

Type 2 Strategic Silviculture Analysis Analysis Information Package

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

Type 2 Strategic Silviculture Analysis **Analysis Information Package** **March 2002**

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1 Introduction

The Ministry of Forests (Port McNeill Forest District and Vancouver Forest Region) has initiated the development of a Type 2 Forest Level Silviculture Strategy for the Kingcome Timber Supply Area (TSA). This information package documents the procedures, assumptions, data and model used in the analysis. Forest Ecosystem Solutions Ltd. has been engaged to prepare the information package and conduct the Type 2 analysis on behalf of the MoF. While not as detailed as an information package for a timber supply analysis, this package will utilize where appropriate format and requirements within the *Provincial Guide for the Submission of Timber Supply Information Packages for Tree Farm Licences, Version 3*.

The purpose of this information package is to:

- Provide a mechanism for communication of technical analysis issues prior to undertaking the Type 2 analysis;
- Provide an opportunity for the MoF and participants to review those technical issues and assumptions that will be used in the preparation of the Type 2 analysis;
- Create a dynamic document which, over time, will ensure that all relevant information is accounted for appropriately in the Type 2 analysis; and
- Increase the efficiency of the Type 2 analysis process by reducing the risk of having analyses discarded due to inappropriate content.

Base data for the Type 2 analysis comes from the TSR 2 resultant dataset.

All data summarized in this package used spatial GIS data and forest inventory polygon (FIP) labels, allowing all Forest Simulation Optimization System (**FSOS**) analyses to be spatially and temporally referenced. **FSOS** will be used to assess silviculture strategies for the Kingcome TSA over a 200 year planning horizon.

2 Process

The Type 2 Silviculture Analysis for the Kingcome TSA is directed through the project contract.

This Information Package is the first of three reports produced for the Type 2 project. The second report is the Analysis Report, and the third is the Preferred Silviculture Program Report.

The background information that guided the assumptions and processes of this analysis includes, but is not limited to, the following:

- Kingcome Timber Supply Area - Timber Supply Analysis Data Package
- Kingcome Timber Supply Area – Timber Supply Analysis Report, November, 2001
- Incorporating Biodiversity and Landscape Units into the Timber Supply Review
- Timber Supply Review Base Case Modelling Assumptions for Biodiversity and Landscape Units
- Request for Proposals – Development of Type 2 Forest Level Silviculture Strategy

2.1 Growth and Yield

Yield information for natural stands was taken from the Kingcome TSA Analysis Report. These yield tables were generated using the variable density yield prediction (VDYP) model.

In this Type 2 project, there are two separate sets of regeneration assumptions: One set is applied in recreating the timber supply review (TSR) analysis and the second for investigating silviculture options.

In recreating the TSR analysis (for the benchmark run described below), yield information was taken from the Kingcome TSA Analysis report. These yield tables were generated using the table interpolation program for stand yields (TIPSY) model.

Yield information for the silviculture strategies was developed by Ken Polsson at the research branch of the Ministry of Forests using the Tree and Stand Simulator (TASS) model.

2.2 Data Preparation and Missing Data

A large resultant, spatial database was delivered to Forest Ecosystem Solutions Ltd. Also serving as the base data for TSR 2, this master database is a complete resultant polygon list, each with unique identification numbers. In order to enable data loading and modelling in **FSOS**, the resultant data set was processed to remove sliver polygons and merge resultant polygons with sufficiently similar attributes. In addition, any areas outside the TSA boundary not managed by the BC Forest Service and many non-productive areas (rock, alpine, etc.) were removed from the data set.

In the resultant data set, there were some park areas on the perimeter of the Kingcome TSA classified as TSA 99. TSA 99 is a code given to protected areas and does not necessarily indicate that an area will not contribute to the total Crown forest area. However, these areas were not observably within the Kingcome TSA boundary, and as such they were removed from the analysis in the data processing phase based on their TSA code. This area, totalling approximately 18,000 hectares, was included in the TSR 2 analysis as contributing to forest cover objectives. Forest Ecosystem Solutions Ltd. did not become aware of the inclusion of these park areas until after the data processing and data loading procedures for the Type 2 had been completed. This area is not available for harvesting and, as such, its absence will have no direct impact on the silviculture strategy. Any volume impact apparent in the base case will be the indirect impact of a smaller total forested landbase for the application of forest cover constraints.

3 Analysis and Scenario Planning

3.1 Analysis Methods

The objective of the Type 2 forest level silviculture strategy is to meet forest-level objectives using incremental silviculture activities.

Through forest level modeling using **FSOS**, the variety of treatments can be considered in light of their ability to satisfy forest-level objectives. A single treatment at the stand level may result in a yield improvement; however, at the forest level, this treatment may be a poor investment when considered together with all other investments, budgets and objectives. Conversely, a treatment at the stand-level that does not appear to represent a significant stand-level benefit may in fact be an important action and satisfy an objective at the forest-level.

Stand management options or treatment regimes describe a series of silviculture actions that are possible for a given stand type. Each treatment within the regime occurs in sequential order and has an associated set of costs, values, employment levels, and timber quality and quantity impacts at a given point in time.

FSOS will determine the appropriate treatment regime for each stand following harvest, or for those stands that were previously harvested and are still treatable. Each regime provides a timeframe of treatments, including harvesting and stand development. Following harvest, the stand may follow the same treatment regime, transform to another regime or receive no treatment at all, based on decisions of costs, values, and overall satisfaction of objectives.

