

SUNSHINE COAST TSA STRATEGIC SILVICULTURE ANALYSIS



ANALYSIS INFORMATION PACKAGE -SUNSHINE COAST TSA -

**Submitted to the Vancouver Forest Region,
B.C. Ministry of Forests**

December 2000

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1. INTRODUCTION

The Ministry of Forests (Sunshine Coast Forest District and Vancouver Forest Region) has initiated the development of a Type 2 Forest Level Silviculture Strategy for the Sunshine Coast 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 between the 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. This dataset includes the 1999 inventory audit and other resource data layers that were utilized in TSR 2, which was in progress during the preparation of this report.

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 Sunshine Coast TSA over a 200 year planning horizon.

2. PROCESS

The Type 2 analysis for the Sunshine Coast TSA is directed through the project contract.

This information package is one of the two Type 2 report. The second report will be the analysis report.

The background information that guided the assumptions and processes employed in this information package includes, but is not limited to, the following reports:

- *Sunshine Coast Timber Supply Area Timber Supply Review – Data Package, May 2000.*
- *Sunshine Coast Timber Supply Area Analysis Report (TSR 1), October 1995*
- *Incorporating Biodiversity and Landscape Units in the Timber Supply Review*
- *Site Index Adjustments for Old-Growth Stands Based on Veteran Trees (Working Paper 36, 1998)*
- *Site Index Conversion Equations for Mixed Species Stands - MoF Research Branch, 1998*
- *Timber Supply Review Base Case Modeling Assumptions for Biodiversity and Landscape Units*
- *Tree Farm Licence Information Package Guidelines*
- *Request for Proposals – Development of Type 2 Forest Level Silviculture Strategies (July 27, 1999)*

As the TSR 2 for the Sunshine Coast TSA was in progress during this project, much of the timber supply analysis related information was provided directly by Craig Robinson of the Vancouver Forest Region.

2.1. Growth and Yield

Base case growth and yield data will utilize those curves that were generated for TSR 2 using the variable density yield prediction (VDYP) model developed by the B.C. Ministry of Forests, Resources Inventory Branch, for estimating timber volumes for all existing 'naturally established' stands. The table interpolation program for stand yields (TIPSY) developed by the B.C. Ministry of Forests, Research Branch, was used to estimate timber volumes for managed stands.

The Research Branch, using The Tree and Stand Simulator (TASS), developed growth and yield information for the intensive silviculture regimes.

2.2. Data Preparation and Missing Data

A large resultant spatial database was delivered to Forest Ecosystem Solutions Ltd. This master database is a complete resultant polygon list, each with unique identification numbers.

3. ANALYSIS AND SCENARIO PLANNING

3.1. Analysis Methods

The objective of the Type 2 analysis is to meet forest-level objectives using incremental silviculture treatment regimes.

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 represent a significant 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 a sequential order and has an associated set of costs, values, employment levels, and timber quality and quantity effects 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 or 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 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. This complexity is often difficult to understand and makes it complicated to develop an incremental silviculture plan.

Scenario planning helps to understand those significant issues that control future outcomes by simplifying the complex interactions. Scenarios are developed to test options through either sensitivity analysis, or they can be based on individual management interests and questions. This allows the forest managers to develop management decisions that based on 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 individually for the development of the preferred option. The actual final silvicultural strategy may be composed of constituents of some or all of the other scenarios.

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

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

Table 1 - Summary of Scenarios

Scenario	Title	Scenario Description
1	Base Case	Re-creation of the TSR 2 Base Case to calibrate model and to test model reliability.
2	Revised Base Case	Includes ingress and OGSi. No incremental silviculture treatments.
3	Silviculture Strategy Base Case	Includes ingress and OGSi plus tree improvement. No incremental silviculture treatments.
4	Timber Volume Scenarios	A set of scenarios varying annual investment budgets. Intent is to determine impact on volume.
5	Timber Value Scenarios	A set of scenarios attempting to increase value through larger piece size and clear wood.
6	Full Biodiversity Scenario	A scenario applying full biodiversity immediately.
7	Old Growth Sensitivity Scenario	A scenario testing the impact on harvest level of creating old growth habitat faster through treatments.
8	Problem Stand Scenario	A scenario attempting to deal with high-density valley bottom problem stands.
9	Preferred Scenario	This scenario may be one of the ones identified before or a whole new scenario.

