

Strathcona TSA Silviculture Strategy (Type 2)

**Prepared For:
Vancouver Forest Region, Forest Practices
British Columbia Ministry of Forests**

**Prepared by:
Doug Williams, Ph.D.
Mike Buell, B.S.F.**

**Cortex Consultants Inc.
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Summary

This report documents a forest-level modeling study that examines the implications of silviculture regime options proposed by the Campbell River Forest District for implementation on the Strathcona TSA. The objective of the project is to provide strategic direction to the District silviculture staff in the design of their silviculture program.

Benefits are evaluated against the TSR base case

A silvicultural planning model was developed using the Woodstock (Remsoft, 1997) modeling language that is consistent with the current TSR model and base case for the TSA, and also fully represents the additional forest-level objectives and silvicultural activities required for silvicultural planning. The landbase and management parameters, described in AAC Rationale for Strathcona TSA (January 2000), are the basis of the silviculture planning model implemented for this study. Using the TSR base case as the point of departure ensures that benefits from incremental silviculture are modelled in a management context consistent with the Chief Forester's assumptions when he set the AAC.

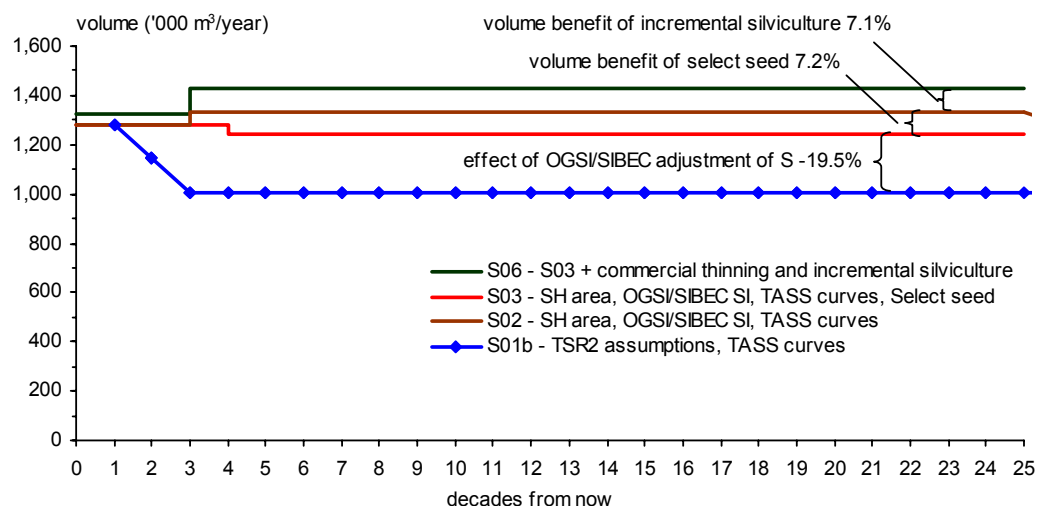
Quantity, quality and financial objectives are evaluated

Scenarios were evaluated for their impacts on four forest-level management objectives: maximizing total timber supply (harvest volume), maximizing the supply of larger dimension logs, maximizing the supply of solid-clear wood, and maximizing financial efficiency.

OGSI/SIBEC: 19.5% increase in LTHL

The site indices of the Strathcona TSA were adjusted with a procedure employing OGSI and SIBEC information in a manner consistent with the TSR timber supply analysis approach. This adjustment of site indices increased the LTHL by 19.5% (Figure E-1) and was accepted as part of the silviculture base case management assumptions. Note that volume harvest effects and benefits on Figure E-1 are expressed as percentage deviations from the base case LTHL.

Figure E-1. Impact of management assumptions on forecast harvest.





14.3% increase in harvest in long term	<p>Figure E-1 shows the impact of intensification of management on timber supply. In the long term, planting select stock will increase harvest levels by 7.2%, and spacing and fertilization increase the harvest level by an additional 7.1%. The contribution of commercial thinning has no independent benefit. However, commercial thinning is employed extensively in the spacing and fertilization scenarios and probably contributes to the 14.3% benefit by allowing optimal timing of the harvest.</p>
13%-21% of cut in solid-clear wood	<p>An aggressive program of pruning can shift volume into higher log grades (J though C), especially if harvest volume benefits from incremental silviculture and select stock are forgone. The analysis found that an optimum pruning program, coupled with incremental silviculture, will return 13% of the LTHL as solid-clear wood, while maintaining the LTHL at its maximum attainable level. If the LTHL is reduced from its maximum level by 14.3%, i.e., forego the volume benefits of planting select stock and incremental silviculture, then 21% of the (reduced) harvest can be recovered as solid-clear wood</p>
50% more volume of 45+ cm logs	<p>The analysis showed that volume harvested in the long term of stems 45+ cm is only slightly affected by incremental silviculture, but if combined with a 14.3% reduction in harvest, the volume recovered as 45+ cm logs increases by 50%.</p> <p>The financial efficiency objective causes the higher site Douglas-fir leading stands to be managed intensively in order to maintain minimum harvest levels. Less valuable stands are managed on longer rotations, causing long-term total and operable growing stock levels to increase 26% and 37%, respectively.</p>
Silviculture regimes	<p>The silvicultural regimes determined by the model differ according to the management objective guiding the analysis. Under the management objective of maximizing volume production, fertilization regimes are emphasized.</p> <p>Fertilization regimes are also employed when the objective is large dimension wood, but the dimension objective is achieved largely by lengthening rotation. Fertilization helps maintain harvest levels.</p> <p>When the management objective is solid clear wood and financial efficiency, the emphasis shifts to stands with regimes that include fertilization and pruning. Just as in the large dimension scenario, the financial efficiency scenario lengthens stand rotation and harvests large dimension pruned, fertilized stands.</p> <p>Under all objectives, regimes that include commercial thinning help maintain harvest levels while allowing the residual stand to be held long enough to develop the desired dimensional characteristics.</p>
First decade activities: space, fertilize and commercial thin	<p>In the first decade, juvenile spacing of good and medium-site Douglas-fir is indicated under all management objectives. Spacing of good site hemlock-leading stands are desirable if the objective is quality (solid clear or dimension) or financial efficiency. Fertilization is scheduled for medium site existing managed Douglas-fir, and commercial thinning is indicated for both good and medium-site Douglas-fir.</p>



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1.0 Introduction

This report documents a forest-level modeling study that examines the implications of silviculture regime options proposed by the Campbell River Forest District for implementation on the Strathcona TSA. The objective of the project is to provide strategic direction to the District silviculture staff in the design of a silviculture program.

A silvicultural planning model was developed that is consistent with the current TSR model and base case for the TSA, and also fully represents the additional forest-level objectives and silvicultural activities required for silvicultural planning.

The TSR base case is the appropriate "point of departure" for the silviculture analysis because it:

- reflects the management unit's current land base, inventory, growth and yield, and management practices;
- is the schedule of timber supply from the base case data set that conforms to Ministry of Forests' conventions regarding harvest flow, and any departures from the standard harvest flow conventions that may have been deemed appropriate by the TSR;
- ensures that the silvicultural planning model is based on the timber supply assumptions for the TSA that the Chief Forester considered (or will consider) in setting the AAC for that TSA.

A major difference between the TSR analyses and this analysis is the choice of forest-level model. The TSR uses the simulation model FSSIM while this analysis was undertaken with a linear programming (LP) model developed using the Woodstock (Remsoft, 1997) modeling language. The LP formulation was selected because of its flexibility and comprehensiveness in representing silviculture activities, its ability to incorporate complex and multiple objectives, and its facility and consistency with economic reasoning. The LP model is referred to in subsequent sections of this report as the Strathcona Silviculture Planning Model (SSPM).

After this introduction, Section 2.0 of this report describes the information requirements for the analysis with special emphasis on changes to the TSR data base and additional information required for the silvicultural analysis. The next section (Section 3.0) describes the results of modelling the scenarios constructed to explore the implications of intensification of management. Section 4.0 reports the long-term silviculture strategy for the TSA-- the regimes selected to achieve the forest-level objectives -- and the silvicultural activities that are feasible in the first decade. Some of the limitations of the study are discussed in Section 5.0





2.0 Data and Management Assumptions

This section describes the data and assumptions used in this analysis that differ from those documented in TSR2 or are additional inputs that are required for the silvicultural analysis. Other forest management assumptions—including forest cover requirements, utilization levels and standards, unsalvaged losses and green-up assumptions—are unchanged from the TSR2 timber supply analysis.

2.1 Changes to the TSR2 Landbase

The data set provided to the project team by Timber Supply Branch contains 177 797 ha operable forest, including NSR (16 239 ha) and Timber Licences (4 210 ha) which will revert to Crown management in the future. All of the NSR area was reclassified as regenerated ages 1-10, as it has been determined to be SR or current NSR (BC MoF, 1999).

Future roads, trails and landings are not removed from the THLB

Loss of productive land to future roads, trails and landings are modelled explicitly with the SSPM, in that a specified percentage of land harvested for the first time is removed from the productive land base. Losses to roads and landings occur at a rate of 6% from harvested natural stands age 90 years and above.

2.2 Adjusting the Site Indices of the TSA

The analysis specifications required that the site indices of the management unit be adjusted to incorporate site index estimates from OGSi surveys and SIBEC. The procedure used to adjust the site indices is fully explained in Appendix F. This appendix also outlines the limitations of the SI adjustments and their substantial impacts on yields for the TSA. MoF District and Region staff considered these limitations and impacts and decided to proceed with the analysis based on the adjusted site indices.

SI adjustment:
Douglas-fir +1.52 m
Hemlock +2.29 m
HemBal +3.39 m

Note that the effect of the adjustment was substantial. The average area weighted site index for Douglas-fir has increased by 1.52 m, and by 2.29 m and 3.39 m for the hemlock and hembal components of the inventory, respectively.

2.3 Silviculture Analysis Units

The inventory file with the SIBEC/OGSi adjusted site indices was aggregated into silviculture analysis units using leading species and site index breaks specified by the District.

The 10 analysis units defined for TSR2 were aggregated by District staff into 9 silviculture analysis units (SAUs) deemed appropriate for the silviculture regimes contemplated for the TSA (see Table 2-1). Mean site index (metres at 50 years) for each SAU was calculated as the area weighted average of the (adjusted SIBEC/OGSi) site indices of its constituent TSR2 analysis units.



Table 2-1. Definition of silvicultural analysis units based on SIBEC and OGSi adjusted site indices.

Silviculture Analysis Units	Type Group	Leading Species	Site Index Range	Total Area	Weighted Average SI	% THLB
1	1-5, 8	Douglas-fir	32 <= SI	17,509	34.4	9.8%
2	1-5, 8	Douglas-fir	27 <= SI < 32	15,585	28.9	8.8%
3	1-5, 8	Douglas-fir	SI < 27	10,529	21.9	5.9%
4	12-14,16,17	Hemlock	27 <= SI	16,186	29.8	9.1%
5	12-14,16,17	Hemlock	22 <= SI < 27	44,670	23.5	25.1%
6	12-14,16,17	Hemlock	SI < 22	14,520	17.2	8.2%
7	15, 18-20, 9-11,21-26	Hem-Bal	22 <= SI	35,803	25.6	20.1%
8	15, 18-20, 9-11,21-26	Hem-Bal	14 <= SI < 22	17,477	18.1	9.8%
9	37-39	Deciduous	all	5,517	26.0	3.1%
subtotal:				177,797		100.0%

2.4 Silvicultural State of the Landbase

The silviculture state of a stand records the information that the manager needs in order to determine what silviculture activities are immediately feasible (not including operational considerations such as harvesting restrictions, accessibility, terrain, or markets). For example, species mix, age, density, basal area, crown closure may be the variables that the silviculturalist considers when deciding the treatment of a stand. These state variables change over time with the development of the stand (growth, competition, mortality) and with silviculture actions (e.g., juvenile spacing).

The TSR timber supply analysis differentiates between stands that are in natural states and managed states in order to assign appropriate yield curves. A silvicultural analysis requires a more complex definition of the silvicultural state of each stand in order to determine feasible management actions and appropriate managed stand yield curves.

Describing the silvicultural state in terms of the variables utilized by the silviculturalists may be appropriate for operational, program-level planning, but is too detailed for strategic planning with a forest-level model. For the purposes of this project, the silviculture state of forest stands was developed from the ISIS and MLSIS data bases and is described in Appendix A.



2.5 Management Practices

Harvesting operability responds to silviculture	In addition to the harvesting methods included in the TSR analysis (conventional clearcutting), this study explicitly models commercial thinning.
Commercial thinning is single entry, 2 possible ages	However, instead of assigning a minimum harvest age for harvesting, minimum operable volumes were calculated from the height, diameter and volume criteria described in the TSR analysis report. Specifying minimum operable volumes allows the model to reduce harvesting ages in response to the volume benefits of intensification of management.
Initial harvest profile is imposed	The development of stands post commercial thinning was simulated with TASS, according to residual stand criteria (trees per hectare, target volume removal) and method (single entry, from below, leaving the largest well-spaced trees) supplied by the District. The District specified two ages of entry. Alternate ages of entry were included in order to provide additional flexibility in re-ordering the harvest queue. The harvest profile for the first decade is imposed on the silviculture model to ensure that silviculture activities selected by the model reflect current operations. The distribution of the first-decade harvest shown in Table 2.2 was constructed from recent forest development plans for the Strathcona TSA. In the first two decades commercial thinning is limited to volumes specified by the District for SAU01 and SAU02. The volume is 45 000 m ³ /year for the first decade and 30 000 m ³ /year for the second.

Table 2-2. Harvest profile (% volume harvested) in the first decade by inventory type, harvest method, and supply block.

Decade 1 constraint	SAU	Age	Harvest Method	Supply Block	% Harvest
Species constraints					
Immature FD	1-3	1-140	N/a	n/a	3
Mature FD	1-3	> 140	N/a	n/a	7
H	4-6	n/a	N/a	n/a	28
H,B	7-8	n/a	N/a	n/a	60
Deciduous	9	n/a	N/a	n/a	2
Total					100
Harvest method constraints					
Conventional	n/a	n/a	Conventional	n/a	84
Heli-logging	n/a	n/a	Heli	n/a	16
Total					100
Supply block constraints					
Sayward SB	n/a	1-140	N/a	Sayward	28
Kyuquot SB	n/a	> 140	N/a	Kyuquot	60
Loughborough SB	n/a	> 140	N/a	Loughborough	12
Total					100

Source: John Andres, Campbell River Forest District.



Base case scenario
assumes basic
silviculture

The base case scenario for this study assumes basic silvicultural practices and models these practices in a manner identical to the TSR timber supply analysis. The remaining scenarios of this study require the simulation of complex silvicultural regimes including spacing, pruning, fertilization and commercial thinning.

Regime diagrams

Alternative management regimes incorporating these incremental silviculture activities and commercial thinning were specified for each SAU by District staff and regime diagrams were constructed that delineate the alternative silvicultural states of each SAU and the feasible transitions between these states. These regime diagrams are useful for communicating the possible development states implied by sets of alternative regimes, and for specifying yield tables required for stands in harvestable states. The regime diagrams for each SAU are included in Appendix B.

Managed stand yield
tables are simulated
with TASS

Each harvesting activity represented in the regime diagrams requires a yield table corresponding to the silvicultural state that it is acting on. Managed stand yield tables were created by Research Branch using TASS. Yield tables for existing natural stands and TSR2 managed stands were obtained directly from the TSR2 data files. The yield tables for each SAU are included in Appendix E.

Costs and labour requirements for implementing the silvicultural treatments are listed in Table 2.3.

Table 2.3. Cost^[DW1] and labour assumptions for silviculture treatments.

Activity	\$/ha	P-day/ha
plant	800	3
space	1200	2
prune	2700	6
fert	275	0.1

Source: John Andres, Campbell River Forest District



2.6 Select Stock and Genetic Gain

The benefits from planting select stock in the Strathcona TSA are evaluated in this study. The genetic gain for each analysis unit specified by the District is listed in Table 2.4 and the calculation of these gains is detailed in Appendix C.

Table 2-4. Genetic gain data for Strathcona TSA.

Species Planted	Genetic Gain
SAU01	14
SAU02	13.99
SAU03	13.94
SAU04	14.98
SAU05	14.9
SAU06	14.8
SAU07	8.4
SAU08	8.24

Source: R. Plandon, MoF Tree Improvement Branch.





3.0 Analysis Results

This section presents the results of the analysis of ten scenarios designed to quantify the impact of silvicultural practices under different assumptions and objectives. The scenarios are described in detail in Appendix D.

3.1 Base Case

Only three silviculture activities are included in the base case – harvesting, planting, and commercial thinning (decades 1 and 2 only), including basic silviculture. No incremental silviculture (spacing, pruning, or fertilization) or commercial thinning after decade 2 is included.

The base case is modelled for two reasons. It demonstrates the consistency of the silviculture model used in this study with the TSR representation of the TSA's timber supply. With the validity of the silviculture model established, scenarios with intensified management or different management objectives can be compared to the base case results and differences can be quantified and attributed to management assumptions.

Base Case Harvest Forecast

Figure 3-1 compares base case harvest forecasts determined for this study with the TSR2 base case harvest forecast.

Figure 3-1
S01a TSR2 landbase

The harvest schedule labeled S01a corresponds to the base case management assumptions applied to the TSR2 landbase, aggregated into SAUs (Table 2-1), and with unadjusted site indices.

