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Analysis Report

TYPE 2 STRATEGIC SILVICULTURE ANALYSIS SOO TSA

PREPARED BY

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Forest Optimization and Resource Utilization Management



Executive Summary

Introduction

This document presents an incremental silviculture strategy for the Soo Timber Supply Area (TSA)

The purpose of the strategy is to guide the application of available incremental silviculture funds to facilitate their most efficient and effective use. It focuses mainly on incremental silviculture activities but also addresses some basic silviculture activities where appropriate.

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

This strategy should not be confused with the allowable annual cut (AAC) determination. AAC's are based on actual practice and current information at the time of the determination. This strategy is about improving the future state of the forests within the Soo TSA and may influence future AAC determinations.

Issues

Harvest Forecast

The TSR 2 initial, medium-term and long-term harvest level is 506,000 m³/year.

Most of the mature timber upon which timber harvesting will depend in the short-term is located on poor growing sites.

Age Class Structure

There is a relatively high proportion of young stands (less than 40 years of age) within the THLB. However, 41% of the THLB is still in stands over 140 years.

Growing Sites

Approximately 27.5% of the sites in the THLB have a site index @50 greater than 22.5 metres and 41% have a site index between 17.5 and 22.4 metres.

Old Growth Site Index (OGSI) and Site Index Biogeoclimatic Ecological Classification (SIBEC) adjustments were included in this analysis. These adjustments showed significant increases in the harvest forecast in all time periods increasing the short-term harvest level by 19% and the long-term harvest level by 80% from TSR 2.

Forest Cover

Forest cover constraints were modeled as per TSR 2.

Quality

Stands of poor quality or low productivity were not included in the timber harvesting land base. TSR 2 netted out 685 ha of non-commercial cover, 22,530 ha of sites with low productivity and 3,166 ha of problem forest types.

Old Forests

Approximately 20% of the THLB is presently older than 250 years and about 34% of the "non-timber harvesting land base" stands are older than 250 years. The harvest forecasts are not sensitive to increasing or decreasing the old seral age requirement by 20 years.

Minimum Harvest Ages (MHA)

Minimum harvest ages are chosen in order to ensure that the timber supply model selects only stands with sufficient merchantable volume and piece size. Timber supply is slightly sensitive to small (10 years) increases or decreases in minimum harvest ages.

Estimates of Existing and Regenerated Stand Volumes

The short-term and mid-term timber supply is somewhat sensitive to increases or decreases in volumes of existing stands.

A 10% increase in managed stand yields allows for an increased harvest forecast in all periods including the initial harvest level. A reduction in managed stand volumes affects only the long-term.

Forest Health Issues

No epidemic forest health issues have been identified.

Issues Relating to Habitat and Non-Timber Forest Resources

- Spotted owl - In May 1997, the Provincial Government approved the Spotted Owl Management Plan. This plan relies on twenty-one management areas distributed throughout the range of the spotted owl within the Chilliwack and Squamish Forest Districts. In the Soo TSA, these areas cover 21.3% of the THLB.
- Deer habitat - Black tail deer habitat management to maintain the current population estimated at approximately 7,700.
- Botanical forest products - A small management zone in the Blackwater Creek area has been designated as a reserve for wild mushrooms. Forest cover requirements for this zone are intended to simulate selection harvesting or a slow rate of timber removal to maintain the mushroom habitat.

Management Objectives

Objective	Objective description
Maximize volume	<ul style="list-style-type: none"> ▪ Fibre ▪ Sawlog; average dbh 40 cm
Increase productive land base	<ul style="list-style-type: none"> ▪ Reduce backlog NSR ▪ Deciduous stand conversion ▪ Lodgepole pine stands - create new markets and convert to Fd stands
Employment	<ul style="list-style-type: none"> ▪ Create stable full time jobs
Produce clear wood	<ul style="list-style-type: none"> ▪ High quality peeler logs ▪ Premium sawlog; average dbh 50 cm
Produce owl habitat	<ul style="list-style-type: none"> ▪ Create multi layer Fd stands ▪ Pruning for habitat ▪ Harvest opportunities to create habitat
Other values	<ul style="list-style-type: none"> ▪ Recreation/visuals ▪ Wildlife ▪ Fisheries ▪ Water ▪ Alternate bioresources (mushrooms) ▪ First Nations/archaeological

Strategic Objectives and Targets

Short- and medium-term

- Increase current harvest level by 5% by increasing the THLB and by increasing volumes in managed stands.
- Create a timber supply capable of supporting a minimum harvest level of at least 5% increase over the base case.

Long-term

- Create a timber supply capable of supporting a harvest level of at least 10% increase over the base case.
- Generate at least 10% of total harvest volume in premium large logs.

Strategies

The following strategies support the achievement of the objectives and targets

1. Increase regenerated stand volumes by using genetically improved seed and fertilizing suitable regenerated stands.
2. Expand the timber harvesting land base through deciduous conversion.
3. Space and fertilize to set up stands for future commercial thinning; maintain options for the future.
4. Increase the value of second growth stands by spacing, pruning and fertilization.
5. Produce Spotted Owl habitat by creating multi-layered Fd stands through spacing, commercial thinning and partial harvesting.

Scenarios

Several scenarios were developed and tested. One of them was the silviculture strategy base case, against which the potential candidates for the preferred scenario were compared. The preferred scenario is the scenario that this strategy is based on.

Several scenarios concentrated on increasing the long and short-term timber supply through incremental silviculture. Investigating the results of the volume-orientated scenarios with the goal of combining the volume and value objectives helped develop the preferred scenario.

Therefore, a strategy was developed that would produce more value while maintaining high harvest levels. This was done by including a value weighting in the estate model optimization function. It was assumed that including the value in the optimization function would schedule more treatments focusing on value, thus increasing the average piece size and overall quality of the future timber flow. According to the analysis, adopting an incremental silviculture strategy as per the preferred scenario could produce the following results:

- A short-term increase of 3%, and a long-term increase of 6% on harvest levels.
- Approximately 50% of the harvested managed Fir volume is projected to have an average diameter greater than 50 cm over most of the planning horizon. For other species, this number is close to 40%.
- Over the planning horizon of 200 years, an average of about 20 hectares of pruning is proposed annually. On average, the clear wood volume will be about 0.6% of total harvest volume throughout the planning horizon. The production of clear wood will not start until the fifth decade.
- 20 silviculture jobs for the next 10 years.
- A short-term increase of 125 TSA level jobs and 259 provincial jobs. A long-term increase of 296 TSA level jobs and 614 provincial jobs.

Incremental Silviculture Program

The following table itemizes the annual treatments in hectares and identifies the annual costs of the program needed to support the incremental silviculture strategy. The budget assumes no net cost for commercial thinning.

DECADE	CT1	CT1/FERT	CT2 ¹	FERT	SPACE/ PRUNE1	FERT/PRUNE2	PRUNE2	SPACE/FERT	SPACE	GRAND TOTAL	BUDGET
1	0.9	7.4	0.0	528.2	12.7	9.2	6.3	411.7	416.8	1393.2	\$1,259,877
2	116.0	37.6	0.0	923.2	11.8	6.5	6.1	144.7	269.5	1515.4	\$742,408
3	227.2	84.3	0.0	1001.7	0.8	6.7	5.1	269.7	286.2	1881.7	\$779,028
4	221.4	88.4	0.0	1253.9	3.2	0.4	0.4	187.8	222.4	1978.0	\$608,553
5	219.7	119.5	42.6	1235.6	7.9	0.8	2.5	227.4	187.0	2042.8	\$632,907
6	227.6	129.8	77.2	1130.5	18.5	6.0	1.9	202.5	194.4	1988.5	\$629,436
7	330.1	99.9	107.3	949.8	12.8	7.4	11.2	160.4	170.1	1849.0	\$567,045
8	327.9	85.9	95.4	982.9	8.8	6.7	6.2	86.9	169.8	1770.4	\$491,153
9	250.9	106.1	57.1	779.3	9.6	3.2	5.6	112.1	240.7	1564.7	\$549,477
10	286.0	75.6	76.2	737.0	7.5	7.4	2.2	127.9	319.9	1639.7	\$599,525
11	189.1	44.1	44.0	674.4	14.9	6.2	1.3	135.9	379.1	1489.0	\$711,666
12	151.1	78.0	115.8	573.5	11.5	5.1	9.8	164.0	378.5	1487.4	\$740,534
13	194.4	58.8	89.9	594.4	9.3	6.1	5.4	180.4	403.2	1541.9	\$742,121
14	263.6	83.6	99.0	662.6	8.3	1.7	7.6	181.4	295.9	1603.7	\$632,386
15	290.0	111.5	69.9	703.8	7.5	5.3	3.0	131.5	297.2	1619.7	\$577,759
16	302.5	103.5	150.7	708.6	12.4	4.4	3.1	174.3	266.0	1725.5	\$617,384
17	305.5	106.0	154.3	746.5	16.7	6.8	5.6	126.2	253.5	1721.0	\$609,451
18	265.2	85.2	202.5	728.6	5.1	9.4	7.3	101.2	168.1	1572.5	\$447,021
19	327.8	90.0	196.9	651.3	20.2	2.9	2.1	102.8	249.6	1643.6	\$545,680
20	273.3	88.3	158.8	576.2	16.0	8.0	12.2	119.2	275.7	1527.7	\$610,610

Incremental Silviculture Program, First Decade

Spacing

Spacing treatments consisted of spacing only, a combination treatment with fertilization and a combination treatment with pruning. Several spacing densities were modelled. The following table illustrates the densities and combination treatments that the strategy proposes, in detail. It also shows the sites (by SI class) where specific treatments regimes are recommended and the annual treatments areas.

Treatment	Ba SI 25	SI 30	Cw SI 22	SI 28	Fd SI 23	SI 29	SI 33	Hw SI 25	SI 30	S SI 22	SI 28	Grand Total
Space to 500 sph					5.8							5.8
Space to 600 sph						3.6	14.8					18.4
Space to 700sph										18.7		18.7
Space to 800 sph			21.1					3.4	27.1			51.6
Space to 900 sph	50.8			9.1								60.0
Space to 1000 sph		95.5										95.5
Space to 500 sph and 1st prune							6.1					6.1
Space to 500 sph and 1st prune (fert. to come)							6.5					6.5
2 nd prune							6.3					6.3
Space to 500 sph and fertilize					59.1							59.1
Space to 600 sph and fertilize						31.3	50.7					82.0
Space to 900 sph and fertilize	134.0											134.0
Space to 650 sph and fertilize (1 CT to come)					30.2							30.2
Space to 750 sph and fertilize (1 CT to come)						11.1						11.1
Space to 800 sph and fertilize (1 CT to come)							46.2					46.2
Space to 1200 sph and fertilize (2 CTs to come)					42.5	6.5						49.1
2 nd prune and fertilize							9.2					9.2
Fertilize	49.6				158.5	126.6	193.5					528.2
Space to 650 sph (1 CT to come)					5.1							5.1
Space to 750 sph (1 CT to come)						5.7						5.7
Space to 800 sph (1 CT to come)							8.0	0.4				8.5
Space to 1000 sph (1 CT to come)				9.5				11.1	7.0			27.6
Space to 1200 sph (2 CTs to come)					21.8	16.2	81.9					119.9
Total	234.4	95.5	21.1	18.6	323.0	200.9	423.3	14.9	34.0	18.7	0.0	1384.5

Different combinations of spacing amount to 841 ha for the first decade. 63.9% (538 ha) of spacing consists of treatments where no commercial thinning is anticipated in the future. The remaining 36.1% (303 ha) of spacing treatments set the stands up for future commercial thinning.

- **Spacing:** A High site Fir, poor site Fir and high site Balsam all have approximately 25% share of proposed spacing. Only 11.7% of spacing is proposed in Hemlock stands (8.2% high site, 3.6% poor site)
- **Space/Fertilize:** The treatment area is allocated for medium site (SI=25) Balsam (33%), poor site (SI=23) Fir (32%), medium site (SI=29) Fir (12%) and high site Fir (24%). It should be recognized that due to the SI adjustments, the poor site classifications represent better site conditions.
- **Space/Prune, 1st lift:** Only high site Fir stands are eligible for this treatment regime, which combines spacing and pruning. Only 12.6 ha are proposed annually for the first decade.

Fertilization

This treatment may be used a stand-alone treatment but it is also used together with spacing, pruning, already discussed above, and commercial thinning.

- **Fertilization:** The proposed treatment area for stand-alone fertilization is almost equally divided between the three Fir site types, (each receiving 30%) with the remaining 10% allocated to medium site Balsam stands.
- **Commercial thinning with fertilization (not shown in the table):** Only 7.4 hectares per year are proposed for the first decade. Only Fir stands were eligible for this treatment. Approximately 88% of this treatment is proposed for the high site Fir stands (SI=33).
- **Fertilize/Prune 2nd lift:** Only 9.2 hectares are proposed annually for the first decade. As this is an expensive treatment it is only eligible in high site Fir.

Commercial Thinning

This is also a combination treatment and can be combined with fertilization. Commercial thinning with fertilization has already been discussed above.

- **Commercial Thinning (not shown in the table):** Only 0.9 hectares of stand-alone commercial thinning are proposed annually for the whole decade. This is due to a lack of eligible stands available for commercial thinning. Commercial thinning increases significantly throughout the planning horizon.

Pruning

Pruning is also a combination treatment and the only stand-alone regime is the second lift pruning. Pruning in combination with fertilization and spacing has already been discussed above.

- ***Prune 2nd lift:*** Only the high site Fir stands that had already received a first pruning lift (in the past according to the history records or subsequently scheduled) are eligible for a 2nd lift treatment. A total of 6.3 hectares annually are proposed over the next ten years.

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1.0 Introduction

Incremental silviculture has been practiced in the Soo Timber Supply Area for over 20 years. Historically, treatment decisions were based on stand-level factors such as species, age or access. Treatment rules and analysis were developed on a stand-level basis, with little consideration for how these treatments affected forest-level objectives and indicators.

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 Soo 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.

The establishment of a free-to-grow stand is required following harvest (basic silviculture) by law and although pre-free-to-grow treatments have timber supply implications, they are not considered in this analysis. The project included a review of relevant information, two workshops with stakeholders, and a forest estate analysis. This report presents the results of an investigation into incremental silviculture opportunities in the Soo TSA.

The Soo Silviculture Strategy is a "Type 2" project in that it uses timber supply analysis and computer modeling to provide additional insight into creating and implementing a plan. The "Type 1" projects are based exclusively on existing information such as recent Timber Supply Reviews. A "Type I" project has been completed for the Soo TSA (Soo Timber Supply Area - Incremental Silviculture Strategy (Interim) - August 31, 1998). It developed a series of project objectives, working targets, and major silviculture strategies for the Soo TSA.

The "Type 2 Analysis Project" is the next step in the process. This step investigates the timber supply aspects of the Type I strategy and provides an analysis to formulate the final strategy. The key concept is that silviculture strategies must be based on forest-level objectives.

The objectives of the Soo 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 Soo 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

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

2.1 Project Procedures

The general steps in developing the silviculture strategy are:

1. Identify forest level timber supply and habitat issues by reviewing existing information. Summarize the issues by time frame (short term = 1-20 years, mid term = 21-70 years, and long-term = greater than 70 years).
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 was used 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 costs. These results are used as input to the forest-level analysis.
6. Conduct forest-level (TSA) analysis to evaluate strategies with respect to short-term, mid-term, and long-term timber and habitat supply and quality issues. The forest-level analysis provided 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 appropriate components for the short-, mid-, and long-term.
8. Define an annual incremental silviculture program spatially for the first ten years.

The following process was used to implement these steps to develop the silviculture strategy:

Workshop #1 was held on December 11th. The workshop was attended by representatives of the Ministry of Forests (Squamish Forest District and Vancouver Forest Region), CRB Logging, Interfor, Western Forest Products, Terminal Forest Products, and Hugh Hamilton Ltd. The purpose of the workshop was to define issues, establish objectives, develop potential strategies and define current treatment regimes from a local perspective.

Based on the input from the workshop participants and a "Background Agenda and Summary Package" distributed prior to Workshop #1, the workshop produced the following results:

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

Stand-level analysis consisted of preparing growth and yield curves for various treatment regimes. Analysis was conducted for the incremental silviculture treatment regimes by Ken Polsson of the MoF Research Branch using the Tree and Stand Simulator (TASS) model. The growth and yield models, Tabular Interpolation Program for Stand Yields for Windows (WinTIPSY) and Variable Density Yield Predictor (VDYP), were also used in 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 FORUM model. The FORUM model analyzes forest systems in a spatial and temporal manner using both simulation and optimization techniques. Both approaches are used in this project, simulation for the base case (essentially a calibration approach) and optimization to determine the preferred treatment schedules. The FORUM model combines the spatial data management capabilities of ARC/INFO GIS and MS Access with landscape optimization capability, simulation model flexibility, and professional experience.

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

The fully spatial approach of the FORUM model allows maps to be produced for time periods, showing the location of silviculture treatments along with graphs and chart reports.

A draft report is prepared for discussion at a second workshop. Feedback from the workshop participants will guide any further analysis that is required and a refining of the "preferred strategy".

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- Ministry of Forests Vancouver Forest Region
- Ministry of Forests Squamish Forest District
- Ministry of Forests Research Branch
- Ministry of Forests Timber Supply Branch
- Squamish Mills
- CRB Logging
- Interfor
- Western Forest Products
- Terminal Forest Products

2.2 Data Acquisition and Manipulation

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

- TSR II resultant dataset, which includes the 1992 re-inventory (FC1 and FIP) and other resource data layers that were utilized in TSR II completed in August 1999; and
- Integrated Silviculture Information System (ISIS) activity data was used.

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 HHL base case);
- HHL base case with site index adjustments;
- HHL base case with site index adjustments and genetic improvements;
- Silviculture Strategy Base Case: which includes:
 - Site index adjustments;
 - Conversion of deciduous stands to coniferous leading at rotation;
 - Existing 0-40 year-old stands on TASS curves;
 - Stands 40-100 with product and value information; and
 - No treatments beyond base case incorporated.
- Optimized Silviculture Strategy Base Case; same as previous run, except the optimization algorithms are applied instead of simulation;
- Timber Volume Optimization Runs: runs using different silviculture budgets to determine the impact on timber flow.
- Preferred Option: an optimization run that combines volume and value objectives.

3.0 Soo TSA

3.1 Description of the TSA

The Soo TSA is situated in the Vancouver Forest Region and is administered from the Squamish Forest District office. The TSA is located north of Vancouver in the Coast Mountains and is bordered by the Sunshine Coast, Lillooet, and Fraser TSAs, as well as Tree Farm License 38 and Garibaldi Provincial Park.