3.2.1. Base Case (Scenario 1)

Re-creating the TSR 2 base case makes it possible to evaluate the model's performance as well as monitor differences between this analysis and TSR 2. The base case assumes some incremental silviculture; stands growing on good and medium sites, except for hemlock/balsam/spruce medium sites, are assumed to receive a spacing treatment.

The base case also includes genetic improvement; the managed stand curves for fir, hemlock and cedar were adjusted upwards by 1.5%. The TSR 2 assumption was that 75% of the seed used is Class A seed with the average genetic worth of 2%. 75%x2% makes 1.5% for genetic worth.

3.2.2. Revised Base Case (Scenario 2)

The revised base case uses old growth site index (OGSI) adjustments for all stands older than 140 years. It also includes ingress. Starting out with higher establishment densities than in the base case incorporated an estimate for ingress. No incremental silviculture treatments are included in this scenario.

3.2.3. Silviculture Strategy Base Case (Scenario 3)

This scenario is identical to previous scenario with the inclusion of the next generation improved seed and corresponding estimated genetic worth.

In addition, in this scenario:

- All past treatments indicated in both ISS and FIP files are placed on appropriate yield curves.
- Stands between 20 and 80 years have value and product information added to their curves.

The silviculture strategy base case is the basis for all the upcoming scenarios, and all the comparisons in this analysis.

3.2.4. Timber Volume Scenarios (Scenario 4)

This is a set of scenarios, which vary the annual investment budget and incorporate multiple incremental silviculture transition options. The intent is to determine the increases in timber quantity.

- No timber value incorporated in the objectives.
- Investment levels are \$500,000, \$1,000,000, \$1,500,000, \$2,000,000 and \$3,000,000
- Helicopter logging treatments were fixed on the do-nothing option.

3.2.5. Timber Value Scenarios (Scenario 5)

This is a scenario(s) incorporating value in the model. It is assumed that including value in the optimization function will allocate the silviculture budget favouring those treatments that increase the value of the harvest, such as spacing and pruning.

3.2.6. Full Biodiversity Scenario (Scenario 6)

This scenario investigates how the silviculture budget would change if the requirement were to meet all the seral targets as per the biodiversity guidebook (early, mature, mature/old, old). One of the value scenarios will be used as the starting point for this scenario.

3.2.7. Old Growth Sensitivity Scenario (Scenario 7)

This scenario will test the impact on harvest level of creating old growth habitat faster through different silvicultural regimes.

3.2.8. Problem Stand Scenario (Scenario 8)

This scenario attempts to deal with the high-density valley bottom problem stands as discussed in the first workshop. As these stands are not currently identified in the inventory data, the completion of this scenario depends on whether or not they can be recognized in the data and further analyzed.

3.2.9. Preferred Scenario (Scenario 8)

This scenario may be one of the previous scenarios, or it may be a new scenario based on the results of all previous scenarios. It is the ‘best’ option that includes all preferred management and serves as a basis for the incremental silviculture strategy. Map output will be limited to the presentation of a 20-year ‘optimized’ silviculture treatment schedule.

3.3. Analysis Assumptions

1. “Normal” market conditions will prevail for demand and prices for timber and fiber.
2. Current Forest Practises 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:
 - +/- 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 Sunshine Coast 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)

Landscape Design Model - *FSOS*

Model Name:	<i>FSOS</i>
Model Developer:	Guoliang Liu
Model Development:	Hugh Hamilton Limited and UBC
Model Type:	Landscape Design Model

Description:

Forest Ecosystem Solutions Ltd. combines the power of advanced computer modeling techniques and GIS tools with expert professional experience. At the center 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.

All possible regeneration alternatives and treatment regimes can be incorporated into the model. Adjusting growth curves or harvesting percentages of the block at specified intervals incorporates complex harvest systems (i.e. partial cutting) and silvicultural treatments. **FSOS** can also account for re-entry delays. **FSOS** can apply multiple regeneration assumptions.

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 map production.

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.

