# Ministry of Forests

## Vancouver Forest Region

## Queen Charlotte Islands Forest District

# Type 2 Strategic Silviculture Analysis
# Analysis Report
# November 2001


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*Type 2 Strategic Silviculture Analysis*
*Analysis Report*

# Executive Summary

## *Introduction*

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

## *Guidelines for Deviating from the Silviculture Strategy*

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

## *Management Objectives*

The following management objectives were identified during Workshop #1:

- Manage the short- and long-term timber supply to yield the maximum possible volume without sacrificing long-term sustainability.
- Manage regenerated stands to yield 8% premium logs by volume, with the majority of the remainder being of good-grade sawlog quality.

The following are the product objectives at the log level for the QC TSA:

**Premium Log:** Pine pole – 30+ cm min diameter over 15 m, few knots (pole);
Cedar pole – 30+ cm min diameter over 15 m, few knots (pole);
Cedar large timber – min. 55 cm & low taper for 10 m, mature wood;
Spruce/Hemlock clear – clear for 5m.

**Sawlog:** Minimum average 45 cm DBH and stand volume of 350 $m^3$/ha

## *Potential Strategies*

| Response Time Frame | Strategy Description | Anticipated result |
|---|---|---|
| Short-Term | 1. Increase the volume of some existing stands through:<br>• Late rotation fertilization. | 1. **Short-, mid- and long-term** timber supply is somewhat sensitive to an increase in existing stand volumes. A 10% increase in stand volumes is anticipated to result in 2% increase in timber supply. |
| Mid-Term | 1. Increase regenerated stand volumes as per the scenario in "Long Term".<br><br>2. Space and fertilize stands.<br><br>3. Increase the value of second growth stands by:<br>• Pruning, spacing and fertilization. | 1. Increased regenerated stand volumes have some impact on mid-term timber supply; however, the greatest impact is in the long term.<br>2. Bring some long-term volumes to the mid term.<br><br>3. Mid-term value increase expected to be modest, as benefits will occur in the long-term. |
| Long-Term | 1. Increase regenerated stand volumes by:<br>• Using genetically improved seed;<br>• Fertilizing suitable regenerated stands;<br><br>2. Increase the value of second growth stands by:<br>• Pruning, spacing and fertilization. | 1. This analysis includes genetic gain in the development of yield curves in TASS with 15% gain for Hw and 11% for Cw. Genetically improved seed for spruce provides weevil resistance but no volume gains. Fertilization increases stand volumes.<br><br>Value increases expected in the long-term. |

## *Scenarios*

The designed scenarios form the basis of the analysis methodology. The first run performed is a base case scenario designed as a benchmark of 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 preferred 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 preferred scenario, a run that represents one of many potentially desirable management strategies.

The results of the analysis show that:

- An annual budget level of $0.5 million is able to increase the harvest value significantly without compromising harvest levels.
- If funding is available, an annual budget of up to $1 million should be used. Beyond $1 million, the improvement in the per cubic metre harvest value is insignificant.
- In the first decade, 71% of available funding should go to spacing, 25% to pruning and 4% to fertilization.

- In the first decade, the treatments should concentrate on good hemlock sites (34% of area treated) and good spruce sites (25% of area treated).

- For the next 10 years, the recommended annual treatment areas are 34 ha of fertilizing, 289 ha of spacing, 16 ha spacing/fertilizing, and 91 ha of pruning.

- Local objectives were set to produce more clearwood over the planning horizon than resulted from this analysis. There should be flexibility to allocate more funds to pruning than this analysis indicates if it is deemed necessary to produce more clearwood to maintain future product options. Pruning should concentrate on lower cost productive sites.

Adopting an incremental silviculture strategy with an average annual budget level of $1 million as per the preferred scenario could produce the following results:

- A modest increase in quadratic mean diameter for all species towards the end of the planning horizon.
- An average increase of $8 per cubic metre in managed stand value over most of the planning horizon.
- An average of over 150,000 cubic metres, or an average of 2.7% of total harvest volume, of clear wood per decade beginning 100 years from now.
- 98 silviculture jobs over the next 10 years.

## *Incremental Silviculture Program*

The following table illustrates the annual treatment areas for different treatment regimes, which comprise the incremental silviculture strategy for the next 100 years. Commercial thinning (CT) is assumed to have no net cost and therefore does not contribute to silviculture expenditure totals.

| Decade | Cedar good/medium | Cedar poor | Hemlock good | Hemlock medium | Hemlock poor | Spruce good | Spruce medium | Total |
|---|---|---|---|---|---|---|---|---|
| 1 | 9.17% | 1.61% | 33.64% | 8.26% | 4.93% | 28.36% | 14.02% | 100% |
| 2 | 10.73% | 1.54% | 30.00% | 11.42% | 0.00% | 30.09% | 16.21% | 100% |
| 3 | 11.24% | 1.51% | 33.86% | 8.71% | 0.02% | 28.69% | 15.97% | 100% |
| 4 | 15.21% | 1.50% | 27.35% | 6.32% | 0.00% | 29.58% | 20.03% | 100% |
| 5 | 16.76% | 1.51% | 33.77% | 7.34% | 0.00% | 20.69% | 19.94% | 100% |
| 6 | 16.80% | 1.42% | 39.90% | 9.04% | 0.00% | 11.31% | 21.54% | 100% |
| 7 | 16.98% | 1.36% | 39.34% | 10.32% | 0.00% | 9.71% | 22.28% | 100% |
| 8 | 18.66% | 1.34% | 33.13% | 9.59% | 0.00% | 9.24% | 28.04% | 100% |
| 9 | 16.18% | 1.24% | 44.11% | 7.48% | 0.07% | 8.70% | 22.22% | 100% |
| 10 | 20.40% | 1.32% | 39.51% | 7.65% | 0.14% | 9.34% | 21.64% | 100% |

## *Incremental Silviculture Program, First Decade*

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

| Analysis Unit | fert | space | space fert | Prune 1 | prune 2 |
|---|---|---|---|---|---|
| Cedar good/medium | N/a | 22 | N/a | N/a | N/a |
| Cedar poor | 16 | N/a | N/a | N/a | N/a |
| Hemlock good | N/a | 140 | N/a | 52 | 1 |
| Hemlock medium | N/a | 8 | N/a | N/a | N/a |
| Hemlock poor | N/a | 18 | N/a | N/a | N/a |
| Spruce good | N/a | 85 | N/a | 38 | 0 |
| Spruce medium | 18 | 16 | 16 | N/a | N/a |
| **Grand Total** | **34** | **289** | **16** | **90** | **1** |

- ***Fertilization:*** This treatment is a stand-alone treatment option on poor Cedar sites. It follows spacing treatments on medium/poor spruce sites. A total of 34 hectares per year are being proposed over the first decade of the planning horizon. Poor cedar sites and medium/poor site spruce stands receive 53% with the remaining 47% allocated to poor cedar sites.

- ***Spacing:*** A total of 289 hectares of annual spacing treatments are proposed for the first decade. Some of the spaced stands are later pruned. Good hemlock sites receive approximately 48% of this treatment. Spruce good has approximately a 29% share.

- ***Space/Fertilize:*** Only medium/poor spruce sites were eligible for this treatment. A total of 16 hectares annually are proposed for the next ten years.

- ***Prune 1:*** These stands receive a spacing treatment as well. The spacing area is included in the "Spacing" above. A total of 90 hectares annually are proposed during the first decade of the planning horizon. Good hemlock sites receive 58% of this treatment with good spruce sites receiving the balance.

- ***Prune 2:*** Only 1 hectare annually is proposed during the first decade of the planning horizon (100% Hemlock good).

## *Recent Developments*

The product objectives, as defined at the beginning of this project, included clear wood. The recommended silviculture strategy proposes some pruning, much of it in hemlock stands, to achieve this objective.

It appears that pruned stands may be more susceptible to serious damage from budworm. This may be the case particularly with pruned hemlock. In those years when the budworm numbers are high, it may be wise to prune less area than recommended in this strategy and concentrate the pruning on spruce stands.

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# 1.0 Introduction

Incremental silviculture has been practiced in the Queen Charlotte Timber Supply Area (TSA) for a number of years. Historically, treatment decisions were based on stand-level factors such as species, age, or access, and treatment rules and analyses were developed on a stand-level basis.

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

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

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

The objectives of the Queen Charlotte TSA Silviculture Strategy are:

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

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

# 2.0 Procedure

## *2.1 Project Procedures*

The general steps in developing the silviculture strategy are:

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

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

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

4. Define potential strategies and treatment regimes. The number of potential strategies and treatment regimes is very large. Local experience is needed to narrow this down to a viable initial set for consideration.

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

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

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

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

Workshop #1 was held December 5th, 2000. The workshop was attended by representatives of the Ministry of Forests (Queen Charlotte Islands Forest District and Vancouver Forest Region), Husby Forest Products, JS Jones, and Forest Ecosystem Solutions Ltd. The purpose of the workshop was to define issues, establish objectives, develop potential strategies and define current treatment regimes from a local perspective.

The workshop produced the following:

- Management issues to be considered,
- Management objectives to guide the analysis and resolve the management issues,
- Potential strategies to meet the objectives, and
- Sample treatment regimes and treatment rules and costs.

Stand-level analysis consisted of preparing growth and yield curves for the various treatment regimes. Using the Tree and Stand Simulator (TASS) model, Ken Polsson of the MoF Research Branch developed yield curves for the incremental silviculture treatment regimes. The growth and yield models Tabular Interpolation Program for Stand Yields for Windows (WinTIPSY) and Variable Density Yield Predictor (VDYP) were also used to create yield curves needed for the analysis. VDYP was used for predicting growth of currently mature and older immature stands. WinTIPSY was used to predict growth of untreated managed stands and to provide understanding of stand-level dynamics in establishing modeling parameters.

The strategic forest-level (management unit) analysis was done using the model ***FSOS***. ***FSOS*** analyzes forest systems in a spatial and temporal manner using both simulation and optimization techniques. Both approaches are used in this project: simulation for the base case and optimization to determine the 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 optimization mode, the model uses a results-oriented approach, based on moving the forest estate towards a user-defined "desired future condition". The model operates by running a series of iterations. Treatments are allocated for each iteration, according to a set of basic rules (for example, specific treatments are restricted to stands of a certain species and age range). Penalties are applied for deviating from the user-defined resource condition, and feedback mechanisms ensure progression towards a near-optimal solution (where further iterations do not result in an improved solution).

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

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

Mr. Larry Sigurdson of the Ministry of Forests, Vancouver Forest Region managed the overall project, and Forest Renewal B.C provided funding. The participation of representatives from the following organizations at the workshops and in other aspects of this project is gratefully acknowledged:

- Ministry of Forests, Forest Practices Branch
- Ministry of Forests, Vancouver Forest Region
- Ministry of Forests, Queen Charlotte Islands Forest District
- Ministry of Forests, Research Branch
- Ministry of Forests, Timber Supply Branch
- Ministry of Environment, Lands, and Parks
- Husby Forest Products
- JS Jones

## 2.2 Data Acquisition and Manipulation

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

- TSR II resultant dataset, which includes the 1999 re-inventory (FC1 and FIP) and other resource data layers that were utilized in TSR II;
- Intensive Silviculture Information System (ISIS ) activity data.

## 2.3 Analysis Methodology

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

- A base case run that emulates the TSR II base case results (called the FESL base case);
- FESL revised base case with site index adjustments;
- Silviculture Strategy Base Case with site index adjustments and genetic improvements;
- Timber Volume Optimization Runs: runs using different silviculture budgets to determine the impact on timber flow.
- Timber Value Optimization Runs: runs using different silviculture budgets to determine the impact on timber value.
- Preferred Option: an optimization run that combines volume and value objectives.

# 3.0 Queen Charlotte TSA Information

## 3.1 Description of the TSA

The Queen Charlotte TSA is situated in the Vancouver Forest Region and is administered from the Queen Charlotte Islands Forest District office in Queen Charlotte City. The TSA lies within the Queen Charlotte Islands, or Haida Gwaii, a group of more than 150 islands located approximately 90 kilometres off the north coast of BC. It covers approximately 45% of the area of the Queen Charlotte Islands. Most of the TSA is located on Graham Island and a relatively small portion is located along the northwest coast of Moresby Island.

Annual precipitation in the area averages more than 4000 mm. Where soil drainage conditions are favourable, growth rates of forests within the Queen Charlotte TSA can be some of the fastest on the BC coast. Approximately 77% of the TSA area is considered productive forest and 18% is currently available for timber harvesting.

Three biogeoclimatic zones are found within the TSA. The CWH zone covers approximately 97% of the area in two subzones, the CWHvh (very wet hypermaritime) and the CWHwh (wet hypermaritime). The MH zone makes up approximately 3% of the area and the AT zone comprises less than 1% of the TSA in areas over 800 metres.

Forests are dominated by western hemlock, western redcedar, Sitka Spruce, and yellow-cedar in the CWH zone with lesser amounts of shore pine, western yew, mountain hemlock and (rarely) deciduous species including red alder. In the MH zone, mountain hemlock and yellow-cedar dominate with a minor component of western hemlock, western redcedar, and Sitka spruce.

The economy of the Queen Charlotte Islands is resource based with forestry as the predominant sector. Forestry employment includes logging, forestry services, and primary timber manufacturing. Primary timber manufacturing occurs at three small to medium sized mills with the TSA; however, the majority of timber is shipped to the mainland for processing.

## 3.2 History of the AAC

**Table 1: Historical Annual Allowable Cut (AAC) levels**

| AAC | Pre-1996 | 1996 |
|---|---|---|
| Conventional | 514,335 $m^3$ | 400,000 $m^3$ |
| Deciduous | | 75,000 $m^3$ |
| Total | 514,335 $m^3$ | 475,000 $m^3$ |

## 3.3 Current Basic Silviculture Systems

The most common practice is to harvest using clear-cut logging and regenerate by planting a mix of acceptable species or by relying on natural regeneration. Deer browsing has eliminated relying on natural regeneration of cedar. Therefore, the district has implemented a strategy to ensure that cedar sites will be regenerated with a mix of cedar and either Sitka spruce or western hemlock. These trees are protected until they are tall enough to be free of brush competition and deer browsing.

