

Type 2 Strategic Silviculture Analysis Analysis Report

Ministry of Forests
Vancouver Forest Region
Port McNeill Forest District
Kingcome Timber Supply Area

Type 2 Strategic Silviculture Analysis
Analysis Report
March 2002

A project submitted by: Forest Ecosystem Solutions Ltd.
#210 – 275 Fell Avenue
North Vancouver BC V7P 3R5

Contact: Antti Makitalo R.P.F
tel. 604-998-2222
fax. 604-986-0361
email: amakitalo@forestecosystem.ca



Forest Ecosystem Solutions Ltd.

#210 – 275 Fell Avenue, North Vancouver BC, Canada V7P 3R5
tel 604-998-2222 fax 604-986-0361

Executive Summary

Introduction

This document presents an incremental silviculture strategy for the Kingcome 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 Kingcome TSA. The only connection between the two is that any improvements resulting from the silviculture strategy may impact future AAC determinations.

Management Objectives

The following objectives were identified in Workshop 1:

Quantity: Maintain the short-term timber supply for as long as possible. Attempt to increase the mid-term timber supply, if possible. Increase the long-term timber supply.

Quality: Manage regenerated stands to yield 4% premium logs by volume, 1% of this being clear wood and the remaining 3% of premium quality. The majority of the remaining trees should be sawlogs.

Scenarios

The designed analysis scenarios form the basis of the analysis methodology. The first scenario 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 mathematical 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 Program, First Decade

The following table presents the annual treatment areas for the next 10 years:

Treatment	Treatment Area (ha), Years 1-5	Treatment Area (ha), Years 6-10	Total Treatment Area (ha), 10 Years
Spacing	183	323	506
SCHIRP Fertilization	50	38	88
Spacing - Pruning 1lift	146	116	263
Spacing - Pruning 1st lift of 2	35	4	38
Pruning 2nd lift	0	35	35
Spacing - Pruning 1 lift + fert	0	1	1

- **Spacing:** A total of 506 hectares of spacing is proposed for the first decade. Medium Hemlock sites receive approximately 61% of this treatment. Good hemlock sites receive the rest (31%).
- **SCHIRP Fertilization:** The proposed treatment area is 88 hectares and it is divided between two Cedar salal types: Medium Cedar salal sites receive 91% with the remaining 9% allocated to poor Cedar salal stands.
- **Space/Prune 1 lift:** This treatment regime combines spacing and pruning. A total of 263 hectares are proposed during the first decade of the planning horizon (62% medium Hemlock sites, 34% good Hemlock sites and 4% of spruce/fir sites).

The following regimes/treatments contributed to the proposed solution, however their share is not significant:

- **Space/Prune 1st lift of 2:** 38 hectares recommended for the next 10 years.
- **Space/Prune 2nd lift of 2:** 35 hectares recommended for the next 10 years.
- **Space/Prune 1 lift/Fertilize:** 1 hectare recommended for the next 10 years.

Incremental Silviculture Strategy

Adopting an incremental silviculture strategy with an average annual budget level of \$268,000 as per the proposed strategy could produce the following results:

- A 3 % higher long-term harvest level.
- Approximately 0.5 % of the timber supply is clear wood starting 100 years from now.
- A modest increase (0 - 7% depending on the decade) in quadratic mean diameter over most of the planning horizon.
- An average increase of over \$3 per cubic meter in managed stand value in the long term.
- 3 annual silviculture jobs over the next 10 years.

Notes on the proposed silviculture strategy:

- The short and medium-term timber supply are not affected (except for CT) by incremental silviculture. The impact of incremental silviculture takes place approximately after 100 years.
- The long-term impacts are relatively modest.
- If funding is available, an average annual budget of \$ 268,000 is able to increase the long-term harvest level by about 3% while providing larger piece sizes and value (proposed strategy).
- In the first decade, the recommended annual treatment areas are 51 ha of spacing (good and medium hemlock sites), 9 ha of SCHIRP fertilization, 30 ha of spacing and pruning (good hemlock sites) and 4 pruning (2nd lift).
- The district should continue investigating the feasibility of commercial thinning and utilization of alder.

Table of Contents

1	Introduction.....	1
2	Procedure	2
2.1	PROJECT PROCEDURE.....	2
2.2	DATA ACQUISITION AND MANIPULATION.....	3
2.3	ANALYSIS METHODOLOGY.....	3
3	Kingcome TSA Information	5
3.1	DESCRIPTION OF THE TSA	5
3.2	HISTORY OF THE AAC	5
3.3	CURRENT BASIC SILVICULTURE SYSTEMS.....	5
3.4	INCREMENTAL SILVICULTURE HISTORY	5
3.4.1	Backlog NSR.....	5
3.4.2	Fertilization	5
3.4.3	Juvenile Spacing.....	6
3.4.4	Pruning.....	6
3.4.5	Conversion.....	6
3.4.6	Commercial Thinning	6
3.4.7	Historical Silviculture Budgets.....	6
3.5	PREVIOUS SILVICULTURE PLANS AND REPORTS.....	6
4	Identification of Issues	8
4.1	GENERAL TIMBER SUPPLY ISSUES.....	8
4.1.1	Harvest Forecast.....	8
4.1.2	Land Base.....	8
4.1.3	Age Class Structure.....	8
4.1.4	Transition from Existing to Managed Stands	9
4.1.5	Green-up Ages.....	9
4.1.6	Adjacency Requirements.....	9
4.1.7	Visually Sensitive Areas.....	9
4.1.8	Low Productivity Cedar Stands.....	9
4.1.9	Estimates of Existing and Future Managed Stand Volumes	10
4.1.10	Old Forests	10
4.1.11	Minimum Harvestable Ages	10
4.1.12	Productivity Estimates of Old Forests.....	10
4.1.13	Quality	10
4.1.14	Conversion.....	10
4.1.15	Forest Health Issues.....	10
4.1.16	Issues Relating to Habitat and Non-timber Forest Resources.....	11
5	Timber Supply Concerns and Analysis Objectives.....	12
5.1	SUMMARY OF TIMBER SUPPLY ISSUES.....	12
5.1.1	Short-term (1-20 years).....	12
5.1.2	Mid-term (21-120 years).....	12
5.1.3	Long-term (120 + years)	12
5.2	TIMBER SUPPLY CONCERNS.....	13
5.3	HIGHER LEVEL OBJECTIVES	13
5.3.1	Provincial Goals	13
5.3.2	Provincial Objectives.....	13
5.3.3	Regional Objectives	13
5.4	LOCAL OBJECTIVES AND OPPORTUNITIES.....	14
5.4.1	Objectives	14
5.4.2	Opportunities.....	14
6	Potential Strategies.....	15

6.1	POTENTIAL STRATEGIES BY RESPONSE TIMEFRAME	15
6.2	GENERAL IMPACTS OF STAND TREATMENTS	15
6.3	TREATMENT REGIMES.....	16
6.4	STAND LEVEL TREATMENT RESPONSES.....	17
7	Stand Level Analysis	19
8	Forest Level Analysis	20
8.1	ASSUMPTIONS.....	20
8.2	WORKING TARGETS	20
8.3	ANALYSIS SCENARIOS.....	21
9	Results	22
9.1	BASE SCENARIOS.....	22
9.2	COMMERCIAL THINNING SCENARIO.....	24
9.3	VOLUME IMPACT SCENARIOS	26
9.4	VALUE SCENARIOS.....	31
9.5	ALDER CONVERSION	37
9.6	PARTIAL HARVESTING SCENARIO	37
9.7	HABITAT SCENARIO	39
10	Proposed Scenario and Incremental Silviculture Strategy	40
10.1	ANTICIPATED SILVICULTURE STRATEGY OUTCOMES	43
10.1.1	<i>Harvest Flow</i>	43
10.1.2	<i>Diameter</i>	44
10.1.3	<i>Value and Quality</i>	45
10.1.4	<i>Employment</i>	46
11	Discussion.....	48
11.1	COMMERCIAL THINNING.....	48
11.2	VOLUME IMPACT SCENARIOS	48
11.3	VALUE SCENARIOS.....	48
11.4	ALDER CONVERSION	49
12	Conclusions	50
12.1	RECOMMENDATIONS	50
13	Recommendations for future analyses and research.....	51
14	References	52

List of Figures

Figure 1: TSR2 base case harvest forecast.	8
Figure 2: Stand level treatment response - Hemlock medium analysis unit.	18
Figure 3: Stand level treatment response - Cedar-salal medium analysis unit.	18
Figure 4: TSR 2 base case and FESL benchmark harvest forecasts.	22
Figure 5: Benchmark and Scenario 2 harvest forecasts.	23
Figure 6: Benchmark, basic silviculture only, and ss base case harvest forecasts.	23
Figure 7: Transition from natural to managed stands in ss base case scenario.	24
Figure 8: Harvest flows, ss base case and commercial thinning scenario.	24
Figure 9: Annual commercial thinning area (ha) over the planning horizon.	25
Figure 10: Commercial thinning in different visual quality classes.	25
Figure 11: Share of commercial thinning volume of the total volume harvested.	26
Figure 12: Harvest forecast, silviculture strategy base case and volume impact scenarios.	27
Figure 13: Operable growing stock for silviculture strategy base case and volume impact scenarios.	27
Figure 14: Silviculture expenditures, volume impact scenarios.	28
Figure 15: Treatment areas, \$0.25 million volume impact scenario.	28
Figure 16: Treatment areas, \$0.5 million volume impact scenario.	29
Figure 17: Treatment areas, \$1 million volume impact scenario.	29
Figure 18: Treatment areas, unlimited budget volume impact run.	30
Figure 19: Harvest flows, silviculture strategy base case and value scenarios.	31
Figure 20: Silviculture expenditures, value scenarios.	32
Figure 21: Treatment areas, \$0.25 million value scenario.	32
Figure 22: Treatment areas, \$0.5 million value scenario.	33
Figure 23: Treatment areas, \$1 million value scenario.	33
Figure 24: Treatment areas, unlimited budget value scenario.	34
Figure 25: Average harvest age, value scenarios.	35
Figure 26: Predicted quadratic mean DBH for cedar stands, value scenarios.	35
Figure 27: Predicted quadratic mean diameter for hemlock stands, value scenario.	36
Figure 28: Predicted value for future managed stands, value scenario.	36
Figure 29: Partial cutting baseline compared to the silviculture strategy base case.	37
Figure 30: Partial cutting with silviculture compared to the partial cutting base line.	38
Figure 31: Annual silviculture budget levels for mitigating partial harvesting.	38
Figure 32: Treatment areas, partial harvesting scenario.	39
Figure 33: Treatment areas, proposed scenario.	41
Figure 34: Harvest level, proposed scenario.	44
Figure 35: Predicted quadratic mean diameter, cedar.	44
Figure 36: Predicted quadratic mean diameter, hemlock.	45
Figure 37: Value per cubic meter; proposed strategy.	46

List of Tables

Table 1: Historical AAC levels.	5
Table 2: Potential strategies by response timeframe.	15
Table 3: Stand treatment impacts.	15
Table 4: Treatment regimes.	16
Table 5: Analysis scenarios.	21
Table 6: Commercial thinning in different analysis units (average share over the planning horizon)	26
Table 7: Treatments available by analysis unit for volume impact runs.	30
Table 8: Cost benefit assessment, all volume impact scenarios.	40

Forest Ecosystem Solutions Ltd.

Kingcome TSA Strategic Silviculture Analysis

Analysis Report

<i>Table 9: Cost benefit assessment, all value scenarios</i>	<i>40</i>
<i>Table 10: Distribution of treatments between analysis units</i>	<i>42</i>
<i>Table 11: Treatments for the first decade.</i>	<i>42</i>
<i>Table 12: Proposed regimes; average annual treatment areas, first decade.....</i>	<i>43</i>
<i>Table 13: Short-term employment benefits, jobs.....</i>	<i>47</i>
<i>Table 14: Long-term employment benefits^a</i>	<i>47</i>

1 Introduction

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

A Type 1 silviculture strategy identifies issues, objectives, and regimes for a management unit using existing information. A Type 1 project was completed for the Kingcome Timber Supply Area (TSA) in August 1998. The Type 2 silviculture strategy compliments the Type 1 project and includes in-depth forest-level modeling to develop incremental silviculture strategies. The key concept of the Type 2 project is that it is based on forest level objectives.

Objectives of the Kingcome TSA Silviculture Strategy were developed by the Workshop 1 participants and consider both timber quantity and quality potentials of silviculture. Quantity objectives are to maintain the current timber supply for as long as possible, attempt to increase the mid-term level, and to increase the long-term level. Participants felt that it was not appropriate to set specific volume targets for the mid- and long-term. Quality objectives are to manage regenerated (managed) stands to yield 4% premium logs by volume, 1% of this being clear wood, and the remaining 3% of premium quality. The majority of the remaining trees should be sawlogs. No specific habitat objectives or targets outside of those identified and managed under the Forest Practices Code were identified in the workshop.

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

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

2 Procedure

2.1 Project Procedure

The methodology employed in the creation of a silviculture strategy for the Kingcome TSA is defined by a number of broad steps. These steps are:

- 1 Identify the forest level timber supply and habitat issues by reviewing existing information. Summarize the issues by time frame (short-, mid-, and long-term).
- 2 By accessing local knowledge and analyzing existing information, identify possible solutions and treatment opportunities.
- 3 Clarify goals and objectives. This step takes provincial-level objectives and adapts them to the local situation.
- 4 Define potential strategies and treatment regimes. Local experience is needed to develop a viable initial set for consideration.
- 5 Conduct a stand-level analysis of the proposed treatment regimes to determine responses and, if possible, costs. These results are used as inputs to the forest-level analysis.
- 6 Conduct forest-level (TSA) analysis to evaluate strategies with respect to short-term, mid-term, and long-term timber and habitat supply and quality issues. The forest-level analysis provides a variety of output products so that the selection of an appropriate strategy could be based on future timber quality and quantity, habitat supply, and forest condition.
- 7 Select an appropriate strategy with suitable components for the short-, mid-, and long-term.

Workshop 1 was held December 11, 2001 at the Port McNeill Forest District boardroom. The workshop was attended by representatives from the Ministry of Forests, Ministry of Water, Air and Land Protection, International Forest Products, Western Forest Products, Mill & Timber, and Forest Ecosystem Solutions Ltd. The purpose of the workshop was to define issues, establish objectives, and define current treatment regimes from a local perspective. The workshop produced the following:

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

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

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

In heuristic 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 **FSOS** allows maps to be produced for any period of time in the planning horizon showing the location of silviculture treatments. Charts and reports are also produced from **FSOS** output.

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

2.2 Data Acquisition and Manipulation

A large resultant, spatial database was delivered to Forest Ecosystem Solutions Ltd from the Ministry of Forests, Vancouver Forest Region. A detailed description of data inputs and processing is provided in Section 2.2 of the Type 2 Information Package (Appendix 1).

2.3 Analysis Methodology

A detailed description of the analysis methodology is provided in the Information Package (Appendix 1). In short, the analysis included:

- A benchmark run that emulates the Kingcome TSA TSR2 base case scenario (Scenario 1),
- A “Basic Silviculture Only” run, which includes no incremental silviculture or genetic gain and uses yield curves for managed stands generated using TASS instead of TIPSYS (Scenario 2).
- A “Silviculture Strategy Base Case” that incorporates genetic gain into TASS curves for future managed stands and serves as a starting point for all subsequent silviculture analysis scenarios (Scenario 3).
- A “Commercial Thinning” scenario that investigates the potential to increase harvest flows through the use of commercial thinning treatments (Scenario 4).
- A set of volume impact scenarios that investigate the opportunity to increase harvest flows through the use of spacing and fertilization treatments at various budget levels (Scenario 5).
- A set of value impact scenarios that investigate the opportunity to increase overall harvest values through the use of spacing, pruning and fertilization treatments at various budget levels (Scenario 6).
- An “Alder Conversion” scenario that investigates the potential to improve harvest volumes and values by converting selected poor cedar sites to alder (Scenario 7).

- A Partial Harvesting scenario that tests the ability of silviculture to mitigate timber supply impacts of partial harvesting regimes (Scenario 8).
- A habitat scenario that investigates the opportunity of silviculture to mitigate timber supply impacts of increased landbase constraints for habitat (Scenario 9).
- A proposed option built upon the results of the previous silviculture strategy scenarios (Scenario 10).

3 Kingcome TSA Information

3.1 Description of the TSA

The Kingcome TSA covers a large part of Northern Vancouver Island as well as an area in the mainland, extending from Knight Inlet to Cape Caution in the northwest and to Tweedsmuir Park in the northeast. The forests within the TSA are quite diverse, but hemlock, amabilis fir, and western redcedar are the predominant species. Lesser amounts of spruce, Douglas-fir, cypress, and deciduous species are also found. Approximately 51% of the TSA is forest land; of this, 29% is considered available for harvesting (15% of the total TSA area). Most of the area excluded for harvesting is inoperable or of low productivity or non-merchantable tree species.

Most of the forested land in the TSA falls within the Coastal Western Hemlock (CWH) biogeoclimatic zone. This zone is found from sea level up to elevations around 1000 metres. The other biogeoclimatic zone prevalent within the Kingcome TSA is the Mountain Hemlock (MH) zone, which is found at elevations above the CWH zone. The Interior Douglas-fir (IDF) and Engelmann Spruce – Subalpine Fir (ESSF) zone occur to a very limited extent within the TSA..

3.2 History of the AAC

Table 1: Historical AAC levels.

Year	Average AAC (m ³ /year)
1993 – 1997	1,463,119
1998 – 2000	1,117,728

3.3 Current Basic Silviculture Systems

The majority of harvesting within the Kingcome TSA is done through clear cutting using ground-based, cable, and helicopter systems. Regeneration is generally achieved via planting.

3.4 Incremental Silviculture History

3.4.1 Backlog NSR

A total of 443 hectares of backlog NSR reforestation was incorporated into the TSR 1 analysis. No backlog NSR was reported in TSR2.

3.4.2 Fertilization

Fertilization of a stand raises the productivity of the site and is the only presently recognized treatment for increasing total stand volume. In addition to increasing total volume, fertilization can also reduce the age at which a stand reaches harvestable size. The ISIS information obtained for the Type 2 project indicates 817 ha of past fertilization in the TSA.

3.4.3 Juvenile Spacing

Juvenile spacing is the removal of less desirable trees within a juvenile stand to manage its density. This reduces competition for water, nutrients, and sunlight among the residual trees and the primary stand-level effect is to cause trees to reach minimum harvestable size sooner. Juvenile spacing can also be employed to manage species composition, forest health issues, and biodiversity or wildlife objectives. Approximately 6,000 ha of have been spaced since 1980.