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;
- 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

All spatial information was received in ARC/INFO format. All data is controlled to the North American Datum (NAD) 83 base. The previous re-inventory for the Sunshine Coast TSA updated forest cover spatial and non-spatial attributes to the fall of 1993. The forest cover inventory has been updated since the re-inventory for depletions to 1999. Also in 1999, a Vegetation Resources Inventory was completed. It provides updated information regarding the height, age and volume of stands in the forest inventory. Annual projections are completed using VDYP. The spatial and attribute data are stored in both the FC1 and FIP file formats, as per the provincial inventory standard database. The spatial inventory data is currently managed through ARC/INFO, which maintains the spatial relationships within the forest inventory as well as the other resource inventory information.

The adjacency file was set for a tolerance of 15 m. This means that the maximum distance between two polygons must be 15 m or less if the two polygons are to be considered adjacent. This distance affects polygon aggregation into harvest units and patches. Generating polygon adjacency at 15 m will prevent small sliver polygons, which may be present in the database, from being a barrier for adjacency.

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 land base are reserved from harvesting, their attributes within forested crown land still contribute to forest cover objectives.

6.1.1. Timber Harvesting Land Base

The net down procedure is an exclusionary process. Once an area has been removed, it cannot be deducted further along in the process. For this reason, the gross area removed is often greater than the net area removed, a result of overlapping resource issues. The following net down is as per the MoF Arc/Info data set for TSR 2.

Table 2 - Timber Harvesting Land Base

Classification	Area Reductions (ha)
Total Land base:	1,555,094
Not directly managed by B.C. Forest Service	553,497
Non-forest	567,975
Total Productive Forest	433,622
Reductions to Total Productive Forest:	
Non-commercial	77
Roads, trails and Landings	5,241
Inoperable	135,312
Low productivity	16,292
Specific cultural heritage resources	43
Environmentally sensitive areas (ESA)	7,143
Recreation	267
Unstable soils	27,561
Goat – Ungulate winter range	2,849
Riparian Areas	9,592
Wildlife Tree Patches	4,882
Total Reductions to Land base	1,330,731
Current THLB	224,363
Future Reductions:	
Future Roads	
Long-Term THLB	

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.

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 3 lists the management zones in the TSA and the rationale used to define these zones.

Multiple resource issues may be present on the same forest area. For example, the watershed management zone may also have areas, which are visually sensitive and require an old growth objective. **FSOS** can accommodate multiple overlapping resource layers. Establishing target levels for each layer does this. The model then schedules harvest units which best meet the target levels for all resource layers as a whole.

Table 3 - Management Zones

Management Zone	Criteria used to Delineate Zone	Rationale/Comment
IRM Zone	All areas on which standard integrated resource management practices occur.	The timber harvesting land base which is considered to be free of extraneous constraints
Visually Sensitivity Preservation Retention Partial Retention Modification	No alteration in practical terms. High sensitivity to alteration Moderate sensitivity to alteration Low sensitivity to alteration	
BEC Variants: CDF mm CWH dm CWH ds1 CWH mm1 CWH ms1 CWH vm1 CWH vm2 CWH xm1 CWH xm2 MH mm1 MH mm2 MH mm2e	Defined in the Biodiversity Guidebook. They determine the natural disturbance regime, and old growth objectives within these zones. Full biodiversity percentages were applied from year 1 and a 45/45/10 rule was applied to each landscape unit.	Old growth objectives will be applied by landscape unit and by variant to ensure representation within each unit.
Islands		Forest cover requirements beyond the Forest Practises Code
Community Watersheds	Areas defined by District Staff	Max (1% *length of 1 st period) disturbance rate.
Aerial Harvest	Area defined by District Staff	
Community Interface	Area defined by District Staff	Area defined by District Staff

Biodiversity, IRM and VQO objectives are applied by landscape unit. All other objectives were applied TSA wide.

7.2. Analysis Units

Table 4 lists the principal criteria used in the aggregation of stands with similar biological characteristics into larger homogeneous units called analysis units (AUs). This aggregation provides the mechanism for application of stand-level modeling and reporting. Each forest cover polygon will be assigned an AU, based on the criteria in Table 4.

