Ministry of Forests

Prince Rupert Forest Region

Kalum Forest District

In Conjunction with

Skeena Cellulose Inc

West Fraser Mills Ltd.

Bell Pole Ltd.

Cypress Consultants

Type 2 Strategic Silviculture Analysis
Analysis Report

November 2001

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

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

Type 2 Strategic Silviculture Analysis
Analysis Report

Executive Summary

Introduction

This document presents an incremental silviculture strategy for the Kalum Timber Supply Area (TSA). The purpose of the strategy is to guide the application of available incremental silviculture funds toward the most efficient and effective treatment programs. The mains focus of the strategy is incremental silviculture; however, some basic silviculture activities are addressed where appropriate.

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

This strategy should not be confused with the allowable annual cut (AAC) determination. The AAC is based on actual practice and current information at the time of the determination while this strategy is concerned with improving the future state of the forests within the Kalum TSA. The only connection between the two is that any improvements resulting from the silviculture strategy may impact future AAC determinations.

Project Steps

The general steps followed for the development of the silviculture strategy were as follows.

1 Identify forest-level timber supply and habitat issues by reviewing existing information.

2 Identify possible solutions and treatment opportunities by accessing local knowledge and analyzing existing information.

3 Clarify goals and objectives.

4 Define potential strategies and treatment regimes.

5 Conduct a stand-level analysis of the proposed treatment regimes to determine responses and costs.

6 Conduct a forest-level (TSA) analysis to evaluate strategies with respect to short-term, mid-term, and long-term timber and habitat supply and quality issues.

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

8 Define an annual incremental silviculture program for the first 10 years.

Steps 1 through 4 were addressed at Workshop 1, held January 13th and 14th, 2000 in Terrace. The workshop was attended by representatives from the Ministry of Forests (Kalum Forest District and Prince Rupert Forest Region), Skeena Cellulose Inc., West Fraser Mills, Bell Pole, Cypress Consultants, and Forest Ecosystem Solutions Ltd. - formerly the FORUM analysis group of Hugh Hamilton Limited.

Management Objectives

The following management objectives were identified at the Workshop:

- Maintain / Increase operable land base.
- Keep opportunities as flexible as possible.
- Maintain / Enhance $ value/ha; poles, clearwood, peelers.
- Maintain / Enhance long-term harvest levels.
- Stabilize / Improve employment.
- Maintain stand health.
- Manage for a variety of potential products and species.
- Account for non-timber resources values.

Working Targets

The following working targets were developed in order to evaluate the strategies and treatment regimes.

Short- and mid-term

- Maintain current harvest levels for as long as possible beyond the TSR 2 forecast of three decades.
- Create a timber supply capable of supporting a minimum harvest level of at least 425,000 m^3/year (a 10 percent increase over TSR 2).

Long-term

- Create a timber supply capable of supporting a harvest level of at least 475,000 m^3/year (10 percent higher than TSR 2).
- Generate at least 10 percent of total harvest volume in premium logs. Premium logs - have qualities that command higher than average prices

Scenarios

The analysis scenarios form the basis of the analysis methodology. The first run was a scenario designed as a benchmark to the TSR2 analysis. The silviculture strategy base case is built in successive steps from this benchmark run and becomes the reference point against which the results of the subsequent incremental silviculture runs and ultimately the preferred scenario are evaluated.

The incremental silviculture runs can be described as two groups of runs: one group which investigates the opportunity for increases in volume flow through incremental silviculture, and the other which investigates those opportunities to increase timber value. The results of the value- and volume-oriented scenarios were analyzed to create the preferred scenario, a run, which produces higher timber values while maintaining or increasing harvest levels. This was achieved by including both value and volume weightings in the optimization function of the forest estate model ***FSOS***. This provides the model with incentives not only to maintain high harvest volumes but also to schedule treatments, which improve piece size and overall value of the future timber supply.

Results

The Kalum TSA group felt that the site indices in the forest inventory file as well as the more recent SIBEC site indices might not accurately reflect conditions in the TSA. Site indices were adjusted for all the silviculture strategy scenarios. The site index adjustments had a dramatic effect on harvest levels throughout the short- to long-term periods. The short-term harvest level increased by 25 percent above the TSR 2 base case. Mid- and long-term harvest was increased by approximately 50 percent.

The majority of the timber supply in the Kalum TSA consists of hemlock leading stands. As hemlock stands are not generally considered good candidates for fertilization, there are limited incremental silviculture treatments available that are known to increase managed stands yields in the TSA. Subsequently, no silviculture strategy could be developed that would significantly increase harvest levels in the TSA.

The results of the analysis show that:

- A minimum annual budget level of $500,000 - net of CT costs - is able to increase the harvest value significantly without seriously compromising harvest levels. Beyond $500,000 the improvement in the per cubic meter harvest value is insignificant.
- If funding is available, an annual budget of up to $1.1 million is able to maintain higher harvest level while providing larger piece sizes and value.
- In the first decade, 79% of available funding should go to the combination treatment of spacing and first pruning. The rest should be used for spacing.
- Spacing and pruning treatments should avoid sites with the site index (BEC adjusted) less than 20.
- Spacing should favor higher density treatments (1,000 and 1,200 sph).
- About 50 ha should be commercially thinned every year. Only the best sites should be commercially thinned.

Adopting an incremental silviculture strategy with an average annual budget level of $1.1 million could produce the following results:

- The harvest flow is maintained at the same level as in the silviculture strategy base case, which did not include incremental silviculture.

- An increase in average piece size of 70% in the long term compared to the no incremental silviculture scenario.

- An average value increase of $15 per cubic meter in the long term compared to the no incremental silviculture scenario.

- 33 silviculture jobs annually over the next 10 years.

- 399 short-term and 440 long-term TSA level jobs annually, and 494 short-term and 545 long-term provincial level jobs annually.

Incremental Silviculture Program, First Decade

- ***Commercial Thinning:*** Only 56 hectares per year are proposed throughout the first 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. Most treatments occur in Hw stands with the site index greater than 28.

- ***Spacing:*** A total of 228 hectares of annual spacing treatments are proposed for the first decade. Hemlock sites with site index between 20 and 23.9 receive approximately 37% of this treatment. Hemlock with site index between 24-27.9 has a 30% share and those hemlock sites with the site index greater than 28 have a 19% share.

- ***Space/Prune:*** A total of 389 hectares annually are proposed during the first decade of the planning horizon

The following table reiterates the proposed annual commercial thinning, spacing and pruning treatments for the first decade in more detail. Hemlock sites with site index between 20 and 24 receive approximately 31% of this treatment. Hemlock sites with site index between 24.1-28 have a 41% share and those hemlock sites with the site index greater than 28 have a 21% share.

Proposed regimes; first decade

Analysis Unit	CT		Space		Space/prune		Total
	ha	%	ha	%	Area	%	
Hw SI <20	0	*0*	29	*12.7*	0	*0*	29
Hw SI 20-24	0	*0*	85	*37.3*	121	*31.1*	206
Hw SI 24.1-28	4	*7.1*	69	*30.3*	161	*41.4*	234
HW SI >28	52	*92.9*	44	*19.3*	80	*20.6*	176
Pine	0	*0*	1	*0.4*	28	*6.9*	29
Grand Total	**56**	***100***	**228**	***100***	**389**	***100***	**673**

Table of Contents

List of Figures

List of Tables

1 Introduction

The Ministry of Forests (MoF) is mandated by legislation to undertake the planning function related to the management of Crown forestland. As part of the service agreement between the MoF and Forest Renewal BC, the MoF is required to recommend conservation and stewardship investment opportunities in support of the strategic objectives identified in the "Forest Renewal BC Strategic Plan 1999-2003". The development of a "Forest Level Incremental Silviculture Strategy" was chosen as the way to accomplish these objectives within the Kalum TSA. The silviculture strategy is intended to assist in directing the use of available incremental silviculture funding to meet timber supply quality and 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 planning.

The Kalum Silviculture Strategy is a "Type 2" project in that it uses timber supply analysis and computer modeling to create a strategy and a plan. The "Type 1" projects are based exclusively on existing information, such as recent Timber Supply Reviews. A "Type 1" project was not done for the Kalum TSA, because of the extensive silviculture planning that the Kalum Forest District had carried out in the past.

The objectives of the Kalum TSA Silviculture Strategy are:

- To identify resource management and timber product objectives and priorities;
- To develop potential strategies to meet the objectives through incremental silviculture treatments;
- To delineate and evaluate the draft strategies in relation to timber quantity, timber quality, habitat supply, and socio-economic issues using forest-level analysis;
- To identify stewardship investment opportunities for the Kalum 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 will influence the future condition of the forest, including the quality and quantity of timber and habitat supply. The silviculture strategy, if implemented, may influence future allowable annual cut (AAC) determinations. Other than this potential future impact, the strategy is not linked to the Timber Supply Review (TSR) process.

2 Procedure

2.1 Project Procedure

The general steps followed for the development of the silviculture strategy are as follows.

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

2 Identify possible solutions and treatment opportunities by accessing local knowledge and analyzing existing information.

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 a forest-level (TSA) analysis to evaluate strategies with respect to short-term, mid-term, and long-term timber and habitat supply and quality issues. The forest-level analysis provides a variety of output products so that the selection of an appropriate strategy could be based on future timber quality, 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 for the first 10 years.

Steps 1 through 4 were addressed by Workshop 1, held January 13th and 14th, 2000 in Terrace. The workshop was attended by representatives from the Ministry of Forests (Kalum Forest District and Prince Rupert Forest Region), Skeena Cellulose Inc., West Fraser Mills, Bell Pole, Cypress Consultants, and Forest Ecosystem Solutions Ltd. Here, issues were defined, objectives were established, and potential strategies and treatment regimes were developed from local knowledge and perspective.

Using input gathered from participants of Workshop 1 and the "Background Agenda and Summary Package" distributed prior to the workshop, the following items were produced:

- 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 (step 5) 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 Projection (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.

Step 6, the strategic forest-level (management unit) analysis, was done using the Forest Simulation and Optimization (***FSOS***) model. The ***FSOS*** model analyzes forest systems in a spatial and temporal manner, using both simulation and optimization techniques. Both approaches are used in this project, simulation for the base case (essentially a calibration approach) and optimization to determine the preferred treatment schedules. The ***FSOS*** model combines the spatial data management capabilities of ARC/INFO GIS and MS Access with the landscape optimization and simulation model and professional experience.

In optimization mode, the model uses a results-oriented approach, based on moving the forest estate towards a user-defined "desired future condition". The model operates by running a series of iterations. Treatments are allocated for each iteration according to a set of basic rules (for example, specific treatments can only occur on stands of 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 (that is, where further iterations do not result in an improved solution).

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

Mr. Lou Tromp, Stand Tending Officer, MoF, Prince Rupert Forest Region, managed the overall project and Forest Renewal B.C provided the funding. The participation of representatives from the following organizations in the workshops and other aspects of this project is gratefully acknowledged:

- Ministry of Forests, Forest Practices Branch
- Ministry of Forests, Prince Rupert Forest Region
- Ministry of Forests, Kalum Forest District
- Ministry of Forests, Research Branch

- Ministry of Forests, Timber Supply Branch
- Skeena Cellulose Inc.
- West Fraser Mills Ltd.
- Bell Pole Company Ltd.
- Cypress Forest Consultants Ltd.

2.2 Data Acquisition and Manipulation

The primary sources of data used for this project were:

- Kalum Land and Resource Management Plan (KLRMP) – supplied the base data for the project; and
- Intensive Silviculture Information System (ISIS) – supplied silviculture history and activity data.

The LRMP data was compiled and delivered by the Ministry of Environment, Lands, and Parks. The condition of the LRMP data, as received by Forest Ecosystem Solutions Ltd., was suitable for the generation of maps (its primary function in the LRMP process) but not for this analysis as the detailed forest modeling of this project requires a precise dataset. One of the problems encountered was that the dataset was compiled from individual mapsheets at both North American Datum (NAD) 27 or 83, which generated overlaps, unmatched edges, and unlinked lines. Polygons without attributes and missing information were other problems that required correction.

2.3 Analysis Methodology

The analysis begins with a re-creation of the TSR 2 base case (referred to as the "benchmark") using the simulation mode. This allows for calibration of the model. With results that closely resemble those of TSR 2, we can be confident that data processing has not caused significant data shifts and that the model is producing reliable results.

In setting the parameters for the optimization scenarios, the analyst must define the timber flow pattern and then the model seeks this timber flow while achieving the other objectives. Through experience, the analyst is able to modify the timber flow to reach a solution that satisfies the objectives at the greatest timber flow level.

Different scenarios were identified through the workshop and followed up with workshop participants. The scenarios provide a sequential process to reach a final scenario that is developed with understanding and results from the previous scenarios. It must be understood that any one of the scenarios can stand alone as a potential management option that can be implemented or further assessed by the Kalum TSA representatives. The analysis scenarios are presented in detail in section 8.3 of this report.

3 Kalum TSA

3.1 Description of the TSA

The Kalum TSA is located within the Prince Rupert Forest Region and is administered from the Kalum Forest District office in Terrace. The TSA is bordered by the Nass, Kispiox, North Coast and Bulkley TSAs, as well as two Tree Farm Licenses (TFL 1 and TFL 41). The total area of the Kalum TSA is 540,818 hectares. Several parks are adjacent to the TSA including the Nisga'a Memorial Park, Lava Bed Provincial Park, the Lakelse Lake Provincial Park, the Hai Lake Park, the Exchamsiks River Provincial Park and the Gitnadoix River Recreation Area. Major rivers in the TSA include the southern Skeena, the lower Nass, the Kitimat, and the Kalum.

A number of First Nations traditional lands are within the Kalum TSA. The Nisga'a have negotiated a treaty that covers a portion of the Kalum TSA. The Haisla, Tsimshian, Carrier Sekani and Wet'suwet'en Nations are in the process of treaty negotiations, and the Gitxsan are conducting bilateral negotiations with the provincial government.

The population of the Kalum TSA is approximately 33,500, with more than seventy-five percent of the residents living in the communities of Terrace and Kitimat. Other small communities within the TSA include Gitlakdamix, Gitwinksihlkw, Kitamaat Village, Kitsumkalum, Kitselas, Rosswood, Thornhill and Usk.

Harvesting, silviculture operations, and the manufacture of wood products at the Skeena Cellulose and West Fraser sawmills in Terrace, and at the Eurocan pulp and paper mill in Kitimat support forestry employment in the area. Smaller processing operations including a cedar pole mill, some small custom-cut sawmills, and a cedar shake and shingle mill are also located in the Terrace area. Most of the timber harvested in the Kalum TSA is processed at mills in the area. Chips from the sawmills are transported to the Skeena Cellulose pulp mill in Port Edward, near Prince Rupert.

The Kalum TSA includes a variety of terrain, ranging from the valley bottoms of the major rivers, through gentle lower slopes and steeper, forested upper slopes, to alpine meadows. The climate is transitional between coastal and interior. The Coastal Western Hemlock (CWH) biogeoclimatic zone extends along the valley bottoms and lower slopes of the Kitimat, Skeena and Kitsumkalum rivers and their tributaries. The Mountain Hemlock (MH) zone is adjacent to and up slope of these areas. Further inland, the Interior Cedar Hemlock (ICH) zone occurs at lower elevations in the Nass and Skeena valleys. The majority of the productive forest land base is in the CWH and the MH zones. The forests of the Kalum TSA are home to a wide variety of wildlife, including large mammals, invertebrates, birds and extensive fish stocks.

Of the 540,818 hectares in the TSA, 34,962 hectares or approximately 6.5 percent are not managed directly by the MoF, including parks, ecological reserves, private land and various special-use permit areas. An additional 306,973 hectares or approximately 57 percent are non-productive areas, which include rock, swamps, alpine areas and water bodies. Productive forestland managed by the MoF totals 198,883 hectares or roughly 37 percent of the total area. Further reductions applied to the productive forestland base result in 95,026 hectares considered being available for timber harvesting (HHL, 2000). Table 1 illustrates the THLB definition for TSR 2, benchmark run and the silviculture strategy base case.

Table 1 - Timber harvesting land base determination.

	TSR 2	**Benchmark run**	**Silviculture Strategy Base Case**
Classification	**Area Reductions (ha)**	**Area Reductions (ha)**	**Area Reductions (ha)**
Total Land Base:	**539,319**	**540,818**	**540,818**
Non-forest	305,698	306,973	306,973
Not directly managed by B.C. Forest Service	36,213	34,962	34,962
Total Productive Forest	**197,408**	**198,883**	**198,883**
Reductions to Total Productive Forest:			
Non-commercial	503	468	468
Inoperable	70,897	72,031	72,031
Humphrys reversion	906	827	827
Deciduous (Aspen, Birch, Alder)	4,041	5,584	-
Problem Forest Types (FTP)	7,090	6,840	7,049
Low productivity sites	808	831	831
Existing Roads, Trails and Landings	3,815	3,771	3,981
Environmentally Sensitive Areas	4,836	6,226	6,536
Riparian Management Areas	4,625	4,510	4,807
Wildlife Tree Patches	1,359	2,650	2,775
Exchamsiks	272	119	133
Nisga'a Lands	-	-	5,598
Total Reductions to Land Base	**99,152**	**103,857**	**105,036**
Current THLB Includes 6,195 ha of NSR	**98,256**	**95,026**	**93,847**
Future Reductions:			
Future Roads	4,076	3,413	3,551
Long-Term THLB	**94,180**	**91,613**	**90,296**

In addition to the reductions depicted in table 1, 6,970 ha of THLB classified as goat habitat was excluded from harvesting to provide for a conservative approach in the analysis.

Hemlock species dominate in stands on about 76 percent of the area, balsam dominates on 8 percent, spruce on 6 percent, lodgepole pine on 5 percent, cottonwood on 4 percent, and cedar on 1 percent (MoF, 1999a).

3.2 History of the AAC

In 1995, the area originally known as the Kalum TSA was split into the two separate timber supply areas now known as the Kalum TSA (previously Kalum South) and the Nass TSA (previously Kalum North). The AAC for the Kalum South area, from 1986 until 1995, was 480,000 cubic metres. This was reduced during the first Timber Supply

Review (TSR I) by approximately three percent to 464,000 cubic metres, effective January 1996 and was further reduced to 459,684 cubic meters, effective January 1, 2000 as a result of the TSR 2 process (MoF, 1999b).

3.3 Land and Resource Management Plan

A Land and Resource Management Plan (LRMP) process is on-going in the Kalum TSA. Representatives of the provincial and local governments, local stakeholder groups and the public are developing a land and resource management plan for the area.

3.4 Current and Basic Silviculture Systems

The primary silviculture system used in the Kalum TSA is clear-cutting, although small areas have been partially cut. Regeneration is a mixture of planting and natural, with decisions made on a site-specific basis to ensure that all stands reach free growing within required time frames.

3.5 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.

3.5.1 Genetically Improved Seed

Much of the planted stock within the TSA is hemlock, with a lesser amount of balsam, pine, and spruce. There is very little hemlock and balsam seed available from seed orchards; therefore, there has been little use of genetically improved seed within the Kalum TSA. It has been used for pine regeneration when it has been available. The TSR 2 base case assumed no use of genetically improved seed. (MoF, 1999b)

3.5.2 Juvenile Spacing

Juvenile spacing is the removal of less-desirable trees within a juvenile stand to manage the stand. This reduces competition for water, nutrients, and sunlight among the residual trees. 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 500 ha of spacing each year for the past 20 years. The annual area spaced was higher between 1993 and 1997, at approximately 1300 ha/year. The TSR 2 base case assumed that all stands on good and medium sites would be spaced at 15 years of age (MoF, 1999b).

3.5.3 Fertilization

Fertilizing a stand raises the productivity of the site and is the only treatment that actually increases the volume of wood grown on a site. Aerial application of urea is the most common fertilization technique. Most fertilization in the province occurs in Douglas-fir and Lodgepole pine stands. Fertilization research trials have been conducted in hemlock stands with inconsistent results. Research shows consistent response in hemlock if nutrient deficiencies are understood at the stand level. However, this requires foliar testing of each stand prior to preparing prescriptions, an action that cannot be undertaken in a forest-level analysis.

3.5.4 Pruning

Pruning is the removal of branches from the bole of the tree to speed the tree's production of clear wood. Two treatments (lifts) of pruning are done, one when the tree is at a height of approximately 7 metres and the second when it reaches around 10 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. Until 1998, approximately 200 ha were pruned within the TSA each year. Since 1998, no pruning has been done.

3.5.5 Commercial Thinning

Commercial thinning (CT) is a thinning program where the removed trees 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.

Over the past 20 years, the Kalum District has undertaken a significant juvenile spacing program, producing candidate stands for CT. Potential CT stands are hemlock and balsam stands that are 40-50 years old on good and medium sites.

In the TSR 2 base case, all balsam and hemlock sites with a site index (SI_{50}) greater than 24 meters are eligible for commercial thinning between 40 and 50 years of age with 35-45 percent of the basal area removed.

3.5.6 Backlog Reforestation

There are currently 4,431 hectares of backlog Not Satisfactorily Restocked (NSR) land within the Kalum TSA. This area consists in part of stands that have proven to be difficult and expensive to treat. The TSR 2 base case assumes that the backlog NSR will be restocked within 20 years.