3.4.4 Pruning

Pruning is the removal of branches from the bole of the tree with the objective of creating clear wood. Pruning treatments can involve one or two lifts, the general rule being that pruning shall leave a crown of not less than 50% of the total tree height. The ISIS file shows that a total of 267 ha have been pruned within the TSA.

3.4.5 Conversion

TSR1 reported 600 hectares of brushing treatments used to remove alder overstory and release hemlock-cedar understory. One treatment identified in the workshop that will be tested in the Type 2 analysis is the regeneration of certain cedar poor sites to alder. It is thought that permitting alder to occupy these sites may lead to improvements in harvest volumes as alder may out-perform cedar on these wet sites.

3.4.6 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. There has been no commercial thinning in the TSA.

3.4.7 Historical Silviculture Budgets

Between \$120,000 and \$150,000 have been expended annually during the last four years in the TSA on backlog reforestation including site preparation, planting, fertilization and caging.

3.5 Previous Silviculture Plans and Reports

Kingcome Timber Supply Area – Incremental Silviculture Strategy (1998)

Also referred to as the “Type 1” silviculture strategy in the introduction of this report, this strategy used existing information (mostly based on TSR1 analysis from the 1995 Kingcome TSA Timber Supply Review Analysis Report) to identify quantity and quality issues and opportunities. The TSR1 base case harvest forecast differs significantly from that of TSR2; therefore, some of the recommendations made in the Type 1 project are no longer appropriate with the new timber supply. The following treatments were recommended in the Type 1 project:

- Increase regenerated stand yields by 20% and achieve green-up three years earlier by:
 - reducing time to regeneration by 2 years by planting all areas;
 - using second generation (Class A) seed or better (requires tree improvement for Balsam);
 - using large planting stock, and/or individual tree fertilizing or planting, and/or seedling protection;
 - brushing for growth enhancement; and
 - fertilizing 500 ha/year of cedar-salal sites to achieve early crown closure.

- Implement partial harvesting regimes in VQO zones.
- Expand the timber harvesting land base by:
 - rehabilitating the remaining 400 ha of backlog NSR and brushing (conifer release) 3000 ha of backlog plantations;
 - draining lowsite wetlands (10 ha trial); and
 - assessing opportunities for rehabilitating non-commercial alder stands back into conifer production.

4 Identification of Issues

4.1 General Timber Supply Issues

The general timber supply issues identified below come from the TSR2 analysis report released in November 2001.

4.1.1 Harvest Forecast

Figure 1 illustrates the TSR2 base case harvest forecast.

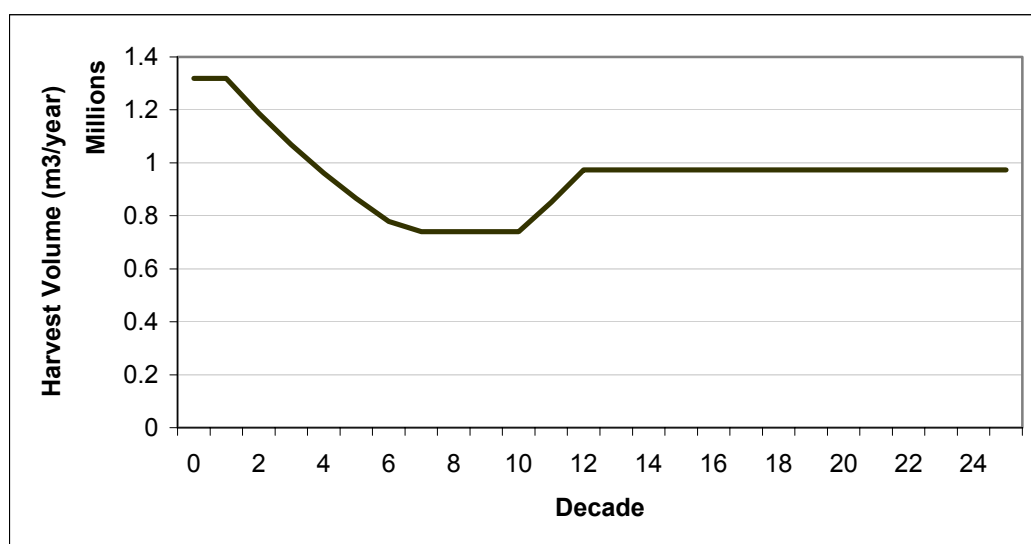


Figure 1: TSR2 base case harvest forecast.

The initial harvest volume is 1,319,000 m³/year. The harvest flow declines by 10% each decade for the first six decades until reaching 740,445 m³/year in decade seven. This level is maintained until decade 10, at which point the timber supply increases by 15% for two successive periods to the long-term level of 973,000 m³/year.

4.1.2 Land Base

Sensitivity analysis showed that a 5 and 10% decrease in the size of the THLB lead to an equivalent reduction in harvest flows. A 5 and 10% increase in the size of the THLB resulted in a 4 and 8% increase in harvest levels, respectively.

4.1.3 Age Class Structure

Currently, about 59% of the THLB is comprised of stands quite evenly distributed between 0 and 100 years old. These stands have primarily originated from past harvesting activities. Approximately 31% of the THLB is older than 250 years, with the remaining 10% of THLB area between 100 and 250 years. Of the productive forest area outside of the THLB, 83% of stands are older than 100 years, and 56% are greater than 250 year old. This large amount of old forest area outside of the THLB means that a relatively small amount of THLB forest will need to be maintained to meet old forest requirements.

4.1.4 Transition from Existing to Managed Stands

For the first 5 decades, the harvest depends almost exclusively on existing natural stands and declines at a rate of 10% per decade. Between decades 6 and 11, the harvest becomes more dependent on managed stands. By decade 12, the harvest volume comes predominately from managed stands. Silviculture treatments that show benefits in managed stands will not yield improvements in the timber supply until these stands form a significant proportion of the harvest.

4.1.5 Green-up Ages

Green-up age is used in the application of harvest constraints in the Integrated Resource Management (IRM), Vancouver Island Land Use Plan (VILUP) Enhanced Forestry Zones (EFZ), and visually sensitive zones. A sensitivity analysis was performed in TSR2 to test the impact of under- or over-estimation of green-up ages within the IRM and EFZ zones. The results indicate that a 5 year increase in green-up ages would yield a short-term decrease in harvest levels of 12.1% and no long-term impact. Reducing green-up ages by 5 years would yield a short-term increase in timber flow of 1.1% and would have no long-term impact.

4.1.6 Adjacency Requirements

To approximate guidelines regarding cutblock adjacency, an assumption was made that no more than 25% of the THLB area within each landscape unit can be below the green-up height. Sensitivity analysis was performed to test the impact of increasing or decreasing the allowable disturbance area. An increase in the allowable disturbance rate to 33% yielded a 1% increase in the short-term harvest level. Decreasing the disturbance rate to 20 % lead to an 8.2% decrease in the short-term harvest level. The long-term harvest level was not affected by either change.

4.1.7 Visually Sensitive Areas

Two sensitivity analyses were performed that tested the impact of changes to the application of constraints regarding visually sensitive areas. The first tested the impact of applying constraints to all visually sensitive areas, not just those identified by the District Manager. This resulted in a 5.1% decrease in short-term timber supply and had no impact on the long-term level.

The second sensitivity analysis tested the impact of changing the allowable disturbance rates within visually sensitive areas. Maximum denudation rates are provided as a range for all recommended visual quality classes; the denudation rate assigned in the base case is close to the mid-point of each range. The sensitivity analysis tested the application of minimum and maximum rates within the range for each RVQC-landscape unit combination. Setting the rate to the high end of the range resulted in a 5% increase in the short-term harvest level and a 4% increase in the long-term level. Setting the target to the low end of the range resulted in a 10.8% decrease in the short-term level and a 8.9% decrease in the long-term level.

4.1.8 Low Productivity Cedar Stands

Some uncertainty exists as to whether or not the less restrictive low productivity definitions used for cedar within the Nahwitti and Hecate Lowlands provide an appropriate level of contribution of these low volume stands. A sensitivity analysis was performed that tested the impact of excluding these additional low volume cedar stands and revealed that excluding these stands would cause a 5.1% reduction in short-term harvest volumes and a 2.5% reduction in long-term levels.

4.1.9 Estimates of Existing and Future Managed Stand Volumes

A 10% reduction or increase in existing stand yield estimates would result in a 10.1% decrease or 8.6% increase in short-term harvest forecasts, respectively. Increases and decreases in existing stand volume estimates have no impact on long-term harvest projections.

Increases and decreases in future managed stand yield estimates yield nearly equivalent increases and decreases in long-term harvest forecasts.

4.1.10 Old Forests

Approximately 31% of the THLB area and 56% of the non-THLB area within the Kingcome TSA is over 250 years old. Requirements for the retention of old forests were calculated based on the assumption that the TSA will eventually be divided into biodiversity emphasis options with a split between low, medium and high emphasis close to 45, 45, and 10% respectively. The constraints were applied to BEC variant – Landscape Unit combinations. Sensitivity analyses on the application of old forest requirements showed no impact on harvest levels.

4.1.11 Minimum Harvestable Ages

Sensitivity analyses were performed that tested the impact of a 5 year increase and decrease of minimum harvestable ages (MHAs). Increasing MHAs by 5 years resulted in a 2.5% decrease in short-term harvest volumes. A 5 year decrease in MHAs yielded a 2% increase in short-term harvest levels. Changes in MHAs had no impact on long-term harvest forecasts.

4.1.12 Productivity Estimates of Old Forests

Site productivity estimates in old stands may be inaccurate as tree heights may not represent actual productivity (due to top breakage, for example) and the fact that it is difficult to determine the age of old trees accurately. Recent province-wide research indicates that productivity of old-growth sites post-harvest may be significantly underestimated. Sensitivity analysis tested the application of old growth site index (OGSI) adjustments in cedar and hemlock stands over 140 years yielded significant increases in mid- and long-term harvest volumes. Mid-term volumes increased by 25.1%, and long-term harvest volumes increased by 21.4%.

4.1.13 Quality

Quality was not modeled in TSR2. Workshop participants felt that there are many opportunities to improve timber quality within the Kingcome TSA; however, these treatments (especially pruning) are considered expensive, are not widely used and are not relevant in the TSR process.

4.1.14 Conversion

Many alder stands are treated as backlog NSR to remove the alder overstory and release the suppressed conifer understory. There are differing opinions as to whether or not this investment is a good one: it is possible that alder would be more productive than conifer crops on certain, wet sites and should be maintained.

4.1.15 Forest Health Issues

No major forest health issues were identified for this analysis. A reduction of 13,583 m³/year is applied to reflect unsalvaged losses incurred through fire and windthrow events. Workshop participants brought up localized spruce weevil damage in spruce plantations and physical damage caused by bears.

4.1.16 Issues Relating to Habitat and Non-timber Forest Resources

Wildlife habitat values are modeled through the constraints applied for biodiversity, adjacency, IRM, riparian, and wildlife tree patch modeling. No reductions or management zones were required to manage for the habitat of any particular species.

5 Timber Supply Concerns and Analysis Objectives

5.1 Summary of Timber Supply Issues

5.1.1 Short-term (1-20 years)

The short-term harvest forecast is sensitive to:

- Increases and decreases in green-up ages;
- Increases and decreases in adjacency requirements;
- Increases and decreases in minimum harvest ages;
- Increase in visual area;
- Increases and decreases in the maximum denudation rates in visual areas;
- Increases and decreases in the size of the timber harvesting land base;
- Exclusion of lowsit cedar stands, and
- Increases and decreases in estimates of existing stand volumes.

5.1.2 Mid-term (21-120 years)

The mid-term harvest forecast is sensitive to:

- Increases and decreases in the size of the timber harvesting land base;
- Exclusion of lowsit cedar stands;
- Increases and decreases in estimates of existing stand volumes, and
- Increases in estimates of productivity of old growth stands.

5.1.3 Long-term (120 + years)

The long-term harvest forecast is sensitive to:

- Increases and decreases in the maximum denudation rates in visual areas;
- Increases and decreases in the size of the timber harvesting land base;
- Exclusion of lowsit cedar stands;
- Increases and decreases in estimates of future stand volumes, and
- Increases in estimates of productivity of old growth stands.

5.2 Timber Supply Concerns

Mid-term timber volumes are insufficient to sustain the short-term harvest forecast. Silviculture may be effective in mitigating midterm timber supply shortfalls. However, sensitivity analyses for TSR2 have indicated that mid-term harvest levels are generally not sensitive to many of the timber supply factors, indicating a lower potential for silviculture to increase mid-term harvest flows.

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

5.3.2 Provincial Objectives

The provincial objectives are based on the following guiding principles:

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

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

1. Minimize interim reduction in timber supply so that the allowable annual cut is not less than 65 million cubic meters;
2. Increase timber supply over the mid-term to a long-term level of 75 million m³; and
3. Maintain the production of premium quality logs at or above 10% of total harvest. (MOF, 1999c)

5.3.3 Regional Objectives

The objectives of the regional incremental silviculture strategy are:

1. 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,

2. 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.
3. 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 in Workshop 1:

Quantity: Maintain the short-term timber supply for as long as possible. Attempt to increase the mid-term timber supply, if possible. Increase the long-term timber supply.

Quality: Manage regenerated stands to yield 4% premium logs by volume, 1% of this being clear wood and the remaining 3% of premium quality. The majority of the remaining trees should be sawlogs.

5.4.2 Opportunities

Short-term

The short-term timber supply may benefit from activities that:

- Achieve green-up earlier,
- Mitigate adjacency limitations,
- Reduce minimum harvest ages,
- Increase existing stand volumes, and
- Expand the timber harvesting land base.

Mid-term

The mid-term timber supply may benefit from activities that:

- Increase existing stand volumes,
- Bring volume forward from the long-term to the mid-term, and
- Expand the timber harvesting land base.

The mid-term timber quality may be improved by activities that:

- Increase the proportion of large logs in a stand (spacing and fertilization) and
- Increase the proportion of clear wood (pruning).

Long-term

The long-term timber supply may benefit from activities that:

- Expand the timber harvesting land base and
- Increase the volume of regenerated stands through a variety of actions.

The long-term timber quality may be improved by activities that:

- Increase the proportion of large logs in a stand (spacing and fertilization) and
- Increase the amount of clear wood (pruning).

6 Potential Strategies

6.1 Potential Strategies by Response Timeframe

Table 2: Potential strategies by response timeframe.

Response Time Frame	Strategy Description	Anticipated Result
Short-term (0-20 years)	<ol style="list-style-type: none"> 1. Achieve green-up 3 years earlier in VQ zones by: <ol style="list-style-type: none"> (a) planting large genetically improved stock; (b) increasing proportion of area planted & plant all areas sooner (to reduce regeneration delay 1- 2 yrs); (c) brush for growth enhancement; and/ or (d) fertilize suitable regenerated stands to increase their growth. 2. Implement partial harvesting/ CT regimes in VQO zones to increase timber supply from areas limited by adjacency constraints. 3. Increase the volume of some existing stand volumes through fertilization. 4. Expand the timber harvesting land base through: <ol style="list-style-type: none"> (a) Rehabilitating non- commercial alder stands. 	<ol style="list-style-type: none"> 1. A 5-year decrease in green-up age resulted in a 1.1% improvement in short term harvest flow. 2. Mitigating adjacency constraints (modeled as an increase in allowable denudation rates from 25% to 33%) lead to a 1% improvement in short term harvest flow. 3. A 10% increase in existing stand volumes resulted in an 8.6% improvement in short-term harvest flow. 4. A 5% increase in the size of the THLB would yield a 4 8% increase in harvest levels.
Mid-term (21 – 120 years)	<ol style="list-style-type: none"> 1. Space all post FG stands to set up for CT. Use CT to bring forward harvest from long term into mid term. 2. Fertilize existing (a) hemlock and (b) cedar stands to raise their volumes. 3. Increase the value of second growth stands by pruning, spacing and fertilization. 	<ol style="list-style-type: none"> 1. Maintain options for CT. Bring some long-term volumes to the mid-term. 2. A 10% increase in existing stand volumes resulted in an 8.6% increase in harvest volume. 3. Mid-term value increase expected to be modest, as benefits will occur in the long term.
Long-term (121 years +)	<ol style="list-style-type: none"> 1. Increase regenerated stand volumes by using genetically improved seed and fertilizing suitable regenerated stands. 2. Increase the value of second growth stands by pruning, spacing and fertilization. 	<ol style="list-style-type: none"> 1. A 10% increase in regenerated stand volumes increased long-term harvest levels by 10%. 2. Value increases expected in the long term.

6.2 General Impacts of Stand Treatments

Table 4 summarizes the impact of silviculture treatments on selected stand attributes.

Table 3: Stand treatment impacts.

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 identified in Workshop 1:

Table 4: Treatment regimes.

Analysis Unit	Space	Space fert	Fert	Space Prune 1 lift	Space Prune 2 lifts	Space Prune Fert	CT	Space CT	Space Fert CT	Site Prep	Do Not Treat
101 Cedar good - cedar							✓				✓
102a Cedar good – hem											✓
102b Cedar good – hem space	✓										
103 Cedar med - cedar							✓				✓
104 Cedar med salal – cedar			✓				✓				✓
105a Cedar med – hem											✓
105b Cedar med – hem space	✓										
106 Cedar poor – cedar							✓				✓
107 Cedar poor salal – cedar			✓				✓				✓
108a Cedar poor – hem											✓
108b Cedar poor – hem space	✓										
109 Hem good	✓			✓	✓		✓	✓			✓
110 Hem med	✓			✓	✓		✓	✓			✓
111 Hem poor											✓
112 Spruce/fir	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
113 Alder – conversion from cedar/salal poor										✓	✓

Treatment parameters:

- Space Hw to 850 sph at 7m.
- Space S to 1000 sph at 7m.
- First lift prune at 7m, prune 3.5m.
- Second lift prune at 9m, prune 5.5m.
- Fertilization at age 12 and again at 20 years for cedar salal sites.
- Fertilization (Spruce/Fir) at time of spacing and/or pruning (7m) and every decade following.
- Fertilization (Spruce/Fir, fertilization only regime) at age 50 and every decade following (without pruning)
- CT at age 45 for good site down to 500 sph
- CT at age 50 for medium site down to 500 sph
- CT at age 55 for poor site down to 500 sph.
- CT spruce at age 40 for all sites down to 400 sph
- Cedar/salal fertilization – increase site indices by 25%
- Cedar – hem space (#102b, 105b, 180b, 202b, 205b, 208b) – to 850 sph at 7m.

