example of the response of a good Douglas-fir site to some silviculture treatments.

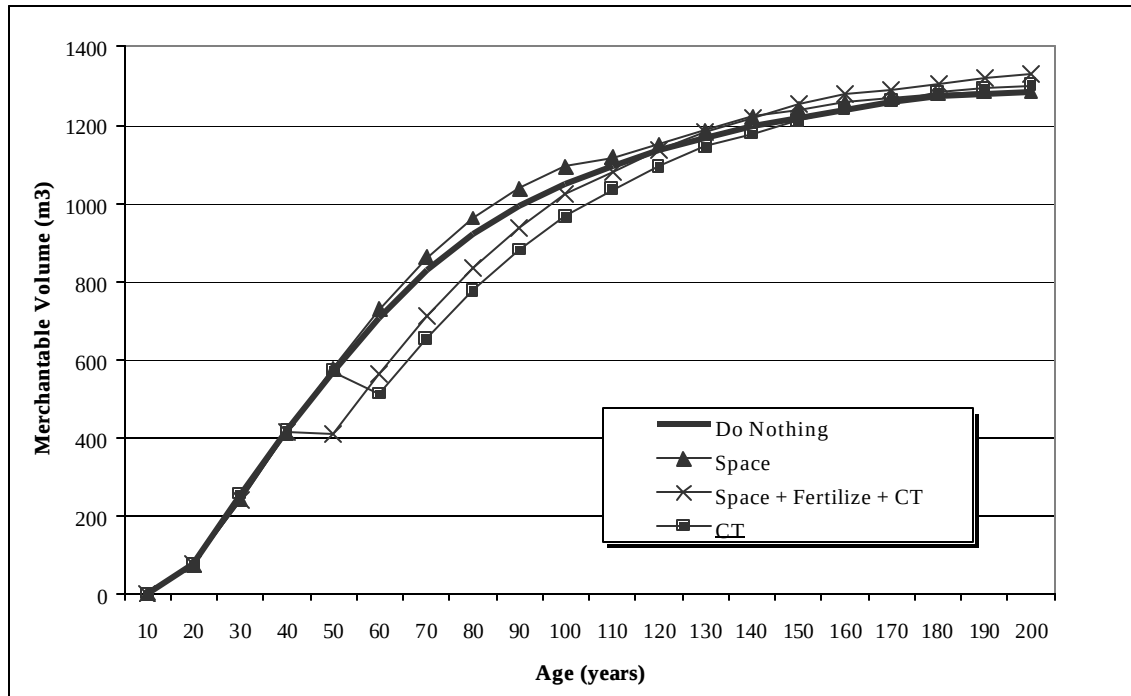


Figure 2 - Response of a good Douglas-fir site to some silviculture treatments

Silviculture treatments may reduce or increase stand yields, depending on the treatment, initial density and site type. Figure 2 shows that on a good fir site commercial thinning regimes compromise final harvest volumes as expected. Spacing appears to produce similar volumes as the “do nothing option” at first and higher volumes after approximately 50 years.

A similar trend was found on a medium fir site (not shown). Spacing produced similar merchantable volumes as the “do nothing” option until year 60, after which the volumes increased. On a poor fir site, spacing reduced stand volumes until year 110 after which the spaced stands had slightly higher stand volumes.

7 Stand Level Analysis

Both the MoF and industry have researched a number of stand-level silviculture treatments to determine the most effective treatments, multiple treatment regimes and rules. The rules, which would include 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. In conjunction with TASS, a program called SmartAxe was used to analyze each log and determine the optimal bucking strategy, maximizing log value based on Statutory Log Grades. The log grade was included in the TASS output yield tables

TASS is a single species, even-aged stand model; therefore, stands were modeled with these assumptions. TASS is calibrated for a limited number of species, so for this analysis, balsam is modeled using a hemlock curve. 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.

8 Forest Level Analysis

The following is a brief overview of the forest level analysis procedure. The process is described more fully in the Analysis Information Package.

8.1 Assumptions

The following assumptions were used as a basis for the analyses:

- Success of results will not be limited by funding availability, source, or ability to deliver the program;
- Normal market conditions will apply to demand and prices for timber and fibre;
- Status quo timber harvesting land base will be applied except where noted;
- The TSR 2 analysis approach will be used;
- 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:
 - +/- 10% change in timber flow between decades;
 - Silviculture investment not to exceed maximum budget level by more than 10%; and
 - No tolerance around age-class targets specified in TSR 2 for optimization.
- Treatment costs were taken from recent experience in the Sunshine Coast TSA and are listed in the Analysis Information Package; and
- Log values were based on historic, third party, second-growth market pricing and are based on the Statutory Log Grades and piece size. For old growth timber, a flat \$100/m³ net revenue was used for all stands.

8.2 Working Targets

The following working targets were identified in the Type 1 project and approved as suitable during Workshop #1. These working targets serve as a measure of the effectiveness of the treatment regimes in fulfilling the objectives identified in section 5.4.

Quantity: Increase the long-term timber supply by 8% without sacrificing long-term sustainability. This is the same objective as in the Type 1 analysis expressed as a percentage.

Quality: Manage regenerated stands to yield at least 10% premium logs by volume, with the majority of the remainder being of sawlog quality.

Premium Log:

Douglas-fir – clear, pruned minimum 5.2 metre log, 45+ cm dbh

Hemlock, Douglas-fir – 55+ cm dbh unpruned log

Cedar – 30+ cm dbh log over 15 metres, few knots

Sawlog:

Minimum average stand dbh of 30 cm , minimum stand volume of 350 m³/ha

8.3 Analysis Scenarios

Scenario	Title	Scenario Description
1	Base Case	<ul style="list-style-type: none"> Re-creation of the TSR 2 Base Case <ul style="list-style-type: none"> Calibrate model Test model reliability.
2	Revised Base Case	<ul style="list-style-type: none"> Base Case TASS curves replace TIPSy curves Yield curves adjusted for OGSi ISIS information included
3	Silviculture Base Case	<ul style="list-style-type: none"> Base Case TASS curves replace TIPSy curves Yield curves adjusted for OGSi ISIS information included Genetic improvement.
4	Timber Volume Scenarios	<ul style="list-style-type: none"> Builds on Silviculture Base Case Series of runs using different annual incremental silviculture budgets <ul style="list-style-type: none"> \$1M \$2.5M \$5M Intent is to determine impact of silviculture on volume.
5	Timber Value Scenarios	<ul style="list-style-type: none"> Builds on Silviculture Base Case Series of runs using different annual incremental silviculture budgets <ul style="list-style-type: none"> \$1M \$2.5M \$5M Intent is to determine impact of silviculture on value
6	Biodiversity Scenario	<ul style="list-style-type: none"> Test the impact of full seral targets on timber supply. Investigate mitigation through silviculture.
7	Deer Management Scenario	<ul style="list-style-type: none"> Investigate the opportunities to create deer habitat through silviculture.
8	Proposed Scenario	<ul style="list-style-type: none"> Builds on Silviculture Base Case Combines value and volume objectives based on feedback on preliminary results.

8.3.1 Base Case (Scenario 1)

Re-creating the TSR 2 base case allows evaluation of the model's performance as well as monitoring differences between the FESL analysis and TSR 2. Any differences between the respective base cases must be quantified and understood for the interpretation of further scenarios and the effect of incremental silviculture on harvest levels in the Sunshine Coast TSA.

8.3.2 Revised Base Case (Scenario 2)

This run includes OGSi adjustments, which were not included in the TSR 2 base case. Managed stands are modeled using TASS curves here whereas managed stands are modeled using TIPSy curves in the base case. In addition, all past silviculture treatments recorded in the ISIS and FIP files are included. No future treatments are included here.

8.3.3 Silviculture Base Case (Scenario 3)

This run is similar to Scenario 2 above, however genetic gain is applied to managed stands. Again, past silviculture treatments are included but no future treatments are applied.

8.3.4 Timber Volume Scenarios (Scenario 4)

Budget levels of \$1, \$2.5 and \$5 million are investigated for their impact on timber volume. All treatment regimes shown in Table 3 in section 6.3 are eligible. Evaluation of volume gain can be made between budget levels as well as to the Silviculture Base Case (no treatments) scenario.

8.3.5 Timber Value Scenarios (Scenario 5)

Budget levels of \$1, \$2.5 and \$5 million are investigated for their impact on timber value. Profit is evaluated on harvest value minus silviculture cost as no harvest costs are incorporated in the analysis. Evaluation of value gain can be made between budget levels as well as to the Silviculture Base Case (no treatments) scenario.

8.3.6 Biodiversity Scenario (Scenario 6)

The intent of this scenario was to test the impact of using full seral (early mature, mature-old and old) requirements on the silviculture strategy base case. It further tested whether silviculture could be used to mitigate the impacts of the above seral requirements.

8.3.7 Problem Stand Scenario

The intent of this scenario was to test the impact of treating over-dense hemlock leading stands. However, adequate data was not available to develop the scenario.

8.3.8 Deer Habitat Scenario (Scenario 7)

The intent of this scenario was to investigate opportunities to create deer habitat through silviculture. However, adequate data was not available to develop the scenario.

8.3.9 Proposed Scenario (Scenario 8)

This scenario combines value and volume objectives as specified by workshop participants. These specifications are determined following participant review of the preliminary results of the volume and value runs.

9 Results

9.1 Base Scenarios

This section presents the results for all the base scenarios run in the analysis. These include the base case, revised base case, and silviculture strategy base case described in section 8.3 above. Results for the base case and revised base case were achieved using simulation while results presented for the silviculture strategy base case were achieved using optimization.

Figure 3 shows the harvest level for the base case benchmark run (FESL base case) and the preliminary harvest level for TSR 2. The FESL base case was run for a 250 year planning horizon as in TSR 2. Subsequent scenarios will be run on a 200-year planning horizon. The FESL base case run is approximately 2% higher than the TSR2 base case. This small difference provides confidence that the model and model inputs are producing reliable results that are comparable to TSR 2.

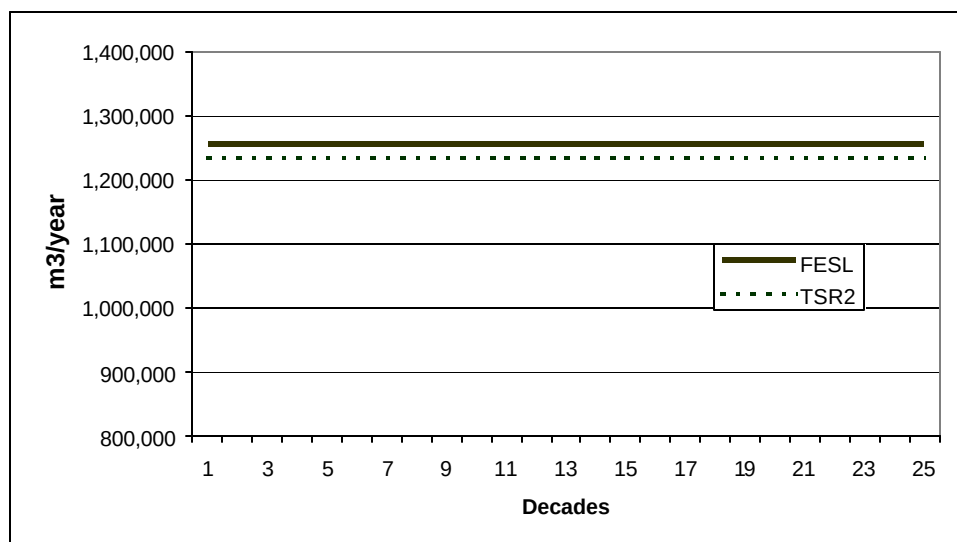


Figure 3 – TSR 2 and FESL base case harvest

Figure 4 shows the harvest level for revised base case with the FESL base case. The harvest flow for the revised base case is slightly higher than the base case run (less than

1% difference) in the short-term. After decade 12, the harvest level in the revised base case increases to approximately 1,333,000 m³/year, a 6% increase over the base case harvest level. This increase is mostly due to the application of OGSi adjustments. As these increases in site index apply to old growth areas after they are harvested, the impact in volume is in the long-term. The addition of past silviculture treatments may also have had an upward impact in the timber supply.

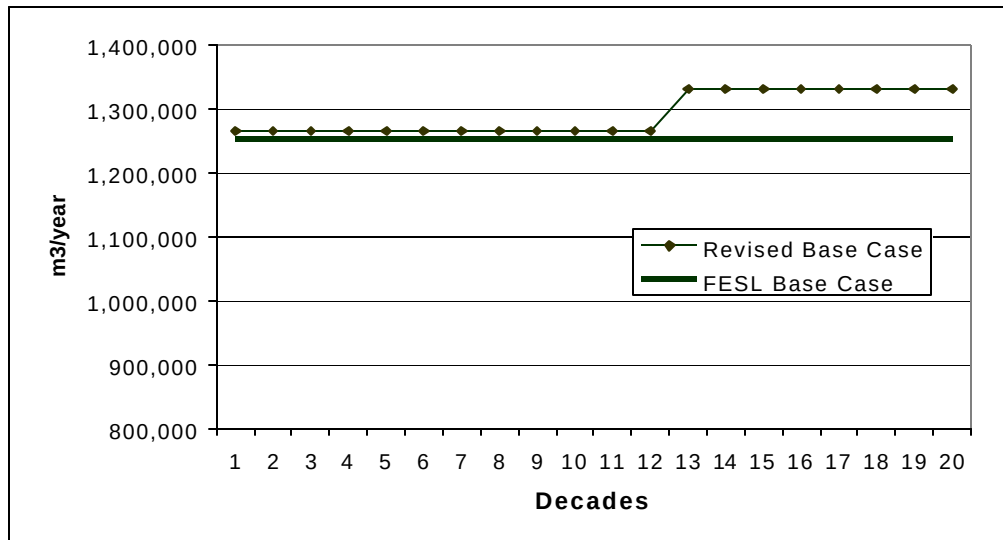


Figure 4 – Revised base case harvest

Figure 5 shows the harvest flow for the Silviculture Strategy (SS) base case as it compares to the FESL base case and the revised base case. The Silviculture Strategy base case is 2.5 % higher than the FESL base case in the short-term. After decade 11, the harvest level increases to 1,378,000 m³/year, an increase of approximately 10% over the FESL base case.