3.6 Previous Incremental Silviculture Plans and Reports

There has been considerable interest in incremental silviculture activities in the Kalum TSA over the last twenty years. The Kalum South Timber Supply Review forecasted a potential deficit in short-term timber supply caused by an imbalanced age class distribution. As a result, the Kalum Forest District developed an "Incremental Strategies Plan" with the following objectives:

- To improve the quality and value of timber resources as well as other resources;
- To increase the flexibility of harvesting schedules, alleviating some of the short-term timber supply shortages. This can be done by reducing age class imbalances as well as making stands merchantable at an earlier age;
- To maintain the long term harvest level (LTHL) at 320,000 m^3/year or increase it to 350,000m^3/year, provided that more funding was available;

- To produce more high quality wood for the future development of secondary re-manufacturing;
- To reduce the harvesting cost through larger piece sizes;
- To increase forest employment and therefore produce greater community stability;
- To increase biological diversity of the second growth forests;
- To provide more employment opportunities for the Native population; and
- To produce 45 cm sawlogs at an 80 year rotation on good and medium sites, and at 120 years on poor sites. (MoF, 1992)

A number of strategies were developed to achieve these objectives. In 1993, the Kalum Forest District produced the "Commercial Thinning Plan for the Kalum Forest District". This plan included the following objectives:

- Alleviate the short-term timber supply concerns by commercially thinning 500 ha per year for 20 years, with average yields of 100 m^3/ha;
- Increase the quality of stands by removing diseased and deformed trees;
- Create employment opportunities for Kitimat and Terrace residents;
- Provide an earlier financial return by extracting volume prior to final harvesting;
- Reduce final harvesting and milling costs by concentrating growth on fewer trees, thereby creating a larger piece size;
- Improve wildlife habitat by enhancing browse species development and shelter for severe weather conditions;
- Enhance stand structure to accommodate other resource values and users.

This plan also included strategies, identified some candidate areas, and proposed treatment regimes.

4 Issue Identification

4.1 General Timber Supply Issues

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

- Short-term - The next twenty years.
- Mid-term - This varies by management unit, but for this analysis, is the period from year 21 to year 120.
- Long-term - The point at which timber supplies reach the steady long-term harvest level - in this case, in decade 12.

4.1.1 Harvest Forecast

The initial harvest level (TSR 2 base case) of 464,000 m^3/year can be maintained for 3 decades, followed by declines of 8.8% and 8.5% until it reaches the mid-term harvest level of 387,000 m^3/year. The harvest remains at this level until decade 12, when it rises to the long-term level of 431,500 m^3/year (MoF, 1999a). The base case harvest forecast was defined by maintaining the current harvest level for as long as possible while avoiding substantial timber supply disruptions in the future. Other harvest flow patterns are also possible, and some are described in the timber supply analysis report.

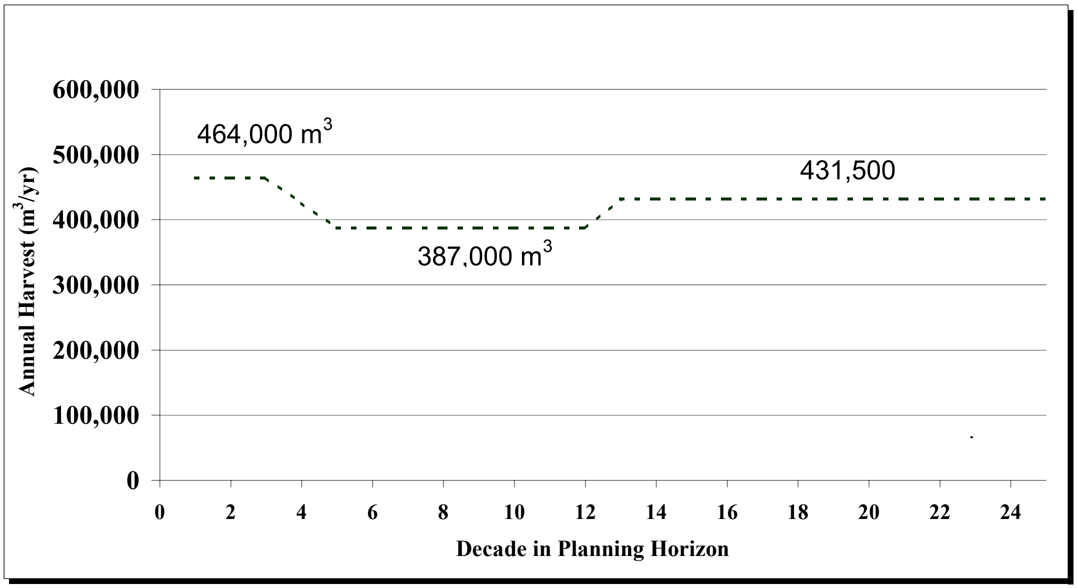

Figure 1 – TSR 2 base case timber flow.

4.1.2 Land Base

The following events or factors have either currently altered the Kalum TSA land base or are expected to do so in the future:

- The Nisga'a Final Agreement has reduced the current THLB by 4,700 ha,
- Other First Nations' land claim negotiations are underway, and the forms of the eventual resolutions are uncertain.
- Kitimat municipality has a municipal boundary over a portion of the TSA. Political pressures may in time influence management activities.
- Terrain classes IV/V have a large constraining influence on the operable land base and the area in these terrain classes may have been overestimated in the ESA inventory data.
- Archaeological Impact Assessments can have an impact at the stand-level to effectively reduce the land base. However, a TSA inventory of archaeological sites has not been conducted to determine the overall effect.
- Accessibility is a factor as the operability line is revised in light of new technology and the variation in market conditions (MoF, 1999b)

4.1.3 Age Class Structure

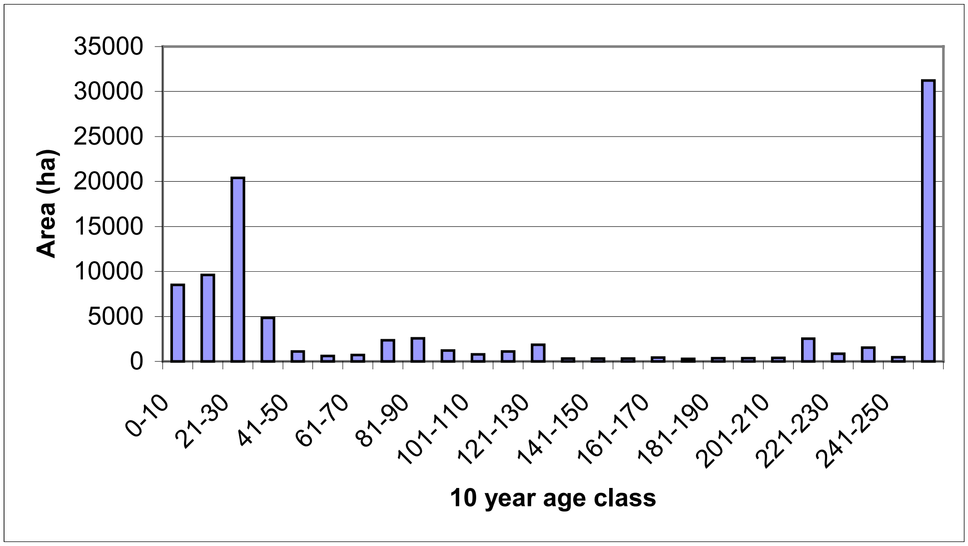

Figure 2 – Current age class distribution.

The age class structure in the THLB is over-represented above 101 years and below 20 years. As a result of past harvesting, about 27 percent of the THLB is in stands 20 years or younger, 15 percent are between 21 and 60 years, 14 percent are between 61 and 100 years, 12 percent are between 101 and 250 years of age, and 32 percent are older than 250 years (MOF, 1999a). This puts a downward pressure on the mid-term timber supply.

4.1.4 Transition from Existing to Managed Stands

In the TSR 2 base case, for the next 60 years most harvesting occurs in existing old stands, with a small portion coming from commercial thinning and short-rotation stands. From decade seven onward, most of the stands harvested are regenerated stands (MoF, 1999a).

4.1.5 Growing Sites

Approximately 75 percent of the sites in the THLB are currently classified as good or medium sites (site index >= 13) (AAC Rationale, page 24). The mean annual increment at minimum harvest age from managed stands is about 4.7 m^3/ha/yr, about 69 percent higher than the 2.8 m^3/ha/yr from existing stands (MoF, 1999b).

The Kalum TSA group felt that the managed stand site indices were underestimated. For this reason the managed stand site indices were increased as described in the analysis information package (appendix 1) and section 9.1 of this report.

Old growth site index (OGSI) adjustments for western hemlock stands greater than 140 years in the Coastal Western Hemlock (CWH) biogeoclimatic zone were included in the TSR 2 base case (MoF, 1999a). This adjustment affected 11.7 percent of the THLB. Additional sensitivity analyses showed that uncertainty about site productivity (primarily in the remaining stands greater than 140 years of age with other leading species or in other biogeoclimatic zones) dramatically affects the long-term and can potentially affect the mid-term timber supply as well.

4.1.6 Forest Cover Requirements

The following forest management zones occur in the Kalum TSA:

- **Integrated resource management** applies to 65.9 percent of the THLB. The TSR 2 base case has a requirement that a maximum of 35 percent of the THLB be less than 3 m 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, 1999a).

- **Kitimat Special Resource Management Zone** was added to the analysis to control the age class distribution in 429 ha in the Kitimat valley. A maximum of 15% of the area less than 15 years of age was set as a target to aid in the development of an even age class distribution. In addition, a target of 20% of the area composed of stands greater than 80 years of age was set.

- **Visual Quality Objectives (VQO's)**

  - *Modification VQO* - applies to 13.1 percent of the THLB and requires that a maximum of 25 percent of the productive forest be < 5m in height.
  - *Partial retention VQO* - applies to 5.9 percent of the THLB and requires that a maximum of 15 percent of the productive forest be < 5m in height.
  - *Retention VQO* - applies to 1.9 percent of the land base and requires that a maximum of 5 percent of the productive forest be < 5m in height.

  The short term-timber supply is insensitive to uncertainty about current forest cover requirements for VQO's. There is a small effect on timber supply in the medium and long-term. This minimal short-term sensitivity results from limited harvesting in the Retention VQO zone, which covers only about 2.3 percent of the land base. (MoF, 1999a)

- **Community watersheds** comprise 1.8 percent of the land base and have a requirement that a maximum of 30 percent of the productive forest is < 5m in height (MoF, 1999a).

Generally, the Kalum timber supply is not sensitive to increasing or decreasing green-up ages (for all forest cover requirements). An increase in green-up ages slightly reduces the amount of time that the current AAC can be maintained and also slightly affects both the mid- and long-term timber supply while a decrease in green-up ages only slightly affects the mid-term timber supply, mostly in partial retention VQO's. (MoF, 1999a)

4.1.7 Not Satisfactorily Restocked (NSR)

The Kalum TSA has 6,493 ha of NSR, of which 4,431 ha is backlog NSR (harvested prior to 1987) and 2,062 is current NSR (harvested or otherwise disturbed after 1987). (MoF, 1999b) In TSR 2, NSR areas are restocked based on the current area within each analysis unit in stands under 20 years of age.

In the Kalum TSA, small areas are fill-planted to bring stocking in NSR areas up to standard. Brushing is used in some areas to bring backlog NSR areas up to standard. The impact of NSR areas was not evaluated as a separate scenario as the backlog NSR area, at 2,062 ha, is relatively small. In addition, these areas are believed to be close to their respective minimum stocking densities and thus do not constitute a major concern.

4.1.8 Quality

Timber quality was not modeled in TSR 2. At Workshop #1, it was noted that there is currently a large supply of mature poor quality wood and a shortage of good sawlogs, Cw poles, and peelers. It was also noted that the better the quality of wood, the more manufacturing options exist.

4.1.9 Old Forests

Approximately 32 percent of the THLB is presently older than 250 years. Old seral guidelines are modeled as per the draft biodiversity emphases of the Forest Practices Code Biodiversity Guidebook. (MoF, 1995) Forest cover objectives for old forests include an assumption that stands will develop old growth attributes at an age of 250 years. An increase in the age that defines old growth can significantly reduce mid-term timber supply. A reduction in the age that defines old growth does not affect the short- or long-term timber supply and has only a small impact on mid-term timber supply (MoF, 1999a).

4.1.10 Minimum Harvest Age (MHA)

Minimum harvest ages are chosen in order to ensure that the timber supply model selects for harvest only stands with sufficient merchantable volume and piece sizes. The timber supply is sensitive over the mid-term, and moderately sensitive over the long-term to substantial changes in minimum harvest ages.

4.1.11 Silviculture Systems

The main silviculture system used in the Kalum TSA is clear-cutting. There has been a small amount of partial cutting in the past (less than 100 hectares per year).

4.1.12 Estimates of Existing and Regenerated Stand Volumes

The short-term and mid-term timber supply is very sensitive to increases or decreases in the estimated volumes of existing stands. The volume estimates for existing stands were confirmed by an inventory audit. The long-term timber supply is not affected by existing stand volumes.

Increases or decreases in the volume of regenerated stands have a significant impact on mid- and long-term timber supplies. A 10 percent increase in managed stand volumes results in a 9.2 percent increase in both mid- and long-term timber supplies (MoF, 1999a).

4.1.13 Candidate Areas Available for Commercial Thinning

The impact of over- or under-estimating the area available for commercial thinning is difficult to predict; however, any impact of this uncertainty would be to the mid- and long-term timber supply. Commercial thinning presently contributes about 1% to the timber supply in the short- and mid-term. (MoF, 1999b)

4.2 Management and Social Issues

The following issues were identified in workshop #1; however, they are beyond the scope of this project and are not considered in the analysis:

- A significant number of areas, although physically operable, may be economically marginal; for example, low quality wood in areas where access is difficult or expensive. Operability was determined in the analysis based solely on physical requirements.
- The appraisal and quota systems do not provide the proper consideration for commercial thinning and are disincentives to undertaking additional CT.
- Overall employment levels have declined in last 20 years due to technology improvements, AAC reductions, and reduced funding for incremental silviculture. By moving the harvesting areas to higher elevations, more of the work is becoming seasonal, which leads to more shut-downs and transient crews.
- The entire TSA has some level of visual concern, but the concern is greatest along the highway travel corridors. Managing for visual resources affects harvesting and road building costs because of smaller blocks and more roads.

4.3 Forest Health Issues

- **Spruce Weevil -** Serious damage to spruce plantations by the spruce weevil have led to the reduction in the quantity of spruce being planted to less than 20% in any area. In stands where spruce is a minor component, it is removed at the time of spacing. Where spruce is less than 5m tall, the majority of these areas are rehabilitated and planted with other species. Where the spruce exceeds 5m in height, these areas are planned for early harvest and will be planted with other species
- **Hemlock Looper** is currently only a concern in pure/mature stands.
- **Voles** can damage young plantations.
- **Ungulates** can damage young plantations by heavily grazing.
- **Porcupines** will gnaw on regeneration and second growth trees, but their overall impact at the forest level is considered minimal.

4.4 Issues Relating to Habitat and Non-Timber Forest Resources

- **Grizzly Bear** – The total area required to maintain grizzly bear habitat is relatively low and has little impact on the total land base. At the stand level, management regimes and timing may need to be specialized to provide suitable grizzly bear habitat. Access is another concern as roads constructed for harvesting also provide access for hunters to previously inaccessible areas.

- **Moose winter range** – Most of the moose winter range overlaps with areas already designated and managed as riparian reserves. Thus, the creation or maintenance of moose winter range itself is not a significant issue in this analysis.

5 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.

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 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.

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 and stands were therefore modeled with these assumptions. TASS is calibrated for a limited number of species, which required that balsam be modeled using hemlock curves for this analysis.

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 mean annual increment (MAI).

6 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 length of time that the existing harvest rate can be maintained is very sensitive to the estimates of timber volumes in existing stands. It is also sensitive to decreases in the land base and higher minimum harvest ages.

The short-term harvest level is limited primarily by harvest flow policies, which guide the rate of decline to mid-term harvest levels. The short-term timber supply could therefore respond to treatments that target mid-term issues. These could include a program of treatments that increase stand volumes and treatments that allow trees to reach merchantable size earlier and therefore decrease minimum harvest age.

6.1.2 Mid-term

Mid-term harvest levels are highly sensitive to increases or decreases in stand volumes for existing stands and quite sensitive to increases or decreases in regenerated stand volumes. Estimates of site productivity could therefore potentially affect mid-term timber supply.

Mid-term harvest levels are also significantly sensitive to increases or decreases in land base and changes in minimum harvest ages.

Uncertainty surrounding green-up age, forest cover requirements for visual quality, and about the landscape biodiversity, as expressed through old forest retention requirements, have a small to moderate impact on timber supply during the transition period to harvesting mainly second growth stands (30-70 years from now). Strategies that potentially increase stand volumes and decrease the age of harvest would be beneficial in minimizing such timber supply deficiencies.

6.1.3 Long-term

Long-term timber supply is very sensitive to estimates of site productivity and regenerated stand volumes. There is also sensitivity to increases or decreases in land base and a slight sensitivity to changes in forest cover requirements for VQO's.

Minimum harvest ages, green-up ages, and maximum disturbance objectives for the integrated resource management zone have very little, if any effect on long-term timber supply. In TSR 2, an increase or decrease in minimum harvest age by 10 years caused an 0.8% decrease and 0.7 % increase in long-term timber supply, respectively. When green-up ages were reduced by five years, there was no impact in the long-term timber supply. Increasing green-up ages by five years decreased the TSR 2 base case long-term harvest level by 0.2%. Decreasing the maximum allowable disturbance from 35% to 25% caused no change in the harvest forecast for TSR 2. The allowable disturbance level would need to be decreased to 18% before impacting the harvest level.

The long-term harvest forecast was shown in TSR 2 to be sensitive to changes in site productivity and stand volumes. Therefore, treatments that increase site productivity and stand volumes such as genetic improvement and fertilization could provide considerable benefit to 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 concerns identified are the future reduction of AAC and the scarcity of quality harvestable timber in the future.

The reduction in AAC and timber scarcity is caused by the current uneven age class distribution, which has a very high proportion of the THLB greater than 250 year and under 50 years. (MoF, 1999a) Timber quality is a concern because of the large area in typically poor, decadent hemlock-balsam stands.

The reductions in current AAC as defined by the TSR 2 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 long-term harvest level is attained when the managed stands make up virtually all of the available harvest volume.

6.3 Higher Level Objectives

The Provincial Incremental Silviculture Strategy specifies the following working targets:

- Minimize interim reduction in timber supply so that the annual allowable cut (AAC) for the province is not less than 65 million m^3/yr;
- Increase timber supply over the mid-term to a long-term level of 75 million m^3 of AAC; and
- Maintain the production of premium quality logs at or above 10 percent of total harvest. (MoF, 1999c)

The Kalum LRMP may provide some additional higher-level objectives when it is finalized.

6.4 Local Objectives

During Workshop #1, the Kalum TSA group identified the following objectives and assigned a priority to each objective to be considered during the analysis. These locally defined objectives are compatible with the provincial working targets.

Table 2 – Local Objectives

Objective Number	Objective description	Relative Value (Lowest most important)	Ranking
01	• Maintain / Increase operable land base. • Keep opportunities as flexible as possible.	13	1
02	• Maintain / Enhance $ value/ha; poles, clearwood, peelers	14	2
03	• Maintain / Enhance long-term harvest levels	15	3
04	• Stabilize / Improve employment	32	4
05	• Maintain stand health	33	5
06	• Manage for a variety of potential products and species	38	6
07	• Account for non-timber resources values	46	7

In order to evaluate success in meeting quality-related objectives (e.g. #02, 06 above), it is necessary to define products in terms of log types that can be determined from inventory data. The following is a list of products and how they are defined within the analysis:

- Small logs - <30cm.
- Medium logs -30cm-50cm.
- Large logs - >50 cm dbh.
- Premium log - logs having qualities that command higher than average prices.
- Saw log - logs having at least 50 percent sound wood and yield lumber mostly above utility grade.
- Fibre log - logs not meeting the saw log definition and yielding mostly utility lumber and chips.

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 of the THLB or utilizing stands not presently included in the TBLB (deciduous or decadent stands);
- Reduce the minimum harvest age; and
- Increase the volume in existing stands (late rotation fertilization).

6.4.2 Mid-term (21 – 120 years)

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

- Increase the volume of existing stands (late rotation fertilization).
- Increase the volume of regenerated stands using fertilization or genetic improvement. The volume can be increased through site index adjustments;

however, this increase is caused by updated site index data, not by any particular treatment.

- 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 "short fall." 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 accomplish this.
- Utilize spacing and fertilization as necessary to set up stands for future commercial thinning.

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

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

- Increase the volume of regenerated stands using fertilization and genetic improvement. The volume can be increased through site index adjustments; however, this increase is caused by updated site index data, not by any particular treatment.
- 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 Potential Strategies by Response Time Frame

To achieve the objectives and overcome the concerns, 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 (by decreasing time for stand to reach green up height);
- Increase regenerated stand volumes by 20 percent;
- Eliminate NSR;
- Substantially increase fertilization program on suitable stands;
- Accelerate the tree improvement program;
- Intensify forest health management to reduce losses to insects and disease; and
- Employ more hardwood forest management.