From the initial harvest level (AAC, January 2000) S01a declines 10% in decade 2 and a further 12% in decade 3. This level (995 000 m³ per year) is maintained through the remainder of the planning horizon.

Comparing S01a to the TSR2 harvest forecast, the TSR2 line drops more quickly and to a lower harvest level—12% in decades 2 and 3, down to 970 000 m³ per year—and then rises in decade 10 to 1 070 000 m³ per year. This harvest level is maintained for the remainder of the planning horizon.

S01b Silvicultural
history landbase

The harvest schedule labeled S01b corresponds to the base case management assumptions applied to the silvicultural history landbase (SH; described in Appendix A) and the SAU's with unadjusted site indices. The silvicultural history landbase more accurately represents the silvicultural state of existing managed stands. The S01b schedule maintains a harvest level of 1 001 000 m³ per year out to the planning horizon and is not distinguishable from S01a on Figure 3-1.

Both S01a and S01b show increases over the TSR2 schedule in the short- to mid-term trough (decades 3-10) while under-performing TSR2 in the long term (by 7%). This is partly due to the model solution process, which assigns a higher priority to the maintenance of the initial harvest level for as long as possible and



the reduction of depth of the mid-term trough, and a lower priority on maximizing the long-term harvest level. This difference may also be accounted by the aggregation of the landbase into different analysis units with different associated yield tables.

S02 OGSi/SIBEC site indices

Scenario S02 corresponds to the base case management assumptions applied to the silvicultural history landbase, with the SAU's site indices adjusted for SIBEC/OGSi. The adjusted site indices allow the model to more accurately reflect the current site productivity of mature and existing managed stands. Under this scenario, the current AAC can be maintained through decade 2, dropping to 1 244 000 m³/year in decade 3. This harvest level can be maintained through the planning horizon, and is 14% higher than the TSR LTHL.

S02 vs. TSR2 OGSi sensitivity analysis

The long-term harvest level of S02 differs from that of the OGSi sensitivity analysis conducted in TSR2 by less than 1.8%. The largest difference between the two scenarios is in the short- to mid-term harvest levels. This difference can be attributed to the TSR applying OGSi to regenerating stands, while the present study applies the OGSi adjustment (at the time of regeneration) to stands currently older than 150 years, and also assigns SIBEC-based site indices to existing managed stands

Also, as stated previously, the model assigns a higher priority to the maintenance of the initial harvest level for as long as possible and the reduction of depth of the mid-term trough, and a lower priority on maximizing the long-term harvest level. This modeling technique coupled with existing and regenerating stands reaching operability limits earlier, allows the model to harvest existing stands that were rationed for harvest later in the mid-term under the base case scenario.

This ability to shift existing mature stands forward in the harvest queue allows the AAC to be maintained longer and eliminates the mid-term trough demonstrated in the TSR2 sensitivity analysis.

S03 Select Seed: Silviculture base case

S03 assumes that select seed is planted, in addition to incorporating the assumptions of S02 and S01b, i.e., SH landbase, OGSi/SIBEC adjustments, and TASS managed stand yield curves. Under S03 assumptions, the initial harvest level can be sustained until decade 3, and rises 4% to its LTHL in decade 4.

S03 is the silvicultural base case and silvicultural benefits will be evaluated against this scenario.

**Figure 3-2:
Harvest by leading species**

Figure 3-2 shows the composition of the base case harvest by leading species. The harvest in decade 1 reflects the harvest profile specified by the District (section 2.5) but in subsequent decades the mix of species, harvesting method, and supply block is determined by the model.

**Figure 3-3
Harvest by natural and managed stands**

Figure 3-3 shows the composition of the base case harvest in terms of natural stands, existing managed stands, and future managed stands. The harvest is composed of existing (natural and managed) stands until decade 7, and is not totally dependent on regenerated managed stands until decade 13.

Figure 3-1. Base case harvest forecasts.

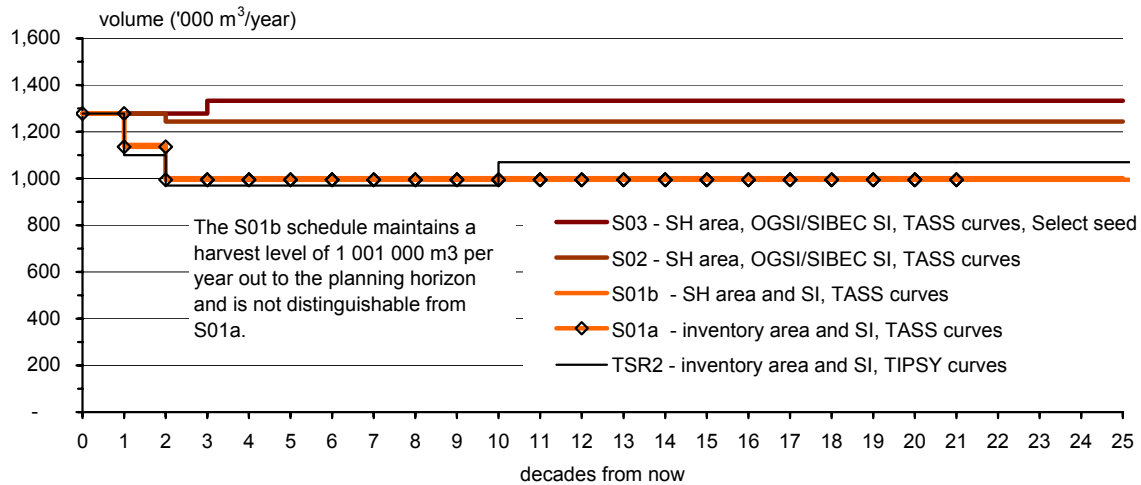


Figure 3-2. Composition by leading species, silviculture base case (S03).

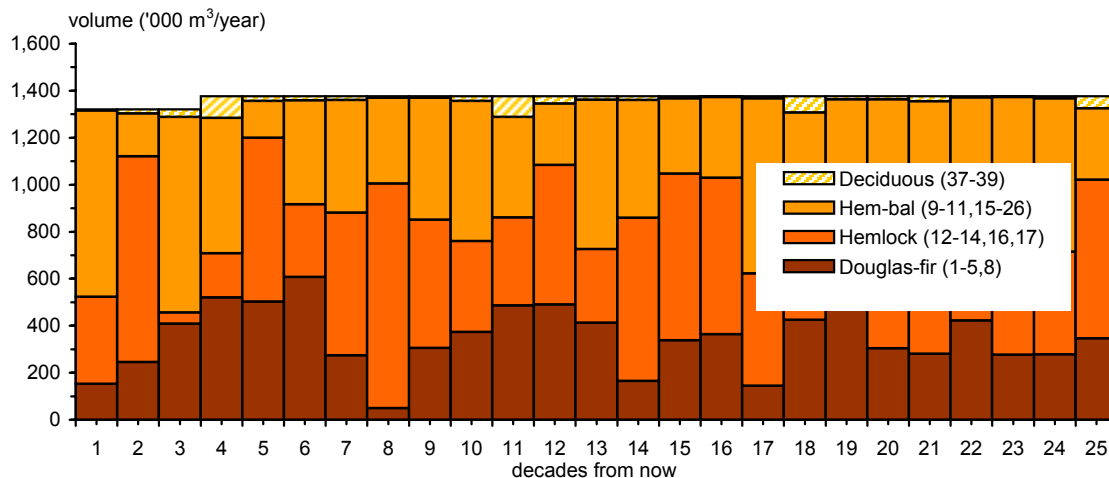
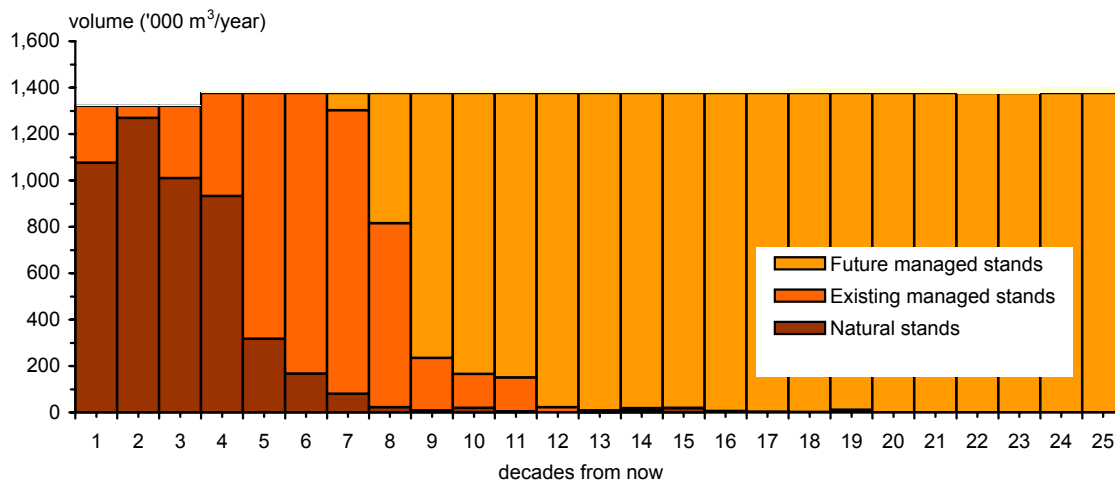


Figure 3-3. Composition by existing natural and managed stands of harvest forecast, silviculture base case (S03).





Response framework	The end of the transition to managed stands (decade 8) is referred to in this study as the end of the mid- term, and the beginning of the long term. The short term is arbitrarily set as decades 1 and 2.
Figure 3-4 Volume per unit area	The harvest forecast by volume per unit area is illustrated in Figure 3-4. The minimum harvestable volume (clearcut) specified by the District for the TSA is 350 m ³ /ha, but a majority of stands harvested have a volume greater than 450 m ³ /ha. Commercial thinning occurs in decades 1 and 2, accounting for volume below 350 m ³ /ha.
Figure 3-5 Harvest by supply block and method	<p>Figure 3-5 forecasts the composition of harvest by supply block and harvesting method. A majority of the harvest is occurring in the Sayward and Kyuquot supply blocks, with the largest amount of heli-logging taking place in the Kyuquot supply block.</p> <p>The volume harvested from the Sayward landscape unit (within the Sayward supply block) in the first two decades is 280 309 m³/year, and in decades 3 the harvest level rises to 360 000 m³/year. This level is maintained through the end of the planning horizon. A harvest analysis of the Sayward Landscape Unit is reported in Appendix G.</p>
Figure 3-6 Age of harvest	The forecast composition of the harvest by age is represented in Figure 3-6. In decades 1 to 3 more than 60% of the harvest is from stands age 250 and above. As the harvest forecast becomes more dependent on managed stands the average harvest age decreases, and the majority of stands are harvested between age 71 and 90.
Figure 3-7 Area harvested and volume per ha	Figure 3-7 plots the area harvested on the left-hand axis, and the harvest volume per hectare on the right-hand axis. Volume per hectare increases during the first 7 decades while the model harvests older, high-volume stands. The trend then decreases and levels out later in the long term (decades 11 to 25) while harvesting is focused on younger managed stands. Note that commercial thinning in the base case occurs only in decade 1 and 2.
Figures 3-8 and 3-9 Grade and diameter distributions	The harvest forecast from managed stands by grade and diameter limit are plotted in Figures 3-8 and 3-9, respectively. In both figures the harvest from natural stands is not differentiated by grade or diameter due to limitations of the VDYP yield tables. Note that the quadratic mean diameter of the harvested managed stands, plotted against the right-hand axis on Figure 3-9, drops steeply while harvesting is concentrated on older exiting managed stands. The quadratic mean diameter drops to a minimum of 25 cm in decade 8 and then remains relatively constant between 25-30 cm from decade 9 out to the planning horizon.

Figure 3-4. Composition of forecast harvest by volume per unit area, silviculture base case (S03).

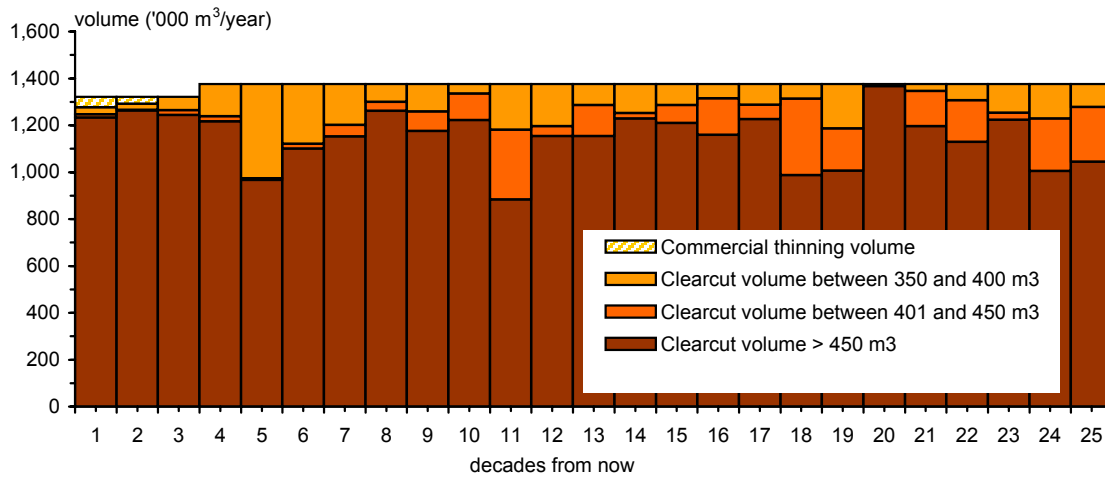


Figure 3-5. Composition of forecast harvest by supply block and harvesting method, silviculture base case (S03).

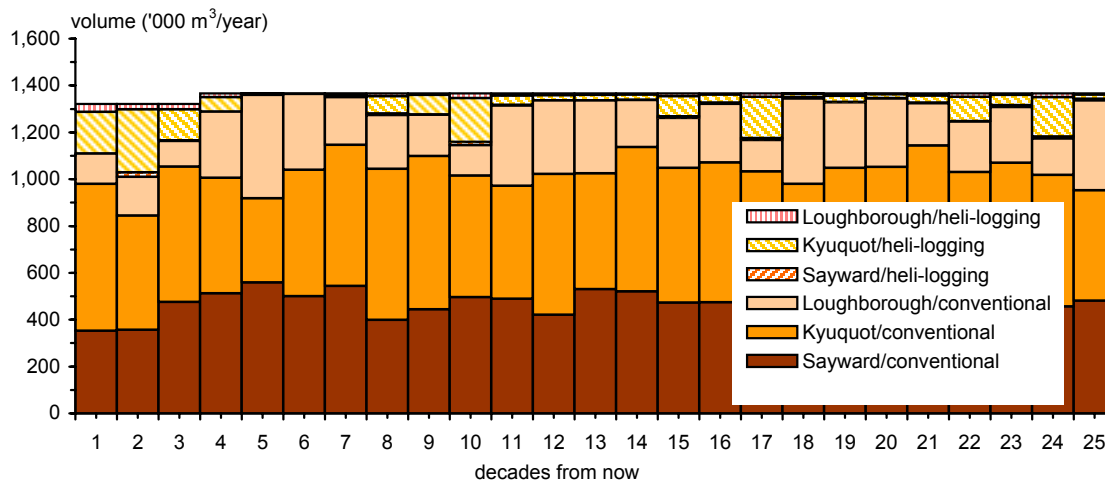


Figure 3-6. Composition of forecast harvest by age, silviculture base case (S03).

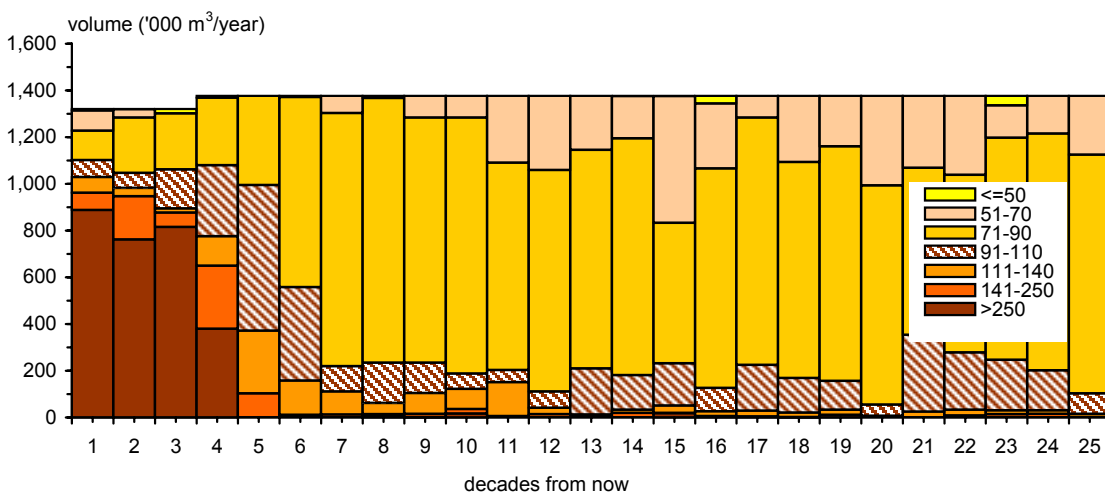


Figure 3-7. Total area and volume per unit area of the forecast harvest, silviculture base case (S03).