Regeneration assumptions for cedar were modified from TSR 2 in two ways.

First, in all cedar analysis units, 20% of stands are assumed to regenerate to hemlock. If these stands are spaced, they regenerate 100% back to cedar. The decision to space and regenerate to cedar or not to treat and remain hemlock will be made by the heuristic model based on the satisfaction of forest level objectives.

Second, in cedar poor and medium sites, 42% of stands were assumed to be cedar salal sites. The percentage estimate of these sites was calculated based on an estimate of cedar salal sites in CWH vm1, vm2 and vh1 BEC variants and then calculated as an area-weighted average of the contribution of these BEC variants to the total cedar poor and medium areas. These sites are eligible for salal cedar hemlock integrated research program (SHIRP) fertilization treatment. Without treatment, these stands follow the same assumptions as original cedar poor and medium stands. Cedar salal fertilization was modeled as an increase in site index of 15%. Initially, the recommended site index improvement was 25% as per Western Forest Products Ltd's experience from their TFL 6. Upon discussions with Albert Nussbaum from the Ministry of Forests Timber Supply Branch, it was decided to adjust these site index improvements down to 15% as a 25% improvement in site index was considered unrealistic.

The following illustrates the division of the original cedar analysis units to reflect the new assumptions:

Cedar good	→ 80% Cedar good
	→ 20% Hemlock good
Cedar medium	→ 46.4 % Cedar medium
	→ 33.6% Cedar salal medium
	→ 20% Hemlock good
Cedar poor	→ 46.4% Cedar poor
	→ 33.6 %Cedar salal poor
	→ 20% Hemlock poor

6.4 Stand Level Treatment Responses

Figures 2 and 4 illustrate the volume growth response of selected silviculture treatments for two analysis units— Hemlock medium and cedar salal medium - as examples. Note that the spacing treatment increases the stand level volume modestly in the long term. A complete summary of analysis units and treatment responses has been included in Appendix 2.

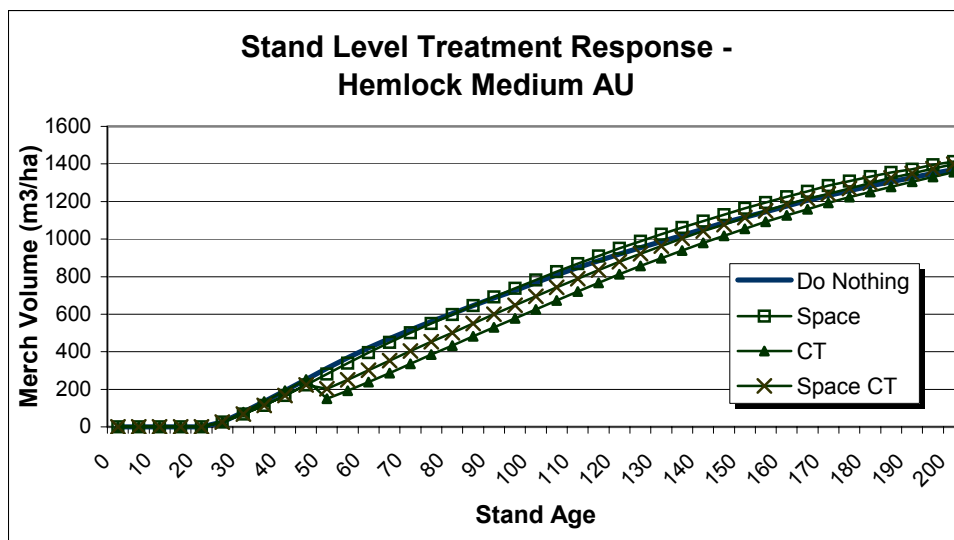


Figure 2: Stand level treatment response - Hemlock medium analysis unit.

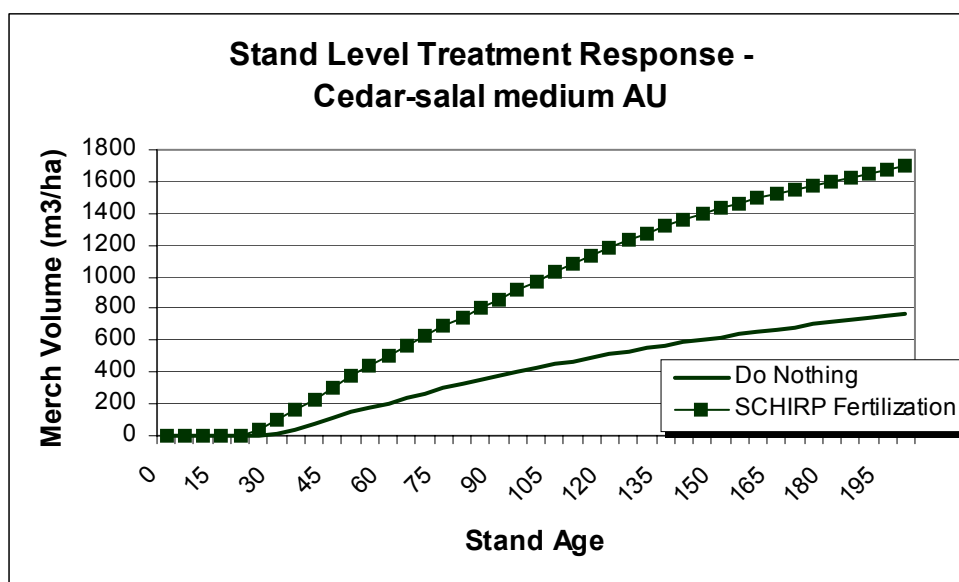


Figure 3: Stand level treatment response - Cedar-salal medium analysis unit.

7 Stand Level Analysis

The use of computer modeling provides yield curves for each stand level treatment regime. 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 involves 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 is a single species, even-aged stand model; therefore, stands were modeled with these assumptions. Output from TASS includes yield information, stand volume, mean piece size by grade, stand height, diameters, and piece size distributions by stand age. VDYP is the computer model used to generate yields for unmanaged mature or older immature stands. The output from VDYP is limited to height, diameter, volume and MAI.

8 Forest Level Analysis

8.1 Assumptions

The objective of the type 2 analysis is different from that of a timber supply review. However, where possible, similar assumptions and data will be utilized. The following assumptions were applied in the type 2 analysis.

- 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;
- Forest Practices Code will be applied;
- MoF timber supply concepts and harvest flow controls will be utilized;
- The analysis will originate with the current AAC and utilization standards;
- Precision for objectives will be applied as follows:
 - Silviculture investment not to exceed maximum budget level by more than 10%; and
 - +/- 5% tolerance around non-timber targets for heuristic analysis.
- Treatment costs were taken from recent experience in the TSA and are listed in the Analysis Information Package.

8.2 Working Targets

The following working targets were developed at Workshop 1. These working targets serve as a measure of the effectiveness of the treatment regimes in fulfilling the objectives identified in section 5.

Quantity: Maintain the short term timber supply as long as possible. Attempt to increase the mid term timber supply if possible. Increase the long-term harvest level. It was felt that it is appropriate not to set specific numerical targets for the mid and long term.

Quality: Manage regenerated stands to yield 4 % premium logs by volume, 1 % of this being clear wood and the remaining 3 % of premium quality. The majority of the remaining trees should be sawlogs.

The following are the refined log product definitions for the analysis:

Premium Log:

- Hemlock, 60+ cm DBH, clear, min 5 m log, not less than 3-4 rings/cm on M/P sites and 2-3 rings/cm on G sites.
- Cedar pole, 45+ cm min DBH, min 20 m log, low taper, min 20 cm top.
- Balsam, 60+ cm DBH, clear 5 m log.

Sawlog:

- Minimum quadratic average stand DBH of 45 cm and min stand vol. of 350 m³/ha cedar and 500 m³/ha for other species.

8.3 Analysis Scenarios

Table 5: Analysis scenarios.

Scenario	Title	Scenario Description
1	Benchmark	<ul style="list-style-type: none"> Simulation Recreation of TSR 2 base case.
2	Basic Silviculture Only	<ul style="list-style-type: none"> Simulation No incremental silviculture. Establishment densities modified from TSR2 to include natural ingress. Regeneration assumptions changed in some cedar analysis units to reflect ingress of hemlock and cedar-salal sites. OGSI adjustments incorporated.
3	Silviculture Strategy Base Case	<ul style="list-style-type: none"> Heuristic Adds second generation genetic gain to scenario 2. Serves as starting point for all subsequent silviculture strategy runs.
4	Commercial Thinning	<ul style="list-style-type: none"> Heuristic Compares to Scenario 3. Commercial thinning is modelled as cost recovering (i.e. no net cost). Investigates the opportunity to increase timber volumes through the use of commercial thinning.
5	Volume Impact	<ul style="list-style-type: none"> Heuristic Compares to Scenario 3. Budget levels: <ul style="list-style-type: none"> \$250,000 \$500,000 \$1,000,000 Unlimited. Investigates the opportunity to increase harvest flows through the use of spacing and fertilization treatments.
6	Value Impact	<ul style="list-style-type: none"> Heuristic Compares to Scenario 3. Budget levels: <ul style="list-style-type: none"> \$250,000 \$500,000 \$1,000,000 Unlimited. Investigates the opportunity to increase timber value through the use of spacing, fertilization and pruning treatments.
7	Alder Conversion	<ul style="list-style-type: none"> Heuristic Compares to Scenario 3. Tests the impact of converting poor cedar salal sites to alder. Assumes an alder SI of 23.7 metres at 25 years and a minimum harvest age of 40.
8	Partial Harvesting/Retention	<ul style="list-style-type: none"> Heuristic Stand-alone scenario. This scenario uses the yield curve reduction percentage applied by Weyerhaeuser in their Timber Supply Analysis for TFL39 to account for partial retention and includes no intensive silviculture. The scenario investigates the opportunity for the use of silviculture to mitigate potential volume impacts caused by the use of partial harvesting systems.
9	Habitat/Biodiversity	<ul style="list-style-type: none"> Heuristic Stand-alone scenario. This scenario applies full seral (early, mature/old, old) requirements immediately (no draw down) as a base line and includes no intensive silviculture. The scenario investigates the opportunity for the use of silviculture to mitigate any impacts caused by increasing biodiversity requirements.
10	Proposed	<ul style="list-style-type: none"> Heuristic Compares to Scenario 3. Budget levels and treatment options are selected based on the results of the previous scenarios.

9 Results

9.1 Base Scenarios

This section presents the results of the base scenarios (Scenarios 1 – 3 described in section 8.3 above). Results for the Benchmark (#1) and Basic Silviculture Only (#2) scenarios were achieved using simulation, while the silviculture strategy base case was developed using heuristic analysis techniques.

Figure 4 shows the harvest forecasts for the benchmark run as compared to the TSR2 base case. The TSR2 base case harvest flow starts at 1,319,000 m³/year, declining by 10% per decade to the midterm harvest level of 740,445 m³/ha for decades 7 through 10. At year 100, the harvest flow increases by 15% for 2 decades to the long-term harvest level of 973,000 m³/ha. The FESL benchmark run has a short-term harvest level that is 11.6% below that of the TSR2 benchmark at 1,165,515 m³/year. This level is maintained for one decade, and then declines to the mid-term level of 819,055 m³/year, which is 10.6% higher than the base case mid-term level. The harvest flow then steps up to the long-term level of 987,211 m³/year (1.5% higher than the TSR2 base case). These differences in harvest flow are likely the result in slight area shifts during the data processing and landbase netdown procedures. Data differences are discussed in the Information Package (Appendix 1).

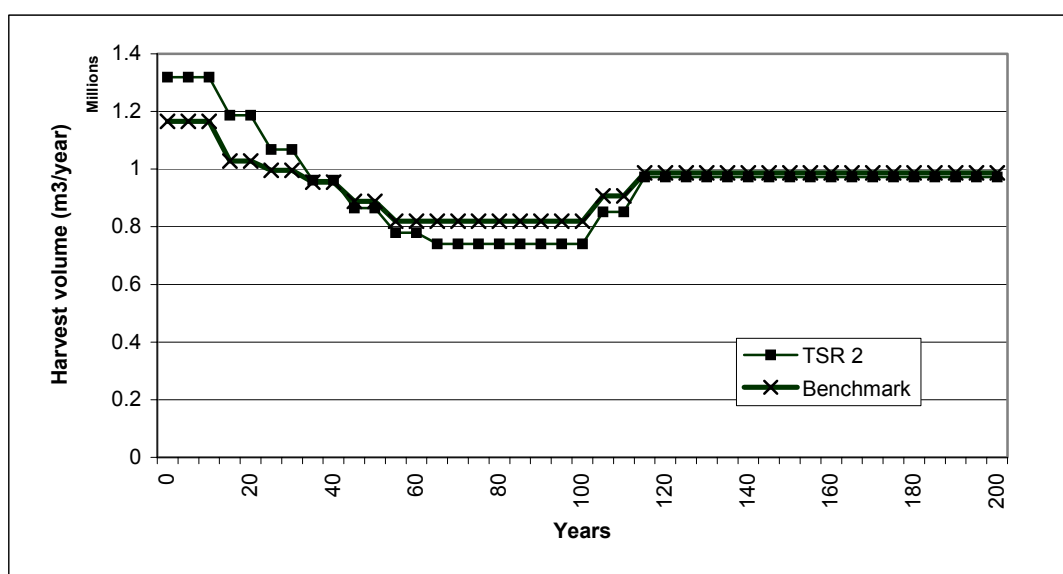


Figure 4: TSR 2 base case and FESL benchmark harvest forecasts.

Figure 5 shows the results of the basic silviculture only scenario (#2) as it compares with the benchmark. The basic silviculture only scenario includes modification of cedar analysis units to reflect hemlock ingress and to account for cedar-salal sites. Also, Old Growth Site Index (OGSI) adjustments were included here. This resulted in a 7.7% increase in short-term harvest flows (to 1,256,274 m³/year), a 15% increase in mid-term harvest levels beginning in year 70 (to 944,620 m³/year), as well as a 15% increase in long-term harvest levels to 1,113,590 m³/year as compared to the benchmark run.

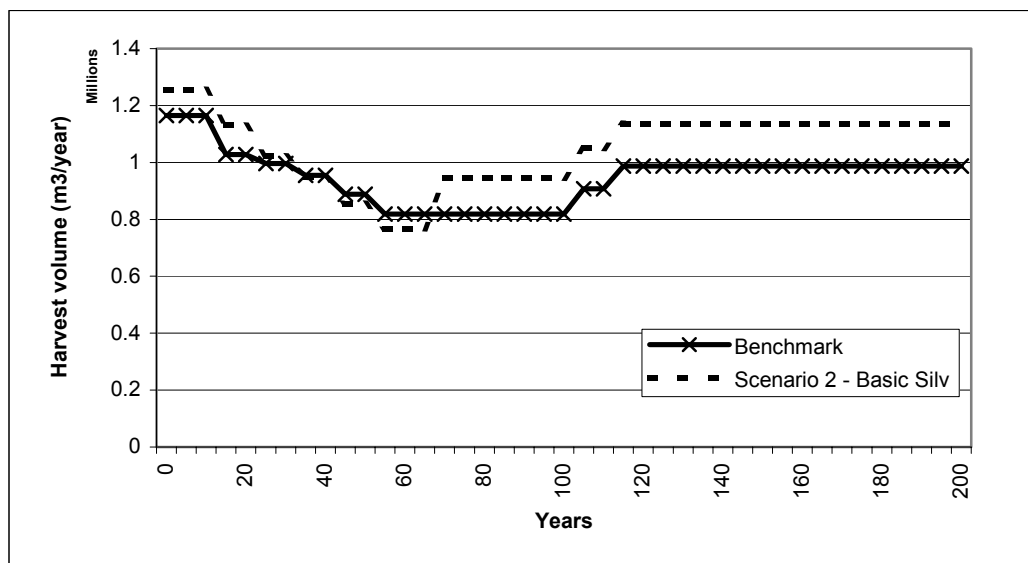


Figure 5: Benchmark and Scenario 2 harvest forecasts.

Figure 6 compares the harvest forecasts of the benchmark scenario, basic silviculture only scenario and the silviculture strategy base case. The inputs to these scenarios differ in that the silviculture strategy base case includes second generation genetic gain. The silviculture strategy (ss) base case takes a slightly different form than the basic silviculture scenario, eliminating the lowest dip in the harvest level and reaching the long-term level 5 years earlier. This long-term level is 6% higher than that of the basic silviculture scenario. Genetic improvements were 7.47% and 12.77 % for planted cedar and hemlock stems, respectively. Sensitivity analysis performed for TSR2 showed that increases in managed stand volumes produced equivalent increases in long-term harvest flows. However, natural ingress dilutes the impact of genetic gain, producing the long-term impact lower than the genetic improvement percentages.

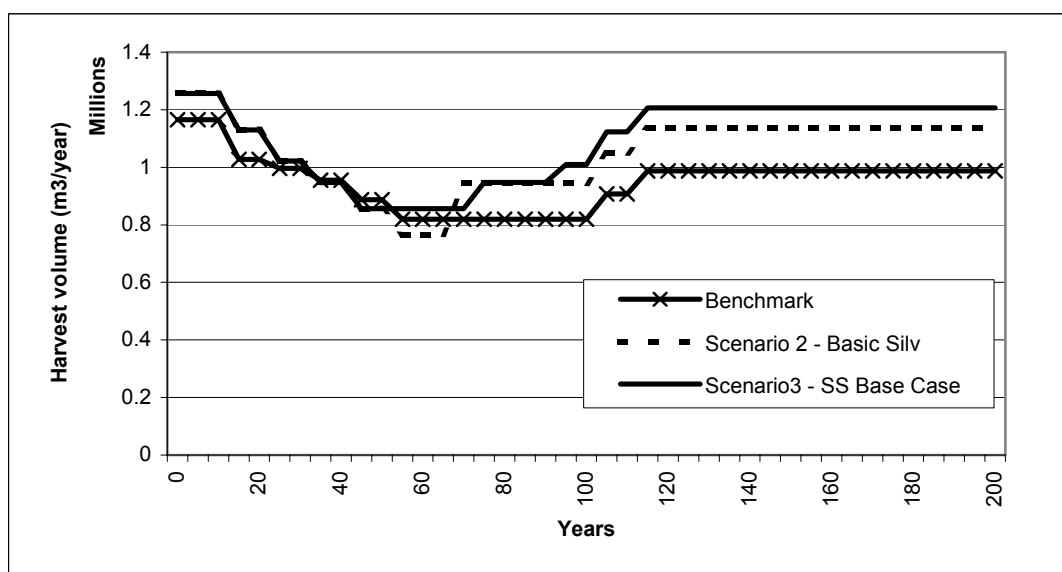


Figure 6: Benchmark, basic silviculture only, and ss base case harvest forecasts.