## 3.4 Incremental Silviculture History

### 3.4.1 Genetically Improved Seed

Currently cedar, hemlock, and Sitka spruce genetically improved seed is used in the TSA.

### 3.4.2 Juvenile Spacing

Juvenile spacing is the removal of less-desirable trees within a juvenile stand to manage the density of the stand. This reduces competition for water, nutrients, and sunlight among the residual trees and the primary stand-level effect is to allow the stand to reach minimum harvest size sooner. Juvenile spacing can also manage species composition, address forest health issues, and meet biodiversity or wildlife objectives. Approximately 45 to 50 per cent of harvested areas are spaced in the TSA.

### 3.4.3 Fertilization

Fertilization of a stand raises the productivity of the site and is the only presently recognized treatment for increasing total stand volume. In addition to increasing total volume, fertilization can also reduce the age at which a stand reaches harvestable size. Periodic fertilization occurs within the TSA but does not currently follow any strategy.

### 3.4.4 Pruning

Pruning is the removal of branches from the bole of the tree with the purpose of creating clear lumber. Pruning can be in the form of either one or two lifts. The rule is that pruning shall leave a length of crown that is not less than 50% of the total tree height. Currently, about 150 ha of pruning is undertaken each year in the Queen Charlotte TSA.

### 3.4.5 Backlog Reforestation

There is currently very little backlog NSR in the TSA apart from areas stocked with undesirable species.

## 3.5 Previous Silviculture Plans and Reports

*Queen Charlotte Timber Supply Area – Incremental Silviculture Strategy (1998)*

This is the "Type I" silviculture strategy project that was referred to in the introduction of this paper. This project used existing information (mostly based on TSR I analysis from the 1994 Queen Charlotte TSA Timber Supply Analysis Report) to identify timber quantity and quality issues and opportunities. The TSR I base case harvest forecast differs significantly from that of TSR II. Thus, some of the recommendations from the Type I project are no longer appropriate with the new timber supply. The following treatments were recommended in the Type 1 project:

- Increase regenerated stand volumes 15% and reduce minimum harvest ages by 10 years by:
  - (a) reducing time to regeneration;
  - (b) using (2nd generation) class A seed or better;
  - (c) using large planting stock; and
  - (d) tea-bagging plantation seedlings and fertilizing 200 ha/yr of cedar-salal sites for early crown closure.
- Improve the quality of the Queen Charlotte timber supply by:
  - (a) pruning 150 ha/year to 5.5 metres,
  - (b) managing selected stands to higher densities to yield pole-sized trees,
  - (c) spacing 400 ha/year to increase average piece sizes and prepare stands for pruning.
- Improve the quantity or quality of future habitat supply by:
  - (a) rehabilitating 60 ha/year of riparian habitat through conifer release, spacing, and planting.

# 4.0 Identification of Issues

## 4.1 General Timber Supply Issues

The following issues are related to timber quantity, timber quality, forest health, and/or habitat within the Queen Charlotte TSA. The following interpretations of the current timber supply conditions in the Queen Charlotte TSA were derived from TSR 2 analysis report, as well as through Workshop #1. The terms short-, mid- and long-term are used throughout and are defined as follows:

- Short-term – The next 20 years.
- Mid-term – The interim period between the short-term and when the harvest volume is in transition from unmanaged to managed stands, here from 21 to approximately 120 years.
- Long-term – The period where the harvest volume is from managed stands, here >120 years.

### 4.1.1 Harvest Forecast

TSR 2 base case initial harvest forecast is 475,000 $m^3$ for 5 decades, after which point it declines by 10% at the end of the fifth, sixth, and seventh decade and 6% at the end of the eighth decade to the long-term harvest level of 323,000 $m^3$. This harvest level represents conditions before the designation of the Duu Guusd areas.

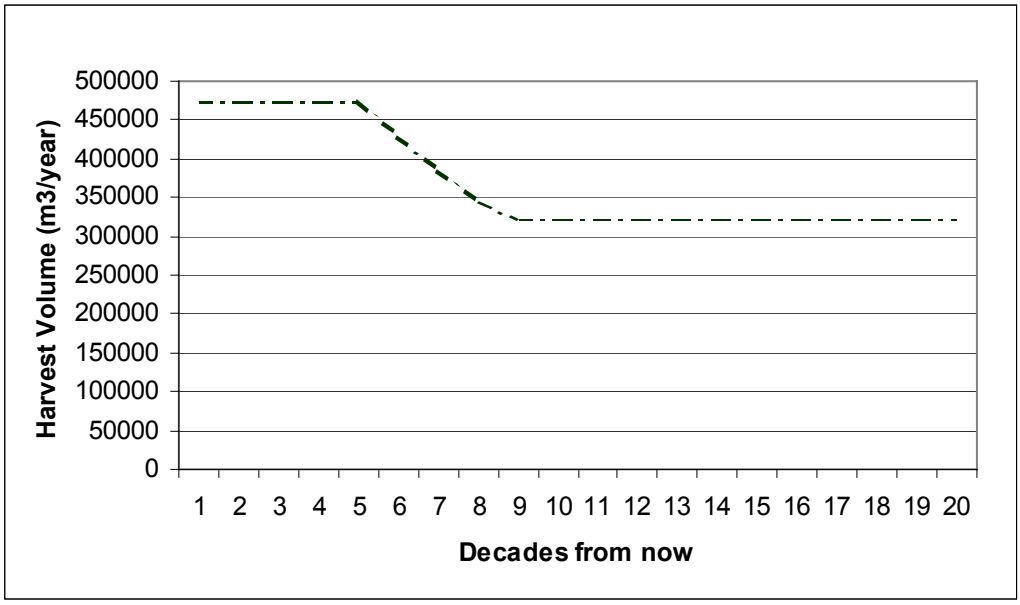


**Figure 1: TSR2 base case harvest forecast.**

### 4.1.2 Land Base

Since TSR I in 1994, the total area in the THLB has increased by 7% due to new operability mapping.

TSR2 investigated the impact of 5 and 10% increases and decreases in THLB area and found that harvest levels increased or decreased proportionately in response.

### 4.1.3 Age Class Structure

Ninety percent of the productive forest within the TSA is over 20 years of age, and approximately two-thirds is over 250 years of age. Most of the forests outside the THLB are old and, while not contributing directly to timber supply, can be used to meet habitat, biodiversity and other non-timber objectives.

### 4.1.4 Transition from Existing to Managed Stands

For the first 11 decades, the timber supply comes almost exclusively from natural stands. The transition to managed stands is quite rapid, with the majority of timber coming from these stands by decade 12. By decade 16, almost all timber harvested comes from managed stands.

### 4.1.5 Growing Sites

Estimates of site index for older stands may be incorrect as height of stands may not accurately reflect site conditions due to top breakage and die back and the fact that it is often difficult to determine the age of old trees. Although Old Growth Site Index (OGSI) projects have been completed throughout the province, no information was included for the Queen Charlotte Islands. To fill this gap, the Vancouver Forest Region conducted the Queen Charlotte Islands Stump Study. Upward adjustments were applied to the site indices of old growth stands upon harvest for a sensitivity analysis in TSR2. With these adjustments, the initial harvest level could be maintained for 25 years longer than in the base case. Furthermore, the long-term harvest level (LTHL) is increased by 80%.

### 4.1.6 Forest Cover Requirements

The following forest management zones occur in the Queen Charlotte TSA:

- Integrated resource management - applies to 48% of the THLB. The base case has a requirement that a maximum of 25% of the THLB within a landscape unit may be less than 3m in height. This requirement is intended to model Forest Practices Code adjacency and green-up requirements. Two sensitivity analyses were performed with allowable disturbance rates of 20 and 15%. Reducing the allowable disturbance rate to 20% had no impact on timber supply; however, reducing this to 15% causes a significant decrease in harvest flow in the short-, mid-, and long-term.

- Visual Quality Objectives (VQO's):
  - Partial Retention VQO - applies to 16% of the THLB. A maximum of 15% of the VQO area within a landscape unit may be less than 6m in height.
  - Retention VQO - applies to 11% of the THLB. A maximum of 5% of the VQO area within a landscape unit may be less than 6m in height.

  The LTHL is slightly sensitive to more restrictive maximum disturbance rates of 10% and 3% for partial retention and retention areas, respectively.

- Community Watersheds – All areas designated as community watersheds have been restricted to 10% of the productive forest area eligible for harvest in a 10 year period.

- Haida Declared Areas of Interest – These were modeled as the IRM layers; however, for the first 20 years these areas were modeled with a maximum 20% green-up rule.

### *4.1.7 Quality*

Quality was not modeled in TSR 2. Objectives identified in Workshop #1 include the following objective for quality:

- Manage regenerated stands to yield 8% premium logs by volume with the majority of the remainder being of good grade sawlog quality.

### *4.1.8 Old Forests*

Approximately two-thirds of the productive area within the TSA is over 250 years of age. Requirements for the retention of old forests for biodiversity objectives applied in TSR2 were calculated based on the assumption that the THLB will eventually be divided into biodiversity emphasis options with approximately 45%, 45%, and 10% of low, intermediate, and high emphasis, respectively. The constraints were applied to every landscape unit – BEC variant combination. Sensitivity analyses on the application of biodiversity guidelines showed no impact on timber flow.

### *4.1.9 Minimum Harvest Ages*

Minimum harvest ages are chosen in order to ensure that the timber supply model selects only stands for harvest with sufficient merchantable volume and piece size. The timber supply is sensitive to increases and decreases in minimum harvest ages. A 10% decrease in minimum harvest ages allows the initial harvest level to be maintained for one decade longer than in the base case. A 10% increase in minimum harvest age forces the timber flow to decrease 5 years earlier. A 20% decrease in minimum harvest age shows no improvement over the 10% decrease, while a 20% increase in minimum harvest age forces the timber flow to decline 20 years earlier than in the base case.

### *4.1.10 Estimates of Existing and Regenerated Stand Volumes*

Existing stand volumes in the base case were adjusted based on the results of the Forest Inventory Audit. The result was an average increase in volume of 53% for cedar-young, 20% for cedar-old, 9% for hemlock-poor, and 8% for hemlock-good. The inventory audit also showed that volumes from spruce stands were being over-estimated by 18%. Without the inventory adjustment the initial harvest level can be maintained for only 1 decade before stepping down to the long-term harvest level.

A sensitivity analysis was also performed to determine the impact of a 10 and 20% increase and decrease in existing stand volumes. Decreasing the estimates of existing stand volumes by 10% forces the harvest flow to step down towards the LTHL after only 2 decades. A decrease of 20% allows an initial harvest level of only 290,000 $m^3$, which must be maintained for 5 decades before increasing to the LTHL.

A 10% increase in existing stand volumes allows the initial harvest level of 475,000 $m^3$ to be maintained for eight and a half decades before stepping down to the LTHL. A 20% increase allows the initial level to be maintained for 10 decades.

### *4.1.11 Forest Health Issues*

No forest health issues were identified for this analysis. A volume reduction of 7,100 $m^3$/year is applied to estimate the unsalvageable volume lost to insect epidemics, fires, wind, or other agents in the THLB.

### *4.1.12 Issues Relating to Habitat and Non-Timber Forest Resources*

- Goshawk Nest Area – The "Queen Charlotte" northern goshawk is currently listed as Identified Wildlife as part of the Forest Practices Code. One goshawk nest has been located within the TSA. As a sensitivity analysis in TSR2, a 12 hectare reserve area was applied around the nest. In addition, a 240 hectare post-fledgling area and a 2400 hectare foraging area were applied with a minimum of 40% mature and 20% old forest and a maximum of 20% early seral forest. These measures had no impact on harvest flow. For the Silviculture Analysis, this constraint was applied in the base case.

- Marbled Murrelet – The Marbled Murrelet is also an Identified Wildlife species. The habitat requirements for this species will be incorporated by the modeling of retention of old forests as described in section 4.1.3 above.

# 5.0 Timber Supply Concerns and Analysis Objectives

## 5.1 Summary of Timber Supply Issues

### 5.1.1 Short-term

The short-term timber supply is sensitive to:

- Increases and decreases in the size of the THLB,
- Increases and decreases in minimum harvest ages,
- Increases and decreases in existing stand volumes, and
- Approximations used to model cutblock adjacency.

### 5.1.2 Mid-Term

The mid-term timber supply is sensitive to:

- Increases and decreases in the size of the THLB,
- Increases and decreases in minimum harvest ages,
- Increases and decreases in existing stand volumes,
- Increases and decreases in managed stand volumes,
- Decreasing allowable disturbance rates in scenic areas,
- Applying Old Growth Site Index adjustments, and
- Approximations used to model cutblock adjacency.

### 5.1.3 Long-term

The long-term timber supply is sensitive to:

- Increases and decreases in the size of the THLB,
- Increases and decreases in managed stand yields,
- Decreasing allowable disturbance rates in scenic areas,
- Applying Old Growth Site Index adjustments, and
- Approximations used to model cutblock adjacency.

## 5.2 Higher Level Silviculture Objectives

### 5.2.1 Provincial Objectives

The provincial objectives are based on the following guiding principles:

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

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

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

### *5.2.2 Regional Objectives*

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

## *5.3 Local Objectives and Opportunities*

### *5.3.1 Objectives*

The following objectives were identified during Workshop #1:

- Manage the short- and long-term timber supply to yield the maximum possible volume without sacrificing long-term sustainability.
- Manage regenerated stands to yield 8% premium logs by volume, with the majority of the remainder being of good-grade sawlog quality.

The following are the product objectives at the log level for the QC TSA:

**Premium Log:** Pine pole – 30+ cm min diameter over 15 m, few knots (pole);
Cedar pole – 30+ cm min diameter over 15 m, few knots (pole);
Cedar large timber – min. 55 cm & low taper for 10 m, mature wood;
Spruce/Hemlock clear – clear for 5m.