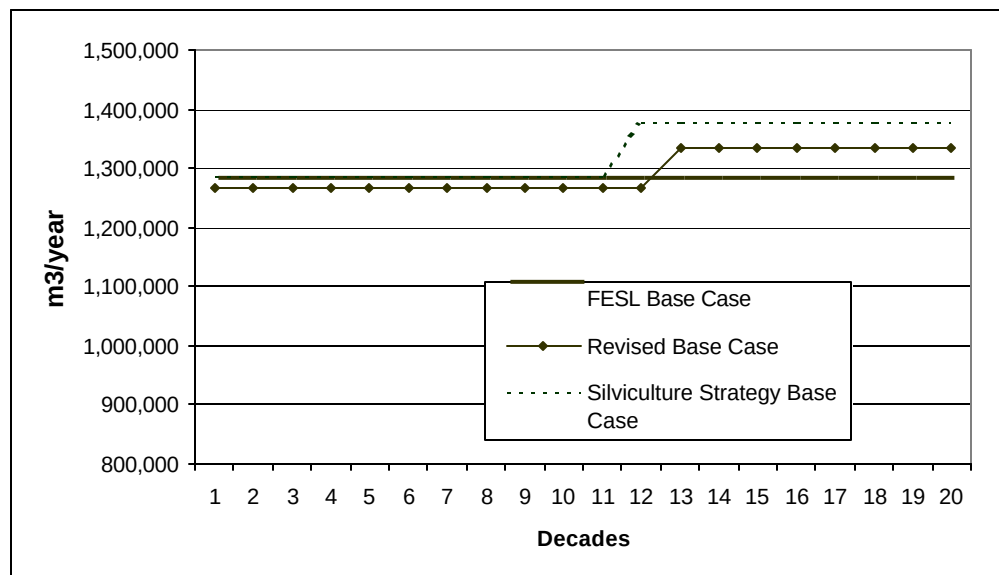


Figure 5 – Silviculture Strategy (SS) base case harvest

As compared to the revised base case, the SS base case is approximately 1.5 and 3.5% higher in the short- and long-term, respectively. This increase above the revised base case can be attributed to the inclusion of genetic gain for managed stands in the Silviculture Strategy base case. Managed stands are harvested throughout the planning horizon; however, the majority of volume harvested in the short-term comes from existing stands as depicted by figure 6. As such, the full impact of genetic gain is realized in the long-term and has only a minor impact in the short- and mid-term.

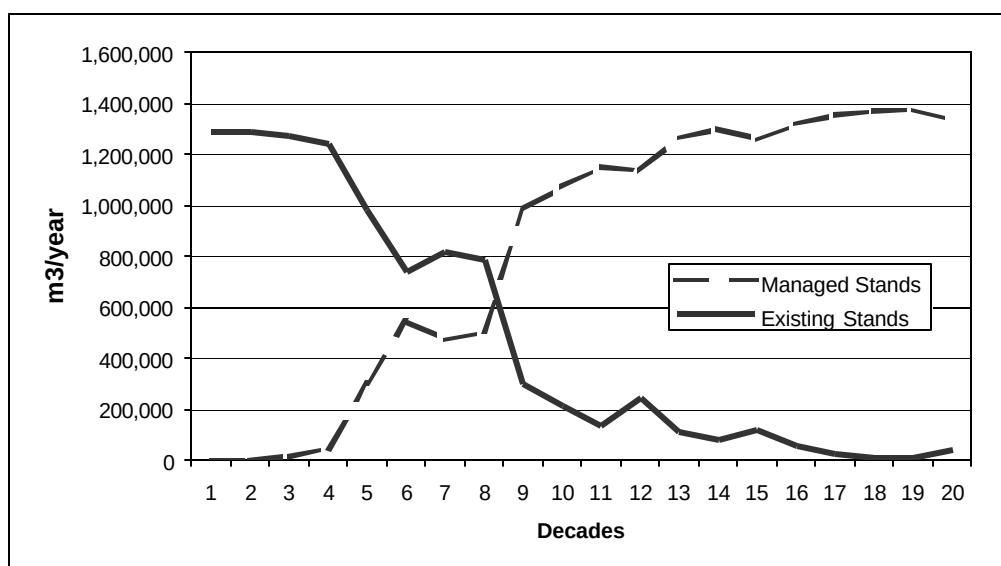


Figure 6 – Transition from existing to managed stands; SS base case

9.2 Volume Scenarios

Figure 7 illustrates the harvest level achieved using 3 different silviculture investment levels: \$1 million, \$2.5 million and \$5 million to maximize harvest level. In reality, the investment levels differ somewhat from \$1 million, \$2.5 million and \$5 million; the tolerance in the modeling allows fluctuations in investment level. Also, sometimes there are not suitable areas for treatments and less money is invested than the set amount. This was the case particularly for the \$5 million scenario. The average budgets for the first 100 years are shown in table 4 for the 3 different volume scenarios.

All investment levels increased the short and mid term harvest by approximately 3 %. The long-term increase was more significant: 7%, 9% and 13% for the 3 different investment levels, respectively.

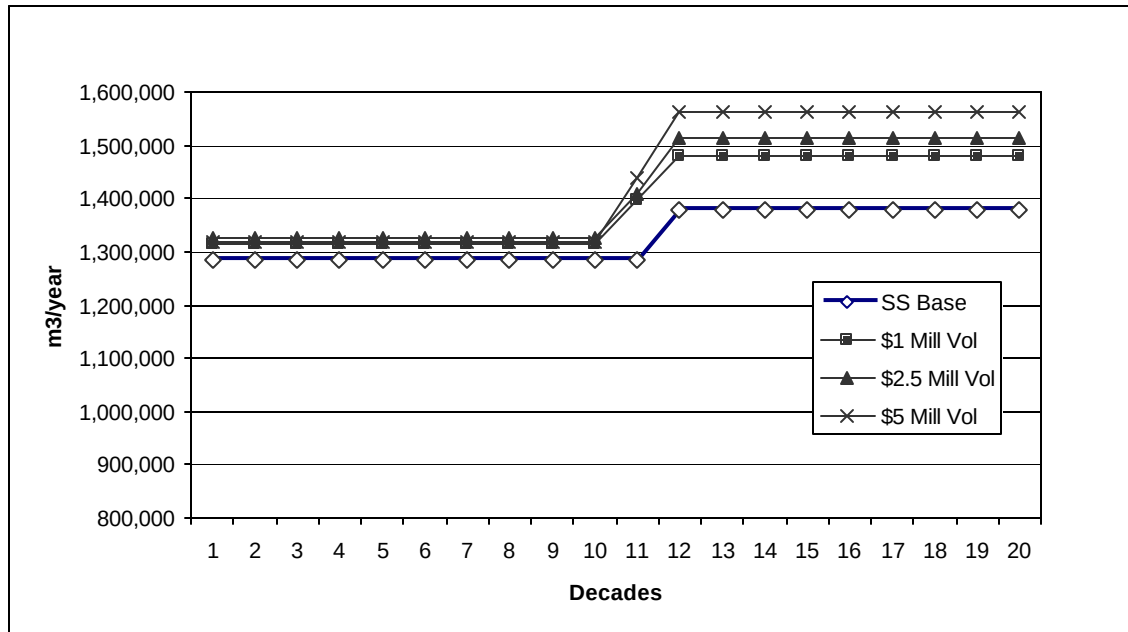


Figure 7 – Volume scenarios harvest

Table 4 – Set versus actual expenditure by the model in volume scenarios

Set Annual Investment Level (\$)	First 100-Year Average (\$)
\$1 Million	\$1,000,406
\$2.5 Million	\$2,067,068
\$5 Million	\$3,658,890

Figures 8, 9 and 10 summarize the silviculture treatments between the 3 different volume runs. The increased harvest is likely the result of fertilization due to its positive impact on tree growth. As figure 9 shows there appears to be a relationship between the annual area fertilized and harvest level. Spacing was also used significantly more with higher budget levels.

There were not significant differences with the use of commercial thinning between the 3 expenditure levels. This is an expected result as commercial thinning was assumed not to have any net cost; i.e., it was assumed that commercial thinning revenues would offset commercial thinning costs.