Figure 7 shows the transition from natural to managed stands in the silviculture strategy base case. Until decade 9, the majority of the harvest volume comes from natural stands. As a result, benefits from silviculture will be largely unavailable until after this point in time (when managed stands comprise most of the harvest).

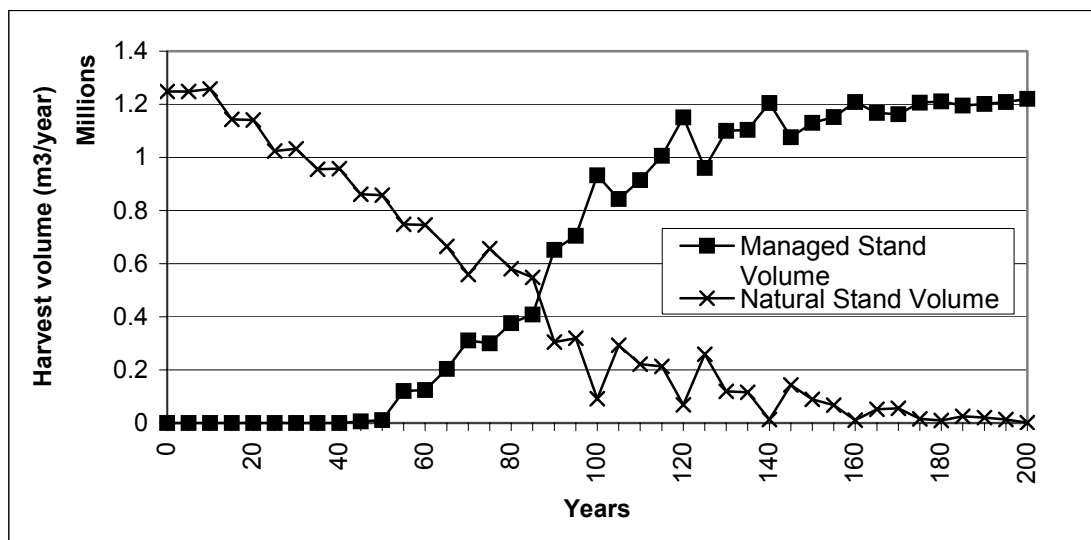


Figure 7: Transition from natural to managed stands in ss base case scenario.

9.2 Commercial Thinning Scenario

Scenario 4 investigated the use of commercial thinning (CT) to increase harvest flows. No other treatments were available. Figure 8 presents the harvest forecast for this scenario. Short- and long-term harvest flows are increased by 7.2% and 5.3 %, respectively. Mid-term volumes were also increased by about 5.2 %.

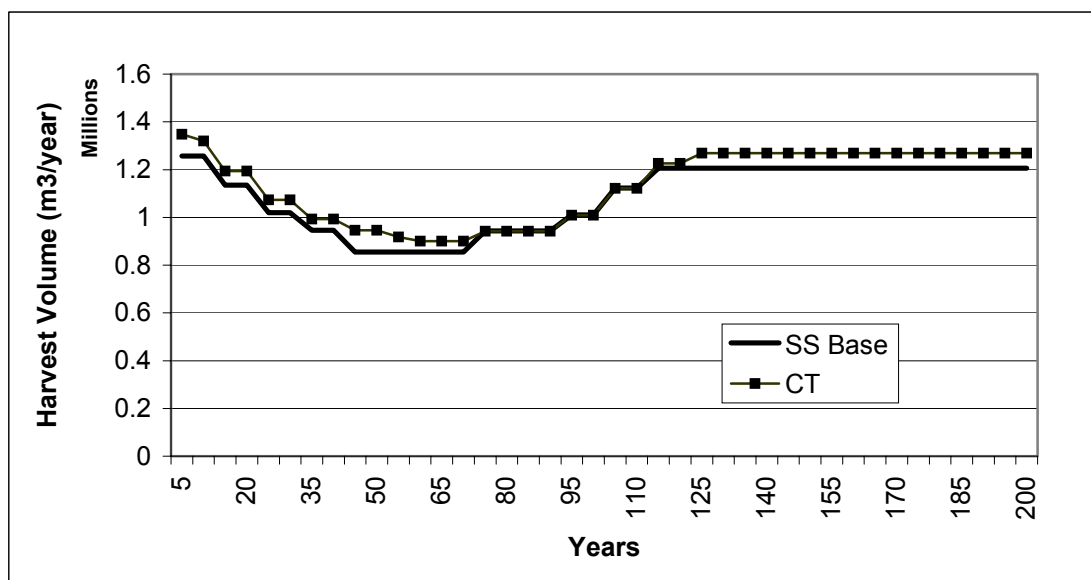


Figure 8: Harvest flows, ss base case and commercial thinning scenario.

It is likely that commercial thinning increases the harvest forecast by allowing for more flexibility in harvest scheduling in general and by allowing for more volume to be removed from stands in visually sensitive areas while still maintaining visual quality objectives. Figure 9 illustrates the volume harvested through commercial thinning in visually sensitive areas. On average almost 40% of commercial thinning took place in visually sensitive areas.

The short and long-term volume increases are consistent with the TSR 2 sensitivity analyses. When constraints on visual quality areas were reduced, short- and long-term volume benefits were realized.

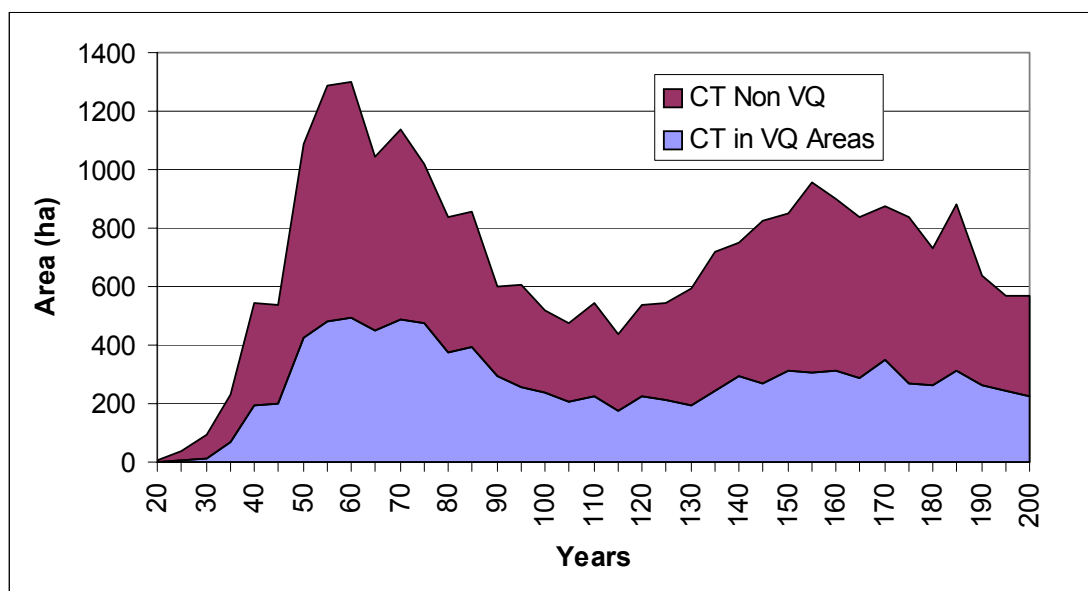


Figure 9: Annual commercial thinning area (ha) over the planning horizon

Figure 10 shows that commercial thinning that took place in visually sensitive areas concentrated on partial retention areas (over 70%).

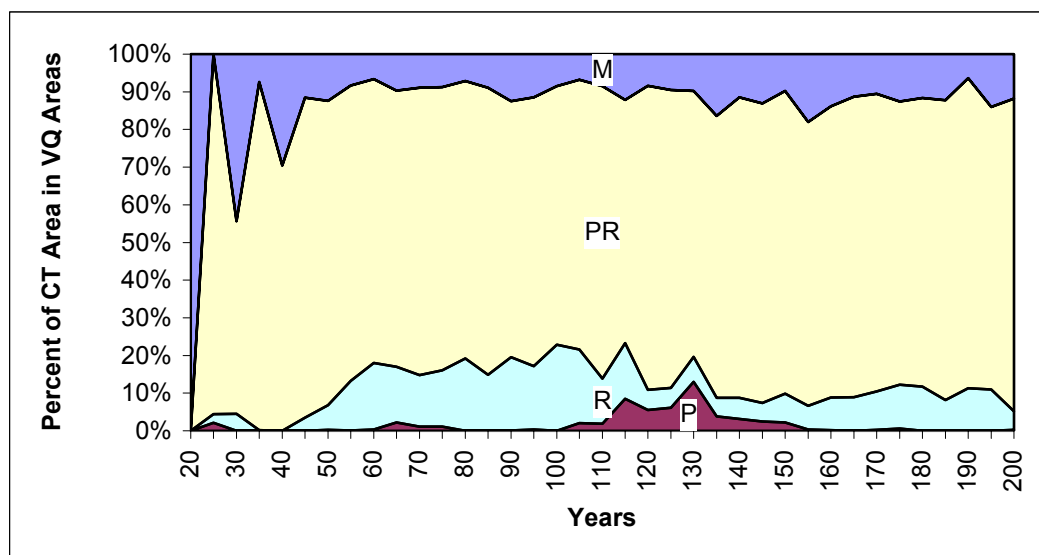


Figure 10: Commercial thinning in different visual quality classes.

Figure 11 illustrates the commercial thinning volume harvested over the planning horizon. Commercial thinning volumes remain small until year 55 when they form approximately 8 % of the harvest. From years 65 to 85, almost 20% of the harvest comes from commercial thinning.

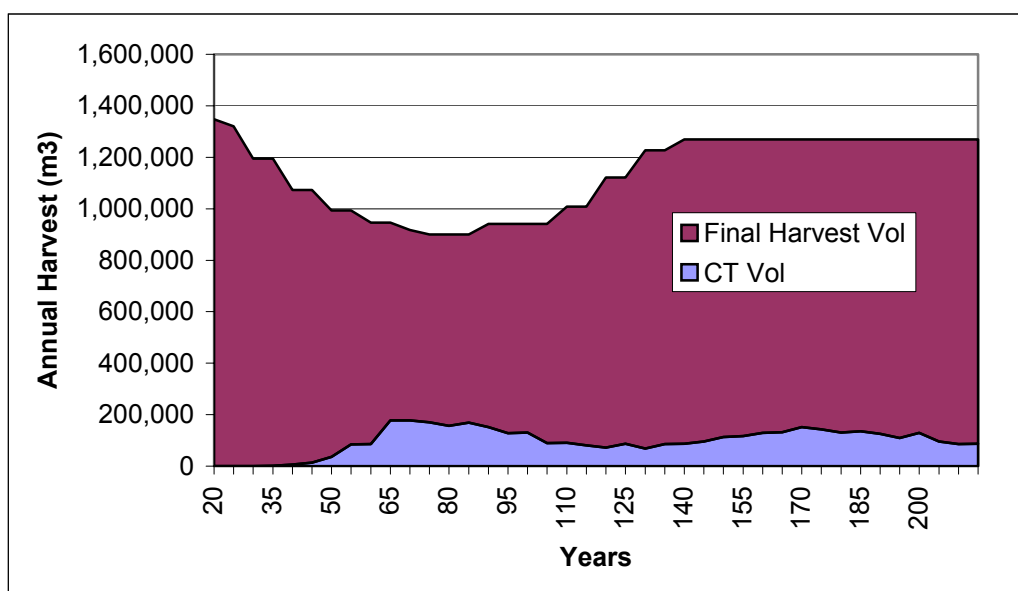


Figure 11: Share of commercial thinning volume of the total volume harvested.

Most commercial thinning takes place on good cedar sites (41.2% of area). Good and medium cedar sites, and good and medium hemlock sites receive 96% of all commercial thinning (Table 6).

Table 6: Commercial thinning in different analysis units (average share over the planning horizon)

Analysis Unit	Cedar good	Cedar medium	Cedar poor	Hemlock good	Hemlock medium	Spruce/fir	Total
Average share of CT area	41.2%	10.3%	0.9%	24.3%	20.3%	3.0%	100%

9.3 Volume Impact Scenarios

This set of runs (described as scenario 5 in table 5 earlier in this document) investigated the opportunity to increase harvest volumes through the use of fertilization and spacing treatments. Four annual budgets (\$0.25 million, \$0.5 million, \$1 million and unlimited) were tested and the model was to treat or not to treat a stand using available treatments within the budget levels to produce volume improvements.

Figure 12 below shows the harvest flows for the volume maximization runs. Short- and mid-term volumes remain unchanged from the silviculture strategy base case. Long-term volume increases range from 5.6% for the \$0.25 million budget to 10.9% for the unlimited budget. The long-term harvest level is reached 10 years earlier for the \$0.5 million, \$1 million and unlimited budget runs than in the \$0.25 million budget run.

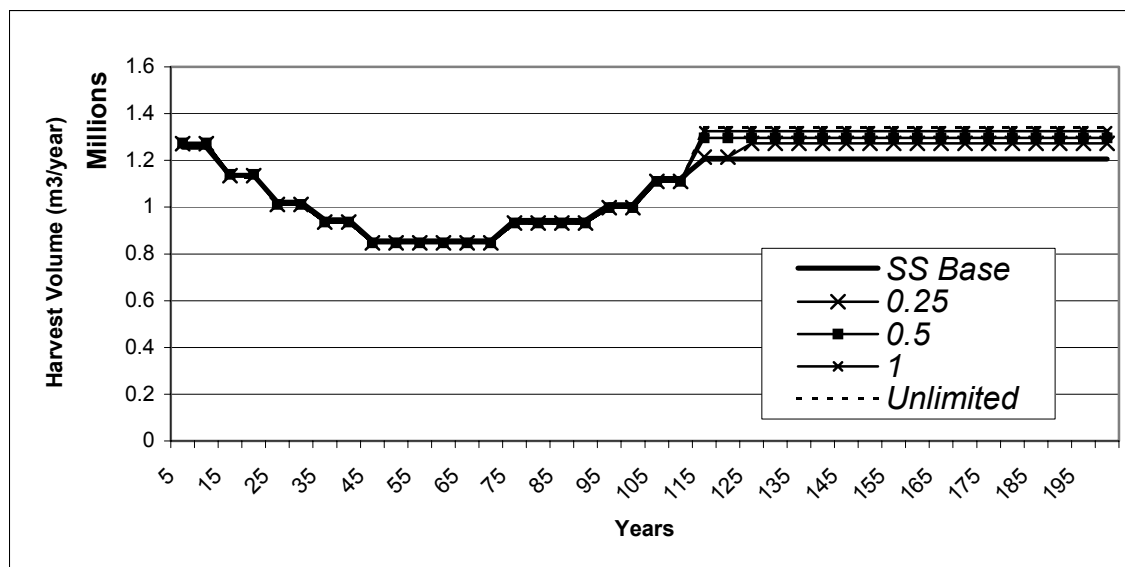


Figure 12: Harvest forecast, silviculture strategy base case and volume impact scenarios.

Figure 13 illustrates the operable or merchantable growing stock (volume above minimum harvest age) for the volume impact scenarios at each budget level. The operable growing stock represents the total volume that is above the minimum harvest age. Throughout the planning horizon there is a significant amount of operable growing stock. All scenarios exhibit an initial growing stock of approximately 60 million m³ and in comparison to the silviculture strategy base case scenario, the most volume impact scenarios maintain higher volumes, likely as a result of the increased stand yields from fertilization. The excess growing stock in the volume scenarios results from fertilized stands being held for forest cover requirements but not being eligible for harvest.

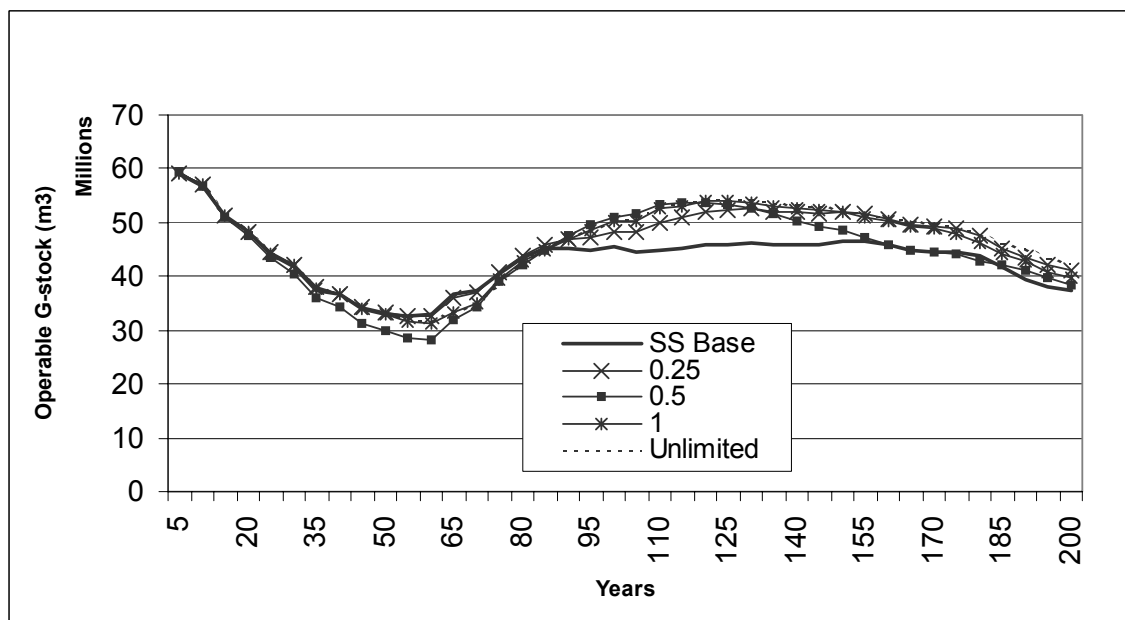


Figure 13: Operable growing stock for silviculture strategy base case and volume impact scenarios.

For all fixed budget scenarios (all but the unlimited budget scenario), the model is forced to spend the available silviculture dollars, where possible. For the unlimited budget scenario, no minimum or maximum expenditure level is set. This results in greater fluctuations in expenditures between periods. Due to tolerance provided to the model as well as lack of available area for treatments, the money spent on silviculture is not always equal to the available budget. Figure 14 below shows the silviculture expenditures for each scenario.