**Sawlog:** Minimum average 45 cm DBH and stand volume of 350 $m^3$/ha

### *5.3.2 Opportunities to Increase Timber Supply and Timber Quality*

***Short-term***

Short-term timber supply may benefit from activities that:

- Expand the timber harvesting land base by including areas presently outside the THLB (improved operability) or utilizing stands not presently included in the THLB;
- Reduce the minimum harvest age; and
- Increase the volume of existing stands.

***Mid-term***

Mid-term timber supply may benefit from activities that:

- Increase volume of existing stands, such as late-rotation fertilization;
- Increase volume of regenerated stands, such as fertilization or genetic improvement.
- Expand the timber harvesting land base, such as improved operability constraints or site rehabilitation.

Mid-term timber quality may benefit from activities that:

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

***Long-term***

Long –term timber supply may benefit from activities that:

- Increase volume of regenerated stands, such as fertilization, genetic improvement; and
- Expand the timber harvesting land base, such as improved operability constraints or site rehabilitation.

Long-term timber quality may benefit from activities that:

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

# 6.0 Potential Strategies

## 6.1 Potential Strategies by Response Timeframe

**Table 2: Potential silviculture strategies by response timeframe.**

| Response Time Frame | Strategy Description | Anticipated result |
|---|---|---|
| Short-Term | 1. Increase the volume of some existing stands through:<br>• Late rotation fertilization. | 1. **Short-, mid- and long-term** timber supply is somewhat sensitive to an increase in existing stand volumes. A 10% increase in stand volumes is anticipated to result in 2% increase in timber supply. |
| Mid-Term | 1. Increase regenerated stand volumes as per the scenario in Long Term.<br>2. Space and fertilize stands.<br>3. Increase the value of second growth stands by:<br>• Pruning, spacing and fertilization. | 1. Increased regenerated stand volumes have some impact on mid-term timber supply; however, the greatest impact is in the long term.<br>2. Bring some long-term volumes to the mid term.<br>3. Mid-term value increase expected to be modest, as benefits will occur in the long term. |
| Long-Term | 1. Increase regenerated stand volumes by:<br>• Using genetically improved seed;<br>• Fertilizing suitable regenerated stands;<br>2. Increase the value of second growth stands by:<br>• Pruning, spacing and fertilization. | 1. This analysis includes genetic gain in the generation of yield curves in TASS with 15% gain for Hw and 11% for Cw. Genetically improved seed for spruce provides weevil resistance but no volume gains. Fertilization increases stand volumes.<br>2. Value increases expected in the long-term. |

## 6.2 Stand Treatments

Table 3 describes the impacts of silviculture on selected stand attributes.

**Table 3: Impacts of silviculture on selected stand parameters.**

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

(Adapted from G. Weetman, SIBC, 1982)

## *6.3 Treatment Regimes*

The following treatment regimes were developed during Workshop #1.

**Table 4: Treatment regimes developed for the Strategic Silviculture Analysis.**

| AU | SP | Regen Delay | OAF1 | OAF2 | Plant/ Natural % | SI | Initial Density | Space | Space Fert | Fert | Space Prune 1 lift | Space Prune 2 lifts | Do Not Treat |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 101 Cedar – low | Cw | 3 | 15 | 5 | 100/0 | 11.4 | 2000 | | | | | | ✔ |
| 102 Cedar – poor | Cw | 3 | 15 | 5 | 50/50 | 13.8 | 3000 | | | ✔ | | | ✔ |
| 103 Cedar – good | Cw | 3 | 15 | 5 | 10/90 | 16.8 | 15000 | ✔ | | | | | ✔ |
| 104 Hemlock – poor | Hw | 3 | 15 | 5 | 5/95 | 13.6 | 30000 | ✔ | | | | | ✔ |
| 105 Hemlock – med | Hw | 3 | 15 | 5 | 5/95 | 15.9 | 20000 | ✔ | | | | | ✔ |
| 106 Hemlock – good | Hw | 3 | 15 | 5 | 5/95 | 22.7 | 20000 | ✔ | | | ✔ | ✔ | ✔ |
| 107 Spruce – med/poor | Ss | 3 | 15 | 5 | 10/90 | 12.3 | 15000 | ✔ | ✔ | | | | ✔ |
| 108 Spruce – good | Ss | 3 | 15 | 5 | 50/50 | 23.6 | 3000 | ✔ | | | ✔ | ✔ | ✔ |
| 111 Cedar – low OGSI | Cw | 3 | 15 | 5 | 100/0 | 15.1 | 2000 | | | | | | ✔ |
| 112 Cedar – poor OGSI | Cw | 3 | 15 | 5 | 50/50 | 18.1 | 3000 | | | ✔ | | | ✔ |
| 113 Cedar – good OGSI | Cw | 3 | 15 | 5 | 10/90 | 20.7 | 15000 | ✔ | | | ✔ | ✔ | ✔ |
| 114 Hemlock – poor OGSI | Hw | 3 | 15 | 5 | 5/95 | 23.8 | 30000 | ✔ | | | ✔ | ✔ | ✔ |
| 115 Hemlock – med OGSI | Hw | 3 | 15 | 5 | 5/95 | 26.6 | 20000 | ✔ | | | ✔ | ✔ | ✔ |
| 116 Hemlock – good OGSI | Hw | 3 | 15 | 5 | 5/95 | 23.6 | 20000 | ✔ | | | ✔ | ✔ | ✔ |
| 228 Spruce – good OGSI | Ss | 3 | 15 | 5 | 50/50 | 28.3 | 3000 | ✔ | | | ✔ | ✔ | ✔ |

[1]Parameters for Treatments:

Space – 1,000 stems/ha at 12 years

Prune (1 lift) – 1st lift 13years to 5.5m

Prune (2 lifts) – 1st lift 8 years to 3 m, 2nd lift 13 years to 5.5 m

Fert (manual) – at age 15 and every 10 years for 100 years (this was modified from Workshop #1 parameters due to limitations for modeling fertilization in TASS).

[2]Plant/Natural % were estimates based on initial densities.

[3] Initial densities are from TSR II.

## 6.4 Stand Level Treatment Responses

Figure 2 illustrates the Spruce medium analysis unit as an example of the yield response to silviculture treatments.

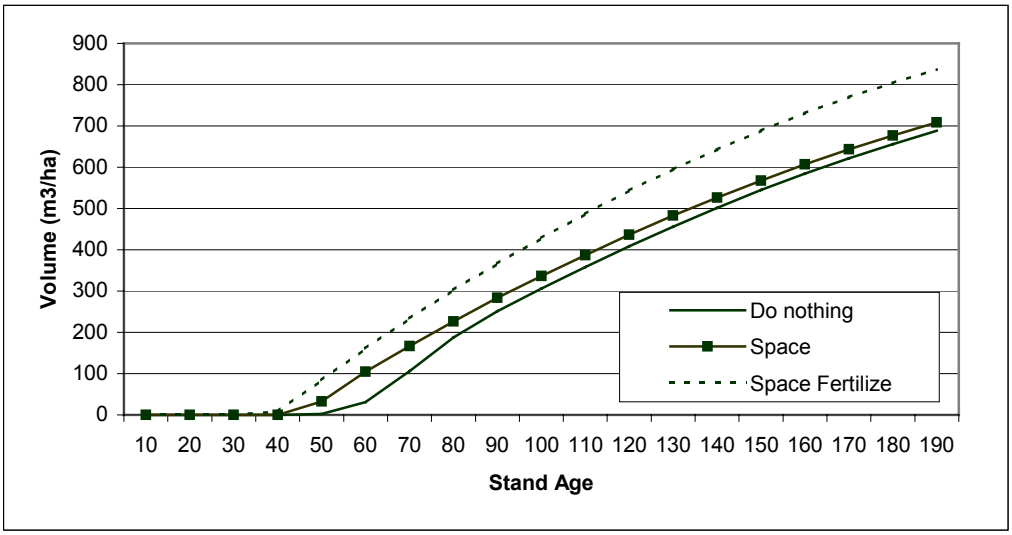


**Figure 2: Stand level responses to silviculture treatments for spruce medium analysis unit.**

# 7.0 Stand Level Analysis

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

The use of computer modeling provides yield curves based on the research results. The Tree and Stand Simulator (TASS) is a computer model that simulates the growth of individual trees and stands. It was developed by the Research Branch of the Ministry of Forests to assess the effects of silviculture treatments and environmental factors on stand growth and yield. Analysis of incremental silviculture strategies generally involved generating custom TASS yield tables for individual treatment regimes. Ken Polsson from the Ministry of Forests Research Branch generated the curves for this analysis. TASS provided yield curves for each aggregate unit. In conjunction with TASS, a program called SmartAxe was used to analyze each log and determine the optimal bucking strategy, maximizing log value based on Statutory Log Grades. The log grade was included in the TASS output yield tables

TASS is a single species, even-aged stand model; therefore, stands were modeled with these assumptions. 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.

# 8.0 Forest Level Analysis

The following is a brief overview of the forest level analysis procedure. The process is described more fully in the analysis information package.

## *8.1 Assumptions*

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

- Success of results will not be limited by funding availability, source, or ability to deliver the program;
- Normal market conditions will apply to demand and prices for timber and fibre;
- Status quo timber harvesting land base will be applied except where noted;
- The TSR II analysis approach will be used;
- Forest Practices Code will be applied;
- Ministry timber supply concepts and harvest flow controls will be utilized;
- The analysis will originate with the current AAC and utilization standards;
- Precision for objectives will be applied as follows:
  - +/- 10% change in timber flow between decades;
  - Silviculture investment not to exceed maximum budget level by more than 10%; and
- Treatment costs were taken from recent experience in the Queen Charlotte TSA and are listed in the analysis information package; and
- Log values were based on historic, third party, second-growth market pricing and are based on the Statutory Log Grades and piece size. For old growth timber, a flat $\$100/m^3$ net revenue was used for all stands.

## *8.2 Working Targets*

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

**Quantity:** Manage the short and long-term timber supplies to yield the maximum possible volume without sacrificing long-term sustainability.

**Quality:** Manage regenerated stands to yield 8% premium logs by volume, with the majority of the remainder being of good grade sawlog quality.

**Premium Log:**

Pine pole – 30+ cm minimum diameter over 15 m, few knots (pole);
Cedar pole – 30+ cm minimum diameter over 15 m, few knots (pole);
Cedar large timber – minimum 55 cm & low taper for 10 m, mature wood;
Spruce/Hemlock clear – clear for 5m.

**Sawlog:**

Minimum average 45 cm DBH and stand volume of 350 $m^3$/ha

## 8.3 Analysis Scenarios

**Table 5 – Analysis Scenarios**

| Scenario | Title | Scenario Description |
|---|---|---|
| 1 | Base Case | ▪ Re-creation of the TSR II Base Case<br>  ▪ Calibrate model<br>  ▪ Test model reliability. |
| 2 | Revised Base Case | ▪ Base Case<br>▪ TASS curves replace TIPSY curves<br>▪ Yield curves adjusted for OGSI<br>▪ Min harvest age: min. 350 $m^3$/ha and 95% mai or 30 cm mean diameter.<br>▪ ISIS information included |
| 3 | Silviculture Base Case | ▪ Base Case<br>▪ TASS curves replace TIPSY curves<br>▪ Yield curves adjusted for OGSI<br>▪ Min harvest age: min. 350 $m^3$/ha and 95% mai or 30 cm mean diameter.<br>▪ ISIS information included<br>▪ Genetic improvement. |
| 4 | Timber Volume Scenarios | ▪ Builds on Silviculture Base Case<br>  ▪ $2 million silviculture budget<br>▪ Intent is to determine impact of silviculture on volume. |
| 5 | Timber Value Scenarios | ▪ Builds on Silviculture Base Case<br>▪ Series of runs using different annual incremental silviculture budgets<br>  ▪ $0.25 million<br>  ▪ $0.5 million<br>  ▪ $1 million<br>  ▪ $1.5 million<br>  ▪ $2 million<br>▪ Intent is to determine impact of silviculture on value |
| 6 | Preferred Scenario | ▪ Builds on Silviculture Base Case<br>▪ Combines value and volume objectives based on feedback on preliminary results. |

### 8.3.1 Base Case (Scenario 1)

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

### 8.3.2 Revised Base Case (Scenario 2)

This scenario includes OGSI adjustments, which were not included in the TSR II base case. Managed stands in this scenario were modeled using TASS rather than TIPSY as in the base case. In addition, all past silviculture treatments recorded in the ISIS and FIP

files were included. No future treatments were included in this scenario. The minimum harvest ages were determined differently from the Base Case: rather than using mai culmination, a combination of minimum volume per hectare and minimum mean dbh and mai was used. To be eligible for harvest, a stand had to have at least 350 $m^3$ per hectare, and reached 95% of mai culmination or mean diameter of 30 cm. This rule was used for all further scenarios.

### *8.3.3 Silviculture Base Case (Scenario 3)*

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

### *8.3.4 Timber Volume Scenario (Scenario 4)*

The objective of this scenario was to test the impact of incremental silviculture on timber volume flow. A single $2 million budget level was assessed since preliminary analysis results showed insignificant volume gains from silviculture. As such, the impact of lower investment levels on volume flow was not investigated.

### *8.3.5 Timber Value Scenarios (Scenario 5)*

Budget levels of $0.25, $0.5, $1, 1.5 and $2 million were investigated for their impact on timber value. Profit was evaluated on harvest value minus silviculture cost as no harvest costs were incorporated in the analysis. Evaluation of value gain can be made between budget levels as well as to the Silviculture Base Case (no treatments) scenario.

### *8.3.6 Preferred Scenario (Scenario 6)*

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

# 9.0 Results and Discussion

## *9.1 Base Scenarios*

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

Figure 3 illustrates the harvest level for the base case benchmark run (FESL base case) and the base case harvest level for TSR2. The TSR2 base case harvest forecast begins at 475,000 $m^3$/year, maintains this level for 5 decades and steps down over 4 decades to the long-term harvest level (LTHL) of 323,000 $m^3$/year beginning at decade 9. The FESL base case benchmark run has a slightly lower harvest forecast. The timber flow begins at 472,728 $m^3$/year, 0.5% below the base case. This level is maintained for 5 decades and, as in TSR2, the harvest flow steps down in 4 decades to the LTHL. Here the LTHL is 314,808 $m^3$/year, 2.5% below the base case level. These slight differences are likely the result of slight area shifts in analysis units resulting from data processing and the application of regeneration assumptions.