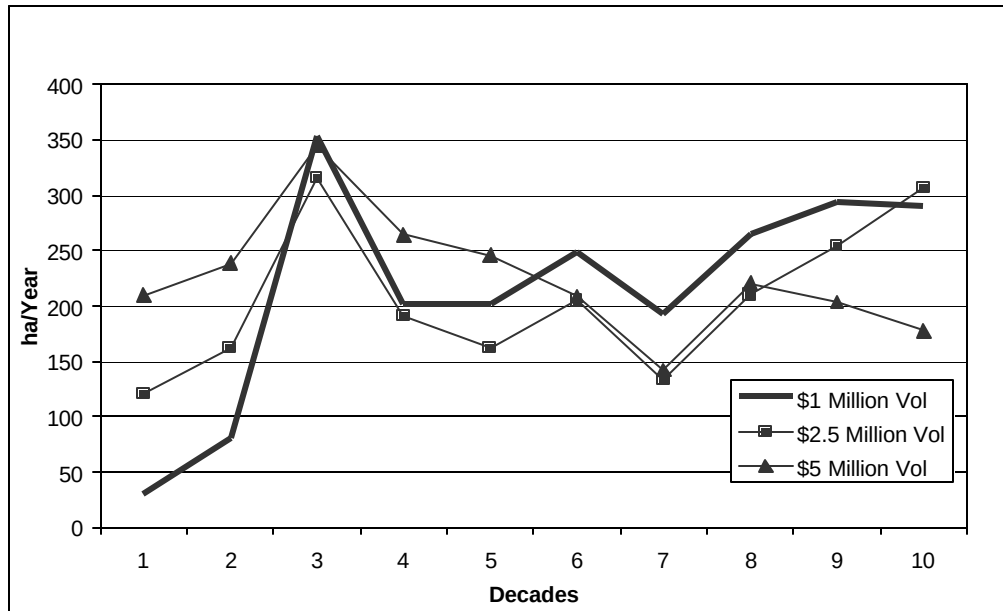


Figure 8 – Commercial thinning (ha/yr); volume scenarios

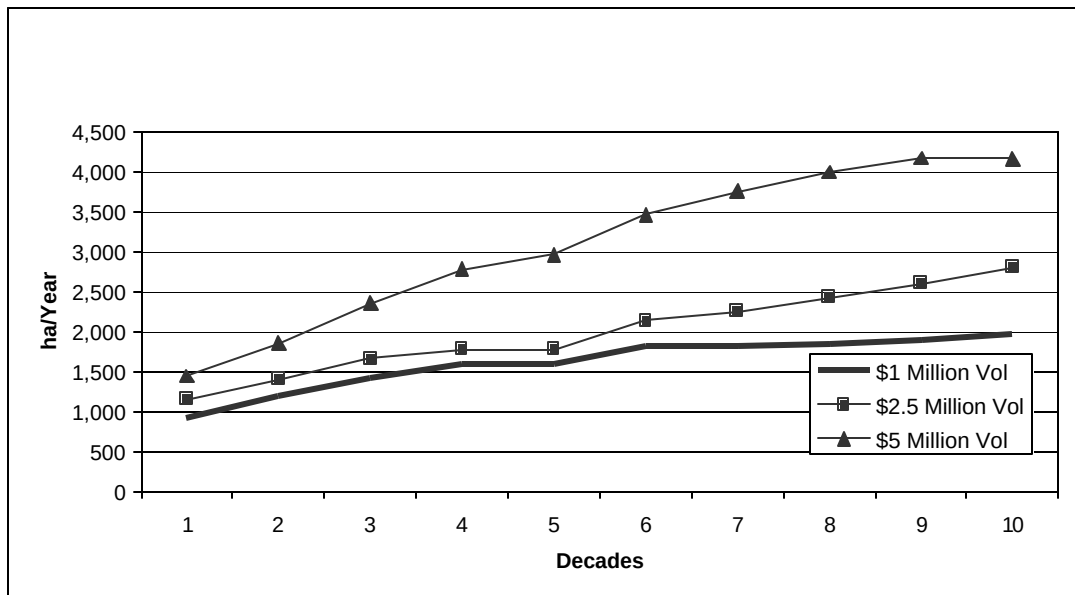


Figure 9 – Fertilization (ha/yr); volume scenarios

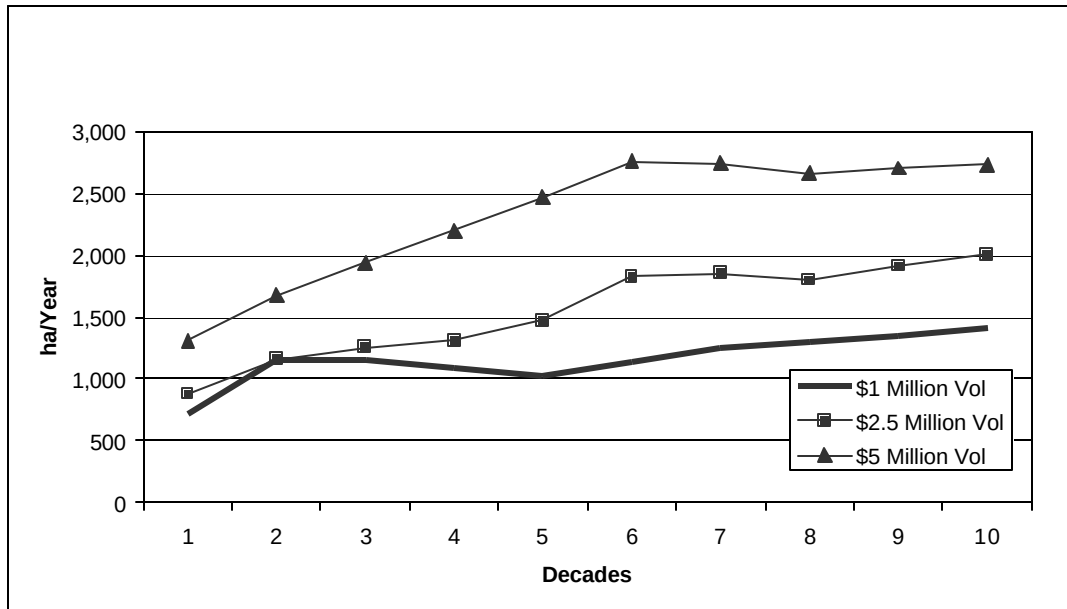


Figure 10 – Spacing (ha/yr); volume scenarios

9.3 Value Scenarios

As identified in the first workshop, the maintenance or enhancement of value is another major objective of the Sunshine Coast TSA group. As a quality-based objective, enhancing the value of the future forest focuses on larger piece sizes and stem diameters to produce higher value forest products such as poles, increased clear wood and peelers. While the future value of any stand may be higher if it is silviculturally treated rather than left to natural development, the aggregation of those incremental treatments across the TSA may not be economically viable depending on the marginal value increase, the timing of costs and the timing of revenue generation.

The harvest level for the value strategies was fixed for each budget level to the SS base case to maintain consistency in timber supply for purposes of comparison. With the harvest level fixed, the model was allowed to produce near-optimal solutions based on the total net present value of the profit for second growth stands in the planning horizon.

Three scenarios were run to test the impact of different levels of investment on value. The budget levels were 1, 2.5 and 5 million dollars. Again, due to tolerance given to the model in applying the budget, expenditures were not exactly equal to available budget. The actual average silviculture expenditures over the next 100 years were as follows:

Table 5- Set versus actual expenditure by the model in value scenarios

Set Annual Investment Level (\$)	First 100-Year Average (\$)
\$1 Million	\$1,011,782
\$2.5 Million	\$2,190,312
\$5 Million	\$4,090,689

Figure 11 compares the average harvest ages between the SS base case and the value scenarios. The figure shows that the average harvest age is somewhat higher when attempting to achieve higher value stands; the stands are generally held a bit longer before they are harvested. This is partly caused by commercial thinning and spacing treatments, which in some cases reduce per hectare yields and require longer rotations to meet the same volumes as in the SS base case.

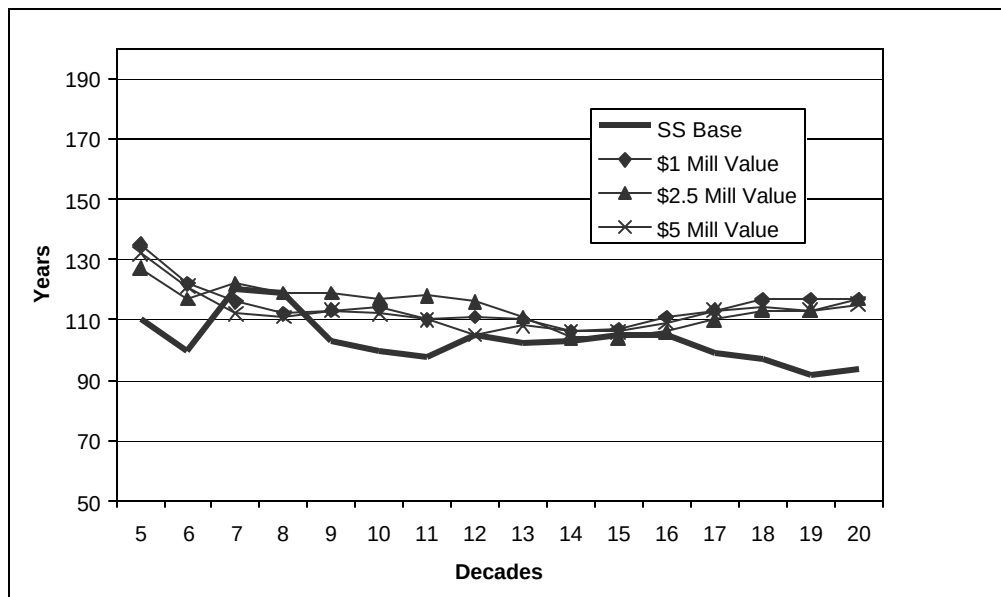


Figure 11 – Average harvest age; value scenarios

Figure 12 shows the quadratic mean diameter comparison over time between the value scenarios and the SS base case for future managed Douglas-fir stands. Figure 13 shows the same for all the other species combined. Silviculture produces larger diameters over time due to spacing and commercial thinning treatments. It is noteworthy that very little improvement in average diameter can be realized when increasing the silviculture investment beyond \$1 million.

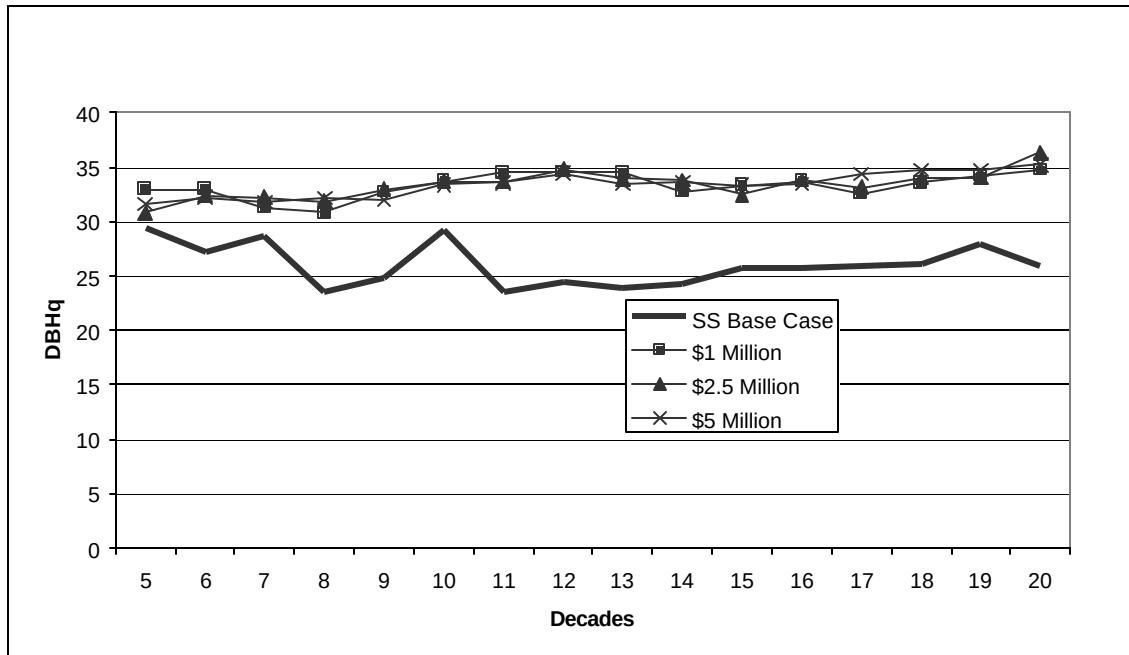


Figure 12 – Predicted quadratic mean diameter for value runs; Douglas-fir

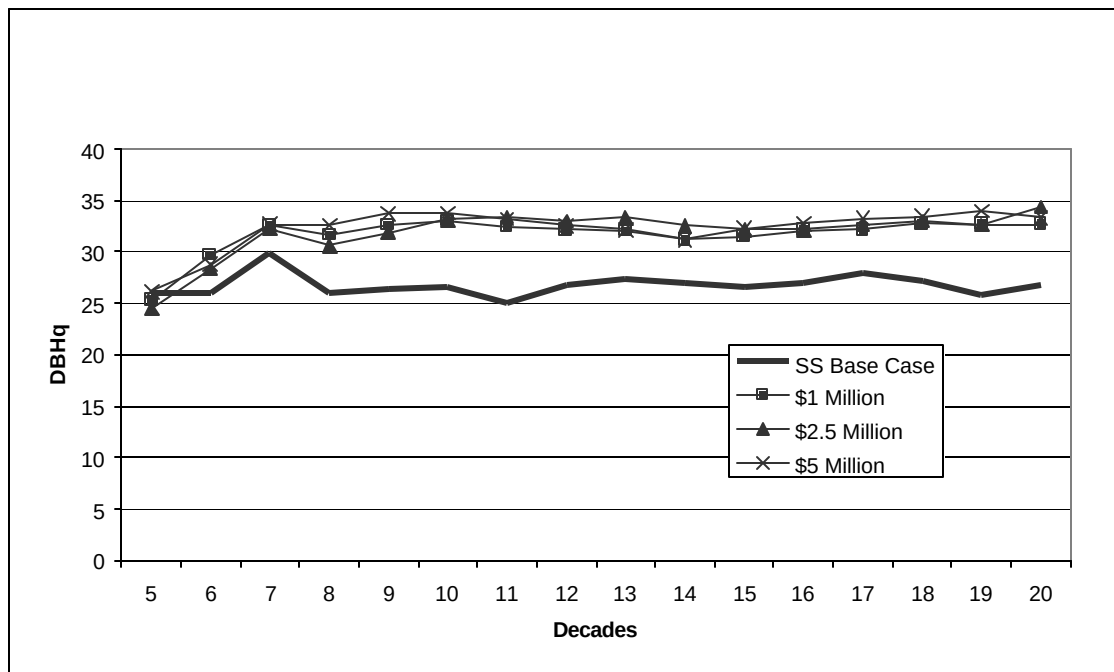


Figure 13 - Predicted quadratic mean diameter for value run; other species

The future mean diameter in the Sunshine Coast TSA is not predicted to be large. This is due to two factors: One third of the THLB consists of poor fir and poor hemlock-balsam-spruce sites, which do not generally produce large timber. Secondly, most of the second

growth timber gets harvested at reasonably young ages to maintain harvest flow. The second growth stands in the SS base case were harvested between 60 and 80 years of age.

Figure 14 shows the per cubic metre values for the different scenarios. As expected, the highest value occurs with the highest level of investment in the \$5 million-budget value optimization scenario. The SS base case has the lowest per cubic metre value of the scenarios. As with the piece size and the average dbh, however, the gain in value is not significant beyond the \$1 million investment.

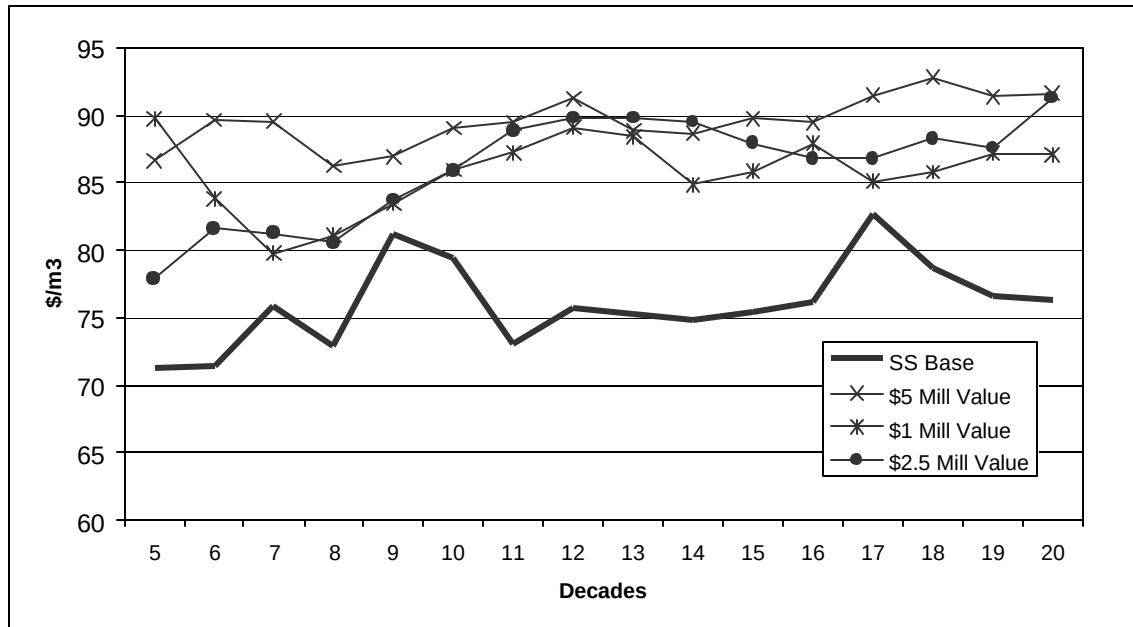


Figure 14 – Value per cubic meter; value scenarios

Figures 15, 16, 17 and 18 show the commercial thinning, spacing, fertilization and pruning treatments for the \$1 and \$2.5 and \$5 million silviculture budget scenarios. The \$5 million scenario invests more in general; however, the total increase in investment is most pronounced for pruning. Commercial thinning is assumed to be revenue neutral in this analysis.