Table 4 - Analysis Units

AU	Species & Site Class	Inventory Type Grp	SI Range
1	Fir – good	1-8	> 32
2	Fir – medium	1-8	26 – 32
3	Fir – poor	1-8	< 26
4	Cedar – good	9-11	≥ 17
5	Cedar – poor	9-11	< 17
6	Hem/Bal/Spruce – good	12-26	> 25
7	Hem/Bal/Spruce – medium	12-26	22 – 25
8	Hem/Bal/Spruce – poor	12-26	< 22
9	Pine – good/medium/poor	27-34, 40-42	All
10	Red Alder	37-38	All
11	Other merchantable deciduous	39, 35-36	All
21	Fir – good XM (CWHxm1, xm2)	1-8	> 32
22	Fir – medium XM (CWHxm1, xm2)	1-8	26 – 32
41	Fir – good Shelt (Shelterwood)	1-8	> 32
51	Fir – medium Shelt (Shelterwood)	1-8	26 – 32
61	Fir – good Shelt XM	1-8	> 32
71	Fir – medium Shelt XM	1-8	26 – 32

The shelterwood analysis unit are located at urban interfaces. It is assumed that 85% of the volume in these stands is harvested on the first entry. The second entry takes place 12 years later removing the remaining 15% of the volume after which the stands are regenerated as per Table 5.

8. REGENERATION ASSUMPTIONS

Within the strategic silviculture analysis, there are two levels to regeneration assumptions. The first level is regeneration trends consistent with the TSR 2 analysis. These assumptions deal with age of regenerating trees, NSR regeneration assumptions, regeneration distributions, site index adjustments etc. The second level, the strategic silviculture level, addresses trajectory options for regenerating stands.

8.1. Yields for Base Case Managed Stands

This section describes the current regeneration regimes for the TSR 2 base case, identifying managed stand conditions for each analysis unit. The operational adjustment factors for all regeneration AUs are 15% for OAF 1. For OAF 2 12% was used for all good and medium fir sites, 12.5% for all good and medium fir sites within CDHxm. The rest of the analysis units were adjusted using 5% for OAF 2.

Table 5 - Existing and Future Managed TIPSy Curves - Planted and Spaced

AU	Regen Delay	OAF1 %	OAF2 %	Plant/Natural %	Density	Space
101 Fir – good	2	15	12	100/0	1200	700
102 Fir – medium	2	15	12	100/0	1200	700
103 Fir – poor	2	15	5	100/0	1200	
104 Cedar – good/medium	2	15	5	90/10	1200	700
105 Cedar – poor	2	15	5	60/40	1200	
106 Hem/Bal/Spruce – good	2	15	5	70/30	1200	700
107 Hem/Bal/Spruce – medium	2	15	5	60/40	1200	
108 Hem/Bal/Spruce – poor	2	15	5	50/50	1200	
109 Pine	2	15	5	0/100	1200	700
121 Fir – good XM (CWHxm1, xm2)	2	15	12.5	100/0	1200	700
122 Fir – medium XM (CWHxm1, xm2)	2	15	12.5	100/0	1200	700
141 Fir – good Shelt (Shelterwood)	2	15	12	100/0	1200	700
151 Fir – medium Shelt (Shelterwood)	2	15	12	100/0	1200	700
161 Fir – good Shelt XM	2	15	12.5	100/0	1200	700
171 Fir – medium Shelt XM	2	15	12.5	100/0	1200	700
202 Fir – medium	2	15	12	100/0	1200	700
203 Fir – poor	2	15	5	100/0	1200	
204 Cedar – good/medium	2	15	5	90/10	1200	700
205 Cedar – poor	2	15	5	60/40	1200	
206 Hem/Bal/Spruce – good	2	15	5	70/30	1200	700
207 Hem/Bal/Spruce – medium	2	15	5	60/40	1200	
208 Hem/Bal/Spruce – poor	2	15	5	50/50	1200	

8.1.1. Genetic Gain Allowances

The base case includes genetic improvement; the managed stand curves for fir, hemlock and cedar were adjusted upwards by 1.5%. The TSR 2 assumption was that 75% of the seed used is Class A seed with the average genetic worth of 2%. 75% $\times$ 2% makes 1.5% for genetic worth.

The genetic worth was adjusted for the silviculture strategy base case and the ensuing analyses to reflect the quality of future seed lots. The second-generation improved seed is not anticipated to be available until 2010. However, this analysis assumed the use of the second-generation seed throughout the

planning horizon. The projected genetic gains for Cw, Fd and Hw were received from the Tree Improvement Branch of the Ministry of Forests. It was assumed that only 75% of the land base received genetically improved seed and the genetic gain was adjusted accordingly. The following table illustrates the genetic gain percentages that were used for managed stands in the analysis (75% of genetic gain).