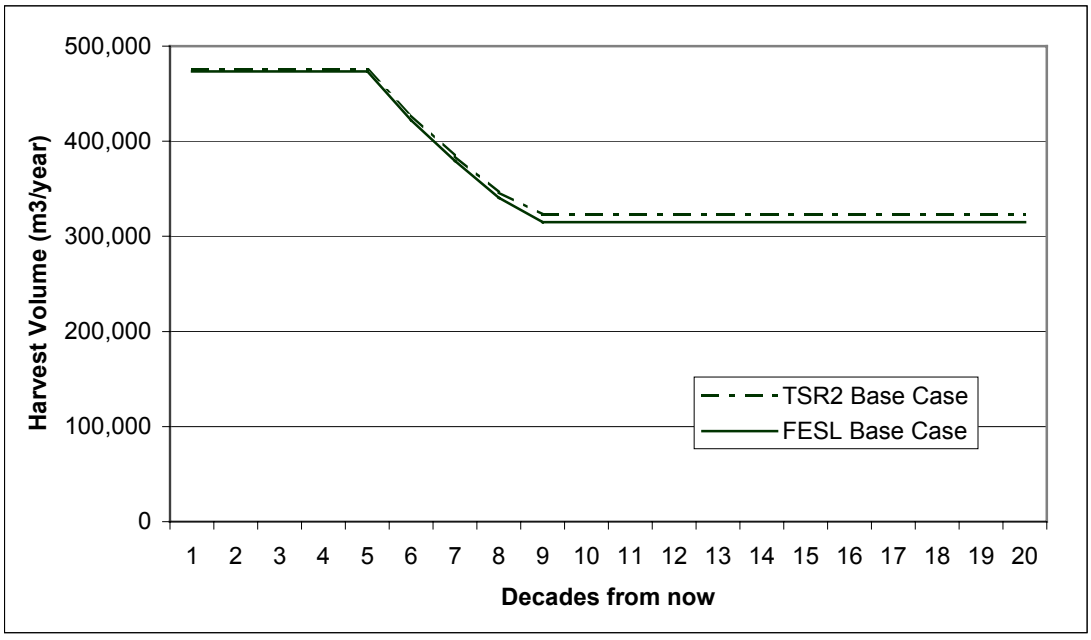


**Figure 3: TSR2 and FESL base case harvest forecasts.**

Figure 4 shows the harvest forecast for the revised base case as compared with the FESL base case. The inclusion of OGSI adjustments in the revised base case significantly increases the long-term harvest level.

The initial harvest level is similar to the FESL base case. The timber flow increases to 510,399 $m^3$/year at period 9 and again in period 10 to the LTHL of 542,709 $m^3$/year. This is a 72% increase in LTHL over the FESL base case.

In TSR2 OGSI adjustments were applied as a sensitivity analysis. The result was an 80% increase above the TSR2 base case, which relates well to the results achieved above.

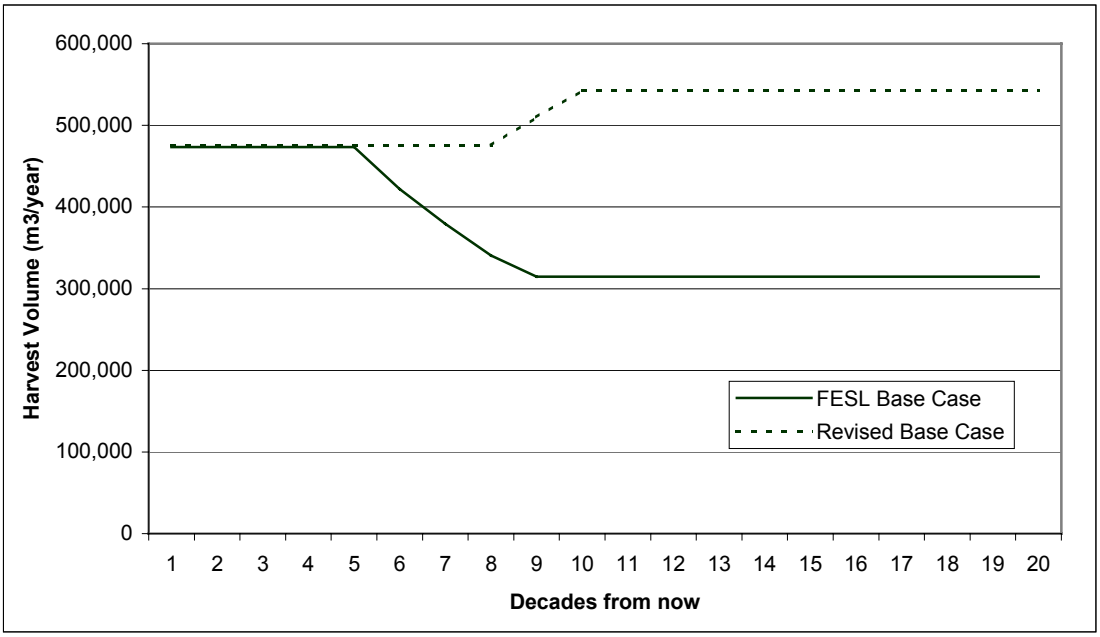


**Figure 4: FESL and revised base case harvest forecasts.**

Figure 5 shows the harvest flow for the Silviculture Strategy base case as it compares to the FESL base case and the revised base case. In addition to OGSI adjustments and past treatments, this scenario also includes adjustments for genetic gain. The increase in long-term timber flow resulting from the inclusion of genetic gain is small at approximately 4%. This is the result of the genetic gain being effectively "diluted" by the large amount of natural ingress in planted stands. For example, yield curves designed for modelling Hemlock good sites assume that initial density will be 20000 seedlings per hectare, 5% of which are planted, genetically improved stock. Due to competition and the inability to recognize planted stock during spacing treatments, the stems remaining after natural thinning and spacing are assumed to be a combination of planted and natural trees. Therefore, while genetic gain for Hemlock seedlings was modeled at 15%, the effective gain on the ground is much less due to loss of these seedlings from competition and spacing.

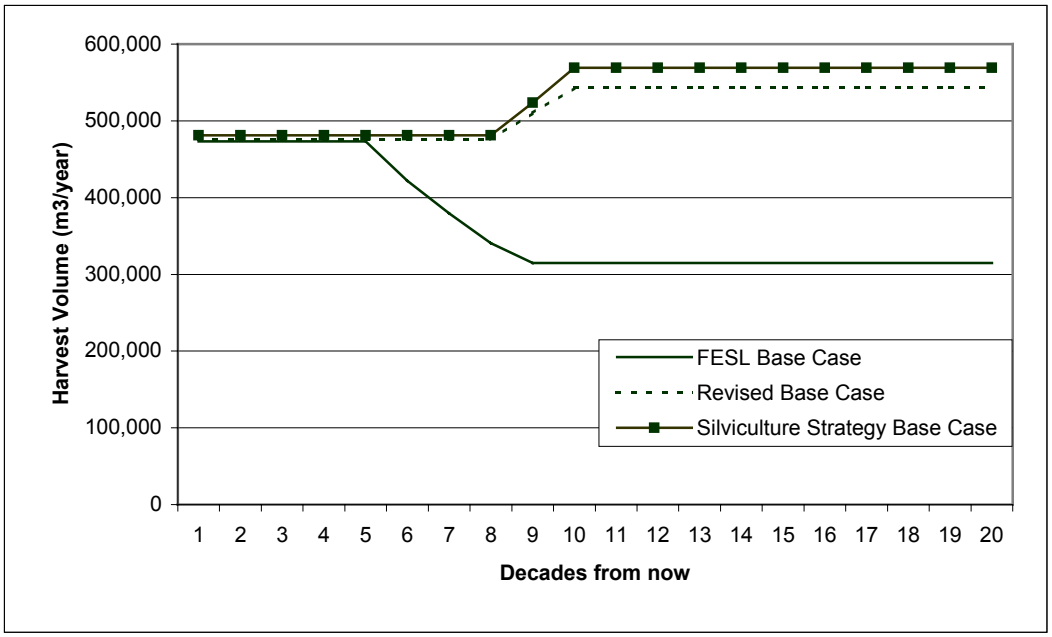


**Figure 5: FESL, revised, and silviculture strategy base case harvest forecasts.**

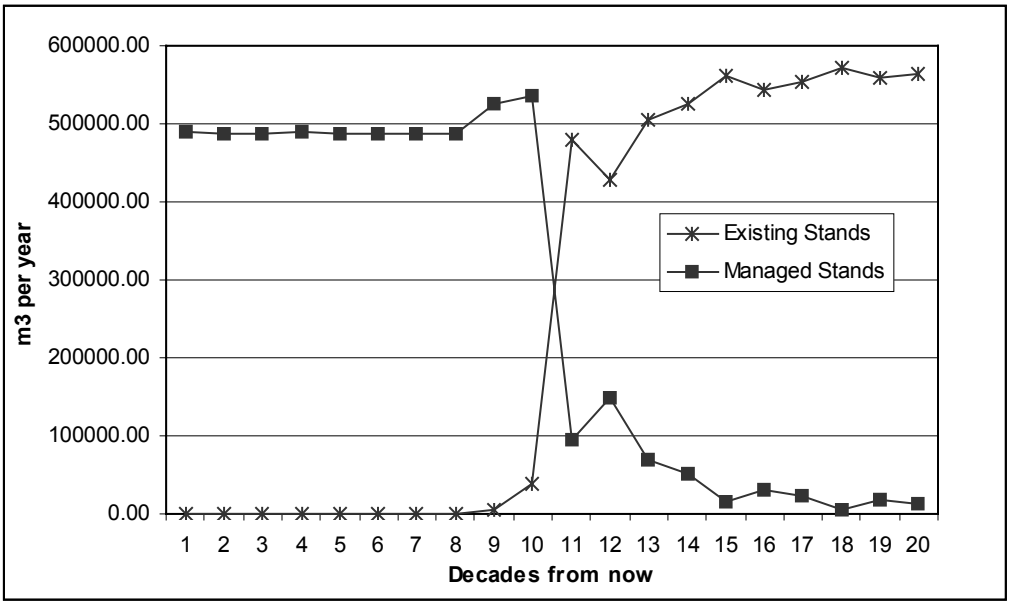


**Figure 6 – Transition from existing to managed stands; silviculture strategy base case.**

Figure 6 shows the transition from existing to managed stands for the silviculture strategy base case. It takes 11 decades until the majority of the annual harvest comes from future managed stands. As a result the benefits from most incremental silviculture will not become available until at least 100-110 years from now.

## 9.2 Volume Scenario

Fertilization is the only currently recognized silviculture treatment that increases the total fibre production of a stand. Fertilization treatments were available in only three analysis units (see Table 4 in *Section 6.3 Treatment Regimes*). As such, the opportunity to increase timber volume in the TSA is limited.

A volume maximization scenario was performed using the highest available silviculture budget level of $2 million. Flexibility is given to the investment level, particularly when maximizing for volume. Therefore, the actual expenditures on silviculture may not always equal the maximum budget level. For this scenario, the actual average silviculture expenditure for the first 100 years was $1.3 million annually; significantly less than the set budget of $2 million, as there were not enough suitable stands available for treatment for such a high budget level. Figure 7 below shows the harvest forecast for this scenario as compared to the Silviculture Strategy base case.

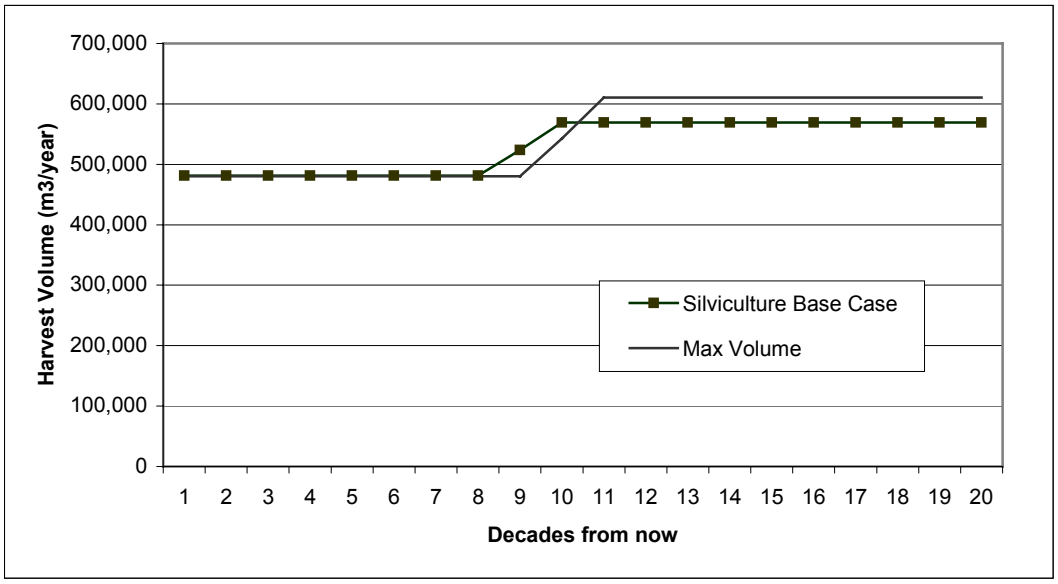


**Figure 7: Volume maximization scenario and silviculture strategy base case harvest forecasts.**

With $1.3 million dollars of annual expenditures on silviculture, the timber flow increased by approximately 7% above the Silviculture base case but only after the transition to managed stands. The LTHL for the volume scenario was 610,371 $m^3$ versus 568,961 $m^3$ of the silviculture strategy base case. Due to this limited improvement in harvest volume from the maximum allowable investment level, lower budget levels were not investigated.