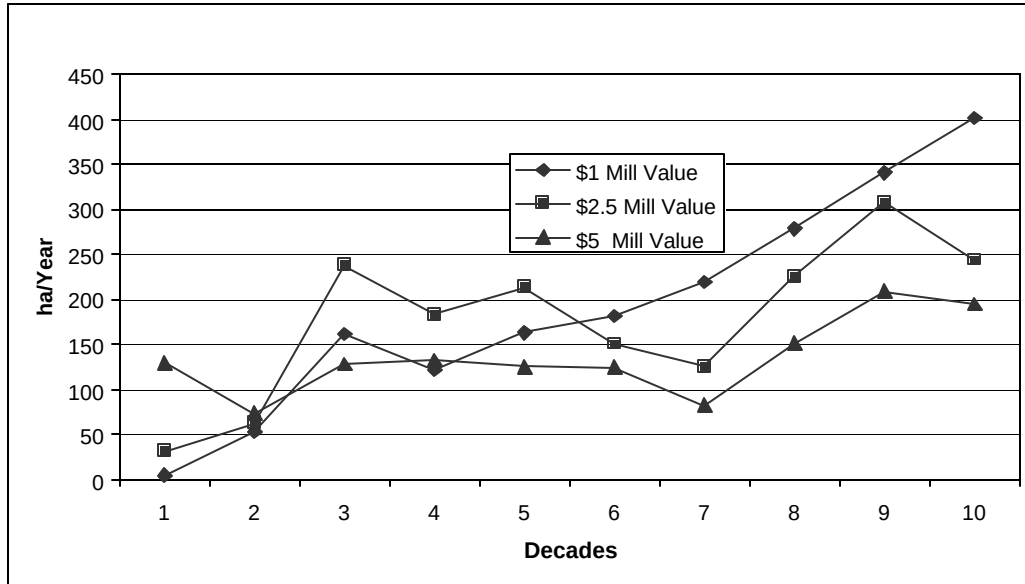


Figure 15 - Commercial thinning (ha/yr); value scenarios

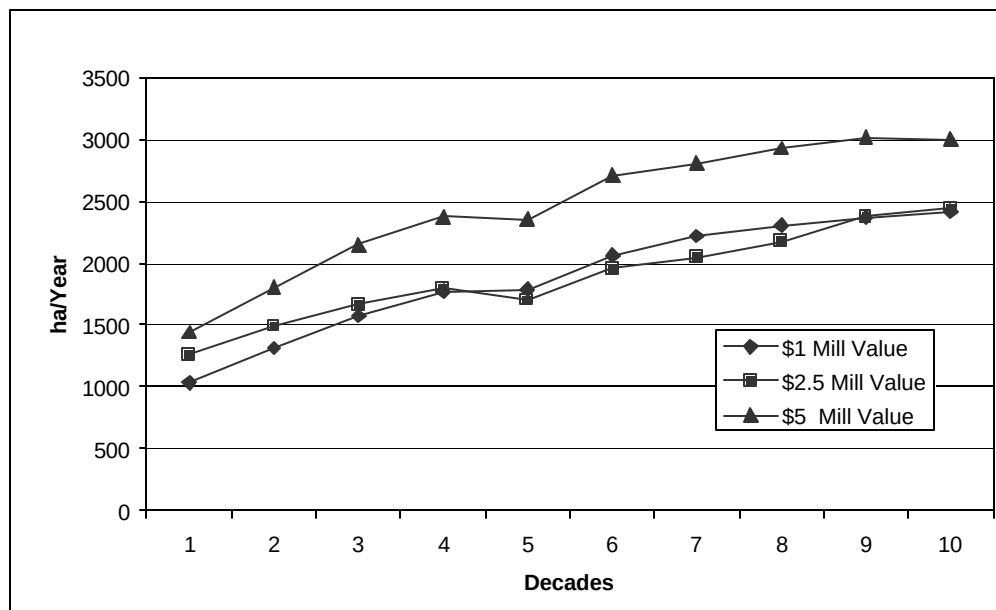


Figure 16 - Fertilization (ha/yr); value scenarios

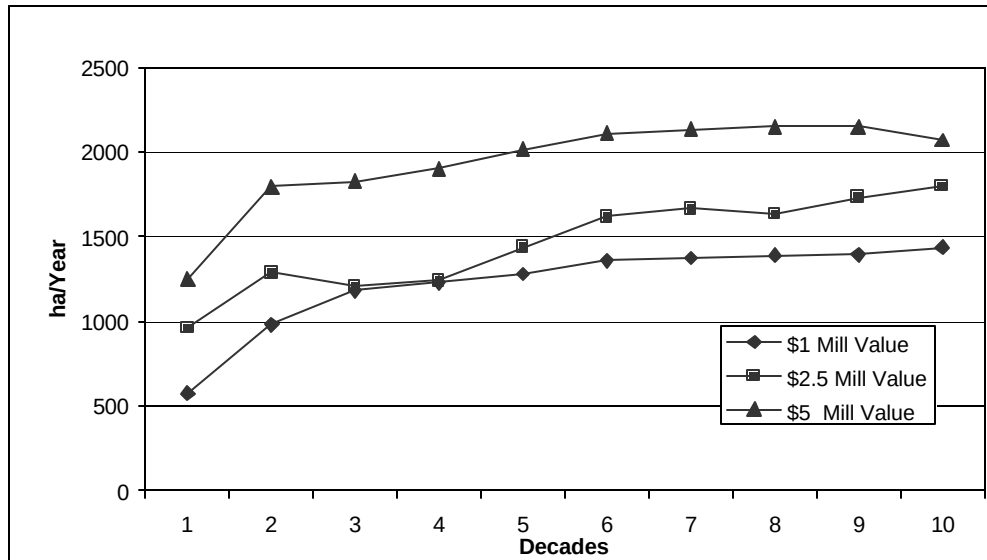


Figure 17 - Spacing (ha/yr); value scenarios

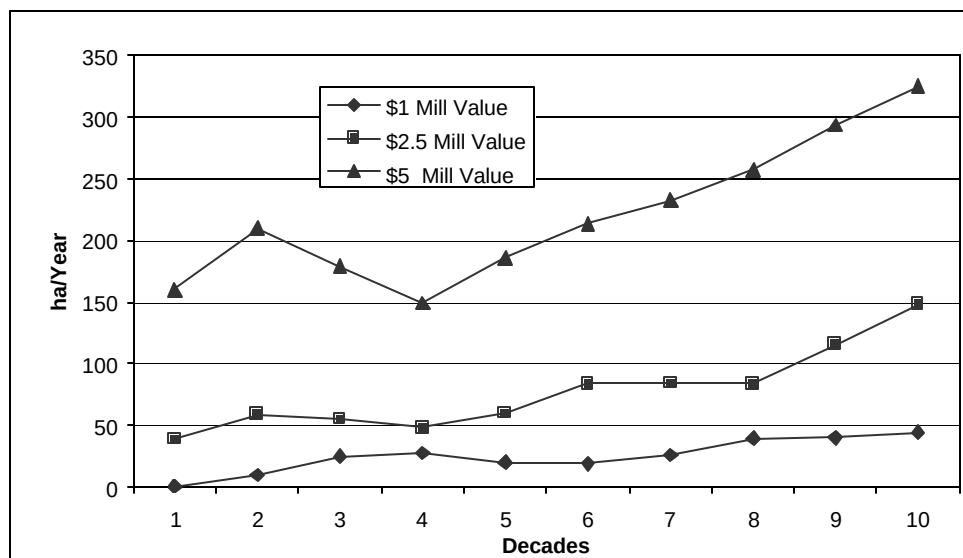


Figure 18 - Pruning (ha/yr); value scenarios

9.4 Biodiversity Scenario

The intent of this scenario was to test the impact of using full seral (early mature, mature-old and old) requirements on the silviculture strategy base case. It further tested whether

silviculture could be used to mitigate the impacts of the above seral requirements. Draft biodiversity emphasis options were used in the analysis for all the landscape units.

As figure 19 illustrates, the SS base case harvest had to be decreased significantly to meet all the seral requirements. The short and mid-term harvest level decreased by 21% and the long-term harvest level decreased by 22%.

Next, several analyses were run at different harvest levels to test whether silviculture could mitigate the impact of full seral requirements. No set budget levels were used, rather the model was allowed to find its own budget level. Only commercial thinning, spacing and fertilization were used as silviculture treatments.

As figure 20 illustrates, with the use of silviculture, the short-term harvest level could be increased close to the SS base case level. The long-term harvest level is higher than the SS base case; in fact, it is at par with the \$2.5 million volume scenario. The average budget level for the first hundred years was approximately \$2.6 million. Figure 21 further illustrates the annual treatments and treatment areas for this scenario.

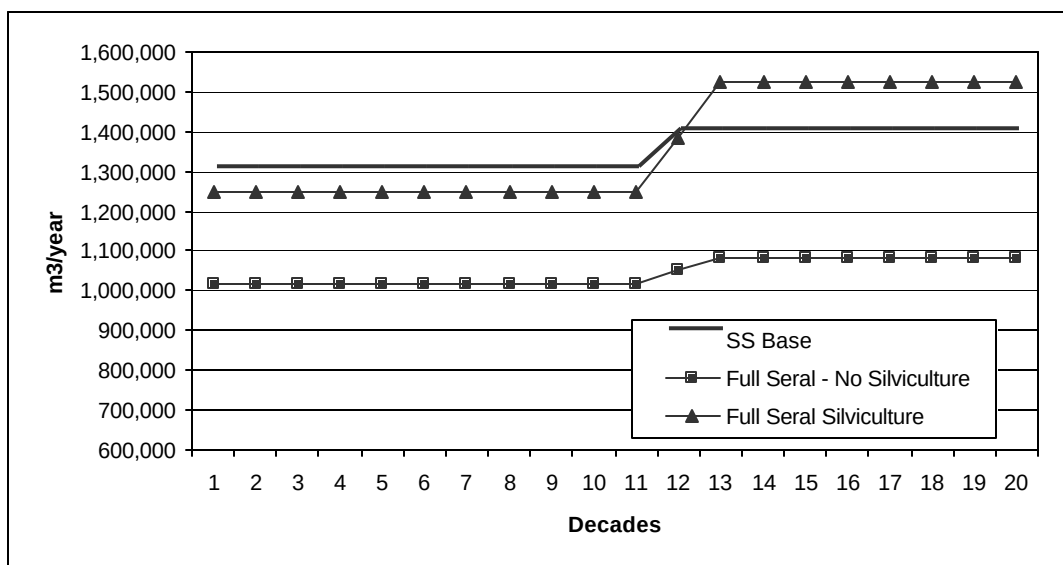


Figure 19 – Full seral harvest level with and without incremental silviculture

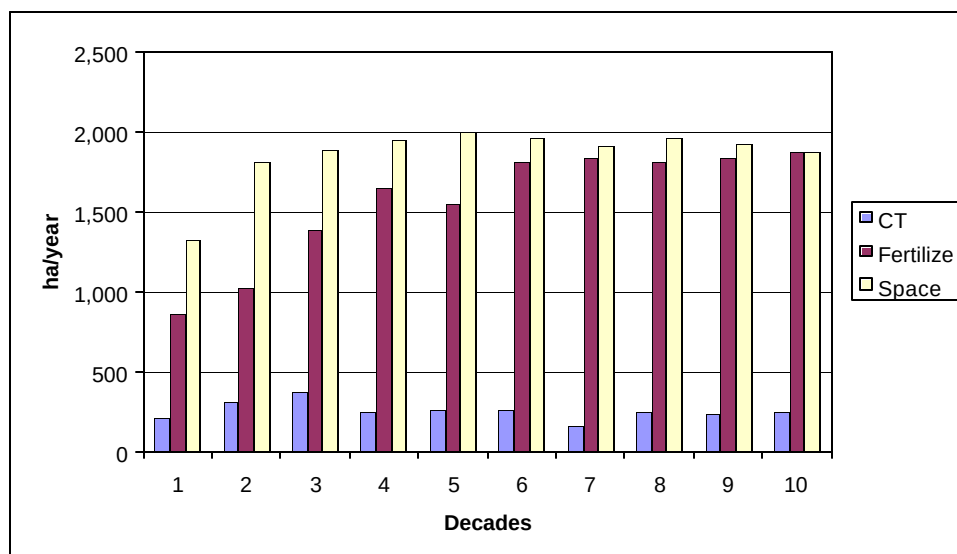


Figure 20 – Treatments in the full biodiversity with silviculture scenario

9.5 Proposed Scenarios

9.5.1 General

The development of a proposed scenario incorporates understanding and results from the previous scenarios in a sequential process to present a solution that satisfies multiple emphases. This process was followed to produce the Sunshine Coast TSA proposed option. This option represents an attempt to balance the benefits identified in the previous scenarios.