A number of forest-level scenarios will be developed and analyzed. These scenarios will eventually lead to the development of a preferred option. This approach presents a sequential and iterative process of analysis - each step providing insight, understanding and direction for the next.

3.2 Scenarios

The development of a strategic silviculture plan is not an easy process. A variety of stand- and forest-level objectives or desired future outcomes, elaborate stand treatment regimes, and long time horizons create complexity in forest dynamics.

Scenario planning helps to understand those significant issues that control future outcomes by simplifying the complex interactions. Scenarios are developed to test options through sensitivity analysis, or alternatively the scenarios can be based on individual management interests and questions. This allows the forest managers to develop management decisions based on a better understanding of the consequences of proposed regimes and their interactions.

Each scenario result describes the silvicultural and forest-level outcome for the management approach defined in that scenario. The scenarios are assessed and presented individually. The preferred silvicultural strategy may be composed of elements of some or all of the other scenarios.

Key items that are assessed within each scenario are the response of important indicators (e.g., timber supply), similar trends across scenarios, tradeoffs between scenarios, and short- and long-term variations.

Both simulation and heuristic analysis techniques will be used in the Type 2 analysis. Table 1 provides a summary of different analysis scenarios.

Table 1: Analysis scenarios.

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

3.2.1 Benchmark (Scenario 1)

This scenario uses MoF TSR 2 analysis assumptions and yield curves and serves as a benchmark between this analysis and TSR 2. Recreating the TSR 2 basecase makes it possible to evaluate the model's performance as well as monitor the differences between this analysis and TSR 2.

3.2.2 Basic Silviculture Only (Scenario 2)

This scenario maintains TSR 2 analysis assumptions with three exceptions.

1. First, TASS curves replace MoF TIPSy curves for managed stands.
2. Second, regeneration assumptions for cedar stands have been modified in two ways.
 - a. Cedar poor and medium analysis units are split to reflect a component of cedar-salal sites, which will be eligible in some scenarios for Salal Cedar Hemlock Integrated Research Program (SCHIRP) fertilization. It is assumed that 42% of cedar poor and medium sites are cedar-salal sites. This assumption was based on an estimate of cedar-salal sites within the CWH vm1, vm2 and vh1 BEC variants and then calculated as an area-weighted average of the contribution of these BEC variants to the total cedar poor and medium areas.
 - b. It is assumed that 20% all cedar sites (good, medium and poor) will convert to hemlock in the absence of spacing.
3. The final deviation from TSR 2 is that site indices in old growth cedar and hemlock stands (>140 years) have received a site index adjustment as per the MoF document "*Site Index Adjustments for Old-growth Stands based on Veteran Trees.*"

No incremental silviculture treatments are incorporated in this scenario.

3.2.3 Silviculture Strategy Base Case (Scenario 3)

This scenario is as per Scenario 2 with the inclusion of second generation genetic gain. The Silviculture Strategy Base Case includes no incremental silviculture treatments and serves as the base case for all subsequent incremental silviculture scenarios

3.2.4 Commercial Thinning (Scenario 4)

This run explores the opportunity to increase harvest volume through the use of commercial thinning treatments. Commercial thinning can be used to obtain harvest volume while maintaining adequate tree cover to fulfill visual quality objectives or other cover objectives. For the purposes of this analysis, commercial thinning is assumed to be cost recovering; that is, it is modeled as having zero net cost.

3.2.5 Volume Impact (Scenario 5)

This scenario investigates the opportunity to increase harvest volumes through the use of spacing and fertilization treatments, alone or in combination, at varying budget levels. \$250,000, \$500,000, \$1,000,000, and Unlimited silviculture budgets are available for testing. The model can select which treatments to perform within the available budget limitations in order to produce volume gains.

3.2.6 Value Impact (Scenario 6)

This scenario tests the opportunity to increase harvest values through the use of spacing, fertilization, and pruning treatments at varying budget levels. \$250,000, \$500,000, \$1,000,000, and Unlimited silviculture budgets are available for testing. The model selects which treatments to perform within the available budget limitations in order to improve harvest values.

3.2.7 Alder Conversion (Scenario 7)

This scenario investigates the possibility of converting poor cedar (wet) sites to alder. Some of these sites have a relatively low site index due, not to low nutrient capital, but rather to a high water table. Alder may perform better on these sites, yielding higher overall volumes and values than cedar. The model will have the choice between leaving eligible stands as cedar, and investing the money in the required site preparation and converting some or all of these stands to alder.

3.2.8 Partial Harvesting / Retention (Scenario 8)

This scenario tests the ability for silviculture to mitigate volume impacts incurred through the use of partial harvesting systems. Yield curves will be reduced by 5.4% to reflect the use partial harvesting systems. This is the volume reduction applied in Weyerhaeuser's Timber Supply Analysis for TFL39 and is used here for lack of better (TSA specific) information. The first run in this scenario will incorporate these volume reductions but no intensive silviculture treatments and will serve as the baseline. The second run will add silviculture treatments to attempt to overcome the volume reductions due to partial harvesting/retention.

3.2.9 Habitat / Biodiversity (Scenario 9)

This scenario will test the ability for silviculture to mitigate timber supply impacts of increased habitat and biodiversity constraints. The first step will be to run the model applying full seral stage targets (early, mature/old, old) without draw down and eliminate the use of silviculture. This will serve as the baseline for this stand-alone scenario. Next, silviculture treatments will be enabled on the landbase. Here we will be able to understand how silviculture interventions may be able to mitigate volume losses due to increases in biodiversity requirements.