After identifying the objectives and issues, the workshop group developed a series of potential strategies designed to meet objectives or mitigate issues in the Kalum TSA. The following strategies related to incremental silviculture will be tested in the analysis:

Table 3 - Incremental Silviculture Strategies

Strategy Number	Response time frame	Objective Met	Strategy Description	Anticipated result
S1	ST	01	Review operability line.	Quantity
S2	MT/LT	01	Convert deciduous stands currently not in the AAC to coniferous stands.	Quantity
S3	LT	01	Rehabilitate non-contributing potentially productive sites, including problem forest types, landings, roads, low sites, and poorly-stocked stands.	Quantity
S4	MT/LT	02	Reduce backlog NSR.	Quantity
S5	All	01	Introduce private land into the land base.	Quantity
S6	All	02	Adopt lower utilization levels.	Quantity
S7		02	Adjust operational adjustment factors to better represent density control and salvage efforts.	
S8	MT/LT	02	Reduce regeneration delay from the TSR approach of 3 years for good, and 6 years for poor sites to a new target of 1-2 years through less reliance on natural regeneration.	Quantity
S9	MT/LT	02	Utilize weevil-resistant spruce in valley bottom high-site lands.	Quantity and quality
S10	All	02	Reduce culmination age or minimum stand criteria to increase the AAC.	Quantity
S11	MT/LT	07,03,05	Increase mean dbh through spacing	Quality
S12	MT/LT	03	Increase clear wood by pruning.	Quality
S13	LT	03	Improve form to improve product value.	Quality
S14		03,07	Encourage / target specific species.	Quality
S15	All	03,04,05	Intermediate harvesting - commercial thinning	Quality and quantity
S16		03	Service specialized markets	
S17	ST	03	Relax export regulations to make marginal stands more viable	Quantity
S18		05	Maintain SPP mix	Habitat
S19		06	Improve inventories	
S20		06	Maintain diversity and distribution	Habitat
S21		01	Are there opportunities / objectives that will allow harvesting in RR2 (4,600 ha)?	
S22		07	Mixed planting of ecologically suitable SPP	Quantity and habitat

7.1 Stand Treatments

Stand treatments were described in general in Section 3.5 and the operational rules for each treatment are defined in the Information Package (Appendix 1). The stand level effects of treatments show which treatment can potentially be used to meet the requirements of the different strategies.

Table 4 – Stand Level Effects of Silvicultural Treatments

Treatment	Min. Harvest Age	Yield	Avg. DBH	Quality
Basic	+		+	+
Spacing	+	+ or -	+	+
Pruning				+
CT	+	+ or -	+	
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 response to the treatment. Some treatments have surrogate techniques to model their effect. For example, site index changes can be used to model fertilization.

7.2 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 (Hw, Cw, Pl), harvest system (ground, cable, all), site index, and stand density. The treatment regimes are combinations of fertilization, pruning, 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 Appendix 1.

Table 5 – Examples of Treatment Regimes

Species	Site Index	Density (sph)	Treatments			Spacing Density
Hw	24-28	>3500	Do nothing			
Hw	24-28	>3500	Space			600 sph @ 20 Yrs
Hw	24-28	>3500	Space			800 sph @ 20 Yrs
Hw	24-28	>3500	Space			1000 sph @ 20 Yrs
Hw	24-28	>3500	Space			1200 sph @ 20 Yrs
Hw	24-28	>3500	Space			1400 sph @ 20 Yrs
Hw	24-28	>3500	Space			1600 sph @ 20 Yrs
Hw	24-28	>3500	Space	Prune 2 lifts		600 sph @ 20 Yrs
Hw	24-28	>3500	Space	Prune 2 lifts		800 sph @ 20 Yrs
Hw	24-28	>3500	Space	Prune 2 lifts		1000 sph @ 20 Yrs
Hw	24-28	>3500	Space	Ct		600 sph @ 20 Yrs
Hw	24-28	>3500	Space	Ct		750 sph @ 20 Yrs
Hw	24-28	>3500	Space	Ct		1000 sph @ 20 Yrs
Hw	24-28	>3500	Space	Ct 1	Ct 2	1200 sph @ 20 Yrs
Hw	24-28	>3500	Ct			
Hw	24-28	>3500	Ct 1	Ct 2		

Historic treatment costs (Appendix 1) were assigned to regimes by the participants and reflect the average costs in the Kalum TSA over the last several years. For the purposes of this project, the costs were assumed to remain relatively constant.

7.3 Stand Level Treatment Responses

Figure 3 provides an example of stand-level responses to different treatment regimes within an analysis unit in the Kalum TSA.

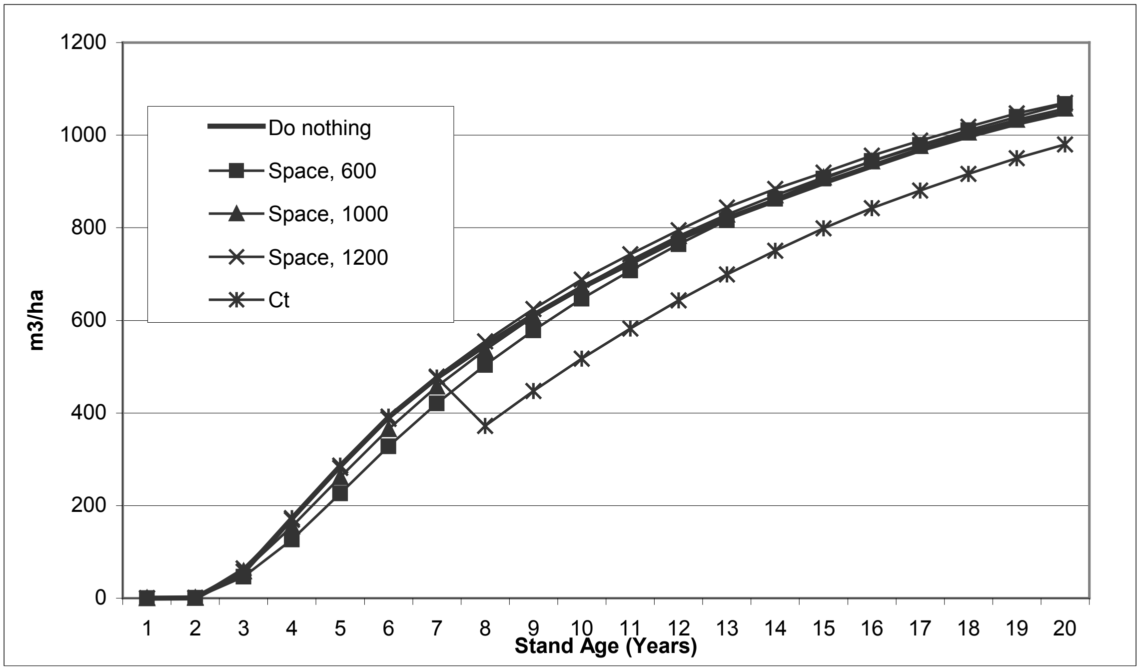

Figure 3- Stand-level Response, Hw, SI = 22, Model Density 3,500-5,000/ha

The "do nothing" treatment option often provides the highest total stand volume. Spacing, while potentially decreasing total stand volume at any particular year (as shown in Figure 3), serves to increase individual tree size and overall quality, which speeds operability and improves value. Commercial thinning is shown as a removal of volume along the yield curve (for example, between years 70 and 80 for the CT curve). As the trees removed here have commercial value, CT can be used to offset short- or mid-term volume shortages. As with spacing, the trees left on the site after commercial thinning grow with the advantage of reduced competition, resulting in larger individual tree sizes.

The various responses shown in Figure 3 represent the numerous treatment pathways a given treatment can follow. Each treatment option may contribute differently to quantity (absolute volume and volume availability) and quality at the forest level. Depending on the scenario being assessed, a pathway will be chosen depending on its contribution to timber quantity and quality. The only mechanism to assess the satisfaction of these objectives and treatment pathway combinations is through the forest level analysis.

8 Forest Level Analysis

The following is a brief summary of the steps used to carry out this part of the project. For more details, please refer to the analysis data package (Appendix 1).

8.1 Assumptions

The following assumptions were used for this analysis:

- Success of results will not be limited by funding availability, source, or ability to deliver the program;
- Normal market conditions will apply to demand and prices for timber and fibre;
- Status quo timber harvesting land base will be applied except where noted;
- The TSR 2 analysis approach will be used;
- The 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;
- Specific levels of precision to be used in the optimization analysis are as follows:
  - +/- 10% change in timber flow between decades;
  - Silviculture investment not to exceed maximum budget level by more than 5%; and
  - Maximum 5% tolerance around age-class targets specified in TSR 2 for optimization to allow for smooth transition strategies to be achieved without impacting timber flows.
- Treatment costs were taken from recent experience in the Kalum TSA and are listed in the data package (Appendix 1);
- CT was treated as partial cuts and tree to truck costs were calculated using the Interior Appraisal Manual;
- Log values were based on historic, third party, and second growth market pricing, and are based on the Statutory Log Grades and piece size. For old growth timber, a flat $100/m^3 gross revenue was initially used for all stands. This value was selected arbitrarily to improve the modeling of old growth harvesting within the model. This value came under question during workshop 2 and as a result was lowered to $60/m^3.

8.2 Working Targets

The following working targets were developed in order to evaluate the strategies and treatment regimes.

8.2.1 Short- and mid-term

- Maintain current harvest levels for as long as possible beyond the TSR 2 forecast of three decades.
- Create a timber supply capable of supporting a minimum harvest level of at least 425,000 m^3/year (a 10 percent increase over the base case).

8.2.2 Long-term

- Create a timber supply capable of supporting a harvest level of at least 475,000 m^3/year (10 percent higher than the base case).
- Generate at least 10 percent of total harvest volume in premium logs.

8.3 Analysis Scenarios

Table 6 provides a summary of the scenarios that were identified in workshop 1 and analysed towards the development of the preferred scenario. A more detailed description of the scenarios follows.

Table 6 – Analysis Scenarios from Workshop 1

Scenario	Title	Scenario Description

1	Benchmark run	➢ Re-creation of the TSR 2 Base Case
		  ➢ Calibrate model
		  ➢ Test model reliability.

2	Benchmark – No Spacing	➢ Benchmark run ➢ No historic spacing unless specified in forest cover information.
3	Revised benchmark	➢ Benchmark run ➢ Yield curves for OGSI and SIBEC adjustments.
4	Genetic Improvement	➢ Benchmark run ➢ Yield curves for OGSI and SIBEC adjustments ➢ Genetic Improvement for future managed stands
5	Nisga'a Lands Removed	➢ Benchmark run ➢ Nisga'a Lands removed as non-ownership.
6	Silviculture Strategy Base Case	➢ Deciduous conversion ➢ Existing 0-40 year-old stands on TASS curves. ➢ No harvesting allowed in the Mountain Goat reserve ➢ Nisga'a Lands removed from THLB ➢ Kitimat SRMZ added. ➢ No future incremental silviculture treatments incorporated. ➢ Optimization algorithms applied.

7	Timber Volume Scenario	➢ Silviculture Strategy Base Case with:
		➢ Unlimited silviculture budget
		  ➢ Determine the impact on volume
		  ➢ Focus is on increasing mid-term flows.

8	Timber Value Scenarios	➢ Silviculture Strategy Base Case with: ➢ Series of runs using different annual incremental silviculture budgets ➢ $0.5M ➢ $1.0M ➢ $2.5M ➢ Intent is to determine impact on value.
9	Preferred Option	➢ Balanced scenario incorporating insight and understanding from previous scenarios.

8.3.1 Benchmark run (Scenario 1)

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

8.3.2 Benchmark run – No Spacing (Scenario 2)

This scenario is a modification of the Benchmark run (Scenario 1) to exclude spacing treatments. As requested by the Kalum TSA group, new TIPSY curves were generated to represent the no spacing option where appropriate. However, where the forest cover information indicated that previous spacing had occurred, the spacing treatment was maintained.

8.3.3 Revised benchmark run (Scenario 3)

This scenario is a continuation of Scenario 2 except that TASS curves with Forest Cover, SIBEC and OGSI adjustments were used in place of VDYP and TIPSY curves. The site index adjustments are listed in Table 8 later in this report. NSR is restocked using the same schedule as the TSR 2 base case.

8.3.4 Genetic Improvement (Scenario 4)

This scenario is identical to Scenario 3 with the exception of a 2% increase in softwood yield volumes to account for planting of genetically improved stock. This adjustment factor was chosen based on discussions with Albert Nussbaum where he indicated that this increase is a generally accepted adjustment level for softwood species in the Kalum TSA.

8.3.5 Nisga'a Lands Removed (Scenario 5)

This scenario is identical to Scenario 1 with the exception that the Nisga'a lands are removed from the productive land base (considered non-ownership) and no longer contribute to seral objectives.

8.3.6 Silviculture Strategy Base Case (Scenario 6)

This scenario introduces all management assumptions to be used in all subsequent runs. Thus, this run serves as a base line for all later runs, which evaluate the impact of silvicultural intervention.

- All past silvicultural activities recognized;
- Genetic improvements incorporated;
- All deciduous stands older than 10 years present in the Kalum 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 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;
- All mountain goat habitats are reserved from harvesting;

- A Kitimat Special Management Resource Zone (SRMZ) was added to control age structure development in the Kitimat Valley. In the Kitimat SRMZ, an early disturbance requirement of allowing a maximum of 15% of the THLB to be less than 15 years old was set to ensure a smooth transition to an uneven-age structure. Also, a goal was set to have at least 20% of the THLB covered by stands 80 years in age or older;
- No future incremental silviculture treatments are incorporated, and
- Optimization algorithms applied.

8.3.7 Timber Volume Scenario (Scenario 7)

In this scenario, an unlimited annual silviculture budget was implemented in order to evaluate the possible volume impact of incremental silviculture. Multiple transitions options (i.e. silviculture treatment regimes) are available to the model, including commercial thinning. Timber values and harvest costs are not yet incorporated, and the planning horizon is 200 years.

8.3.8 Timber Value Scenarios (Scenario 8)

Scenario 8 is in fact a set of scenarios, which vary the annual silviculture budget level to evaluate the impact of silvicultural intervention on timber value. Again, multiple transition options are available to the model, including commercial thinning. The objective is to evaluate changes in timber quality. Investment levels used are $500,000, $1,000,000, and $2,500,000 per year. The planning horizon is 200 years and the analysis uses net present value to evaluate the feasibility of different silvicultural investments at the forest level. This scenario also provides for comparison of dollar values between the different silvicultural investment scenarios and the silviculture strategy base case.

8.3.9 Preferred Option

Based on the results of all previous scenarios, this scenario attempts incorporate insight and understanding from previous scenarios.

During workshop 2, upon evaluation of the results of the above scenarios, some changes to the model inputs were made. These changes are summarized in table 8.

Table 7 – Changes to model inputs resulting from Workshop 2.

Input	*Description of change*
Discount Rate	The discount rate was originally set to 4%. This was changed in workshop 2 to 2.5% to account for a 1.5% increase in real prices.
Old Growth Value	The value of old growth was originally set to $100/m^3$, primarily for reasons related to ease of modelling. It was decided in workshop 2 that it is important to use a more realistic value for old growth wood. The new value is $60/m^3$.
Prune Value	After review of the initial results, it was decided that the real value increase gain by pruning through increases in clear wood had not been adequately accounted for. Therefore, a value multiplier was used to determine the timber values for pruned stands. The multipliers were based on the MoF report Clear Wood Values from Pruning (MoF, 2000). In the report a pruned hemlock stand would have, on average, 15% clear wood with a 3.6 fold increase in value. Based on this, a value multiplier of 1.39 was used for all pruned stands with the exception of pine stands where a multiplier of 1.35 was used.

9 Results and Discussion

9.1 Site Index

The TSR 2 base case utilized site indices from the forest inventory file with an upward OGSI adjustment for regenerated hemlock stands of 10 m. The Kalum TSA group felt that the site indices in the forest inventory file as well as the more recent SIBEC site indices might not be accurate. For this reason, it was decided that the site indices for the silviculture analysis should be adjusted.

The Kalum TSA group provided the adjustments for the existing forest inventory site indices. The adjustments for the SIBEC site indices were based on a site index review, within the Kalum TSA. Two hundred and thirty-six openings were chosen from the Integrated Silviculture Information System (ISIS). The selected openings met the following criteria:

- They were selected at random,
- Growth intercept methodology was used to determine the site index,
- Stands were 15 to 40 years old, and
- The site index survey of each opening was done between 1995 and 2000.

The chosen openings were located in three biogeoclimatic subzones: CWH ws, CWH vm, and ICH mc. The site index of each opening (from ISIS) was summed and the weighted average was generated. This weighted average site index was then compared to the SIBEC site index. The difference of these two site indices was used as an adjustment factor. Table 8 illustrates the site index adjustments used in this analysis.

Table 8 – Site index adjustments

Species	SI Adjustment Elevate FC SI by	SI Adjustment Elevate SIBEC by
Hw/S/B/C	8	4
Pine	0	0
Ac	0	0

9.2 Commercial Thinning

All budgets presented in this report are net of commercial thinning costs. Commercial thinning is not a silviculture treatment that is eligible for FRBC incremental silviculture funding. This is because it is generally expected that commercial thinning revenues cover commercial thinning costs.

In this analysis commercial thinning costs were generally higher than commercial thinning revenues with some exceptions. It is important to note that this does not mean that commercial thinning is not a viable silviculture treatment. Rather, it means that using the assumptions in the analysis, there are cases where commercial thinning pays and those where it does not.

It is inherently difficult to include costs when modeling activities over long time periods. Commercial thinning costs were assigned the same way as other harvesting costs using the MoF appraisal procedures. The revenues were based on the log values by grade. Both costs and revenues per cubic meter were assumed to remain constant throughout the planning horizon. This may or may not be the case. For the above reasons, the costs and revenues should only be used as means to achieve acceptable solutions that at least consider monetary values in the analysis. They should not be taken out of this context and used to make decision whether commercial thinning in this case is profitable or not in an individual stand or a group of stands.

9.3 Validation and Sensitivity Scenarios (Scenarios 1 – 5)

This section outlines the scenarios used to validate the model. These scenarios also help test and quantify the various assumptions used in the analysis.

Figure 4 illustrates the timber flow comparison between the TSR 2 base case, the benchmark run, and the Nisga'a sensitivity. The purpose of the benchmark run is to compare the models and ensure that ***FSOS*** results are not significantly different from TSR 2. The benchmark run follows the TSR 2 base case with only a slightly higher long-term harvest level (431,963 m^3 vs. 431,500 m^3). The relative similarity between the benchmark run and the TSR 2 base case provides confidence that the analysis results are not influenced by model differences.

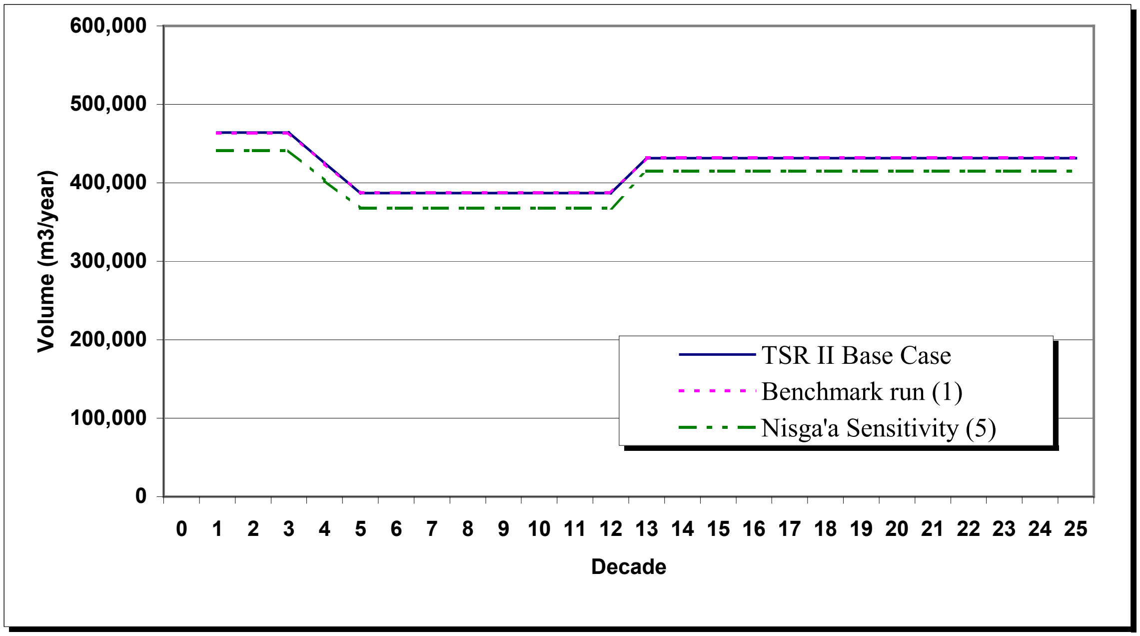

Figure 4: Harvest flow; TSR 2 Base Case, benchmark run and Nisga'a Sensitivity (Note: the TSR 2 and benchmark run overlap, hence the benchmark run is not visible.)