As presented in the volume strategy scenarios (Section 9.2), the assessment of different budget levels indicated that the required investment level for maximizing volume flows is somewhere around \$3.6 million per annum. A subjective decision was made that the proposed option should attempt to modestly increase the harvest level from the SS strategy base case and the value scenarios while still providing larger diameters and value per cubic meter.

The value scenarios indicated that investment levels greater than \$1 million did not significantly increase the timber quality at the TSA level. Therefore, a strategy was developed that would produce more volume than the base case while maintaining the higher quality of the long-term timber supply. This was done by:

- Choosing budget level of \$1.5 Million with a 10 % tolerance for variance in budget level. This budget level was chosen as it was expected that it would facilitate an increase in the harvest level;
- Setting the harvest flow 10% higher than the SS base case with 7% flow tolerance. This allowed the model to set its own harvest level within the tolerance;

- Maintaining the value weighting in the optimization function the same as in the value scenarios.

During the preparation of this report some of the original TSR 2 regeneration assumptions were changed. In addition, it became evident that some of the cost assumptions used earlier in this analysis may have been biased by temporarily inflated cost structures driven by Forest Renewal BC related funding. For this reason, several additional analysis runs were completed. The following will present both the original strategy and the proposed strategy based on the updated cost and regeneration information.

9.5.2 Original Incremental Silviculture Strategy

Figure 21 and table 6 summarize incremental annual silviculture treatments by 10-year periods over the next 100 years with the average annual budget of \$1.6 million. Over the first 20 years, almost 18,750 ha of spacing and over 25,000 ha of fertilization are scheduled. Fertilization increases future stand yields and is a significant contributor to the increase in the long-term harvest. It provides a cost-efficient treatment to increase future managed stand yields and quality, and the Sunshine Coast TSA should consider implementing and maintaining a substantial fertilization program relative to the area treated by other incremental activities.

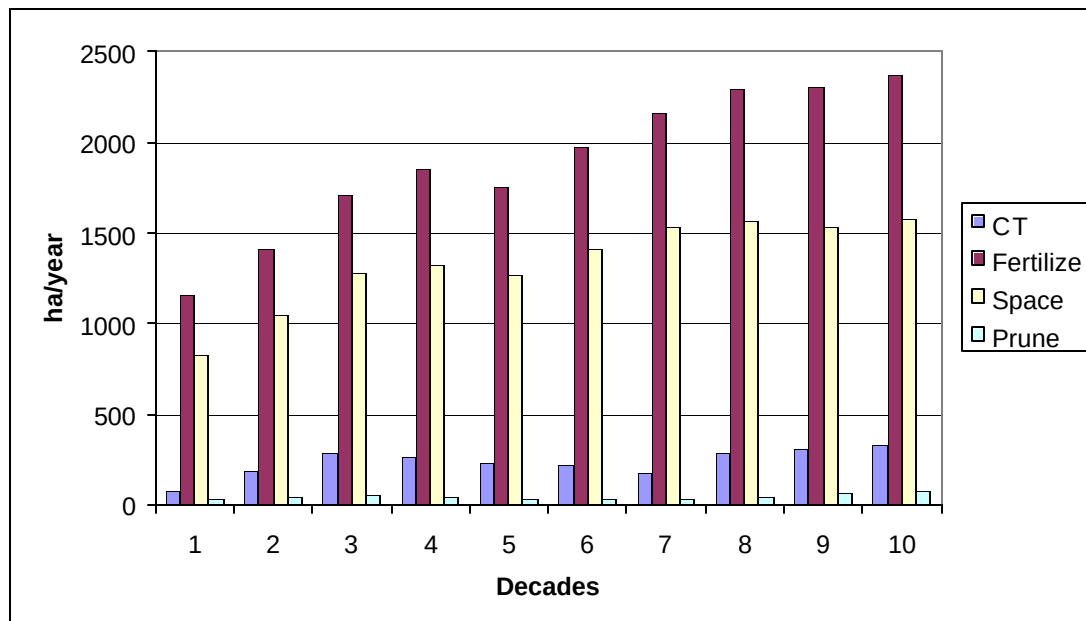


Figure 21 – Silviculture treatments (ha/yr); original strategy

Table 6 - Silviculture treatments (ha/yr); original strategy

Decade	CT	Fertilize	Space	Prune
1	78	1156	827	32
2	188	1411	1048	41
3	286	1712	1278	54
4	265	1854	1322	42
5	235	1757	1271	26
6	222	1971	1409	29
7	169	2169	1528	34
8	288	2293	1565	39
9	306	2304	1535	62
10	328	2369	1579	80

While area treated is dominated by fertilization, only a small amount of pruning is proposed in this scenario. Pruning is a costly treatment ranging from \$1500–2500/ha. It is a treatment option only in good and medium Douglas-fir stands.

Juvenile spacing also comprises a significant portion of the area treated and through the first ten years averages approximately 827 ha/year.

The following table examines the proposed treatments in more detail showing the annual areas treated by different regimes for the first 100 years.

Table 7 – Proposed detailed regimes for the original strategy

Decade	ct	ct fert	fert	space	space fert	space prunes	space prune fert	Grand Total
1	78	0	762	424	371	10	22	1667
2	149	39	856	516	491	15	26	2094
3	185	102	953	603	621	17	37	2520
4	177	88	1057	598	683	15	27	2648
5	162	72	979	552	692	13	13	2489
6	120	101	1119	641	739	17	12	2756
7	44	125	1230	696	798	18	16	2934
8	149	139	1321	716	810	16	24	3181
9	168	139	1377	723	749	23	39	3226
10	174	154	1428	756	743	35	44	3345

The following table illustrates how treatment totals are divided between analysis units during the first 100 years. Most treatments occur on medium and poor fir sites (70% to 80% of all treatments).

Table 8 – Distribution of treatments between analysis units

Decade	Cedar good/medium	Fir good	Fir medium	Fir poor	HemBalSpruce good	HemBalSpruce medium	Total
1	6.25%	4.40%	33.52%	41.76%	4.48%	9.58%	100%
2	8.20%	6.98%	33.01%	41.00%	7.46%	3.35%	100%
3	7.19%	7.07%	33.33%	40.26%	8.04%	4.11%	100%
4	6.08%	8.41%	35.44%	41.09%	5.25%	3.73%	100%
5	4.75%	9.51%	35.96%	42.31%	3.09%	4.36%	100%
6	4.92%	10.82%	31.77%	42.96%	3.94%	5.58%	100%
7	5.33%	9.96%	33.19%	42.65%	2.42%	6.45%	100%
8	4.94%	9.28%	33.43%	40.90%	4.64%	6.80%	100%
9	5.42%	9.49%	35.01%	38.72%	4.96%	6.40%	100%
10	5.82%	9.55%	36.74%	37.38%	4.69%	5.83%	100%

When examining the proposed treatments for the first decade, the following trends can be found:

- **Commercial Thinning:** Only 78 hectares per year are proposed for the whole decade. This is likely due to a lack of eligible stands available for commercial thinning as the amount of commercial thinning increases significantly throughout the planning horizon.
- **Fertilization:** This treatment usually follows spacing or spacing/pruning treatments with 762 hectares per year being proposed over the first decade of the planning horizon. The proposed treatment area is divided between two Fir site types: Fir poor sites receive 60% with the remaining 40% allocated to medium site Fir stands.
- **Spacing:** A total of 424 hectares of annual spacing treatments are proposed for the first decade. Medium HemBalSpruce sites receive approximately 38% of this treatment. Cedar good/medium has a 24% share and Fir poor a 20% share.
- **Space/Fertilize:** A total of 371 hectares annually are proposed for the next ten years. The treatment area is allocated for medium site Fir (48%), poor site Fir (42%) and good site Fir (9%).
- **Space/Prune:** Only good and medium site Fir stands are eligible for this treatment regime, which combines spacing and pruning. As both pruning lifts occur during one decade, this treatment includes spacing, pruning 1st lift and pruning 2nd lift. A total of 10 hectares annually are proposed during the first decade of the planning horizon (40% Fir good, 60% Fir medium).
- **Space/Prune/Fertilize:** Only good and medium site Fir stands are eligible for this treatment regime, which combines spacing, pruning and fertilization. As both pruning lifts occur during one decade, this treatment includes spacing,

fertilization, pruning 1st lift and pruning 2nd lift. A total of 22 hectares annually are proposed during the first decade of the planning horizon (14% Fir good, 86% Fir medium).

Table 9 reiterates the proposed annual spacing, fertilization and pruning treatments for the first decade in more detail.

Table 9 – Proposed regimes; first decade

Analysis Unit	ct	fert	space	space fert	space prune	space prune fert	Total
Cedar good/medium	N/a	N/a	104	N/a	N/a	N/a	104
Fir good	12	8	12	34	4	3	73
Fir medium	32	300	23	179	6	19	559
Fir poor	N/a	454	84	158	N/a	N/a	696
HemBalSpruce good	34	N/a	41	N/a	N/a	N/a	75
HemBalSpruce medium	N/a	N/a	160	N/a	N/a	N/a	160
Grand Total	78	762	424	371	10	22	1667

9.5.3 Proposed Incremental Silviculture Strategy

Upon completing the original Type 2 analysis runs and interpreting the results it became evident that some of the treatment costs may have been overestimated. Also, it was felt that some of the cost zones should be adjusted. Furthermore, the original analysis used regeneration assumptions from TSR 2. Those assumptions were recently modified to account for the current practise of converting some hemlock stands to Douglas-fir stands.

Several additional analysis runs were completed with updated regeneration assumptions and treatment cost assumptions. All other assumptions were kept identical to those of the original analysis. The treatment costs were changed as follows:

Table 10 – Amended treatment costs

Treatment	Cost Zone					
	Low		Medium		High	
	Old Cost	New Cost	Old Cost	New Cost	Old Cost	New Cost
Spacing (per ha)	\$1200	\$800	\$1700	\$1000	\$2400	\$1500
Pruning 1 st lift (per ha)	\$1800	\$1350	\$2200	\$1350	\$2500	\$1550
Pruning 2 nd lift (per ha)	\$1500	\$1550	\$2100	\$1550	\$2300	\$1550
Fertilization (per ha)	\$150	\$150	\$200	\$200	\$250	\$250
Commercial Thin (per ha)	\$0	\$0	\$0	\$0	\$0	\$0

There were also changes to the cost zones as per the following table:

Table 11 – Amended cost zones

Landscape Unit	Original Cost Zone	New Cost Zone
Homathko	High	High
Southgate	High	High
Bute West	High	Medium
Bute East	High	Medium
Bishop	High	High
Toba	High	Medium
Brem	High	Medium
Quatam	High	Medium
Homfray	High	Medium
Powell Daniels	High	Low
Brittain	High	Medium
Skwawka	High	Medium
Jervis	High	Medium
Bunster	Low	Low
Haslam	Low	Low
Lois	Low	Low
Sechelt	Low	Low
Chapman	Low	Low
Cortes	Medium	Low
Texada	Medium	Low
Powell Lake	Medium	Low
Narrows	Medium	Low
Salmon	Medium	Low
Howe	Medium	Low

Original TSR 2 documents assumed that all hemlock stands would regenerate to hemlock and remain that way until the end of the rotation. The district staff now feel that current practise is different: they estimate that a large portion of hemlock leading stands will be converted to Douglas fir. The following table illustrates the changes made in hemlock transitions (regeneration assumptions) for the additional analysis runs.

Table 12 – Amended regeneration assumptions; hemlock leading stands

Analysis Unit	Old Transition		New Transition	
	% Hemlock	% Fir	% Hemlock	% Fir
Hemlock Good	100	0	33	77
Hemlock Medium	100	0	44	56
Hemlock Poor	100	0	71	29

All tested runs used the same assumptions as the original analysis, except for the changes in costs and transitions as documented above. The intent was to use the same harvest level as in the original strategy if possible. The analyses performed are listed below:

Table 13 – Additional analysis runs

Analysis	Costs	Transitions
Analysis 1	New Costs	Old Transitions
Analysis 2	75% of New Costs	Old Transitions
Analysis 3	New Costs	New Transitions
Analysis 4	75% of New Costs	New Transitions
Analysis 5	New Costs, forced budget	New Transitions

Note that when using 75% of the new costs, only spacing and pruning costs were adjusted.

Analyses 1 and 2 used hemlock transitions from the original analysis and tested the sensitivity of analysis results to treatment costs. Analyses 3, 4 and 5 used new hemlock transitions (current practise) and also tested the sensitivity of analysis results to treatment costs.

Only Analyses 3 and 5 were considered for the proposed silviculture strategy, as they both represented the best estimates of treatment costs and used regeneration assumptions that are considered current practise. Analysis assumptions and inputs for analyses 3 and 5 were identical except for the fact that analysis 3 allowed budget fluctuations from one decade to another, whereas analysis 5 maintained the annual silviculture budget throughout the planning horizon. As maintaining a consistent budget was considered important, Analysis 5 results were designated as the basis for the proposed silviculture strategy.

Figure 22 and Table 14 summarize incremental annual silviculture treatments by 10-year periods over the next 100 years with the average annual budget of \$1.5 million. Over the first 10 years, almost 6,110 ha of spacing and over 7,530 ha of fertilization are scheduled.