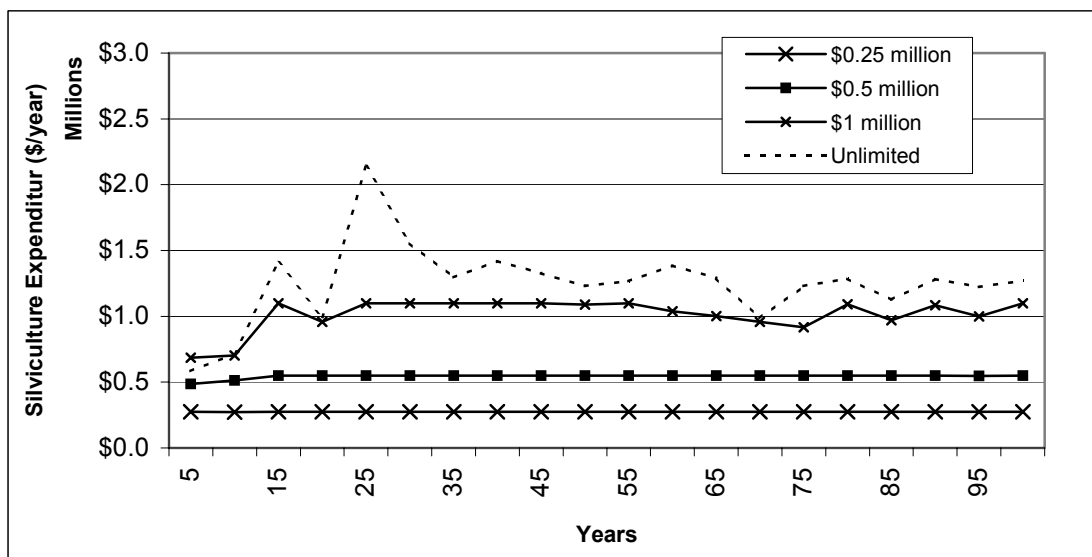


Figure 14: Silviculture expenditures, volume impact scenarios.

Figures 15-18 show the treatments selected by the model for each of the four volume impact scenarios.

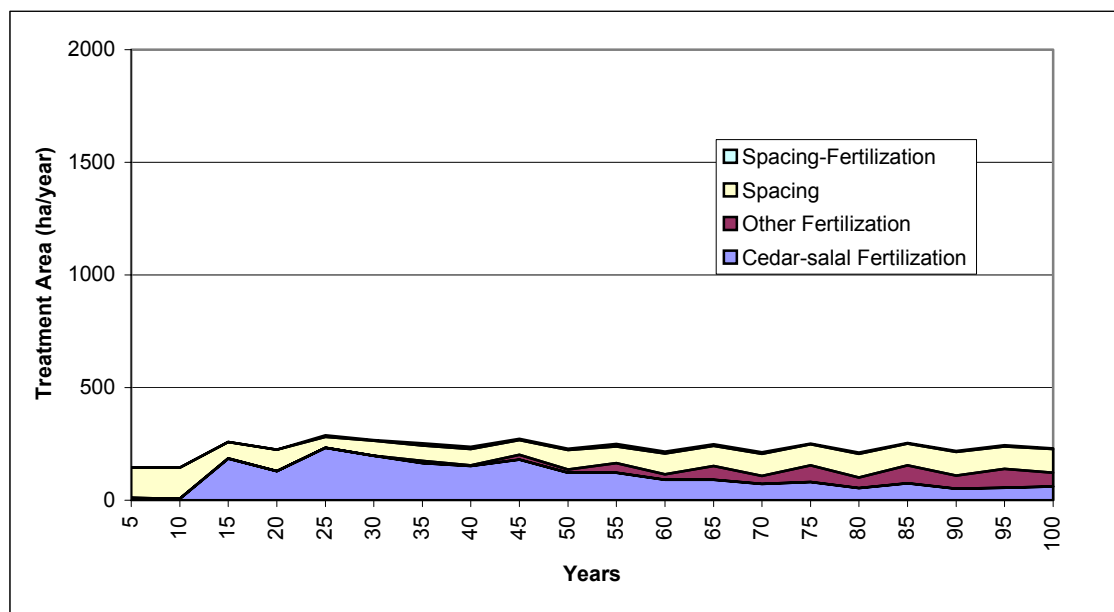


Figure 15: Treatment areas, \$0.25 million volume impact scenario.

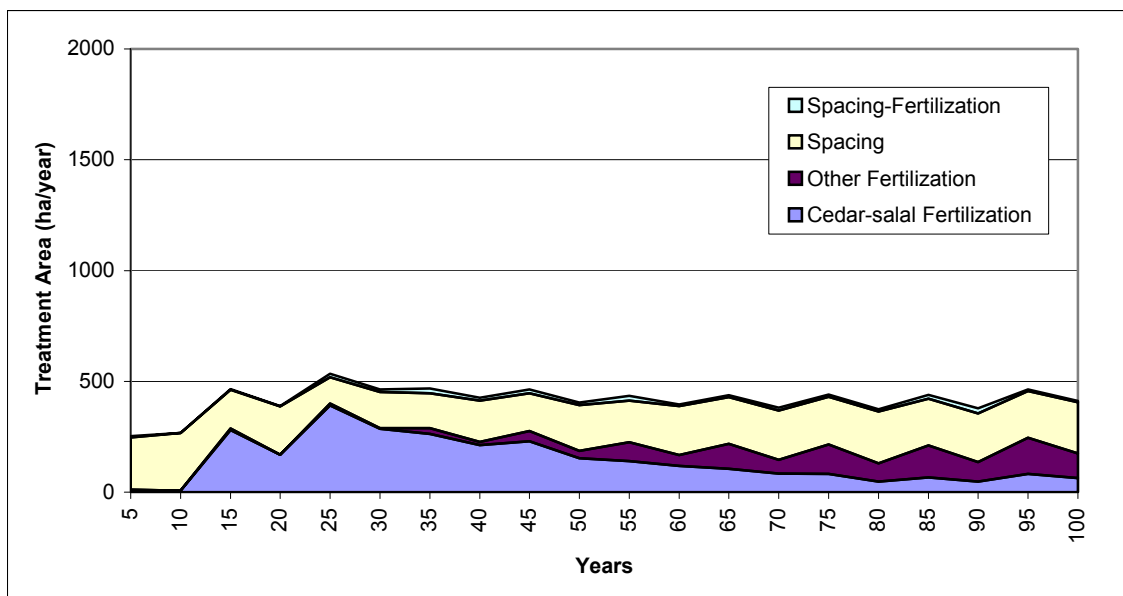


Figure 16: Treatment areas, \$0.5 million volume impact scenario.

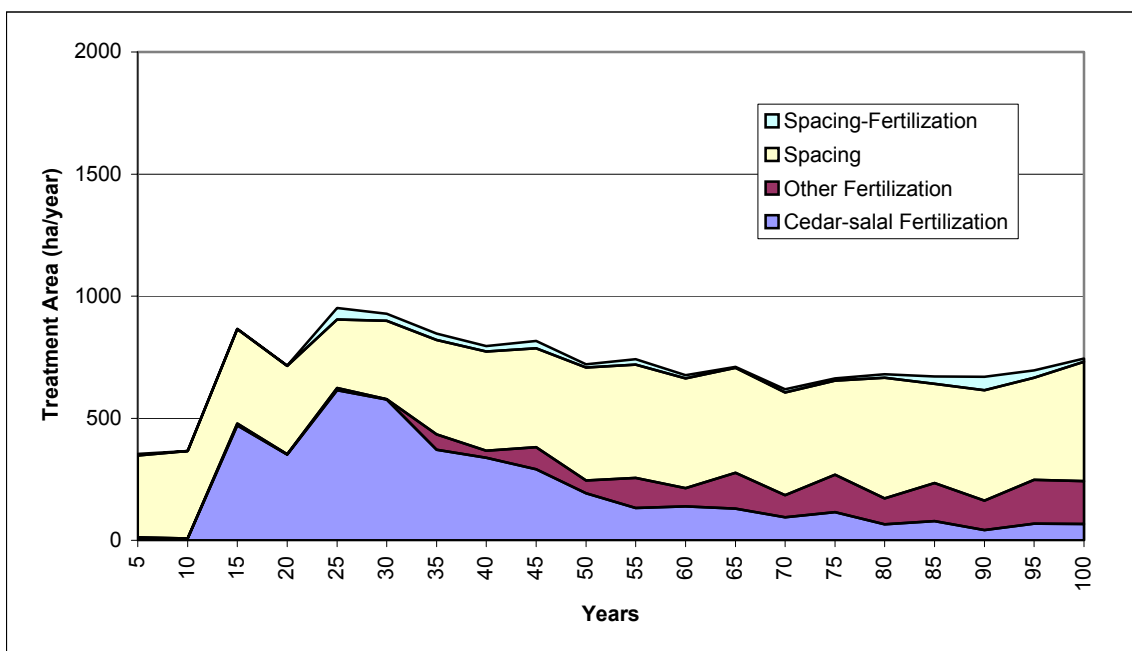


Figure 17: Treatment areas, \$1 million volume impact scenario.

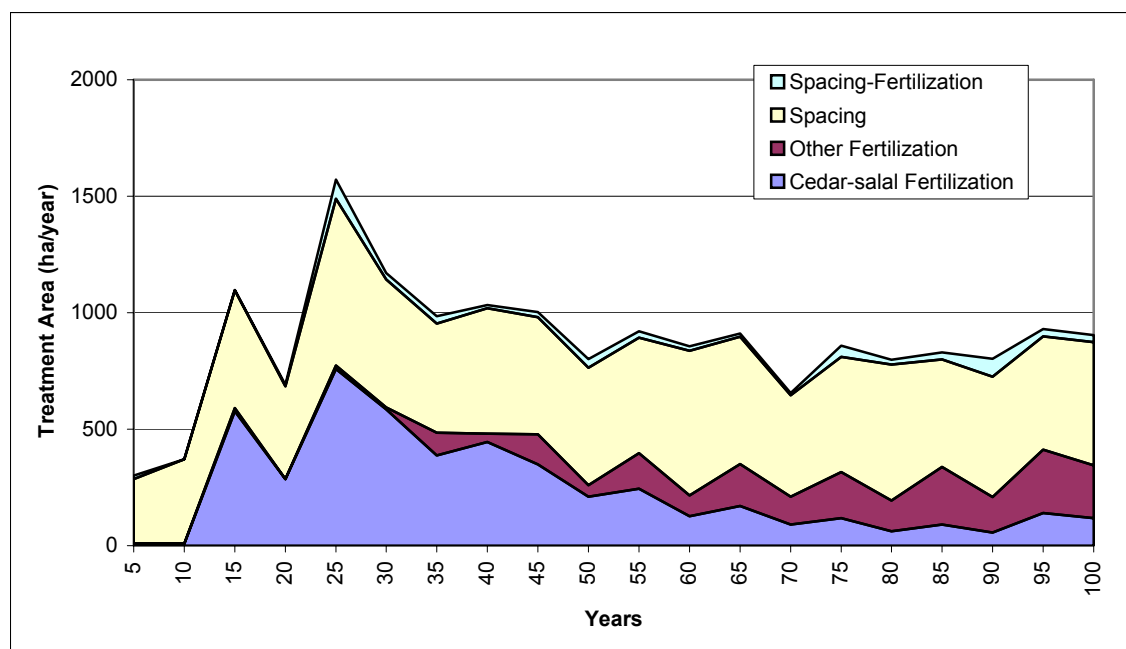


Figure 18: Treatment areas, unlimited budget volume impact run.

In all scenarios, cedar-salal fertilization and spacing are the most common treatments. Spacing increases most dramatically with the increases in budget levels, although spacing produces only a small volume increase compared to the other treatments. The relatively large increase in spacing can be attributed to the available treatment areas: while other treatments may provide larger benefits, the area eligible for these treatment is much smaller, and the maximum possible selection of these treatments occurs at lower budget levels. Table 7 shows the analysis unit distribution and the available treatments for the volume impact scenarios. As can be seen in Table 7, spacing is by far the most available treatment.

Table 7: Treatments available by analysis unit for volume impact runs.

Managed AU	Area	Percent Area	Possible Treatments
Cedar good - cedar	29377.2	17%	none
Cedar good - hem	7215.4	4%	space
Cedar med - cedar	14814.8	9%	none
Cedar med - hem	6141.5	4%	space
Cedar salal	10832.8	6%	SCHIRP fertilization
Cedar poor - cedar	1385.0	1%	None
Cedar poor - hem	559.0	0%	Space
Cedar poor salal	980.4	1%	SCHIRP fertilization
Hem good	32973.7	20%	space
Hem med	31417.0	19%	space
Hem poor	28754.3	17%	none
Spruce/fir	4511.8	3%	space, space-fert, fert

9.4 Value Scenarios

This set of scenarios investigated the opportunity to improve timber value through the use of silviculture. As with the volume impact scenarios, four different annual budgets (\$0.25 million, \$0.5 million, \$1 million, and unlimited) were tested. Here, the model could treat a stand or leave it untreated in consideration to improve value.

The harvest flows for the value runs were maintained at the same level as the silviculture strategy base case with a 3% tolerance to maintain consistency in timber supply for purposes of comparison, as shown in Figure 19 below. With harvest levels fixed, the model was allowed to produce near-optimal solutions by including a total discounted profit (4% discount rate) for second growth stands over the planning horizon in the objective function together with volume and non-timber targets.

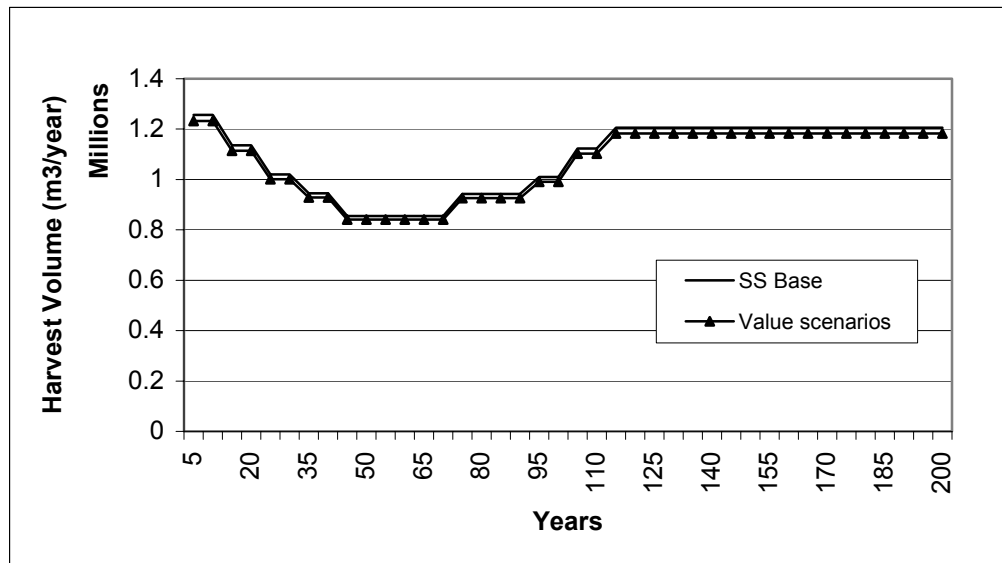


Figure 19: Harvest flows, silviculture strategy base case and value scenarios.

As with the volume impact runs, the yearly expenditures are not always equal to the target budget level. Figure 20 provides the silviculture expenditures for the first 100 years of the planning horizon.

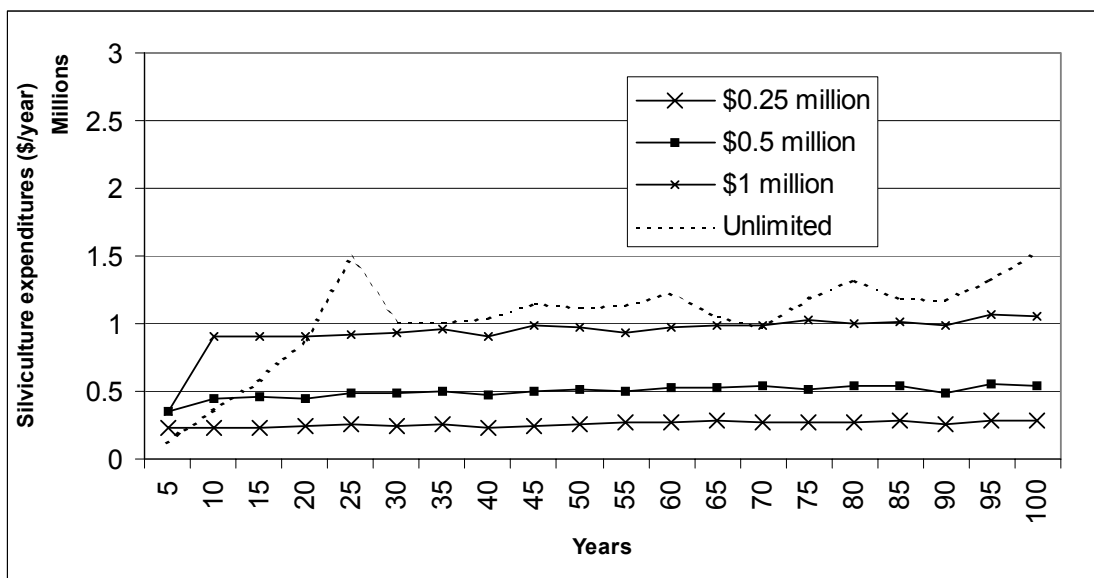


Figure 20: Silviculture expenditures, value scenarios.

Figures 21 – 24 show the treatments selected by the model over the first 100 years for each of the four value scenarios.