Harvesting, silviculture operations, and the manufacture of wood products at the Interfor sawmill in Squamish and at the Western Pulp pulp mill at Woodfibre support forestry employment in the area. There is substantial movement of wood fibre across TSA boundaries. About 50 % of the timber harvested within the TSA is processed there, while about 50% of the wood processed in the TSA is brought in from outside the TSA boundaries (MOF 1996).

The Soo TSA includes a considerable amount of steep, mountainous terrain. The biogeoclimatic zones in the TSA are Coastal Western Hemlock (CWH), the Mountain Hemlock (MH) zone, the Alpine Tundra zone, and further inland, there are small areas of the Interior Douglas-fir zone, and the Engelmann Spruce-Subalpine Fir zone. The forests of the Soo TSA are home to a wide variety of wildlife, including large mammals, invertebrates, birds and extensive fish stocks.

Of the total TSA area, only 299,838 hectares are productive Crown forest. Further reductions applied to the productive forest land base result in 124,312 hectares considered to be available for timber harvesting (HHL, 2000).

Stands with Douglas-fir as the dominant species cover about 51 percent of the THLB, while western hemlock/amabilis fir stands cover 39 percent. Western red cedar, spruce, and cottonwood comprise a small component of the land base (MOF, 1996).

3.2 History of the Allowable Annual Cut (AAC) in the TSA

In 1980, the allowable annual cut (AAC) was determined at 669,635 cubic metres. In 1982, the TSA boundary was adjusted and the AAC was raised to 700,000 cubic metres. This remained in effect until 1989, when it was raised to 705,000 cubic metres to permit some deciduous harvesting under a temporary license. As of January 1, 1992, the AAC was reduced by 18 percent to 580,000 cubic metres. This was further reduced to 506,000 cubic metres on January 1, 1996, including a partition of 2500 cubic metres for cottonwood-leading forest types. Effective October 1, 2000, the AAC was set at 503,000 cubic meters with a 90,000 cubic meter partition for helicopter logging. The partition for cottonwood-leading forest types was removed in this decision.

3.3 Current Basic Silviculture Systems

The primary silviculture system used in the Soo TSA is clearcutting. However, other silvicultural systems are becoming more prevalent. These systems include: group

selection, shelterwood, seed tree and commercial thinning (MOF, 1996). Approximately 1,100 hectares are harvested annually (MOF, 1998). Regeneration is a mixture of planting and natural, with decisions made on a site-specific basis to ensure the stand reaches free-to-grow within required time frames.

3.4 Incremental Silviculture History

Incremental silviculture includes activities such as genetic improvement, juvenile spacing, fertilization, pruning, commercial thinning, and backlog reforestation which are beyond the basic silviculture activities required to establish a free-growing stand.

The Soo TSA has had an aggressive, intensive silviculture program with the objective of providing a 47,000 m³/yr AAC increase above basic silviculture productivity levels.

3.4.1 Genetically Improved Seed

This is widely available for Douglas fir, and is used extensively. The TSR base case accounted for long-term volume gains anticipated from the use of genetically improved seed (MOF, 1999).

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 quicker. Juvenile spacing can also manage species composition, address forest health issues, and meet biodiversity or wildlife objectives. There has been an average of about 600 to 900 ha of spacing each year.

3.4.3 Fertilization

Fertilization of a stand raises the productivity of the site and is the only treatment presently recognized to actually increase stand volume. Aerial application of urea is the most common technique. There is a fertilization program underway which fertilizes about 1100 hectares per year. Fertilization can raise the productivity of a site and reduce the age at which a stand reaches harvestable size.

3.4.4 Pruning

Pruning is the removal of branches from the bole of the tree with the purpose of creating clear lumber. Two treatments (lifts) of pruning are done, when the tree is at 7 m and at 12 m. The rule is that pruning shall leave a length of crown that is not less than 50% of the total tree height. To ensure optimal use of funding for pruning, no stands shall be pruned unless the stand has been juvenile spaced first. At present, the district prunes approximately 25 ha each year.

3.4.5 Commercial Thinning

Commercial thinning (CT) is a program where the thinning occurs when the trees being removed have commercial value. It is assumed that CT will produce a positive net stand

value after treatment. Commercial thinning can capture stand mortality, concentrate growth on fewer stems, increase the merchantable proportion of a stand, and increase timber value.

Currently, commercial thinning is limited to small areas managed by the Small Business Forest Enterprise Program. Stands are generally suitable for commercial thinning when they are 40 to 60 years old. There is a relatively small area of this age class in the TSA.

3.4.6 Backlog Reforestation

There are currently 3803 ha of NSR (MOF, 1999). Most of this is current NSR (3,231 ha). The backlog NSR of 572 ha will be assumed to be restocked within the next 10 years (MOF, 1999).

One concern raised at the workshops is the non-performance of NSR and marginally SR stands in the Coast/Interior transition zone. Many of these stands require fill-planting, however; the confidence in identifying these stands from the inventory datasets is low. Therefore, the inventory dataset was utilized according to the polygon data labels.

3.5 Previous incremental silviculture plans and reports

Soo Timber Supply Area - Draft Forest Land Management Plan (1992)

In addition to considerable information on general resource management directions, the two most pertinent parts of this document are the product objectives and the incremental silviculture goals and strategies.

The product objectives are defined by species (Douglas fir, balsam, hemlock, cedar) and site index. Rotation ages, heights, diameters, and harvest volumes are specified. Goals and strategies are defined for incremental silviculture. Strategies are defined for spacing, pruning, fertilization, stand conversion, commercial thinning, and forest health. The strategy specifies number of hectares per year for each treatment and describes how candidate areas will be selected.

Soo Timber Supply Area - Forest Management Strategy (1994)

This appears to be an updated version of the 1992 Draft Forest Land Management Plan (FLMP). It includes the same items as described for the FLMP above, but does have additional detail for the product objectives.

Soo 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 Soo TSA Timber Supply Analysis Report) to identify timber quantity and quality issues and opportunities. The TSR I base case showed an initial harvest level of 506,000 m³/year, followed by declines over the next two decades of 13% and 11% respectively.

The recommended silviculture strategy was mostly oriented towards increasing the supply of sawlogs in the mid-term period in order to address the imminent reduction in harvest levels shown in the TSR I base case. There was a lesser emphasis on quality, with an objective of achieving 2% premium logs by volume in regenerated stands. A number of strategies were recommended to achieve the objectives, including the following:

- Reduce minimum harvest ages of younger existing stands and newly regenerated stands by 10 years through a number of identified practices;
- Increase the volume of 2000 ha of coastal Douglas fir, age class 3 existing stands through fertilization;
- Design stocking levels on some existing stands to facilitate a possible commercial thinning program in the period 40-70 years from now;
- Create owl habitat in 10% of spaced areas;
- Increase regenerated stand volumes by 20%; and
- Expand the timber harvesting land base by 1% by restocking 250 ha of backlog NSR and rehabilitating 1000 ha of poor site Pl.

4.0 Issues Identification

4.1 General Timber Supply Issues

The issues discussed below significantly affect the timber supply in the Soo TSA from the perspective of timber quantity, timber quality, forest health and habitat. The following interpretations of the current timber supply conditions in the Soo TSA are derived from the information presented in the Soo Timber Supply Analysis Report, the Soo AAC Rationale, and Workshop #1. The terms short-term, mid-term and long-term are used throughout and are defined as follows:

- Short-term - This refers to the next twenty years.
- Mid-term - This varies from one management unit to another, but in this case is the period from year 21 to year 70. This period was chosen to maintain consistency with the definitions used in the Type I silviculture strategy project.
- Long-term - The time at which the majority of the timber harvest is from managed stands, starting at year 71 for the TSR II base case.

The following items are aspects of timber supply that are relevant to a silviculture strategy.

4.1.1 Harvest Forecast

The initial, medium-term and long-term harvest level is 506,000 m³/year. It was also found that it is possible to sustain an initial harvest level of 607,200 m³/year for one decade before starting a decline to the long-term harvest level of 506,000 m³/year. This is a considerably different harvest forecast than was shown in TSR I. Much of this difference is likely due to a larger THLB, mostly because of much more helicopter harvesting land base.

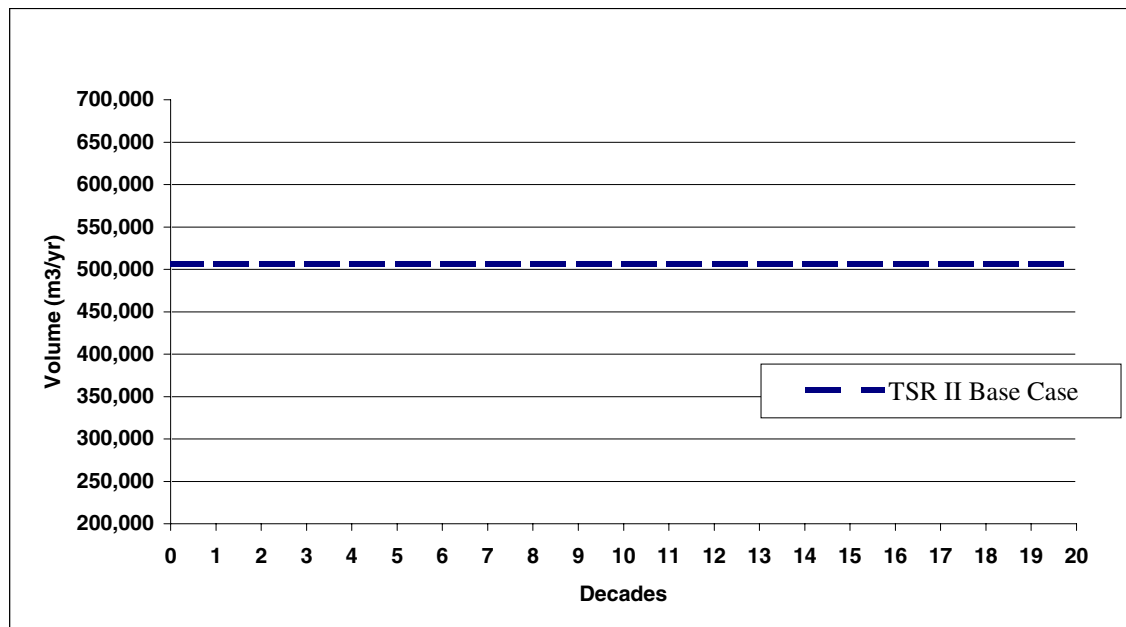


Figure 1 – TSR II Base Case

4.1.2 Land Base

The overall land base has expanded, due to addition of helicopter area as noted above. The conventional land base has diminished in size, however, mostly due to creation of new parks.

The timber supply is not sensitive to a 10% reduction in the size of the THLB until beyond the sixth decade. An increase in the size of the THLB would have an immediate positive effect on the harvest forecast.

4.1.3 Age Class Structure

The age class structure has been altered as a result of past harvesting. There is a relatively high proportion of young stands (less than 40 years of age) within the THLB. However, 41% of the THLB is still in stands over 140 years (MOF, 1999). Most of the mature timber upon which timber harvesting will depend in the short-term is located on poor growing sites (MOF, 1996). This has potential implications on the quality of future regenerated stands; spacing/fertilization regime may be required to produce a crop of acceptable quality in a reasonable time frame.

4.1.4 Transition from Existing to Managed stands

In the TSR II base case over the next 100 years, most harvesting occurs in existing old stands. From decade 10 onward, most of the stands harvested are regenerated stands (MOF, 1999).

4.1.5 Growing Sites

Approximately 27.5% of the sites in the THLB have a site index @50 greater than 22.5 metres and 41% have a site index between 17.5 and 22.4 metres (MOF, 1999b).

Old Growth Site Index (OGSI) and Site Index Biogeoclimatic Ecological Classification (SIBEC) adjustments were included in TSR II as sensitivity analyses but not in the base case. These adjustments showed significant increases in the harvest forecast in all time periods (MOF, 1999).

4.1.6 Forest Cover Requirements

The following forest management zones occur in the Soo TSA:

- Integrated resource management - applies to 76.6% of the THLB. The base case has a requirement that a maximum of 33% of the THLB be less than 3m in height. This requirement is intended to model Forest Practices Code adjacency and green-up requirements. The timber supply is not sensitive to forest cover requirements used to model adjacency (MOF, 1999).
- Spotted owl management - 15.8% of the THLB is in the spotted owl SRMZ and 5.5% is in the candidate spotted owl (IRM) areas. The SRMZ requires that a minimum of 67% of the land base be in stands older than 100 years of age. The candidate areas have a requirement that a maximum of 33% of the land base is < 3m in height with additional WTP requirements (MOF, 1999).
- This analysis modeled all owl areas using the 67%/100-year rule. In addition, commercial thinning was used for the silviculture strategy base case, volume scenarios and the preferred scenario. All owl areas had to meet a 5.0% WTP. This modeling approach is more conservative than the one used in TSR II. However, it is not expected to have an impact on the results.
- Deer habitat management - 7.5% of the THLB is included in the four deer management zones (migration zone, rotation zone, spring zone, and selection zone). The migration zone requires a minimum of 80% greater than 3 metres in height, while the other zones require a minimum of 50% of the area greater than 50 years of age.
- Visual Quality Objectives (VQO's):
 - Modification VQO's - applies to 5.2% of the THLB and has a requirement that a maximum of 25% of the productive forest is < 5m in height.
 - Partial retention VQO's - applies to 16.3% of the THLB and has a requirement that a maximum of 15% of the productive forest is < 5m in height.
 - Retention VQO's - applies to 1.9% of the land base and has a requirement that a maximum of 5% of the productive forest is < 5m in height.
- The short-, mid-, and long-term timber supply showed no response to raising or lowering the green-up height by one metre in the VQO zones. Lowering the

maximum allowable disturbance limit showed no response in the short- or mid-term and only a very slight decrease in the harvest forecast in decade 26 (MOF, 1999).

- Community watersheds - Twenty-three community watersheds have been identified within the Soo TSA. These areas were restricted to 10% of the forested area being eligible for harvest within a ten-year period. No sensitivity results were reported for this (MOF, 1999).

4.1.7 Quality

Quality was not modeled in TSR II. In Workshop #1, it was noted that producing good quality sawlogs was more important than just producing additional fibre. It was also noted that the better the quality of wood, the more manufacturing options there are.

4.1.8 Old Forests

Approximately 20% of the THLB is presently older than 250 years and about 34% of the "non-timber harvesting land base" stands are older than 250 years (MOF, 1999). Forest cover objectives for old forests include an assumption that stands will develop old growth attributes at an age of 250 years. The harvest forecasts are not sensitive to increasing or decreasing the old seral age requirement by 20 years. Old seral guidelines are modeled as per the draft biodiversity emphasis options.

4.1.9 Minimum Harvest Ages (MHA)

Minimum harvest ages are chosen in order to ensure that the timber supply model selects only stands with sufficient merchantable volume and piece size. Timber supply is slightly sensitive to small (10 years) increases or decreases in minimum harvest ages.

4.1.10 Estimates of Existing and Regenerated Stand Volumes

The short-term and mid-term timber supply is somewhat sensitive to increases or decreases in volumes of existing stands.

A 10% increase in managed stand yields allows for an increased harvest forecast in all periods including the initial harvest level. A reduction in managed stand volumes affects only the long-term (MOF, 1999).

4.2 Forest Health Issues

There were no epidemic forest health issues identified. Most concerns were on a stand-level basis, and are not included in this analysis.

4.3 Issues Relating to Habitat and Non-Timber Forest Resources

- Spotted owl - In May 1997, the Provincial Government approved the Spotted Owl Management Plan. This plan relies on twenty-one management areas distributed throughout the range of the spotted owl within the Chilliwack and Squamish Forest Districts. In the Soo TSA, these areas cover 21.3% of the THLB.

- Deer habitat - Black tail deer habitat management to maintain the current population estimated at approximately 7,700 (MOF, 1994).
- Botanical forest products - A small management zone in the Blackwater Creek area has been designated as a reserve for wild mushrooms. Forest cover requirements for this zone are intended to simulate selection harvesting or a slow rate of timber removal to maintain the mushroom habitat.

5.0 Stand Level Modeling

5.1 Approach

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

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

TASS is a single species, even-aged stand model; therefore, stands were modeled with these assumptions. TASS is calibrated for a limited number of species, so for this analysis, balsam is modeled using a hemlock curve. Output from TASS includes: yield information, stand volume, mean piece size by grade, stand height, diameters, and piece size distributions by stand age. VDYP is the computer model used to generate yields for unmanaged mature or older immature stands. The output from VDYP is limited to height, diameter, volume and MAI.

6.0 Timber Supply Concerns and Analysis Objectives

Objectives describe a desired future state with respect to a particular resource or resource use. They should be measurable, either directly or indirectly, as a basis for evaluating whether the direction expressed in the silviculture strategy is achieving the stated goals and objectives.

6.1 Summary of Timber supply Issues:

6.1.1 Short-term

The increase in land base since the last AAC determination has led to an initial harvest level (the current AAC) that can be maintained throughout the short-, mid-, and long-term time horizons. The short-term harvest forecast is not particularly sensitive to most of the standard sensitivity analyses. The exceptions are an increase in land base, increase in site index of old stands, and a 10% increase in yields from managed stands.

Given the harvest flow used for the base case, the increase in managed stand yields shows an immediate increase in the harvest level of 5.5%. This immediate increase results from more merchantable managed volume being ready earlier, which allows for a higher harvest level from the existing growing stock (MOF, 1999). The short-term could therefore respond to any treatment measures that target managed stand volumes.

6.1.2 Mid-term

Mid-term harvest levels are sensitive to decreases in stand volumes for existing stands and to increases in regenerated stand volumes. Mid-term harvest levels are also significantly sensitive to increases or decreases in the land base. Treatments that increase stand volumes would be beneficial.

6.1.3 Long-term

Long-term timber supply is very sensitive to estimates of site productivity and regenerated stand volumes. Treatments that increase site productivity and increase stand volumes, such as fertilization, could provide considerable benefit in long-term harvest levels.

6.2 Timber Supply Concerns and Causal Analysis

In reviewing the TSR documents and discussion with the workshop participants, the primary timber supply concern is identified as the future reduction of AAC and the scarcity of harvestable quality timber in the future.

In general, the reduction in AAC and timber scarcity is caused by a current uneven age class distribution, which has a very high proportion of the THLB greater than 250 year and under 50 years (see MOF, 1999a). The quality concerns are addressed by the age of the current stands being harvested. With the current average harvest age of approximately 300 years, these stands are in the process of break-up.

The reductions in current AAC, as defined by the TSR II base case, occur as the availability of existing stands becomes limited and harvesting shifts to managed stands, which at that time have lower volume per ha at harvest due to their relatively low harvest age. The LTHL is attained when the managed stands make up virtually all the AAC.

6.3 Higher Level Objectives

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

1. Minimize interim reduction in timber supply so that the annual allowable 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)

6.4 Local Objectives

During Workshop #1, the group identified the following objectives and then assigned a priority to each objective, providing an assessment of importance to be considered during the analysis.