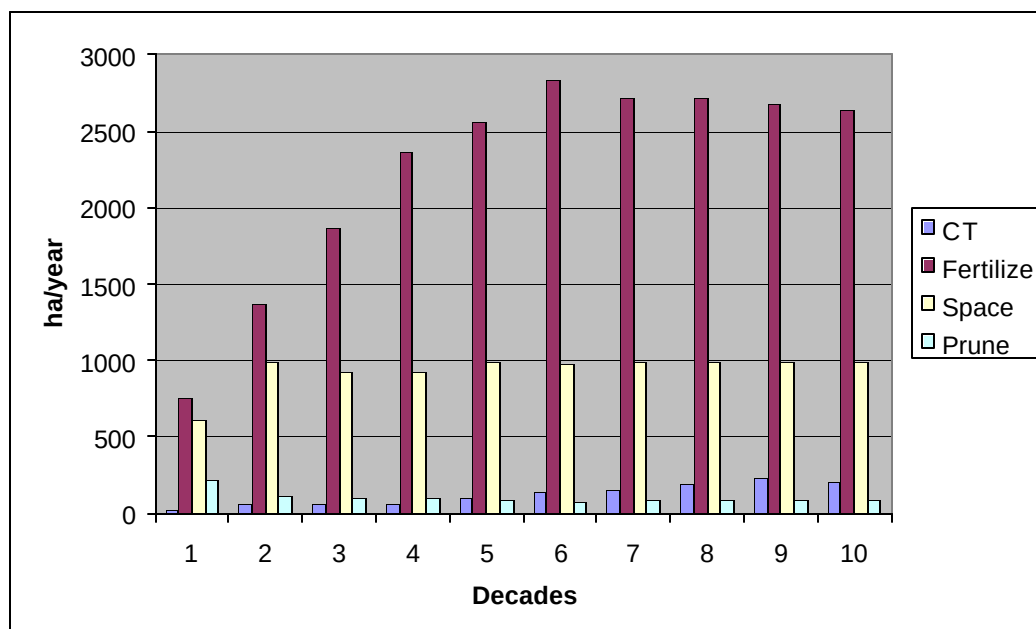


Figure 22 – Silviculture treatments (ha/yr); proposed strategy

Table 14 - Silviculture treatments (ha/yr); proposed strategy

Decade	CT	Fertilize	Space	Prune
1	26	753	611	218
2	57	1373	995	114
3	62	1869	925	96
4	66	2359	929	99
5	102	2559	996	84
6	141	2830	983	73
7	148	2719	990	85
8	196	2719	986	83
9	231	2684	997	87
10	210	2643	995	94

The lower cost increased proposed pruning significantly from the original strategy. During the first two decades a grand total of 3,320 ha of pruning is proposed.

The following table examines the proposed treatments in more detail showing the annual areas treated by different regimes for the first 100 years.

Table 15 – Proposed detailed regimes for the proposed strategy

Decade	ct	ct fert	fert	space	space fert	space prunes	space prune fert	Total
1	26	0	475	295	98	38	180	1112
2	57	0	752	348	533	27	87	1805
3	62	0	1339	366	463	28	68	2325
4	57	8	1773	325	505	27	72	2768
5	53	49	1941	394	518	32	52	3039
6	61	80	2198	407	504	24	49	3322
7	48	100	2121	459	446	32	53	3259
8	113	83	2110	428	475	32	51	3292
9	95	137	2004	432	479	23	65	3233
10	123	87	2030	427	474	42	52	3235

The following table illustrates how treatment totals are divided between analysis units during the first 100 years. Most treatments occur on medium and poor fir sites.

Table 16 – Distribution of treatments between analysis units

Decade	Cedar g/m	Fir g	Fir m	Fir p	HBS g	HBS m	Total
1	6.4%	1.6%	34.7%	40.6%	6.5%	10.2%	100%
2	4.5%	7.0%	33.5%	48.6%	2.3%	4.1%	100%
3	4.5%	9.1%	31.5%	49.7%	4.1%	1.2%	100%
4	2.5%	9.1%	34.0%	50.5%	2.2%	1.8%	100%
5	3.8%	10.2%	31.1%	51.1%	2.0%	1.7%	100%
6	3.8%	11.6%	29.0%	51.9%	1.8%	1.9%	100%
7	3.0%	10.7%	30.8%	50.2%	1.7%	3.6%	100%
8	3.1%	9.7%	34.1%	47.6%	2.3%	3.2%	100%
9	2.7%	9.6%	36.0%	46.3%	2.6%	2.8%	100%
10	3.4%	10.8%	39.1%	41.1%	3.1%	2.5%	100%

When examining the proposed treatments for the first decade, the following trends can be found:

- **Commercial Thinning:** Only 26 hectares per year are proposed for the whole decade.

- **Fertilization:** This treatment usually follows spacing or spacing/pruning treatments with 475 hectares per year being proposed over the first decade of the planning horizon. The proposed treatment area is divided between two Fir site types: Poor Fir sites receive 67% with the remaining 33% allocated to medium site Fir stands.
- **Spacing:** A total of 295 hectares of annual spacing treatments are proposed for the first decade. Medium HemBalSpruce sites receive approximately 38% of this treatment. Cedar good/medium has a 24% share.
- **Space/Fertilize:** A total of 98 hectares annually are proposed for the next ten years. The treatment area is allocated for poor site Fir (85%) and mediumr site Fir (15%).
- **Space/Prune:** Only good and medium site Fir stands are eligible for this treatment regime, which combines spacing and pruning. As both pruning lifts occur during one decade, this treatment includes spacing, pruning 1st lift and pruning 2nd lift. A total of 38 hectares annually are proposed during the first decade of the planning horizon (79% Fir medium, 21% Fir good).
- **Space/Prune/Fertilize:** Only good and medium site Fir stands are eligible for this treatment regime, which combines spacing, pruning and fertilization. As both pruning lifts occur during one decade, this treatment includes spacing, fertilization, pruning 1st lift and pruning 2nd lift. A total of 180 hectares annually are proposed during the first decade of the planning horizon (3% Fir good, 97% Fir medium).

Table 17 reiterates the proposed annual spacing, fertilization and pruning treatments for the first decade in more detail.

Table 17 – Proposed regimes; first decade

Analysis Unit	ct	fert	space	space fert	space prune	space prune fert	Total
Cedar good/medium			71				71
Fir good	3				8	6	18
Fir medium	11	155	3	13	30	173	386
Fir poor		320	47	85			452
HemBalSpruce good	11		61				73
HemBalSpruce medium			113				113
Grand Total	26	475	295	98	38	180	1112

9.6 Anticipated Silviculture Strategy Outcomes, Original Strategy

9.6.1 Harvest Flow

Figure 23 compares the short, mid and long-term harvest level for the SS base case, Volume maximization and the original strategy scenarios. The original strategy has a 1.1 % higher short-term harvest level and 4.2 % higher long-term harvest level than the SS base case. While the original strategy scenario has a lower harvest level than volume maximization, it represents a balanced solution between volume and value.

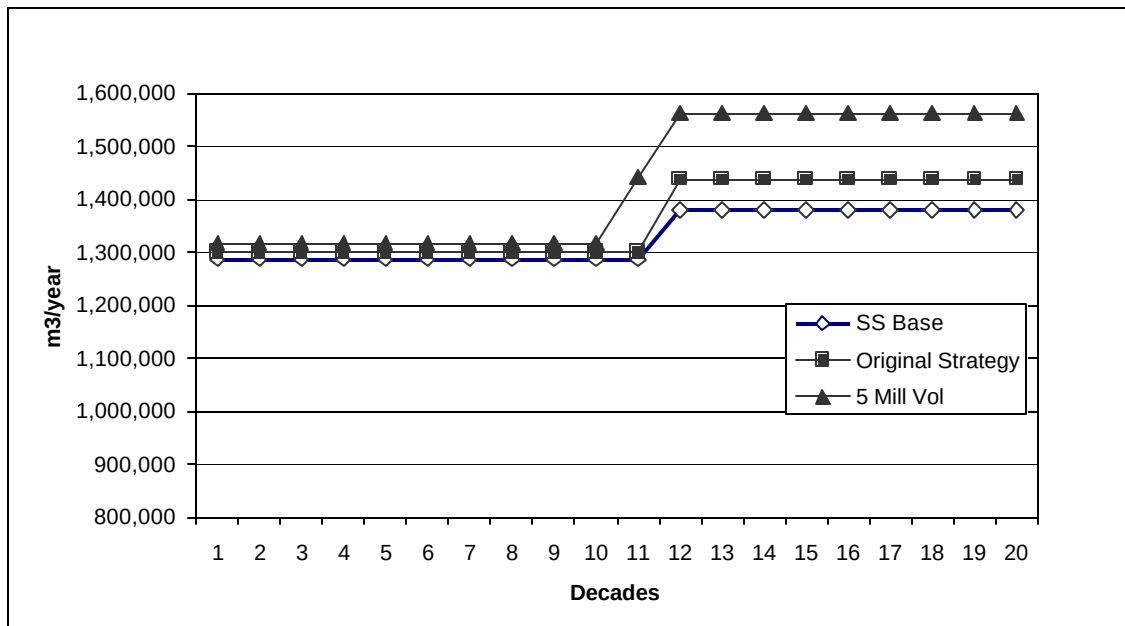


Figure 23 – Harvest level; original strategy scenario

9.6.2 Diameter

Table 18 shows managed stand quadratic mean diameters for all analysis units within the TSA that received treatments comparing the original strategy with the Silviculture Strategy Base Case.

Table 18 – Predicted quadratic mean diameter for all treated analysis units; SS base case – Original

Decade	SS Base	S	SS Base	S	SS Base	S	SS Base	S	SS Base	S	SS Base	S
	<i>Cedar g/m</i>	<i>Cedar g/m</i>	<i>Fir g</i>	<i>Fir g</i>	<i>Fir m</i>	<i>Fir m</i>	<i>Fir p</i>	<i>Fir p</i>	<i>HBS g</i>	<i>HBS g</i>	<i>HBS m</i>	<i>HBS m</i>
5	31.5	24.6	33.3	26.3	29.5	32.9	28.0	27.0	29.3	28.9	24.8	23.6
6	24.9	28.4	34.1	31.6	26.5	37.1	28.7	27.8	29.7	33.8	25.3	27.5
7	26.9	31.1	31.9	31.8	28.4	36.9	25.4	26.9	31.0	34.9	27.6	31.4
8	28.9	31.3	31.6	34.3	25.6	38.4	21.1	26.3	36.7	34.4	30.8	33.7
9	30.1	31.6	35.1	40.1	26.7	40.4	21.0	28.1	28.4	38.6	25.5	35.3
10	27.2	33.0	37.8	42.4	26.7	40.4	22.4	27.9	28.8	39.2	26.7	36.4
11	26.9	34.0	45.8	42.4	27.3	41.3	19.8	27.3	31.3	40.1	25.7	34.6
12	27.8	34.5	41.6	45.2	28.3	41.1	19.9	27.4	32.6	40.7	26.9	35.1
13	28.5	35.8	42.6	48.6	29.0	41.1	19.7	27.3	32.7	42.6	27.0	34.5
14	28.8	36.0	43.5	52.1	28.8	41.6	20.1	26.8	32.7	44.2	27.6	33.5
15	28.7	36.9	41.0	53.7	29.2	42.5	20.7	26.4	34.4	43.9	27.7	33.6
16	27.3	36.5	41.8	52.8	29.1	42.8	21.0	26.6	31.8	46.1	28.7	31.6
17	31.2	36.8	44.6	51.1	30.0	42.8	20.3	26.2	31.1	47.3	28.5	33.5
18	28.2	37.3	44.5	54.7	29.1	42.7	20.4	26.9	32.0	46.0	27.4	33.1
19	26.8	38.4	43.9	55.9	28.0	43.1	21.8	27.4	32.5	48.0	25.2	33.9
20	26.6	37.3	39.5	54.4	26.8	44.6	20.9	27.8	33.3	45.8	24.9	34.9

All treated analysis units have a greater mean diameter for most decades.

9.6.3 Value and Quality

Figure 24 compares the value per cubic meter between the original strategy, SS base case and the \$5 million value scenario. The value per cubic meter is derived from the log values, which form part of the input data in the analysis as described in the Analysis Information Package. The log values are assumed to remain constant throughout the planning horizon. The gain in the value per cubic meter is achieved through larger log sizes and clear wood. Spacing and fertilization can increase the sizes of logs and pruning creates clear wood.

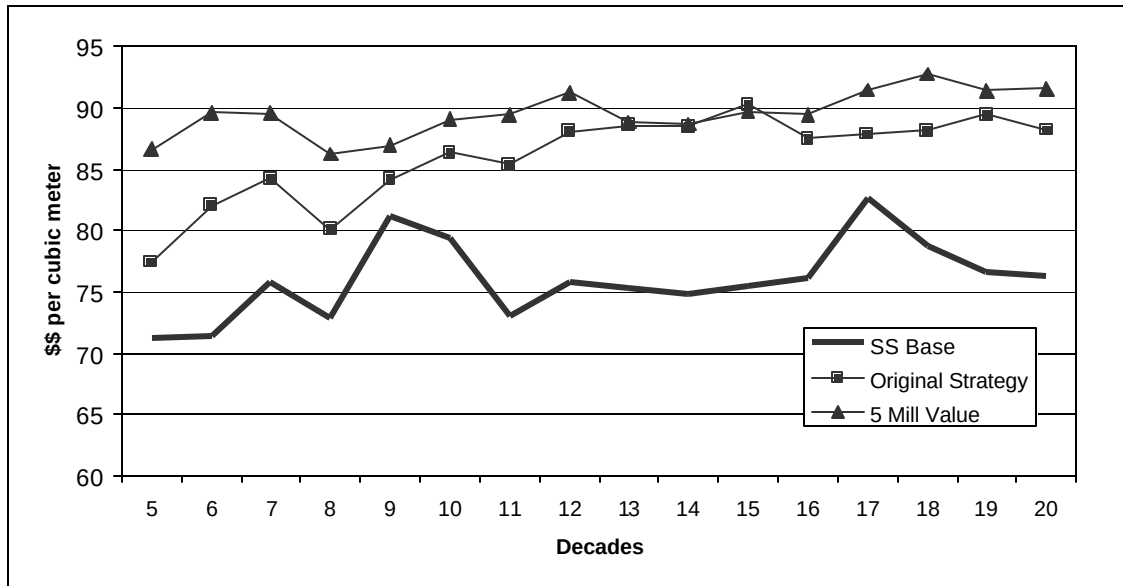


Figure 24 - Value per cubic meter; original strategy

The original strategy does not quite reach the per cubic meter value of the \$5 million value scenario. However, the value stays well above the SS base case. The high per cubic meter value for the \$5 million value scenario is primarily due to significant expenditures on pruning.