3.2.10 Preferred (Scenario 10)

The results of the incremental silviculture scenarios as they compare to the Silviculture Strategy Base Case will be used to design this Preferred Scenario. Effective treatments and budget levels will be selected based on the outcomes of previous scenarios.

3.3 Analysis Assumptions

1. "Normal" market conditions will prevail for demand and prices for timber and fibre.
2. Current Forest Practices Code requirements are maintained throughout the planning horizon.
3. MoF timber supply concepts and harvest flow rules are followed (maintain current harvest as long as possible with reasonable declines in the future - 10%/decade). No patch objectives are applied to this analysis on seral requirements.
4. Specific levels of precision are used in the optimization analysis are as follows:
5.
 - +/- 10% change in timber flow between decades.
 - Silviculture investment not to exceed maximum budget level by more than 10%.
 - 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.

4 Models

The following software were used in the preparation of the strategic silviculture analysis and data package for the Kingcome TSA:

- **FSOS** time-step simulation model and **FSOS** forest estate optimization model;
- MoF Variable Density Yield Program (VDYP);
- MoF Table Interpolation Program for Stand Yields for Microsoft Windows (WinTIPSY).
- MoF Tree and Stand Simulator (TASS)

4.1 Landscape Design Model – FSOS

Model Name: **FSOS**
Model Developer: Guoliang Liu
Model Development: Hugh Hamilton Ltd., Forest Ecosystem Solutions Ltd. and UBC

Description:

Forest Ecosystem Solutions Ltd. combines the power of advanced computer modeling techniques and GIS tools with expert professional experience. At the centre is a landscape optimization model called **FSOS** (Forest Simulation Optimization System). The model uses C++ programming language and can be run with both Windows '98 and Windows NT operating systems. The model interfaces directly with Microsoft Access for data management. The Timber Supply Branch of the MoF accepted the use of FSOS for timber supply analysis in August 1998. **FSOS** uses dynamic heuristic and simulation techniques to schedule harvest units based on 1) patch and seral objectives defined by non-timber (e.g. old-growth, biodiversity, visuals, habitat, watershed, etc.) resource values and 2) timber management objectives (e.g. even flow, volume levels, opening size distribution, species quotas). Harvest and approximate cut block shape and size over the planning horizon are an output of the model. Modeling of strict adjacency and seral constraints is accomplished using simulation modeling. The data structure is identical for both heuristic and simulation models, which prevents extensive data loading procedures when switching between techniques.

FSOS uses the multiple resultant polygons created by GIS overlay as the basic model unit, allowing great flexibility in creating a variety of potential harvest unit configurations by amalgamating these resultant polygons. Amalgamations of the harvest units through time create early seral openings and mature and old growth patches consistent with planned patch management strategies defined by higher level plans. Managing for specific patch size distributions within each seral class is also inherent within the model framework and is an extremely effective way to meet long-term biodiversity objectives. High weightings can be applied to relatively important resource objectives or objectives which are difficult to achieve. The objective function (evaluation equation) provides the means to evaluate the relative "success" between differing solutions. For each iteration, the model calculates a "penalty" based on the deviation of a given solution from the target values. Optimal solutions achieve targets quickly for highly weighted parameters in order to minimize the total "penalty" over the planning horizon. With optimization, "constraints" can be violated. As all resource values are tracked throughout the planning horizon, where and when this occurs is part of the model output.

The initial inventory data represents the gross land base, which includes both operable and inoperable areas and the contributing and non-contributing timber harvesting land base. This is required as inoperable and other reserve areas contribute to the achievement of non-timber objectives. From GIS overlay, the land base is divided into resultant polygons, each with a unique set of attributes. Treatments are applied to each polygon based on these attributes. Analysis unit, forest type, forest age, silvicultural treatment, user allocation, site index, non-timber resource objectives or any other parameter can define treatment type and regime.

FSOS uses individual stand ages to project the current age structure of stands in the analysis area. As stands age, they move into and out of age classes established as a basis for meeting target objectives. For example, age classes may be established as ≤ 40 yrs, 41-120 yrs, 121-250 yrs, and > 250 yrs.

The planning horizon length can vary as required. **FSOS** can produce spatially and temporally explicit plans over 20 years or for multiple rotations. A unique feature of **FSOS** is its ability to integrate strategic, tactical and operational planning phases into one process. Analysis runs include harvest timing and location for each period, as well as long-term, sustainable harvest levels.

Harvest rules that are used in **FSOS** are:

- Minimum stand age before a stand can be harvested;
- Maximum stand age, at which the stand is scheduled for cutting within a certain number of years (i.e. 10);
- Green-up period required before adjacent patches can be harvested (this is not between openings but between patches. Patch size in early seral can reflect desired cut block size distributions).

A range of priorities can also be applied to include the following:

- Stands at risk from fire, disease or insects;
- Species preferences to meet mill requirements;
- Opening size distribution;
- Piece size requirements;
- Silviculture investment;
- Even volume flow; and
- Minimize transportation costs.

The reporting functions of **FSOS** are extensive. The data for each period is easily accessible for any analysis unit, zone, polygon, landscape unit, etc. and gives an overview of the forest state at any point in time. Species compositions, age structure, patch distribution, harvest scheduling, treatment cost, product values and many other variables are tracked and reported by period. Reporting functions are highly effective for the direct comparison of sensitivity analysis and scenario options. **FSOS** is linked directly to the powerful ArcView environment for the easy production of high-quality maps.