Table 1 – Local Objectives

Objective Number	Objective type	Objective description	Relative Value	Ranking
01	Maximize volume	<ul style="list-style-type: none"> ▪ Fibre ▪ Sawlog; average dbh 40 cm 	8	1
02	Increase the productive land base	<ul style="list-style-type: none"> ▪ Reduce backlog NSR ▪ Deciduous stand conversion ▪ Lodgepole pine stands - create new markets and convert to Fd stands 	19	2
03	Employment	<ul style="list-style-type: none"> ▪ Create stable full time jobs 	25	3
04	Produce clear wood	<ul style="list-style-type: none"> ▪ High quality peeler logs ▪ Premium sawlog; average dbh 50 cm 	28	4
05	Produce owl habitat	<ul style="list-style-type: none"> ▪ Create multi layer Fd stands ▪ Pruning for habitat ▪ Harvest opportunities to create habitat 	30	5
06	Other values	<ul style="list-style-type: none"> ▪ Recreation/visuals ▪ Wildlife ▪ Fisheries ▪ Water ▪ Alternate bioresources (mushrooms) ▪ First Nations/archaeological 	35	6

In order to evaluate success in meeting timber quality-related objectives (e.g. #01, 04 above), it is necessary to define products in terms of log types that can be determined from inventory data.

Product definitions:

- Premium log:
Douglas fir, 50cm min dbh, pruned 5m first log.
Balsam: 40-45 cm min dbh, small tight knots, pruned 5m first log
- Saw log: Stands having 250 stems/ha 50 cm+ dbh and average dbh of 40 cm.
- Fibre log: Everything else (MOF, 1998)

6.4.1 Short-Term (1-20 years)

Short-term timber supply may benefit from activities that:

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

6.4.2 Mid-term (21-70 years)

The quantity of mid-term timber supplies may benefit from treatments 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 by including helicopter logging outside of the THLB, and by site rehabilitation;
- Bring forward harvest from long-term into mid-term to fill in mid-term "shortfall". This is due to increased stand volumes in regenerated stands (e.g. long-term harvest level rises so the difference between the mid-term level and the long-term level is greater). Commercial thinning may do this;
- Spacing and fertilization as necessary to set up stands for future commercial thinning; and

The quality of mid-term timber supplies may benefit from treatments that:

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

6.4.3 Long-term (70+ years)

The quantity of long-term timber supplies may benefit from treatments that:

- Increase volume of regenerated stands, such as fertilization, genetic improvement.
- Expand the timber harvesting land base by including helicopter logging outside of the THLB, and by site rehabilitation;

The quality of long-term timber supplies may benefit from treatments that:

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

7.0 Potential strategies by response time frame

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

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

Table 2 – Potential Strategies

Response Time Frame	Strategy Description	Anticipated result
Short-Term	<ol style="list-style-type: none"> 1. Expand the timber harvesting land base by: <ul style="list-style-type: none"> • Deciduous stand conversion. 2. Increase the volume of some existing stands through: <ul style="list-style-type: none"> • Late rotation fertilization. 	<ol style="list-style-type: none"> 1. As per TSR II, short-, mid- and long-term timber supply is sensitive to changes in the size of THLB base. Stand conversion and eliminating backlog NSR amount to an increase of ha in THLB. 2. Short-, mid- and long-term timber supply is somewhat sensitive to an increase in existing stand volumes. A 10% increase in stand volumes is anticipated to result in 2% increase in timber supply.
Mid-Term	<ol style="list-style-type: none"> 1. Increase regenerated stand volumes as per the scenario in Long Term. 2. Space and fertilize to set up stands for future CT. 3. Increase the value of second growth stands by: <ul style="list-style-type: none"> • Pruning, spacing and fertilization. 4. Produce Owl Habitat by creating: <ul style="list-style-type: none"> • Multi-layer Fd stands though spacing, commercial thinning and partial cutting. • Pruning for habitat. 	<ol style="list-style-type: none"> 1. Increased regenerated stand volumes have some impact on mid-term timber supply; however, the greatest impact is in the long term. 2. Maintain options for CT. Bring some long-term volumes to the mid term. 3. Mid-term value increase expected to be modest, as benefits will occur in the long term.
Long-Term	<ol style="list-style-type: none"> 1. Increase regenerated stand volumes by: <ul style="list-style-type: none"> • Using genetically improved seed; • Fertilizing suitable regenerated stands; 2. Increase the value of second growth stands by: <ul style="list-style-type: none"> • Pruning, spacing and fertilization. 	<ol style="list-style-type: none"> 1. This analysis assumes 4% gain for Fd and 2% genetic gain for other softwood species on 75% of the land base. Using 2nd generation improved seed would increase gain significantly. Assume a 6% long-term timber supply impact if 75% of THLB were modeled. Value increases expected in the long-term.

7.1 Stand Treatments

Stand treatments were described in general in Section 3.4, and the operational rules for each treatment are defined in the Analysis Information Package. The stand-level effects of various treatments show which treatment can be used to meet the requirements of the different strategies.

Table 3 – Stand Level Effects of Various Treatments

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)

Not all treatments can, or are being, modeled in this analysis. The primary restriction is the ability of TASS to model the treatment and show a reaction to the treatment. Some treatments have surrogate techniques to model their effect. For example, site index changes can be used to model fertilization.

7.1 Potential Treatment Regimes

The potential treatment regimes are specified for a variety of stand types, based on local experience. The stand types are defined based on combinations of leading species (Fd, Hw, B, Cw, S and Pl), and site index. The treatment regimes are combinations of fertilization, pruning (first and second lift), spacing and commercial thinning. The following table provides examples of the treatment regimes considered in stand and forest level analysis. For a complete listing of treatment regimes, please see the Analysis Information Package.

Table 4 – Examples of Treatment Regimes

Species	Site Index	Density	Treatment Regimes			
Fd	23	2000	Do nothing			
Fd	23	2000	Space			
Fd	26	2000	Space	Fert		
Fd	26	2000	Space	Fert	Ct	
Fd	23	2000	Space	Ct		
Fd	23	2000	Space	1st CT	2nd CT	
Fd	26	2000	Space	1st CT	2nd CT	fert
Fd	23	2000	Ct			
Fd	23	5000	Do nothing			
Fd	23	5000	Space			
Fd	26	5000	Space	Fert		
Fd	26	5000	Space	Fert	Ct	
Fd	23	5000	Space	Ct		
Fd	23	5000	Space	1st CT	2nd CT	
Fd	26	5000	Space	1st CT	2nd CT	fert
Fd	23	5000	Ct			
Fd	29	2000	Do nothing			
Fd	29	2000	Space			
Fd	32	2000	Space	Fert		
Fd	32	2000	Space	Fert	Ct	
Fd	29	2000	Space	Ct		
Fd	29	2000	Space	1st CT	2nd CT	
Fd	32	2000	Space	1st CT	2nd CT	fert
Fd	29	2000	Ct			

Historic treatment costs (Analysis Information Package) were assigned to regimes by the Workshop participants and reflect the average costs in the Soo TSA over the last several years.

7.2 Stand Level Treatment Responses

Figure 7.3 illustrates stand level response of different treatment regimes within an analysis unit in the Soo TSA. Do nothing refers to a regenerated stand growing on a TASS yield curve and receiving no incremental silviculture treatments. Existing stands grow on VDYP yield curves.

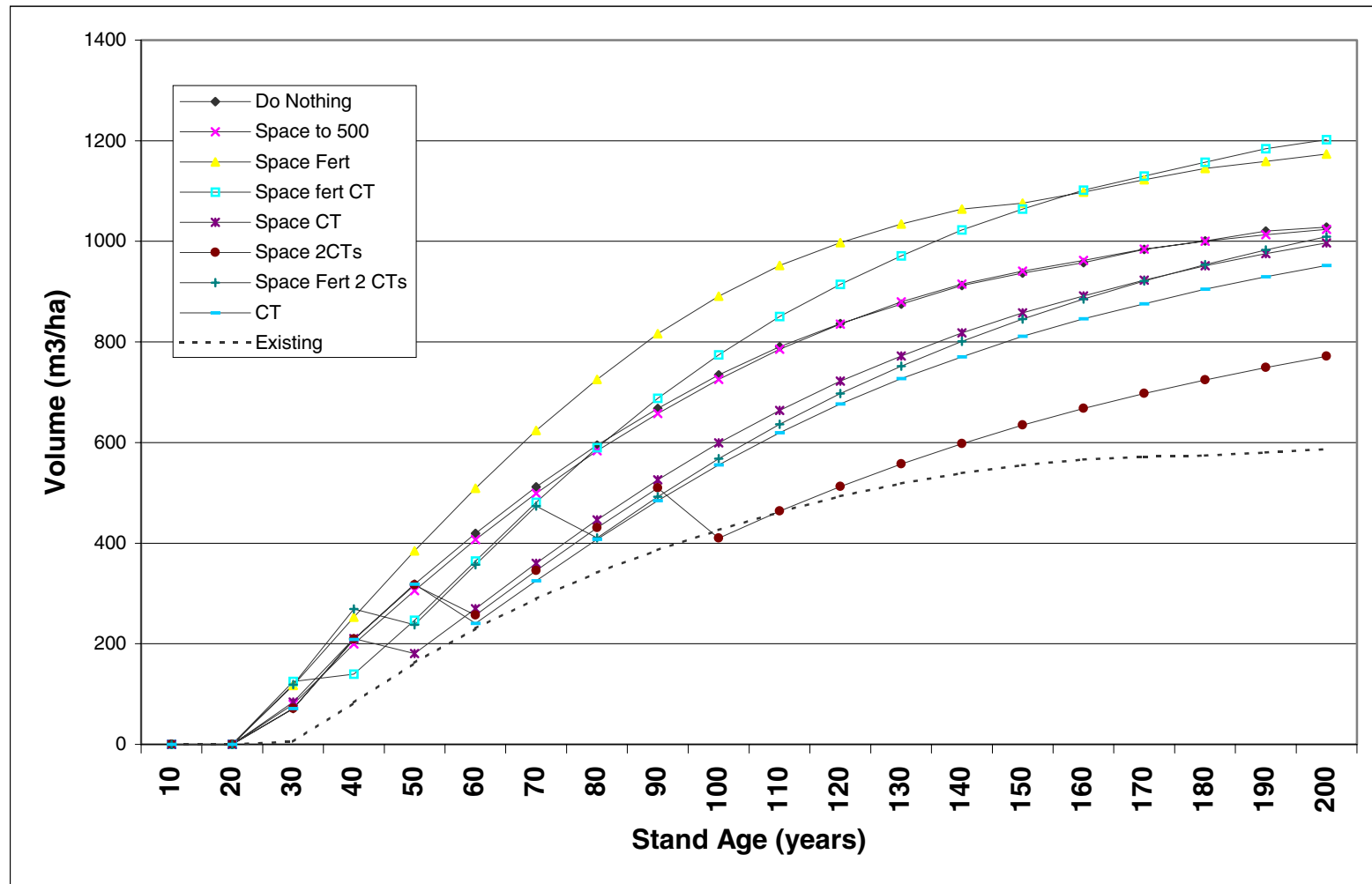


Figure 2 - Stand Level Responses, Fd, Medium Site, SI = 26-32

8.0 Forest Level Analysis

The following description is a brief summary of the procedures followed in carrying out this part of the project. For more details, please refer to the data 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
 - Maximum 5% tolerance around age-class targets specified in TSRII for optimization (1% for owl habitat) to allow for smooth transition strategies to be achieved without impacting timber flows.
- Treatment costs were taken from recent experience in the Soo TSA and are listed in the Analysis Information Package; and
- Log values were based on historic, third party, second-growth market pricing and are based on the Statutory Log Grades and piece size. For old growth timber, a flat \$100/m³ net revenue was used for all stands.

8.2 Working targets

In order to evaluate the effectiveness of potential strategies and treatment regimes, the following working targets were developed:

8.2.1 Short- and medium-term

- Increase current harvest level by 5% by increasing the THLB and by increasing volumes in managed stands.
- Create a timber supply capable of supporting a minimum harvest level of at least 531,000 m³/year. (5% increase over base case)

8.2.2 Long-term

- Create a timber supply capable of supporting a harvest level of at least 557,000 m³/year. (10% increase over base case).
- Generate at least 10% of total harvest volume in premium large logs.

8.3 Analysis methodology

After the dataset has been prepared for modeling, it is loaded in the model and the analyst then undertakes the simulation runs. The simulation runs, specifically the timber flow, provide a starting point for the optimization runs.

In setting the parameters for the optimization runs, the analyst has to define the timber flow pattern and then the model optimally achieves this timber flow while achieving the other objectives. Through experience, the analyst modifies the timber flow to reach a solution that meets the objectives at the greatest timber flow.

8.4 Scenarios

Table 5 provides a summary of different analysis scenarios.

Table 5 - Analysis Scenarios

Scenario	Title	Scenario Description
1	Base Case	<ul style="list-style-type: none"> Re-creation of the TSR II Base Case <ul style="list-style-type: none"> Calibrate model Test model reliability.
2	Revised Base Case	<ul style="list-style-type: none"> Base Case Yield curves for OGSi and SIBEC adjustments.
3	Genetic Improvement	<ul style="list-style-type: none"> Base Case Yield curves for OGSi and Sibec Adjustments Genetic improvement.
4	Silviculture Strategy Base Case	<ul style="list-style-type: none"> Deciduous conversion. Existing 0-40 year-old stands on TASS curves. No treatments beyond base case incorporated except for treatments in Spotted Owl areas. Simulation
5	Optimized Silviculture Strategy Base Case	<ul style="list-style-type: none"> Deciduous conversion. Existing 0-40 year-old stands on TASS curves. No treatments beyond base case incorporated except for treatments in Spotted Owl areas. Optimization algorithms applied
6	Timber Volume Scenarios	<ul style="list-style-type: none"> Optimized Silviculture Base Case Series of runs using different annual incremental silviculture budgets <ul style="list-style-type: none"> \$1.75M \$0.87M \$0.50M \$0.0 Intent is to determine impact on volume.
7	Preferred Scenario	<ul style="list-style-type: none"> Optimized Silviculture Base Case Set budget level with NPV in the objective function.

8.4.1 HHL Base Case (Scenario 1)

Re-creating the TSRII base case allows the evaluation of the model's performance as well as monitoring differences between the HHL analysis and TSRII. Any differences between the base cases will be useful in understanding volume differences in the subsequent runs. The base case assumed some incremental silviculture: spacing on all good, medium, and some poor sites. Also, fertilization on 17% of the THLB was assumed at ages of 20, 30 and 40 years for regenerated stands.

8.4.2 Revised Base Case (Scenario 2)

- Base case revised to incorporate TASS curves with SIBEC and OGSII adjustments. Site index adjustments are listed in Table 8.6 of the Analysis Information Package;
- Spacing treatments were as in the base case; all good, medium, and some poor sites were spaced.
- The management of existing managed stands as in the base case, i.e., same spacing and fertilization assumptions were applied; and
- Elimination of backlog NSR at the same schedule as the TSRII base case.

8.4.3 Genetic Improvement (Scenario 3)

This scenario is identical to Scenario 2 with the exception of a 4% increase in Douglas-fir leading stands and a 2% increase in other softwood yield volumes to account for planting of genetically improved stock. This increase is a generally accepted adjustment level for softwood species.

8.4.4 Silviculture Strategy Base Case (Scenario 4)

Introduces all management assumptions to be used in the silviculture strategy analyses:

- All past silvicultural activities recognized;
- Genetic improvements incorporated;
- All deciduous stands older than 10 years present in the Soo THLB will be converted to softwood after the first rotation, while deciduous stands less than 10 years old convert on the same schedule as existing backlog NSR;
- Managed stands, which are defined as stands up to 40 years of age, and stands between 40 and 100 years, have both value and product information added to their respective yield curves. Stands in both categories are available for commercial thinning when appropriate;
- Spotted Owl management areas receive spacing and commercial thinning treatments.
- Some fertilization occurs as per historical treatment levels.
- No other future incremental silviculture treatments are incorporated.

8.4.5 Optimized Silviculture Strategy Base Case (Scenario 5)

Same as Scenario 4, except the optimization algorithms of the model are applied. A tolerance of 5% around some age-class targets was set to allow flexibility for transition strategies.

8.4.6 Timber Volume Scenarios (Scenario 6)

This is a number of scenarios using different annual investment budgets and incorporating multiple transition options, including commercial thinning. The intent is to determine the increases in timber quantity associated with silviculture investment.

- No timber value or harvest costs incorporated;
- Schedule from scenario 5 provides the starting point from which solutions are improved;
- A planning horizon of 200 years, reporting for 200 years; and
- Investment levels are \$0, \$500,000, \$840,000 and \$1,750,000 per year.

8.4.7 Preferred Scenario (Scenario 7)

Based on the results of all previous scenarios, scenario 7 attempts to combine quality and volume. Map output will be limited to the presentation of all treatments in the first 10-year period based on the 'optimized' silviculture treatment schedule.

9.0 Results and Discussion

9.1 Site Index

Uncertainty surrounding forest management, particularly in managing natural forest ecosystems, is well documented, and must be assessed in any strategic planning exercise. One cause of uncertainty is the accuracy of forest inventory data that is utilized in strategic analysis activities. The accuracy of the site indices in the Soo TSA forest inventory has been questioned.

TSRII utilized site indices from the forest inventory file. Sensitivity analyses were used to test the impact of the Site Index Biogeoclimatic Ecosystem Classification (SIBEC) and Old Growth Site Index (OGSI) values. The results show potential benefits to the Soo TSA harvest levels; however, their effects and actual magnitude are unknown and should be tested through local calibration (BC Ministry of Forests, 1999a).