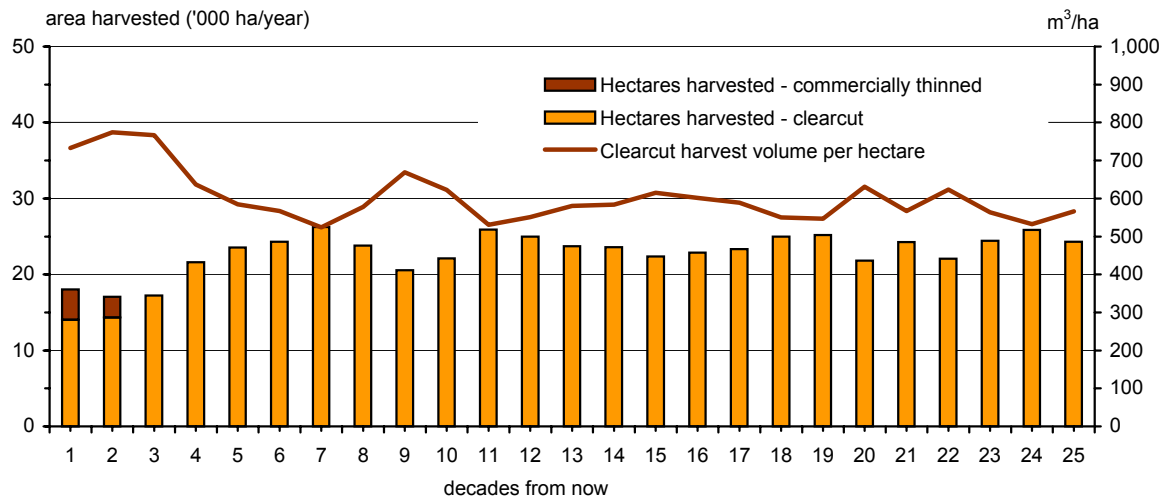


Figure 3-8. Composition of forecast harvest of managed stands by grade, silviculture base case (S03).

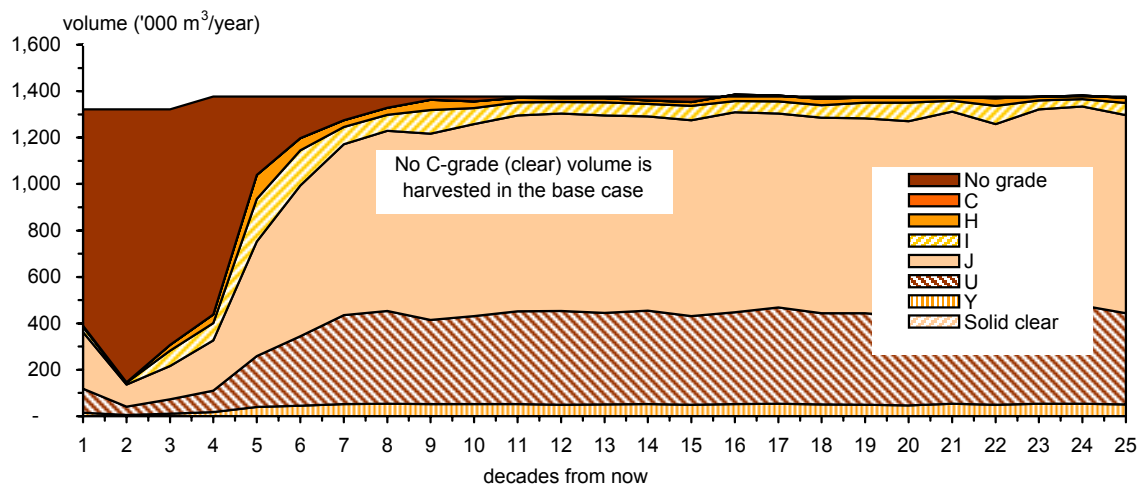
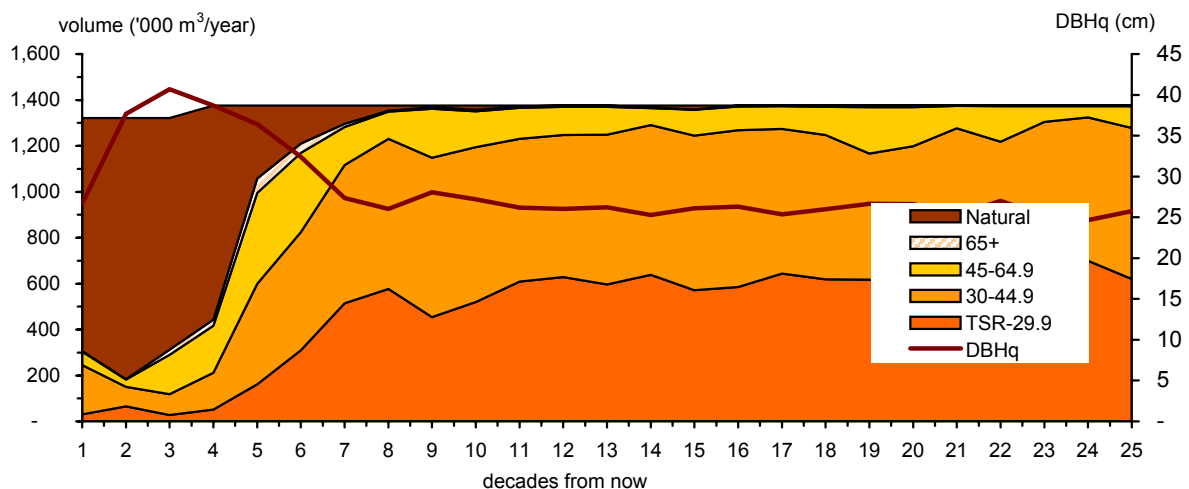


Figure 3-9. Composition of forecast harvest of managed stands by dimension, silviculture base case (S03).





Changes in the Silvicultural State of the Base Case

Figure 3-10
Stable inventory measures indicate a sustainable LTHL

Figure 3-10 plots the total and operable growing stock over the planning horizon. The operable growing stock declines through the transition to managed stands and remains relatively constant in the long term (decades 8-25). The stability of these inventory measures indicates that the long-term harvest level (LTHL) is likely to be sustainable.

Figure 3-11
Only retention zone constraints are tight

Figure 3-11 tracks the disturbance (percent not greened-up) for three of the management zones. Green-up requirements in the retention zone ($\leq 5\%$) are tight in decades 3-25. The partial retention and IRM zones never reach their disturbance limits ($\leq 15\%$ and $\leq 25\%$ respectively). No other zones are binding.

Figure 3-12
The model focuses harvesting on good/medium site fir and hemlock/balsam

Figure 3-12 tracks the change in silvicultural state of the THLB over the planning horizon. At the end of the first decade, the THLB is composed of approximately 55 000 ha of natural existing stands, 120 000 ha of existing and future (created by the model) managed stands, and about 2 900 ha of Timber Licences. The Timber Licences are harvested and regenerated as managed stands by the end of decade 2, and the area of natural stands and existing managed stands are steadily reduced as harvesting and regeneration convert them to future managed stands. In the early long-term (decade 11) approximately 12% of the total harvest will come from existing managed stands. Out of 6 500 ha existing managed stands remaining, approximately 3 500 ha will be harvested. The majority of stands that are harvested have volumes between 400 and 450 m³/ha. Note that at the end of decade 25 there remains approximately 5 000 ha of natural stands and 600 ha of existing managed stands that have not been harvested. These natural stands are predominantly poor site fir, and poor site hemlock/balsam.

The model considers the objectives over the entire planning horizon

The reason why the model leaves the low productivity stands is logical. The model selects stands for harvesting that optimize its timber supply objectives across the entire planning horizon, namely to maximize short, medium and long term-timber supply (in that order). It has calculated that harvesting the low site stands will return a small yield and that the stand will not attain operable volume (350 m³/ha) again for a long time (approximately 110 years for cedar, 130 years for fir, and 170 for the hemlock balsam). The stand may not be accessible again within the planning horizon. Focusing harvesting on higher site stands with shorter rotations increases the productivity of the THLB and increases timber supply over the planning horizon.

Simulation models, such as FSSIM, use a simple harvest selection rule, such as oldest first, and cannot consider the future implications of harvesting a stand. This is a significant difference between simulation and LP models and underlines the importance of having a clear objective when forecasting timber supply.

Figure 3-13
Operable forest age class distribution

Figure 3-13 shows the progression of the age class distribution of operable timber on the TSA over the planning horizon. Age class 410 includes all stands 410 years or older, although the model tracks stands for 700 years before converting them to the regenerating state. By decade 20, almost all of the stands age class 230 or older are poor site fir, cedar or hemlock.

Figure 3-10. Total and operable growing stock forecast, silviculture base case (S03).

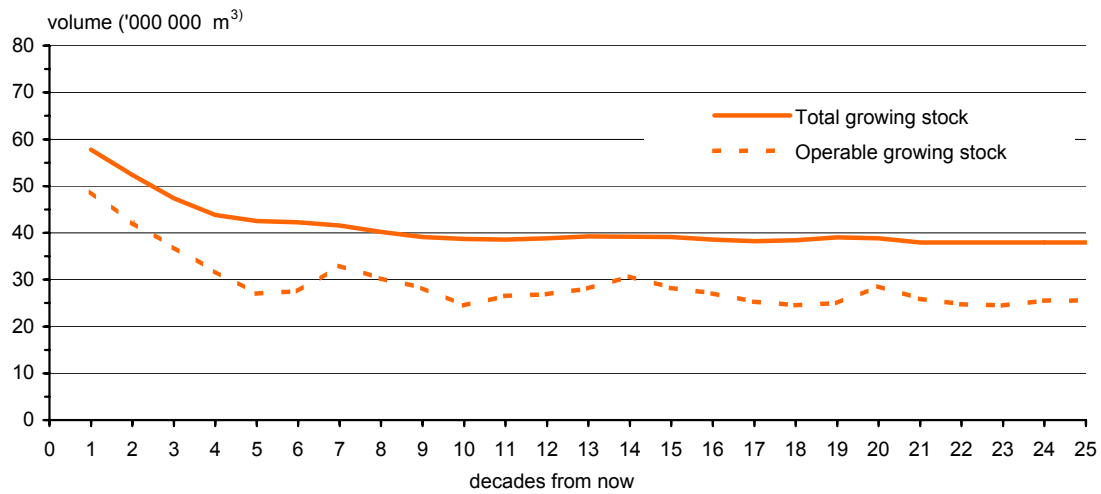


Figure 3-11. Percent disturbed (not greened-up) by constraining management zones, silviculture base case (S03).

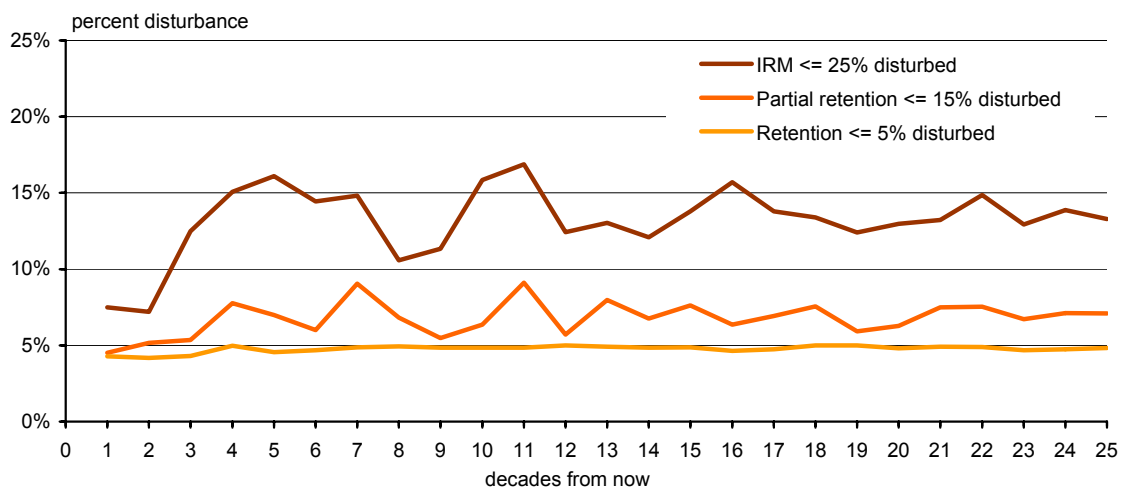


Figure 3-12. Aggregate silviculture state area forecast, silviculture base case (S03).

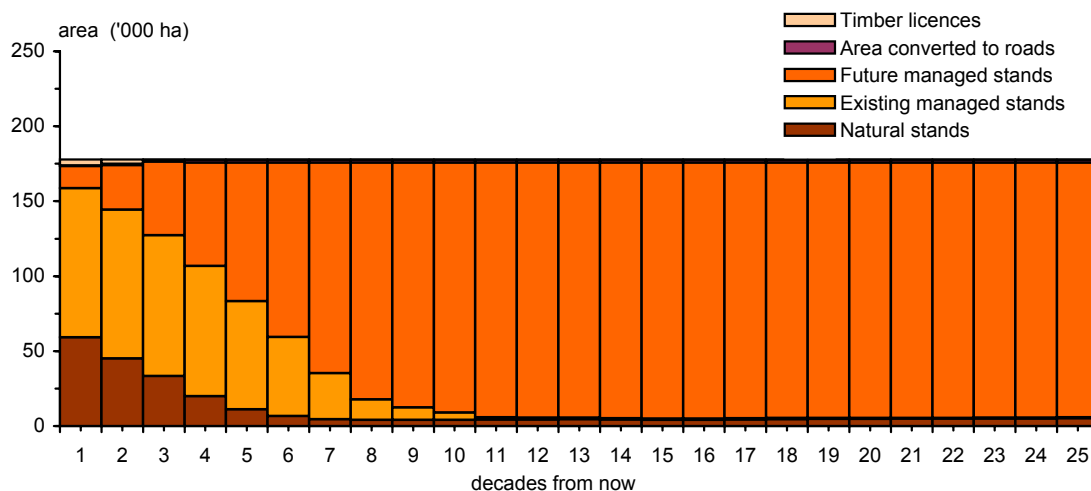
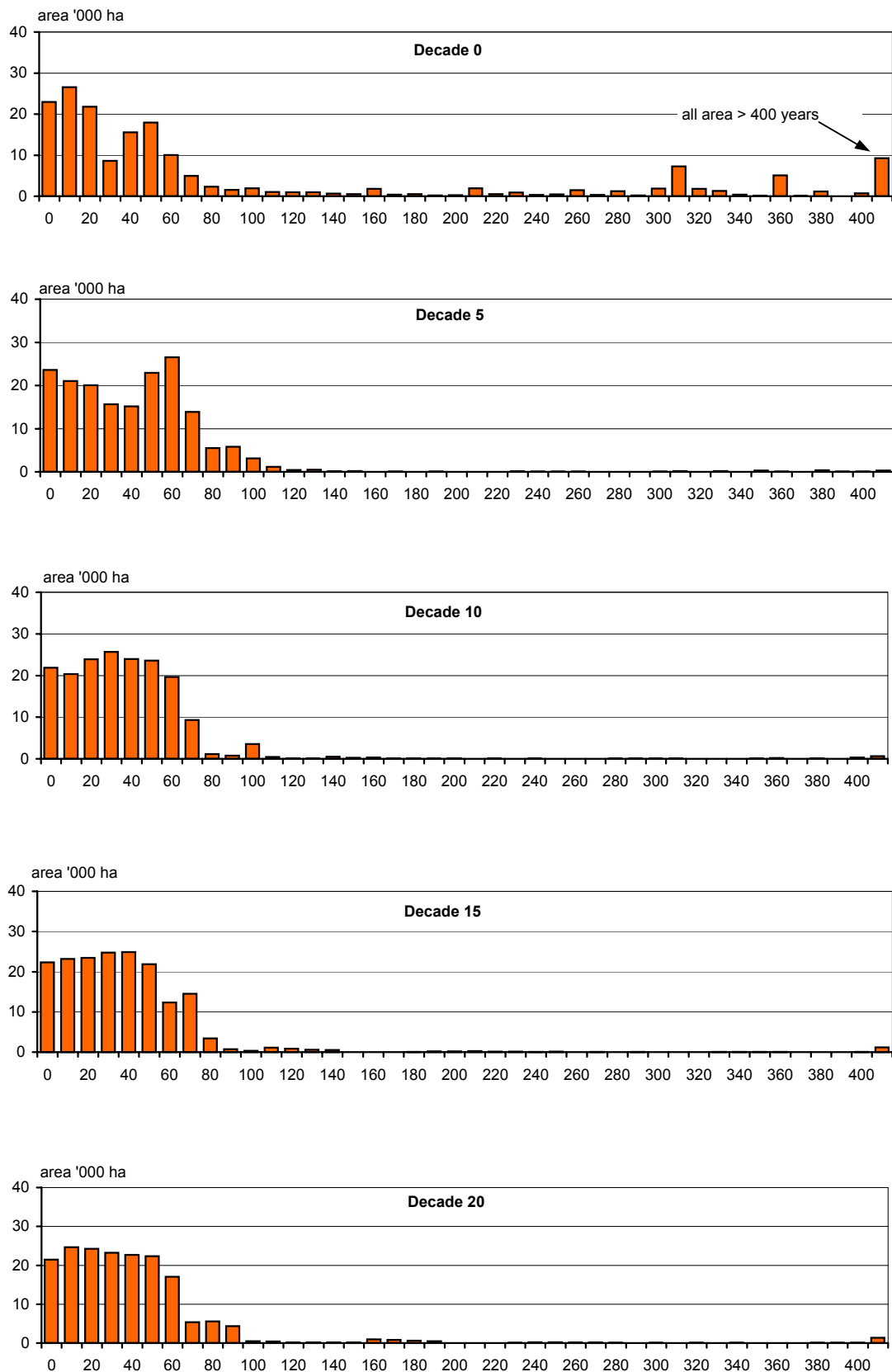


Figure 3-13. Forecast age distribution of operable area for total inventory, silviculture base case (S03).