As requested by the Kalum Forest District, an additional scenario was run to test the impact of removing the Nisga'a lands (~ 4,700 ha) from the THLB. Based on this land withdrawal, the initial harvest is reduced to 440,000 m^3 while the long-term harvest level drops down to 413,970 m^3. This sensitivity analysis also compares well with the TSR 2 sensitivity analysis, which established a long-term harvest level of 411,000 m^3 per year after the removal of the Nisga'a Lands.

Scenario 2 is designed to demonstrate the effect that the past spacing program had on timber supply. For this scenario, new TIPSY curves were used to represent a no-spacing option. These new curves were utilized on all managed stands except where spacing was an attribute in the forest cover information.

As shown in Figure 5, the mid-term harvest level remains approximately 3 percent lower than in the benchmark run. This reduction likely results from the increased time required for the young stands to reach a harvestable size. The long-term harvest level is slightly lower as well (427,449 m^3) for the same reason; increased harvest ages mean a decreased number of rotations within the planning horizon and lower overall volumes.

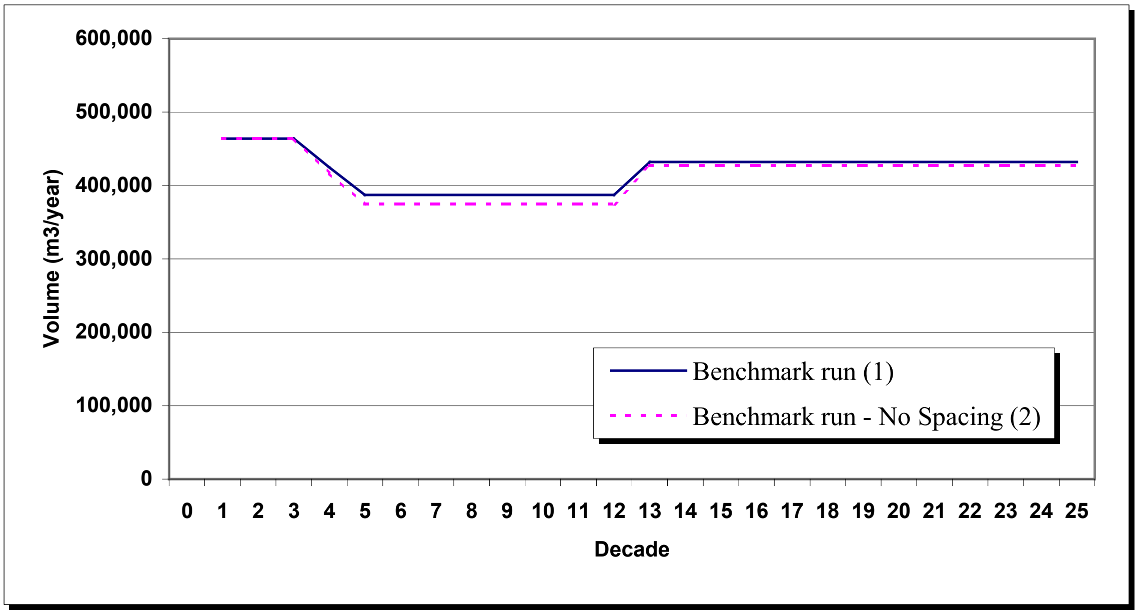

Figure 5 – Harvest flow; benchmark run and No Spacing option

Figure 6 illustrates Scenarios 3 (revised benchmark run) and 4 (genetic improvement) compared to Scenario 1 (Benchmark run). Scenario 3 represents the Benchmark run with site index adjustments as per Table 8. The proposed site index adjustments have a dramatic effect on harvest levels throughout the short- to long-term periods. Initially, the harvest level is increased by 25 percent above the benchmark run, and a further 33 percent greater than the present harvest level within the Kalum TSA. Mid- and long-term increases are equally dramatic with approximately 50 percent increases in resulting harvest levels.

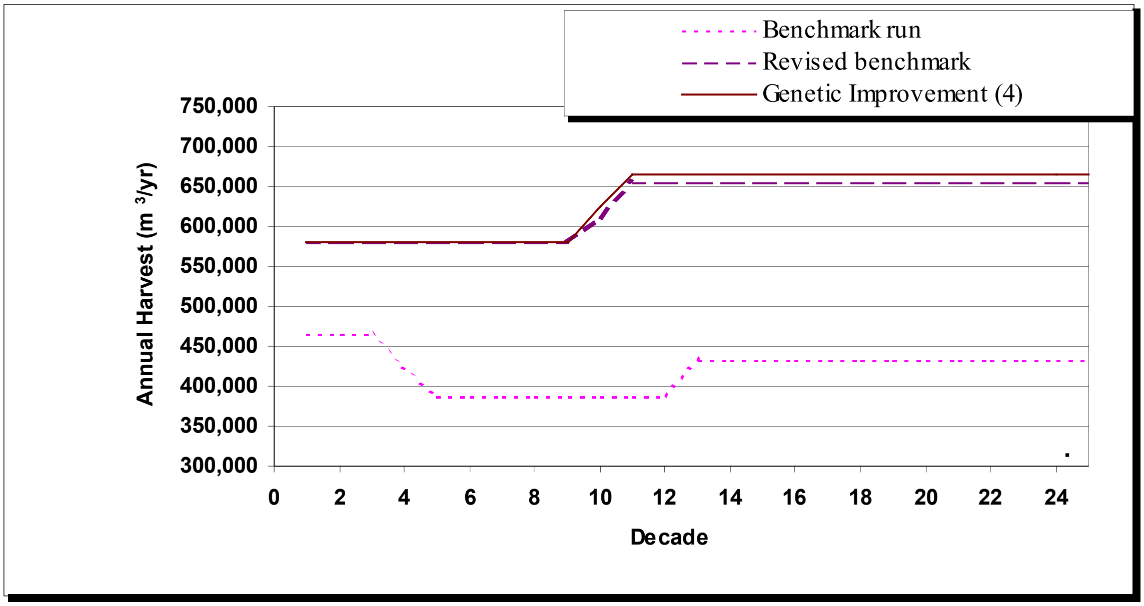

Figure 6 – Harvest flow; benchmark run, revised benchmark run and genetic improvement

Harvest level increases result from the fact that young stands are now growing much faster, providing for larger second-growth volumes that are merchantable sooner. This allows the liquidation of older forests to be compressed in time and increases the rate at which stands become eligible for harvest. The harvest will move from existing natural stands to future managed stands approximately 20 years sooner following Scenario 3 as compared to the benchmark run (Figure 6). Furthermore, as can be seen from Figure 7, the average harvest age remains lower in the revised benchmark run as compared to the benchmark run throughout the planning horizon. This is caused by the harvest rule that selects stands for harvest when they reach a certain mean dbh, height, and volume. The faster growth rates in the revised benchmark run allow these minimum harvest criteria to be reached sooner.

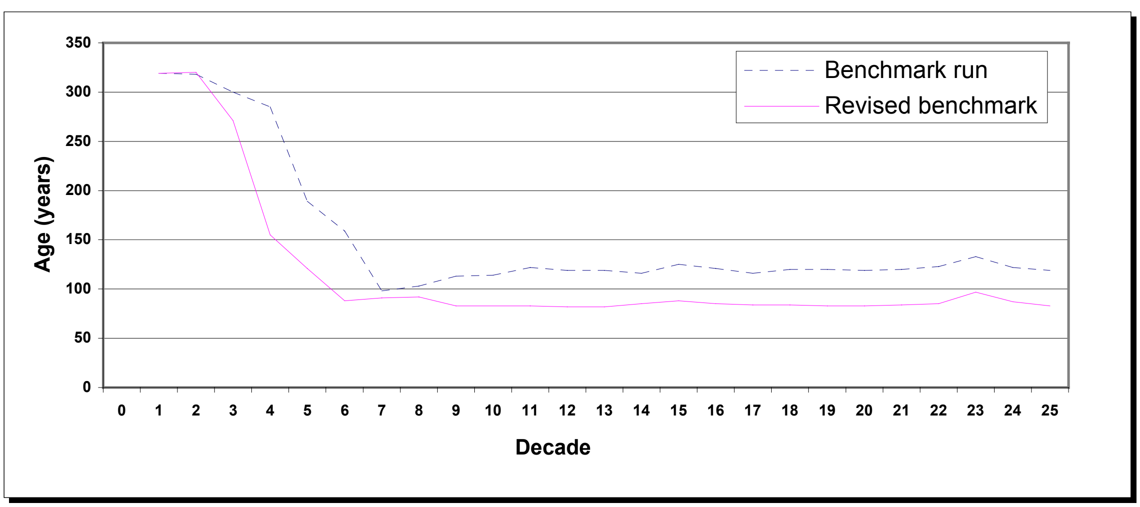

Figure 7 - Average Harvest Age; benchmark vs. revised benchmark

Genetically improved seed for the Kalum TSA is currently not produced in significant quantities and provides minimal improvement in growth rates above either natural regeneration or planted stock derived from wild seed. At present, most managed stands develop from wild seed rather than seed orchard stock. However, the collected wild seed is selected from the best-formed trees. Scenario 4 illustrates the minor effect of genetic gain on the long-term harvest level. As documented on page 21 of the Analysis Information Package, Scenario 4 applies a genetic gain of 2% to the revised benchmark run (Scenario 3). There is no impact in the short-term and mid-term (as genetic improvement is only realized in future planted trees) and a minimal increase in the future harvest level. The genetic gain was applied to all further scenarios.

9.4 Silviculture Strategy Scenarios (6-9)

The silviculture strategy scenarios utilized a standardized set of base assumptions, with varying budget levels to determine the impact on timber volumes and values generated by silviculture investment. Optimization analysis techniques (target-based) used for the majority of these scenarios provide the ability to achieve set objectives such as volume or value maximization based on a given budget level and specific costs and values. Simulation results fit within a range of constraints but do not always satisfy targeted objectives such as piece size, values, investment levels, and so on.

Scenario 6 provides a baseline for testing the impact of silviculture on volume and value of future harvest. Figure 8 illustrates the resulting harvest level for the silviculture strategy base case (Scenario 6) compared to the benchmark run (Scenario 1). Since the Nisga'a lands were removed from the timber harvesting land base and the Kitimat SRMZ targets were applied in Scenario 6, the short- and long-term harvest level is lower than in the revised benchmark run (Scenario 3). However, the short-term harvest level for the silviculture strategy base case (Scenarios 6) is still approximately 16 percent higher than the benchmark run with the mid- and long-term harvest levels increases of approximately 47 and 37 percent, respectively.

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

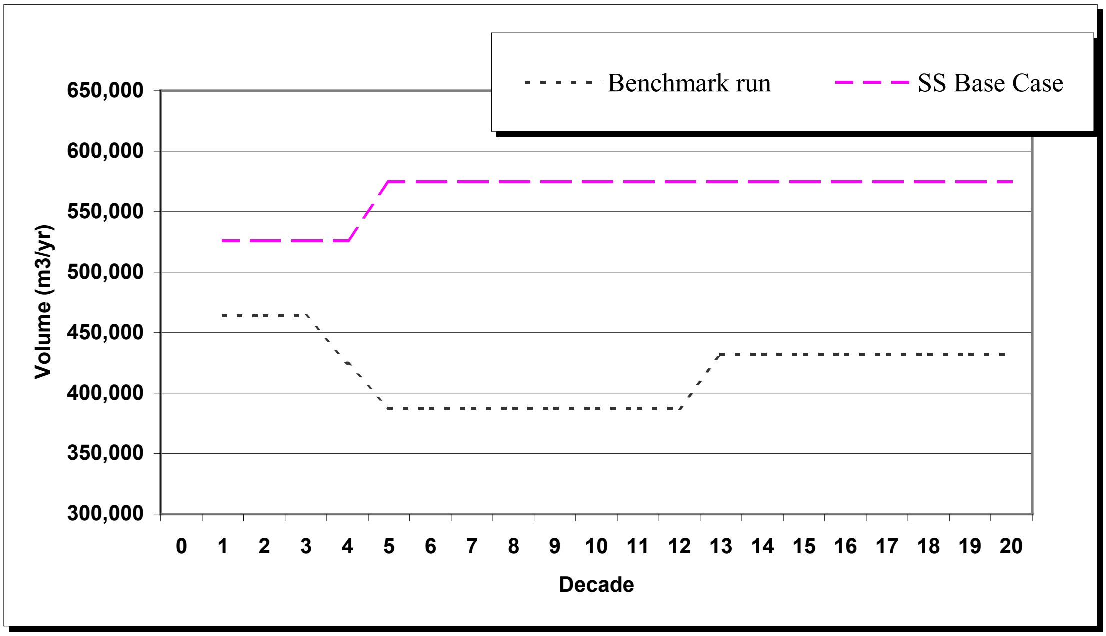

Figure 8 - Scenario 6; silviculture strategy base case

9.5 Silviculture Strategy Volume Scenario

As mentioned in section 8.3.9, concerns were raised during workshop 2 regarding some of the model inputs used to run test volume and value scenarios. These inputs were changed for the final set of the silviculture strategy volume and value scenarios.

The maintenance and enhancement of long-term harvest levels was one of the foremost objectives of the Kalum TSA group, both in its ability to generate economic viability and maintain employment levels. As such, the strategy within the Type 2 project was to undertake a series of analyses to test the benefit of incremental silviculture on harvest flows. The silviculture strategy base case and the prior scenarios did not include any future forecasting of incremental silviculture activities (only existing silviculture) or budget.

Initially, the intention was to test the impact of silviculture on harvest volume by using a range of budget levels. In testing several budget levels, no significant impact on short- through long-term harvest level was achieved. It was therefore decided to allow the model to set its own annual budget to maximize the harvest level. This unlimited budget run was the only run performed to investigate the opportunities for maximizing volume and is referred to below as the "volume strategy."

The average annual budget level for the first 100 years was approximately $950,850; however, there was great variation in the budget between different decades. As an example, during the second decade the annual expenditures were projected to be $301,400, however, during the third decade, the annual expenditures went up to $1.9 million.

Silviculture activities were not able to produce an immediate improvement in the short-term harvest level. The mid- and long-term timber flows increase only marginally as a result of incremental silviculture. This is expected as the main incremental silviculture tools available were spacing and commercial thinning, both known to have limited impact on harvest flows. While spacing may allow for earlier harvest of stands and thus increase harvest levels in some cases, the minimum harvest ages in the Kalum TSA are in most cases determined by cover constraints, not the actual harvest rule.

While the short-term volume flow is not impacted by silvicultural expenditures in the analysis, it is important to note that these volumes may have been affected by past silviculture treatments. The increase in mid- and long-term timber flows is likely due to the potential to accelerate harvest from second growth stands, which as a result of silvicultural intervention (primarily spacing) become eligible for harvest sooner.

Figure 9 shows the resulting harvest level from the volume strategy (Scenario 8) as compared to the silviculture strategy base case (Scenario 6). In the short-term, both harvest levels follow the same trajectory until decade 4. At the mid-term, both the silviculture strategy base case and volume optimizations are able to sustain an increase in timber flow. The silviculture strategy base case was able to make a single step to a LTHL of ~580,000 m^3/yr in one decade, while the volume optimization scenario took two decades to reach a mid-term harvest level of ~590,000 m^3/yr until decade 13, when the final increase to a LTHL of ~605,000 m^3/yr was achieved.

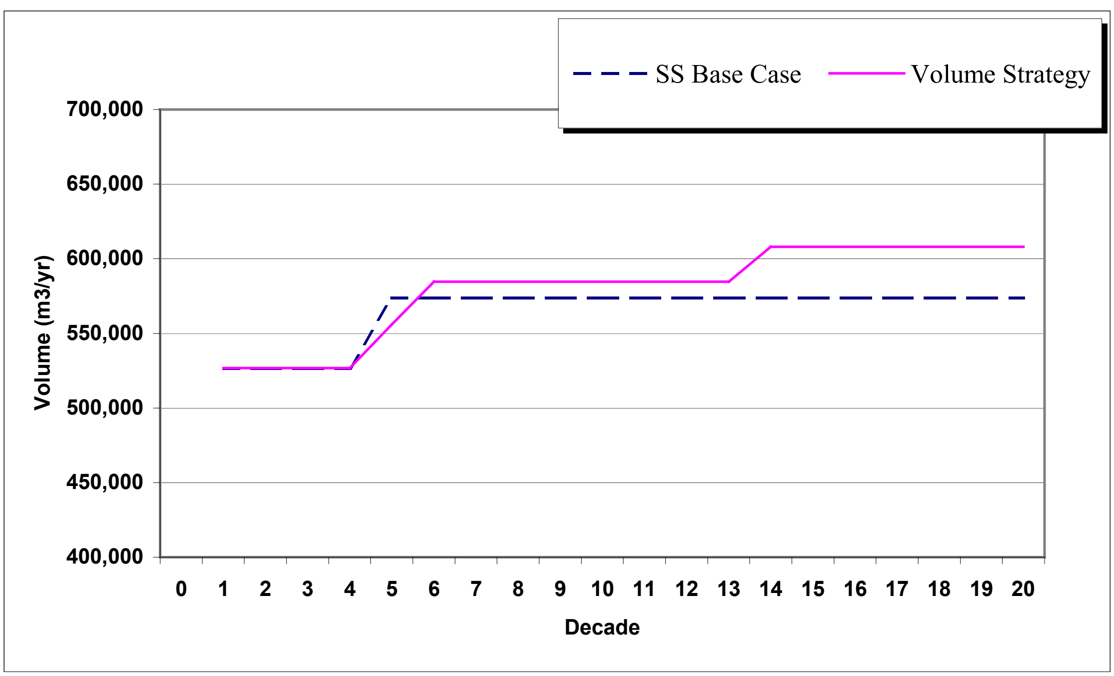

Figure 9 – Harvest flow; volume strategy and silviculture strategy base case

Figure 10 compares the average harvest ages between the silviculture strategy base case and the volume strategy. The figure shows that the average harvest age is somewhat higher when maximizing for volume; some spacing, pruning and commercial thinning treatments reduce per hectare stand yields and the stands are generally held a bit longer before they are harvested.

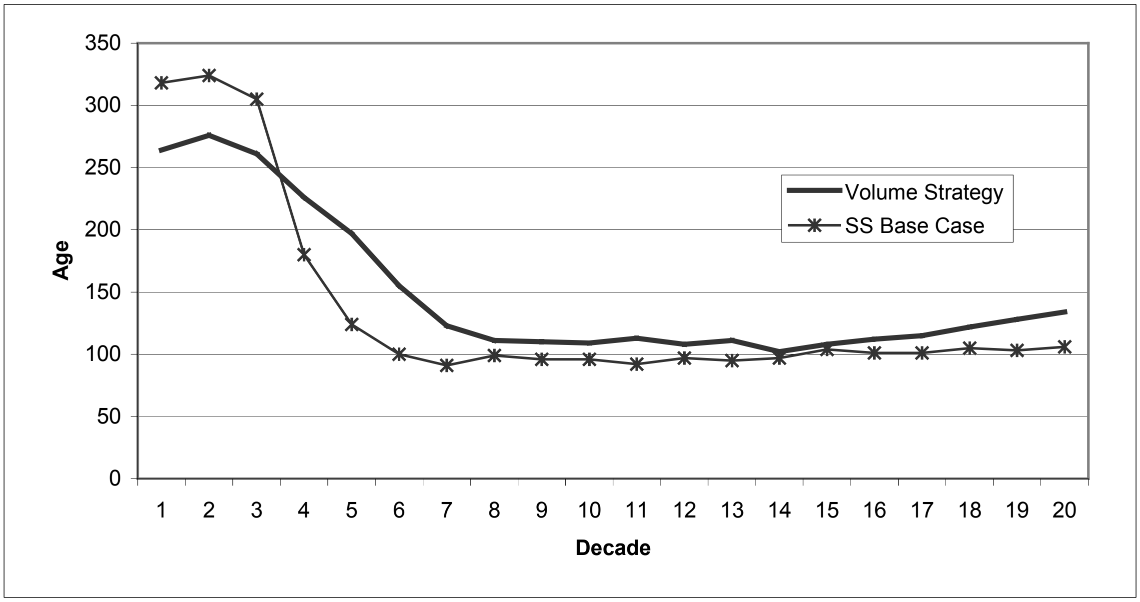

Figure 10: Average harvest age, volume strategy and silviculture strategy base case.

As expected, the average per hectare harvest volume for the volume strategy tends to be lower than the silviculture strategy base case (Figure 11). Spaced and commercially thinned stands are harvested with less volume per hectare at final harvest.