Table 6 - Genetic Gain for the Incremental Silviculture Scenarios

Species	Projected Availability of Seed	Genetic Gain	75% of Genetic Gain (Weighted Average)
Cw Maritime, low elevation	1,400,000	11 %	8.25 %
Fd Maritime, low elevation	1,200,000	14%	
Fd Maritime high elevation	50,000	5%	
Fd Maritime/Sub Maritime	40,000	4%	
Fd Weighted Average		13.34 %	10.01 %
Hw Maritime low elevation	100,000	15%	
Hw Maritime high elevation	45,000	2%	
Hw Weighted Average		10.97 %	8.22 %

8.2. Existing Managed Immature

Table 7 provides information, by analysis unit and leading species, for the area by age class of planted and spaced second growth immature stands, applied in TSR 2.

Table 7 - Existing Managed Immature by Age Class

Analysis Unit	Area Managed (%)	
	Age 1-20	Age > 20
All Douglas-Fir	100	0
All Cedar	100	0
All Hem/Bal/Spruce	100	0
All Pine	0	0
Red Alder	0	0
Other Merchantable Deciduous	0	0

All scenarios use the above definition for managed stands, however, from the silviculture strategy onward also older stands with a history of management were considered managed stands.

8.3. Not Satisfactorily Restocked

In *FSOS*, NSR is modeled using negative ages, which are applied to reflect the NSR restocking schedule. All NSR is considered current and is assumed to regenerate within specified regeneration delay period as per Table 5. NSR is restocked in proportion to the current area of each analysis unit in stands less than 20 years old.

8.4. TASS Curves

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

treatment, etc. For each AU, the stakeholder group in Workshop #1 identified a series of treatment regimes. The TASS curves were generated for each regime after which the regimes were tested from a forest-level perspective using FSOS.

The TASS curves provide a range of treatment regimes for regenerating stands. From these treatment options, a “good” treatment option for each stand based on forest-level objectives can be determined. The treatment regimes are shown in Table 8.

Table 8 – Incremental Silviculture Treatment Regimes

AU	SP	SI	Regen Delay	OAF1	OAF2	Silviculture Strategy Options ¹									
						Plant/ Natural %	Initial Density	FTG Density	Space	Space Fert	Space Fert Ct	CT	Space Prune	Space Prune fert	Do Not Treat
101 Fir – good	Fd	35.4	2	15	12	100/0	2420	2200	✓	✓	✓	✓	✓	✓	✓
102 Fir – medium	Fd	27.7	2	15	12	100/0	2640	2400	✓	✓	✓	✓	✓	✓	✓
103 Fir – poor	Fd	19.2	2	15	5	100/0	2860	2600	✓	✓					✓
104 Cedar – good/medium	Cw	24.6	2	15	5	90/10	2750	2500	✓						✓
105 Cedar – poor	Cw	14.3	2	15	5	60/40	2420	2200							✓
106 Hem/Bal/Spruce – good	Hw	27.5	2	15	5	70/30	4950	4500	✓			✓			✓
107 Hem/Bal/Spruce – medium	Hw	23.6	2	15	5	60/40	4950	4500	✓						✓
108 Hem/Bal/Spruce – poor	Hw	17.3	2	15	5	50/50	4620	4200							✓
109 Pine	Pl	16.3	2	15	5	0/100	2200	2000							✓
121 Fir – good XM (CWHxm1, xm2)	Fd	33.2	2	15	12.5	100/0	2420	2200	✓	✓	✓	✓	✓	✓	✓
122 Fir – medium XM (CWHxm1, xm2)	Fd	27.2	2	15	12.5	100/0	2640	2400	✓	✓	✓	✓	✓	✓	✓
141 Fir – good Shelt (Shelterwood)	Fd	35.4	2	15	12	100/0	2420	2200	✓	✓	✓	✓	✓	✓	✓
151 Fir – medium Shelt (Shelterwood)	Fd	27.6	2	15	12	100/0	2640	2400	✓	✓	✓	✓	✓	✓	✓
161 Fir – good Shelt XM	Fd	33.2	2	15	12.5	100/0	2420	2200	✓	✓	✓	✓	✓	✓	✓
171 Fir – medium Shelt XM	Fd	27.5	2	15	12.5	100/0	2640	2400	✓	✓	✓	✓	✓	✓	✓

¹ Parameters for Treatments:

Space – 700 stems/ha at 12 years

Prune – 1st lift 12 years (3.1 m), 2nd lift 18 years (5.6 m)

CT - 40 to 70 years, 300 sph @ 30 cm quad mean DBH – 20 year delay to MHA

Fert (aerial) – 15, 25, 35, 45, 55 years

Stands in the heli-logging zone do not receive any treatments; they regenerate to the ‘do nothing’ option.