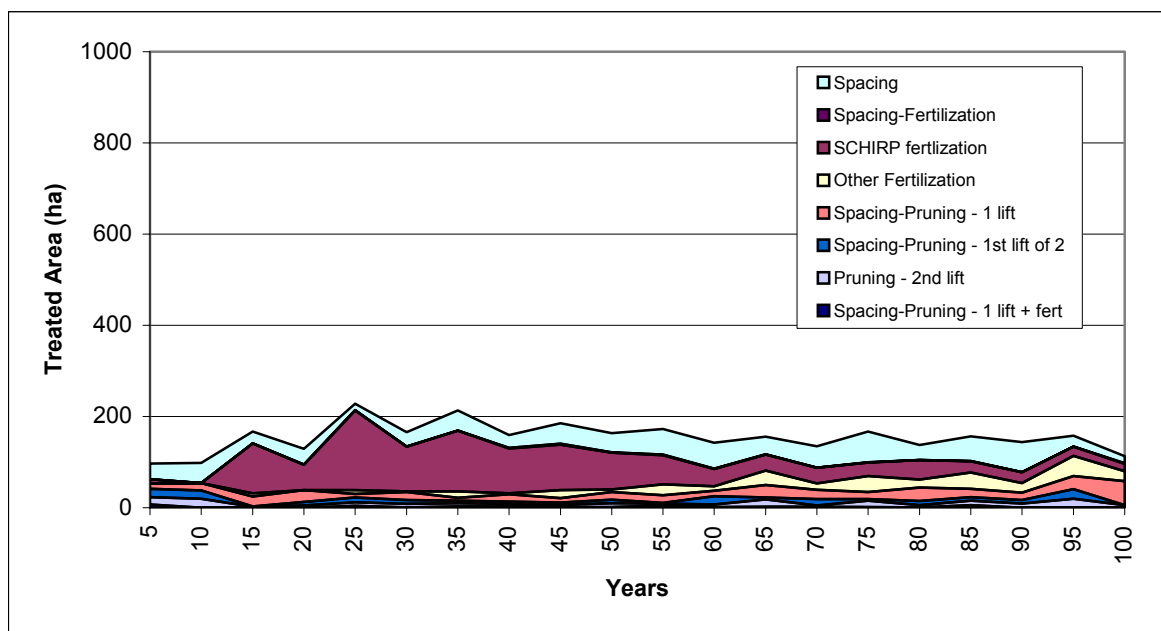


Figure 21: Treatment areas, \$0.25 million value scenario.

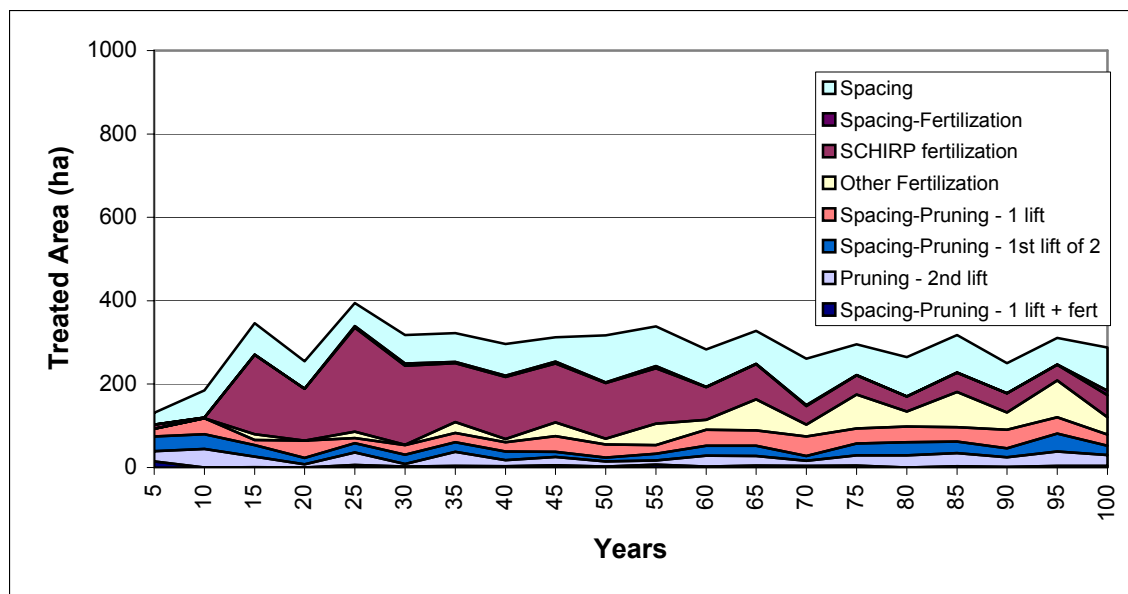


Figure 22: Treatment areas, \$0.5 million value scenario.

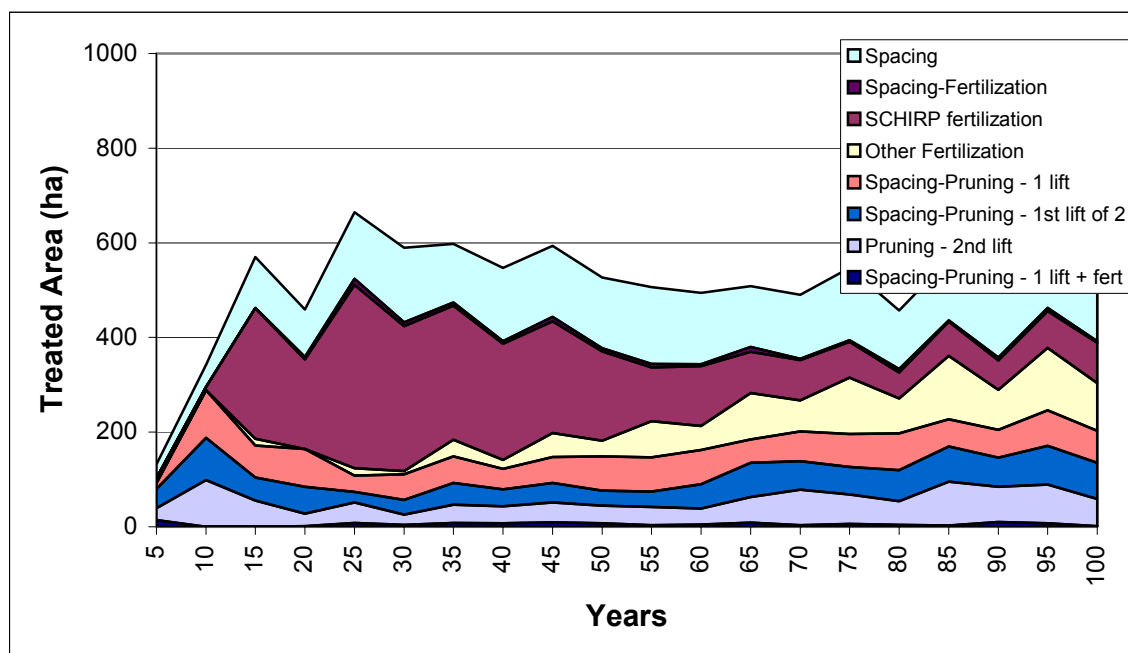


Figure 23: Treatment areas. \$1 million value scenario.

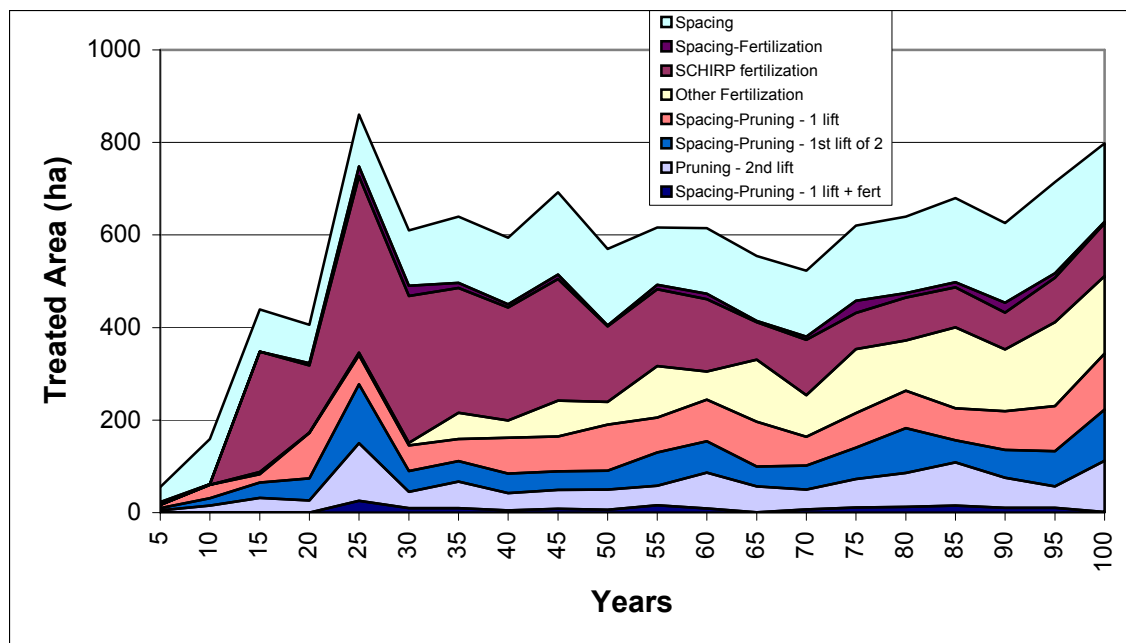


Figure 24: Treatment areas, unlimited budget value scenario.

As with the volume scenarios, a considerable amount of spacing and SCHIRP fertilization is undertaken. Various pruning treatments also comprise a significant proportion of the area treated. When considering the high cost associated with pruning (see Table 22 of Information Package (Appendix 1) for treatment costs), pruning treatments account for a large portion of the budget, especially at higher budgets.

Figure 25 shows that average harvest age increases slightly when silviculture treatments are applied. Managed stands are harvested at a later age as many silviculture treatments, spacing and pruning in particular, may increase the minimum harvest ages.

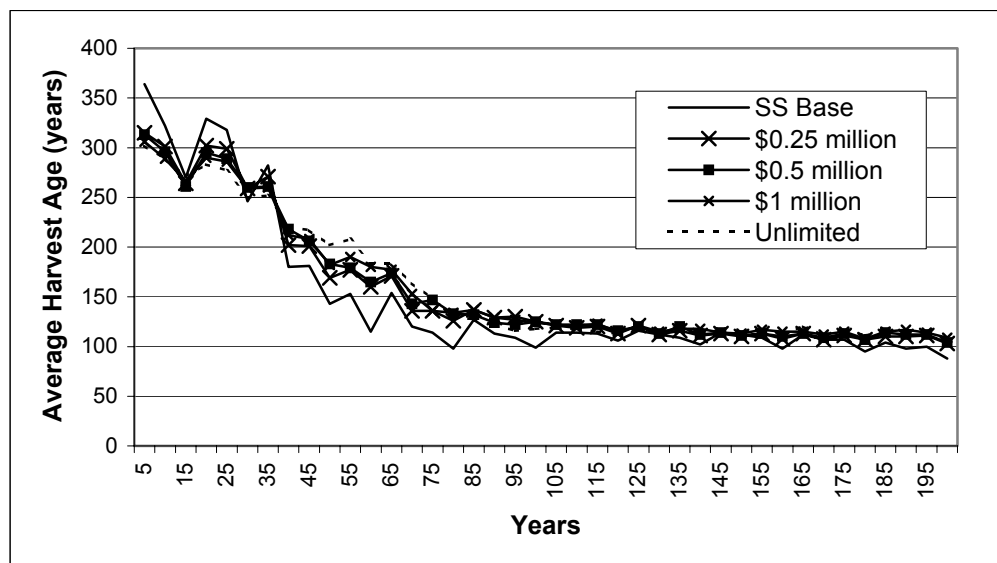


Figure 25: Average harvest age, value scenarios.

Figures 26 – 27 show the quadratic mean diameter (DBHq) over time for the value scenarios and the silviculture strategy base case for managed stands. Silviculture generally produces larger diameters over time.

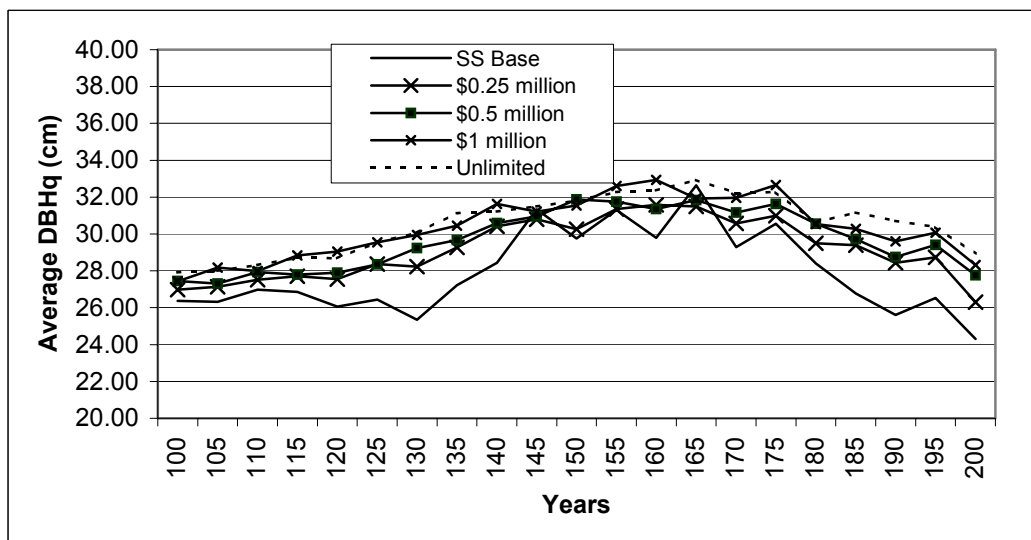


Figure 26: Predicted quadratic mean DBH for cedar stands, value scenarios.

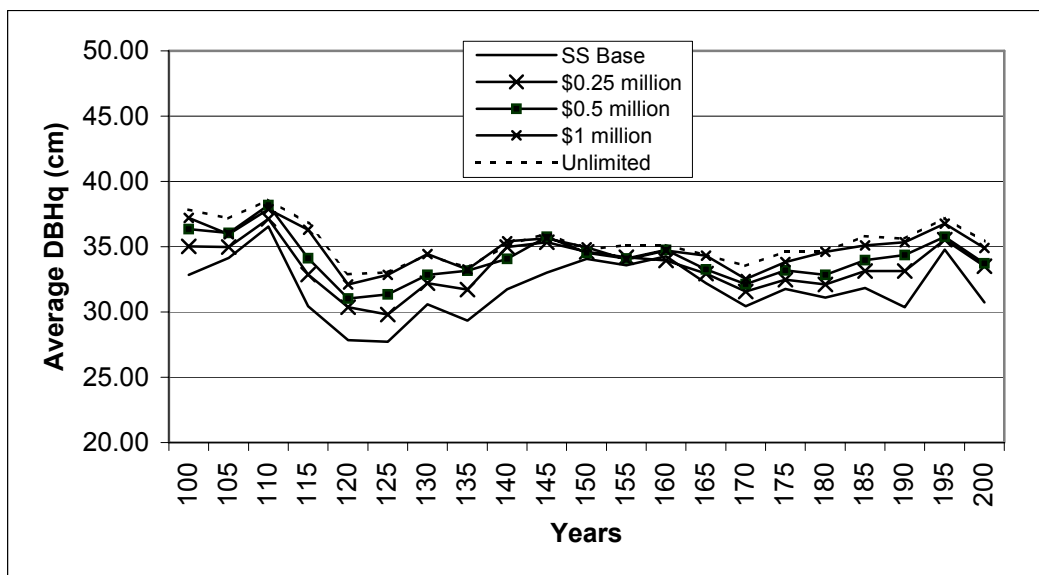


Figure 27: Predicted quadratic mean diameter for hemlock stands, value scenario.

Figure 28 illustrates the per cubic meter value created by different budget levels. All budget levels produced more value per cubic meter than the silviculture strategy base case. The results are shown only from 100 years on as by this time all the harvested stands are managed stands.

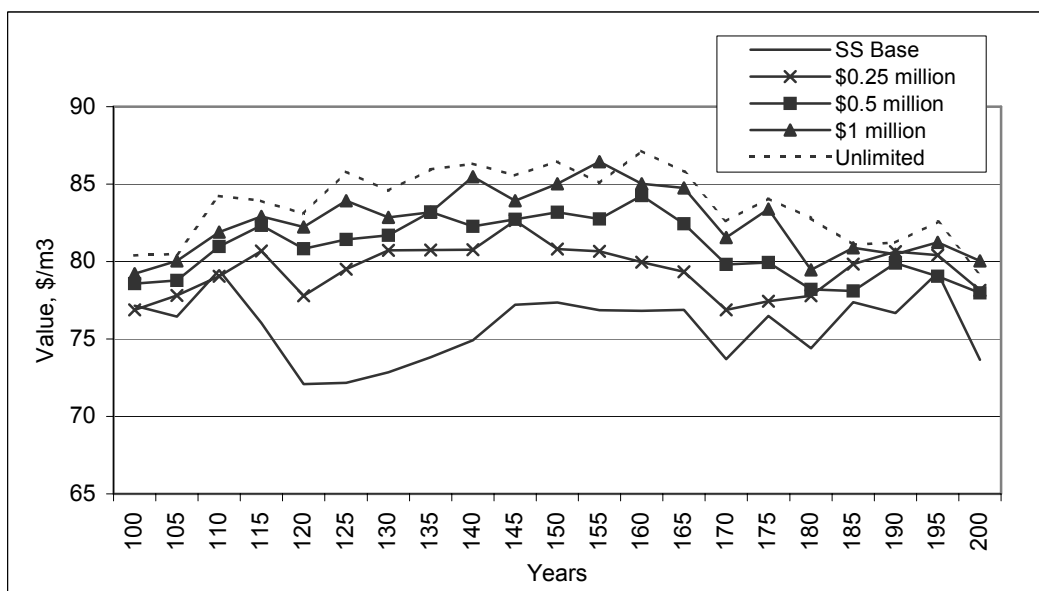


Figure 28: Predicted value for future managed stands, value scenario.

9.5 Alder Conversion

This scenario (#7) investigates the opportunity to increase harvest flows through the conversion of poor cedar salal stands to alder. In this scenario, poor cedar salal stands currently under 40 years of age are eligible for conversion to alder. Older stands are eligible for conversion after harvest.

No volume benefit was realized in this scenario. This could be due to the small percentage of the total THLB area eligible for conversion. In total, 980.4 hectares of poor cedar salal sites are available for conversion to alder. This amounts to only 0.6 % of the total THLB area.

9.6 Partial Harvesting Scenario

Partial harvesting refers to the various harvest methods where a number of standing trees are left on site. If partial harvesting is used as a regeneration method, the silvicultural systems used are usually the seed tree and the shelter wood systems. When partial harvesting is used for reasons other than reforestation (forest cover, biodiversity) it is usually called retention. Partial cutting can be used to satisfy several objectives; however, it often results in a decrease in the harvested volume that is attainable from a site.

The purpose of this scenario (#8) was to test the ability of silviculture to mitigate harvest flow reductions resulting from the use of partial cutting. Volume reductions were estimated at 5.4 percent, which was the reduction used by Weyerhaeuser in their timber supply analysis for TFL 39. This estimate was used, as there is no partial harvesting information available specific to the Kingcome TSA.