Figure 8 shows the treatments performed over the first 100 years. As expected, the most prevalent treatment is fertilization as it provides the opportunity to increase the total volume of a stand. The spacing treatments, while not increasing total volume, can have a positive impact on merchantable volume. Many of the areas that are fertilized are also spaced. The fertilization treatment regime (as described in Section 6.3 above) is a repeat

fertilization treatment. Thus, the total amount of fertilization shown in each period includes treatments initiated in earlier periods.

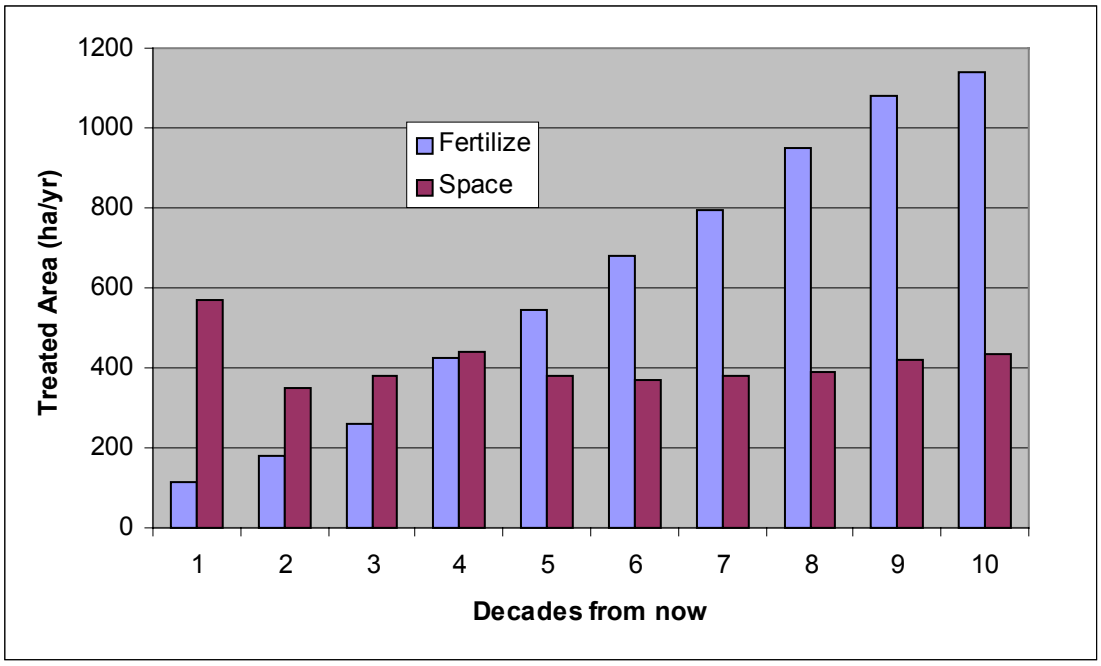


**Figure 8: Treated area by treatment regime; volume maximization scenario.**

## *9.3 Value Scenarios*

The maintenance and enhancement of the future forest value focuses on larger piece sizes and stem diameters as they relate to higher value forest products such as poles, large timbers, and clearwood. In Workshop 1, budget levels of $0.2, $0.5, $1, $1.5, and $2 million were suggested for investigating the opportunity to increase value within the TSA. All five budget levels ($250,000 instead of $200,000) were investigated.

The harvest level for the value strategies was initially fixed for each budget level to the SS base case with a 4% volume tolerance to maintain consistency in timber supply for purposes of comparison.

Figure 9 illustrates the achieved harvest level for the value scenarios.

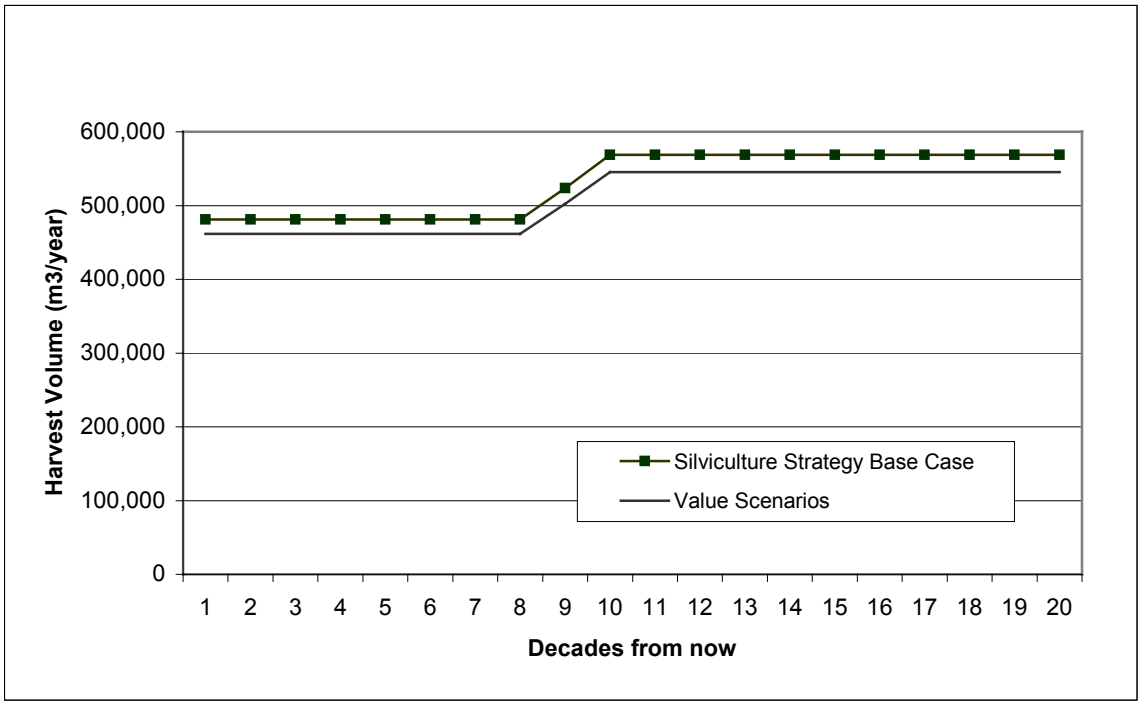


**Figure 9 – Value strategy harvest level**

With the harvest level fixed, the model was allowed to produce near-optimal solutions based on the total discounted profit for second growth stands over the entire planning horizon.

Table 6 shows the actual 100-year average silviculture expenditures for the value scenarios.

**Table 6: Average 100-year silviculture expenditure for different maximum budget levels.**

| Maximum Budget Level | Actual Average Expenditure |
|---|---|
| $250,000 | $265,476 |
| $500,000 | $473,684 |
| $1,000,000 | $944,788 |
| $1,500,000 | 1,341,681 |
| $2,000,000 | $1,816,347 |

Figure 10 shows the average harvest age for managed stands for the Silviculture Strategy base case and some of the value scenarios.

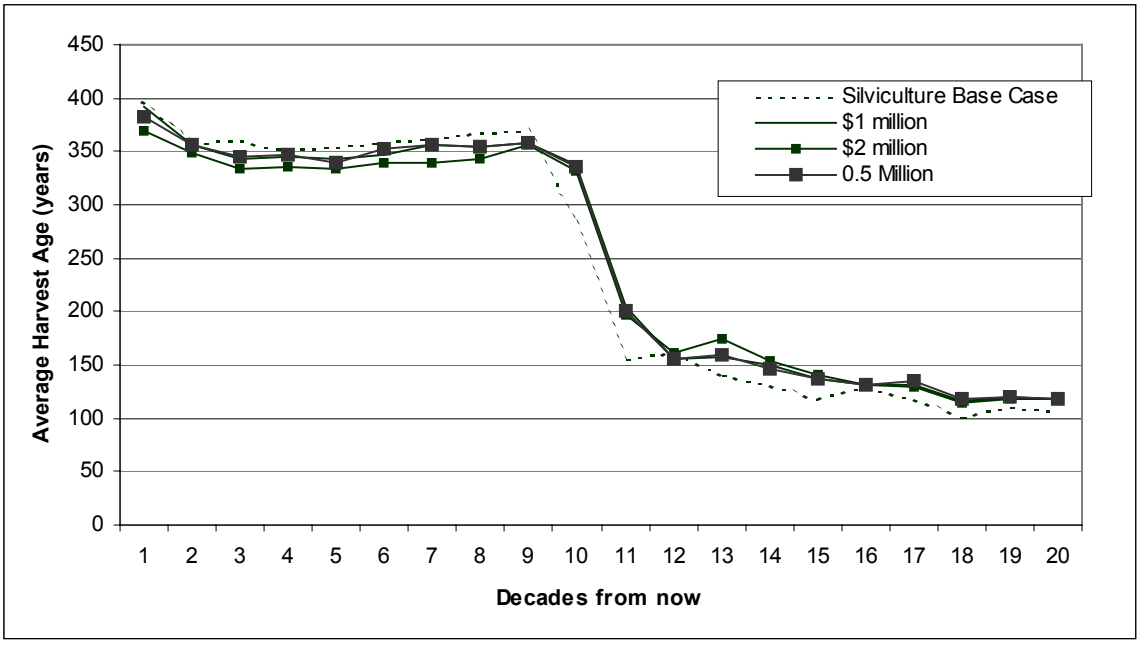


**Figure 10 – Average harvest age**

Figure 10 illustrates that somewhat higher average harvest ages result when attempting to achieve higher stand value. The treated stands are harvested at a later age, which potentially provides higher stem value and volume.

Figures 11, 12 and 13 show the quadratic mean diameter comparison over time between some value scenarios and the SS base case for future managed stands. Silviculture generally produces larger diameters over time due to spacing; however, no one budget level appears to be superior.

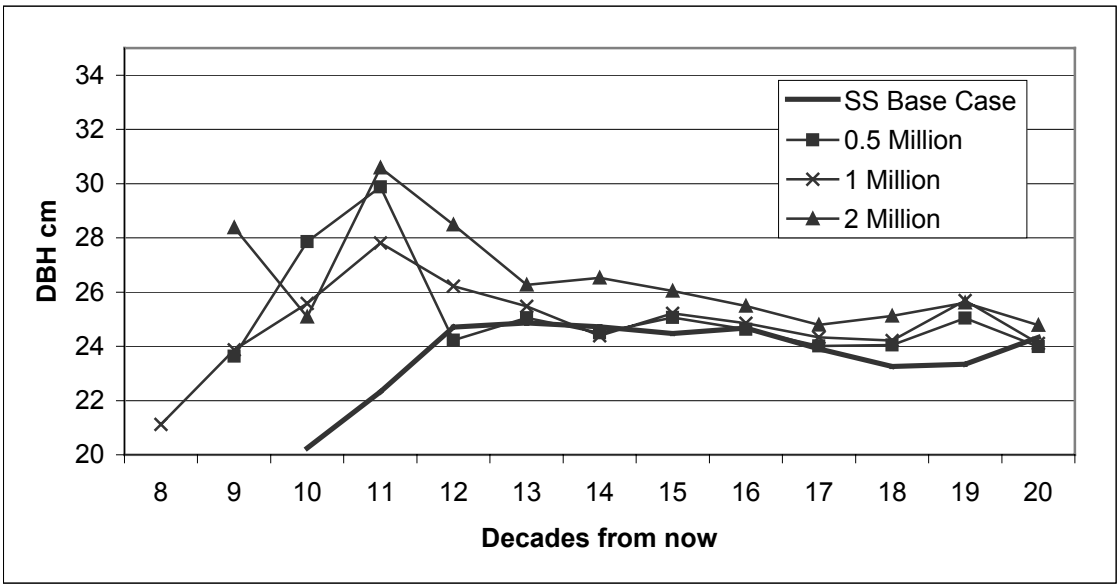


**Figure 11 – Predicted quadratic mean diameter for cedar; value scenarios**

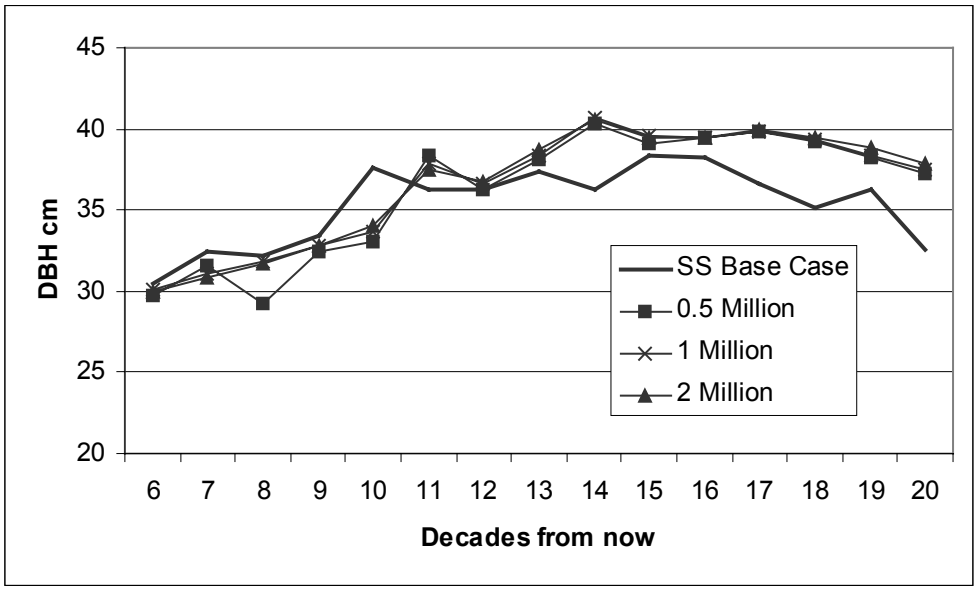


**Figure 12 – Predicted quadratic mean diameter for hemlock; value scenarios**

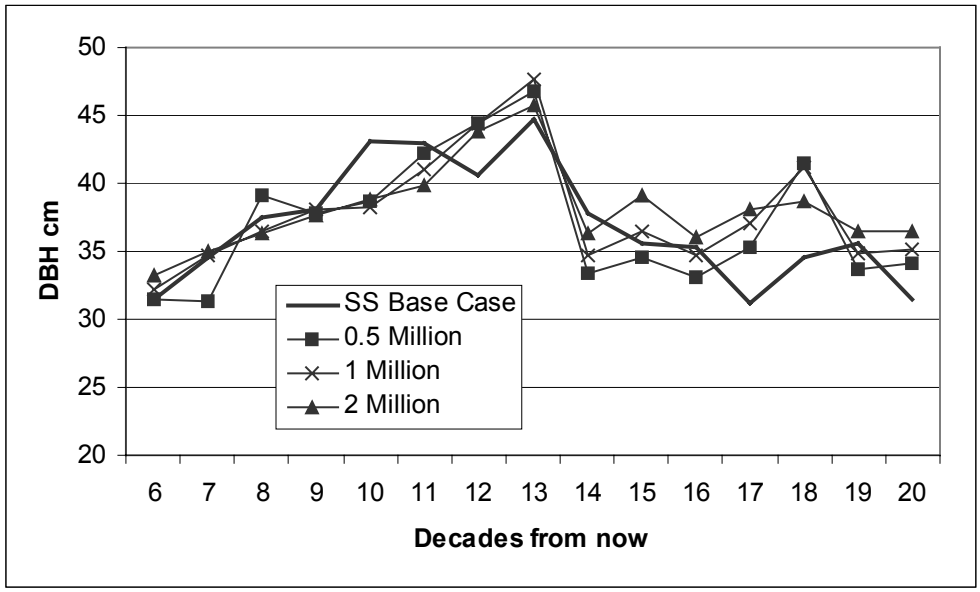


**Figure 13 – Predicted quadratic mean diameter for spruce; value scenarios**

Figure 14 shows the per cubic metre values for some of the value scenarios. As expected, the highest value occurs with the highest level of investment in the $2 million-budget value optimization scenario. The SS base case has the lowest per cubic metre value of the scenarios.