Updates to the land base can be applied by two methods. Changes to applied net downs occur in the database framework by reapplying net down percentages. Changes to layer boundaries or additions or subtractions from the land base require the data be altered in the G.I.S. environment.

Although it is possible to use height as a target definition, cover targets are usually applied by age as a surrogate for height. Using patch and age class distribution indicators can achieve all cover targets. Age class distribution targets can be set as minimums, maximums, or desired levels. For example, wildlife habitat cover requirements may be achieved by having 70% of the management zone greater than 100 years of age.

Some other capabilities of **FSOS** include:

- Negative ages;
- Multiple constraints (guidelines) by unit, zone or group;
- Yearly age distribution;
- Volume Operational Adjustment Factors (OAFs) and land OAFs;
- Equivalent Clearcut Area curve constraints;
- Spatial and temporal referencing of neighbouring polygons;
- Multi-species stands;

- No maximum planning horizon;
- Opening size distribution;
- Timber flow management;
- Landscape metrics options; and
- Economic indicators.

5 Forest Inventory

Forest cover information for the Kingcome TSA is split between two inventories – Vegetation Resource Inventory (VRI) and Forest Cover (FC). New VRI data is available for approximately two-thirds of the TSA; the old forest cover data was used for the remaining third. Both the VRI and FC files were updated to reflect recent harvesting using cut block maps produced from satellite imagery, forest development plans, and the Integrated Silviculture Information System (ISIS) records.

As noted previously, all data used for this analysis is from the Kingcome timber supply analysis conducted by the Ministry of Forests for TSR 2. A complete description of the data inputs can be found in the Kingcome TSA Timber Supply Review Analysis Information Package.

6 Description of Landbase

Determination of the timber harvesting land base (THLB) results from a sequential procedure where stands ineligible for harvest due to poor stand quality, non-merchantable species, specific geographical or management reductions, or site sensitivity are systematically removed from the land base. Although portions of the forested land base are reserved from harvesting, their attributes within forested crown land still contribute to forest cover objectives. The netdown procedure for the strategic silviculture analysis generally followed that of TSR 2; however, there were some exceptions. As noted previously, in the TSR 2 analysis some 18,184 hectares of parks outside of the TSA boundary were included in the productive forest area. These areas were not included in the Type 2 data set (see Section 2.2 above for discussion). Also, after the data processing had been completed, Forest Ecosystem Solutions Ltd. learned of approximately 4,135 hectares of timber licence reversion areas that had been manually added to the THLB in the TSR 2 analysis. As these areas were not readily identifiable, they were left out of the Type 2 analysis. However, after the netdown procedure had been completed for the Type 2 dataset, the total THLB area was very close (within 0.5%) of the TSR 2 analysis.

6.1 Timber Harvesting Landbase

The netdown procedure is an exclusionary process. Once an area has been removed, it cannot be deducted further along in the process. Table 2 presents the netdown procedure for the Strategic Silviculture Analysis.

Table 2: Timber harvesting land base definition.

Classification	Area
Productive Forest	589,877
Parks and Reserves	11,556
Inoperable	215,553
Low Site	116,361
Non-merchantable types	1,544
ESA	38,681
Unstable Terrain	11,258
Riparian	17,348
Wildlife Tree Retention	2,974
Roads	5,637
<i>Total reductions</i>	<i>420,913</i>
Current Timber Harvesting Land Base	168,963
Future Reductions: Future Roads	5,651
Long-term Timber Harvesting Land Base	163,312

6.2 Productive Forest

There are 589,877 hectares of productive forest within the Kingcome TSA. This represents the forested area that will contribute to forest cover objectives and/or the THLB. All non-forest and non-productive areas, as well as areas not managed by the BC Forest Service were removed during the data processing phase of the analysis and, as such, do not appear in the netdown.

6.3 Parks and Reserves

A total of 11,556 hectares were removed from the timber harvesting land base to account for parks and other reserves. These areas were identified as ownership codes 60-N, 63-N, 67-N, and 69-N.

6.4 Inoperable

Inoperable reductions were done as per the TSR 2 analysis and are summarized in Table 3.

Table 3: Inoperable definitions.

Inoperable Definition	Operability Zones	Criteria
Operability Classification	1, 3, 4	I or N
Klinaklini Supply Block	5	Completely excluded
Slope reductions	2, 4	>60% zone 2, >80% zone 4
Specific Areas	2, 4	Specific mapsheet numbers
Alder	all	If >50% alder, reductions applied by mapsheet. All areas with <50% alder completely excluded.

A total of 215,553 hectares were removed from the THLB as inoperable. Any areas with a logging history were not removed as inoperable.

6.5 Low Site

Low site reductions were applied as per Table 4 below and removed a total of 116,361 hectares.

Table 4: Low site definitions.

Species	Minimum Volume (m ³)		Minimum Site Index
Cedar (not in Hecate Lowlands)	350	OR	12.7
Cedar (Hecate Lowlands)	340	OR	12.4
Hemlock & Balsam	500	OR	13.8
Spruce	500	OR	10.8
Fir	500	OR	20.2

6.6 Non-merchantable Types

All pine and deciduous stands (other than alder) were removed as non-merchantable forest types. This removed a total of 1,544 hectares from the THLB.

6.7 Environmentally Sensitive Areas

Reductions for environmentally sensitive areas (ESAs) based on ESA mapping were done as per Table 5 below and removed a total of 38,681 hectares.

Table 5: ESA reductions.