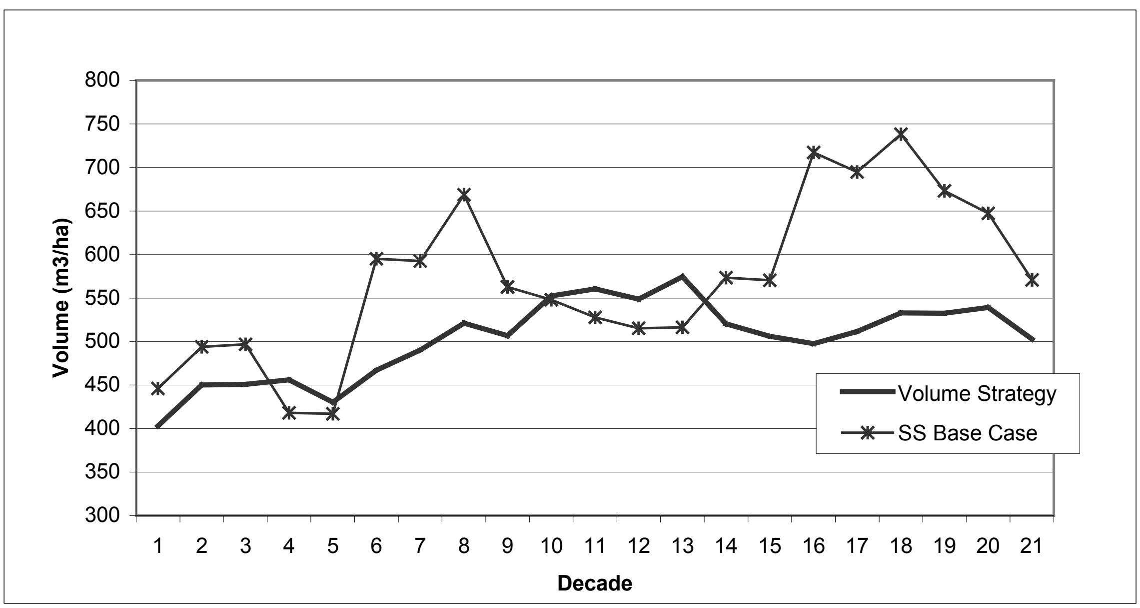

Figure 11: Average harvest volume per hectare, volume strategy and silviculture strategy base case.

Figure 12 shows the piece size comparison (m^3/tree) over time between the volume strategy and the silviculture strategy base case for managed stands. Silviculture produces a significantly larger piece size over time due to spacing and commercial thinning treatments.

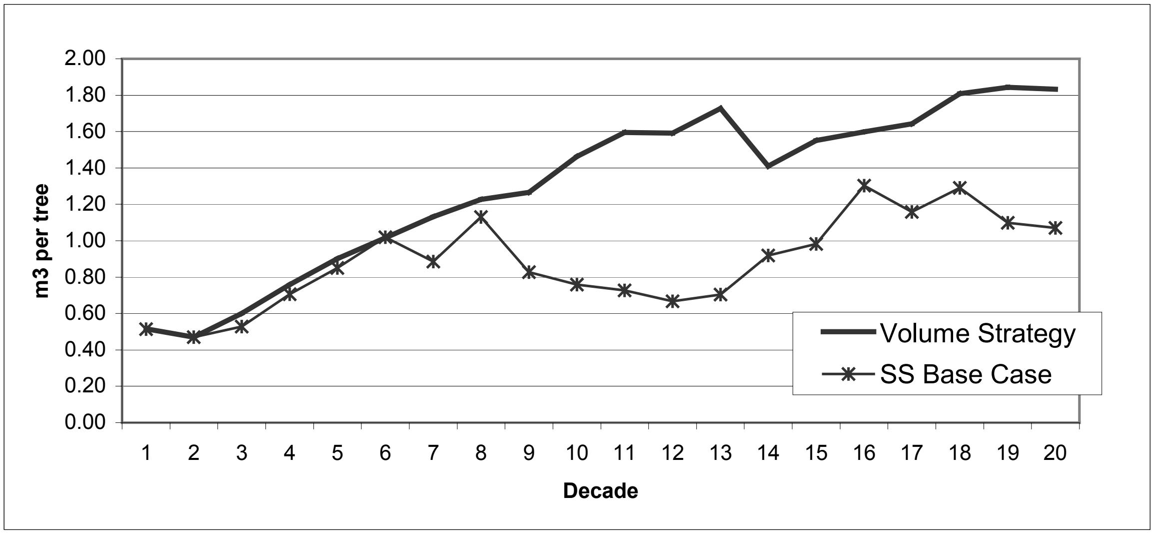

Figure 12: Average piece size; volume strategy and silviculture strategy base case.

Although improving value was not an objective for this scenario, silviculture treatments employed to increase volume flow had an impact on predicted timber value as can be seen from the higher average cubic metre value for the maximize volume scenario (Figure 13).

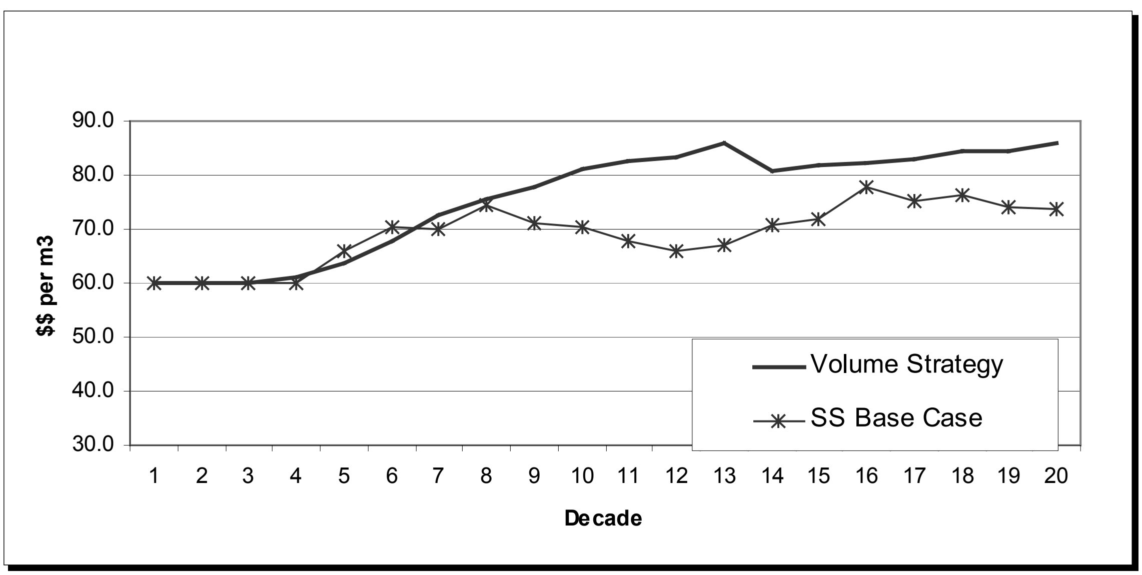

Figure 13 – Predicted harvest value per m^3 for all stands; volume strategy

Figure 14 shows the average annual treatment areas over the next 100 years for the volume strategy. On average, approximately 640 hectares are spaced to varying densities and just over 700 hectares are commercially thinned every year. A relatively minimal area (less than 30 hectares) is fertilized in periods 7 through 10 (not shown).

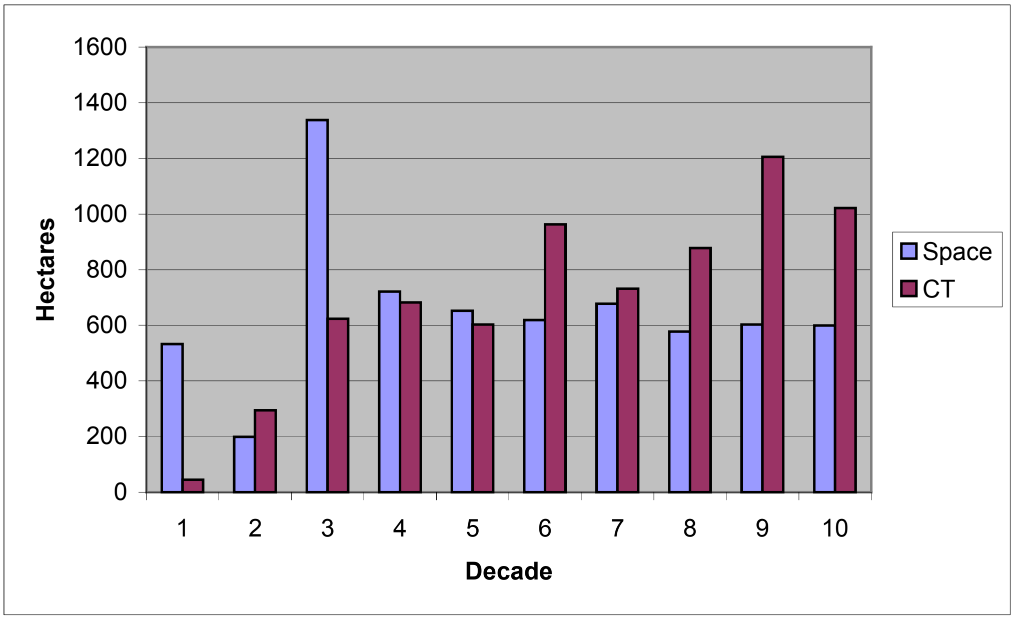

Figure 14 – Annual (ha) spacing and commercial thinning; volume strategy

9.6 Silviculture Strategy Value Scenarios

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

Figure 15 illustrates the harvest level used in the value strategy scenarios compared to the volume strategy (Scenario 7) and silviculture strategy base case (Scenario 6). The harvest level for the value strategies was fixed for each budget level to maintain consistency in timber supply for purposes of comparison. This harvest level was selected based on the volume flow of the silviculture strategy base case with a 10% tolerance to allow for flow dynamics. With the harvest level fixed, the model was allowed to produce near-optimal solutions based on the total discounted value of the profit of all stands over the planning horizon.

As can be seen from Figure 15, the harvest level remains below the level of the silviculture strategy base case (6) and the volume strategy (7). This is expected, as the objective was to optimize for value, not volume. It may not be possible to maintain high harvest levels profitably when there is some harvesting of marginal timber. Figure 15 reveals that the long-term harvest level tends towards the lower end of the 10% tolerance for all value scenarios which indicates that optimal harvest flow for profit maximization is less than in the silviculture strategy base case, and significantly less than for volume maximization. These results are largely dependent on market pricing and cost assumptions.

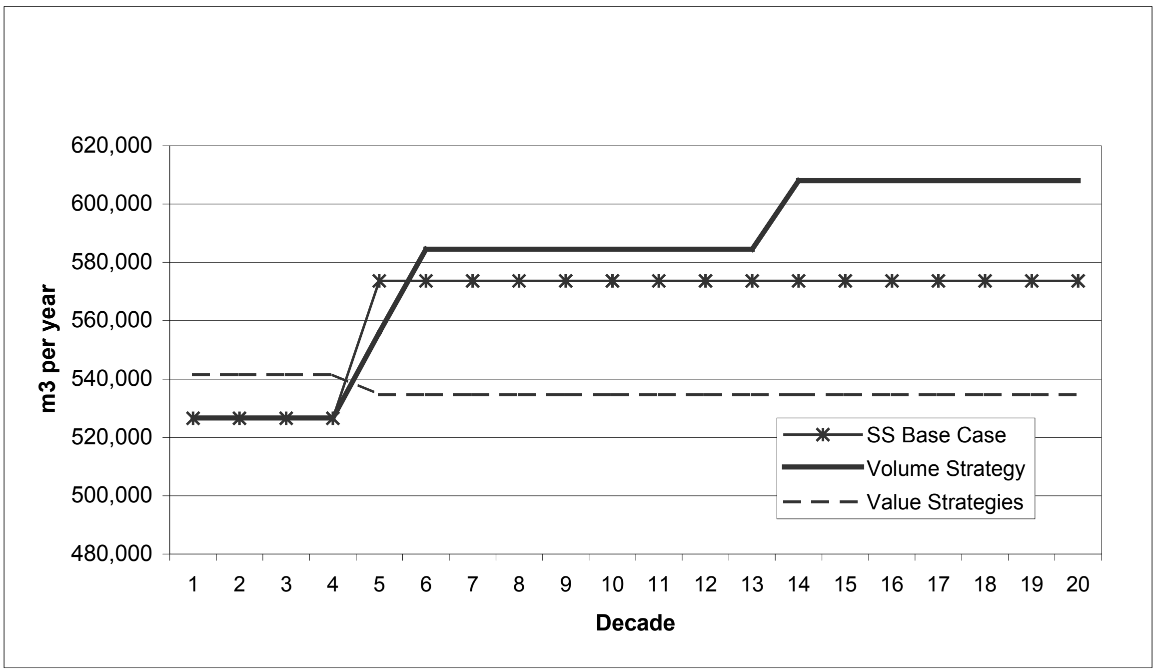

Figure 15 – Harvest flow; value strategies

Three scenarios were run to test the impact of different levels of investment on value. The budget levels were 0.5, 1 and 2.5 million dollars; however, due to tolerance given to the model in applying the budget, expenditures were not exactly equal to available budget. The actual average silviculture expenditures over the next 100 years were as follows:

Table 9 – Set versus actual budget levels, net of CT; value scenarios

Set Annual Investment Level ($)	First 100-Year Average ($)
$0.5 Million	$478,251
$1.0 Million	$883,135
$2.5 Million	$1,466,847

Figure 16 compares the average harvest ages between the silviculture strategy base case and the value scenarios. The figure shows that the average harvest age is higher when attempting to achieve higher value stands; the stands are generally held a bit longer before they are harvested as some spacing, pruning and commercial thinning treatments may reduce stand yields.

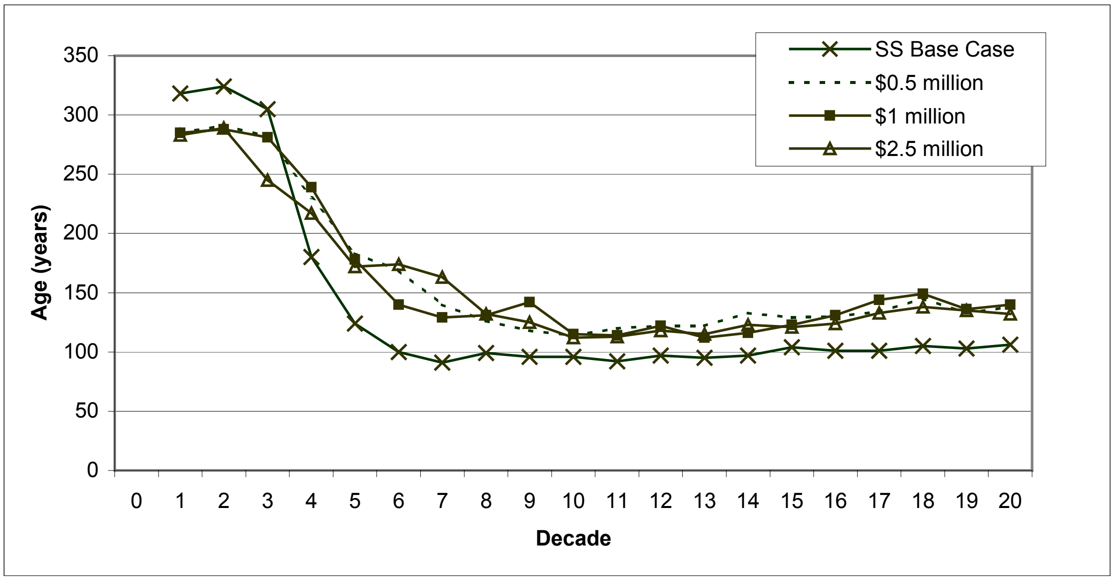

Figure 16 - Average harvest age, silviculture strategy base case and value scenarios

The average per hectare harvest volumes for the value scenarios are shown in Figure 17.

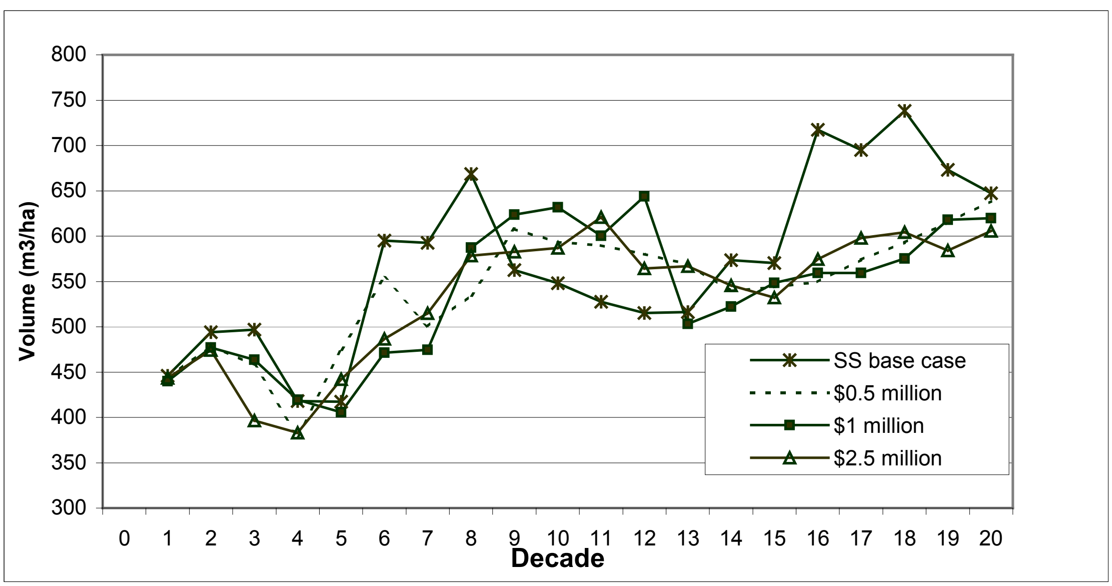

Figure 17: Average harvest volume per hectare, value scenarios

Figure 18 shows the piece size comparison (m^3/tree) between the value scenarios and the silviculture strategy base case. The value scenarios produce significantly larger piece sizes over time due to spacing and commercial thinning treatments. However, it appears that investing beyond $0.5 million annually does not increase the average piece size significantly.

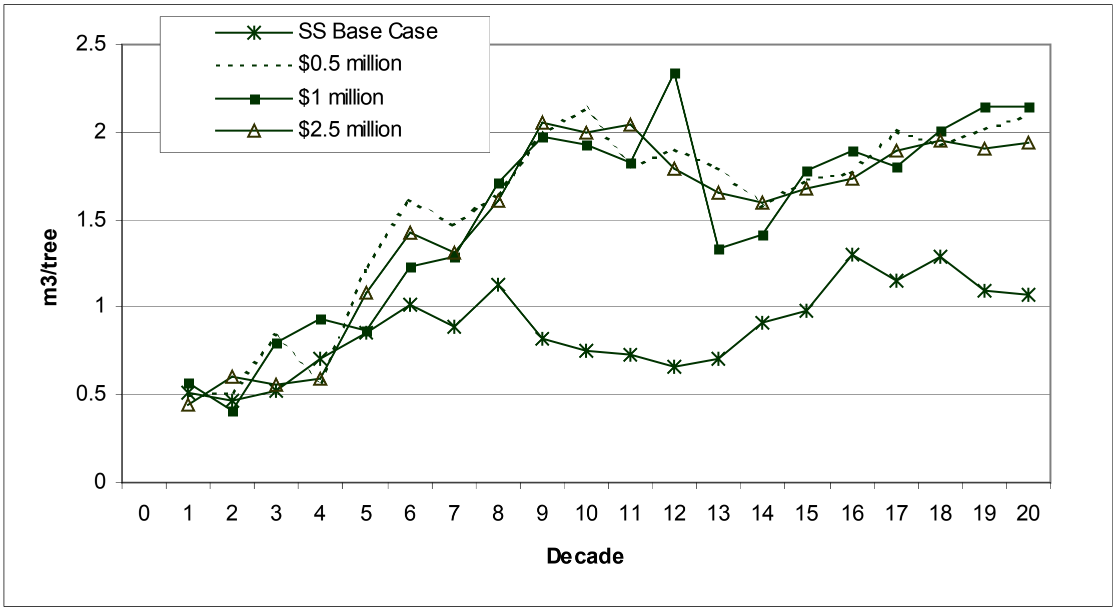

Figure 18: Average piece size; silviculture strategy base case and value scenarios.

Figure 19 shows the predicted per cubic metre values for the different value scenarios. As expected, the highest value occurs with the highest level of investment, however, the differences between the value scenarios are not significant.

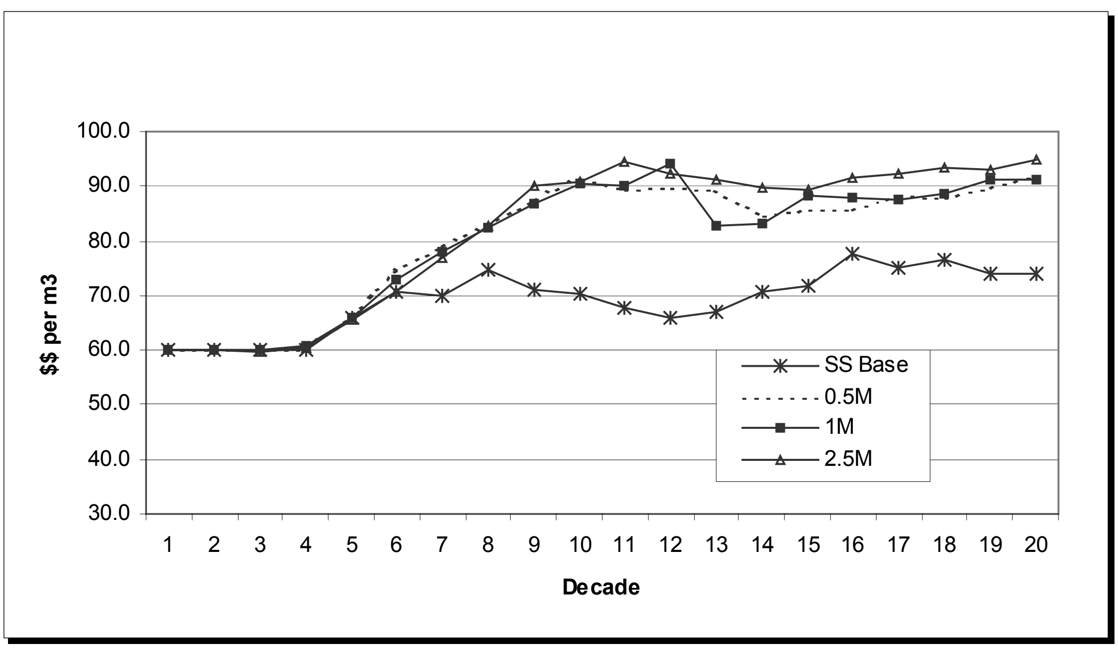

Figure 19 - Predicted harvest value per m^3 for all stands; value strategies

Figures 20 and 21 show the spacing and pruning treatments for the $0.5 million, 1 million and 2.5 million silviculture budget scenarios. The $2.5 million scenario invests more in both spacing and pruning; however, the total increase in investment is most pronounced for pruning since it is the highest cost treatment.