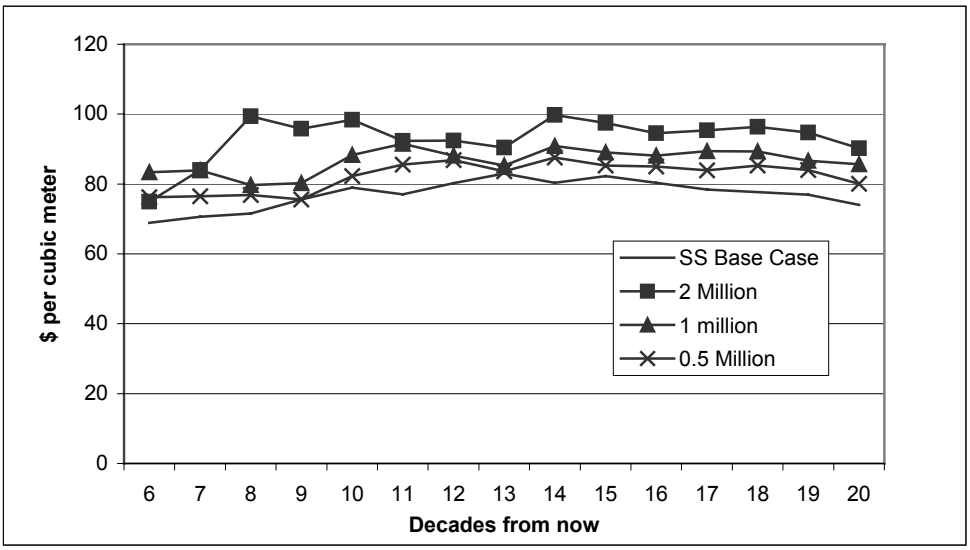


**Figure 14 – Value per cubic metre; value scenarios**

Figures 15, 16, and 17 show the spacing, fertilization and pruning treatments for the value scenarios. The $2 million scenario invests more in general; however, the total increase in investment is most pronounced for pruning.

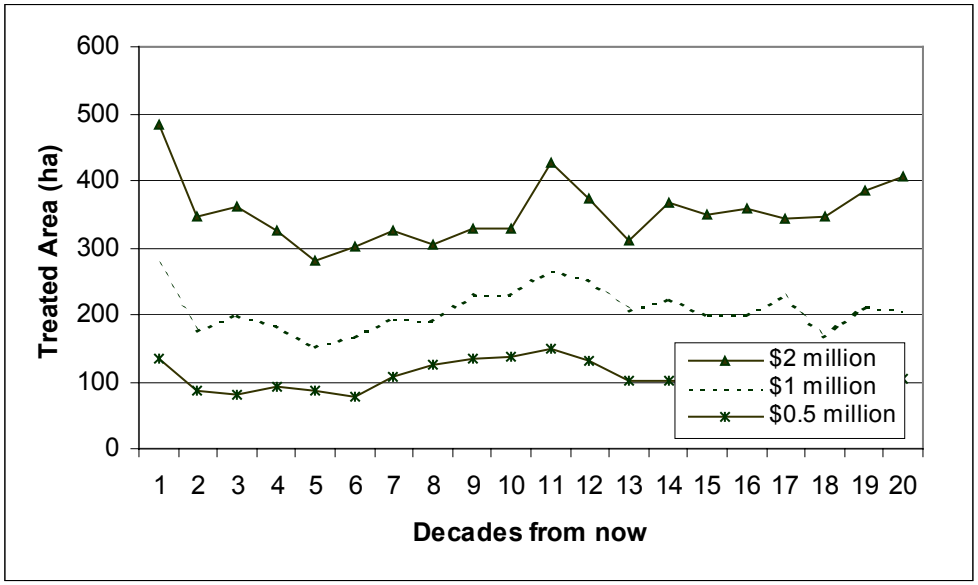


**Figure 15 - Spacing (ha/yr); value scenarios**

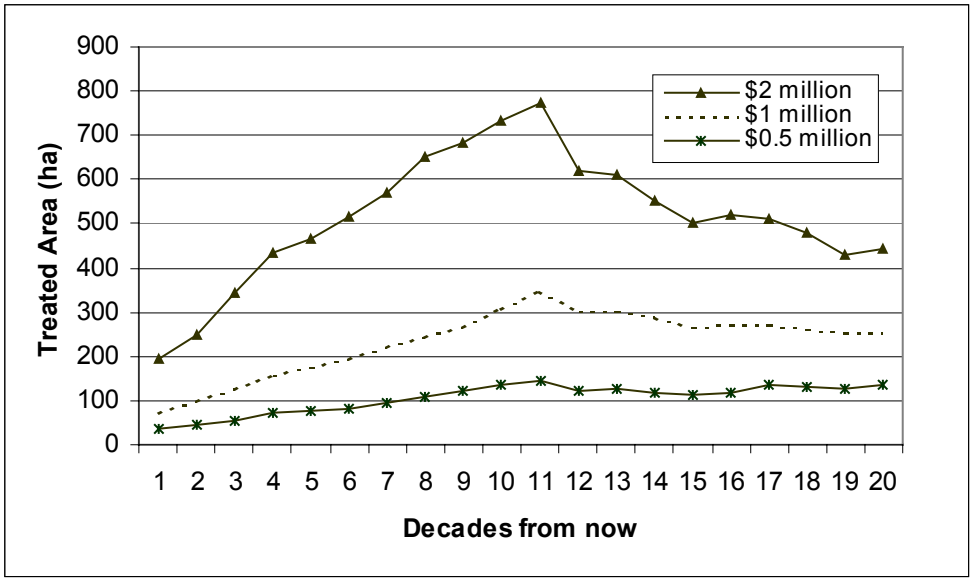


**Figure 16 - Fertilization (ha/yr); value scenarios**

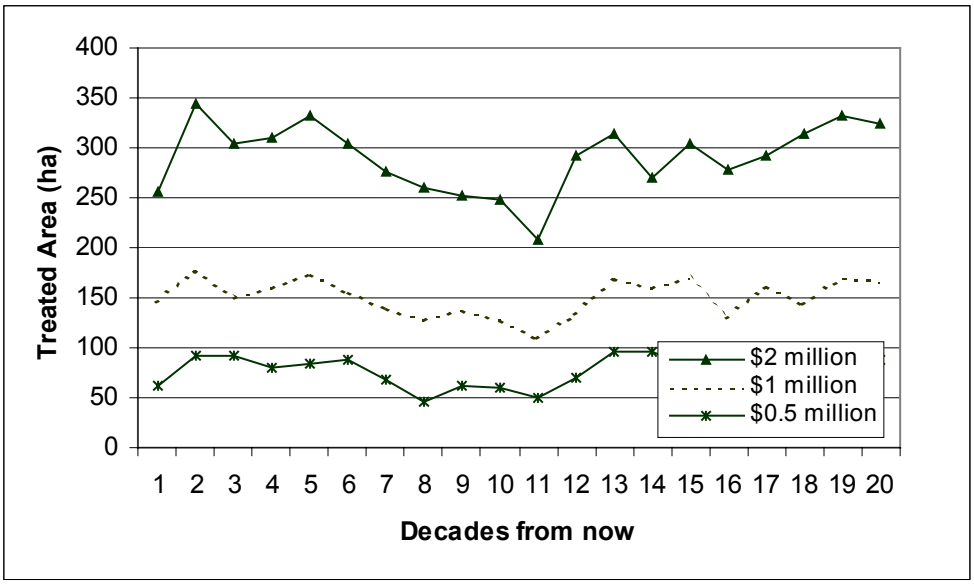


**Figure 17 - Pruning (ha/yr); value scenarios**

## 9.4 Preferred Scenario

### 9.4.1 General

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

As presented in the volume strategy scenarios (Section 9.2), the opportunities to increase annual harvest through intensive silviculture are limited. Significant annual expenditures appear to increase the harvest level only modestly and only in the long term.

With the limited opportunities to increase harvest levels, incremental silviculture is limited to enhancing the value of the treated stands. The value scenarios indicated that each investment level increased the per cubic metre value of the future managed stands. The value increase was most significant up to approximately $1 million of expenditures after which the increase levels off as can be seen in Figure 18.

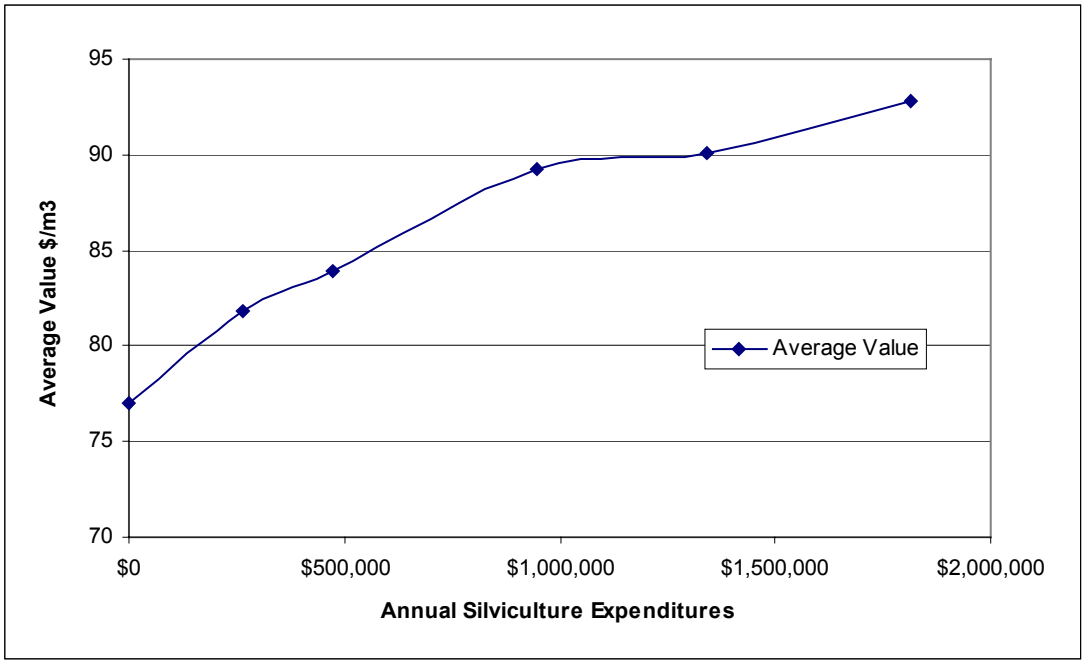


**Figure 18 – Average value per $m^3$ of future managed stands at different investment levels.**

A strategy was developed that would produce at least the same volume as the base case while maintaining a higher quality long-term timber supply. This was done by:

- Choosing a budget level of $1 Million with a 10 % tolerance for variance in budget level for increases in the budget;
- Setting the harvest flow at the SS base case level;
- Maintaining the value weighting in the optimization function the same as in the value scenarios.

### *9.4.2 Proposed Incremental Silviculture Strategy*

Figure 19 and Table 7 summarize incremental annual silviculture treatments by 10-year periods over the next 100 years with the average annual budget of $962,999.