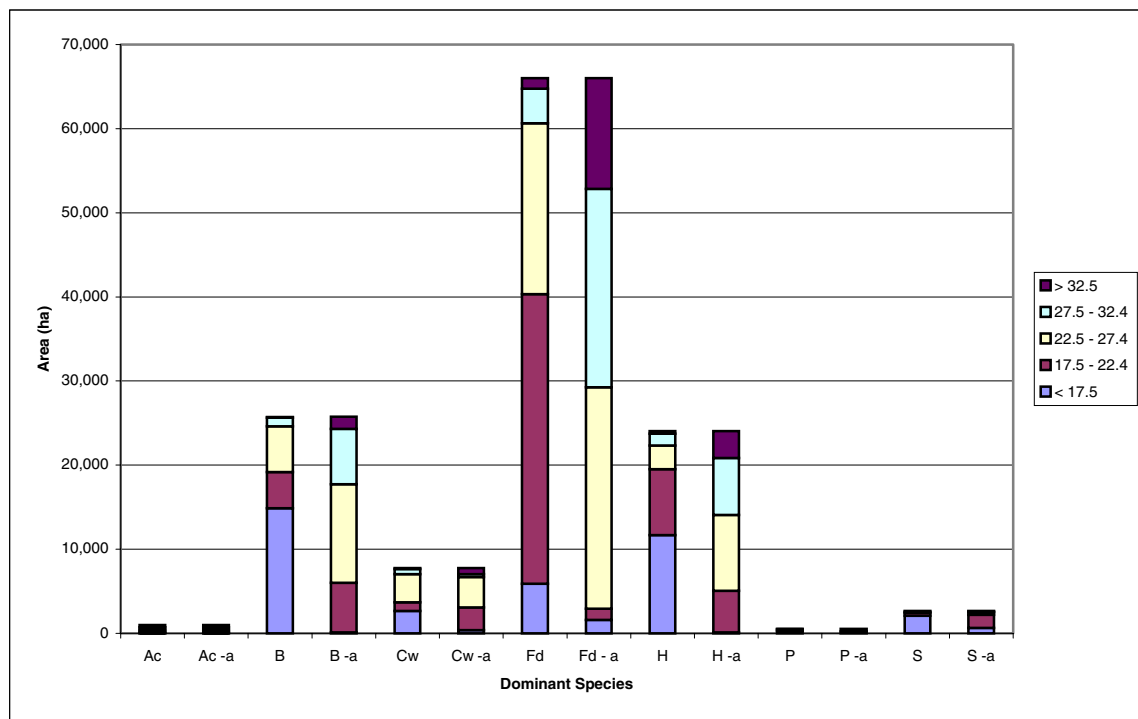


Figure 3 – The Impact of Site Index Adjustments on Site Classes and their Distribution.

For the purposes of this Type 2 analysis, it was suggested by the MoF that the site indices should be adjusted to better represent actual site quality and that the resulting incremental silviculture plan reflect this. The impact of these adjustments is shown in Figure 3. Before adjustments, fir SI greater than 32.5 m covered only 1.9% of all the fir sites. After the adjustments (Fd-a) this SI class accounted for 20% of all the fir sites. The shift in the 27.5-32.4 m SI class was even more significant: from 6.2% to 35.7%.

The adjustments were based on local knowledge, and not through statistically acceptable local sampling. While they may better reflect on the ground site quality, there will be uncertainty around their precision. As such, the results produced should be interpreted with caution, particularly regarding the significant resulting increases in harvest level, as presented below. The increases in site index have considerably altered future forest productivity through 1) an increase in managed stand volumes, 2) an increase in the diameter and piece sizes of stems, and 3) reducing the time for a given stand to reach minimum harvest criteria. A combination of increased volume accumulation and decreased time required to reach a desired condition significantly increases short-, mid- and long-term harvest levels.

9.2 Validation Scenarios

This section outlines the scenarios used to validate the model and progressively test and quantify the applications of various assumptions used in the strategic silviculture analysis scenarios.

Figure 4 shows the analysis results for the first 3 scenarios. The HHL base case (scenario 1) follows the TSR II base case, resulting in a slightly lower long-term harvest level (501,000 m³ vs. 506,000 m³).

Scenario 2 revised the HHL base case by incorporating the OGSI, SIBEC and forest cover site index adjustments, as per page 29 of the Analysis Information Package. As shown in Figure 4, the increases in site index have a dramatic effect on potential harvest levels in the Soo TSA. The initial harvest increased by 19% and the long-term level increased by 80% to 895,700 m³. Harvest level increases result from the fact that young stands are growing much faster, providing for larger second-growth volumes which are merchantable sooner, making older forests eligible for harvest sooner. The harvest will move from existing natural stands to future managed stands sooner, as compared to the HHL base case.

Scenario 3 shows the impact of genetic improvement. As on the revised base case, there is a small gain (1.4%) in the long-term harvest level. The gain is small, partly because the revised base case already incorporated some genetics as per page 23 of the Information Package.

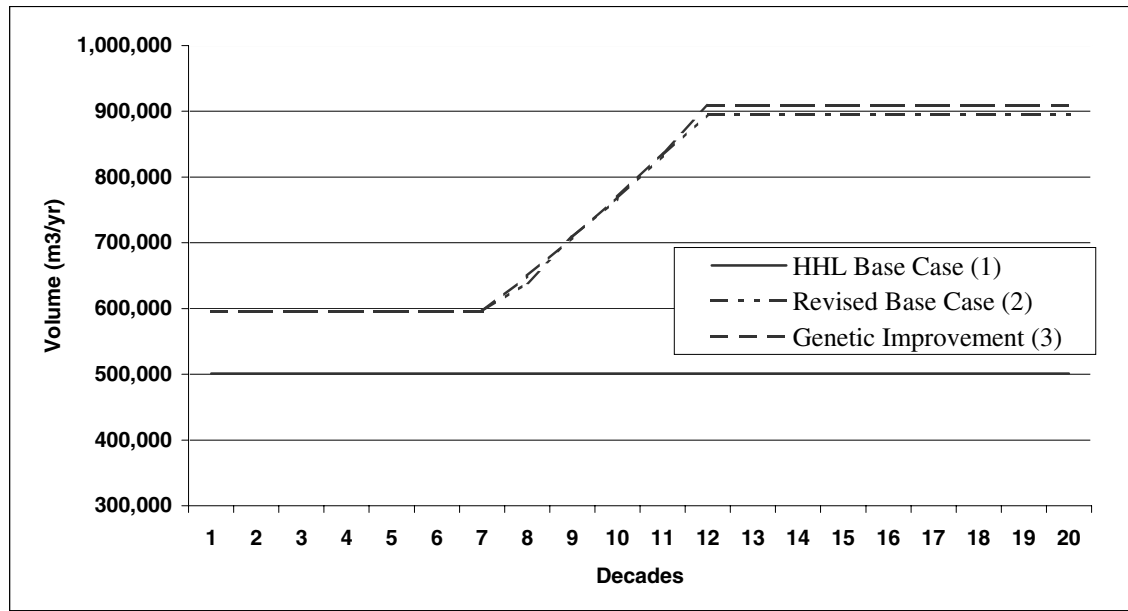


Figure 4 – Harvest Level for Scenarios 1, 2 & 3

9.3 Silviculture Strategy Scenarios

The silviculture strategy scenarios utilized a standardized set of base assumptions, while varying budget levels and model weightings to determine the impact of silviculture investment on timber volumes and quality. The optimization or target-based scenarios that were selected for the majority of these scenarios provide an ability to achieve set objectives, such as volume maximization based on a given budget level and specific costs and values. Simulation results fit within a range of constraints but don't necessarily satisfy targeted objectives (e.g. piece size, values, investment levels, etc.).

In order to test compatibility between simulation and optimization algorithms, as well as provide a baseline for the volume and value options, Scenarios 4 and 5 were completed. Figure 5 illustrates the resulting harvest level for the silviculture strategy (SS) base case (Scenario 4) and the optimized silviculture strategy (SS) base case (Scenario 5) compared to the HHL base case (Scenario 1).

The initial harvest level in both of these scenarios is higher than in previous scenarios because of the impact of using TASS yield curves for all the existing, less than 40 year-old stands instead of VDYP curves. Also, some commercial thinning is incorporated within the spotted owl management areas. The initial harvest for the silviculture strategy base case is approximately 5% higher than the revised base case. The long-term harvest level is very similar for scenarios 2, 3, 4 and 5, around 900,000 m³

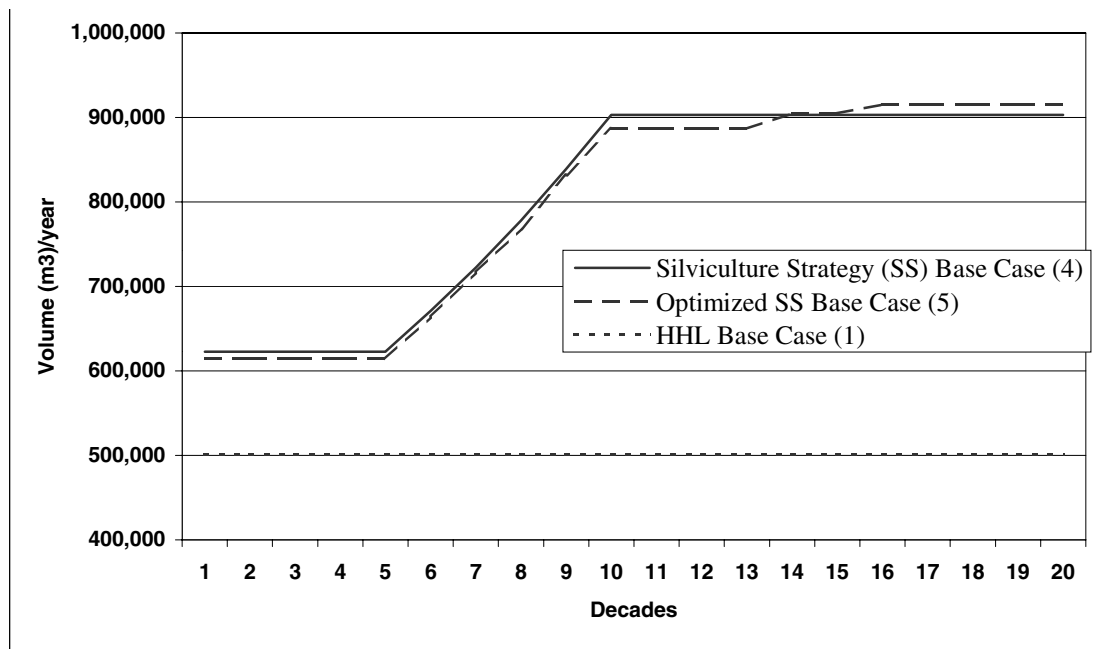


Figure 5 – Harvest Level for Scenarios 4 & 5

For the purposes of comparison, the simulation and optimization results are very similar (Figure 5). The optimization produces slightly lower harvest levels earlier in the planning horizon and somewhat higher harvest levels late in the planning horizon. These small differences are caused by the simulation meeting all its constraints one decade at the time while optimization looks forward to the end of the planning horizon and attempts to optimize the objective function for all the decades within the planning horizon simultaneously. Their overall similarity provides confidence that although the algorithms in these scenarios were different, the results are comparable when the analysis parameters are identical. All further scenarios will be compared to the silviculture strategies base case for assessment of the benefits from incremental silviculture.

All visual quality, old growth, IRM, watershed and SRMZ objectives were satisfied for all optimization scenarios.

9.4 Silviculture Strategy Volume Scenarios

The enhancement of long-term harvest levels was one of the top objectives (coupled with log size) expressed in Workshop 1 by the workshop participants. It is also the top objective identified in the Interim Silviculture Strategy for the Soo TSA (Type 1 Analysis). As such, the main strategy within the Type 2 project was to undertake a series of analyses to test the impact of incremental silviculture on future harvest levels. The silviculture strategy base case scenarios (4&5) and the prior scenarios did not include any future forecasting of incremental silviculture activities (only existing silviculture) or budget. Within the analysis component of the Type 2 project, the intent of using the optimization model is to find the most cost-effective schedule of incremental silviculture treatments that increase the long-term harvest level.

The Soo TSA workshop participants decided that the tested budget levels would be 50%, 100%, 150% and 200% of the existing budget. Existing budget was calculated from historical annual treatments (ha) multiplied by treatment costs supplied by the Squamish Forest District totaling \$1.75 million. It was also decided that an unlimited budget option should be investigated together with the optimized SS base case. Note that the optimized SS base case assumes commercial thinning and spacing treatments in the spotted owl areas. Commercial thinning was used as a surrogate to partial cutting in the analysis. The Optimized SS Base Case also assumes that fertilization re-occurs in historically fertilized areas.

In the course of the analysis, it was found that there was no reason to proceed beyond the budget level of \$1.75 million, as the increased budget provided no apparent benefit to timber supply. The different budget levels tested were:

- *Optimized SS Base Case:* This incorporated variable annual budgets based on future spacing and commercial thinning activities within the spotted owl management areas. It also included further fertilization treatments for those stands that have been fertilized in the past.
- *\$0.5 Million:* On average, the expenditure was \$550,000 as the analysis allowed 10% tolerance around the target budget level of \$0.5 million. During the first decade, the annual expenditures were only \$100,000 more than in the optimized silviculture strategy base case. On average, the annual expenditures were almost \$400,000 more.
- *\$0.87 Million:* On average, the expenditure was around \$950,000. During the first decade, the annual expenditures were approximately \$500,000 more than in the optimized silviculture strategy base case. On average, the annual expenditures were almost \$800,000 more.
- *\$1.75 Million:* On average, the expenditure was around \$1.5 million. The budget level may be less than the tolerance would normally allow in cases where there are no available areas for treatments. This is demonstrated during decade 2 in Table 6. During the first decade, the annual expenditures were approximately \$900,000 more than in the optimized silviculture strategy base case. On average, the annual expenditures were almost \$1,300,000 more.

Table 6 – Annual Expenditures by Decade for Different Volume Scenarios

Decade	Optimized SS Base Case	\$0.5 Million	\$0.87 Million	\$1.75 Million
1	\$454,068	\$549,942	\$956,080	\$1,344,686
2	\$192,681	\$548,640	\$783,397	\$861,394
3	\$194,139	\$549,976	\$956,665	\$1,581,364
4	\$299,185	\$549,966	\$956,845	\$1,389,910
5	\$177,226	\$549,989	\$956,763	\$1,396,615
6	\$29,568	\$549,932	\$900,820	\$1,455,866
7	\$17,327	\$548,770	\$784,203	\$1,179,697
8	\$52,318	\$549,893	\$953,003	\$1,575,944
9	\$108,358	\$549,976	\$956,566	\$1,477,033
10	\$163,880	\$549,553	\$953,972	\$1,471,996
11	\$231,694	\$550,020	\$951,823	\$1,524,178
12	\$159,936	\$549,837	\$956,458	\$1,575,191
13	\$226,940	\$549,833	\$954,044	\$1,575,676
14	\$172,600	\$549,960	\$956,829	\$1,488,266
15	\$162,344	\$548,977	\$951,807	\$1,575,486
16	\$113,474	\$549,450	\$953,662	\$1,579,562
17	\$137,827	\$549,942	\$955,644	\$1,575,996
18	\$91,595	\$549,723	\$955,511	\$1,593,007
19	\$68,584	\$549,780	\$874,850	\$1,571,177
20	\$134,539	\$549,637	\$897,881	\$1,575,162

The following 4 tables show the detailed treatment schedule for the different volume scenarios.

Table 7 - Optimized Silviculture Strategy Base Case; Annual Treatment Areas (ha) by Decade

Decade	CT1	CT1/fert	CT2¹	fert	space	space/fert	fert/ prune2	Prune2	Total
1	0.0	0.0	0.0	472.5	282.6	84.5	5.1	17.7	862.4
2	42.6	1.3	0.0	560.8	65.4	3.8	0.0	0.0	673.7
3	77.9	7.3	0.0	540.4	53.1	7.0	0.0	0.0	685.7
4	107.2	1.9	0.0	535.0	68.8	0.0	0.0	0.0	712.8
5	138.3	23.7	42.6	357.5	76.0	0.0	0.0	0.0	638.1
6	78.3	5.9	76.9	94.2	115.7	0.0	0.0	0.0	370.9
7	147.6	0.0	100.9	10.2	60.2	0.0	0.0	0.0	318.9
8	71.2	1.5	89.4	5.5	55.2	0.0	0.0	0.0	222.9
9	61.0	0.0	59.4	0.0	103.7	0.0	0.0	0.0	224.1
10	132.2	0.0	74.3	0.0	191.2	0.0	0.0	0.0	397.7
11	83.1	0.0	38.2	0.0	205.0	0.0	0.0	0.0	326.4
12	69.8	0.0	66.8	0.0	189.1	0.0	0.0	0.0	325.7
13	121.7	0.0	54.9	0.0	164.8	0.0	0.0	0.0	341.4
14	159.3	0.0	93.3	0.0	72.7	0.0	0.0	0.0	325.4
15	200.1	0.0	51.2	0.0	71.1	0.0	0.0	0.0	322.3
16	194.5	0.0	102.5	0.0	71.5	0.0	0.0	0.0	368.5
17	137.7	0.0	132.6	0.0	102.0	0.0	0.0	0.0	372.3
18	109.4	0.0	215.7	0.0	44.7	0.0	0.0	0.0	369.8
19	88.7	0.0	214.7	0.0	50.5	0.0	0.0	0.0	353.8
20	103.2	0.0	163.0	0.0	81.9	0.0	0.0	0.0	348.1

¹ CT2 is used as a surrogate to partial cutting in this analysis.