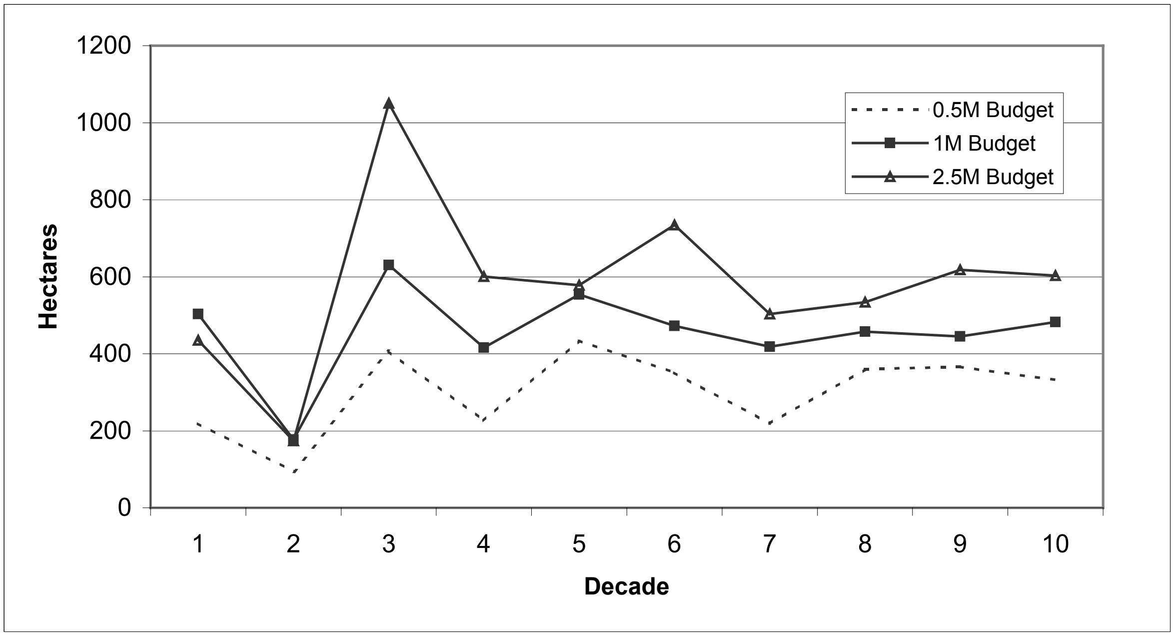

Figure 20 – Annual spacing (ha); value scenarios

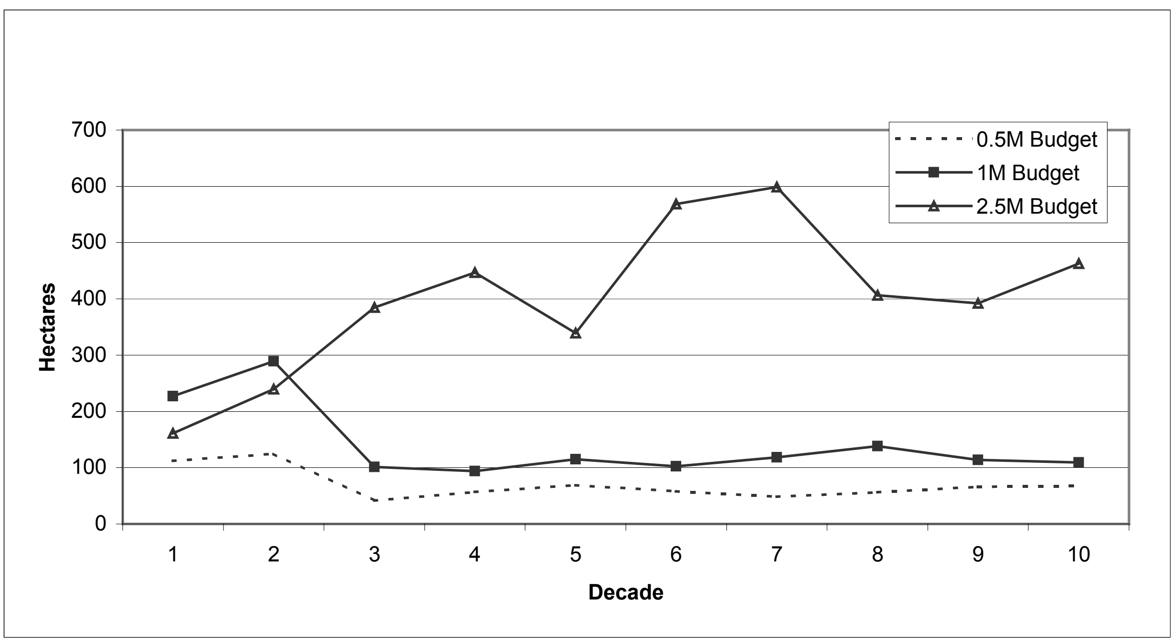

Figure 21 - Annual pruning (ha); value scenarios

Figure 22 illustrates the proposed annual commercial thinning areas for each of the value scenarios. As can be seen from the figure, there is no relationship between the budget and the annual commercial thinning activity. This is expected, as commercial thinning revenues, in many cases, offset commercial thinning expenditures. As a result, the commercial thinning activity is only marginally dependent on the set budget level in this analysis.

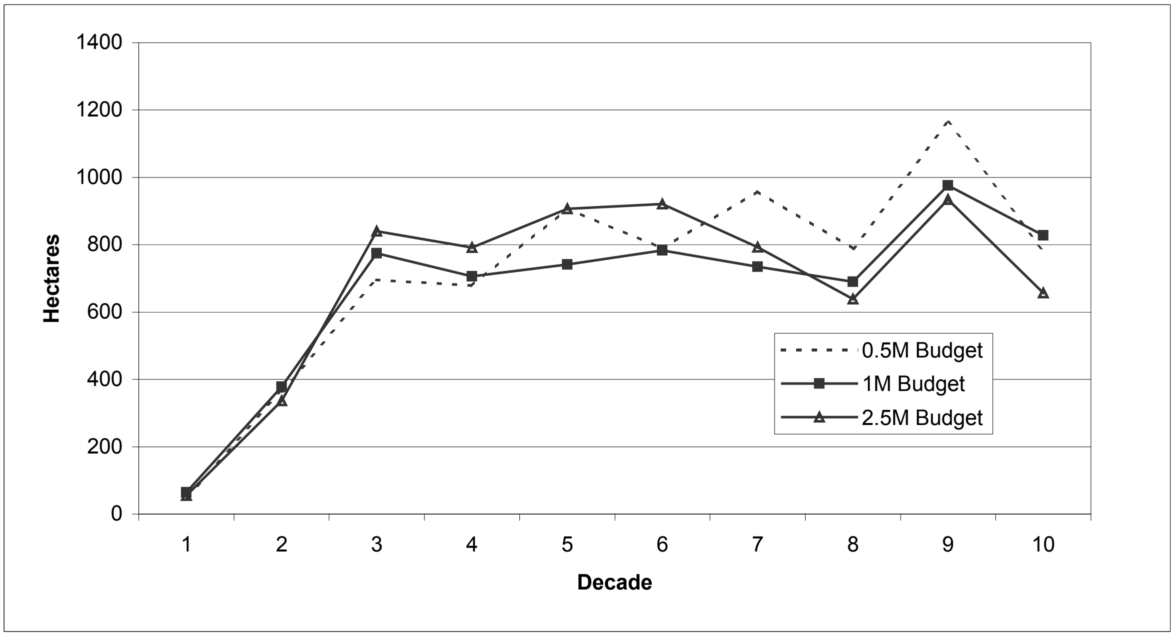

Figure 22 - Annual commercial thinning (ha); value scenarios

9.7 Silviculture Strategy Preferred Option

The development of a preferred scenario incorporates understanding and results from the previous scenarios to present a solution that satisfies more than a single emphasis. This solution represents an attempt to balance the benefits identified in the previous scenarios.

As presented in the value strategy scenarios (Section 9.6), the assessment of different budget levels indicated that the piece size and value per cubic meter improved only marginally beyond expending $0.5 million annually in incremental silviculture. However, the achieved harvest in the value scenarios was lower than the SS base case harvest level. A decision was made that the preferred option should attempt to meet the SS base case harvest level, while creating value through silviculture. Several analysis runs at different budget levels indicated that approximately $1 million annual incremental silviculture expenditures (net of CT costs) were required to maintain harvest flow at the SS base case level while producing higher quality stands.

9.7.1 Proposed Incremental Silviculture Strategy

Figure 23 and Table 10 summarize incremental annual silviculture treatments by 10-year periods over the next 100 years with the average annual budget of $1.1 million. Over the first 20 years, almost 8,383 ha of spacing and over 8,780 ha of pruning are scheduled.

Commercial thinning plays an important role throughout the first century. It is required to maintain the harvest flow.

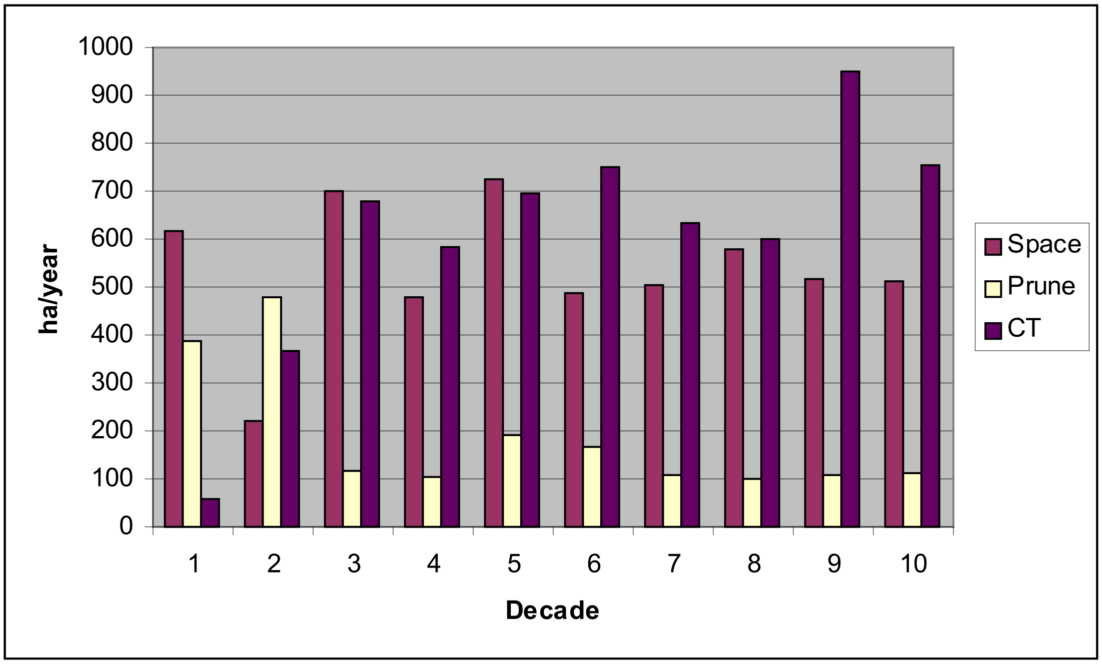

Figure 23 – Annual silviculture treatments (ha/yr); preferred scenario

Table 10 – Annual silviculture treatments (ha/yr); preferred scenario

Decade	CT	Fertilize	Space	Prune
1	56	0	617	389
2	366	0	221	480
3	678	0	700	117
4	582	0	479	102
5	695	1	726	191
6	749	0	487	168
7	634	11	503	107
8	600	6	580	101
9	951	3	517	108
10	754	3	511	112

While area treated is dominated by spacing and commercial thinning there is also significant amount pruning, particularly during the first two decades. The spacing area includes those spacing treatments that are carried out in conjunction with pruning.

Table 11 examines the proposed treatments in more detail showing the annual areas treated by different regimes for the first 100 years.

Table 11 - Proposed detailed regimes for the silviculture strategy

Decade	CT 1	CT 1000	CT 1200	CT 1600	CT 600	CT 750	CT2	CT2 1200	Fert	Fert 1000	Fert 1200	Fert 600	Fert 800	Fert CT	Prune 2 1000	Prune 2 600	Prune 2 800	Space 1000	Space 1200	Space 1400	Space 1600	Space 600	Space 750	Space 800	Space Prune 1 1000	Space Prune 1 600	Space Prune 1 800	Total
1	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83	80	8	9	33	4	9	79	159	151	673
2	366	0	0	0	0	0	0	0	0	0	0	0	0	0	0	79	159	27	36	7	3	20	15	23	17	31	43	976
3	661	7	0	0	7	2	0	0	0	0	0	0	0	0	0	17	31	160	173	70	25	111	94	40	10	10	6	1469
4	460	11	34	0	1	1	76	0	0	0	0	0	0	0	0	10	10	89	116	15	27	77	43	34	16	36	25	1087
5	299	42	18	0	47	40	249	0	0	0	0	0	0	0	1	16	36	99	221	45	46	101	62	38	12	41	61	1497
6	312	45	75	0	53	74	155	34	0	0	0	0	0	0	0	12	41	89	144	33	39	57	28	44	8	34	11	1350
7	179	133	43	0	60	40	164	16	0	0	0	0	1	10	0	8	34	102	173	17	26	66	31	35	11	18	25	1202
8	99	46	108	3	50	48	170	75	0	2	0	0	2	2	0	11	18	139	147	30	19	89	66	42	14	11	22	1239
9	563	40	104	0	56	32	114	43	0	0	3	0	0	0	0	14	11	128	132	37	30	69	39	22	15	20	24	1520
10	296	85	124	0	45	54	42	108	0	0	0	0	2	1	0	15	20	109	143	28	29	54	53	43	13	20	20	1327
Total	**3292**	**407**	**506**	**3**	**319**	**291**	**970**	**276**	**0**	**2**	**3**	**0**	**5**	**12**	**1**	**182**	**360**	**1025**	**1365**	**289**	**253**	**677**	**435**	**332**	**195**	**380**	**389**	**12340**

Commercial thinning treatments concentrate on those treatment regimes that do not include spacing. Commercial thinning without spacing (first commercial thinning) is the treatment of choice in about 50% of all the commercial thinning during the first 100 years. Second commercial thinning is the next popular choice with 19% area. Little commercial thinning is combined with other treatments, particularly at the beginning of the planning horizon. Starting from the 3rd decade, existing spaced stands receive some commercial thinning treatments.

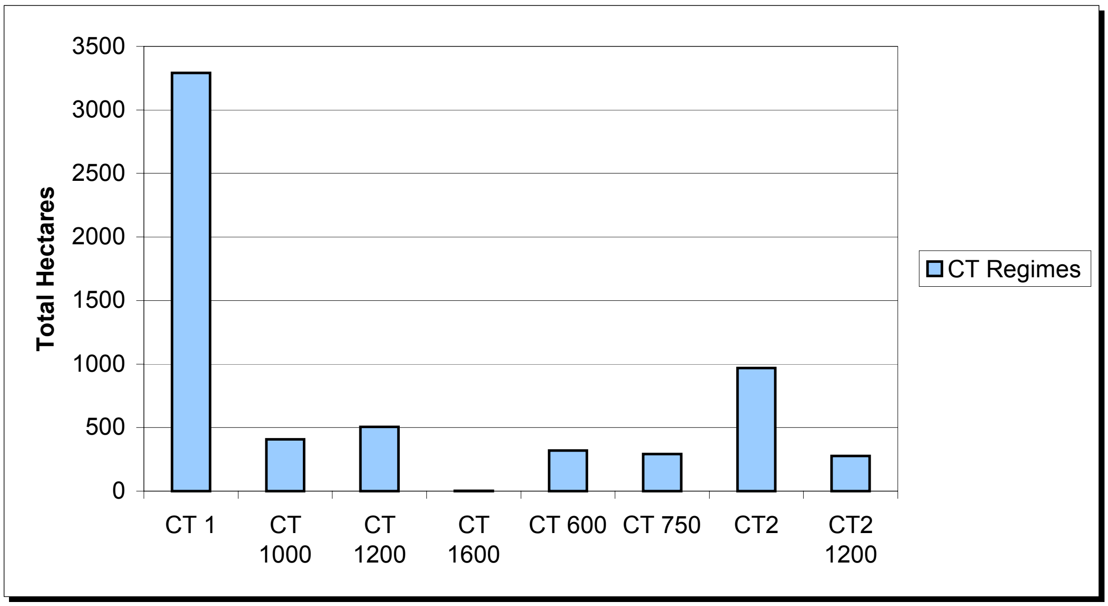

Figure 24 – Commercial thinning treatments, first 100 years

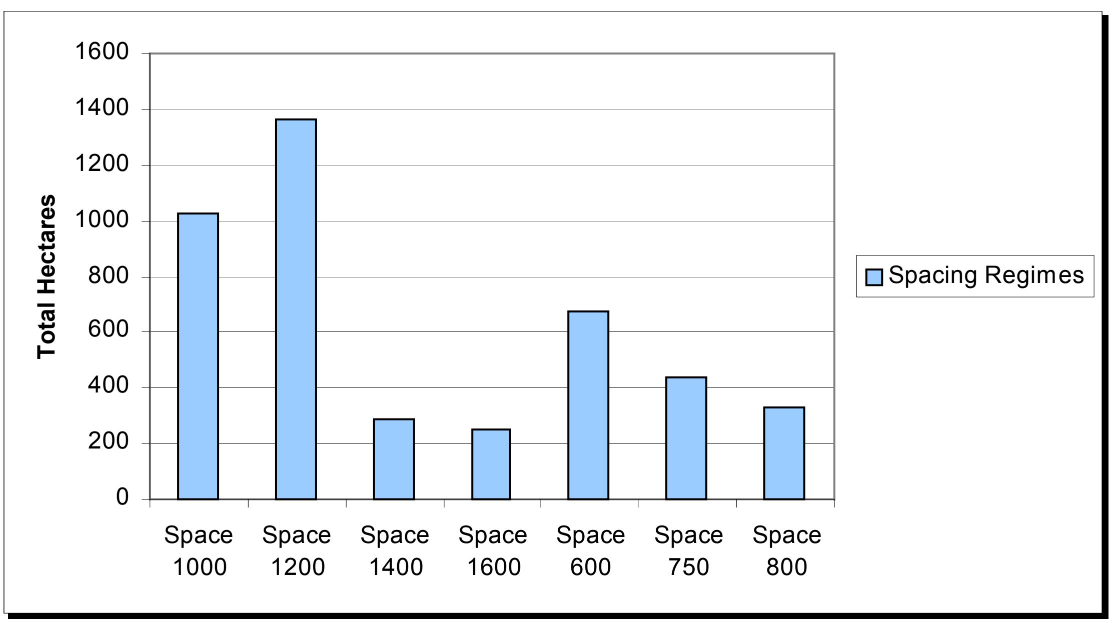

Figure 25 – Spacing treatments, first 100 years

Spacing concentrates on treatments with relatively high densities of trees after treatment. The regimes with 1,000 and 1,200 leave trees are the most popular, however some of the lower density regimes were chosen as well as shown in Figure 25.

Pruning treatments were all combination treatments with spacing. Figure 26 illustrates the total area pruned in the preferred scenario by pruning regime over the first 100 years. Most pruning occurred in combination with spacing to 600 and 800 stems per hectare.