As a first step, a “baseline” run was completed to determine the harvest level achievable with use of partial cutting but without silviculture. The result is shown in Figure 28 below.

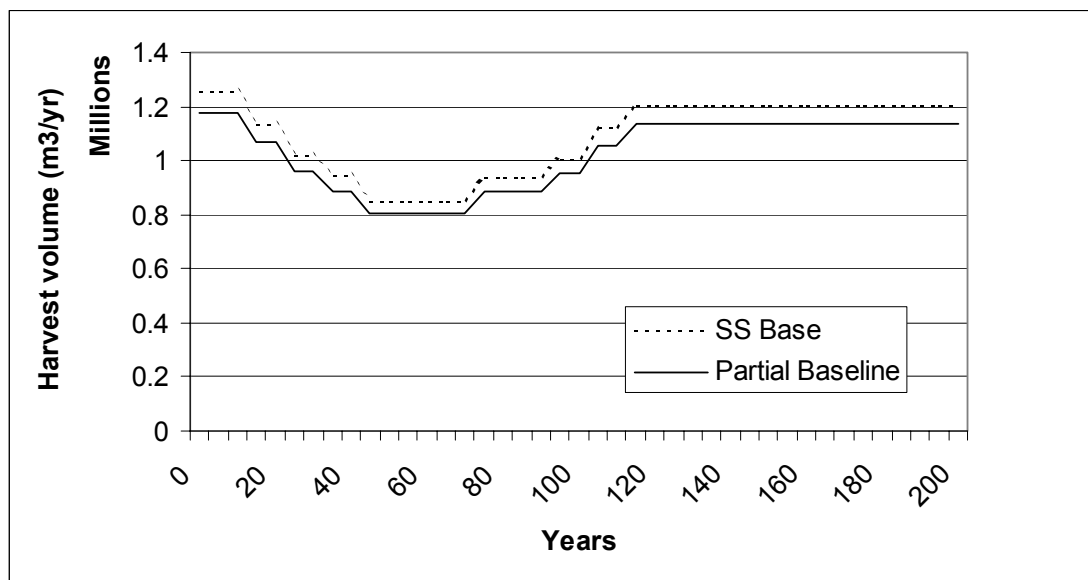


Figure 29: Partial cutting baseline compared to the silviculture strategy base case.

The harvest flow with use of partial cutting (based on the 5.4% volume reduction of yield curves) is approximately 6% lower than that of the silviculture strategy base case.

The next phase of this scenario allowed the model to use silviculture in order to increase harvest volumes. Figure 28 below shows the results.

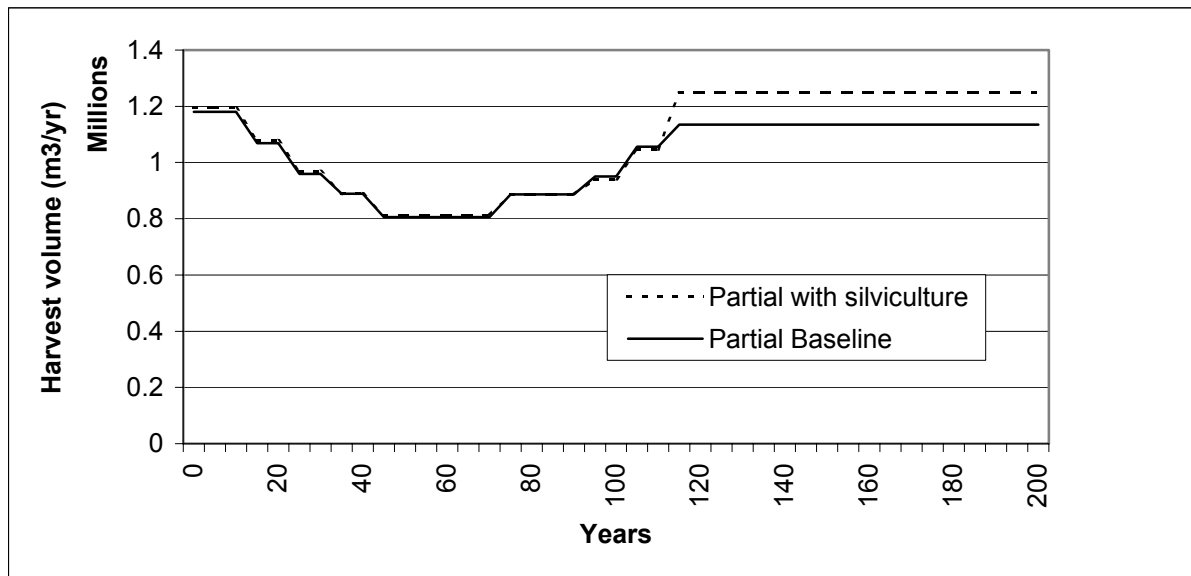


Figure 30: Partial cutting with silviculture compared to the partial cutting base line.

The long-term harvest level with the use of silviculture increases by 6.3% (from 1,134,444 m³/year to 1,206,018 m³/year).

An unlimited budget was used for this scenario – annual budget levels for the first 100 years of the planning horizon are provided in Figure 30.

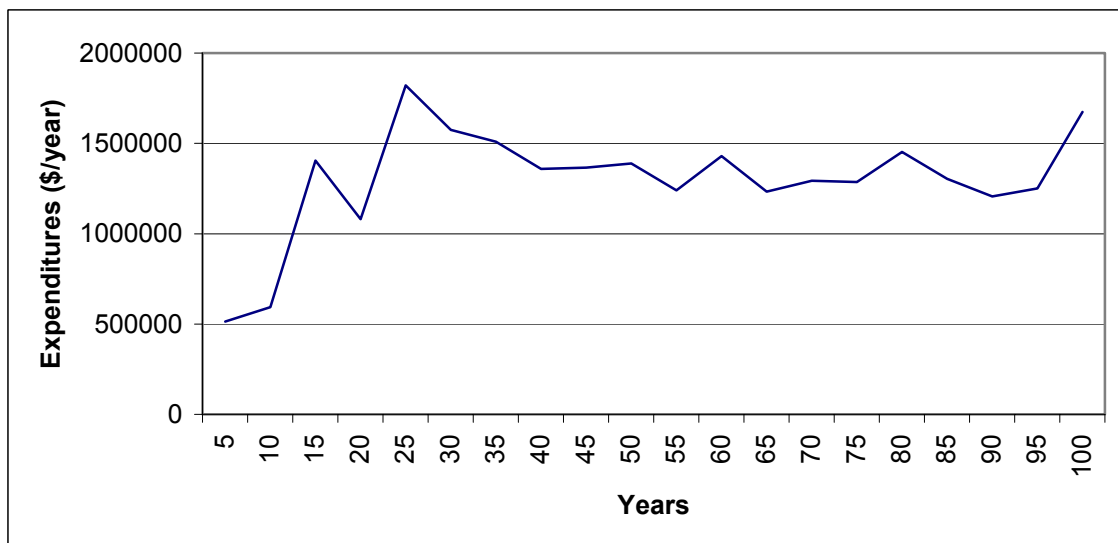


Figure 31: Annual silviculture budget levels for mitigating partial harvesting.

Figure 31 shows the treatments selected by the model for this scenario.

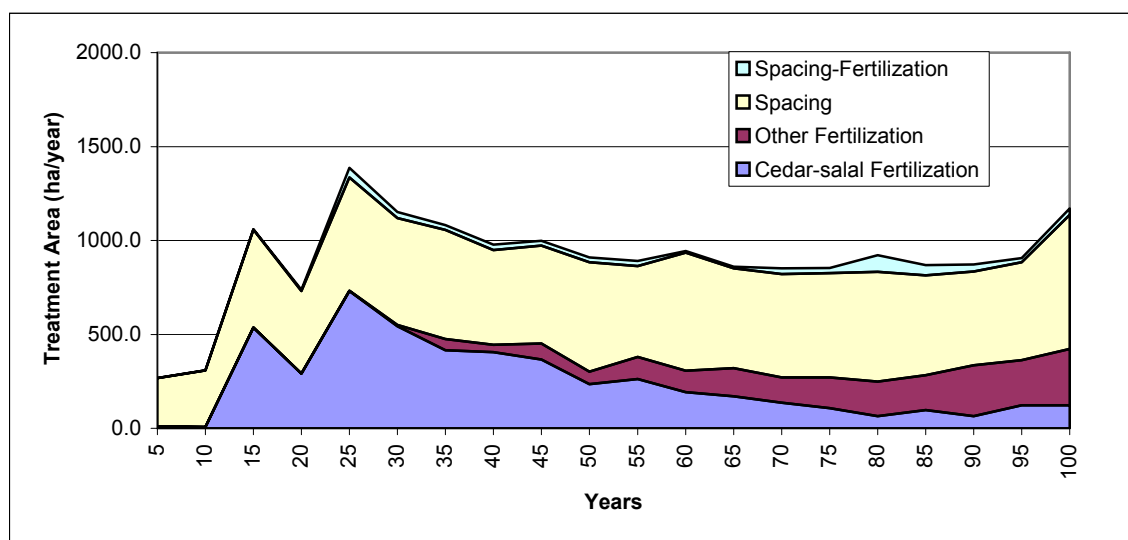


Figure 32: Treatment areas, partial harvesting scenario.

The results of this scenario compare well to the results of the other scenarios in the analysis where the objective was volume maximization. Long-term volume improvements for the earlier runs ranged from 5.6% to 10.9%, where the long-term increase for this scenario is 6.3%. The treatments selected are also similar to the earlier volume runs.

9.7 Habitat Scenario

For the habitat scenario(#9), the application of seral stage requirements was modified. Instead of applying old growth constraints with draw down (full target met in 210 years) as was done in the base case, all seral constraints (early, mature and old, and old) were applied without draw down (i.e. full targets met immediately). The intention was to test the use of silviculture to mitigate possible reductions in timber harvest. However, the change in the application of seral stage targets had no impact on timber flow. This is mostly consistent with the results of the sensitivity analysis conducted for the Kingcome TSA timber supply analysis. The only exception was using early, mature and old seral requirements where the timber supply analysis found a temporary timber supply shortfall of 7% in the 10-year period between 45 and 55 years.

10 Proposed Scenario and Incremental Silviculture Strategy

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

Each of the volume scenarios exhibited increases in the harvest levels. Overall, the unlimited budget scenario and the \$1million scenario resulted in the highest achievable harvest level over the entire planning horizon and the \$0.25 million scenario the lowest. There was no short or medium term impact and even the long-term impact was modest ranging from 5.4% to 10.9%.

In order to assess the harvest level increases compared to the silviculture investment, a simple cost benefit assessment was completed. This assessment provides a comparison that helped in the determination of the proposed scenario. Table 8 illustrates an average cost benefit for volume impact scenarios based on the increases in the harvest level as compared to the silviculture strategy base case scenario. This assessment is simplified, does not incorporate any discounting, and is intended to give direction only.

Table 8: Cost benefit assessment, all volume impact scenarios.

Scenario	Average Harvest/Year over 200 Years	Average Cost/Year over 200 Years	Average Cost to Increase Harvest by 1 m ³
SS Base Case	1,089,911	N/a	N/a
0.25 Million	1,113,591	\$273,284	\$11.5
0.50 Million	1,127,276	\$526,810	\$14.1
1.0 Million	1,140,146	\$982,853	\$19.6
Unlimited Budget	1,144,470	\$1,116,548	\$20.5

Table 8 illustrates that the \$0.25 million scenario has the lowest cost per 1 m³ of increase in average annual harvest at \$11.5/m³.

A similar simple cost benefit assessment was completed for the value impact scenarios as well to assess value increases compared to the silviculture investment. Table 9 illustrates an average cost benefit for value scenarios based on the increases in the value as compared to the silviculture strategy base case scenario. This assessment is simplified, does not incorporate any discounting, and is intended to give direction only. In particular, one should bear in mind that no value increases are fully realized until managed stands form the majority of the harvest, 90-100 years from now.

Table 9: Cost benefit assessment, all value scenarios.

Scenario	Average Value/Year over 200 Years (Managed Stands)	Average Cost/Year over 200 Years	Average Cost to Increase Value by \$1
SS Base Case	\$50,488,897	N/a	N/a
0.25 Million	\$55,664,855	\$268,469	\$0.05
0.50 Million	\$58,482,739	\$523,940	\$0.07
1.0 Million	\$60,712,814	\$1,006,435	\$0.10
Unlimited Budget	\$62,437,170	\$1,349,841	\$0.11

Table 9 illustrates that the \$0.25 million scenario has the lowest cost per \$1 increase in value, which over the entire planning horizon averages to \$0.05.

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 \$0.25 Million with a 10 % tolerance for variance in budget level;
- Setting the long-term harvest flow somewhat higher (3%) than the silviculture strategy base case;
- Maintaining the value weighting in the optimization function the same as in the value scenarios.

Figure 33 summarizes incremental **annual** silviculture treatments by 5-year periods over the next 100 years with the average annual budget of \$ 268,500. As with the previous scenarios, a considerable amount of spacing and SCHIRP fertilization is proposed. Some pruning is also recommended in this scenario. Over the first 20 years, approximately 900 ha of spacing and over 1,300 ha of fertilization are scheduled. There are approximately only 15 to 20 ha annually of recommended pruning treatments.

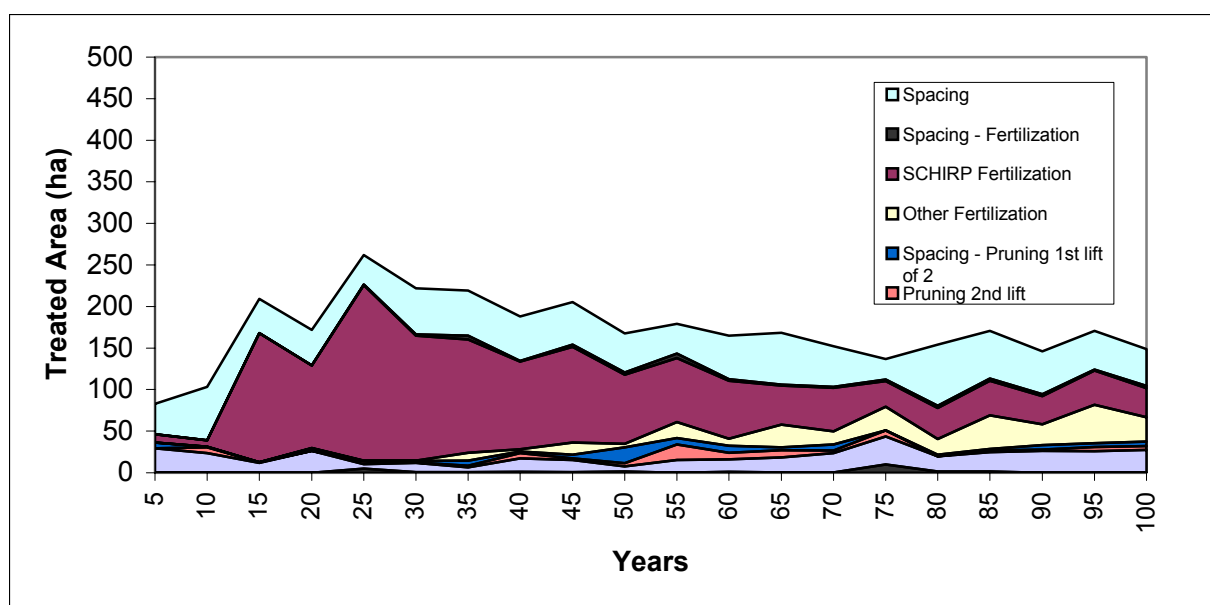


Figure 33: Treatment areas, proposed scenario.

The following table illustrates how treatment totals are divided between analysis units during the first 100 years. Most treatments occur on medium cedar – salal sites (over 40% of all treatments). Medium hemlock sites also receive a significant portion of all treatments.

Table 10: Distribution of treatments between analysis units

Years	Cedar good	Cedar med	Cedar med salal	Cedar poor	Cedar poor salal	Hem good	Hem med	Spruce/fir	Total
5	0.0%	0.0%	10.2%	0.0%	1.9%	2.8%	62.6%	22.5%	100%
10	0.0%	0.0%	7.4%	0.0%	0.0%	0.2%	18.9%	73.5%	100%
15	0.0%	0.0%	49.9%	0.0%	24.3%	0.1%	1.3%	24.4%	100%
20	0.0%	0.0%	57.8%	0.0%	0.0%	0.1%	37.6%	4.5%	100%
25	6.7%	0.0%	61.7%	0.0%	18.8%	2.3%	6.4%	4.1%	100%
30	11.3%	0.0%	67.8%	0.0%	0.0%	1.3%	17.1%	2.5%	100%
35	9.6%	0.0%	62.0%	0.0%	0.2%	6.8%	17.8%	3.5%	100%
40	7.5%	0.1%	56.3%	0.0%	0.0%	2.8%	27.5%	5.9%	100%
45	6.9%	0.0%	55.7%	0.0%	0.5%	11.0%	21.6%	4.2%	100%
50	9.9%	0.6%	49.8%	0.0%	0.0%	5.3%	29.5%	4.8%	100%
55	5.3%	0.1%	42.6%	0.0%	0.4%	16.3%	29.1%	6.2%	100%
60	9.2%	0.9%	41.5%	0.0%	0.5%	7.7%	29.7%	10.5%	100%
65	16.3%	0.0%	28.0%	0.0%	0.1%	18.7%	26.3%	10.6%	100%
70	10.8%	0.1%	33.9%	0.0%	0.6%	12.5%	32.1%	10.0%	100%
75	3.6%	0.0%	22.5%	0.0%	0.1%	29.4%	32.3%	12.1%	100%
80	12.7%	0.0%	23.8%	0.1%	0.5%	22.0%	23.4%	17.4%	100%
85	8.4%	0.7%	24.2%	0.0%	0.2%	27.0%	21.8%	17.6%	100%
90	4.8%	0.6%	21.7%	0.0%	1.4%	21.7%	22.5%	27.3%	100%
95	3.4%	0.1%	23.6%	0.0%	0.6%	28.5%	21.6%	22.2%	100%
100	7.2%	1.0%	21.0%	0.0%	2.3%	22.7%	27.9%	17.8%	100%

Table 11: Treatments for the first decade.