Table 8 - \$0.5 Million Budget; Annual Treatment Areas (ha) by Decade

Decade	CT1	CT1/fert	CT2 ¹	fert	Space/ prune1	space	space/fert	Fert/ prune2	Prune2	Grand Total
1	0.4	6.6	0.0	477.7	9.0	371.2	137.9	4.1	2.5	1009.5
2	125.5	42.6	0.0	583.7	2.5	230.0	66.4	3.5	3.0	1057.3
3	185.1	32.0	0.0	646.0	3.1	128.2	116.3	1.8	0.7	1113.1
4	175.6	26.9	0.0	749.6	5.1	145.5	70.7	0.0	0.0	1173.4
5	184.9	59.0	42.6	629.4	11.1	132.5	105.1	2.5	0.6	1167.7
6	211.2	64.3	77.2	442.3	14.7	191.2	146.4	2.0	0.0	1149.2
7	331.2	49.4	101.9	464.2	11.8	174.3	101.4	3.5	5.6	1243.2
8	288.6	55.8	94.1	492.7	11.6	147.3	57.3	1.1	4.5	1152.8
9	189.1	66.4	66.0	423.5	5.7	171.6	37.0	2.2	4.0	965.4
10	233.3	37.6	77.5	420.1	5.1	256.0	58.4	1.7	3.7	1093.3
11	184.7	25.3	39.6	384.9	8.3	290.1	53.1	0.0	0.3	986.3
12	151.6	31.9	101.9	281.4	4.7	287.0	58.4	0.0	4.8	921.7
13	197.9	30.6	70.0	236.5	3.2	281.4	76.9	3.6	0.0	900.0
14	233.0	38.7	99.7	252.6	5.4	214.7	79.3	0.7	0.4	924.6
15	268.4	38.7	57.7	292.4	10.9	208.6	70.0	1.7	0.3	948.7
16	282.6	50.0	139.9	292.0	12.0	210.0	91.9	2.8	0.6	1081.6
17	272.7	38.7	158.6	346.0	11.4	200.4	95.4	3.6	3.8	1130.7
18	250.4	43.4	197.7	378.8	14.2	167.5	70.7	1.8	2.7	1127.3
19	280.1	37.7	202.9	379.0	15.1	207.9	76.1	2.8	4.2	1205.7
20	252.2	35.9	169.9	380.4	21.0	224.2	102.2	3.2	4.1	1193.0

¹ CT2 is used as a surrogate to partial cutting in this analysis.**Table 9 - \$0.87 Million Budget; Annual Treatment Areas (ha) by Decade**

Decade	CT1	CT1/fert	CT2 ¹	fert	Space/ prune1	space	space/fert	fert/ prune2	Prune2	Grand Total
1	0.4	7.4	0.0	494.1	62.0	489.0	335.6	20.9	7.5	1416.9
2	121.8	41.0	0.0	817.1	19.3	274.7	113.6	23.7	21.8	1433.0
3	203.1	55.3	0.0	921.8	5.8	229.6	259.8	15.3	1.1	1691.8
4	183.6	60.6	0.0	1174.0	6.8	213.0	166.4	2.9	0.0	1807.2
5	198.7	102.2	42.6	1140.9	17.9	181.5	205.6	2.1	0.9	1892.3
6	196.9	146.6	77.2	992.9	26.2	187.4	177.5	3.0	0.8	1808.6
7	266.0	92.2	103.3	875.1	21.5	167.3	152.1	5.3	8.7	1691.5
8	274.0	84.1	96.0	904.9	21.7	151.4	97.6	2.6	9.6	1641.9
9	179.0	91.8	65.0	722.3	17.9	191.4	75.5	3.6	5.7	1352.2
10	244.5	68.3	74.1	655.8	18.5	267.6	100.7	6.9	5.4	1441.9
11	174.1	55.3	37.1	568.5	28.4	329.1	121.2	5.3	0.2	1319.3
12	139.9	53.0	120.4	515.3	20.3	373.4	124.8	4.0	9.0	1360.0
13	178.0	67.2	77.3	473.7	15.4	341.2	161.1	11.5	3.9	1329.3
14	235.8	80.9	99.9	532.9	16.5	277.5	160.9	3.7	1.2	1409.5
15	259.7	89.7	55.4	608.3	16.4	241.3	136.5	6.8	3.8	1417.8
16	283.4	104.1	137.6	626.8	15.7	244.6	152.1	3.1	3.0	1570.3
17	266.6	94.2	159.6	669.3	12.0	215.9	135.1	4.3	6.1	1563.0
18	256.5	87.9	182.2	678.7	17.8	134.7	87.5	3.2	2.2	1450.8
19	240.8	81.9	198.7	610.2	16.0	205.6	93.4	2.5	4.1	1453.3
20	260.4	73.7	175.3	549.5	14.9	232.8	100.5	2.2	8.9	1418.2

¹ CT2 is used as a surrogate to partial cutting in this analysis.

Table 10 - \$1.75 Million Budget; Annual Treatment Areas (ha) by Decade

Decade	CT1	CT1/fert	CT2 ¹	fert	Space/ prune1	space	space/fert	Fert/ prune2	Prune2	Grand Total
1	0.9	8.6	0.0	525.8	72.2	676.0	500.6	34.0	18.5	1836.6
2	118.0	45.3	0.0	1023.7	35.7	260.4	148.6	30.0	11.0	1672.8
3	213.9	110.7	0.0	1111.2	12.8	466.2	447.1	28.3	2.8	2392.9
4	200.6	105.5	0.0	1573.9	28.3	274.9	301.6	3.4	1.1	2489.4
5	212.0	146.1	42.6	1676.2	54.8	218.4	310.0	3.8	4.4	2668.4
6	195.3	219.4	77.2	1582.5	65.3	197.3	277.2	15.4	4.7	2634.2
7	251.6	143.9	104.5	1419.5	51.4	208.3	195.9	17.0	17.7	2409.8
8	263.6	129.8	96.0	1467.4	49.2	189.5	137.3	18.5	12.0	2363.5
9	179.5	151.3	66.9	1121.9	57.7	298.7	144.5	11.3	9.5	2041.4
10	220.3	99.1	73.4	1031.3	65.2	328.1	197.4	17.1	11.2	2043.2
11	198.7	88.5	33.1	938.6	68.4	421.4	236.6	20.3	9.1	2014.6
12	139.9	83.8	119.8	909.5	44.4	483.4	289.7	21.9	14.0	2106.3
13	192.1	107.3	71.9	985.7	34.8	486.9	293.1	24.1	8.4	2204.3
14	252.8	118.0	105.4	1137.6	42.4	366.1	288.2	9.7	2.1	2322.4
15	325.9	170.5	82.7	1225.2	52.3	268.8	257.5	17.9	5.0	2405.7
16	313.7	177.7	129.7	1274.8	51.6	273.5	270.7	9.6	9.9	2511.3
17	271.6	146.9	142.7	1333.2	33.3	251.3	258.0	19.3	13.4	2469.8
18	303.5	119.4	167.5	1320.1	39.2	174.4	143.2	11.4	7.5	2286.3
19	259.8	170.5	192.9	1112.6	36.4	264.6	184.8	7.0	7.4	2236.0
20	259.0	147.8	178.7	1030.6	27.4	329.2	157.9	8.6	16.2	2155.5

¹ CT2 is used as a surrogate to partial cutting in this analysis.

Note that fertilization occurs only if the stand has already been spaced. All stands that receive the space/fertilize treatment will be further fertilized every ten years until age 70 unless they are harvested sooner. Fertilization was assumed to increase the site index of fir by 3 meters and the site index of balsam by one meter.

The optimization model attempts to maximize the average harvest level over the planning horizon. The average harvest levels and the corresponding average budget levels for the different volume scenarios were as follows:

Table 11 – Average Harvest and Budget Levels for Different Volume Scenarios

Volume Scenario	Average Annual Budget	Average Annual Harvest
<i>Optimized SS Base Case:</i>	\$159,414	799,323 m ³ /year
<i>\$0.5 Million:</i>	\$549,690	833,310 m ³ /year
<i>\$0.87 Million:</i>	\$928,341	844,385 m ³ /year
<i>\$1.75 Million:</i>	\$1,468,410	847,962 m ³ /year

Figure 6 shows the average harvest level in relation to average annual budgets. It appears that investment in incremental silviculture produces diminishing returns in terms of resulting harvest levels. There are significant average harvest level increases up to \$0.5 million annual budget with smaller benefits to \$0.87 million. Beyond \$1.75 million there is very little benefit in harvest level.

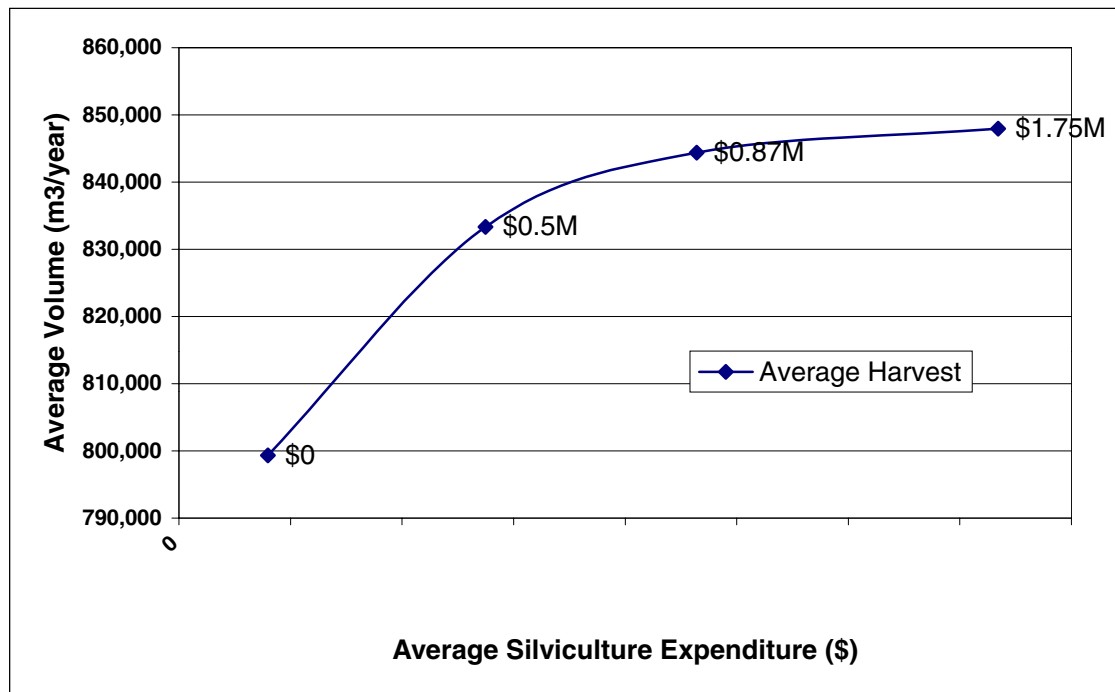


Figure 6 – Average Harvest over the Planning Horizon in Relation to Average Annual Expenditure

The highest investment level did not produce the greatest long-term harvest level. While the \$1.75 million investment had consistently highest harvest levels until decade 11, the \$0.87 million scenario had a slightly higher long-term harvest level, 974,000m³ per year vs. 966,000m³ per year from decade 12 until the end of the planning horizon. This is likely due to the fact that the \$1.75 million scenario was able to produce higher mid-term harvest levels through aggressive spacing and commercial thinning, which somewhat compromised the long-term harvest level.

Figure 7 depicts the resulting harvest levels of the different incremental silviculture budgets. The differences in harvest levels are not large. However, it is evident that increasing the annual investment from the SS base case increases the long-term harvest level (LTHL). The LTHL of the SS base case is 915,000 m³ per year versus a LTHL ranging from 957,000m³ to 974,000m³ per year for the 3 different investment levels. The silviculture investment model developed for the Soo TSA was used to identify the most cost-effective treatments associated with increased harvest levels across the planning horizon.

In the short-term (5 decades), the different investment scenarios produced slightly higher harvest volumes than the SS base case (615,000 m³). The \$0.5 million scenario had a short-term harvest level of 624,000 m³. The short-term harvest level was 630,000 m³ for the two higher investment level scenarios. These slightly higher short-term harvest levels compared to the SS base case result from managed stands reaching minimum harvest criteria earlier due to fertilization and other silviculture treatments. This shortens the transition from existing to managed stands and increases the harvest levels in the short-term.

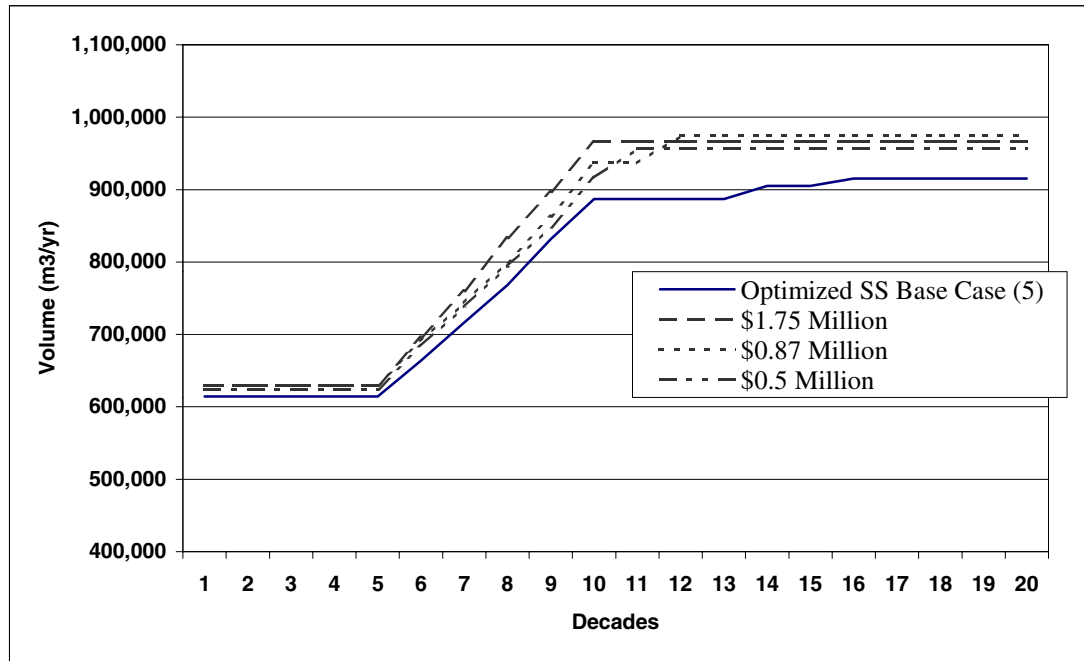


Figure 7– Volume Scenario Harvest Levels

Figure 8 illustrates the predicted average harvest volume per hectare for the 4 different volume scenarios. Maximizing the average harvest level over the planning horizon does not necessarily lead to higher per hectare volumes, as the stands may grow faster and produce a large piece size; they are also harvested younger to maintain high volume flow.

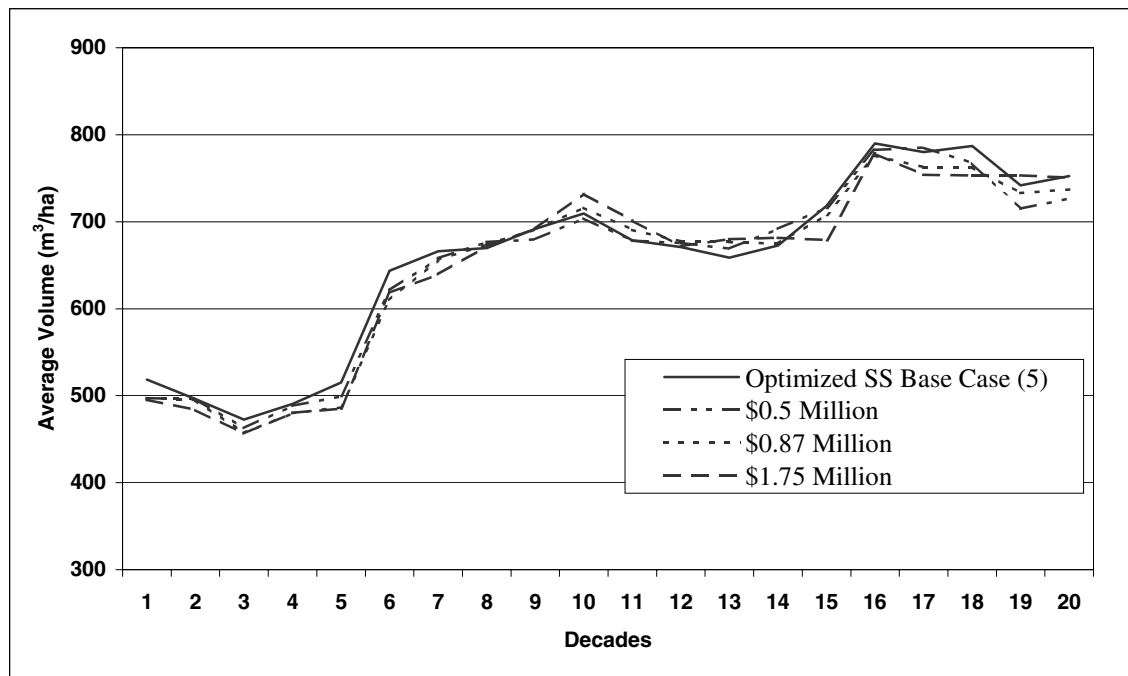


Figure 8– Predicted Average Harvest Volume per Hectare – Volume Scenarios

Figure 9 illustrates the impact of incremental silviculture on the predicted piece size of future managed stands. The higher budget levels result in greater piece size due to the effect of spacing, fertilization and commercial thinning. As shown in figure 19, the managed stands start contributing significantly to total harvest between the 3rd and the 4th decade. This corresponds to the initiation of increased piece size due to incremental silviculture.

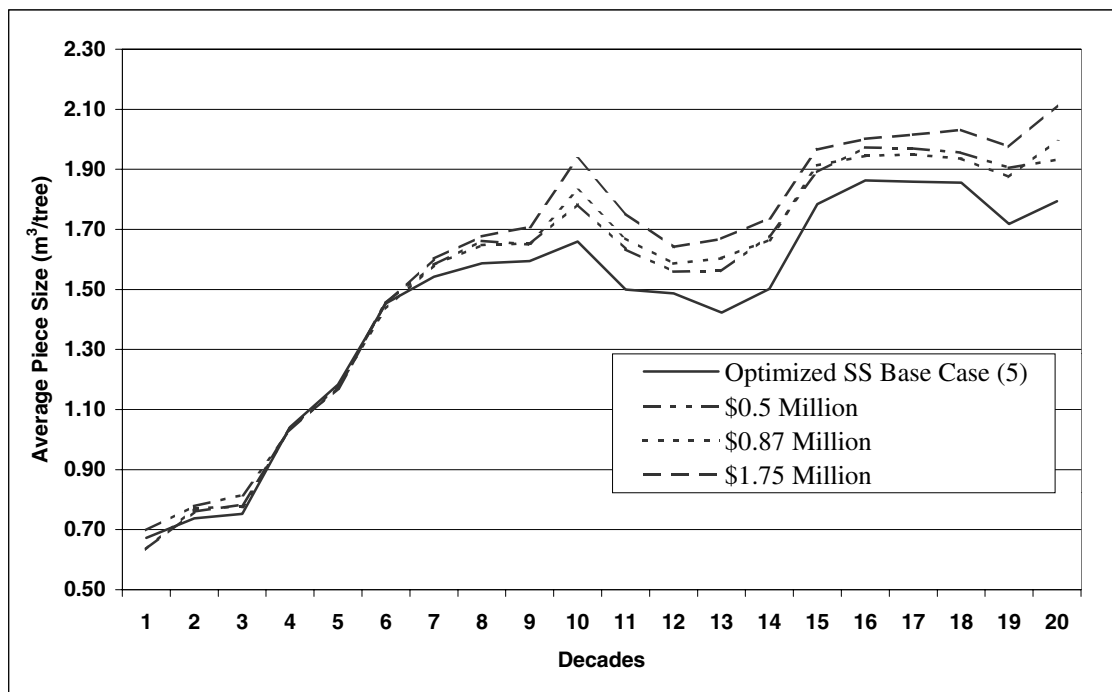


Figure 9 – Predicted Average Piece Size of Future Managed Stands – Volume Scenarios

9.5 Silviculture Strategy Preferred Option

9.5.1 General

Forest management is a complex undertaking. The attempt to manage for a variety of objectives within a given geographic area over several hundred years is a daunting task. Scenario planning approach provides an assessment of the suitability of the many management objectives. It attempts to help in understanding the relationship between objectives within different scenario analyses. Finally, the attempt to balance all objectives or find a compromise is a common goal of forest management and tends to dictate many planning processes. The development of a preferred scenario incorporates understanding and results from the previous scenarios in a sequential process to present a solution that does not just satisfy a single emphasis. This process was followed to produce the Soo TSA preferred option. It must be recognized that this option represents an attempt to balance the benefits identified in the previous scenarios and is not necessarily a judgment of choice or like, which remains a task for the managers of the TSA and the stakeholders within it.