ESA Category	Reduction %
S1 (highly sensitive soils)	80
S2 (moderately sensitive soils)	20
R1 (recreation – high sensitivity)	100
R2 (recreation – moderate sensitivity)	50
W1 (wildlife habitat – high value)	100
W2 (wildlife habitat – moderate value)	50
P1 or P2 (difficult regeneration)	100
A1 (avalanche buffer)	100

6.8 Unstable Terrain

Additional reductions based on slope percent were also done to account for terrain class IV areas which were not mapped as ESA2. The following table provides the percent of the total area within each slope class that received a 20% reduction for terrain class IV areas.

Table 6: Class IV slope reduction areas.

Slope Class	Percent Area
0 – 20%	3.5
21 – 40%	15.8
41 – 60%	38.9
61 – 80%	50.6
81 – 100%	43.1
>100%	32.7

In total, 11,258 hectares were removed for unstable terrain.

6.9 Riparian

To account for reductions for riparian reserve and management zones, an 8.9% reduction was applied to every THLB polygon. This resulted in 17,348 hectares being removed for riparian areas.

6.10 Wildlife Tree Retention

The following reduction percentages were applied to THLB polygons based on BEC subzone to account for wildlife tree patches (WTPs). A total of 2,974 hectares was removed here.

Table 7: Wildlife tree patch retention.

BEC subzone	Reduction %
CWH vh	1.4
CWH vm	1.84
CWH xm	3.5
CWH dm	1.14
MH mm	0.52

6.11 Existing and Future Roads

Table 8 documents the reductions made for existing and future roads. In total, 5,637 and 5,651 hectares were removed for existing and future roads, respectively.

Table 8: Reductions for roads, trails and landings.

	Year of Harvest	Reduction %
Existing roads, trails and landings	Pre-1995	7.0
	1995 - 1999	6.0
Future roads, trails and landings	Post 1999	6.0

7 Inventory Aggregation

Inventory aggregation is a process of simplifying the landscape into similar units. It identifies management zones or resource emphasis areas for the application of unique forest cover and spatial structure requirements, as well as for the application of growth and yield information. The aggregation must recognize both the similarities and differences in forest stand productivity as well as management objectives and prescriptions. This section describes the criteria and rationale behind the aggregation in this analysis.

7.1 Management Zones

Management zones are geographically referenced areas that require unique management considerations. Areas requiring the same management regime or the same forest cover requirements are grouped into management zones. Table 9 lists the management zones and the rationale used to define these zones.

Multiple resource issues may be present on the same forest area due to overlapping management zones. For example, a watershed management zone may also have areas, which are visually sensitive and require an old growth objective. **FSOS** can accommodate multiple overlapping resource layers by establishing target levels for each layer. The model then schedules harvest units and/or treatments, which best meet the target levels for all resource layers simultaneously.

Table 9: Definition of management zones.

Management Zone	Applied Areas
IRM Zone	Timber harvesting land base by Landscape Unit (LU)
Visually Sensitivity Preservation Retention Partial Retention Modification	Total forested area by LU
BEC Variants: AT p CWH dm CWH ds 2 CWH vh 1 CWH vm 1 CWH vm 2 CWH vm 3 CWH ws 2 CWH xm 2 ESSFmw ESSFmw h ESSFxv 1 IDF dw IDF ww MH mm 1 MH mm 2 MH mm 2e	Total forested area by LU / BEC variant combination
VILUP EMZ	Total forested area by LU
VILUP SMZ	Total forested area by LU

7.2 Analysis Units

Table 10 lists the principal criteria used in the aggregation of stands with similar biological characteristics into larger homogeneous units called analysis units (AUs) used in the TSR 2 analysis. These analysis units were modified slightly for the Type 2 analysis for cedar AUs. In the Type 2 analysis, 20% of all cedar stands regenerate to hemlock without spacing. Also, cedar medium and poor AUs were split to include an AU cedar-salal sites, which will be eligible for treatment in the silviculture scenarios.

Table 10: Definition of analysis units.

AU	Species & Site Class	Inventory Type Group	SI Range
1	Cedar good	9-11	≥20
2	Cedar medium	9-11	≥15 and <20
3	Cedar poor	9-11	<15
4	Hemlock good	12-20	≥25
5	Hemlock medium	12-20	≥20 and <25
6	Hemlock poor	12-20	<20
7	Spruce	21-26	all
8	Alder	37-38	all

8 Regeneration Assumptions

Within the strategic silviculture analysis, there are two separate sets of regeneration assumptions. Scenario 1 uses TIPSy curves for regenerated (managed) stands as was the case in the TSR2 analysis. All other scenarios for the silviculture strategy regenerate to TASS curves. TASS provides treatment and reporting options not available in TIPSy, and as such is the model used to generate the silviculture treatment regimes required for the silviculture strategy.

8.1 Yields for Benchmark Managed Stands

This section presents the yield assumptions for managed stands in the benchmark (Scenario 1) run.

8.1.1 Genetic Gain Allowances

Genetic gain for these yield curves is as per TSR2: 2.5 % for western hemlock (Hw), 5.2% for western redcedar (Cw).

8.1.2 Existing Managed Immature

Table 11 provides the immature plantation history (that is, the criteria used in assigning currently young stands to managed or unmanaged curves) as was used in TSR 2.

Table 11: Immature plantation history.