3.2 Management for Timber Quantity

This section presents the results of intensifying management (incremental silviculture) with the objective of maximizing the quantity of timber harvested out to the planning horizon. This is accomplished by incorporating the District-supplied management regimes into the model, and allowing harvesting by commercial thinning. The incremental silviculture budget is unlimited. The incremental silviculture budget is unlimited for both scenarios.

Commercial Thinning and Intensive Silviculture Scenarios

Figure 3-14
Incremental silviculture

Figure 3-14 shows the incremental benefits from commercial thinning (S04), and spacing and fertilization (S06). These scenarios were implemented with the management objective of maximizing the quantity of timber harvested, and assumed an unlimited silviculture budget.

S04 Commercial
thinning

Commercial thinning regimes – which may also include juvenile spacing – increase the harvest in decades 3-25 by 0.4%¹. In accordance with the model's schedule of priorities, commercial thinning is used to bring harvest forward to fill the mid-term trough. Note that this scenario applies commercial thinning to the base case with select stock (S03) and does not reflect the commercial thinning that might occur when fertilization regimes are employed (S06).

S06 Spacing and
fertilization – Maximize
volume scenario

Implementing spacing and fertilization regimes, in addition to select stock and commercial thinning regimes, allows the current AAC to be maintained until decade 3. In decade 5, S06 returns an increment of 7% over scenario S03 (base case with select stock) and this level is sustainable through the long term.

Figure 3-15
Harvest by leading
species

Figure 3-15 shows the harvest by leading species for S06. Comparing this figure with the base case figure (Figure 3-2) increased amounts of fir are being harvested in order to capture increased volume benefits from spaced and fertilized stands.

Figure 3-16
Transition to managed
stands

Figure 3-16 shows the transition in the timber supply from natural stands to managed stands for the maximum volume scenario (S06). Comparing this figure to the base case (S03; see Figure 3-3), it is notable that the transition is not accelerated with the intensification of management, as one might expect. This is because the S03 assumptions of select stock and adjusted site indices have increased yields from regenerated stands to the point where no falldown occurs, and currently mature operable stands have not been rationed.

¹ Unless otherwise described, all increment percentages in this report are calculated with reference to the silviculture base case harvest level (S03).

Figure 3-14. Impact of commercial thinning, spacing and fertilization on the forecast harvest.

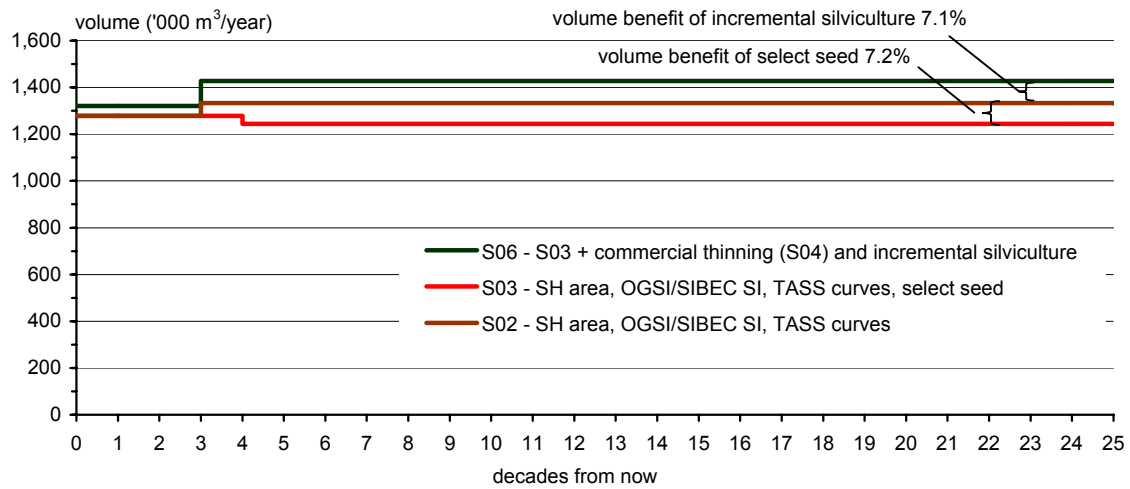


Figure 3-15. Composition by leading species, maximum harvest volume scenario (S06).

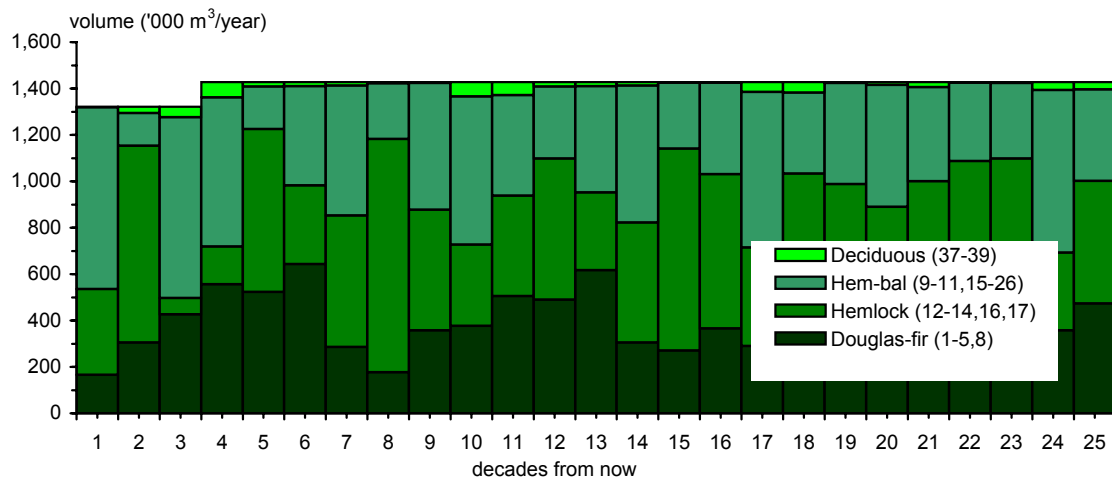


Figure 3-16. Composition by existing natural and managed stands of harvest forecast, maximum harvest volume scenario (S06).

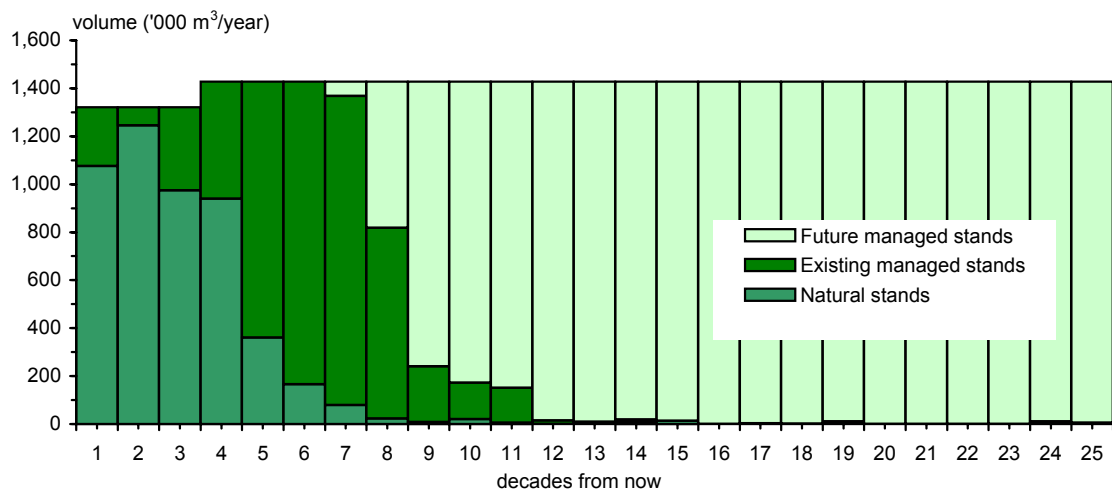




Figure 3-17
Volume per ha
harvested

Figure 3-17 shows the harvest by volume per unit area. Comparing this figure with the equivalent base case Figure 3-4, with intensified management more stands with volume over 450 m³/ha are being harvested.

Figure 3-18
Harvest by supply
block and method

Figure 3-18 illustrates the composition of the forecast harvest by supply block and harvesting method. There is no discernable shift when comparing this figure to the base case Figure 3-5.

Figure 3-19
Age of harvested
stands

The composition of the harvest forecast by age is shown in Figure 3-19. Once again there is little difference between this figure and the base case Figure 3-6.

One small difference is evident during the transition to regenerated managed stands and into the early late-term. During periods 12-14 the model shifts harvest from stands age 91-100 years to stands with aged 71-90 years. Fertilization activities have made these stands operationally feasible at an earlier age.

Figure 3-20
Clearcut vs
commercial thinning

Figure 3-20 compares the area harvested by clearcutting versus commercial thinning. Over the entire planning horizon the area commercially thinned is constrained to be less than specified percentages of the total supply block area (Table 3-1).

Table 3-1. Commercial thinning constraints applied over the entire planning horizon.

Stand	SAU	Supply block	% of total supply block area
Future managed	SAU01	Sayward	<= 40
Future managed	SAU02	Sayward	<= 20
Future managed	SAU01	Kyuquot, Loughborough	<= 10
Future managed	SAU02	Kyuquot, Loughborough	= 0
Existing managed	SAU01	Sayward	<= 90
Existing managed	SAU02	Sayward	<= 30
Existing managed	SAU01	Kyuquo, Loughborough	<= 25
Existing managed	SAU02	Kyuquot, Loughborough	<= 10

Source: John Andres, Campbell River Forest District

The area commercially thinned changes little over periods 3 to 5 as the model concentrates on clearcutting existing stands, enabling regeneration to higher yield managed stands. Commercial thinning becomes more extensive in decade 12 due to scarcity of operable timber. These higher levels of commercial thinning allow the model to maintain the harvest level in decades 11-12, before the end of the transition to dependence on regenerated managed stands.

Figure 3-17. Composition of forecast harvest by volume per unit area, maximum harvest volume scenario (S06).

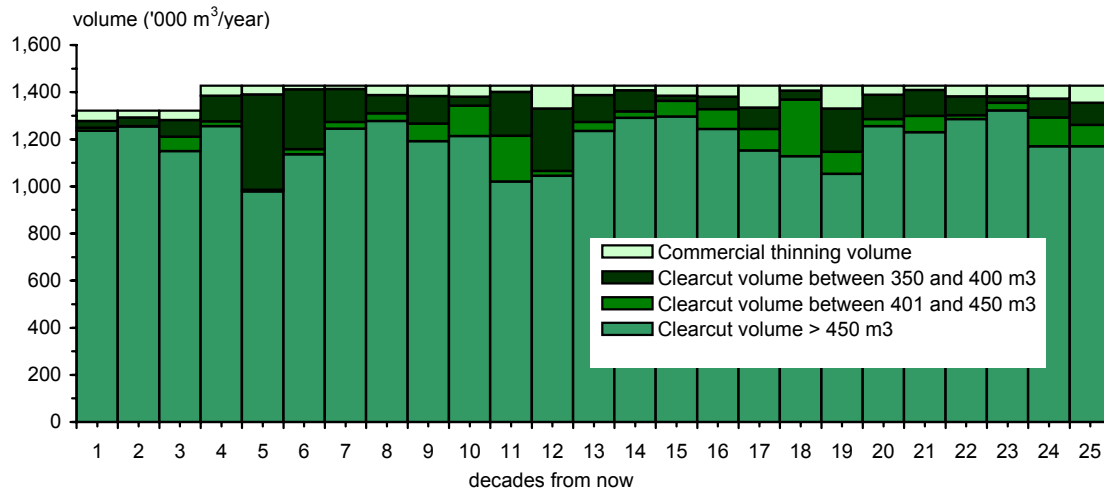


Figure 3-18. Composition of forecast harvest by supply block and harvesting method, maximum harvest volume scenario (S06).

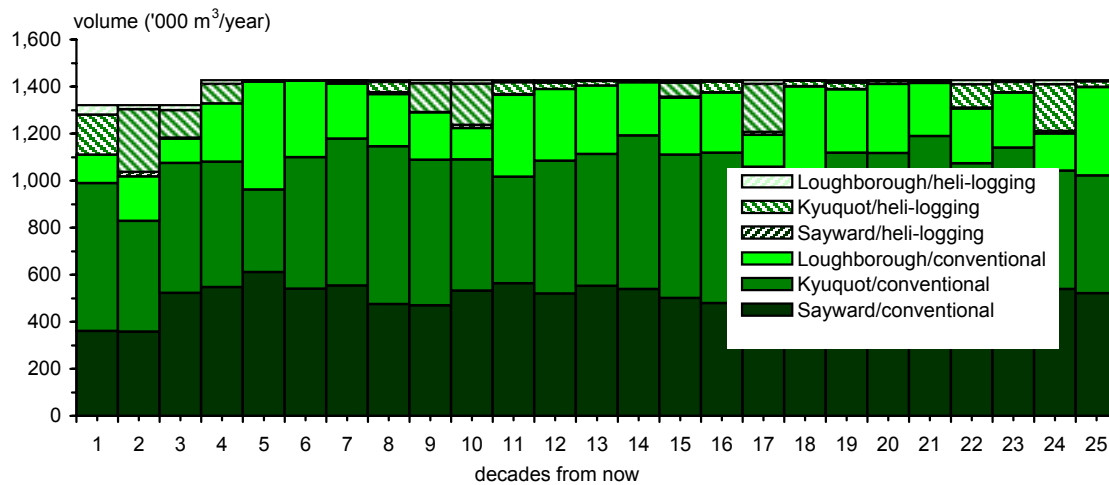


Figure 3-19. Composition of forecast harvest by age, maximum harvest volume scenario (S06).

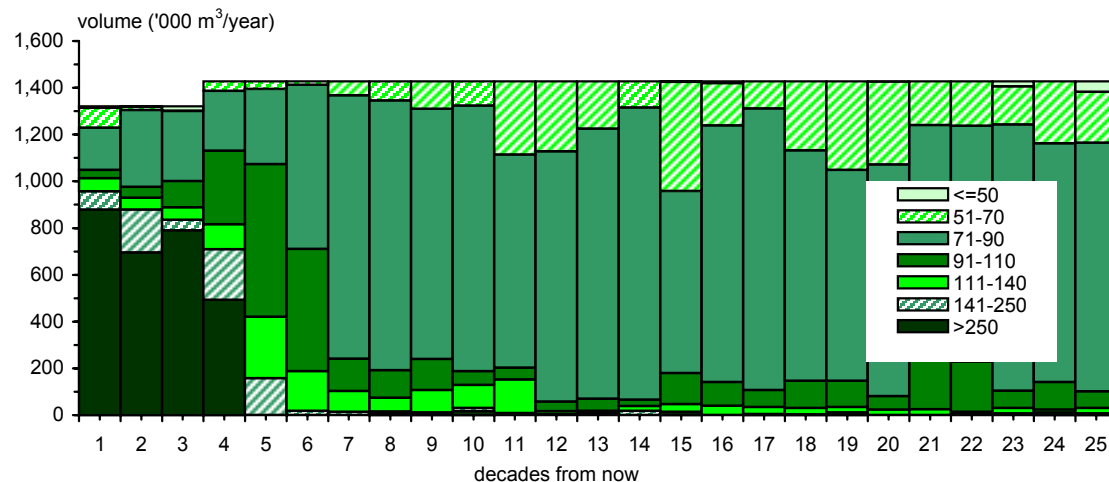


Figure 3-20. Total area and volume per unit area of the forecast harvest, maximum harvest volume scenario (S06).

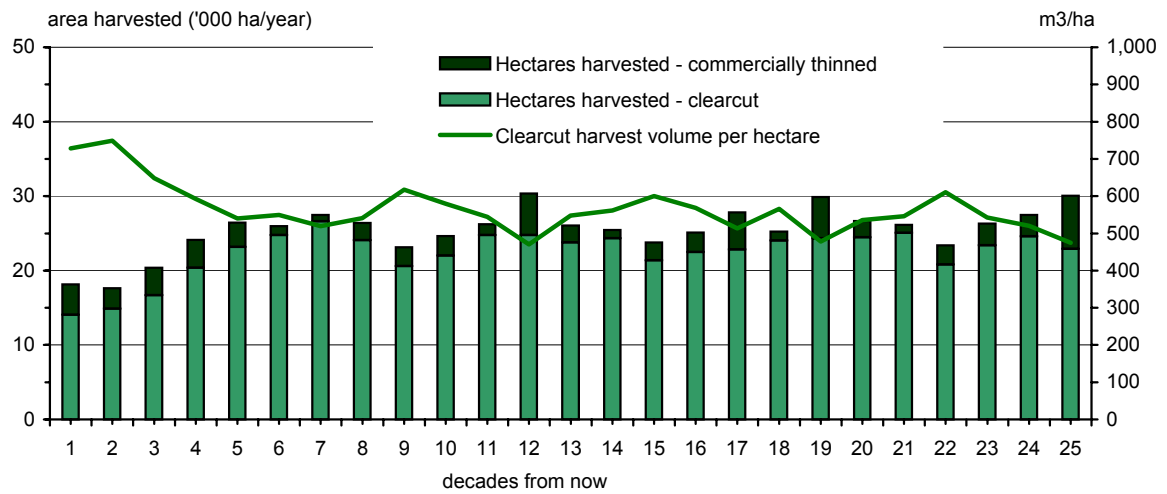


Figure 3-21. Composition of forecast harvest of managed stands by grade, maximum harvest volume scenario (S06).