It is assumed that the densities depicted in the table model natural ingress adequately.

Existing managed stands were determined to be all stands that were 20 years in age or less. Where treatments could be confirmed in the ISIS database or in the FIP database, existing managed stands were placed on the appropriate point on the yield curve based on age and previously applied treatments.

Where information could not be directly linked to ISIS, the forest cover information was used.

8.4.1. Minimum Harvest Age Criteria

The same criteria as in the TSR 2 base case were used to determine the minimum harvest age (MHA) for TASS yield curves. The lowest minimum age at which all the criteria were achieved defined the MHA. The actual harvest age was defined by model scheduling.

Table 9 – Minimum Harvest Age Criteria

Analysis Units		Minimum Volume/ha	Harvest Age
1	Fir – good	300 m ³ /ha	95% of max MAI
2	Fir – medium	300 m ³ /ha	95% of max MAI
3	Fir – poor	300 m ³ /ha	95% of max MAI
4	Cedar – good	300 m ³ /ha	95% of max MAI
5	Cedar – poor	300 m ³ /ha	95% of max MAI
6	Hem/Bal/Spruce – good	300 m ³ /ha	95% of max MAI
7	Hem/Bal/Spruce – medium	300 m ³ /ha	95% of max MAI
8	Hem/Bal/Spruce – poor	300 m ³ /ha	95% of max MAI
9	Pine – good/medium/poor	300 m ³ /ha	95% of max MAI
10	Red Alder	300 m ³ /ha	95% of max MAI
11	Other merchantable deciduous	300 m ³ /ha	95% of max MAI

For commercially thinned stands MHA is at least 20 years later than commercial thinning.

8.4.2. Site Index Adjustments

Prior to reassignment of a yield curve, existing mature stands (>140 years) had OGSi adjustments applied, after harvest, according to the *Site Index Adjustments for Old-Growth Stands Based on Veteran Trees* (1998) study. No SIBEC adjustments were applied, as it was assumed that the recently completed inventory audit and the resulting site index adjustments represented the best available information.

8.5. ISIS Integration

The linkage from ISIS to the forest cover is not a 1-to-1 relationship. Currently, an opening number is used to link the two databases; however, within each opening, the forest cover data may have several forest cover polygons, and ISS several treatment units. The number of sub-components in the opening may or may not be equal between ISS and the forest cover information.

Where a 1-to-1 relationship existed, the FIP database was updated with ISS data based on the leading species within each opening. Where a direct linkage was not achieved, the data was linked based on

leading species and a tolerance around reported areas and a “best-fit” was achieved. With this method, a high usability of the ISIS data was achieved.

8.6. Regeneration Delay

The regeneration assumption made in the Timber Supply Review was used for the silviculture strategy analyses. The effective regeneration delay is 2 years.

9. PROTECTION

9.1. Unsalvaged Losses

Unsalvaged losses are losses due to natural events that are non-recoverable and result in a decrease in the productivity of the TSA. These losses focus on the epidemic losses, such as losses due to fire, insects and diseases that are not salvaged, whereby the endemic losses are accounted for through operational adjustments and net down reductions. The analysis uses the values and rationale from the TSR 2 data package. The losses for wind, fire, mammals and insects total 12,211 m³/year.

Volumes are removed from the modeled harvest levels to represent net available volume.

10. INTEGRATED RESOURCE MANAGEMENT

The intent of this section is to provide details on how modeling methodology will integrate non-timber resource values with timber objectives.

10.1. Forest Cover Requirements

Table 10 outlines the forest cover objectives for the Sunshine Coast TSA, by management zone, for maintaining non-timber values. Forest cover objectives are applied to model biodiversity values, hydrological recovery, and visual quality objectives by placing maximum and/or minimum boundaries on specific age distributions, focusing largely on young age and old age forests.