As presented in the volume strategy scenarios (Section 9.4), the assessment of different budget levels indicated that the most attractive investment level for maximizing volume flows is somewhere around \$0.8 million. A subjective decision was made that the preferred option should attempt to maintain the harvest level from the previous scenarios, particularly from the \$0.87 million scenario, while providing greater piece sizes as per the quality objectives identified in Workshop 1 and the Interim Silviculture Strategy.

Therefore, a strategy was developed that would produce more value while maintaining the high volume flow levels. This was done by:

- Choosing budget level of \$1 Million with a 10 % tolerance for variance in budget level;
- Setting the harvest flow at the same level as in the \$0.87 Million volume scenario with a 2 % tolerance for variance in the flow level;
- Including a net present value weighting in the optimization function.

It was assumed that including the net present value in the optimization function would schedule more treatments focusing on value, thus increasing the average piece size and overall quality of the future timber flow.

9.5.2 Proposed Incremental Silviculture Strategy

Table 12 summarizes incremental annual silviculture treatments by 10-year periods. Over the first 20 years, almost 13,000 ha of spacing and over 20,000 ha of fertilization are scheduled. Through the mid-term, there is a significant increase in fertilization treatments from decade 3 until decade 8 in which the existing younger managed stands (40-year-old) will be fertilized regularly until harvest. It is likely that some of the current backlog areas will be treated, further increasing the area fertilized during the mid-term. Fertilization results in an increase in future stand yields and are a significant contributor to the increase in long-term harvest. The cost of fertilization treatments in the Soo TSA range from \$150-300/ha and as the most inexpensive option provides a cost-efficient treatment to increase future manage stand yields. The significance of the fertilized area being scheduled for treatment represents a direction for the Soo TSA to consider implementing and maintaining a substantial fertilization program relative to the area treated by other incremental activities.

Table 12 – Preferred Scenario; Annual Treatment Areas (ha) by Decade

Decade	CT1	CT1/fert	CT2 ¹	Fert	Space/prune1	Fert/prune2	Prune2	Space/fert	Space	Grand Total
1	0.9	7.4	0.0	528.2	12.7	9.2	6.3	411.7	416.8	1393.3
2	116.0	37.6	0.0	923.2	11.8	6.5	6.1	144.7	269.5	1515.4
3	227.2	84.3	0.0	1001.7	0.8	6.7	5.1	269.7	286.2	1881.7
4	221.4	88.4	0.0	1253.9	3.2	0.4	0.4	187.8	222.4	1978.0
5	219.7	119.5	42.6	1235.6	7.9	0.8	2.5	227.4	187.0	2042.8
6	227.6	129.8	77.2	1130.5	18.5	6.0	1.9	202.5	194.4	1988.5
7	330.1	99.9	107.3	949.8	12.8	7.4	11.2	160.4	170.1	1849.0
8	327.9	85.9	95.4	982.9	8.8	6.7	6.2	86.9	169.8	1770.4
9	250.9	106.1	57.1	779.3	9.6	3.2	5.6	112.1	240.7	1564.7
10	286.0	75.6	76.2	737.0	7.5	7.4	2.2	127.9	319.9	1639.7
11	189.1	44.1	44.0	674.4	14.9	6.2	1.3	135.9	379.1	1489.0
12	151.1	78.0	115.8	573.5	11.5	5.1	9.8	164.0	378.5	1487.4
13	194.4	58.8	89.9	594.4	9.3	6.1	5.4	180.4	403.2	1541.9
14	263.6	83.6	99.0	662.6	8.3	1.7	7.6	181.4	295.9	1603.7
15	290.0	111.5	69.9	703.8	7.5	5.3	3.0	131.5	297.2	1619.7
16	302.5	103.5	150.7	708.6	12.4	4.4	3.1	174.3	266.0	1725.5
17	305.5	106.0	154.3	746.5	16.7	6.8	5.6	126.2	253.5	1721.0
18	265.2	85.2	202.5	728.6	5.1	9.4	7.3	101.2	168.1	1572.5
19	327.8	90.0	196.9	651.3	20.2	2.9	2.1	102.8	249.6	1643.6
20	273.3	88.3	158.8	576.2	16.0	8.0	12.2	119.2	275.7	1527.7

¹ CT2 is used as a surrogate to partial cutting in this analysis.

Table 12 presents the short through long-term treatment summaries for the preferred scenario. Tactical results from this scenario are presented in map form in the Appendix to represent the spatial location of the first two decades of treatments. This spatial schedule of silviculture treatments presents the first steps that could be taken to reach the mid- and long-term conditions presented in the graph and tabular reports. These results are based on computer modeling over long time frames and as such are subject to uncertainty. The map schedules are meant to act as direction and as such the MoF staff should determine solution quality and actual scheduling.

While area treated is dominated by fertilization only a minimal amount of pruning is proposed in the preferred scenario but does continue throughout the entire planning horizon. It must be recognized that pruning is one of the most costly of all incremental silviculture treatments ranging from \$1200–2400/ha and is only eligible in high site Fir stands.

Juvenile spacing also comprises a significant portion of the area treated and through the first ten years averages approximately 420 ha/year. In addition to an increase in future managed volume, spacing will permit earlier growth of larger tree diameters (Figures 16 and 17).

More treatments are proposed in the preferred scenario compared to the \$0.87 million scenario (Table 9, page 36) with increases in both area fertilized and spaced. The differences between the two scenarios are more evident in Figures 10 and 11, which summarize all incremental treatments for the two scenarios. It must be noted that the sum of treatments in Figures 10 and 11 are different from those in Tables 9 and 12. Figures 10 and 11 aggregate all treatments separately even if they occur in the same polygon, i.e., 100 hectares of space/fertilize counts for 100 hectares of spacing and 100 hectares of fertilization.

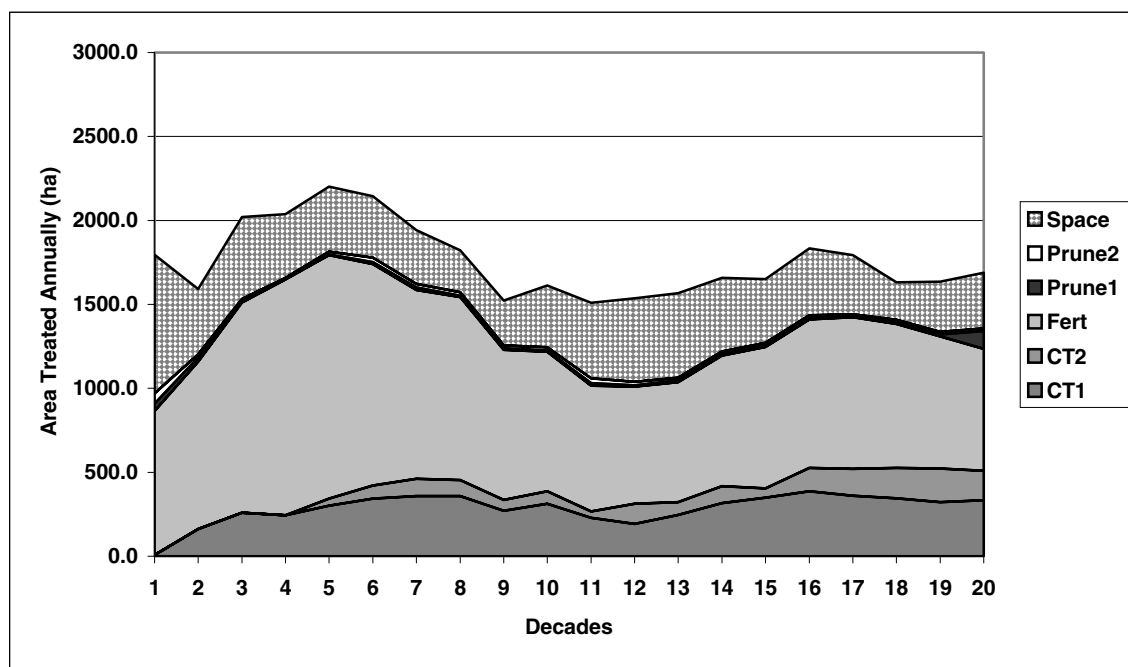


Figure 10 – Area Treated Annually - \$0.87 Million Budget, Volume Maximization

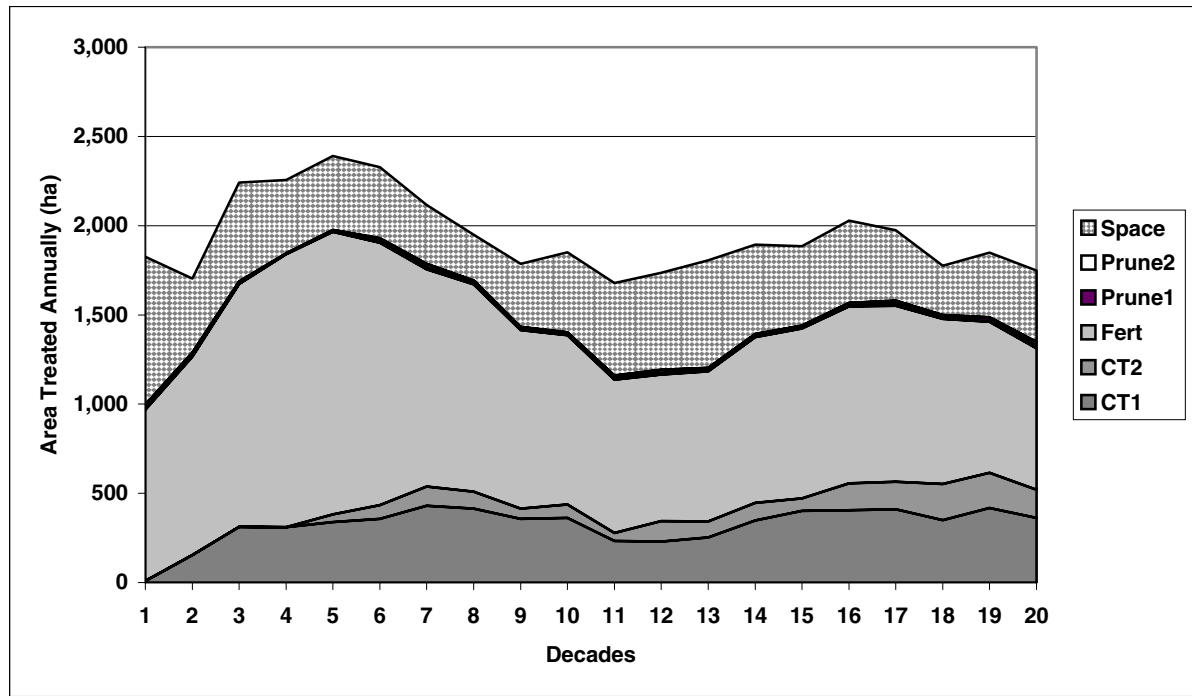


Figure 11 – Area Treated Annually – Preferred Scenario

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

- **Commercial Thinning:** Only 9 hectares are proposed for the whole decade. This is likely due to a lack of eligible stands available for commercial thinning as the amount of commercial thinning increases significantly throughout the planning horizon.
- **Commercial thinning with fertilization:** Only 74 hectares are proposed for the first decade. Only Fir stands were eligible for this treatment. Approximately 88% of this treatment is proposed for the high site Fir stands (SI=33).
- **Space/Fertilize:** A total of 4,117 hectares are proposed for the next ten years. The treatment area is allocated for medium site (SI=25) Balsam (33%), poor site (SI=23) Fir (32%), medium site (SI=29) Fir (12%) and high site Fir (24%). It should be recognized that due to the SI adjustments, the poor site classifications represent better site conditions.
- **Fertilization:** This treatment usually follows spacing or spacing/pruning treatments with 5,282 hectares being proposed over the first decade of the planning horizon. The proposed treatment area is almost equally divided between the three Fir site types, (each receiving 30%) with the remaining 10% allocated to medium site Balsam stands.

The results indicate that high site fir stands were fertilized often. This result should be viewed with caution, as it may be partly due to the stand level modelling (TASS) of the fertilization effect. TASS applied a 3-meter site index increase to all fir stands regardless of the site. This may have exaggerated the impact of fertilization on productive fir sites and thus made it an attractive treatment choice in the estate model

- ***Space/Prune, 1st lift:*** Only high site Fir stands are eligible for this treatment regime, which combines spacing and pruning. A total of 127 hectares are proposed during the first decade of the planning horizon.
- ***Spacing:*** A total of 4,168 hectares of spacing treatments are proposed for the first decade. High site Fir, poor site Fir and high site Balsam all have approximately 25% share of proposed spacing. Only 11.7% of spacing was in Hemlock stands (8.2% high site, 3.6% poor site)
- ***Prune 2nd lift:*** Only the high site Fir stands that had already received a first pruning lift (in the past according to the history records or subsequently scheduled) were eligible for a 2nd lift treatment. A total of 63 hectares were proposed over the next ten years.
- ***Fertilize/Prune 2nd lift:*** Only 92 hectares are proposed for the first decade. As this is an expensive treatment it is only eligible in high site Fir.

Figure 12 illustrates the allocation of the annual expenditures to treatments for the first decade. Treatment expenditures are divided between fertilization, pruning and spacing. Juvenile spacing and spacing with fertilization are the most dominant treatments (by expenditure) in the first decade treating those stands that are developing from the stand initiation phase through to the stem exclusion phase thereby enhancing the survival, growth and value of the residual stand. Commercial thinning treatment expenditures are presented net of commercial thinning revenues and include the commercial thinning with fertilization treatment regime. The majority of expenditures (85.6%) are for spacing (38.1%) and spacing with fertilization (47.5%) treatments during the first decade.

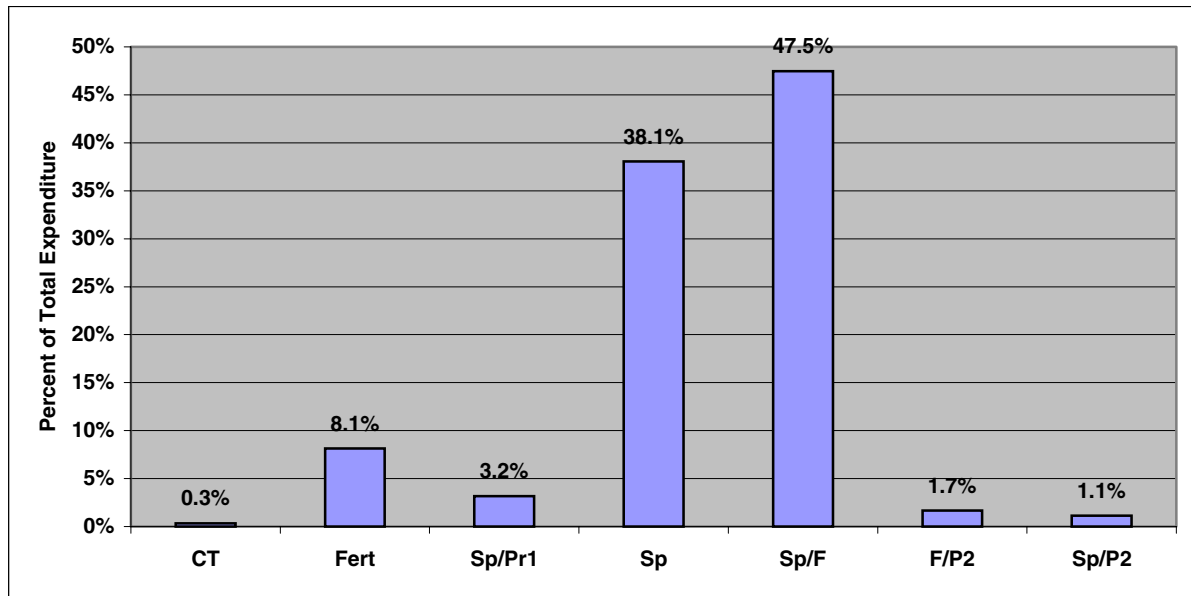


Figure 12 – Percent of Total Incremental Silviculture Expenditures by Treatment, First Decade

Table 13 shows the proposed annual spacing, fertilization and pruning treatments for the first decade in more detail. Different combinations of spacing amount to 841 ha for the first decade. 63.9% (538 ha) of spacing consists of treatments where no commercial thinning is anticipated in the future. The remaining 36.1% (303 ha) of spacing treatments set the stands up for future commercial thinning.

Table 13 – Proposed spacing and fertilization treatment areas (ha) in detail, first decade.

Treatment	Ba		Cw		Fd			Hw		S		Grand Total
	SI 25	SI 30	SI 22	SI 28	SI 23	SI 29	SI 33	SI 25	SI 30	SI 22	SI 28	
Space to 500 sph					5.8							5.8
Space to 600 sph						3.6	14.8					18.4
Space to 700sph										18.7		18.7
Space to 800 sph			21.1					3.4	27.1			51.6
Space to 900 sph	50.8			9.1								60.0
Space to 1000 sph		95.5										95.5
Space to 500 sph and 1st prune							6.1					6.1
Space to 500 sph and 1st prune (fert. to come)							6.5					6.5
2 nd prune							6.3					6.3
Space to 500 sph and fertilize					59.1							59.1
Space to 600 sph and fertilize						31.3	50.7					82.0
Space to 900 sph and fertilize	134.0											134.0
Space to 650 sph and fertilize (1 CT to come)					30.2							30.2
Space to 750 sph and fertilize (1 CT to come)						11.1						11.1
Space to 800 sph and fertilize (1 CT to come)							46.2					46.2
Space to 1200 sph and fertilize (2 CTs to come)					42.5	6.5						49.1
2 nd prune and fertilize							9.2					9.2
Fertilize	49.6				158.5	126.6	193.5					528.2
Space to 650 sph (1 CT to come)					5.1							5.1
Space to 750 sph (1 CT to come)						5.7						5.7
Space to 800 sph (1 CT to come)							8.0	0.4				8.5
Space to 1000 sph (1 CT to come)				9.5				11.1	7.0			27.6
Space to 1200 sph (2 CTs to come)					21.8	16.2	81.9					119.9
Total	234.4	95.5	21.1	18.6	323.0	200.9	423.3	14.9	34.0	18.7	0.0	1384.5

Table 14 illustrates the annual projected expenditures by decade for the preferred option, as compared to the \$0.87 Million scenario. The expenditures are moderately higher for the preferred scenario as more money is spent on treatments to increase stem quality and subsequently increase value. Commercial thinning expenditures are included as the difference between commercial thinning revenues and costs. Due to the assumed treatment costs and product prices, commercial thinning revenues do not satisfy the costs and in fact, throughout the planning horizon, the annual commercial thinning revenues are, on average, \$400,000 less than commercial thinning costs.