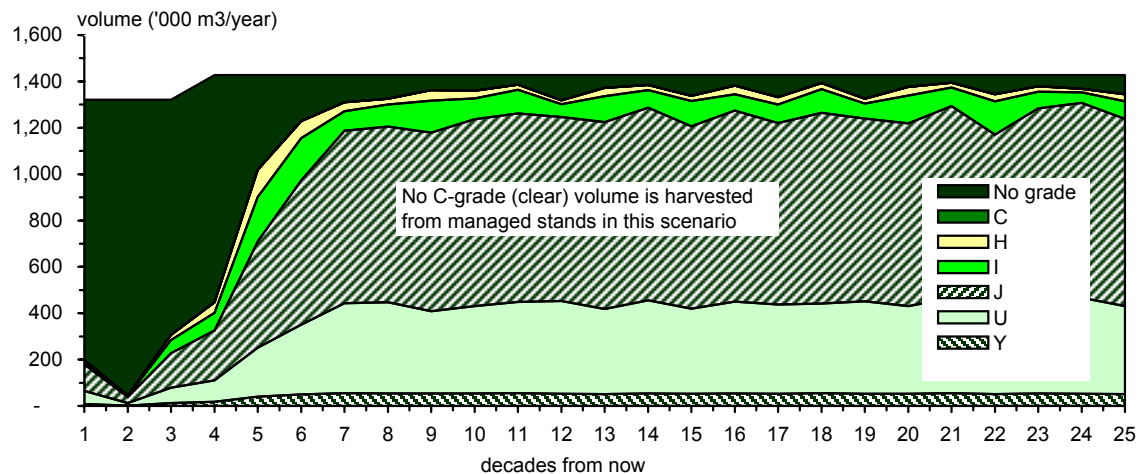


Figure 3-22. Composition of forecast harvest of managed stands by dimension, maximum harvest volume scenario (S06).

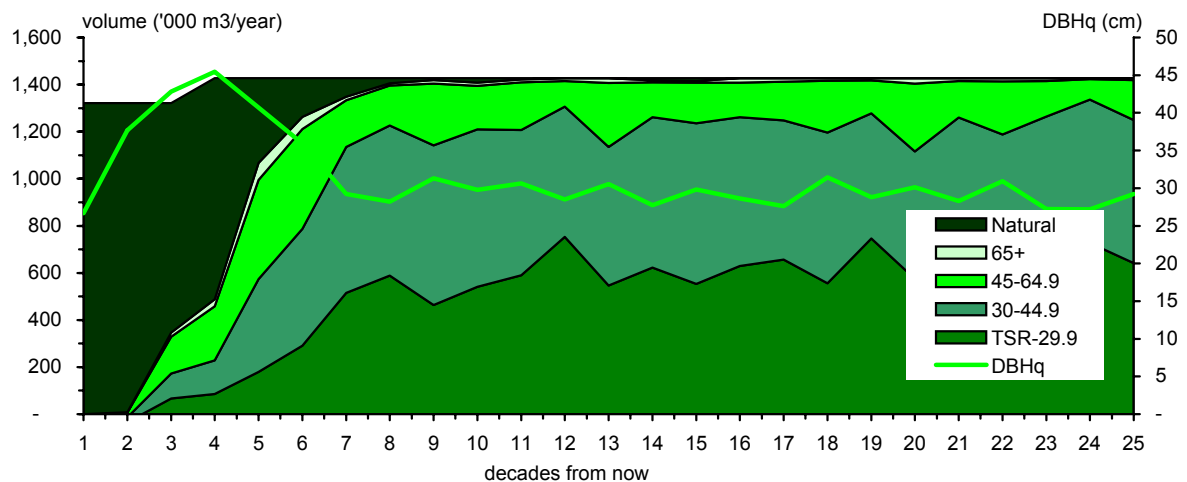




Figure 3-21
Composition of harvest
by grade

Figure 3-21 shows the composition by grade of the harvest from managed stands. Over decades 11-20, the volume harvested of J and U grades decreased from the S03 levels by 40.6 thousand m³/year and 8.6 thousand m³/year respectively. The harvest of Y grade increased with respect to S03 by 2.27 thousand m³/year, as did I grade (31 thousand m³/year), H grade (6.3 thousand m³/year) and the “not graded” portion (61 thousand m³/year).

The portion of the harvest labeled “not graded” is due to incomplete TASS managed stand yield tables, as well as limitations of VDYP in simulating natural stand volume by grade classes.

Figure 3-22
Composition of harvest
by diameter limit

Figure 3-22 shows the composition of the harvest by diameter limit from managed stands. Intensifying silviculture (S06) results in an average DBHq of 29 cm in the long term, compared to the 26 cm for the base case (Figure 3-9).

Optimal Management for Maximizing Harvest Quantity

Figures 3-23, 3-24, and 3-25 plot the area by treatment, treatment costs, and direct silviculture employment benefits, respectively, for the harvest maximization scenario.

Figure 3-23
Treatment area

Figure 3-23 shows that the fertilization program (including repeats) increases in size from 115 ha per year in decade 1 to an average of 1497 ha per year in decades 6-25. The area juvenile spaced per year also increases in size from 393 ha spaced per year in decade 1 to an average of 791 ha spaced per year in decades 6-25.

Figure 3-24
Treatment cost

The cost of spacing and fertilization (Figures 3-24) and the silviculture employment outputs of these programs (Figures 3-25) follow a similar pattern. The average cost of spacing and fertilization over the planning horizon is \$852 834 per year.

Figure 3-25
Employment

The regimes implemented to achieve the quantity benefits described in this section will be discussed in Section 4.

Figure 3-23. Treatment area forecast, maximum harvest volume scenario (S06).

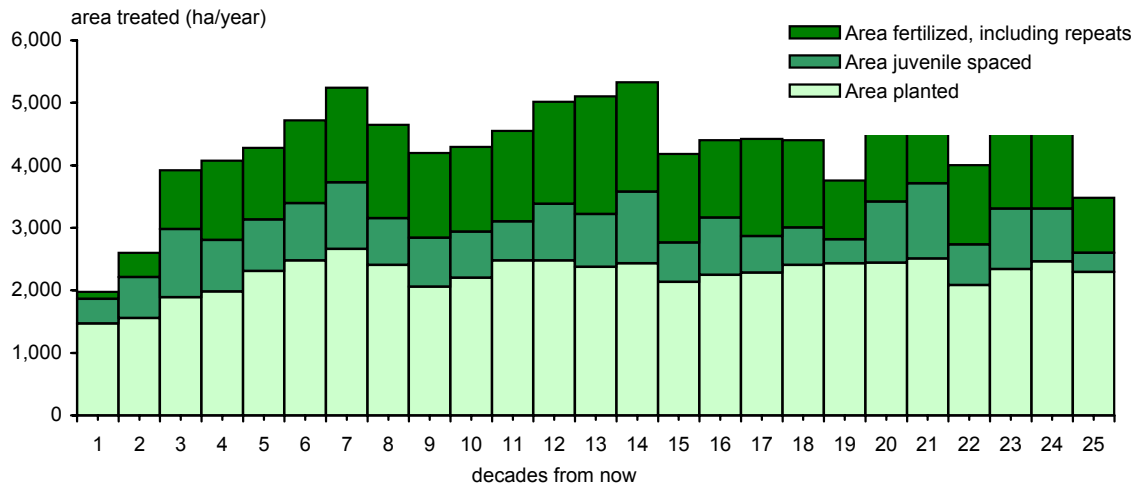


Figure 3-24. Treatment cost forecast, maximum harvest volume scenario (S06).

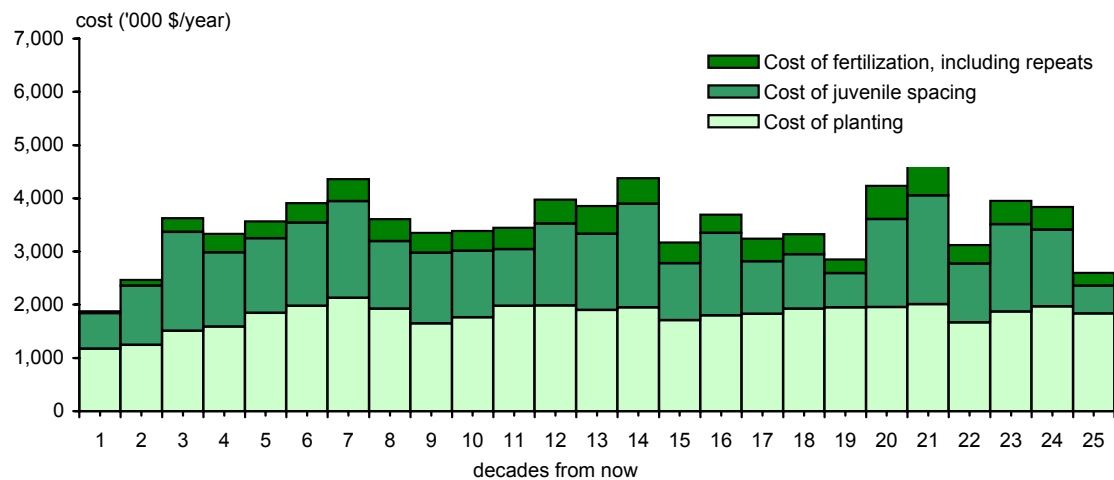
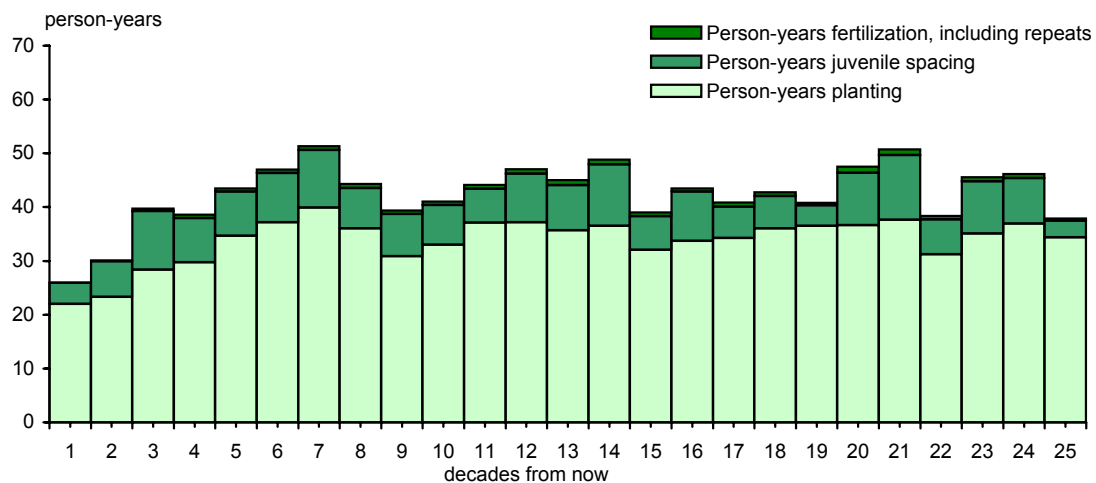


Figure 3-25. Silviculture direct employment forecast, maximum harvest volume scenario (S06).





3.3 Management for Timber Quality – Solid-Clear Wood

This section presents the results of two scenarios that implement silviculture treatments in order to achieve timber quality objectives. The objectives are to maximize the yield of solid clear wood (scenario S08) and the yield of large logs (scenario S09).² Both scenarios maximize the quality objective in the long term and assume that sufficient silviculture can be undertaken in the short and medium term to establish a sustainable long-term output. The budget for incremental is assumed to be unlimited.

S08: Maximize solid clear wood

A schedule of harvesting and silviculture that maximizes the production of solid clear wood is unlikely to also maximize volume production. In order to evaluate the trade-offs between total volume and solid wood production, the S08 scenario was evaluated with the harvest schedule constrained to be equal to the maximum harvest schedule forecast in scenario S06 (S08a), equal to scenario S02 (S08b), and $\geq 80\%$ of S02 (S08c). Spacing, pruning, fertilization and commercial thinning activities were scheduled as required to maximize the models objectives and meet the constraints.

Figure 3-26
Decrease in harvest level causes shift to higher grades

Figure 3-26 shows the grade distribution of stands harvested in the long term with alternative harvest levels. Scenarios S08b and S08c, with harvest levels relaxed compared to S06, result in increased volumes of grades C through J. Allowing the harvest level to decrease 20% from the S02 harvest level captures extra volume in grades C through I. Maintaining the S06 harvest level forces the model to focus harvest on lower grades U through Y.

Figure 3-27
Area pruned

Figure 3-27 shows the area pruned with alternative harvest levels. Relaxing the harvest level from the S06 harvest level allows the model to increase pruning activities increasing the production of clear wood and desirable log grades. The greatest difference in the area pruned occurs in decades 2 to 5. In S08c the model is pruning stands in order to increase volume from solid clear in the long-term, leading to an increase in volume from grades C through I.³

Figure 3-28
Pruning expenditures

Figure 3-28 shows the pruning costs with alternative harvest levels. Pruning costs are highest in S08b and S08c, reflecting the increased pruning activity with the decrease in harvest level.

² The volume of solid clear wood available from a harvested stand was simulated using TASS by MoF Research Branch (pers. com., Ken Polsson). The resulting yield tables were supplied to this project and are listed in Appendix E.

³ District staff commented that I grade logs would not result from pruning because of large knots size allowances.

Figure 3-26. Grade distribution of stands harvested in the long term at alternative harvest levels, maximum solid-clear scenario (S08).

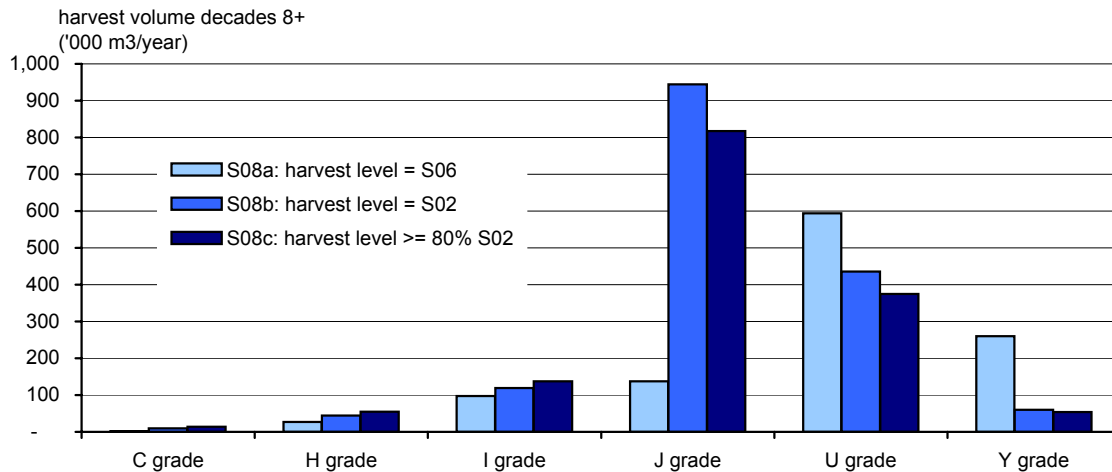


Figure 3-27. Area pruned at alternative harvest levels, maximum solid clear scenario (S08).