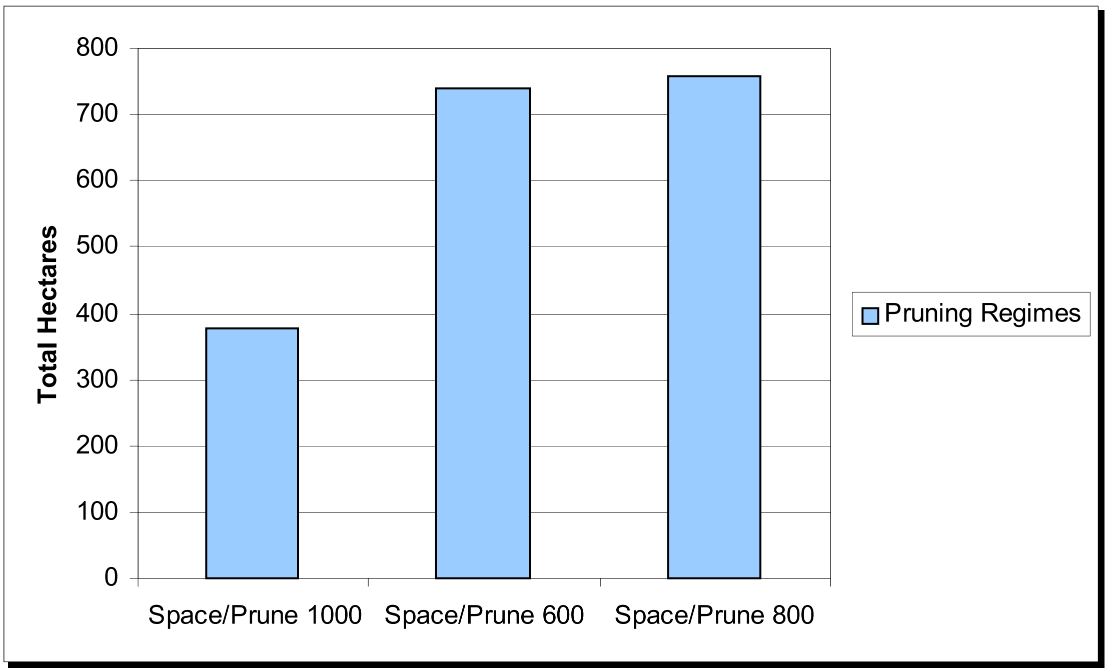

Figure 26 – Pruning treatments, first 100 years

The following table illustrates how treatment totals are divided between analysis units during the first 2 decades. Most treatments occur on sites with site index greater than 24 (60% to 70% of all treatments).

Table 12 - Distribution of treatments between analysis units

Decade	Hw SI <20	Hw SI 20-24	Hw SI 24.1-28	HW SI >28	Pine	Total
1	4.28%	30.58%	34.73%	26.08%	4.33%	100.00%
2	1.55%	20.46%	24.88%	45.52%	7.59%	100.00%

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

- ***Commercial Thinning:*** Only 56 hectares per year are proposed throughout the first 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. Most treatments occur in Hw stands with the site index greater than 28.

- ***Spacing:*** A total of 228 hectares of annual spacing treatments are proposed for the first decade. Hemlock sites with site index between 20 and 23.9 receive approximately 37% of this treatment. Hemlock with site index between 24-27.9 has a 30% share and those hemlock sites with the site index greater than > 28 have a 19% share.

- ***Space/Prune:*** A total of 389 hectares annually are proposed during the first decade of the planning horizon

Table 13 reiterates the proposed annual commercial thinning, spacing and pruning treatments for the first decade in more detail. Hemlock stands with site index between 20 and 24 receive approximately 31% of this treatment. Hemlock sites with site index between 24.1-28 have a 41% share and those hemlock sites with the site index greater than > 28 have a 21% share.

Table 13 - Proposed regimes; first decade

Analysis Unit	CT		Space		Space/prune		Total
	ha	%	ha	%	Area	%	
Hw SI <20	0	*0*	29	*12.7*	0	*0*	29
Hw SI 20-24	0	*0*	85	*37.3*	121	*31.1*	206
Hw SI 24.1-28	4	*7.1*	69	*30.3*	161	*41.4*	234
HW SI >28	52	*92.9*	44	*19.3*	80	*20.6*	176
Pine	0	*0*	1	*0.4*	28	*6.9*	29
Grand Total	**56**	***100***	**228**	***100***	**389**	***100***	**673**

The combination of spacing and first pruning use 79% of the incremental silviculture budget during the first decade, while the rest (21%) consists of different spacing treatments.

9.8 Anticipated Silviculture Strategy Outcomes

9.8.1 Harvest Flow

Figure 22 compares the short, mid and long-term harvest level for the SS base case, volume maximization, value strategies and the preferred scenario. While there are differences between the resulting harvest levels, the preferred scenario represents a balanced solution between volume and value.

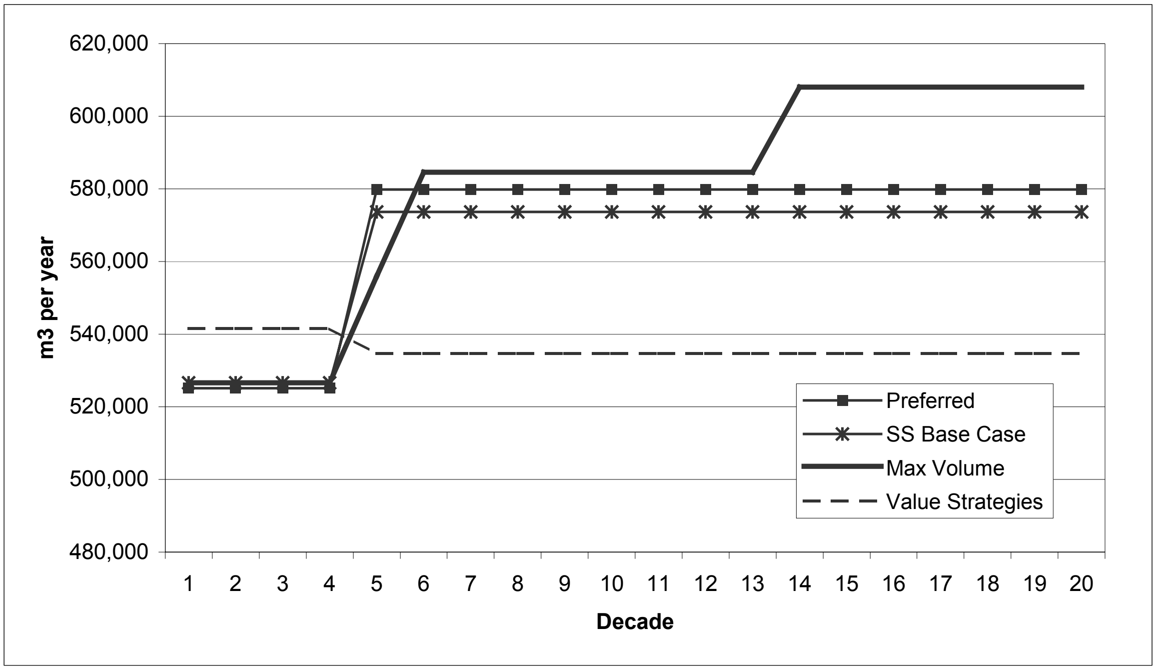

Figure 27 - Harvest level; preferred scenario

Figure 28 shows the transition from existing stands to managed stands for the silvilculture strategy. The transition occurs later than in the SS base; stands are held longer as a result of reduced per hectare yields due to spacing and commercial thinning.

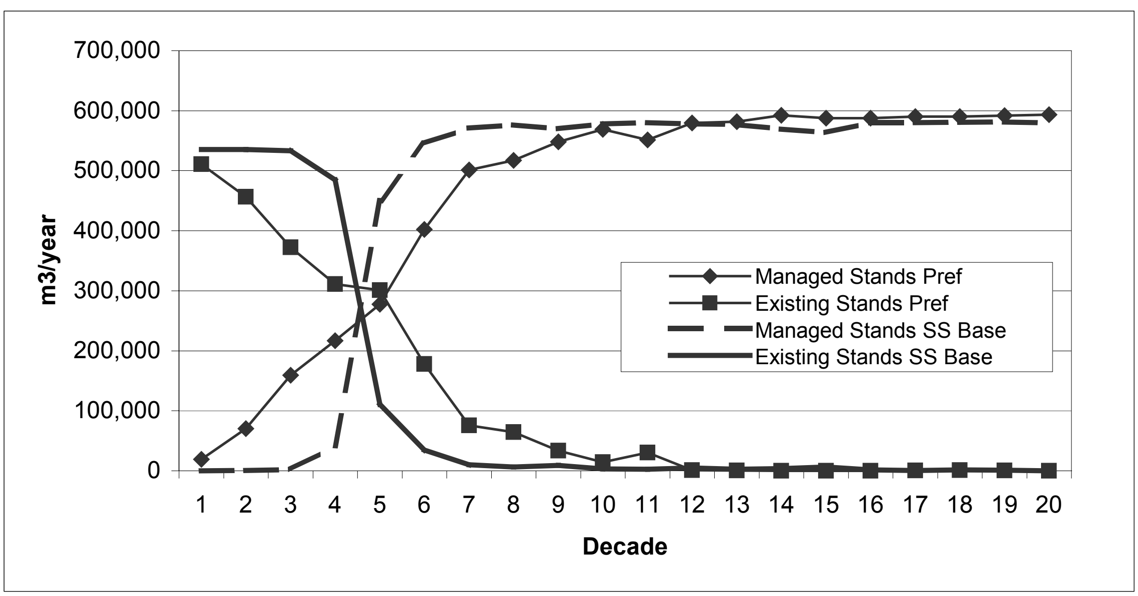

Figure 28 - Transition from existing to managed stands; preferred scenario

Figure 29 shows the average harvest age for the preferred scenario compared to the SS base case, volume maximization and the 2.5 million value scenario. The average harvest age is slightly higher for the preferred scenario than that in the SS base case. The same reason that delayed the transition to managed stands increases the average harvest age; spacing and commercial thinning reduce yields and require longer rotations.

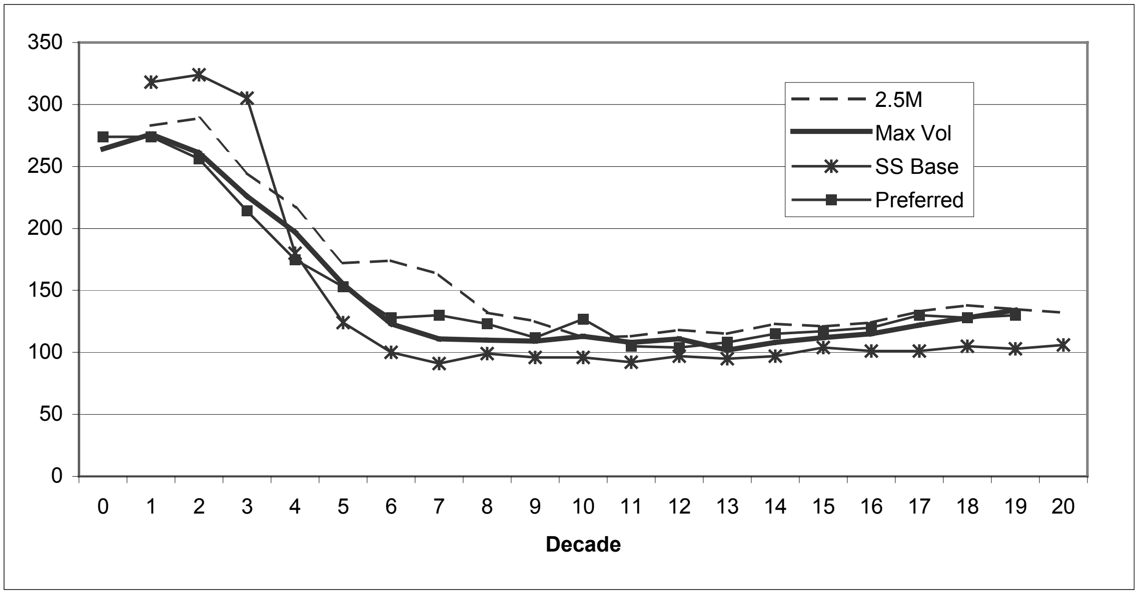

Figure 29 - Average harvest age, preferred scenario

9.8.2 Piece Size

Figure 30 illustrates the predicted piece size of the preferred scenario over the TSA compared to the SS base case, volume maximization and the $2.5 Million value scenario. As can be seen from the graph, the proposed strategy produces a higher mean diameter than the SS base case but does not significantly differ from the piece size achieved in the other two scenarios.

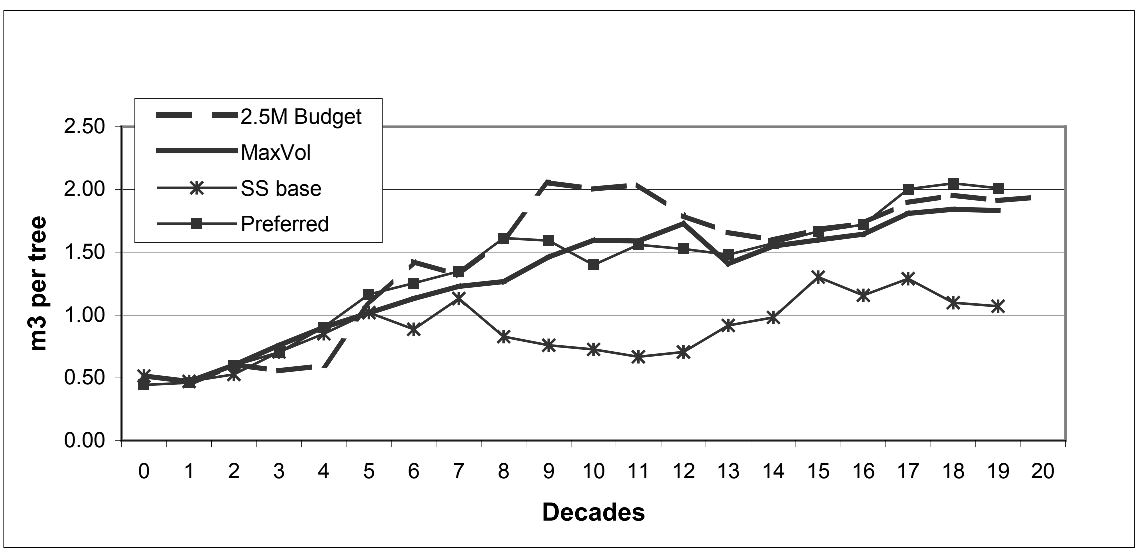

Figure 30 - Predicted piece size for the preferred scenario

9.8.3 Value and Quality

Figure 31 compares the predicted value per cubic meter between the preferred scenario, SS base case, volume maximization and the $2.5 million value scenario. The value per cubic meter is derived from the log values, which form part of the input data in the analysis as described in the Analysis Information Package. The log values are assumed to remain constant throughout the planning horizon. The gain in the value per cubic meter is achieved through larger log sizes and clear wood. Spacing and fertilization can increase the sizes of logs and pruning creates clear wood.

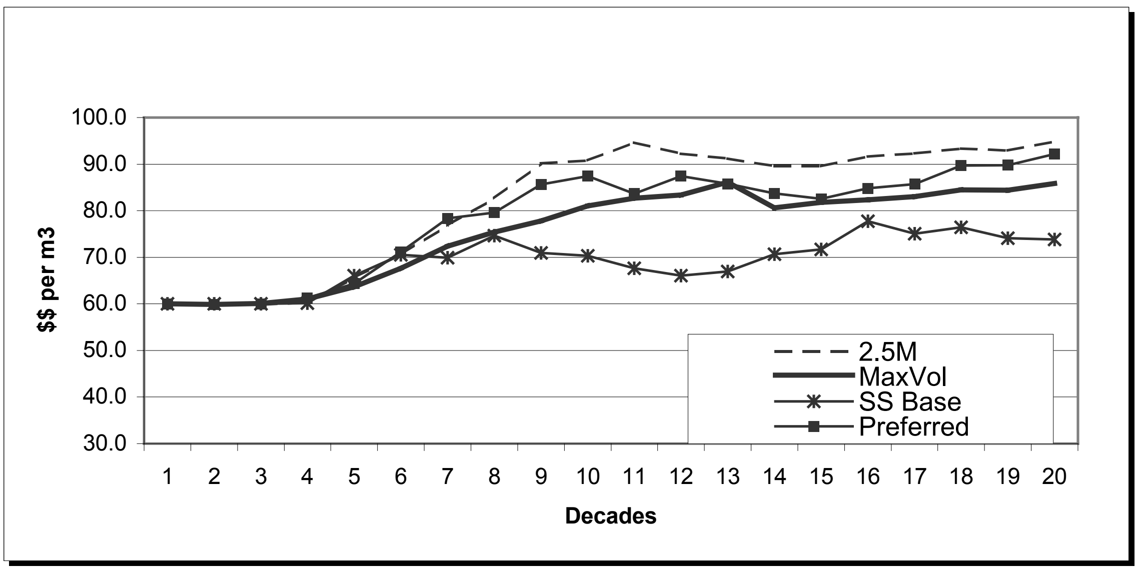

Figure 31 – Predicted value per cubic meter for all stands; preferred scenario

The preferred scenario does not quite reach the per cubic meter value of the $2.5 million value scenario. However, the preferred scenario value stays well above the SS base case. The high per cubic meter value for the $2.5 million value scenario is primarily due to significant expenditures on pruning.

9.8.4 Employment

Tables 14 and 15 illustrate the short- and long-term employment created by incremental silviculture. In the short-term, incremental silviculture creates mostly direct jobs associated with silviculture treatments. The long-term employment opportunities are related to the projected changes in harvest level. The long-term employment created by the preferred scenario is essentially the same as that of the silviculture strategy base case; the harvest level for these two scenarios was identical. Employment multipliers were derived from the TSR II Socio-Economic Analysis compiled by the Economics and Trade Branch of the Ministry of Forests.

There is no direct relationship between the preferred scenario and SS base case harvest level with the TSR II base case, and subsequent employment in the Kalum TSA. The purpose of the employment comparison is to show potential 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.

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

Table 14 - Short-term employment benefits

Year	Space	Prune	Fertilize	CT	Total
1	19.0	12.0	0	1.6	32.6
2	19.0	12.0	0	1.6	32.6
3	19.0	12.0	0	1.6	32.6
4	19.0	12.0	0	1.6	32.6
5	19.0	12.0	0	1.6	32.6
Sub Total	**95.1**	**60.0**	**0**	**7.8**	**162.9**
6-10	95.1	60.0	0	7.8	162.9
11-15	34.1	91.2	0	50.8	176.1
16-20	34.1	91.2	0	50.8	176.1
Total 20 Years	**258.4**	**302.5**	**0**	**117.2**	**678.1**

Table 15 - Long-term employment benefits[a]

Decade	Harvest ('000)	TSA Jobs by Decade	Provincial Jobs by Decade
1	525	3,991	4,936
2	525	3,991	4,936
3	525	3,991	4,936
4	525	3,991	4,936
5	580	4,407	5,450
6	580	4,407	5,450
7	580	4,407	5,450
8	580	4,407	5,450
9	580	4,407	5,450
10	580	4,407	5,450
11	580	4,407	5,450
12	580	4,407	5,450
13	580	4,407	5,450
14	580	4,407	5,450
15	580	4,407	5,450
16	580	4,407	5,450
17	580	4,407	5,450
18	580	4,407	5,450
19	580	4,407	5,450
20	580	4,407	5,450
Total	**11,377**	**86,468**	**106,947**

[a]Multipliers as per TSR II; TSA 0.76, Province 0.94 per 1,000 m^3 of AAC

9.9 Discussion

9.9.1 Stand Yields

The majority of the timber supply in the Kalum TSA consists of hemlock leading stands. As hemlock stands are not generally considered good candidates for fertilization, there are limited incremental silviculture treatments available that are known to increase managed stands yields in the TSA. In fact, many of the available treatment regimes reduce stand yields as modeled by TASS. Figures 32-35 demonstrate the impact of the most common spacing and commercial thinning regimes in the preferred scenario on yield at the stand level. The figures show the stand yields for the default stand density and for all site index classes.