Table 14 – Annual Expenditures by Decade – Preferred Scenario

Decade	\$0.87 Million	Preferred Option
1	\$956,080	\$1,264,267
2	\$783,397	\$885,692
3	\$956,665	\$1,179,298
4	\$956,845	\$1,131,394
5	\$956,763	\$1,119,493
6	\$900,820	\$965,593
7	\$784,203	\$874,642
8	\$953,003	\$1,012,478
9	\$956,566	\$1,085,715
10	\$953,972	\$1,054,196
11	\$951,823	\$1,008,120
12	\$956,458	\$1,071,279
13	\$954,044	\$1,055,583
14	\$956,829	\$1,052,911
15	\$951,807	\$1,067,172
16	\$953,662	\$1,050,567
17	\$955,644	\$1,036,661
18	\$955,511	\$956,657
19	\$874,850	\$1,028,085
20	\$897,881	\$1,016,908

The associated costs of commercial thinning are dependent on future markets; operational efficiency, and actual treatment costs and revenues may well be different from those included in this analysis. If in the future, additional harvest volume (and associated income and revenue) is required from commercial thinning stands in intermediate development stages a determination of feasibility should be further assessed.

Table 15 provides an analysis regarding the profitability of commercial thinning in this analysis. The commercial thinning costs were compared to commercial thinning revenues, stand by stand, to determine where in the TSA commercial thinning would at least break even. The analysis was conducted for the entire planning horizon and did not use net present value, rather, all comparisons were made using today's dollars. The table shows that according to the analysis, commercial thinning can be profitable throughout the TSA.

Table 15 – CT Treatment areas (ha) by Species/Site and LU where CT was Profitable in the Analysis

LU	Cedar H	Cedar L	Cedar/Spruce	Fir 23	Fir 29	Fir 33	Fir Nat	Hem bal Nat	Grand Total
Billygoat	178.79		9.75	408.81	451.10	494.78	33.32		1576.56
Birkenhead	64.53		10.02	426.55	585.13	417.77	45.10		1549.10
Callaghan	36.22			8.26	28.17		10.67		83.32
E. Howe Sound	63.58	2.09	17.73		76.36	22.41	38.70		220.87
Gates	53.07			130.45	458.66	158.35	37.29		837.82
Indian	149.84				61.19		3.82		214.86
L. Squamish	91.11		30.83	77.28	302.86	319.95	383.73	2.58	1208.35
Lizzie	292.10			301.45	350.44	786.80	35.28		1766.07
Mamquam	211.41	3.63	84.51		148.92	237.03	401.24		1086.72
Meager	160.92		1.93						162.85
Railroad	73.66								73.66
Rogers	87.53			86.40	207.31	300.73	308.92		990.89
Ryan	49.99		1.63	28.20	9.93	45.33			135.08
Sloquet	201.92		48.57	50.38	1284.84	120.83	146.66		1853.20
Soo	144.98			246.68	453.57	168.38	171.50		1185.11
Tuwasus	154.36			734.74	2043.09	364.12	19.06		3315.36
U. Lillooet	11.89								11.89
Whistler	117.29			262.49	132.80	273.06	34.87		820.51
Grand Total	2143.20	5.71	204.96	2761.70	6594.36	3709.54	1670.17	2.58	17092.23

Figure 13 further illustrates the treated areas (ha) by species/site that were profitable for commercial thinning in this analysis. Fir sites dominate; however, this is expected as over 50% of the land base consists of fir stands.

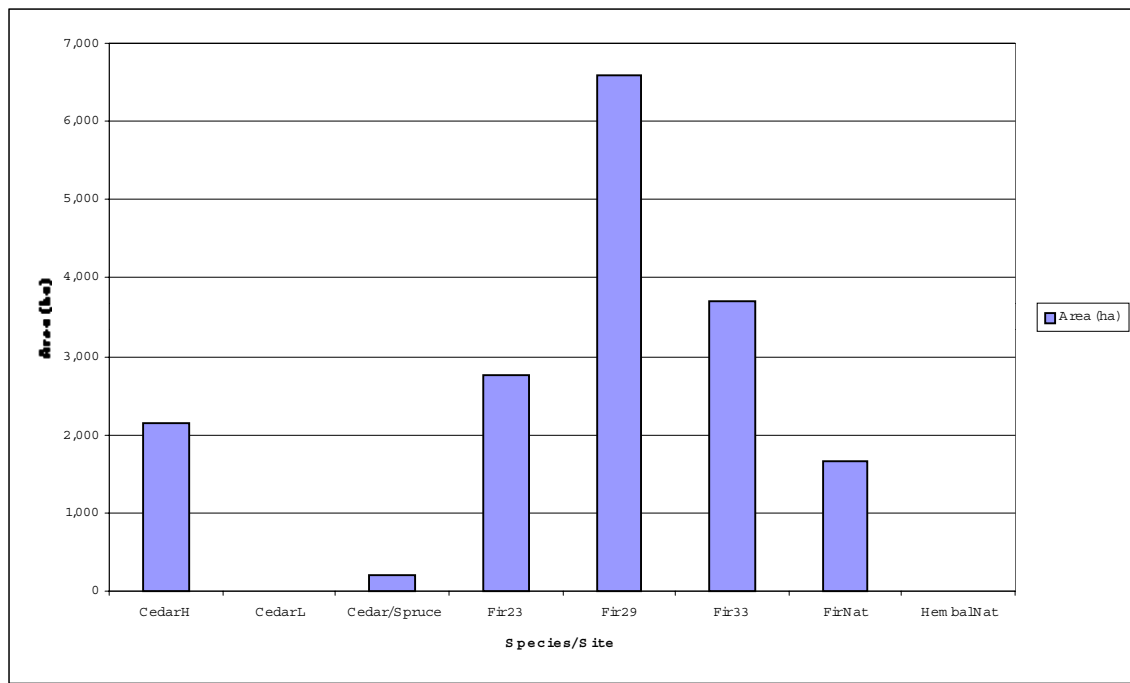
**Figure 13 – Treatment Areas (ha) by Species/Site where CT was Profitable in the Analysis**

Table 16 shows the proposed budget levels less commercial thinning costs and revenues.

Table 16 – Annual Expenditure by Decade – Preferred Scenario Net of Commercial Thinning

Decade	CT Included	Net of CT
1	\$1,264,267	\$1,259,877
2	\$885,692	\$742,408
3	\$1,179,298	\$779,028
4	\$1,131,394	\$608,553
5	\$1,119,493	\$632,907
6	\$965,593	\$629,436
7	\$874,642	\$567,045
8	\$1,012,478	\$491,153
9	\$1,085,715	\$549,477
10	\$1,054,196	\$599,525
11	\$1,008,120	\$711,666
12	\$1,071,279	\$740,534
13	\$1,055,583	\$742,121
14	\$1,052,911	\$632,386
15	\$1,067,172	\$577,759
16	\$1,050,567	\$617,384
17	\$1,036,661	\$609,451
18	\$956,657	\$447,021
19	\$1,028,085	\$545,680
20	\$1,016,908	\$610,610

It must be recognized that beyond the short-term, the investment levels tested became less rational and are presented only to comprehend long-term averages in terms of investment and volume flow implications. Table 17 shows the average annual budget and harvest over the planning horizon for the preferred scenario. The average budget is approximately \$110,000 greater for the preferred scenario while the average harvest is around 3,000 m³ per year less than that of the \$0.87 Million investment scenario. Some of the volume has been compromised (producing less volume) by the treatments that increase piece size and value. The same can be seen from Figure 14 whereby the long-term harvest level of the preferred scenario is slightly less than that of the \$0.87 Million investment scenario.

Table 17 – Average Harvest and Budget Levels – Preferred Scenario

Scenario	Average Annual Budget	Average Annual Harvest
<i>Preferred:</i>	\$1,045,836	841,100 m ³ /year
<i>\$0.87 Million:</i>	\$928,341	844,385 m ³ /year

Figure 14 compares the short, mid and long-term harvest level for the optimized SS base case, the 0.87 million budget and the preferred scenarios. While there are minor differences between the resulting harvest levels the preferred scenario represents a balanced solution between volume and value. The scenarios presented in Figure 14 illustrates significant increases in harvest level across the entire planning horizon as a

result of the site index adjustment as compared to the current harvest rate in the Soo TSA of 503,000 m³.

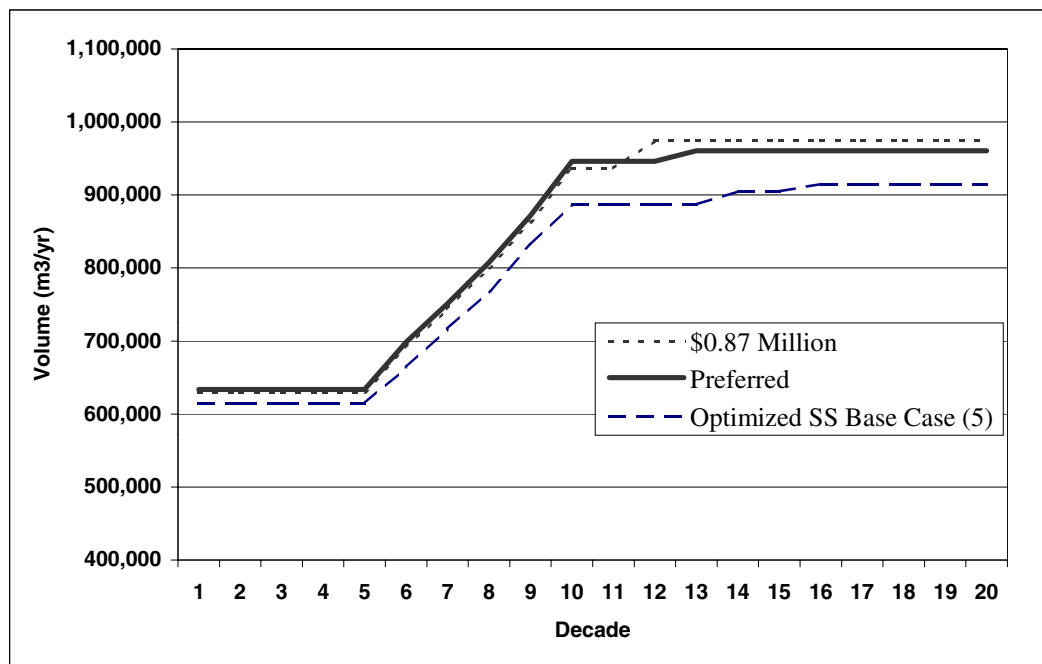


Figure 14 – Preferred Scenario Harvest Level

Figure 15 illustrates the predicted piece size (volume per tree) of the preferred scenario compared to the SS base case and the \$0.87 million investment scenario. As can be seen from the graph, the proposed strategy produces a higher average piece size than the other two scenarios and satisfies the goal to increase stem value while maintaining the volume flows. The increased piece size demonstrates that incremental silviculture can modify future stem sizes. The responses in piece size are realized between period 6 and 7 when the results of incremental silviculture are achieved and the future managed stands comprise the majority of the harvest volume.

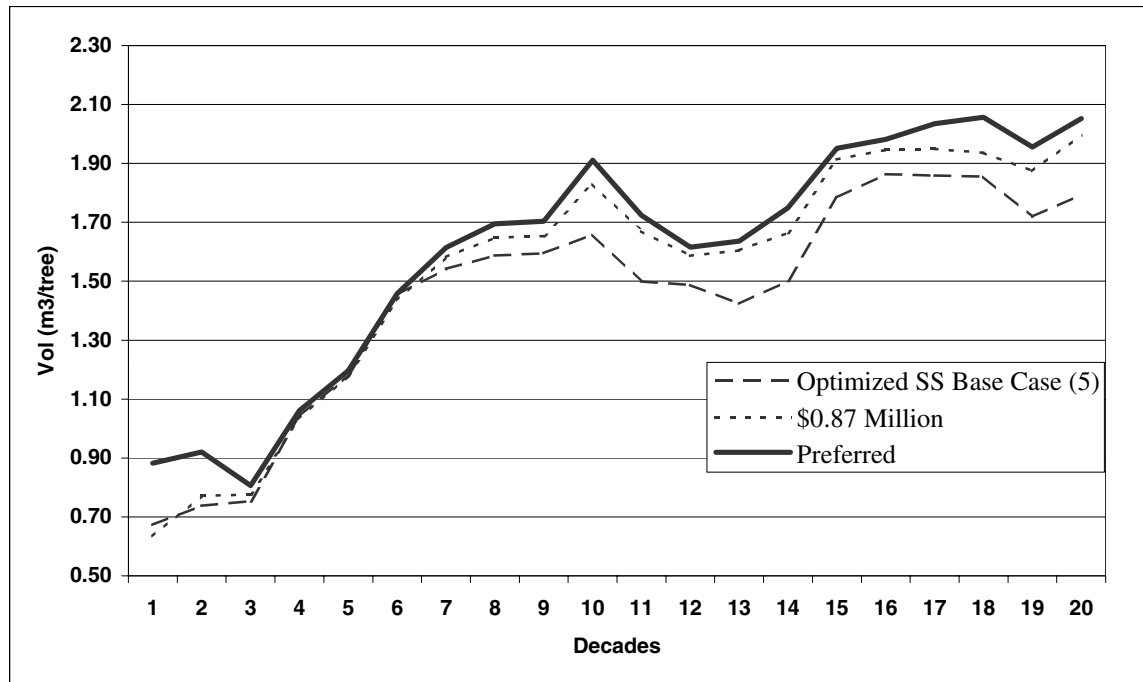


Figure 15 – Predicted Average Piece Size of Future Managed Stands – Preferred Scenario

Figures 16 and 17 show the projected volume (in percent of total managed stand harvest volume) in three diameter classes: less than 40 cm, 40 to 49 cm and greater than or equal to 50 cm. These classes follow the workshop definitions for a premium log (>50 cm) and saw log (>40 cm). After 80 years, it is projected that approximately 50% of the Douglas fir harvest volume comes from diameter classes greater than 50 cm, and about 35% of volume of other species comes from diameter classes greater than 50 cm.

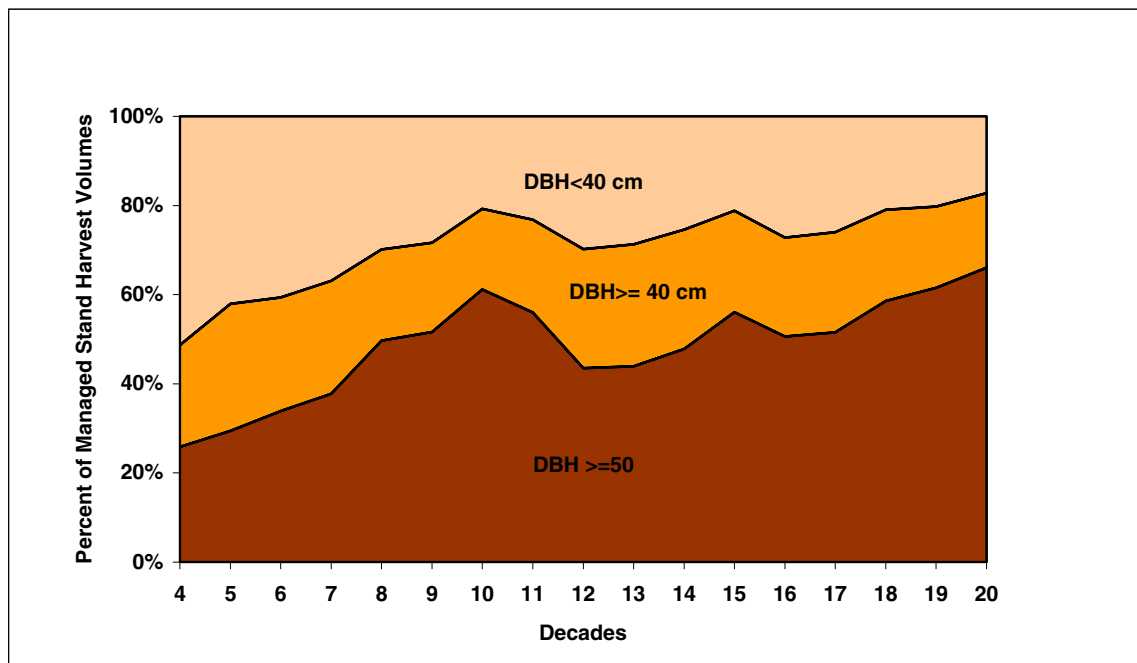


Figure 16 - Percent of Managed Stand Harvest Volume in Three Diameter Classes, Fd

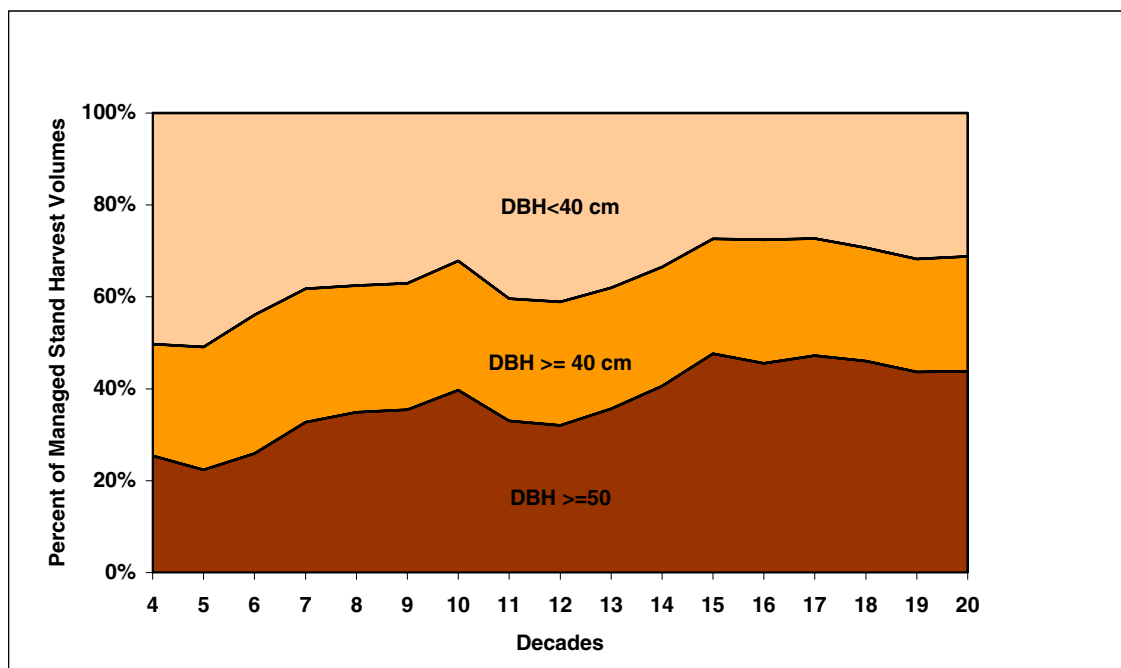


Figure 17 - Percent of Managed Stand Harvest Volume in Three Diameter Classes, Other Species

Figure 18 illustrates the projected grade distribution of the managed stand harvest for the preferred scenario starting at decade 4. The fourth decade was chosen as the starting point for Figures 16, 17 and 18, as the harvest from managed stands constitutes approximately 10% of the total harvest at decade 4 and increases from there on (Figure 19). By decade 6, 80% of the harvest is satisfied by managed stands.