Pruning was an eligible treatment only on good and medium fir sites. Table 19 illustrates the predicted volume of clear wood compared to the total harvest volume and harvest volume from pruned stands.

Table 19 - Predicted annual volume of clear wood from pruning, original strategy

Decade	Total Harvest Volume	Clear Volume	%	Volume from Pruned Stands	Clear Volume	%
5	1,300,642	2,851	0.22%	7,099	2,851	40%
6	1,300,642	6,247	0.48%	16,615	6,247	38%
7	1,300,642	9,233	0.71%	26,771	9,233	34%
8	1,300,642	4,814	0.37%	13,876	4,814	35%
9	1,300,642	7,214	0.55%	21,663	7,214	33%
10	1,300,642	7,449	0.57%	21,243	7,449	35%
11	1,300,642	3,775	0.29%	11,304	3,775	33%
12	1,436,529	5,989	0.42%	18,308	5,989	33%
13	1,436,529	4,486	0.31%	13,622	4,486	33%
14	1,436,529	5,462	0.38%	17,549	5,462	31%
15	1,436,529	4,353	0.30%	12,513	4,353	35%
16	1,436,529	5,345	0.37%	15,457	5,345	35%
17	1,436,529	5,662	0.39%	16,661	5,662	34%
18	1,436,529	6,140	0.43%	18,291	6,140	34%
19	1,436,529	4,972	0.35%	14,677	4,972	34%
20	1,436,529	6,270	0.44%	18,336	6,270	34%

The significant production of clear wood starts during the 5th decade. The clear wood percent exceeds 0.5 % in decade 9 and 10, but generally stays between 0.3 and 0.4 %.

9.6.4 Employment

Tables 20 and 21 illustrate the short- and long-term employment created by incremental silviculture. In the short-term, incremental silviculture creates mostly direct jobs associated with silviculture treatments. The long-term employment opportunities are related to the projected changes in harvest level. Table 12 compares the long-term jobs created by the proposed scenario to the silviculture strategy base case. Employment multipliers were utilized from the TSR 2 Socio-Economic Analysis by the Economics and Trade Branch of the Ministry of Forests.

As can be seen from Table 21, there is an apparent net gain of jobs from the original strategy compared to the SS base case. The purpose of the employment comparison is to show potential relative employment changes as a result of silviculture investment.

There is no direct relationship between the harvest level that may be achieved through silviculture and the TSR 2 base case, and subsequent employment in the Sunshine Coast TSA. The only direct relationship between harvest levels and employment in the TSA is based on the actual AAC determination.

The potential to produce higher quality timber may result in value-added job opportunities that have not been assessed in this analysis.

Table 20 – Short-term employment benefits, jobs

Year	Space	Prune	Fertilize	CT	Total
1	18.4	2.0	0.6	0.9	21.9
2	18.4	2.0	0.6	0.9	21.9
3	18.4	2.0	0.6	0.9	21.9
4	18.4	2.0	0.6	0.9	21.9
5	18.4	2.0	0.6	0.9	21.9
Sub Total	91.9	9.8	3.2	4.3	109.3
6-10	91.9	9.8	3.2	4.3	109.3
11-15	116.4	12.4	3.9	10.5	143.2
16-20	116.4	12.4	3.9	10.5	143.2
Total 20 Years	416.7	44.4	14.3	29.5	504.9

Table 21 – Long-term employment benefits^a

Decade	Harvest Increment (‘000)	Incremental TSA Jobs by Decade	Incremental Provincial Jobs by Decade
1	15	108.0	396.0
2	15	108.0	396.0
3	15	108.0	396.0
4	15	108.0	396.0
5	15	108.0	396.0
6	15	108.0	396.0
7	15	108.0	396.0
8	15	108.0	396.0
9	15	108.0	396.0
10	15	108.0	396.0
11	15	108.0	396.0
12	58	417.6	1531.2
13	58	417.6	1531.2
14	58	417.6	1531.2
15	58	417.6	1531.2
16	58	417.6	1531.2
17	58	417.6	1531.2
18	58	417.6	1531.2
19	58	417.6	1531.2
20	58	417.6	1531.2
Total	689	4946.4	18136.8

^aMultipliers as per TSR 2, TSA 0.74, Province 2.64 per 1,000 m³ of AAC

9.7 Anticipated Silviculture Strategy Outcomes, Proposed Strategy

9.7.1 Harvest Flow

Figure 25 compares the short, mid and long-term harvest level for the SS base case, original strategy and the proposed strategy. It is important to note that the analysis assumptions were different for the proposed strategy (different regeneration assumptions and cost assumptions) and as such the differences in harvest flows cannot be attributed to any particular silviculture regime related factor. The harvest level is lower than that of the SS base case; converting hemlock stands to Douglas resulted in smaller harvest volumes for those stands.

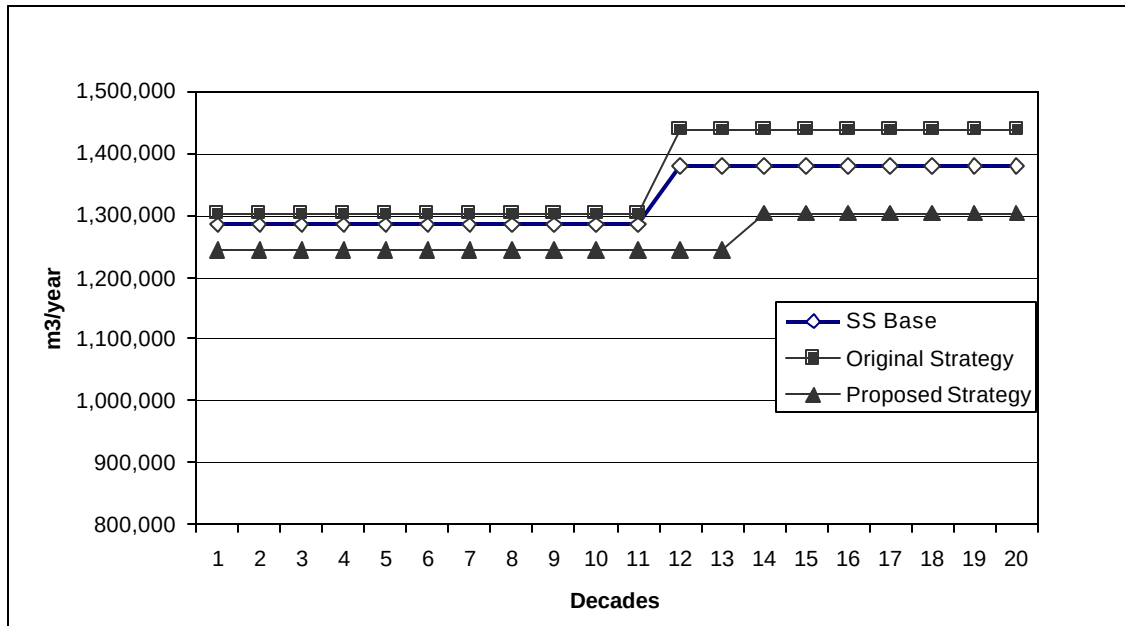


Figure 25 – Harvest level; proposed strategy

9.7.2 Diameter

Table 22 shows managed stand quadratic mean diameters for all analysis units within the TSA that received treatments comparing the proposed strategy with the SS base case.

All treated analysis units have a greater mean diameter for most decades.

Table 22 – Predicted quadratic mean diameter for all treated analysis units; SS base case – Proposed

Decade	SS Base	Prop	SS Base	Prop	SS Base	Prop	SS Base	Prop	SS Base	Prop	SS Base	Prop
	<i>Cedar g/m</i>	<i>Cedar g/m</i>	<i>Fir g</i>	<i>Fir g</i>	<i>Fir m</i>	<i>Fir m</i>	<i>Fir p</i>	<i>Fir p</i>	<i>HBS g</i>	<i>HBS g</i>	<i>HBS m</i>	<i>HBS m</i>
6	24.9	37.9	34.1	35.3	26.5	34.9	28.7	27.2	29.7	38.9	25.3	34.3
7	26.9	37.2	31.9	37.5	28.4	36.7	25.4	28.0	31.0	38.8	27.6	35.1
8	28.9	39.1	31.6	40.8	25.6	38.6	21.1	28.9	36.7	41.5	30.8	36.8
9	30.1	41.1	35.1	41.9	26.7	38.3	21.0	29.5	28.4	43.5	25.5	38.5
10	27.2	42.5	37.8	45.5	26.7	39.7	22.4	29.9	28.8	43.1	26.7	40.2
11	26.9	42.8	45.8	44.5	27.3	40.7	19.8	30.7	31.3	44.3	25.7	41.5
12	27.8	42.6	41.6	47.6	28.3	40.6	19.9	30.4	32.6	44.7	26.9	41.8
13	28.5	42.4	42.6	49.3	29.0	40.7	19.7	30.4	32.7	46.7	27.0	43.1
14	28.8	42.6	43.5	49.2	28.8	40.6	20.1	30.8	32.7	48.2	27.6	41.9
15	28.7	42.9	41.0	48.0	29.2	40.9	20.7	30.6	34.4	47.9	27.7	40.1
16	27.3	41.6	41.8	48.0	29.1	41.5	21.0	30.5	31.8	47.9	28.7	39.7
17	31.2	42.5	44.6	47.7	30.0	42.1	20.3	30.4	31.1	49.7	28.5	38.9
18	28.2	43.1	44.5	49.5	29.1	42.4	20.4	30.6	32.0	52.0	27.4	40.0
19	26.8	43.4	43.9	47.5	28.0	43.0	21.8	30.8	32.5	51.8	25.2	41.0
20	26.6	43.9	39.5	48.5	26.8	42.6	20.9	30.9	33.3	51.0	24.9	41.4

9.7.3 Value and Quality

Figure 26 compares the value per cubic meter between the original strategy, SS base case and the proposed strategy. The value per cubic meter is derived from the log values, which form part of the input data in the analysis as described in the Analysis Information Package. The log values are assumed to remain constant throughout the planning horizon. The gain in the value per cubic meter is achieved through larger log sizes and clear wood. Spacing and fertilization can increase the sizes of logs and pruning creates clear wood.

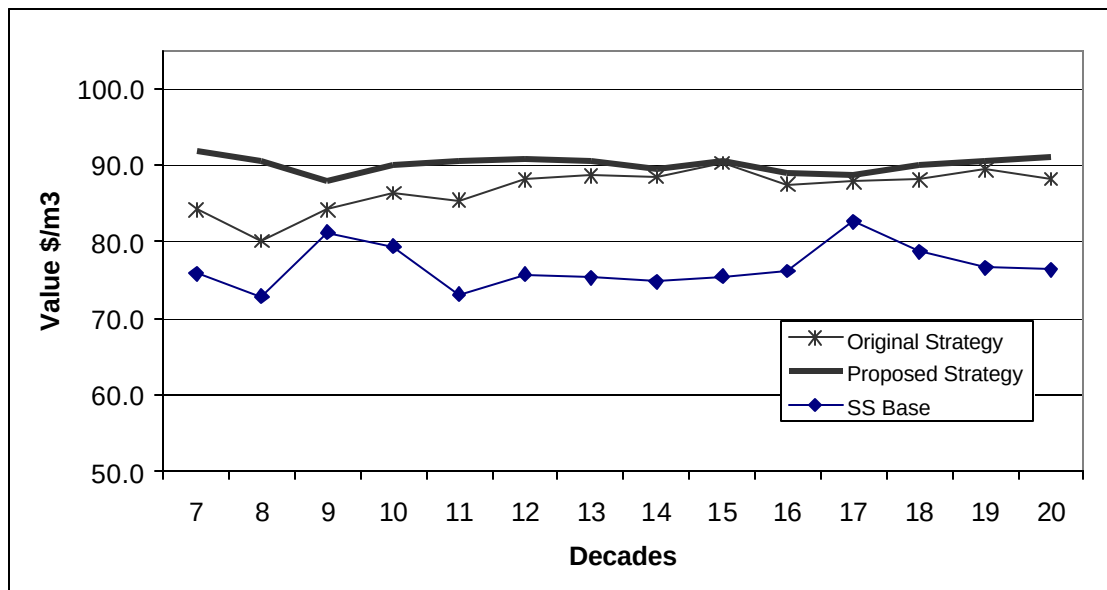


Figure 26 - Value per cubic meter; proposed scenario

Pruning was an eligible treatment only on good and medium fir sites. Table 23 illustrates the predicted volume of clear wood compared to the total harvest volume and harvest volume from pruned stands.