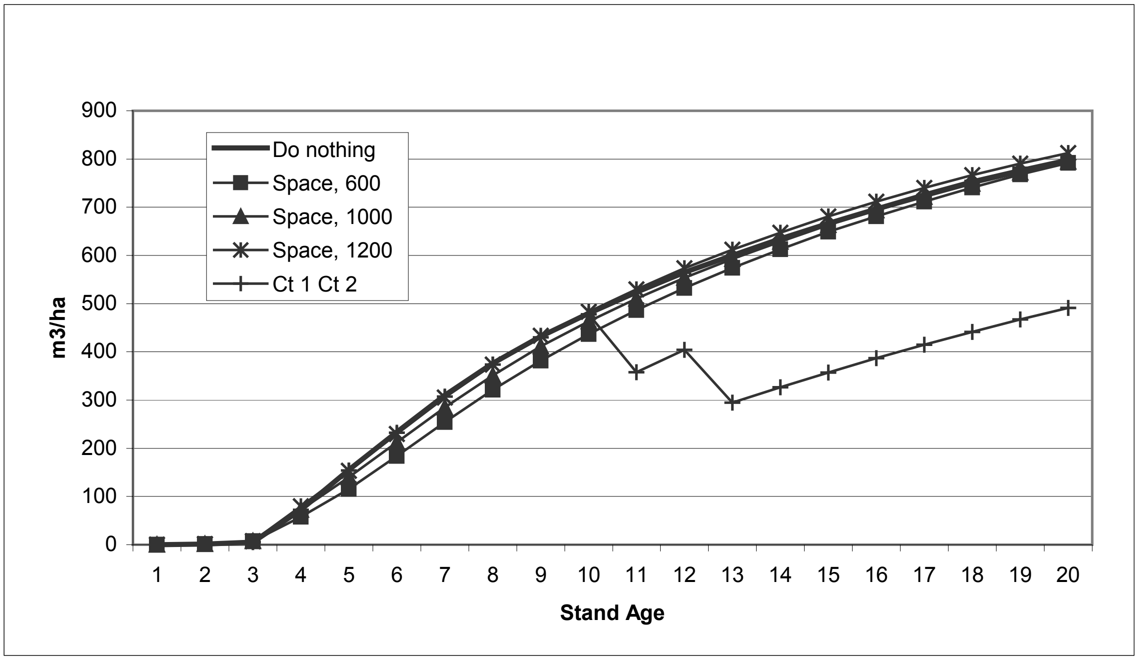

Figure 32 – Predicted Stand Yield as per TASS, Hw, SI=18, Density 3500-5000

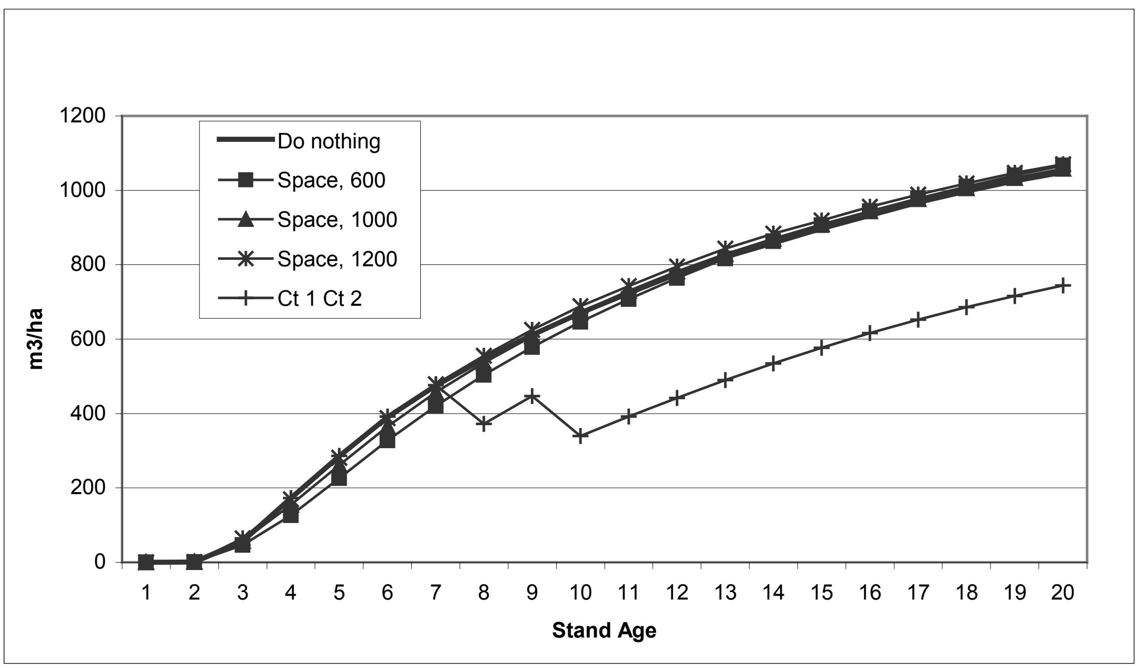

Figure 33 - Predicted Stand Yield as per TASS, Hw, SI=22, Density 3500-5000

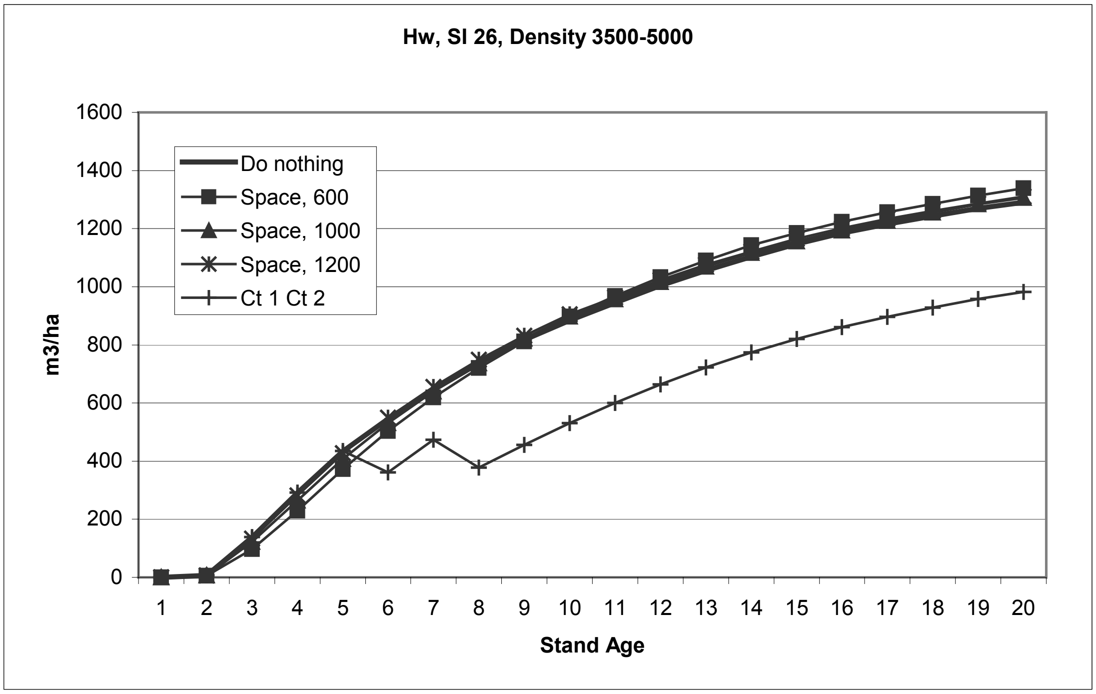

Figure 34 - Predicted Stand Yield as per TASS, Hw, SI=26, Density 3500-5000

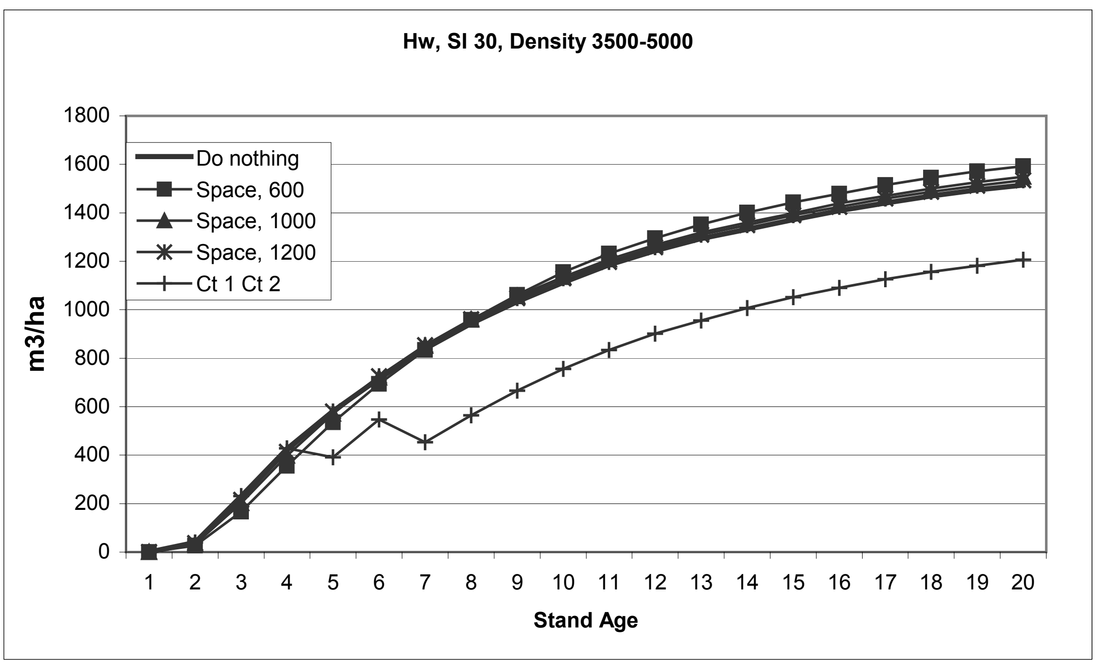

Figure 35 - Predicted Stand Yield as per TASS, Hw, SI=28, Density 3500-5000

Figures 32, 33, 34 and 35 demonstrate that in lower site classes spacing generally lowers stand yields. In better site classes the more aggressive treatments, such as spacing down to 600 stems per hectare, lower stand yields as well. However, some of the denser spacing regimes, such as 1,200 stems per hectare, produce somewhat higher stand yields in TASS, particularly later in the planning horizon.

The above silviculture treatment impacts on stand yields are a significant factor in this analysis. The model often chose an aggressive spacing regime that reduced the stems down to 600 per hectare. This choice was likely the result of attempting to increase the value of managed stands through larger piece sizes. However, this treatment regime reduces stand yields and puts significant downward pressure on the harvest at the forest level.

As maintaining the harvest at a desired level was also an important objective along with harvest value, those denser spacing regimes (1,000 and 1,200 stems per hectare) that increased yields were also chosen to compensate for the above yield losses. The same applies to commercial thinning. It was necessary to use commercial thinning extensively to meet the harvest flow targets for different decades throughout the planning horizon.

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

- Spacing regimes that increased yields were favored;
- Commercial thinning was used to meet the harvest targets when necessary;
- Annual budgets were allowed to vary indiscriminately from one decade to another. This is not realistic with most government funded silviculture programs.

9.9.2 Average Harvest Age vs. Minimum Harvest Age

Several figures in this report illustrate the average harvest age over the planning horizon for different silviculture investment scenarios. There are many factors impacting the average harvest age. Among those are:

- Age class distribution of the timber harvesting land base and non-timber harvesting land base;
- Cover constraints;
- Expected annual harvest flow;
- Minimum harvest ages.

Minimum harvest ages define the minimum age at which a stand can be harvested. In this analysis, minimum harvest ages were defined based on a minimum per hectare volume, diameter at breast height and mean annual increment. Table 16 shows the minimum harvest ages for all analysis units in the analysis with no incremental silviculture treatments incorporated as in the SS base case.

Table 16 – Minimum Harvest Ages

Species	Site Index	Density	MHA
Hw	18	350	92
Hw	18	600	80
Hw	18	1000	73
Hw	18	2500	93
Hw	18	5000	104
Hw	18	7000	110
Hw	22	350	68
Hw	22	600	60
Hw	22	1000	60
Hw	22	2500	70
Hw	22	5000	80
Hw	22	7000	82
Hw	26	350	60
Hw	26	600	60
Hw	26	1000	60
Hw	26	2500	60
Hw	26	5000	60
Hw	30	1000	60
Hw	30	2500	60
Hw	30	5000	60
Hw	30	7000	60
Pl	22	5000	80

As can be seen from Table 16, the minimum harvest age in most analysis units is 60 with few close to 100 and over. Yet, the average harvest age in the SS base case analysis run (figure 10) is around 100 years over the long run. This indicates that the average harvest age is affected by factors other than the minimum harvest age. Cover constraints, particularly old growth targets and green-up are likely to have the greatest impact.

Many stand level silviculture analyses draw conclusions over the impact of incremental silviculture on stand rotations. It is often believed that incremental silviculture can reduce stand rotations without compromising harvested volumes. This can be true, particularly when fertilization is used as a silvicultural tool.

In the Kalum TSA there is very little potential for fertilization due to the prevalence of hemlock stands. For this reason, incremental silviculture is limited to spacing and commercial thinning. Table 17 demonstrates the impact of the most common spacing and commercial thinning regimes in the preferred scenario on minimum harvest ages. The table also shows the volume per hectare at the minimum harvest age.

Table 17 - Minimum harvest ages and corresponding volume/ha, Hw, density 3500-5000

SI	Do nothing		Space 600		Space 1000		Space 1200		CT1/CT2	
	MHA	**Vol @ MHA**	MHA	Vol @ MHA	MHA	Vol @ MHA	MHA	Vol @ MHA	MHA	Vol @ MHA
18	**104**	**480**	71	254	80	351	83	373	140	327
22	**80**	**546**	60	328	60	365	63	387	110	392
26	**60**	**545**	60	503	60	531	60	549	60	456
30	**60**	**716**	60	693	60	720	60	726	80	564

Compared to the "do nothing" option, minimum harvest ages are either the same or lower due to spacing and higher due to commercial thinning. However, in almost all cases the volume per hectare at minimum harvest age is lower as a result of spacing or commercial thinning. These lower per hectare volumes would decrease annual harvest level, if the stands were harvested at minimum harvest ages. However, they are not. The stands are held longer to maintain the harvest flow. Table 18 shows the ages at which the four different silviculture regimes meet the per hectare volume of the "do nothing" option.

Table 18 – Ages at which "Do nothing" MHA volume/ha met

SI	Do nothing	Space 600	Space 1000	Space 1200	CT1/CT2
	MHA	Age at which "Do nothing vol met	Age at which "Do nothing vol met	Age at which "Do nothing vol met	Age at which "Do nothing vol met
18	**104**	110	105	100	195
22	**80**	85	85	80	145
26	**60**	65	65	60	105
30	**60**	65	60	60	100

In most cases, the treated stand have to be held longer than the non-treated stands if the same per hectare harvest volume is desired. This is reflected in the higher average harvest age for all the investment scenarios. Whether the goal was to maximize the annual harvest volume or stand value, all scenarios that included incremental silviculture had somewhat higher average harvest ages than the SS base case.

9.9.3 Pruning

All scenarios that attempted to bring forward more value using incremental silviculture proposed to expend significant amounts of the budget in pruning. The model favored pruning as a treatment because of the high value assigned to the clear wood component in the modelling assumptions. Should the value of clear wood be higher more pruning would be proposed and vice a versa. It is important to recognize the uncertainty of the clear wood value as well as the model's sensitivity to it.

10 Conclusions

The intent of this report is to provide strategic direction for an incremental silviculture program in the Kalum TSA. The Kalum TSA group identified local objectives during the first workshop. With 7 main objectives and complex forest management issues in the Kalum TSA, a scenario planning analysis approach was required to analyze and understand the local forest dynamics and the potential influences of different strategies on incremental silviculture.

Maintaining or increasing the TSA's operable landbase provides a direct benefit to short-, mid- and long-term harvest levels and was identified as a high priority objective for the Kalum TSA Type 2 analysis. While there are many techniques to maintain or increase the operable landbase, only deciduous conversion was included in this analysis. The conversion of deciduous stand types was initiated from Scenario 6 through 9.

Increasing the timber value per hectare has the potential to reduce the future harvest of marginal stands and increase the amount of large and premium logs harvested in the Kalum TSA. Assessment of value can follow many different techniques. For the purposes of this analysis, a discounted value at forest-level was used as the value indicator in the optimization function. Harvesting costs, silviculture treatment costs, and harvest values by grade were considered. The scheduled treatments are significantly influenced by the given costs and values used in the analysis and results should be interpreted with caution. Results are more reasonable in the short-term but may be less realistic in the future, given market adjustments and operational cost efficiencies.

The value based and preferred scenarios attempted to increase the overall value of stands harvested within the Kalum TSA. The analysis demonstrates that there is sufficient opportunity to do so. The piece sizes and per cubic meter values were increased significantly through value optimization.

"Maintain or enhance the long-term harvest level" was the third-ranking objective identified by the Kalum TSA group to be addressed in the Type 2 analysis. In the sequence from the benchmark scenario (no site index adjustments) to the SS base case there was a 37% increase in the long-term harvest level as a result of the Kalum TSA group's site index adjustment. While the true site index adjustment remains uncertain, the potential for future harvest level increases is extremely attractive. Within the scenario that attempted to maximize harvest levels, there are very minimal increases in long-term harvest levels as a result of stand level volume responses from incremental silviculture. As such, a TSA site index adjustment that verifies the adjustments used in this analysis provides the best investment action for potential short- through long-term harvest level increases.

The Kalum TSA group identified employment stabilization or improvement as a forest level management objective. Incremental silviculture jobs, as a result of the intensive treatment activities, provide direct employment and any increases in harvest level will also provide increased employment. As a result of site index adjustments, the preferred scenario shows significant increases in harvest level as compared to the TSR 2 base case, and a corresponding potential increase in harvest- related employment. The relationship between increased profit, revenue, higher value products and employment was not investigated.

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 Kalum TSA group was considered within the Type 2 analysis by the landbase netdown, establishing seral distribution targets for each BEC variant within each landscape unit in the TSA, and establishing VQO requirements within visually sensitive areas, as well as the requirements for the Deep Creek watershed, Thunderbird resource zone, and the Kitimat Special Resource Management Zone. The required conditions were met for all scenarios, ensuring that non-timber resources are adequately considered when analyzing potential strategic silviculture schedules. In addition, the goat reserves were removed from the timber harvesting land base to provide for a conservative analysis approach.

In developing the objectives for the Kalum Type 2 analysis, the TSA group considered the harvest level issues presented in TSRII, specifically the 80 year mid-term decline of approximately 70 000 m^3/year below the current harvest level. While there was no direct objective (Table 1) to address this forecasted decline, it does provide a future harvest level concern and was identified in the provincial silviculture strategy. Adjusting site indices for the entire TSA based on local experience and opinion eliminated any opportunity to quantify the potential of incremental silviculture to directly improve the future timber supply. Based on the results of the volume strategy, it was shown that incremental silviculture had little short-, mid- or long-term volume benefits, but provides the potential for significant value benefits for long-term managed stands. If the effects of raising the site indices had been completely understood at the beginning of this project, it is possible that objectives for the analysis could have been different. These objectives should be reviewed periodically and adapted based on new objectives, understanding, information and knowledge.

10.1 Incremental Silviculture Strategy

Section 9.7.1 proposes the following silviculture strategy for the Kalum TSA for the next 10 years: The recommended annual treatment areas are 56 hectares of commercial thinning, 228 hectares of spacing, and 389 hectares of combined spacing and pruning. The locations of these treatments have been identified on the preferred scenario map in attached maps. 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.

This strategy is not intended to represent the only or best strategy for the TSA. Even within the existing analysis assumptions, many other feasible strategies could be produced depending on the preferences of individuals. These results are intended to provide direction for incremental silviculture planning.

Should the harvest costs, product prices, stand yields, fluctuations in annual budgets etc. be different or change drastically through time, the silviculture strategy would likely be very different from the one proposed. Therefore, we recommend consideration of the trends, such as:

- A minimum annual budget level of $500,000 - net of CT costs - is able to increase the harvest value significantly without seriously compromising harvest levels. Beyond $500,000 the improvement in the per cubic meter harvest value is insignificant.

- If funding is available, an annual budget of up to $1.1 million is able to maintain higher harvest level while providing larger piece sizes and value (preferred scenario). While the harvest value per cubic meter is not significantly increased by the increased investment, long-term harvest level is approximately 40,000 m^3 per year higher than with the $500,000 budget. At $80-$90 per cubic meter of harvest value, this scenario could potentially produce over $3 million more total value annually. The 40,000 m^3 more harvest would also sustain 304 more TSA jobs and 376 provincial jobs for each decade.

- In the first decade, 79% of available funding should go to the combination treatment of spacing and first pruning. The rest should be used for spacing.

- Spacing and pruning treatments should avoid sites with the site index (BEC adjusted) less than 20.

- Spacing should favour higher density treatments (1,000 and 1,200 sph).

- About 50 ha should be commercially thinned every year. Only the best sites should be commercially thinned.

11 Future Analysis Recommendations

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

- Limit the number of potential transitions i.e., treatment regimes. 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. For example, the site index adjustments in this analysis solved the mid-term timber supply problem outlined in TSR 2. Incremental silviculture is no longer necessary to deal with the mid-term timber supply.

- 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. As experience leads to efficiency, shorter time frames in the future are possible.

- Consider establishing proposed periods for review of objectives and analysis for incremental silviculture to ensure results remain up-to-date.

12 References

Atherton, L.P. 1999. Incremental Silviculture Strategy for B.C. - Working paper #2: Concepts and Strategy of Planning - Proposed Planning Framework. February 19, 1999. Forest Practices Branch, Victoria, B.C.

B.C. Ministry of Forests. 2000. Clear Wood Values from Pruning, Madison's Canadian Lumber Reporter, and The Tree and Stand Simulator (TASS). December 2000. Victoria. B.C.

B.C. Ministry of Forests. 1999a. Kalum Timber Supply Analysis Report. March, 1999. Victoria, B.C.

B.C. Ministry of Forests. 1999b. Kalum Timber Supply Area - Rationale for Allowable Annual Cut (AAC) Determination. November, 1999. Victoria, B.C.

B.C. Ministry of Forests. 1999c. Incremental Silviculture Strategy for B.C. - Power Point Presentation. 1999. Victoria, B.C.

B.C. Ministry of Forests. 1998. Soo Timber Supply Area - Incremental Silviculture Strategy (interim). August 31, 1998, Victoria, B.C.

B.C. Ministry of Forests. 1993 Commercial Thinning Plan for the Kalum Forest District. 1993. Terrace, B.C.

B.C. Ministry of Forests. 1992. Kalum Forest District - Incremental Strategies Plan. 1992. Terrace, B.C.

B.C. Ministry of Forests and Ministry of Environment, Lands, and Parks. 1999. Resource Planning Framework - Guidelines for the Development of Resource Management Plans for 2000/01 (working draft). June 30, 1999. Victoria, B.C.