Analysis Unit	Area Managed			
	Age 1 - 10	Age 11 - 20	Age 21 - 30	Age 31 - 40
All	100%	36%	12%	0%

8.1.3 Regeneration Assumptions for the Benchmark (Scenario 1)

Table 12 provides the regeneration assumptions used for the benchmark and basic silviculture only scenarios. These assumptions are as per TSR 2, with the exception that in TSR 2 20 hectares per year of alder stands are regenerated back to alder. This was omitted from this analysis for simplicity.

Table 12: Regeneration assumptions for benchmark scenario.

Current AU	Future AU	% Conv.	Initial Density*	Regen Delay	OAF1	OAF2
1 Cw good	101 Cw good	100	3000	1	15	5
2 Cw med	102 Cw med	100	3000	2	15	5
3 Cw poor	103 Cw poor	100	3000	2	15	5
4 Hw good	104 Hw good	100	5000	2	15	5
5 Hw med	105 Hw med	100	5000	2	15	5
6 Hw poor	106 Hw poor	100	5000	4	15	5
7 Spruce	107 Spruce	100	2000	1	15	5
8a Alder good	104 Hw good	100	5000	2	15	5
8b Alder med	105 Hw med	100	5000	2	15	5
8c Alder poor	106 Hw poor	100	5000	2	15	5

* Some natural ingress was incorporated into yield curves for TSR 2.

8.2 Not Satisfactorily Restocked

In **FSOS**, NSR is modeled using negative ages, which are applied to reflect the NSR restocking schedule. All current NSR is assumed to regenerate within specified regeneration delay period as per Table 12 above. NSR is restocked on a pro-rata basis within each analysis unit.

8.3 Yields for Silviculture Strategy Managed Stands

This section presents the yield assumptions used for the creation of TASS curves for the silviculture strategy analysis. TASS curves replace TIPS curves described above for scenarios 2-10.

8.3.1 Regeneration Assumptions for TASS curves (Scenarios 2-10)

Table 13 below presents the regeneration assumptions used for the creation of TASS curves for the silviculture strategy scenarios (Scenarios 2-10).

Table 13: Regeneration assumptions for TASS curves.

Current AU	Future AU	% Conv.	Initial Density	Plant Dens.	Nat'l Dens.	SI ₅₀	Regen Delay PI/Nat	OAF1	OAF2	Genetic Gain*
1 Cw good	101 Cw good	80	3000	1200	1800	23.3	1/3	15	5	2.99
	102 Hw good	20	3800	0	3800	23.3	0/3	15	5	0
2 Cw med	103 Cw med	46.4	3000	1200	1800	16.5	2/3	15	5	2.99
	104 Cw med salal	33.6	3000	1200	1800	16.5	2/3	15	5	2.99
	105 Hw med	20	3800	0	3800	16.5	0/3	15	5	0
3 Cw poor	106 Cw poor	46.4	3000	1200	1800	13.4	2/3	15	5	2.99
	107 Cw poor salal	33.6	3000	1200	1800	13.6	2/3	15	5	2.99
	108 Hw poor	20	3800	0	3800	13.5	0/3	15	5	0
4 Hw good	109 Hw good	100	5000	1200	3800	28.4	2/3	15	5	3.06
5 Hw med	110 Hw med	100	5000	1200	3800	22.2	2/3	15	5	3.06
6 Hw poor	111 Hw poor	100	5000	1200	3800	15.8	4/3	15	5	3.06
7 Spruce	112 Spruce	100	2000	1200	800	24.6	1/3	15	5	0
8a Alder good	111 Hw good	100	5000	1200	3800	28.4	2/3	15	5	3.06
8b Alder med	112 Hw med	100	5000	1200	3800	22.2	2/3	15	5	3.06
8c Alder poor	113 Hw poor	100	5000	1200	3800	15.8	2/3	15	5	3.06

* Genetic gain percentages presented here reflect a 7.47% and 12.77% genetic worth for planted Cw and Hw, respectively. Cedar analysis units that regenerate to Hw do so through out-competition of planted stock by natural ingress and, as such, have zero genetic gain applied.

8.3.2 Genetic Gain Allowances for TASS curves

Based on information from the MoF Research Branch, there should be adequate second-generation hemlock and cedar seed available for the Kingcome TSA by 2007/2008. For this analysis, we assumed that second-generation seed would be available from 2002 on. This assumption is made to simplify modeling and, considering the length of the planning horizon, is unlikely to have a significant impact on the analysis. Genetically improved stock is assumed to be only available for those cedar and hemlock stands growing below 600 metres elevation in the following BEC variants: CWH dm, ds2, vh1, vm1, and xm2. Genetic gain is estimated at 8% for cedar and 14% for hemlock. In order to further simplify its application, genetic gain was applied to all cedar and hemlock analysis units and the gain was adjusted downward to reflect the lack of genetic stock for stands over 600 metres elevation. Table 14 provides the details of this adjustment of genetic gain percentages.

Table 14: Calculation of genetic worth for application to all cedar and hemlock stands.

Species	GW	Total THLB Area (ha)	Elev<600m (ha)	% of Total	Model GW
Cedar	8%	71,306	66,596	93.39%	7.47%
Hemlock	14%	92,126	84,020	91.20%	12.77%

8.3.3 Treatment Regimes

The strategic silviculture analysis focuses on determining the optimal timing and treatments given certain forest cover objectives, employment objectives, budgeting, timber flow criteria, timber volumes, costs of treatments, etc. For each AU, the stakeholder group in the pre-analysis workshop identified potential treatment regimes. The TASS curves were generated for each regime for testing from a forest-level perspective using **FSOS**. The treatment regimes are shown in Table 15. These curves were developed using the parameters provided in Table 13 above.