By applying Forest Ecosystem Solutions Ltd.'s analysis approach, 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.

Table 10 - Management Zones and Forest Cover Objectives – Base Case Scenario

Resource	Zone	THLB Area (ha)	Prod Area (ha)	Cover Requirement			
				Age 1	Max % < age 1	Age 2 (years)	Min % > (1/ 70/ 140)
IRM^a		115,299	132,501	13	33	-	-
Visual Quality	Preservation			16	1	-	-
	Retention			16	5	-	-
	Partial Retention			17	15	-	-
	Modification			16	25	-	-
BEC Variants^a	CDF mm	1,124	1,196	-	-	250	7.0/ 8.0/ 9.0
	CWH dm	64,992	73,965	-	-	250	7.0/ 8.0/ 9.0
	CWH ds1	11,390	13,350	-	-	250	7.0/ 8.0/ 9.0
	CWH mm1	299	330	-	-	250	7.0/ 8.0/ 9.0
	CWH ms1	5,402	6,534	-	-	250	7.0/ 8.0/ 9.0
	CWH vm1	34,875	40,957	-	-	250	10.0/ 12.0/ 14.0
	CWH vm2	47,145	56,008	-	-	250	10.0/ 12.0/ 14.0
	CWH xm1	34,317	37,174	-	-	250	7.0/ 8.0/ 9.0
	CWH xm2	5,261	5,946	-	-	250	7.0/ 8.0/ 9.0
	MH mm1	10,072	11,811	-	-	250	14.0/ 17.0/ 20.0
	MH mm2	550	708	-	-	250	14.0/ 17.0/ 20.0
	MH mm2e	0	0	-	-	250	14.0/ 17.0/ 20.0
	ATp	4809	301	-	-	250	14.0/ 17.0/ 20.0
Islands		13,979	15,764	13	25	-	-
Water Supply	23 community watersheds	24,280	26,480	5	10	-	-
Aerial Harvest	SRMZ	8,340	11,034	14	33	-	-
Community Interface		30,684	33,278	17	25	-	-

^a Applied by individual landscape unit

11. TIMBER OBJECTIVES

11.1. Timber Values

Timber values used within the analysis are based on a series of piece size groupings - similar to industrial grading - for each species. The analysis is based on average log diameter, taper, and 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 database. The data is based on indexed monthly averages for the 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 11. Figure 1 depicts per cubic meter pricing for different grades by incremental top diameter.