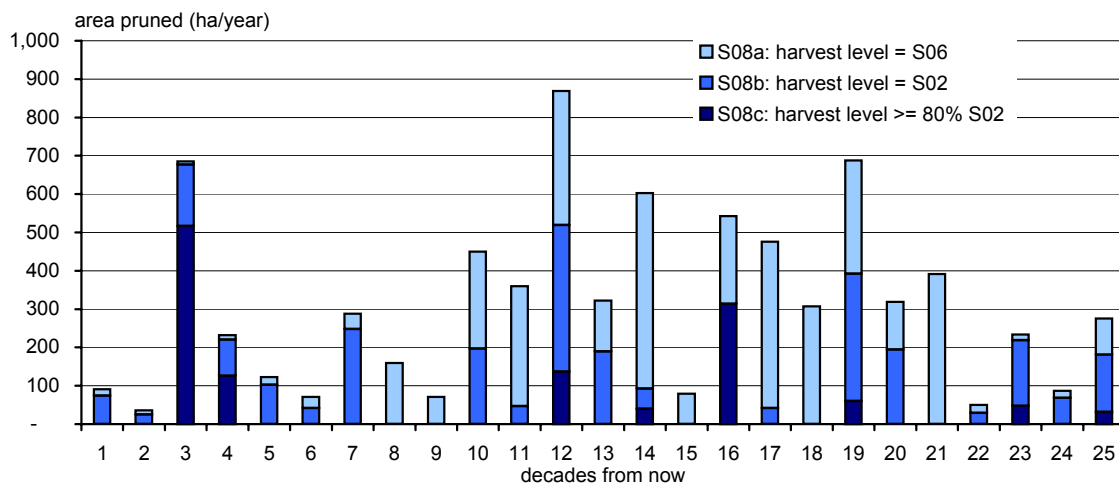
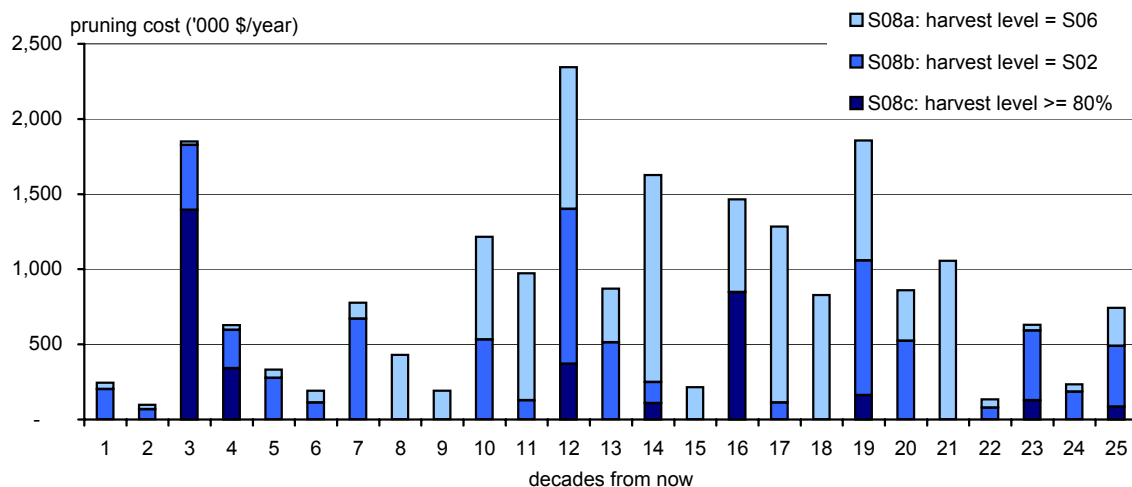


Figure 3-28. Pruning costs at alternative harvest levels, maximum solid-clear scenario (S08).





3.4 Management for Timber Quality – Dimension

S09: Maximize piece size (65 cm+)

This scenario was implemented by determining the schedule of harvests and silviculture that maximize the harvest of stands with an average DBH ≥ 65 cm, i.e., the model maximized the volume produced from a yield table that was compiled with utilization limits of 65+ cm DBH. The harvest schedule was constrained to the maximum volume harvest schedule forecast in scenario S06 (S09a), scenario S02 (S09b), and $\geq 80\%$ of S02 (S09c). All incremental silviculture activities (except pruning) were allowed. As with the solid clear scenario (S08) the harvest flow constraint had to be relaxed in order to increase the volume from stands 65+ cm.

Figure 3-29
Volume is traded off for piece size

The dimension distribution of stands harvested in the long term at alternative harvest levels is illustrated in Figure 3-29. Relaxing the harvest levels from the S06 harvest level allows the model to capture increased amounts of larger dimension volume. When the harvest volume is allowed to decrease further (S09c) the amount of volume harvested from the 45-64.9 and 65+ dimension distributions increases.

Figure 3-30
Age at harvest increases

Figure 3-30 shows the age distribution of stands harvested in the long term at alternative harvest levels. More than 40% of the S09a harvest volume is from stands age 50-59 as opposed to 52% of the harvest coming from stands age 140+ for S09c. Relaxing the harvest level from S06 allows the model to lengthen rotations and harvest older stand increasing the amount of volume from larger dimension distributions.

3.5 Management for Financial Efficiency

S10: Maximize financial efficiency

This scenario determines the schedule of harvests and silviculture that maximize the discounted net revenue (discount rate of 4% per decade) at the forest level. The discounted net revenue was calculated by subtracting harvesting and incremental silviculture costs from harvest revenue for each decade of the planning period, and discounting the net revenue back to the present. All incremental silviculture activities were allowed. The silviculture budget was unlimited but it was required to be the same in each decade 8-20.

Figure 3-31
Maximize financial efficiency

In Figure 3-31, the harvest forecast from scenarios S03 and S06 are compared to the scenario S10. The forecast harvest flow for S10 is constrained to be $\geq$ the S03 (silviculture base case) harvest level and $\leq$ the S06 (max volume production) harvest level; it tracks the lower limit (S03 LTHL) until decade 17, when it increases to its upper limit (S06 LTHL).

Figure 3-32
Treatment area forecast

Figure 3-32 shows the treatment area forecast for scenario S10. Comparing this figure to the maximum intensive management scenario (S06) Figure 3-23, the area treated in S10 is somewhat less than S06, but still substantial.

Figure 3-33
Growing stock

The increased productivity from the spacing and fertilization program implemented under S10 is not taken as a harvest increment in decades 4-16, as occurs with S06. Instead it is retained in the inventory (Figure 3-33). Both total and operable growing stock levels for S10 diverge from the S06 levels and increase by 26% and 37%.

Figure 3-29. Dimension distribution of stands harvested in the long term at alternative harvest levels, maximum dimension scenario (S09)

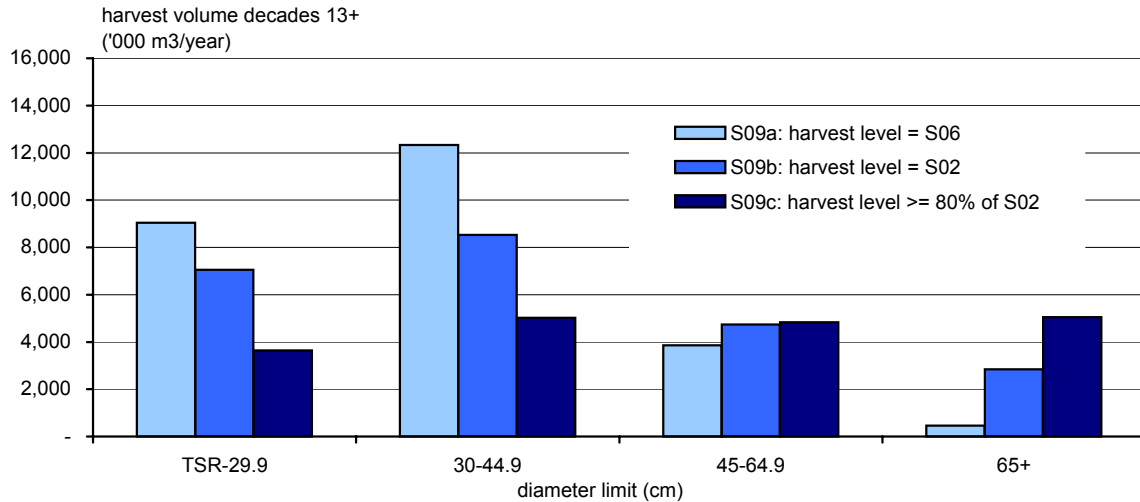


Figure 3-30. Age distribution of stands harvested in the long term at alternative harvest levels, maximum dimension scenario (S09).

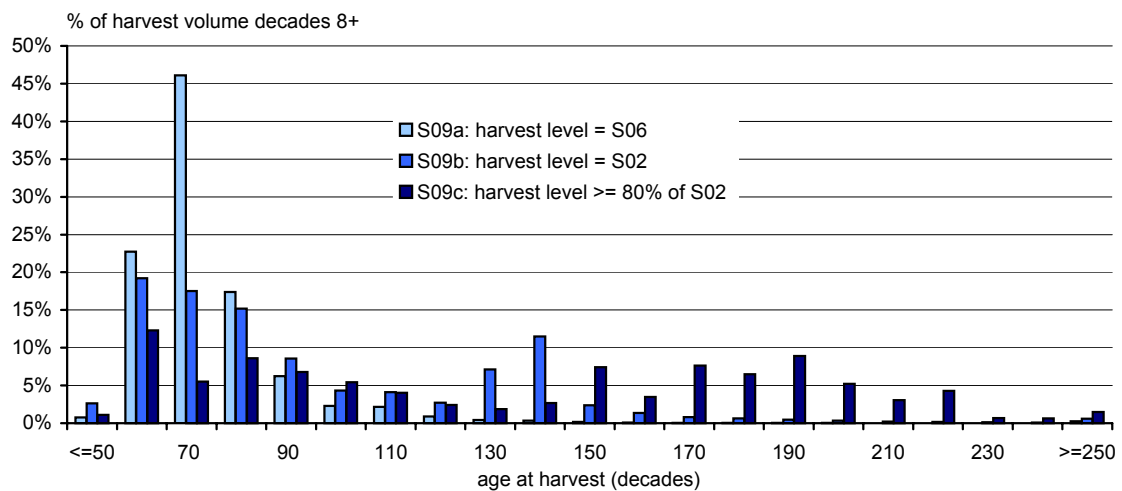


Figure 3-31. Forecast harvest with a management objective of financial efficiency (S10).

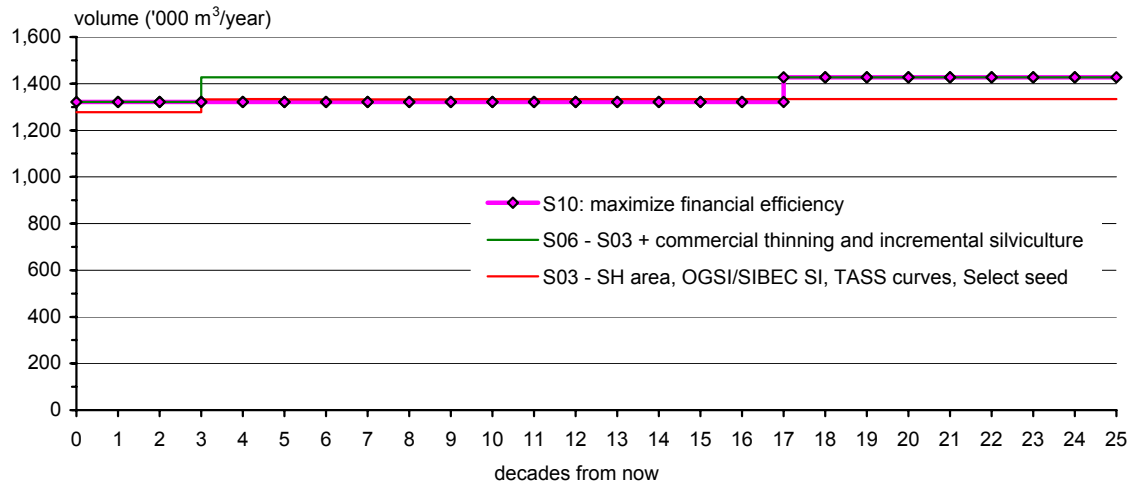


Figure 3-32. Treatment area forecast, financial efficiency scenario (S10).

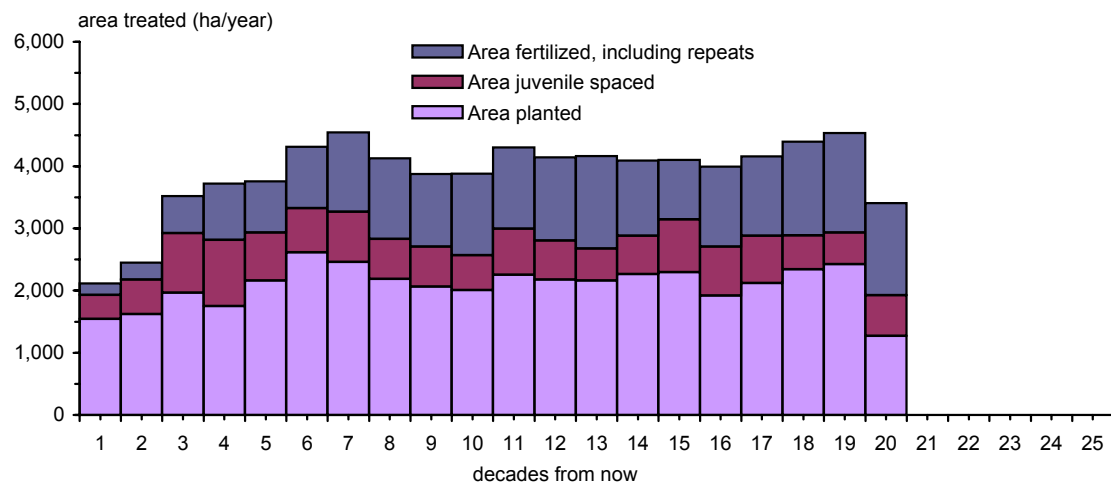
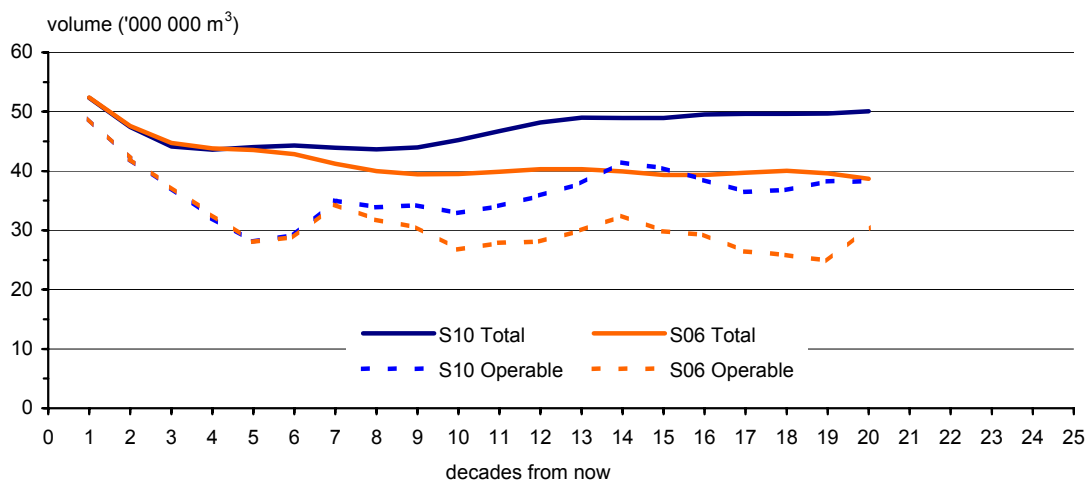


Figure 3-33. Total and operable growing stock, scenarios S06 and S10.







4.0 Silviculture Strategy

The previous section (3.0) described the potential productive capacity of the TSA under various management objectives, and also described the impact of intensified management on indicators of the state of the forest. This section (4) reports the silviculture strategies developed by the model to meet the four management objectives embodied by scenarios S06, S08b, S09b, and S10 i.e.,

- S06 – Maximize harvest volume, compiled to TSR utilization standards, employing select stock, spacing, fertilization and commercial thinning
- S08a– Maximize harvest volume of solid-clear wood produced in the long term, employing the silvicultural treatments available to S06, and also pruning. The harvest flow (compiled at TSR2 utilization levels) is constrained to exceed or equal the forecast harvest levels attained with scenario S02 (no select seed).
- S09b – Maximize harvest volume complied at a utilization level of 65 cm dbh, employing the silvicultural treatments available to S06. The harvest flow (compiled at TSR2 utilization levels) is constrained to exceed or equal the forecast harvest levels attained with scenario S02 (no select seed).
- S10 – Maximize discounted net revenue, employing the silvicultural treatments available to S06. Harvest flow constraints were relaxed in the mid-term.

Strategic and Tactical Plans

The silviculture strategy has two parts – the strategic plan that schedules silviculture (including harvesting) out to the 25 decade planning horizon and the tactical plan that implements the strategic plan in the first decade. The strategic plan identifies the regimes selected by the model as contributing maximally to the management objectives, while the tactical plan applies these optimal regimes to the silvicultural opportunities available in the first decade.

4.1 Strategic Plan

The strategic plan is reported in detail in Table 4-1.