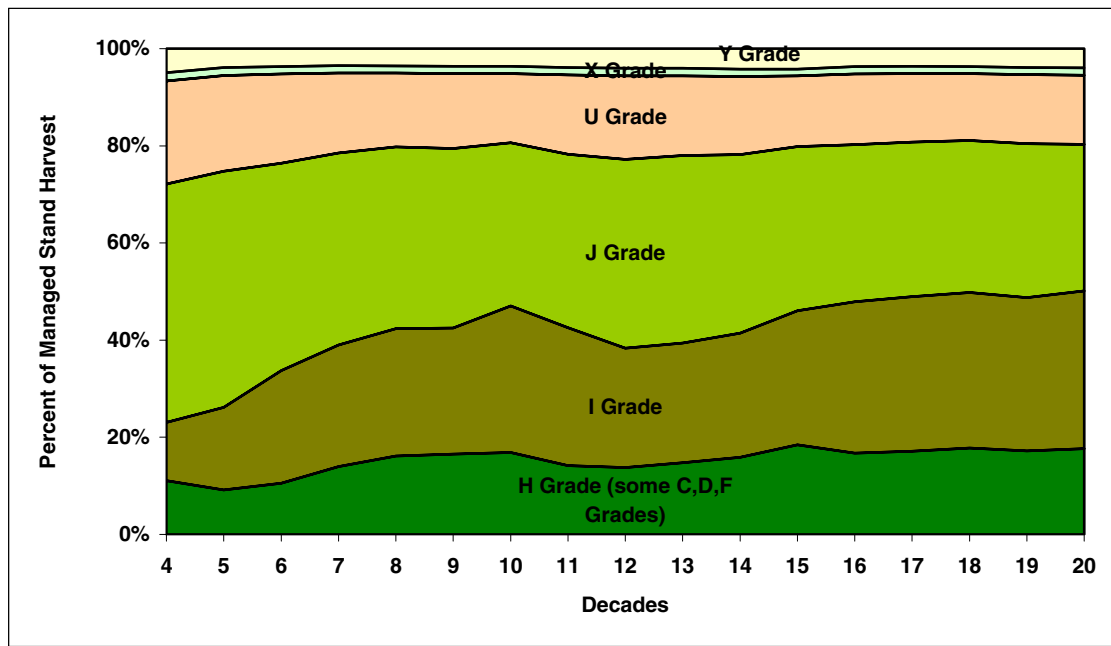


Figure 18 – Percent of Managed Stand Harvest Volume by Grade

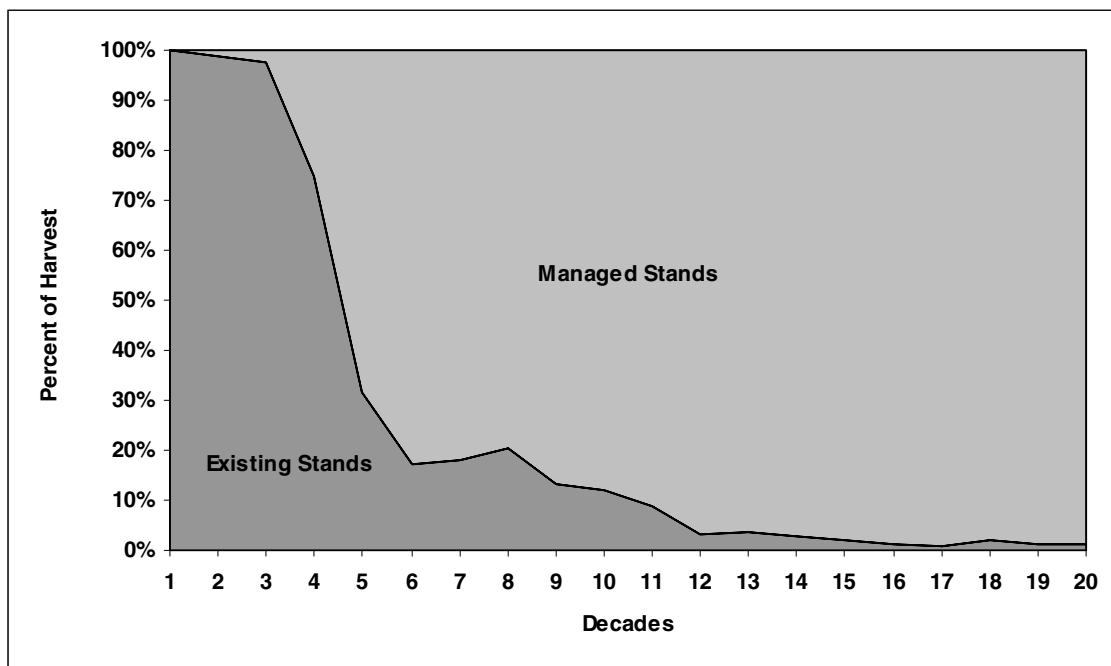


Figure 19 – Harvest from Existing Stands and Managed Stands as Percent of Total Harvest

On average, between 10% and 20% of the future harvest volume is projected to produce H or better grades (Figure 18).

Over the planning horizon of 200 years, an average of about 20 hectares of pruning is proposed annually. On average the clear wood volume will be about 0.6% of total harvest volume throughout the planning horizon. The production of clear wood will not start until the fifth decade as depicted in the following table.

Table 18 – Clear Wood Portion of the Total Harvest

Decade	Clear Wood/Yr m ³	Total Harvest m ³	Clear Wood %
1	0	633,763	0.00%
2	0	633,763	0.00%
3	0	633,763	0.00%
4	91	633,763	0.01%
5	7,430	633,763	1.17%
6	8,054	698,606	1.15%
7	8,175	751,196	1.09%
8	2,261	807,635	0.28%
9	3,192	871,922	0.37%
10	8,570	946,155	0.91%
11	4,836	946,155	0.51%
12	1,805	946,155	0.19%
13	3,876	960,670	0.40%
14	4,073	960,670	0.42%
15	7,765	960,670	0.81%
16	5,161	960,670	0.54%
17	7,298	960,670	0.76%
18	5,288	960,670	0.55%
19	3,866	960,670	0.40%
20	5,429	960,670	0.57%

Tables 19 and 20 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 with the long-term employment opportunities related to the projected changes in harvest level. Table 19 compares the long-term jobs created by the preferred scenario to the silviculture strategy base case. Employment multipliers were utilized from the TSR II Socio-Economic Analysis (with an adjustment for the TSA multiplier as proposed by Sinclair Tedder of the Economics and Trade Branch of the Ministry of Forests). The multiplier was increased from 0.52 to 0.65 as a result of the start-up of the Interfor Squamish sawmill, which was closed during the preparation of TSR II.

As can be seen from Table 20, there is an apparent net gain of jobs from the preferred scenario compared to the SS base case. Several factors must be recognized regarding this result.

Firstly, there is no direct relationship between the preferred scenario and SS base case harvest level with the TSR II base case, and subsequent employment in the Soo TSA. The purpose of the employment comparison is to show relative employment changes as a result of silviculture investment. The only direct relationship between harvest levels and employment in the TSA is based on the actual AAC determination.

Secondly, if the preferred scenario results are presented in comparison to the TSR II or HHL base case employment levels, there is a very significant increase in employment.

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

Table 19 - Incremental Silviculture Jobs^a Created

Year	Space	Prune	Fertilize	CT	Total
1	18.40	1.25	0.53	0.09	20.62
2	18.40	1.25	0.53	0.09	20.62
3	18.40	1.25	0.53	0.09	20.62
4	18.40	1.25	0.53	0.09	20.62
5	18.40	1.25	0.53	0.09	20.62
Sub Total	92.02	6.23	2.67	0.46	103.10
6-10	92.02	6.23	2.67	0.46	103.10
11-15	46.02	3.87	3.09	8.53	62.91
16-20	46.02	3.87	3.09	8.53	62.91
Total 20 Years	276.08	20.19	11.52	17.98	332.03

^a1 job = 180 man days

Table 20 - Long-Term jobs^a on a TSA and Provincial Level

Decade	Harvest Increment ('000)	TSA Jobs by Decade	Provincial Jobs by Decade
1	19	125	259
2	19	125	259
3	19	125	259
4	19	125	259
5	19	125	259
6	35	225	468
7	35	225	468
8	39	257	533
9	40	261	543
10	59	386	801
11	59	386	801
12	59	386	801
13	74	480	997
14	56	361	750
15	56	361	750
16	45	296	614
17	45	296	614
18	45	296	614
19	45	296	614
20	45	296	614
Total	836	5,431	11,280

^aMultipliers; TSA 0.65 as per Sinclair Tedder (MoF), Province 1.35 (TSR II) per 1,000 m³ of AAC

10.0 Results, Discussion and Recommendations

The intent of this report is to provide strategic direction for an incremental silviculture program in the Soo 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 and understanding the local forest dynamics and the potential influences of different incremental silviculture strategies. Overall, this project should provide the participants with appropriate strategic-level decision support information to meet future forest management objectives. The 6 main objectives, the relative success of their achievement and the implications associated with each are outlined below.

1. Timber Volume Maximization

Maximizing volume was identified as the highest-ranking management objective. Secondary objectives include the production of premium logs and quality sawlogs. Premium logs were defined as having a greater than 50 cm average dbh and a pruned 5 meter first log. Sawlogs were defined as having an average dbh of 40 cm. An additional requirement was to have the average dbh of the largest 250 stems per hectare greater than 50 cm.

As expected, site index adjustments significantly improved timber volumes throughout the planning horizon, masking the influence that treatments may have had on current timber supply trends. However, significant conclusions can be drawn from the *magnitude* of increase between the Silviculture Strategies Base Case and subsequent scenarios testing varying degrees of silviculture investment.

Timber supply in the Soo TSA was relatively responsive to incremental silviculture, and forecasted the long-term harvest level from 915,000 m³/yr in the SS Base Case to an average of approximately 965,000 m³/yr for all other investment scenarios. This is slightly higher than the desired annual objective of 47,000 m³/yr (B.C. Ministry of Forests, 1999c). The funding level of around \$750,000 represents the point at which incremental investment results in diminishing volume returns.

Incremental silviculture increases the harvest level at each stage of the planning horizon. Silviculture investment in thinning alleviates the dependence of existing natural stands in the short-term, effectively increasing the available volume. Commercial thinning allows the maintenance of forest cover objectives while providing harvest opportunities in a constrained land base. Spacing and fertilizing makes stands available for harvest at an earlier age than a similar stand that has not been treated, while simultaneously enhancing product value by producing larger stems. Earlier availability means firstly less reliance in the short- and mid-term on natural stands and enhanced stand cycling.

Spacing, thinning, and fertilizing allow stands to maintain more rapid growth in older ages as compared to those with no treatments (Debell et al., 1997) and in the long-term translates into older stands with much greater productivity than untreated stands, also positively influencing the size and quality of the stems harvested. With an emphasis on value, the preferred scenario (\$1 million budget level) realized a much greater piece size over time compared with an untreated scenario (Figure 15).

While not all product objectives were achieved or directly addressed in the analysis (such as the 5-meter pruned first logs), one can draw some definite conclusions from the analysis results: the preferred scenario was able to increase the percentage of large logs being harvested from future managed stands, which represents a variety of potential products focused on large log diameters. Approximately 50% of the harvested managed Fir volume is projected to have an average diameter greater than 50 cm over most of the planning horizon. For other species, this number is close to 40%. Although not reported on, pruning treatments are scheduled throughout the planning horizon and will eventually provide future volume of pruned logs.

Figure 18 - managed stand harvest volume by grade - illustrates that the preferred scenario shows the proportion of H (including minor amounts of C, D and F) and I grades increasing over time, while reducing the proportion of J and U grades, with a minor component of X, and Y grades. This distribution of future harvest by grade, demonstrates the variety of potential products that may be achievable through an investment in incremental silviculture and a long-term trend toward larger, better quality logs.

2. Increase the Productive Land Base

Increasing the TSA's operable land base provides a direct benefit to short-, mid- and long-term harvest levels, and was identified as the second highest priority objective to be considered for the Soo TSA Type 2 analysis. Deciduous conversion and the reduction of backlog NSR were included in this analysis. The ability of low site stands to support commercial growth is questionable and they were excluded from the analysis. Due to its relationship to silviculture activities, the conversion of deciduous stand types was initiated from Scenario 4 through 7. Deciduous conversion was not included as a sensitivity analysis, so the actual benefit to the short- to long-term harvest level is unknown.

Further assessment of land base additions can and should be verified through the TSR and LRMP processes, focusing on the collection of required information and research to support any analysis. The increase of the TSA's operable land base provides a direct relationship to forecast harvest levels, and the objective to maximize the operable land base within the Soo TSA should continue. The opportunity to harvest deciduous and the implications of its conversion to a more commercial stand type should be further assessed.

3. Employment

Employment is typically forecast in timber supply analysis processes by using employment multipliers applied to a given harvest level. The application within Type 2 analyses is not as linear. Incremental silviculture jobs, as a result of the intensive treatment activities, provide direct employment, whereas any increases in harvest level will also provide increased employment. The preferred scenario recognizes an increase in harvest level, as compared to the silviculture strategy base case, and a corresponding potential increase in long-term employment. Employment and the uncertainty in projecting it will be dependent on the actual site index adjustments and future timber supply analysis and AAC determination. Furthermore, this project has not attempted to analyze the relationship between increased profit, revenue, higher-value products and employment.

4. Produce Clearwood

Pruning to 5m over two lifts creates high quality peeler logs. Over the planning horizon of 200 years, an average of about 20 hectares of pruning is proposed annually. This is just under half of the desired pruning of 50 ha/yr (B.C. Ministry of Forests, 1999c). Given the low cost/benefit ratio for pruning, few stands are selected for pruning in the analysis. If additional pruning is desired to ensure product differentiation in the TSA, good fir stands, which are scheduled for spacing, could also be candidates for pruning.

5. Owl Habitat

The purpose of applying treatments in the silviculture strategy scenarios was to initiate the opportunity for stand treatments in order to accelerate the creation of preferred stand characteristics while still realistically representing timber volumes from these areas. The actual success of habitat management cannot be directly modeled, but results from proper management prescriptions at the stand level.

Silviculture investment can enhance the structural diversity required in Owl habitat (Debell et al., 1997). For example, spacing can be used to create small openings in the developing canopy which results in the development of multi-layered canopies as well as the understory shrubs and herbs. Thinning provides a mechanism to increase understory light levels to allow shade tolerant species to thrive while fertilization, in combination with other treatments, can increase stand development and crown differentiation when applied to older stands. Underplanting was not addressed in this analysis, but should be considered in the Owl habitat zone where understory species seed sources may be lacking.

6. Resource Values

Non-timber resource values have a significant influence on the management of forested land and as such, must be considered in all resource analysis projects. Accounting for non-timber values as a locally derived objective for the Soo TSA, was considered within the Type 2 analysis by removing deer reserves from the land base, establishing seral distribution targets for each BEC variant within each landscape unit in the TSA, and establishing VQO requirements within visually sensitive areas. The spotted owl cover constraints were modeled as per TSR II and the required conditions were met for all scenarios, ensuring that non-timber resources are adequately considered when analyzing potential strategic silviculture schedules.

10.1 Summary of Conclusions

In developing the objectives for the Soo Type 2 analysis, the TSA group considered the harvest level issues presented in TSR II. Rationally adjusting site indices for the entire TSA based on local experience and opinion (and the associated increase in harvest level) eliminated any opportunity to quantify the potential of incremental silviculture to directly improve the future timber supply in relation to TSR II base case. On the basis of the volume maximization strategy results, it was shown that incremental silviculture had little short-term volume benefits but provides the potential for more mid- and long-term volume gains as well as significant value benefits in the long-term for managed stands. If the quantitative effects of raising SI had been completely understood at the beginning of the project, the MoF and other stakeholders may have developed some of the objectives differently.

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 Soo TSA. Different assumptions in the modeling would likely produce slightly differing results. Rather than taking one solution as the direction for incremental silviculture, we recommend consideration of the trends, such as:

- A long-term annual budget level of around \$1,000,000 appears to bring the most balanced results, i.e., producing value without compromising volume;
- Without factoring in commercial thinning costs and revenues, the budget level is around \$600,000.
- The recommended annual budget level for the first decade, excluding commercial thinning, is approximately \$1.2 million.
- If the maximization of long-term harvest levels were the objective, a long-term budget level of \$700,000 to \$800,000 – including CT - would be sufficient, potentially at the expense of piece size;
- Most treatments occur on Fir sites, however, a significant area of Balsam (SI=25) is spaced and fertilized.
- For the next 10 years, the recommended annual treatment areas are 8 hectares of commercial thinning, 841 hectares of spacing, 957 hectares of fertilization, and 28 hectares pruning.
- For the first 20 years, treatments are relatively evenly distributed across the TSA.

The location of these treatments have been identified on the Preferred Scenario map in the Appendix. The presentation of the map delineates 10 years worth of treatments. Further, the attached maps will provide tactical assistance in suggesting where the proposed treatments might be carried out in the field.

11.0 Future Analysis Recommendations

In order to make subsequent analyses of a similar nature more efficient, several recommendations are proposed.

- Although not a problem with this analysis, it is important to limit the number of potential transitions. Careful selection of differing regimes will allow for a greater concentration within a single treatment type and increase model sensitivity. Also, limiting the number of transitions decreases run times significantly and allows for more sensitivity analyses to be undertaken within a similar time frame.
- Large site index adjustments, which have not been validated statistically, might reduce the usability of the results.
- There is uncertainty whether the stand level model TASS adequately represents stand types in the coastal – interior transition zone. Particularly the hemlock/balsam stand in the Soo TSA may not grow according to the stand level model
- Given the complexity of the analyses, a considerable time frame is required to complete this type of project properly. Ideally, data should be delivered in a usable format at least 8-9 months prior to the project completion date although as experience leads to efficiency, shorter time frames in the future are possible.
- Delivery of spatially accurate data (slivers, neatlines removed and map edges properly merged) would have helped speed data-loading procedures, though HHL has now developed vector-cleaning tools for most data-cleaning requirements.

12.0 References

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