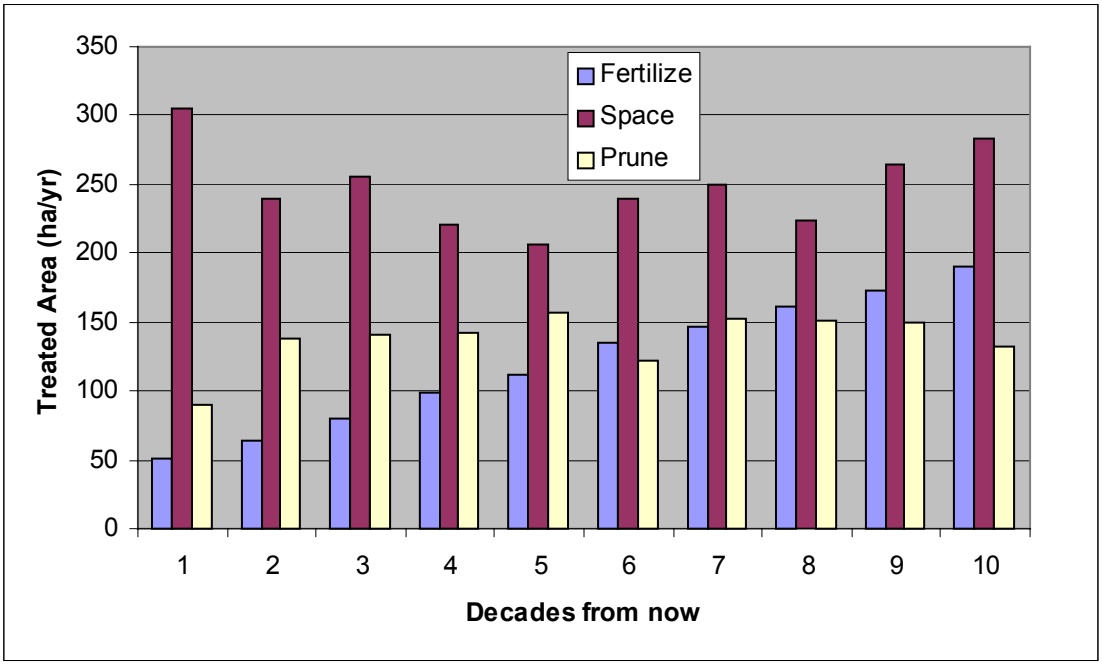


**Figure 19 – Silviculture treatments (ha/yr); preferred scenario**

**Table 7 - Silviculture treatments (ha/yr); preferred scenario**

| Decade | Fertilize | Space | Prune |
|---|---|---|---|
| 1 | 50 | 305 | 90 |
| 2 | 64 | 240 | 137 |
| 3 | 80 | 255 | 140 |
| 4 | 99 | 220 | 142 |
| 5 | 112 | 206 | 157 |
| 6 | 135 | 240 | 122 |
| 7 | 146 | 249 | 152 |
| 8 | 162 | 224 | 151 |
| 9 | 173 | 265 | 149 |
| 10 | 190 | 283 | 132 |

The area treated is almost evenly divided between fertilization, spacing and pruning over the long term. During the first decade, 101 ha of fertilization, 287 ha of juvenile spacing and 96 hectares of pruning are proposed.

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

**Table 8 – Proposed detailed regimes for the silviculture strategy**

| Decade | fert | space | space fert | Prune 1 | prune 2 |
|---|---|---|---|---|---|
| 1 | 34 | 289 | 16 | 90 | 1 |
| 2 | 57 | 233 | 7 | 98 | 39 |
| 3 | 70 | 246 | 9 | 112 | 28 |
| 4 | 89 | 209 | 11 | 93 | 49 |
| 5 | 105 | 200 | 6 | 121 | 36 |
| 6 | 125 | 230 | 9 | 88 | 33 |
| 7 | 141 | 244 | 5 | 122 | 31 |
| 8 | 153 | 215 | 9 | 97 | 54 |
| 9 | 168 | 260 | 5 | 113 | 37 |
| 10 | 186 | 279 | 4 | 104 | 29 |

The following table illustrates how treatment totals are divided between analysis units during the first 100 years. Treatments are rather evenly distributed with good and medium spruce sites, poor hemlock sites and poor cedar sites receiving the bulk of the treatments.

**Table 9 – Distribution of treatments between analysis units (OGSI incorporated)**

| Decade | Cedar good/medium | Cedar poor | Hemlock good | Hemlock medium | Hemlock poor | Spruce good | Spruce medium | Total |
|---|---|---|---|---|---|---|---|---|
| 1 | 9.17% | 1.61% | 33.64% | 8.26% | 4.93% | 28.36% | 14.02% | 100% |
| 2 | 10.73% | 1.54% | 30.00% | 11.42% | 0.00% | 30.09% | 16.21% | 100% |
| 3 | 11.24% | 1.51% | 33.86% | 8.71% | 0.02% | 28.69% | 15.97% | 100% |
| 4 | 15.21% | 1.50% | 27.35% | 6.32% | 0.00% | 29.58% | 20.03% | 100% |
| 5 | 16.76% | 1.51% | 33.77% | 7.34% | 0.00% | 20.69% | 19.94% | 100% |
| 6 | 16.80% | 1.42% | 39.90% | 9.04% | 0.00% | 11.31% | 21.54% | 100% |
| 7 | 16.98% | 1.36% | 39.34% | 10.32% | 0.00% | 9.71% | 22.28% | 100% |
| 8 | 18.66% | 1.34% | 33.13% | 9.59% | 0.00% | 9.24% | 28.04% | 100% |
| 9 | 16.18% | 1.24% | 44.11% | 7.48% | 0.07% | 8.70% | 22.22% | 100% |
| 10 | 20.40% | 1.32% | 39.51% | 7.65% | 0.14% | 9.34% | 21.64% | 100% |

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

- ***Fertilization:*** This treatment is a stand-alone treatment option on poor cedar sites. It follows spacing treatments on medium/poor spruce sites. Thirty-four hectares per year are being proposed over the first decade of the planning horizon. Poor cedar sites and medium/poor sites stands receive 53%, with the remaining 47% allocated to poor cedar sites.

- ***Spacing:*** A total of 289 hectares of annual spacing treatments are proposed for the first decade. Some of the spaced stands are further pruned. Good hemlock sites receive approximately 48% of this treatment while spruce good receives approximately a 29% share.

- ***Space/Fertilize:*** Only medium/poor spruce sites were eligible for this treatment. A total of 16 hectares annually are proposed for the next ten years.

- ***Prune 1:*** These stands receive a spacing treatment as well. The spacing area is included in the "Spacing" above. A total of 90 hectares annually are proposed during the first decade of the planning horizon. Good hemlock sites receive 58% of this treatment with good spruce sites receiving the balance.

- ***Prune 2:*** Only1 hectare annually is proposed during the first decade of the planning horizon (100% Hemlock good).

Table 10 reiterates the proposed annual spacing, fertilization and pruning treatments for the first decade in more detail.

**Table 10 – Proposed regimes; first decade**

| Analysis Unit | fert | space | space fert | Prune 1 | prune 2 |
|---|---|---|---|---|---|
| Cedar good/medium | N/a | 22 | N/a | N/a | N/a |
| Cedar poor | 16 | N/a | N/a | N/a | N/a |
| Hemlock good | N/a | 140 | N/a | 52 | 1 |
| Hemlock medium | N/a | 8 | N/a | N/a | N/a |
| Hemlock poor | N/a | 18 | N/a | N/a | N/a |
| Spruce good | N/a | 85 | N/a | 38 | 0 |
| Spruce medium | 18 | 16 | 16 | N/a | N/a |
| **Grand Total** | **34** | **289** | **16** | **90** | **1** |

### 9.4.3 Recent Developments

The product objectives, as defined at the beginning of this project, included clear wood. The recommended silviculture strategy proposes some pruning, much of it in hemlock stands, to achieve this objective.

It appears that pruned stands may be more susceptible to serious damage from budworm. This may be the case particularly with pruned hemlock. In those years when the budworm numbers are high, it may be wise to prune less area than recommended in this strategy and concentrate the pruning on spruce stands.

## 9.5 Anticipated Silviculture Strategy Outcomes

### 9.5.1 Harvest Flow

Figure 20 compares the short-, mid- and long-term harvest level for the SS base case, the preferred scenario and the value scenarios. The preferred scenario has the same harvest level as the SS base case.

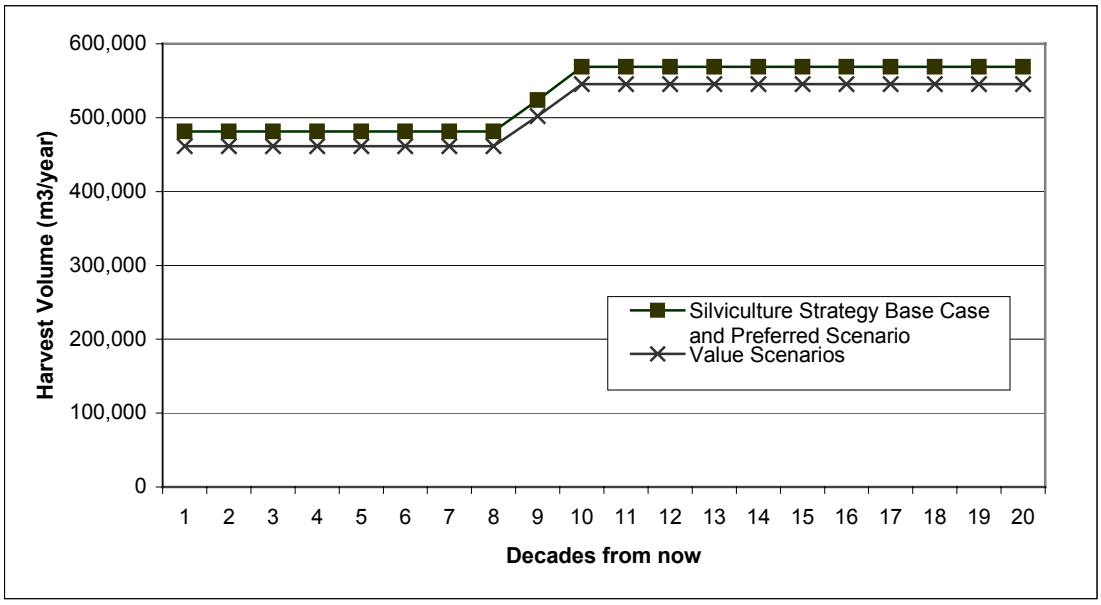


**Figure 20 – Harvest level; preferred scenario**

### 9.5.2 Diameter

Figures 21, 22 and 23 illustrate the predicted quadratic mean diameter of the preferred scenario over the TSA compared to the SS base case and the $2 Million value scenario for cedar, hemlock and spruce. As can be seen from the graph, the proposed strategy

produces a higher mean diameter than the SS base case, however, the differences are not significant, particularly for spruce and cedar.

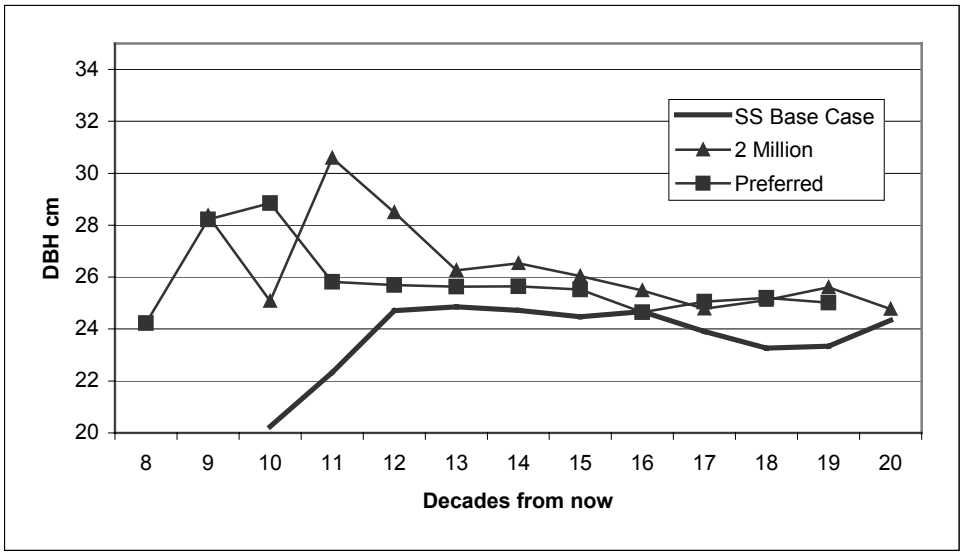


**Figure 21 – Predicted quadratic mean diameter for the preferred scenario; Western redcedar**

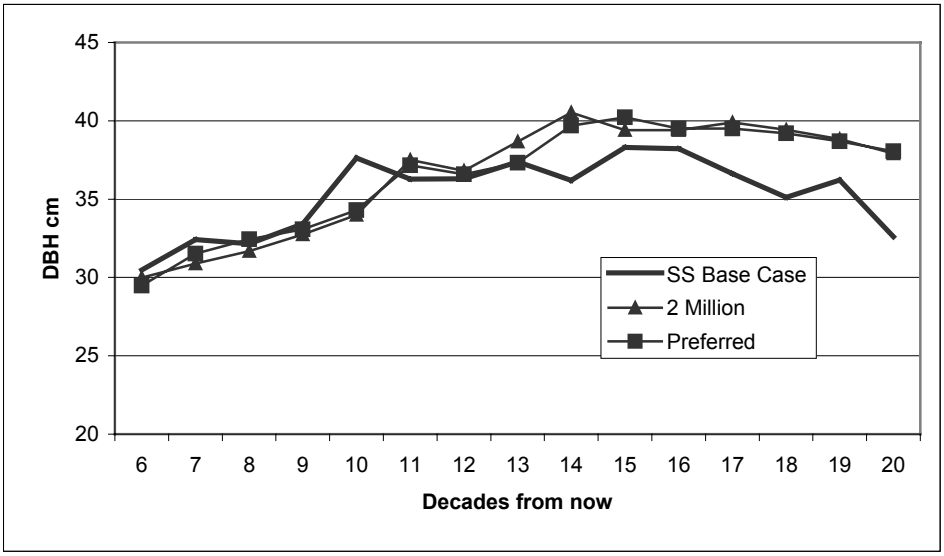


**Figure 22 - Predicted quadratic mean diameter for the preferred scenario; Hemlock**

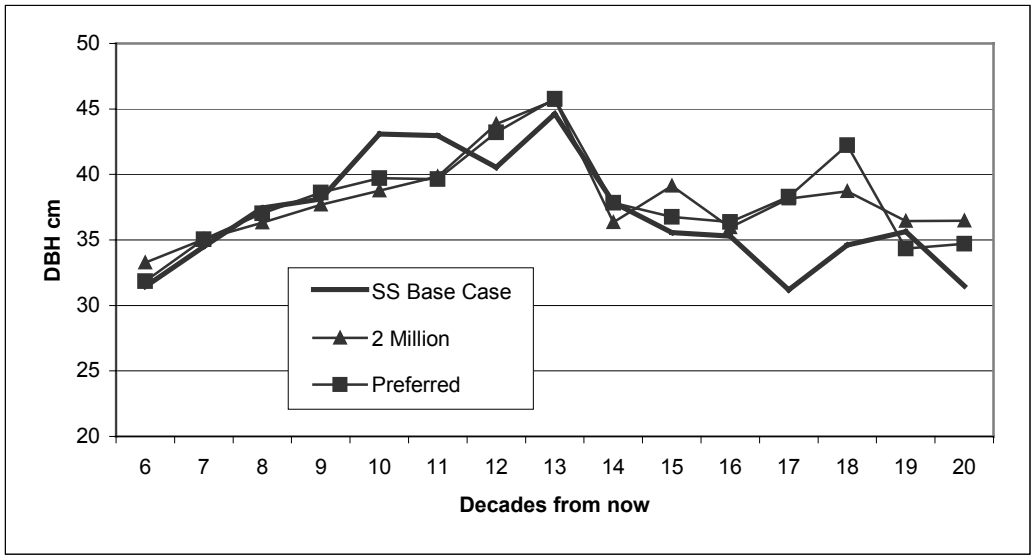


**Figure 23 - Predicted quadratic mean diameter for the preferred scenario; Spruce**

### *9.5.3 Value and Quality*

Figure 24 compares the value per cubic metre between the preferred scenario, SS base case and the $2 million value scenario. The value per cubic metre 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 metre is achieved through larger log sizes and clear wood. Spacing and fertilization can increase the sizes of logs and pruning creates clear wood.