For each silvicultural analysis unit, the model has selected regimes that best meet the management objectives that drive the scenario. For SAU01 and SAU02, the dominant regimes, i.e., the regimes that are applied to most of the regenerated land, are diagrammed in this section to aid comprehension of the regimes selected by the model. The percent of regenerated landbase managed by each regime pathway is displayed on the diagram to the right of the final treatment code, CC or clearcutting. Other treatment codes used in the diagrams are:

- Plt – plant
- JS – juvenile space
- Pr – prune
- Fe – fertilize (10-year cycle)

Table 4-1. Strategic plan– area managed by each silviculture regime for three management objectives, decades 1-25

Silvicultural Regime ¹	Decades 1-25			
	S06 ha (%) ²	S08b ha (%)	S09b ha (%)	S10 ha (%)
SAU01: Fd leading, ITG 1-8, WSI=34.4				
Plant to 1200 sph, clearcut	45,226	11,879	25,781	22,822
Plant to 1600 sph, clearcut	5,581	37,858	7,122	20,311
Total area regenerated	50,806	49,737	32,902	43,133
Plant to 1200 sph, JS to 750 sph, clearcut	11114 (22%)	2630 (5%)	7644 (23%)	7394 (20%)
Plant to 1200 sph, JS to 750 sph, CT, clearcut	34112 (67%)	5429 (11%)	17236 (52%)	4275 (12%)
Plant to 1200 sph, JS to 750 sph, prune, clearcut	-	2864 (6%)	-	-
Plant to 1200 sph, JS to 750 sph, prune, CT, clearcut	-	956 (2%)	-	-
Plant to 1600 sph, JS to 900 sph, clearcut	1939 (4%)	4557 (9%)	5127 (16%)	1262 (37%)
Plant to 1600 sph, JS to 900 sph, CT, clearcut	-	1666 (3%)	1129 (3%)	6378 (17%)
Plant to 1600 sph, JS to 900 sph, prune, clearcut	-	16768 (34%)	-	-
Plant to 1600 sph, JS to 900 sph, prune, CT, clearcut	-	14868 (30%)	-	-
Existing managed, planted to 1200 sph, JS to 750 sph, CT, clearcut	1931	1018	1645	538
Existing managed, planted to 1200 sph, JS to 750 sph, prune, CT, clearcut	-	278	-	-
Existing managed, planted to 1600 sph, JS to 750 sph, CT, clearcut	1931	925	1424	1295
Existing managed, planted to 1600 sph, JS to 750 sph, prune, CT, clearcut	-	308	-	-
Existing managed, natural stand 3000 sph, JS to 750 sph, CT, clearcut	4934	5398	3118	4358
SAU02: Fd leading, ITG 1-8, WSI=28.9				
Plant to 1200 sph, clearcut	523	24,587	13,746	20,981
Plant to 1600 sph, clearcut	45,454	22,156	23,010	16,933
Total area regenerated	45,976	46,743	36,756	37,914
Plant to 1200 sph, fert, clearcut	403 (1%)	363 (1%)	1173 (3%)	2925 (8%)
Plant to 1200 sph, JS to 750 sph, clearcut	-	195 (0.4%)	1536 (4%)	916 (2%)
Plant to 1200 sph, JS to 750 sph, fert, clearcut	120 (0.3%)	8833 (19%)	5603 (15%)	9667 (27%)
Plant to 1200 sph, JS to 750 sph, fert, CT, clearcut	-	597 (1%)	5434 (15%)	14749 (40%)
Plant to 1200 sph, JS to 750 sph, fert, prune, clearcut	0%	5212 (11%)	-	-
Plant to 1200 sph, JS to 750 sph, fert, prune, CT, clearcut	-	9387 (20%)	-	-
Plant to 1600 sph, JS to 900 sph, clearcut	-	196 (0.4%)	1568 (4%)	894 (2%)
Plant to 1600 sph, JS to 900 sph, fert, clearcut	37429 (81%)	4197 (9%)	15570 (42%)	5904 (16%)
Plant to 1600 sph, JS to 900 sph, fert, CT, clearcut	3639 (8%)	2645 (6%)	4391 (12%)	1229 (3%)
Plant to 1600 sph, JS to 900 sph, fert, prune, clearcut	-	7779 (17%)	-	-
Plant to 1600 sph, JS to 900 sph, fert, prune, CT, clearcut	-	384 (1%)	-	-
Existing managed, Plant to 1200 sph, JS to 750 sph, fert, CT, clearcut	82	64	98	147
Existing managed, Plant to 1200 sph, JS to 750 sph, fert, prune, CT, clearcut	-	21	-	-
Existing managed, Plant to 1600 sph, JS to 750 sph, fert, CT, clearcut	82	64	98	98
Existing managed, Plant to 1600 sph, JS to 750 sph, fert, prune, CT, clearcut	-	21	-	-
Natural regeneration, JS to 500 sph, fert, clearcut	374	349	357	324
Natural regeneration, JS to 750 sph, fert, clearcut	240	40	95	95
Natural regeneration, JS to 750 sph, CT, clearcut	0	461	140	242
Natural regeneration, JS to 750 sph, fert, CT, clearcut	9815	7674	9526	8358
SAU03: Fd leading, ITG 1-8, WSI=21.9				
Plant to 800 sph, clearcut	-	3,121	3,752	3,090
Plant to 1200 sph, clearcut	21,347	13,762	15,743	16,255
Total area regenerated	21,347	16,882	19,495	19,345
Plant to 1200 sph, fert, clearcut	14971 (70%)	9137 (54%)	10047 (52%)	8701 (45%)
SAU04: H leading, ITG 12-14,16-17, WSI=29.8				
Plant to 1600 sph, clearcut	4,734	4,711	3,241	4,776
Plant, ingrowth to 3000 sph, clearcut	42,609	42,395	29,168	42,988
Total area regenerated	47,343	47,105	32,409	47,765
Ingrowth to 3000 sph, JS to 850 sph, clearcut	35748 (76%)	28190 (60%)	24990 (77%)	35329 (74%)
SAU05: H leading, ITG 12-14,16-17, WSI=23.5				
Plant to 1200 sph, clearcut	10,774	10,697	11,547	10,453
Plant, ingrowth to 3000 sph, clearcut	86,192	85,576	92,372	83,621
Plant, ingrowth to 10000 sph, clearcut	10,774	10,697	11,547	10,453
Total area regenerated	107,740	106,970	115,465	104,526
Plant, ingrowth to 10000 sph, JS to 1000 sph, clearcut	9376 (9%)	6370 (6%)	7762 (7%)	7320 (7%)
SAU06: H leading, ITG 12-14,16-17, WSI=17.2				
Plant to 1200 sph, clearcut	2,577	2,170	2,570	2,425
Plant, ingrowth to 3000 sph, clearcut	20,618	17,357	20,559	19,398
Plant, ingrowth to 10000 sph, clearcut	2,577	2,170	2,570	2,425
Total area regenerated	25,773	21,696	25,698	24,248
Plant, ingrowth to 10000 sph, JS to 1000 sph, clearcut	1979 (8%)	1010 (5%)	1301 (5%)	1514 (6%)

¹ Any stand that is fertilized will be repeat fertilized until harvest

² Percentages are % of area regenerated treated by incremental silviculture activities

Table 4-1. (continued) Strategic plan-- area managed by each silviculture regime for three management objectives, decades 1-25

Silvicultural Regime	Decades 1-25			
	S06 ha (%) ¹	S08b ha (%)	S09b ha (%)	S10 ha (%)
SAU07: H,B leading, ITG 9-11,15,18-20,21-26, WSI=25.6				
Plant to 1200 sph, clearcut	10,046	9,382	9,997	9,253
Plant, ingrowth to 3000 sph, clearcut	80,372	75,054	79,974	74,025
Plant, ingrowth to 10000 sph, clearcut	10,046	9,382	9,997	9,253
Total area regenerated	100,464	93,817	99,967	92,532
Plant, ingrowth to 10000 sph, JS to 1000 sph, clearcut	7792 (8%)	5252 (6%)	6760 (7%)	6238 (7%)
SAU08: H,B leading, ITG 9-11,15,18-20,21-26, WSI=18.1				
Plant to 1200 sph, clearcut	3,811	3,272	3,511	3,561
Plant, ingrowth to 3000 sph, clearcut	30,490	26,180	28,089	28,486
Plant, ingrowth to 10000 sph, clearcut	3,811	3,272	3,511	3,561
Total area regenerated	38,113	32,725	35,111	35,607
Plant, ingrowth to 10000 sph, JS to 1000 sph, clearcut	2815 (7%)	1797 (5%)	2219 (6%)	2042 (6%)
SAU09: Deciduous leading, ITG 35-42, WSI=26				
Plant to natural, clearcut	2,894	2,027	2,674	2,691
Plant to 1200 sph, clearcut	4,341	3,040	4,011	4,036
Plant to 1600 sph, clearcut	4,341	3,040	4,011	4,036
Total area regenerated	11,576	8,108	10,697	10,763
Plant to 1600 sph, JS to 800 sph, clearcut	65 (1%)	73 (1%)	1908 (18%)	979 (9%)
Plant to 1600 sph, JS to 800 sph, prune, clearcut	0%	2869 (35%)	0%	1884 (18%)
Average area planted annually (ha/year)	1,797	1,695	1,634	1,663
Average area spaced annually (ha/year)	701	605	535	570
Average area pruned annually (ha/year)	-	247	-	154
Average area fertilized annually (ha/year)	268	196	199	204
Average area commercially thinned annually (ha/year)	226	214	177	181

¹ percentages are % of area regenerated treated by incremental silviculture activities

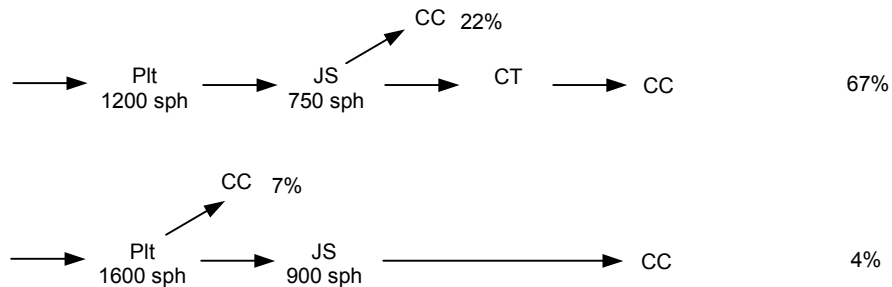


SAU01

Fd leading SI=34.4

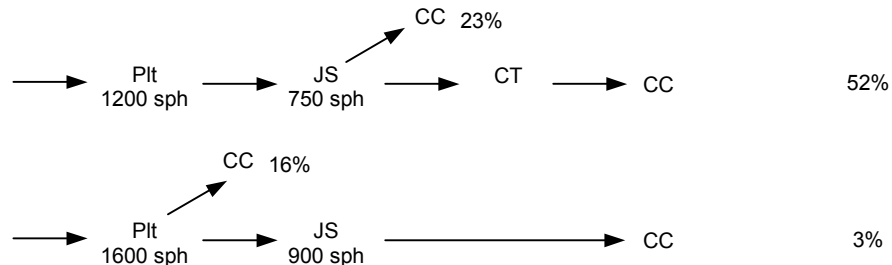
If the management objective is to maximize volume production (S06) then the dominant regime employed on SAU01 is to establish stands at 1200 sph and subsequently space those stands to 750 sph, followed by commercial thinning. This accounts for 89% of the area of SAU01 regenerated by the model. A further 4% is planted to 1600 sph, spaced to 900 sph, and then held for clearcutting. The remaining 7% of the land base is planted to 1600 sph and then held until clearcut.

Max volume S06



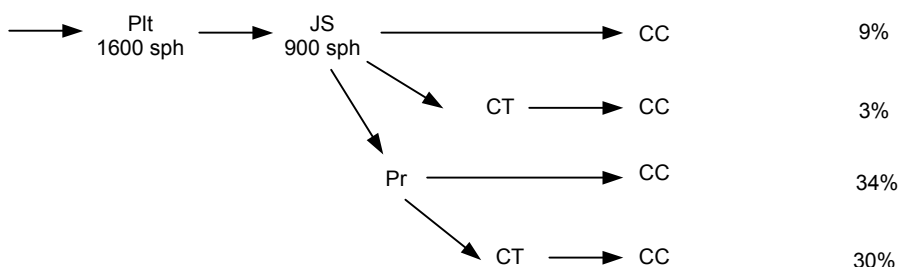
When the management objective is the production of larger dimensions (S09b), the same regimes are employed, although with a shift to the higher planting density. As noted in section 3.4, the larger dimensions are achieved through longer rotations, rather than incremental silviculture. Consequently, the area of SAU01 regenerated in S09b is 32 902 ha as compared to 50 806 ha for scenario S06.

Max dimension S09b



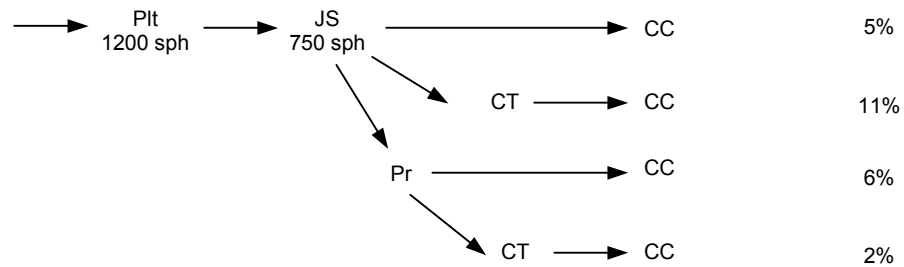
When the objective is to maximize clear wood (S08b) then the dominant regimes employed include pruning activities. The dominant regime for S08b, accounting for 76% of the area managed, plants to 1600 sph, followed by spacing to 900 sph and pruning, and CT.

Max solid clear S08b



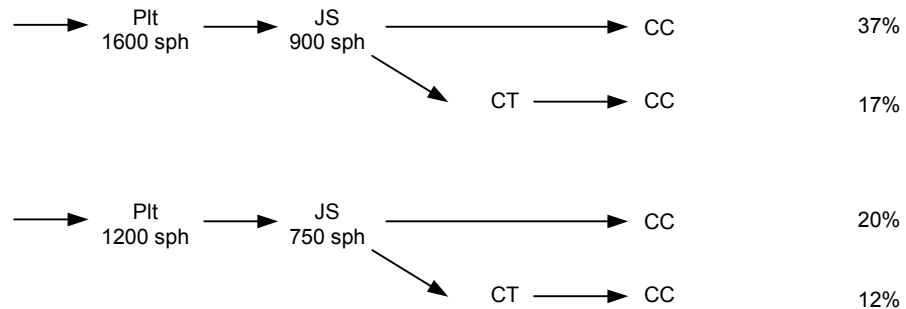


Max solid clear S08b
(continued)



The incremental silviculture regimes implemented with the objective of maximizing financial efficiency (S10) are identical to dominant regimes of S08b, but without pruning.

Max financial
efficiency S10



Existing managed stands of SAU01 are generally managed by the same regimes as the future managed stands, except that two-thirds of them are currently in a state resembling spaced natural stands.

Note that pruning regimes were considered in this scenario but were not utilized as they were detrimental to financial efficiency.

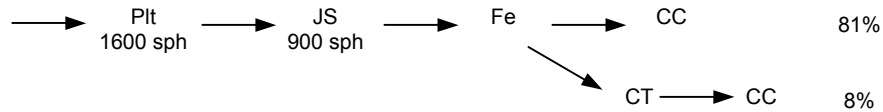


SAU02

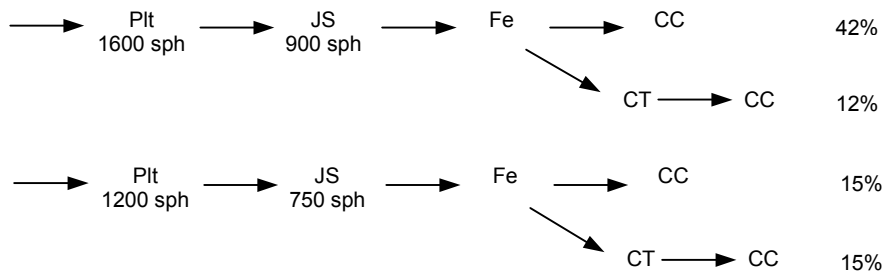
Fd leading SI=28.9

If the management objective is to maximize volume production (S06) and large dimension wood (S09b), then the dominant regimes employed on SAU02 include fertilization. Both S06 and S09b use a regime that plants 1600 sph, spaces to 900 sph, followed by a fertilization cycle. Most of the S06 regenerated area that is not managed by the dominant regime (11%) is planted to 1600 sph and held with no further management until clearcutting.

Max volume S06



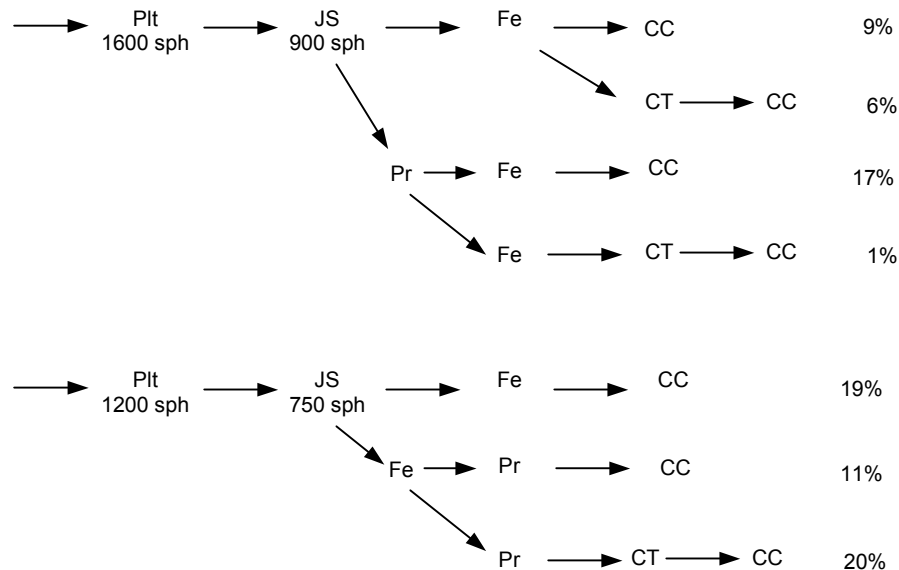
Max dimension S09b



S09b also employs a regime that plants to lower density (1200 sph) and spaces to a lower density (750 sph). The remainder of regenerated land (5%) under S09b is planted to 1600 sph and held for clearcutting.