Treatment	Treatment Area (ha), Years 1-5	Treatment Area (ha), Years 6-10	Total Treatment Area (ha), 10 Years
Spacing	183	323	506
SCHIRP Fertilization	50	38	88
Spacing - Pruning 1lift	146	116	263
Spacing - Pruning 1st lift of 2	35	4	38
Pruning 2nd lift	0	35	35
Spacing - Pruning 1 lift + fert	0	1	1

When examining the proposed treatments for the first decade (Table 11), the following trends can be found:

- **Spacing:** A total of 506 hectares of spacing is proposed for the first decade. Medium Hemlock sites receive approximately 61% of this treatment. Good hemlock sites receive the rest (31%).
- **SCHIRP Fertilization:** The proposed treatment area is 88 hectares and it is divided between two Cedar salal types: Medium Cedar salal sites receive 91% with the remaining 9% allocated to poor Cedar salal stands.

- **Space/Prune 1 lift:** This treatment regime combines spacing and pruning. A total of 263 hectares are proposed during the first decade of the planning horizon (62% medium Hemlock sites, 34% good Hemlock sites and 4% of spruce/fir sites).

The following regimes/treatments contributed to the proposed solution, however their share is not significant:

- **Space/Prune 1st lift of 2:** 38 hectares recommended for the next 10 years.
- **Space/Prune 2nd lift of 2:** 35 hectares recommended for the next 10 years.
- **Space/Prune 1 lift/Fertilize:** 1 hectare recommended for the next 10 years.

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

Table 12: Proposed regimes; average annual treatment areas, first decade

Regime	Cedar med salal	Cedar poor salal	Hemlock good	Hemlock med	Spruce/fir	Total
Spacing			19.6	31.0		50.6
SCHIRP Fertilization	8.0	0.8				8.8
Spacing - Pruning 1lift			8.8	16.3	1.2	26.3
Spacing - Pruning 1st lift of 2			3.8			3.8
Pruning 2nd lift			3.5			3.5
Spacing - Pruning 1 lift + fert					0.1	0.1
Total	8.0	0.8	35.7	47.3	1.3	93.1

10.1 Anticipated Silviculture Strategy Outcomes

10.1.1 Harvest Flow

Figure 34 compares the short; mid and long-term harvest level for the silviculture strategy base case, Volume impact at \$0.25 million and the proposed scenario. The proposed strategy has a 3 % higher long-term harvest level than the silviculture strategy base case. While the proposed scenario has a lower harvest level than the volume impact scenario, it is intended to represent a balanced solution between volume and value.

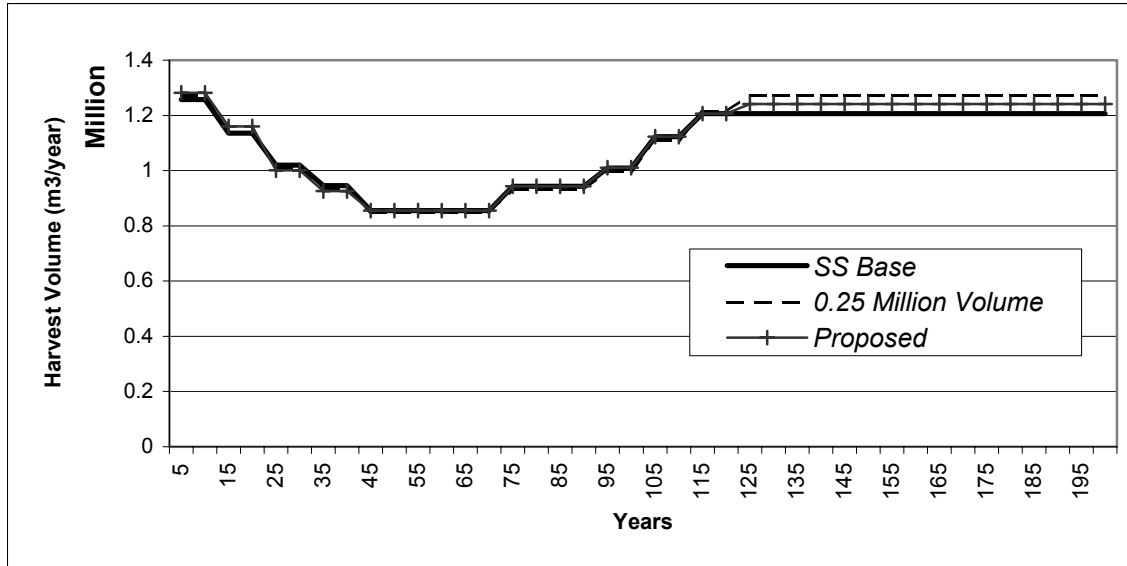


Figure 34: Harvest level, proposed scenario

10.1.2 Diameter

Figures 35 and 36 show managed stand quadratic mean diameters for Cedar and Hemlock comparing the proposed strategy with the silviculture strategy base case and the \$0.25 million value scenario.

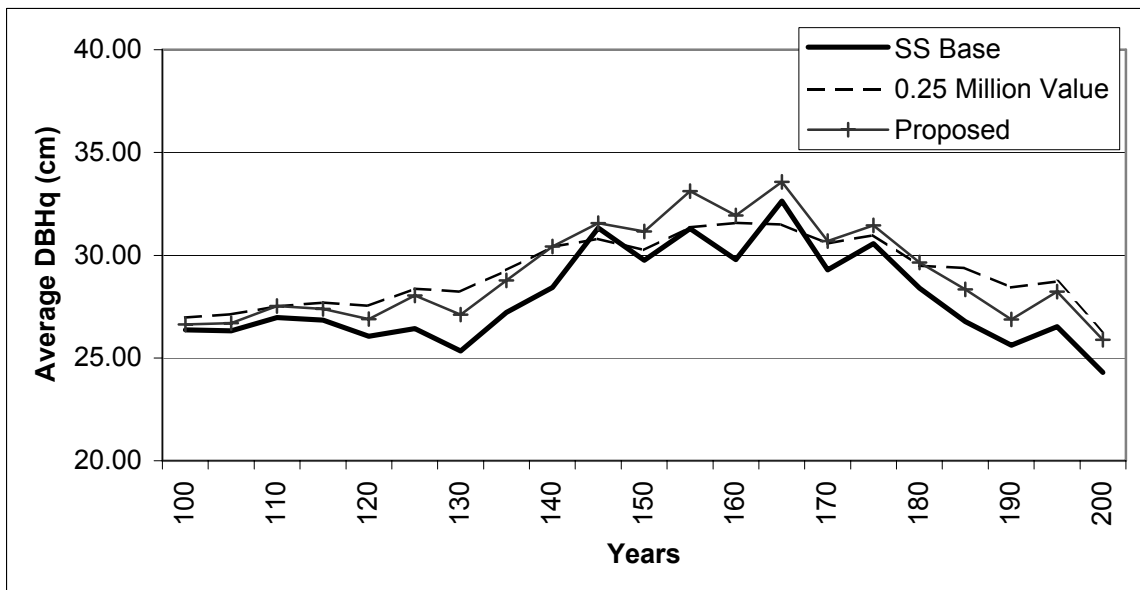


Figure 35: Predicted quadratic mean diameter, cedar.

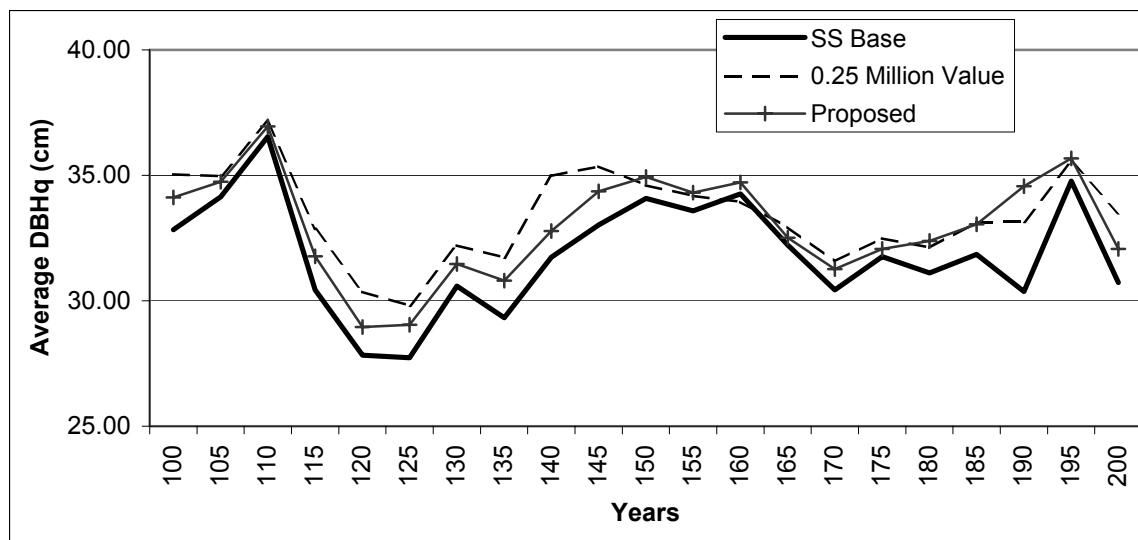


Figure 36: Predicted quadratic mean diameter, hemlock.

The proposed scenario shows modest increases in mean quadratic diameter over the silviculture strategy base for both cedar (0-7%) and hemlock (0-5%). It is important to note that these increases will not take place until 100 years from now.

10.1.3 Value and Quality

Figure 37 compares the value per cubic meter between the proposed silviculture strategy, silviculture strategy base case and the 250,000 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 mainly through larger log sizes and to some extent through producing clear wood. However, the amount of clear wood is only about 0.5 % of the total timber supply throughout the second half of the planning horizon (100-200 years).

As Figure 37 illustrates the proposed silviculture strategy produces higher value per cubic meter over the planning horizon. However, this trend is not evident until approximately 100 years from today.

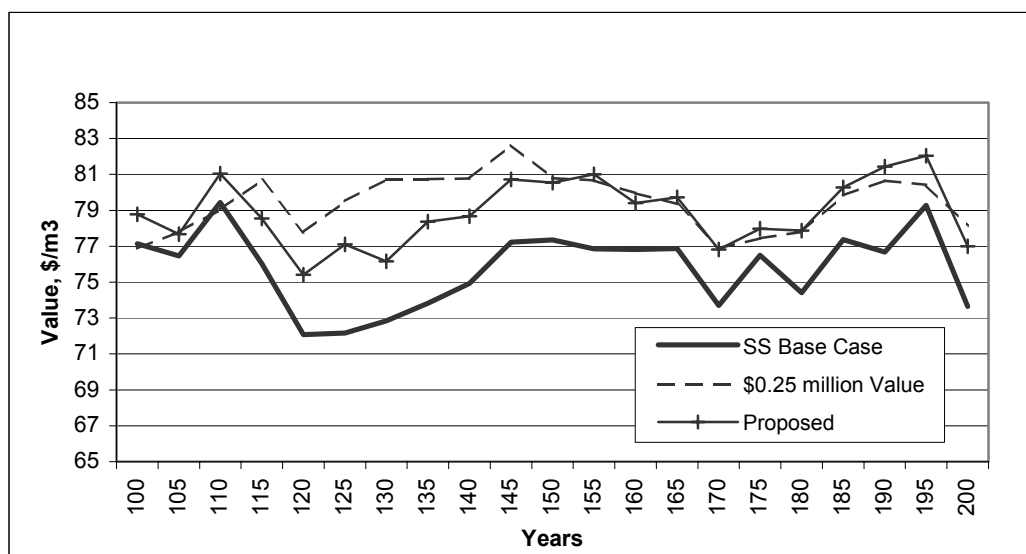


Figure 37: Value per cubic meter; proposed strategy

10.1.4 Employment

Tables 13 and 14 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 14 compares the long-term jobs created by the proposed scenario to the silviculture strategy base case. Employment multipliers are from the TSR 2 Socio-Economic Analysis by the Economics and Trade Branch of the Ministry of Forests.

As can be seen from Table 14, there is an apparent net gain of jobs from the proposed silviculture strategy compared to the silviculture strategy base case in the long run. The table also shows some net losses for the third and fourth decades. These losses are to some extent an artefact of modelling; the intent was to try and maintain the silviculture strategy base case harvest levels in the short and medium terms. However, the model produced somewhat higher volume levels for decades 1 and 2 than the silviculture strategy base case at the expense of decades 3 and 4. These short-term differences from the silviculture strategy base case are not caused by the silviculture strategy, but rather the difficulty of recreating exactly the same harvest levels as in the silviculture strategy base case using heuristic techniques.

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 timber supply review, and subsequent employment in the Kingcome TSA. The only direct relationship between harvest levels and employment in the TSA is based on the actual AAC determination that the Chief Forester makes from time to time.

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

Table 13: Short-term employment benefits, jobs

Year	Space	Prune	Fertilize	Total
1	1.7	1.1	0.01	2.8
2	1.7	1.1	0.01	2.8
3	1.7	1.1	0.01	2.8
4	1.7	1.1	0.01	2.8
5	1.7	1.1	0.01	2.8
5-Year annual average	1.7	1.1	0.01	2.8
Years 6-10 annual jobs	2.1	0.9	0.01	3.0
Years 11-15 annual jobs	1.2	0.4	0.18	1.8
Years 16-20 annual jobs	1.7	0.9	0.12	2.7
Average annual jobs over 20 years	1.7	0.8	0.1	2.6

Table 14: Long-term employment benefits^a

Decade	Harvest Increment ('000)	Incremental Annual TSA Jobs by Decade	Incremental Annual Provincial Jobs by Decade
1	25	11.5	67.2
2	24	11.2	65.4
3	-20	-9.0	-53.1
4	-19	-8.8	-51.9
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	0	0	0
11	0	0	0
12	1	0.2	1.4
13	36	16.4	96.2
14	36	16.4	96.2
15	36	16.4	96.2
16	36	16.4	96.2
17	36	16.4	96.2
18	36	16.4	96.2
19	36	16.4	96.2
20	36	16.4	96.2
Total	296.4	136.3	800.1

^aMultipliers as per TSR 2, TSA 0.46, Province 2.7 per 1,000 m³ of AAC

11 Discussion

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

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

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

11.1 Commercial Thinning

The results of this analysis show that commercial thinning would be able to increase short, mid and long-term timber harvest in the TSA. However, the analysis assumed that all commercial thinning in the TSA would be able to recover associated costs. It also assumed that commercial thinning could be carried out anywhere in the TSA. As it is likely that commercial thinning would only be available in limited cases due to costs and accessibility, only a limited amount (if any) should be included in the silviculture strategy for the TSA.

11.2 Volume Impact Scenarios

Each of the volume scenarios exhibited increases in the harvest levels. Overall, the unlimited budget scenario and the \$1million scenario resulted in the highest achievable harvest level over the entire planning horizon and the \$0.25 million scenario the lowest. There was no short or medium term impact and even the long-term impact was modest ranging from 5.4% to 10.9%.

All volume scenarios proposed a significant amount of SCHIRP fertilization. This is understandable as the modelling assumptions for this treatment increased the yields of cedar salal sites considerably. It is important to verify through further research what the true increases in yield are.

11.3 Value Scenarios

This set of scenarios investigated the opportunity to improve timber value through the use of silviculture. Here, the model could treat a stand or leave it untreated in consideration to improve value.

A considerable amount of spacing and SCHIRP fertilization was proposed. Pruning treatments also comprised a proportion of the area treated. When considering the high cost associated with pruning treatments, they accounted for a large portion of the budget, especially at higher budget levels.

11.4 Alder Conversion

No volume benefit was realized in this scenario. As the THLB that was eligible for conversion was only 980 hectares in size there would not be any forest level value benefit from alder conversion either. However, several questions remain:

- Does 980 ha represent a realistic area for conversion candidate areas?
- Only poor and wet cedar sites with particular attributes were candidates; some suggest that good sites should be converted to alder, not poor sites.

12 Conclusions

This report and the attached analysis information package have documented analysis assumptions, procedures and results for the Kingcome TSA type 2 incremental silviculture analysis. The results show that there are opportunities to increase both volume and value of the timber supply. However, these increases in timber supply and its value will not take place until several decades from now when future managed stands form the majority of harvest.

Commercial thinning is the only treatment that showed harvest volume increases in the short and mid term as well. Due to accessibility problems and the cost of commercial thinning, the TSA may only be able to commercially thin a fraction of the areas showed in this report.

12.1 Recommendations

The proposed strategy is only one of potentially many desirable approaches for the Kingcome TSA. Different assumptions in the modeling would likely produce different 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:

- The short and medium - term timber supply are not affected (except for CT) by incremental silviculture. The impact of incremental silviculture takes place approximately after 100 years.
- The long-term impacts are relatively modest.
- If funding is available, an average annual budget of \$ 268,000 is able to increase the long-term harvest level by about 3% while providing larger piece sizes and value (proposed strategy).
- In the first decade, the recommended annual treatment areas are 51 ha of spacing (good and medium hemlock sites), 9 ha of SCHIRP fertilization, 30 ha of spacing and pruning (good hemlock sites) and 4 ha of pruning (2nd lift).
- The district should continue investigating the feasibility of commercial thinning and utilization of alder.

13 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 link forest management decisions to ecosystems and their functions. It would greatly help decision-making and improve stand and forest level analyses - such as this type 2 - to complete ecological (TEM) mapping for the TSA.
- Some local practising silviculturists feel strongly about growing and utilization of alder in the TSA. The topic deserves attention when allocating research funds.

14 References

- Atherton, L.P. 1999. Incremental Silviculture Strategy for B.C. - Working paper #2: Concepts and Strategy of Planning - Proposed Planning Framework. February 19, 1999. Victoria, B.C.
- B.C. Ministry of Forests. 2000. Clear Wood Values from Pruning, Madison's Canadian Lumber Reporter, and The Tree and Stand Simulator (TASS). December 2000. Victoria. B.C.
- B.C. Ministry of Forests. 2001. Kingcome Timber Supply Area, Timber Supply Review, Analysis Report. November 2001. Victoria. B.C.
- B.C. Ministry of Forests. 1998. Kingcome Timber Supply Area, Incremental Silviculture Strategy (Interim) Version 1.0. August 1998. Victoria B.C.
- B.C. Ministry of Forests and Ministry of Environment, Lands, and Parks. 1999. Resource Planning Framework - Guidelines for the Development of Resource Management Plans for 2000/01 (working draft). June 30, 1999. Victoria, B.C.
- Nigh, G.D. 1998. Site Index Adjustments for Old-growth Stands Based on Veteran Trees. Research Branch, B.C. Ministry of Forests 1998. Victoria, B.C.
- Nussbaum, A.F. 1998. Site Index Adjustments for Old-growth Stands Based on Paired Plots. Research Branch, B.C. Ministry of Forests 1998. Victoria B.C.
- Memorandum from the Director of the Timber Supply Branch of the Ministry of Forests. December 1, 1997. *"Incorporating Biodiversity and Landscape Units in the Timber Supply Review."*