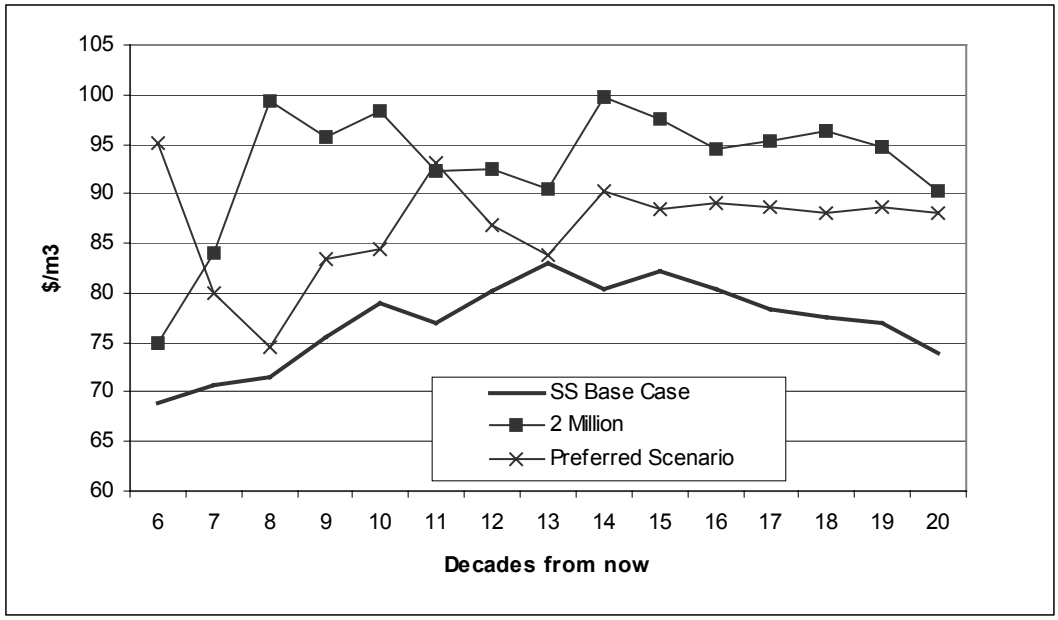


**Figure 24 - Value per cubic metre; preferred scenario**

The preferred scenario does not reach the per cubic metre value of the $2 million value scenario. However, the preferred scenario value stays well above the SS base case. The high per cubic metre value for the $2 million value scenario is primarily due to significant expenditures on pruning.

Table 11 illustrates the predicted volume of clear wood compared to the total harvest volume and harvest volume from pruned stands.

**Table 11 - Predicted decadal volume of clear wood from pruning, preferred scenario**

| Decade | Total Harvest Volume | Clear Volume | % | Volume from Pruned Stands | Clear Volume | % |
|---|---|---|---|---|---|---|
| **6** | 4,807,183 | 8,244 | 0.17% | 21,240 | 8,244 | 38.81% |
| **7** | 4,807,183 | 17,182 | 0.36% | 64,762 | 17,182 | 26.53% |
| **8** | 4,807,183 | 4,391 | 0.09% | 18,462 | 4,391 | 23.78% |
| **9** | 5,222,000 | 23,532 | 0.45% | 84,670 | 23,532 | 27.79% |
| **10** | 5,704,632 | 62,985 | 1.10% | 255,064 | 62,985 | 24.69% |
| **11** | 5,704,632 | 288,802 | 5.06% | 974,867 | 288,802 | 29.62% |
| **12** | 5,704,632 | 157,706 | 2.76% | 794,019 | 157,706 | 19.86% |
| **13** | 5,704,632 | 55,442 | 0.97% | 229,739 | 55,442 | 24.13% |
| **14** | 5,704,632 | 126,687 | 2.22% | 573,591 | 126,687 | 22.09% |
| **15** | 5,704,632 | 102,481 | 1.80% | 455,301 | 102,481 | 22.51% |
| **16** | 5,704,632 | 169,293 | 2.97% | 722,953 | 169,293 | 23.42% |
| **17** | 5,704,632 | 178,406 | 3.13% | 746,158 | 178,406 | 23.91% |
| **18** | 5,704,632 | 157,732 | 2.76% | 663,787 | 157,732 | 23.76% |
| **19** | 5,704,632 | 188,742 | 3.31% | 786,597 | 188,742 | 23.99% |
| **20** | 5,704,632 | 208,667 | 3.66% | 977,205 | 208,667 | 21.35% |

The production of clear wood starts during the 6$^{th}$ decade. The clear wood percent exceeds 5 % during decade 11 and seems to stabilize at around 3% towards the end of the planning horizon.

### *9.5.4 Employment*

Tables 12 and 13 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 13 illustrates the long-term jobs created by the preferred scenario. As the harvest level is the same as the silviculture strategy base case, the long-term employment level remains the same. Employment multipliers were utilized from the TSR 2 Socio-Economic Analysis by the Economics and Trade Branch of the Ministry of Forests.

There is no direct relationship between the preferred scenario and SS base case harvest level with the TSR 2 base case, and subsequent employment in the Queen Charlotte TSA. The purpose of the employment forecast is to show relative employment changes (none

in this case) as a result of silviculture investment. The only direct relationship between harvest levels and employment in the TSA is based on the actual AAC determination.

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

**Table 12 – Short-term employment benefits, jobs**

| Year | Space | Prune | Fertilize | Total |
|---|---|---|---|---|
| 1 | 6.8 | 3.0 | 0.0 | 9.8 |
| 2 | 6.8 | 3.0 | 0.0 | 9.8 |
| 3 | 6.8 | 3.0 | 0.0 | 9.8 |
| 4 | 6.8 | 3.0 | 0.0 | 9.8 |
| 5 | 6.8 | 3.0 | 0.0 | 9.8 |
| **Sub Total** | **33.9** | **15.0** | **0.1** | **49.1** |
| 6-10 | 33.9 | 15.0 | 0.1 | 49.1 |
| 11-15 | 26.7 | 21.8 | 0.2 | 107.9 |
| 16-20 | 26.7 | 21.8 | 0.2 | 107.9 |
| **Total 20 Years** | **121.2** | **73.6** | **0.6** | **314.0** |

**Table 13 – Long-term employment benefits[a]**

| Decade | Harvest ('000) | TSA Jobs by Decade | Provincial Jobs by Decade |
|---|---|---|---|
| 1 | 481 | 2,120 | 13,668 |
| 2 | 481 | 2,120 | 13,668 |
| 3 | 481 | 2,120 | 13,668 |
| 4 | 481 | 2,120 | 13,668 |
| 5 | 481 | 2,120 | 13,668 |
| 6 | 481 | 2,120 | 13,668 |
| 7 | 481 | 2,120 | 13,668 |
| 8 | 481 | 2,120 | 13,668 |
| 9 | 525 | 2,310 | 14,700 |
| 10 | 569 | 2,504 | 15,932 |
| 11 | 569 | 2,504 | 15,932 |
| 12 | 569 | 2,504 | 15,932 |
| 13 | 569 | 2,504 | 15,932 |
| 14 | 569 | 2,504 | 15,932 |
| 15 | 569 | 2,504 | 15,932 |
| 16 | 569 | 2,504 | 15,932 |
| 17 | 569 | 2,504 | 15,932 |
| 18 | 569 | 2,504 | 15,932 |
| 19 | 569 | 2,504 | 15,932 |
| 20 | 569 | 2,504 | 15,932 |

**[a]Multipliers as per TSR 2, TSA 0.44, Province 2.80 per 1,000 $m^3$ of AAC**

# 10.0 Discussion

## 10.1 Interpreting Forest Level Analysis Results

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

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

### 10.1.1 Modeling for Multiple Objectives Simultaneously

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

### 10.1.2 Volume Scenarios

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

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

### 10.1.3 Value Scenarios

In these scenarios the optimization function now included value as one of the variables. Value was defined as net present value. All silviculture costs and estimated harvest

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

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

Pruning is an expensive treatment that creates significant value in this analysis. Stands that were pruned received a significant value increase as per the Ministry of Forests, 2000 report: Clear Wood Values from Pruning, Madison's Canadian Lumber Reporter, and The Tree and Stand Simulator (TASS). On average, the value increase due to pruning varied from 1.53 to 2.06 fold for a stand compared to a similar stand with no pruning. As a result, a significant portion of the budgets was spent on pruning treatments in spite of their cost.

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

Section 9.3 presents the results of three different value scenarios, each investing $0.5 million, $1 million and $2 million annually in incremental silviculture. The $0.5 million investment yielded significant gains in average diameter and value per cubic metre over the SS base case that assumed no incremental silviculture. Further increases in the budget did not bring significant gains in mean diameters and per cubic metre value, in spite of the fact that diameter-enhancing treatments, such as spacing, increased significantly in some cases. This is likely caused by several factors:

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

### *10.1.4 Stand Yields*

Many of the available treatment regimes reduce stand yields as modeled by TASS. While commercial thinning may help to increase harvest levels by shifting harvest from

one period to another, it generally reduces merchantable stands volumes. Spacing treatments may work either way. Often they reduce stand yields, however, in some cases, dense stands, particularly on better sites, may benefit from spacing and produce not only larger diameters and piece sizes, but also higher per hectare merchantable volumes.

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

- Fertilization was used to enhance yields.
- Spacing regimes that increased yields were favoured;

# 11.0 Conclusions

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

**Maximum possible volume** without sacrificing long-term sustainability was the first management objective identified at the first workshop. The quantity of timber supply in the Queen Charlotte TSA was not responsive to incremental silviculture. The volume maximization scenario indicated that the timber supply would increase only moderately, even at significant investment levels. This is likely due to the species mix in the TSA; hemlock, the dominant species in the TSA is not a good candidate for fertilization; the only currently recognized incremental silviculture treatment that increases stand volumes.

The preferred scenario has the same harvest level as the SS base case. While the preferred scenario has a lower harvest level than volume maximization, it represents a balanced solution between volume and value.

**Increase timber quality** was another management objective identified by the Queen Charlotte TSA group. More specifically, the goal is to manage regenerated stands to yield 8% premium logs by volume, with the majority of the remainder being of good grade sawlog quality.

The analysis results show significant gains in average diameters and amounts of clear wood due to incremental silviculture. Both average diameter and clear wood can be used as indicators for quality.

## *11.1 Recommendations*

While the Preferred Scenario may appear as the "best" solution, it is important to emphasize that it is only one of potentially many desirable approaches that the Ministry of Forests can follow in the Queen Charlotte TSA. Different assumptions in the modeling would likely produce slightly differing results. Also, this analysis cannot factor in less concrete but important goals, such as, maintaining options for the future. For this reason, rather than taking one solution as the direction for incremental silviculture, we recommend consideration of the trends, such as:

- An annual budget level of $0.5 million is able to increase the harvest value significantly without compromising harvest levels.

- If funding is available, an annual budget of up to $1 million should be used. Beyond $1 million, the improvement in the per cubic metre harvest value is insignificant.

- In the first decade, 71% of available funding should go to spacing, 25% to pruning and 4% to fertilization.

- In the first decade the treatments should concentrate on good hemlock sites (34% of area treated) and good spruce sites (25% of area treated).

- For the next 10 years, the recommended annual treatment areas are 34 ha of fertilizing, 289 ha of spacing, 16 ha spacing/fertilizing, and 91 ha of pruning.

- Local objectives were set to produce more clearwood over the planning horizon than resulted from this analysis. There should be flexibility to allocate more funds to pruning than this analysis indicates if it is deemed necessary to produce more clearwood to maintain future product options. Pruning should concentrate on lower cost productive sites.

- As it appears that pruned stands, particularly hemlock stands, may be more susceptible to serious damage from budworm, there should be flexibility in pruning less area in those years when the budworm numbers are high.

# 12.0 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 side indices locally.
- There is uncertainty whether the stand level model TASS adequately represents different stand types and treatment regimes. Investment decisions may depend greatly on the responses that TASS shows to different treatment regimes. It is important for this stand level modelling work to continue.
- It is important to determine whether the operational adjustment factors used in several analyses are reasonable.
- Creating old growth conditions through silviculture in areas that do not contribute to timber harvesting may allow harvesting of old growth timber somewhere else. Investing in these kinds of silviculture activities can be attractive as the benefits can be received immediately, rather than several years from now. However, in many areas of the province there are no agreed upon definitions for old growth other than age. Research is needed in this area of silviculture.

# 13.0 References

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# 14.0 Guidelines for Deviating from the Silviculture Strategy

File: 22130-20/SILV STRATEGY
Date: October 24, 2001

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

1. **Objectives**

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

2. **Inventory and yield predictions**

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

3. **Budgets**

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

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