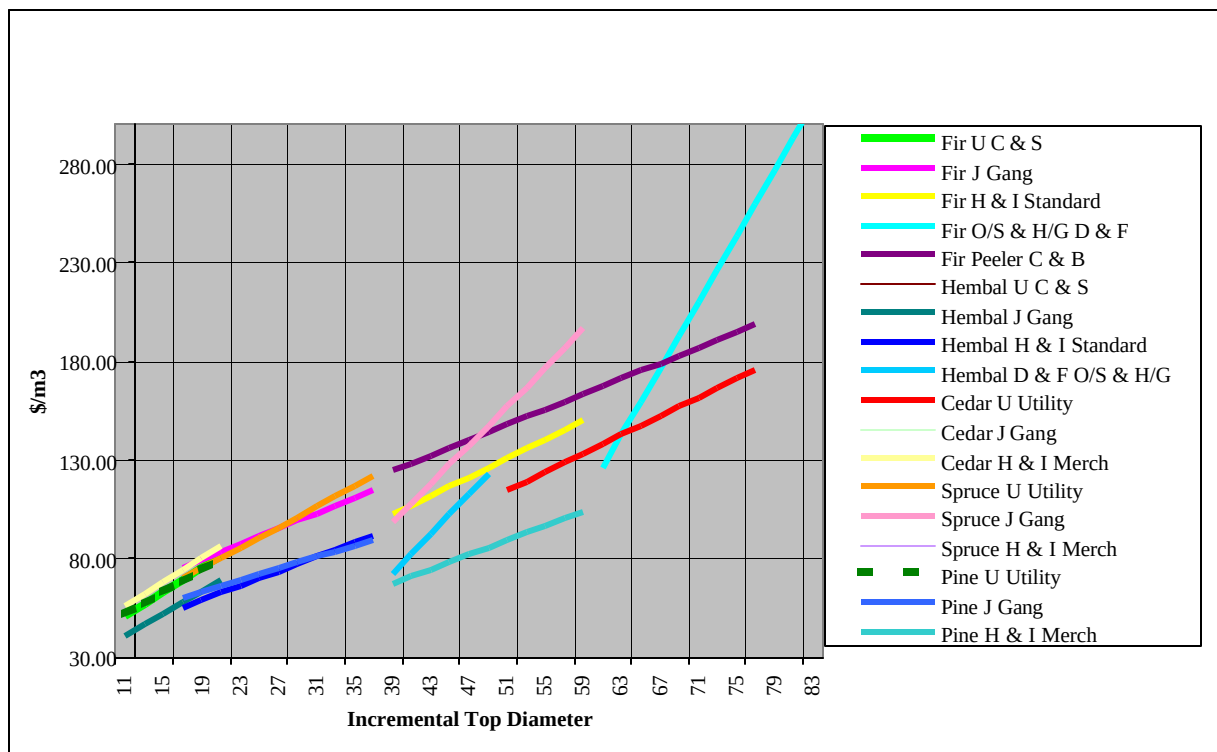


Figure 1 - Second Growth Timber Value by Species Grade; Sort at Howe Sound

Table 11 - Summary of Second Growth Selling Prices by Diameter Class

Species	Statutory Grades	Assumed Industrial Sorts	Average	Max.	Min.	Upper Quartile	Lower Quartile	Incremental Top Diameters In 2 cm Classes (l.b.)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
			Selling Price	Selling Price	Selling Price			11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75	77	79	81	83																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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All timber values are based on domestic pricing, regardless of whether export opportunities for the wood exist.

11.2. Pruning Value

Some feel that the grades and their valuation do not reflect the increase in log value due to pruning adequately. For this reason the stand values of pruned stands were increased as per Table 12.

Table 12 – Percent Clear Volume per ha and Corresponding Value Increase

Leading Species	% Clear (m³/ha)	Value Multiplier (20 year Avg.)	Stand Value Multiplier
Fdc	15%	3.7	1.41
Hw	15%	3.6	1.39
Cwr	15%	3.0	1.30

11.3. Treatment Costs

Treatment costs for the analysis are based on industry information obtained after the first workshop. Table 13 shows the treatment costs used in the analysis. Table 14 illustrates the landscape units within each cost zone.

Table 13 - Treatment Costs

Treatment	Cost Zone			
	Low	Medium	High	Person Days
Spacing (per ha)	\$1200	\$1700	\$2400	4.0
Pruning 1 st lift (per ha)	\$1800	\$2200	\$2500	6.0
Pruning 2 nd lift (per ha)	\$1500	\$2100	\$2300	5.0
Fertilization (per ha)	\$150	\$200	\$250	0.1
Commercial Thin (per ha)	\$0	\$0	\$0	2.0

Table 14 - Cost Zones in the Sunshine Coast TSA

Landscape Unit	Cost Zone
Homathko	High
Southgate	High
Bute West	High
Bute East	High
Bishop	High
Toba	High
Brem	High
Quatam	High
Homfray	High
Powell Daniels	High
Brittain	High
Skwawka	High
Jervis	High
Bunster	Low

Haslam	Low
Lois	Low
Sechelt	Low
Chapman	Low
Cortes	Medium
Texada	Medium
Powell Lake	Medium
Narrows	Medium
Salmon	Medium
Howe	Medium

11.4. Commercial Thinning

Commercial thinning is assumed to have no net cost. The analysis assumes that commercial thinning will be carried out only in the low cost zone landscape units covering approximately 32% of the timber harvesting land base. Stands between the ages of 40 and 70 years are eligible for commercial thinning when they reach the quadratic mean diameter at breast height of 30 cm. These stands are thinned down to 300 stems per hectare. The minimum harvest age gets delayed by 20 years if the stand is commercially thinned.

11.5. Fertilization

Fertilization, in scenarios is applied after every 10 years starting at age 15 until age 55.

11.6. Value Analysis

In the analysis, all silviculture costs and product values can be aggregated at the forest level and used as they are, or brought back to today's dollars using different discount rates. The model can be used to find a solution that would increase the value of the solution over the planning horizon.