Table 23 - Predicted annual volume of clear wood from pruning, proposed strategy

Decade	Total Harvest Volume	Clear Volume	%	Volume from Pruned Stands	Clear Volume	%
5	1,271,569	10,243	0.81%	26,107	10,243	39%
6	1,265,323	19,552	1.55%	52,002	19,552	38%
7	1,263,172	23,113	1.83%	65,240	23,113	35%
8	1,249,810	26,572	2.13%	77,130	26,572	34%
9	1,244,461	19,842	1.59%	57,983	19,842	34%
10	1,242,825	21,251	1.71%	63,635	21,251	33%
11	1,237,052	19,212	1.55%	57,863	19,212	33%
12	1,228,636	20,512	1.67%	62,229	20,512	33%
13	1,226,290	17,203	1.40%	52,794	17,203	33%
14	1,309,737	14,841	1.13%	44,499	14,841	33%
15	1,312,717	17,376	1.32%	51,461	17,376	34%
16	1,310,863	14,991	1.14%	44,997	14,991	33%
17	1,310,535	16,845	1.29%	49,150	16,845	34%
18	1,325,739	14,956	1.13%	44,972	14,956	33%
19	1,315,301	16,425	1.25%	48,133	16,425	34%
20	1,323,103	20,348	1.54%	60,493	20,348	34%

The significant production of clear wood starts during the 5th decade. The clear wood percent is considerably higher than in the original scenario staying above one percent throughout most of the planning horizon.

9.7.4 Employment

Table 24 illustrates the short-term employment created by incremental silviculture. In the short-term, incremental silviculture creates mostly direct jobs associated with silviculture treatments. The long-term employment comparison with the SS Base case is not appropriate because the SS base case was based on different analysis assumptions.

Table 24 – Short-term employment benefits, jobs

Year	Space	Prune	Fertilize	CT	Total
1	13.6	13.3	0.4	0.3	27.6
2	13.6	13.3	0.4	0.3	27.6
3	13.6	13.3	0.4	0.3	27.6
4	13.6	13.3	0.4	0.3	27.6
5	13.6	13.3	0.4	0.3	27.6
Sub Total	67.9	66.6	2.1	1.4	138.0
6-10	67.9	66.6	2.1	1.4	138.0
11-15	110.6	34.8	3.8	3.2	152.4
16-20	110.6	34.8	3.8	3.2	152.4
Total 20 Years	356.9	202.9	11.8	9.2	580.8

10 Discussion

10.1 Interpreting Forest Level Analysis Results

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

- The range of possible budget levels and silviculture regimes is 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; let it be value, volume, dbh etc.
- Heuristic optimization type models work well when trying to balance different competing objectives, such as volume, value and non-forest values. However, the results of optimization 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.

10.1.1 Modeling for Multiple Objectives Simultaneously

This analysis used simulation and optimization techniques. All scenarios involving silviculture budget allocations, and therefore silviculture strategy development, used simulated annealing; a pseudo optimization technique that finds near optimal solutions. The *FSOS* model attempted to find a near optimum solution for the combination of annual harvest, value and non-forest resources while expending the desired budget in incremental silviculture. Different weights given to different variables, in this case, annual harvest, value and non-forest resources can control the results.

10.1.2 Volume Scenarios

These scenarios tested how different annual investment levels impact harvest level in the short and long term. Only harvest flow and non-timber resources are optimized. In simplistic terms, the set budget levels are expended and the model finds the most efficient treatment combinations to meet the desired harvest levels without violating the set cover constraints.

With the limited number of variables in play (harvest volume, cover constraints) it is reasonably easy to understand the results. Those regimes that impact harvest flow (fertilization, commercial thinning and some spacing regimes) are usually chosen.

10.1.3 Value Scenarios

In these scenarios the optimization function now included value as one of the variables. Value was defined as net present value. All silviculture costs and estimated harvest revenues were aggregated at the forest level for each decade. The difference was brought

back to today's dollars using a 4% discount rate. The model was then used to find a solution that would maximize the forest level difference between costs and revenues over the planning horizon while maintaining the desired harvest level and meeting all the cover constraints.

The model would invest in those silviculture regimes that would create value, i.e., where the discounted difference between costs and revenues would be greatest. However, treatments that also supported the set harvest targets would be favoured.

Pruning is an expensive treatment that creates significant value in this analysis. Stands that were pruned received a significant value increase as per the Ministry of Forests, 2000 report: Clear Wood Values from Pruning, Madison's Canadian Lumber Reporter, and The Tree and Stand Simulator (TASS). On average, the value increase due to pruning varied from 1.6 to 2 fold for a stand compared to a similar stand with no pruning. As a result, a portion of the budgets was spent on pruning treatments in spite of their cost.

When including value in the analysis, the results, particularly in relation to variables such as average diameter and average value per cubic meter, are difficult to interpret. The composition of the harvest in each decade is impacted by silviculture treatments; however, it is also impacted by harvest scheduling.

Section 9.3 presents the results of three different value scenarios, each investing \$1 million, \$2.5 million and \$5 million annually in incremental silviculture. The \$1 million investment yielded significant gains in average diameter and value per cubic meter over the SS base case that assumed no incremental silviculture. Further increases in the budget did not bring significant gains in mean diameters and per cubic meter value, in spite of the fact that diameter enhancing treatments, such as spacing, doubled in some cases. This is likely caused by several factors:

- Harvest schedules in all value scenarios are independent of each other and different. As long as the overall solution is near optimum for net present value, harvest volume and cover constraints, an individual stand will get harvested whether its diameter is smaller or larger than in another scenario.
- The model does not optimize for diameter or piece size. It optimizes for a combination of value - expressed as net present value – harvest volume and cover constraints.
- Using set budget levels forces the model to spend funds whether it makes sense or not. Money may not be spent where it produces most value and/or largest dimensions.

10.1.4 Stand Yields

Many of the available treatment regimes reduce stand yields as modeled by TASS. While commercial thinning may help to increase harvest levels by shifting harvest from one period to another, it generally reduces merchantable stands volumes. Spacing treatments may work either way. Often they reduce stand yields, however, in some cases,

dense stands, particularly on better sites, may benefit from spacing and produce not only larger diameters and piece sizes, but also higher per hectare merchantable volumes.

In the volume maximization scenarios, incremental silviculture was able to increase the harvest flow for following reasons:

- Fertilization was used to enhance yields.
- Spacing regimes that increased yields were favoured;
- Commercial thinning was used to meet the harvest targets when necessary;

10.1.5 Pruning

The original strategy proposed little pruning compared to other available silvicultural treatments. Pruning was not proposed mainly due to its high costs; other silviculture regimes provide value at significantly lower costs.

The proposed strategy includes significantly more pruning than the original strategy. The analysis for the proposed strategy used a different set of costs and regeneration assumptions in the analysis, as documented earlier in this report.

The production of clearwood from the TSA will stay at modest levels throughout the planning horizon. An additional scenario was constructed to determine what level of expenditure would be required to produce significantly more clearwood using the cost level from the original strategy. Only pruning treatments were included (space/prune, space/fertilize/prune). The following table illustrates the anticipated annual clearwood volumes by decade from the TSA over the planning horizon with an average annual budget of \$4.4 million. At this budget level the clearwood percent reaches 5 in decade 14. Approximately 700 hectares (both lifts) are pruned and spaced annually.

Table 25 – Annual Clearwood at annual \$4.4 million pruning budget

Decade	Total Harvest Volume	Clear Volume	%
5	1,363,494	162	0.01%
6	1,363,477	1,882	0.14%
7	1,363,506	13,040	0.96%
8	1,363,394	20,742	1.52%
9	1,336,706	37,660	2.82%
10	1,336,505	49,610	3.71%
11	1,336,565	52,733	3.95%
12	1,336,518	63,380	4.74%
13	1,336,566	60,549	4.53%
14	1,389,409	74,118	5.33%
15	1,454,234	73,881	5.08%
16	1,454,360	68,629	4.72%
17	1,454,391	71,595	4.92%
18	1,454,393	82,704	5.69%
19	1,454,397	83,473	5.74%
20	1,454,397	81,818	5.63%

11 Conclusions

The intent of this report is to provide strategic direction for an incremental silviculture program in the Sunshine Coast TSA, while considering current forest management objectives and the potential to increase harvest volume and value. Workshop participants identified local objectives during the first workshop supported by direction provided by the Interim Incremental Silviculture Strategy. A scenario planning analysis approach was developed to provide a sequential process for analyzing the potential influences of different incremental silviculture strategies. Overall, this project should provide appropriate strategic-level decision support information to meet future forest management objectives.

Increase timber diversity and quality was one of the management objectives identified by the Sunshine Coast TSA group. The analysis results show significant gains in average diameters and modest amounts of clear wood due to incremental silviculture. Both average diameter and clear wood can be used as indicators for quality.

The management objective of increased timber diversity is difficult to quantify and model. From the perspective of providing varying product choices, the strategies tested created annual harvests consisting of larger diameter stands (treated) and stand with large clear wood components (pruned stands). Those stands that remained untreated produced smaller diameters. However, it is not known whether any of the tested strategies actually increased diversity of timber supply. In fact, the opposite may be true as a large portion of the current timber supply comes from existing stands with great timber diversity.

Increase volume was another management objective identified at the first workshop. Timber supply in the Sunshine Coast TSA was relatively responsive to incremental silviculture; all tested investment levels (volume scenarios) increased the short and mid term harvest by approximately 3 %. The long-term increase was more significant: 7%, 9% and 13% for the 3 different investment levels, respectively. These increases are close to the desired annual objective of 8% increase in the long-term harvest as stated in the working targets (8.2).

The proposed strategy has a lower short and long-term harvest level than the SS base case due to regeneration assumptions that converted hemlock stands to Douglas fir stands.

Make old-growth attributes available earlier through silviculture was identified as an important management objective that could potentially bring immediate habitat and timber flow benefits. Modeling of this objective was not possible as there are no generally accepted definitions for old growth attributes for different BEC variants. Age is currently used as a surrogate definition for old growth.

Make over-dense hemlock/fir/cedar stands productive for habitat and timber was also identified as a management objective that should be addressed in this analysis. However, the available inventory data does not identify these stands, nor was there any additional data available that would have made it possible to separate them from the rest

of the data. As such it was not possible to complete a scenario that would investigate the impact of silviculture in managing these problem stands.

11.1 Recommendations

The proposed strategy is only one of potentially many desirable approaches that the Ministry of Forests can follow in the Sunshine Coast TSA. Different assumptions in the modeling would likely produce slightly differing results. 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:

- If funding is available, an annual budget of up to \$1.5 million - net of CT costs - is able to maintain a reasonable harvest level while providing larger piece sizes and value (proposed strategy).
- In the first decade, 8% of available funding (9% of area treated) should go to the combination treatment of spacing and fertilization; 20% (27% of area treated) should go to spacing and 6% (43% of area treated) to fertilization of already spaced stands. The remaining 66% should be invested in pruning treatments (spacing/pruning, spacing/fertilization/pruning).
- In the first decade, the recommended annual treatment areas are 26 ha of commercial thinning, 475 ha of fertilizing, 295 ha of spacing, 98 ha spacing/fertilizing, 38 ha of hectares spacing/pruning and 180 hectares of spacing/pruning/fertilizing.
- Local objectives were set to produce more clearwood over the planning horizon than resulted from this analysis. There should be flexibility to allocate more funds to pruning than this analysis indicates if it is deemed necessary to produce more clearwood to maintain future product options. Pruning should concentrate on lower cost productive fir sites.
- The district should continue investigating the feasibility of using silviculture to create old growth conditions in the non—contributing land base (often riparian areas) to free up old growth harvesting opportunities elsewhere.

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 impact the results of any forest estate model significantly. There is uncertainty throughout the province regarding the accuracy of site indices used in different analyses. Work should continue to determine correct site indices locally.
- 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 shows to different treatment regimes. It is important for this stand level modelling work to continue.
- It is important to determine whether the operational adjustment factors used in several 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.

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Guidelines for Deviating from the Silviculture Strategy

File: 22130-20/SILV STRATEGY

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Occasionally, it will be necessary to deviate from the set of silviculture activities recommended in the Silviculture Strategy. In most Management Units in the province, the current Silviculture Strategy is the most comprehensive and rigorous evaluation of silviculture options ever conducted. Nevertheless, no Silviculture Strategy is perfect; each will always require fine-tuning. For the following reasons, it may be necessary to deviate from the plan:

1. Objectives

The complex, multiple objectives of real-world silviculture programs are imperfectly represented in the Silviculture Strategy analysis. Objectives and policies may change quickly from those assumed during the development of this Silviculture Strategy. If the objectives assumed in the Silviculture Strategy do not match the current objectives, it may be necessary to deviate from the plan.

2. Inventory and yield predictions

The inventory and yield predictions used in this analysis may contain errors. If over time, new information comes to light identifying deficiencies in the yield and landbase assumptions, it may be necessary to deviate from the plan.

3. Budgets

Budget levels, delivery mechanisms, and estimates of the impact of treatments on stand value change over time. These changes may necessitate deviations from the plan.

Thus, though this Silviculture Strategy represents a major step forward in silviculture planning, deviations from this plan may be required. **When deviation is required, it is important that the rationale for the deviation be formally documented and attached to the current Silviculture Strategy.** Considerable resources have been invested in the development of this strategy, so deviations from this plan should not be undertaken lightly. A proposed deviation from the plan should be substantiated with rigorous analysis and justification.