Table 15: Incremental silviculture treatment regimes.

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

8.3.4 Cedar Analysis Units

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

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

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

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

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

8.3.5 Minimum Harvest Age Criteria

Minimum harvest ages are defined by three criteria: volume, maximum mean annual increment (MAI), and diameter (measured as quadratic mean diameter (DBHq)). Minimum volume and diameter requirements are provided in Tables 16 and 17, respectively. Minimum harvest age is defined as the age where a stand reaches the minimum volume requirement and has either achieved 95% of its maximum MAI or has reached the minimum diameter limit.

Table 16: Minimum volume requirements for determination of minimum harvest ages.

Species	Minimum Volume (m ³ /ha)
Cedar	350
Hemlock	500
Spruce	500

Table 17: Minimum diameter requirements for determination of minimum harvest ages.

Species	Site Quality	Minimum DBHq (cm)
All species	Good	42
All species	Medium	37
All species	Poor	35

8.3.6 Site Index Adjustments

Old-growth Site Index (OGSI) adjustments were applied to old-growth cedar and hemlock stands for TASS. The adjustment equations came from the MoF document "*Site Index Adjustments for Old-growth Stands based on Veteran Trees*." Although the results of the paired-plot approach to estimating site index adjustments are considered more reliable, no information is available in this report for species represented in our analysis units. It is believed that the veteran tree approach actually underestimates site index adjustments, so any introduced bias would be conservative. Site index adjustment equations are present for only cedar and hemlock and, as such, only these analysis units receive adjustments.

SIBEC adjustments were not applied to any of the analysis units. The site index estimates within the Kingcome TSA may be lower than surrounding TFLs; however, we do not have local information needed for SIBEC. SIBEC adjustments are performed using site series, information which we do not have for the Kingcome TSA. In addition, SIBEC adjustments are often large: applying these adjustments without appropriate ecological mapping and site series study data for the TSA has the potential to introduce a significant bias into the analysis.

8.3.7 ISIS Integration

Past silviculture treatment information was obtained from the Integrated Silviculture Information System (ISIS). Treatments on file included spacing, fertilization, and pruning. Only spacing treatments on file were compiled and included in the analysis, as there were insignificant areas of pruning and fertilization in the past. Spacing treatments in ISIS were not linked to the data set by forest cover polygon; instead, the total spacing area was assigned *pro rata*. Spaced areas were assumed to have occurred in only hemlock stands growing on good sites. The treatments were split into age classes with reference to the disturbance date provided in the ISIS data file. Hemlock stands within the appropriate age classes were updated (through yield curve assignment) to reflect spacing treatments until the total spaced area identified in the ISIS file was represented in the TSA.

8.3.8 TASS Regeneration Delay

The regeneration delay used in the strategic silviculture analysis is the same as that used for the TSR 2 analysis and is provided in Table 13 above.

9 Protection

9.1 Unsalvaged Losses

Unsalvaged losses are losses due to natural events that are not salvaged and result in a decrease in the productivity of the TSA. This analysis uses the same rationale and reductions for unsalvaged losses as TSR 2. These reductions are provided in Table 18 below.

Table 18: Unsalvaged losses.

Cause of Loss	Annual Unsalvaged Loss (m ³ /year)
Fire	3,083
Windthrow	10,500
<i>Total</i>	<i>13,583</i>

10 Integrated Resource Management

Table 19 outlines the forest cover objectives for the Kingcome TSA for maintaining non-timber values. Forest cover objectives are applied to model forest values by placing maximum and/or minimum boundaries on specific age distributions, focusing largely on young age classes and old forests.

In FSOS, forest cover objectives can be viewed as either targets or constraints. In simulation mode, forest cover constraints can be applied that must coincide with harvesting actions. In the optimization approach, targets will be set which will attempt to develop and schedule harvest units to best achieve age class and timber flow objectives. Some trade-offs between objectives may occur.

10.1 Forest Cover Requirements

Table 19: Forest Cover Requirements.

Resource	Zone	Type 2 Area (ha)		Applied to	Cover Requirement			
		Forested	THLB		Age 1 (years)	Max % < Age 1	Age 2 (years)	Min % > Age 2
IRM		158,956.4	125,961.3	THLB Area by LU	13 (3m)		-	-
Visual Quality	Preservation	5,026.7	1,010.4	Forested Area by LU	18 (5m)	0.6	-	-
	Retention	13,890.6	6,878.3	Forested Area by LU	18 (5m)	3	-	-
	Partial Retention	63,652.5	31,468.8	Forested Area by LU	18 (5m)	9.7	-	-
	Modification	6,202.1	3,644.1	Forested Area by LU	18 (5m)	20.5	-	-
BEC Variants/ NDT	AT p / NDT 5	1,360.8	12.6	Exclude from harvest	-	-	-	-
	CWH / NDT 1	524,540.2	167,722.1	Forested Area by LU	-	-	250	9.7/ 11.7/ 13.6
	CWH / NDT 2	22,982.9	162.8	Forested Area by LU	-	-	250	6.7/ 8.1/ 9.4
	ESSF / NDT 3	3,219.5	0.0	Forested Area by LU	-	-	250	6.7/ 8.1/ 9.4
	IDF / NDT 4	8,946.4	0.0	Forested Area by LU	-	-	250	9.7/ 11.7/ 13.6
	MH / NDT 1	28,826.7	1,065.4	Forested Area by LU			250	14.2/ 17.1/ 19.9 ¹
VILUP EMZ		16,029.0	13,022.6	Forested Area by LU	8 (1.3m)	25		
VILUP SMZ		21,445.8	6,618.5	Forested Area by LU			80	25/ 30 ²

¹ Constraints are applied using a 45-45-10% split between low, intermediate and high biodiversity emphasis and assuming 1/3 draw down is applied in low emphasis areas (full target not required until 210 years from now).

² Constraint is 25% in Brooks Bay, Goletas Channel, and West Coast Nahwitti Lowlands SMZs and 30% in the Johnstone Strait SMZ.

11 Timber Objectives

11.1 Timber Values

Timber values used within the analysis are based on a series of piece size groupings for each species, similar to industrial grading. The analysis is based on average log diameter, taper, knot size and rings per inch. Logs will be bucked to provide optimal lengths for value.

The product selling prices for the analysis were derived using MoF second growth coastal log survey data with all incidental volumes removed from the analysis. The data is based on indexed monthly averages for seven years ending December 15, 1999. The indexing is by the British Columbia consumer price index. The second growth selling prices are summarized in Table 20. Figure 1 depicts per cubic metre pricing for different grades by incremental top diameter.

Table 20: Summary of second growth selling prices by diameter class.

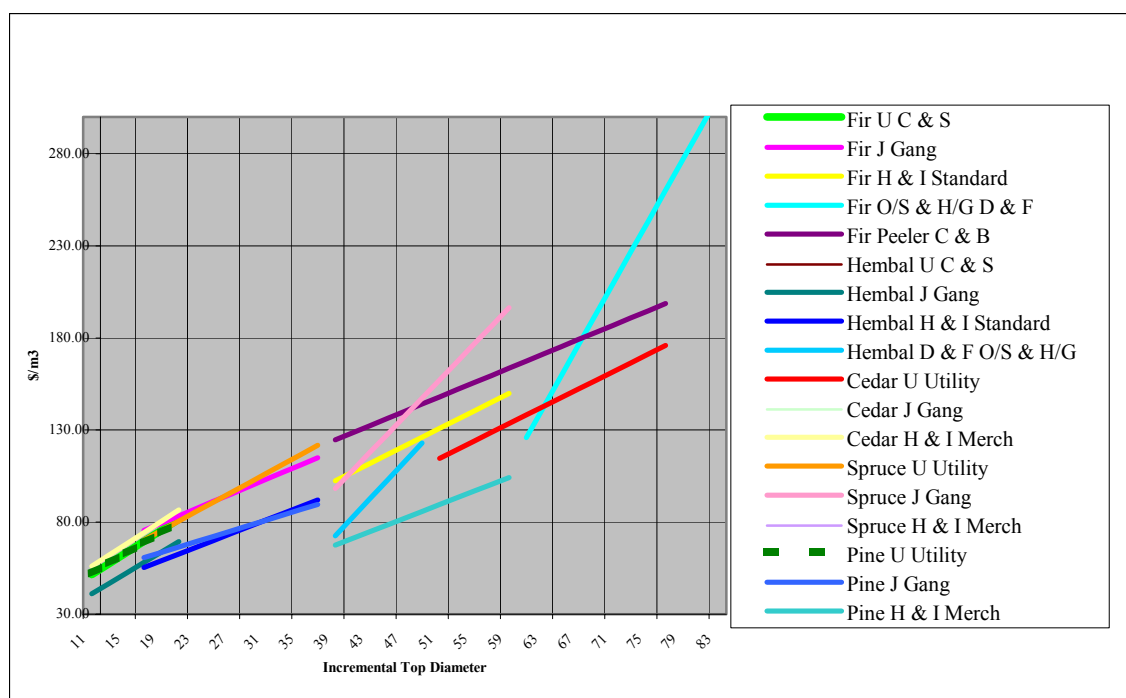


Figure 1: Second growth timber value by species grade; sort at Howe Sound.

11.2 Pruning Value

It had been identified that log grades and their valuation often do not reflect the log value gain from pruning adequately. For this reason, clear wood values of pruned stands were increased as per Table 21. Value multipliers were taken from the report *Clear Wood Values From Pruning* by the Silviculture Practices Section of the Forest Practices Branch of the MoF (December 2000). Clear wood percentages are calculated from TASS output.

Table 21: Clear wood value multipliers.

Species	Clear Wood Value Multiplier
Hw	3.6
Ss*	3.5

*As no value multiplier was available for spruce, the multiplier for pine was used.

11.3 Treatment Costs and Employment

Table 22: Treatments costs and associated employment levels.

Treatment	Island portion of TSA		Mainland portion of TSA	
	Cost (\$/ha)	Person Days/ha	Cost (\$/ha)	Person Days/ha
Fertilization of cedar/salal sites	600	0.2	720	0.22
Fertilization, spruce	300	0.1	360	0.11
Spacing	1,800	4.0	1,980	4.4
Pruning, first lift	1,900	5.0	2,090	5.5
Pruning, second lift	2,000	5.0	2,200	5.5
Site Prep, (alder conversion)	1,000	2.0	1,100	2.2
Commercial Thinning	No net cost	2.0	No net cost	2.2

11.4 Value Analysis

All treatment costs and harvest revenues are aggregated at the forest level and discounted at a rate of 4% for comparison at equivalent present value. The model uses this value to find a solution that will maximize the forest-level difference between revenues and costs over the planning horizon.

12 References

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