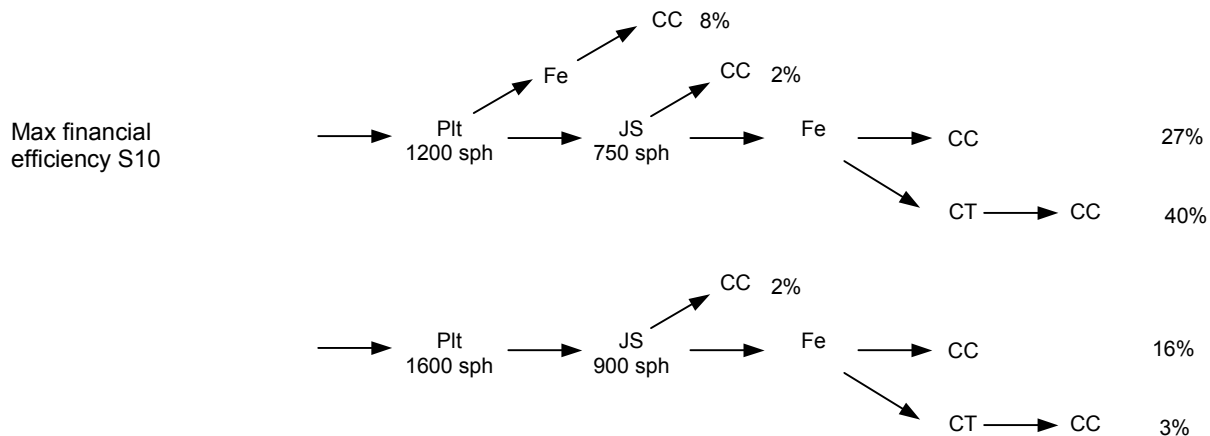
The dominant regimes employed by scenarios that maximize clear wood (S08b) include pruning and fertilization activities. Note that only 78% of the area regenerated is managed with the incremental silviculture regimes shown here. An additional 3% is managed by various incremental silviculture regimes and 19% is planted to 1600 sph and held for clearcutting.

Max clears S08b





The incremental silviculture regimes implemented with the objective of maximizing financial efficiency (S10) are more diverse than those associated with the other management objectives. Note that the model found that pruning was not financially attractive at a discount rate of 4%.



SAU03
Fd leading SI=21.9

Under all management objectives, the only incremental silviculture regime employed for SAU03 is to plant to 1200 sph and fertilize. Otherwise, the maximum volume (S06) management regime is to plant to 1200 sph and hold until clearcut. For scenarios where piece size and clear wood are desired (S08b, S09b, S10) about 10-15% of the stands were planted to 800 sph.

SAU04
H leading SI=29.8

Under all management objectives, the regime applied to stands that have ingressed to 3000 sph is to space back to 850 sph. Otherwise, the management regime is to plant to 1600 sph and hold until clearcut.

SAU05
SAU06
SAU07
SAU08

Four of the silvicultural analysis units have the same regime. In each analysis unit, following regeneration, 10% of the area is established at 1200 sph, 80% ingresses to 3000 sph, and 10% ingresses to 10000 sph. Juvenile spacing to 1000 sph occurs only on stands the stands with 10000 sph.

SAU09
Deciduous leading
SI = 26

SAU09 follows the TSR assumption of planting 25% of the regenerated area to natural stands (deciduous leading) and 75% to select stock (Fd leading). Out of this select stock, 50% is planted at 1200 sph, and 50% is planted to 1600 sph. Following establishment at 1600 sph, Fd stands are spaced to 800 sph. When the objective is to maximize sold clear wood the model prunes over 24% of the regenerated area.

Strategy Summary

Under the management objective of maximizing volume production, fertilization regimes are selected.

Fertilization regimes are also employed when the objective is large dimension wood, but the dimension objective is achieved largely by lengthening rotation. Fertilization helps maintain harvest levels.

When the management objective is solid clear wood and financial efficiency, the emphasis shifts to stands with regimes that include fertilization and pruning.



Just as in the large dimension scenario, the financial efficiency scenario lengthens stand rotation and harvests large dimension pruned, fertilized stands.

Under all objectives, regimes that include commercial thinning help maintain harvest levels while allowing the residual stand to be held long enough to develop the desired dimensional characteristics.

In all objectives the model selects the analysis units that reap the greatest volume per hectare for each hectare treated for the specified objective. The analysis units which have the most intense activity are SAU01 and SAU02 with over 84% of the total area regenerated treated with incremental silviculture activities.

As a general comment, the strategy developed above is limited in its ability to meet the timber and financial objectives by the restricted scope of the silvicultural regimes provided to the analysis, and by the constraints specified on the operability of various silvicultural activities.

4.2 Tactical Plan

The tactical plan is reported in Table 4-2.

The strategic plan identifies the regimes that maximally contribute to the management objectives specified for the TSA. However, in the first decade the opportunity to implement those regimes is constrained by the operational realities of the harvesting queue and the inventory of existing managed timber.

The planting activities reported in Table 4-2 are generated by the harvesting activities undertaken in the first decade. Spacing activities are implemented for SAU01, SAU02, and SAU04.

SAU01
Fd leading SI=34.4

Juvenile spacing is scheduled under all management objectives, although the area spaced under the financial efficiency objective is roughly one quarter of the area spaced under the other objectives. Commercial thinning of existing managed stands is scheduled under all management objectives.

SAU02
Fd leading SI=28.9

Juvenile spacing is scheduled under all management objectives, but at a much lower rate than SAU01. Under all management objectives, existing managed stands that have been previously spaced to 500 sph are fertilized, and commercial thinning is scheduled on existing managed stands that have been spaced to 750 sph.

SAU04
H leading SI=29.8

Juvenile spacing of existing managed stands are scheduled under solid-clear, dimension, and financial efficiency management objectives.

Comment

There may well be other silvicultural opportunities apparent on the TSA in the current (first decade) that are consistent with the silviculture strategy discussed in Section 4.1. The modelling methods employed in this study are designed for the efficient determination and evaluation of strategic plans. Greater resolution in the first decade requires spatial methods operating at a finer time scale.

Table 4-2 Tactical Plan - area treated by silviculture activity for each management objective in decade 1

Silvicultural Regime	Decade 1			
	S06 ha	S08b ha	S09b ha	S10 ha
SAU01: Fd leading, ITG 1-8, WSI=34.4				
Plant 1200 sph	861	152	316	422
Plant 1600 sph	0	140	121	398
Total area regenerated	861	292	438	820
JS (planted 1200 sph) to 750 sph	1,677	1,524	1,580	1,538
JS (planted 1600 sph) to 900 sph	1,677	1,535	1,599	1,527
PR (existing managed, JS to 750 sph)	-	408	-	-
PR (existing managed, JS to 900 sph)	-	477	-	-
CT (existing managed 750 sph)	1,846	2,189	1,845	2,578
SAU02: Fd leading, ITG 1-8, WSI=28.9				
Plant 1200 sph	134	1,118	229	281
Plant 1600 sph	507	269	773	210
Total area regenerated	641	1,387	1,002	492
JS (planted 1200 sph) to 750 sph	165	383	194	331
JS (planted 1600 sph) to 900 sph	165	158	160	153
FE (existing managed, JS to 500 sph)	246	228	233	208
FE (existing managed, JS to 750 sph)	165	370	186	322
FE (existing managed, JS to 900 sph)	165	146	153	136
Area refertilized (existing managed)	581	737	588	625
PR (existing managed, JS to 750 sph)	-	53	-	-
PR (existing managed, JS to 900 sph)	-	50	-	-
CT (existing managed 750 sph)	2,236	1,906	2,253	1,605
SAU03: Fd leading, ITG 1-8, WSI=21.9				
Plant 800 sph	-	43	23	44
Plant 1200 sph	9	135	142	111
Total area regenerated	9	178	165	155
SAU04: H leading, ITG 12-14,16-17, WSI=29.8				
Plant 1600 sph	417	356	394	323
Plant 3000 sph	3,757	3,203	3,546	2,907
Total area regenerated	4,175	3,559	3,940	3,230
JS (existing managed, 3000 sph) to 850 sph	-	155	77	189
SAU05: H leading, ITG 12-14,16-17, WSI=23.5				
Plant 1200 sph	1,638	2,492	2,206	2,575
SAU06: H leading, ITG 12-14,16-17, WSI=17.2				
Plant 1200 sph	136	312	286	290
SAU07: H,B leading, ITG 9-11,15,18-20,21-26, WSI=25.6				
Plant 1200 sph	7,074	6,182	6,787	5,918
SAU08: H,B leading, ITG 9-11,15,18-20,21-26, WSI=18.1				
Plant 1200 sph	75	1,709	720	2,042
SAU09: Deciduous leading, ITG 35-42, WSI=26				
Natural regeneration	18	37	28	21
Plant 1200 sph	28	56	42	32
Plant 1600 sph	28	56	42	32
Total area regenerated	73	149	113	85





5.0 Limitations of the Study

This study is a descriptive analysis. It quantifies the changes in productive capacity of the Strathcona TSA that result from alternative management objectives and intensifying silvicultural management.

This study is not prescriptive: it makes no recommendations concerning the appropriate management objectives and does not specify a desirable level of expenditure and intensity of management.

Prescriptive studies should follow confirmation of the descriptive model

The critical components of the physical production model (yield tables, silviculture history, and regime diagrams) should be confirmed before addressing the question of the appropriate level of silviculture investment.

5.1 Accuracy of the Yield Tables

All of the biology in the modelling process is contained in the yield curves. The remainder of the model is an accounting system that selects yield tables and moves hectares through feasible sequences (regimes) of activities. Therefore the accuracy of the forest-level yield forecasts of the model is largely associated with the accuracy of the yield tables, specifically the managed-stand yield tables developed with TASS.

TASS-TIPSY issues

In the execution of this project, it became apparent that a top-height adjustment was required in the development of the TASS tables to make them consistent with TIPSY managed stand yield tables. The inclusion of this adjustment necessitated the development of “work-around” procedures to simulate the application of juvenile spacing, pruning and commercial thinning to fertilized stands and stands grown from select stock (incorporating genetic gain). The yield tables developed for this study (Appendix E) – and in particular, the “work-arounds” devised to deal with the TIPSY-TASS differences – should be reviewed for plausibility, and, subsequently, the forest-level productivity forecasts reported in this document should be considered in light of this review.

TASS is central to silviculture strategies

The accuracy and scope of TASS is central to the development of meaningful silviculture strategies and forest-level plans. The strengthening of TASS should be encouraged and its proper application in studies such as this should be clarified and documented.

5.2 Representation of Silvicultural History

The accurate assignment of existing managed stands to silvicultural states is essential if the model is to develop a plausible schedule of management actions in the initial decades. The assignment of the existing managed stands to the inventory data set used in this study (Appendix A) was accomplished with an *ad hoc* procedure that is unlikely to be accurate. The representation of silviculture history in the model should be reviewed in conjunction with consideration of the short-term silviculture program (section 4.2).



Ultimately the silvicultural history records should be spatially integrated with the inventory database.

5.3 Modelling of Regimes

Just as the biology in the modelling process is contained in the yield curves, the alternative development pathways that a stand may take as the result of management actions are embodied in the regime diagrams. The diagrams must be accurate with respect to the transitions that occur when a stand is treated, and must be of appropriate scope—i.e., include sufficient management actions and development pathways to account for the current and future management of the stands.

Operability issues

Of special concern are limitations on management actions that are related to operability factors not included in the silvicultural state of the model. For example, according to a regime diagram, a stand may be operable for commercial thinning if certain target volume and residual tree requirements are met. However, the silviculturalists may know that only 30% of the terrain is appropriate for commercial thinning, regardless of whether the stand meets the target volume and residual tree criteria. These operability constraints must be implemented in the model in order to obtain reasonable results.



Appendix A– The Current Silvicultural State of the Strathcona TSA

Assignment of existing managed stands to a silvicultural state

The accurate assignment of existing managed stands to silvicultural states is essential if the model is to develop a plausible schedule of management actions in the initial decades.

The silviculture state of a stand records the information that the manager needs in order to determine what silviculture activities are immediately feasible (not including operational considerations such as harvesting restrictions, accessibility, terrain, or markets). For example, the species mix, age, density, basal area, crown closure may be the variables that the silviculturalist considers when deciding the treatment of a stand. These state variables change over time with the development of the stand (growth, competition, mortality) and with silviculture actions (e.g., juvenile spacing).

Describing the silviculture state at this level of detail is appropriate for tactical, program-level planning, but is too detailed for strategic planning with a forest-level model. For the purposes of this project, the silviculture state of (aggregations of) forest stands will be described by the list of treatments already applied. The possible silviculture states for the Strathcona TSA are listed in Table B-1 (Appendix B).

The assignment of the existing managed stands to the inventory data set used in this study was accomplished with an *ad hoc* procedure. From ISIS, a table was constructed that listed for each analysis unit and age class combination the total area recorded as planted, juvenile spaced, pruned and fertilized.

Each of these records (analysis unit x age class) was subdivided into additional records according to a set of rules based on logical silviculture practices:

1. The priority for areas to be fertilized will be, first, areas pruned, second, areas spaced but not pruned, and third, areas planted but not subsequently spaced or pruned.
2. The priority for areas to be pruned will be, first, areas spaced, and second, areas planted but not subsequently spaced.
3. The priority for areas to be spaced will be areas that have been previously planted.
4. If the area fertilized or pruned or spaced exceeds the area planted, then it is assumed that the treatments were applied to natural stands, and the same hierarchy of treatment priorities applies.

While it is unlikely that applying these rules to the ISIS data has resulted in the exact silviculture state of the TSA, the procedure is unambiguous and results in a unique set of silviculture states for each age class of each analysis unit. Table A-1 summarizes the relevant silvicultural history for the Strathcona TSA as obtained from ISIS. In Table A-2 this history is allocated across the inventory as existing managed stands.

Table A-1. Silviculture history of the Strathcona TSA

Activity year	Juvenile spacing (ha)	Pruning (ha)	Fertilization (ha)
1974	32		
1975	182		
1976	63		
1977	270		
1978	1,221		1,792
1979	3,737		5,547
1980	3,630		86
1981	4,253		1,696
1982	2,834		
1983	2,769	32	
1984	878	23	127
1985	763		
1986	982		3,959
1987	813	82	1,261
1988	1,651	359	681
1989	978	54	782
1990	1,088	2	
1991	1,019	214	
1992	1,541	565	1,599
1993	984	301	1,040
1994	1,489	432	805
1995	810	425	1,667
1996	550	147	1,620
1997	949	524	820
1998	261	118	2,180
1999	81	202	6
2000	34	12	3
	33,863	3,491	25,671
Average			
1990-1996	1,247	348	1,122

Source: ISIS

Table A-2. Initial silviculture state of the Strathcona TSA

State Code	Silviculture State	FD			H,B			Decid all SI	Inoperable	Total
		FD SI>=32 SAU01	27<=SI<32 SAU02	FD <27 SAU03	H SI>=27 SAU04	H 22<=SI<27 SAU05	H <22 SAU06	SI>=22 SAU07	H,B <22 SAU08	
eA12	Existing managed, planted 1200 sph	473	1,488						30	1,991
eA16	Existing managed, planted 1600 sph	473	1,488						266	2,227
N30	Natural regen 3000 sph			9,436	7,192	24,180	12,569	10,993	3,127	67,496
N30S50	Natural regen 3000 sph, PCT to 500 sph	1,337	3,348							4,685
N30S75	Natural regen 3000 sph, PCT to 750 sph	3,806	11,870							15,676
N30S75-F	Natural regen 3000 sph, PCT to 500 sph, fertilized		199							199
N30S75-T	Natural regen 3000 sph, PCT to 750 sph, CT	380								380
N30S85	Natural regen 3000 sph, PCT to 850 sph					3,457	1,621	1,864	703	7,644
NImmature	Natural, existing, immature age <= 140	4,393	1,422	1,912	5,065	8,987	1,506	6,745	1,379	31,408
NMature	Natural, mature, age > 140	27	105	1,282	39	582	8,745	1,605	23,440	243,015
TL	Timber lease	4	9	172	0	87	1,347	231	3,194	5,043
		10,893	19,929	12,801	12,296	37,293	25,788	21,438	31,843	379,766



Appendix B– Regimes Diagrams

Regime diagrams are the “blueprint” for the construction of the silviculture modules of the forest-level model.

The silviculture regime specifies a sequence of management actions that may be applied to the stands of the silviculture analysis unit for which the regime was designed. Each of these actions causes a change in the silvicultural state of the stand and so alternative regimes result in alternative development pathways that a silviculture analysis unit may follow.

A series of alternative regimes was specified for each the 12 silviculture analysis units defined for the Strathcona TSA, and the alternative development pathways were plotted (Figures B-1 to B-12). The arcs of these diagrams correspond to silviculture actions and the nodes represent the silviculture state of the stand. Tables B-1 and B-2 explain the codes used in the diagrams and Table B-3 lists the treatment specification for each feasible regime. Note that clearcut harvesting (clc_m) may occur from any treatment state (including planting and ingress only), but the activity arcs that would lead back to regenerating (R) are not shown in the regime diagrams in order to maintain legibility. Also, forest stands are not required to progress along a pathway – a stand may remain in any state indefinitely.

Table B-1. State codes

Code	Treatment state
NImmature	Natural existing age ranging from 11-140 (Cw), 21-140 (H/B,S), 61-140 (FD)
NMature	Natural existing age > 140
Existing managed stands	
N30	Natural regen 3000 sph
N30----F	Natural regen 3000 sph, fertilized
N30S50	Natural regen 3000 sph, space to 500 sph
N30S50--F	Natural regen 3000 sph, space to 500 sph, fertilized
N30S75	Natural regen 3000 sph, space to 750 sph
N30S75-T	Natural regen 3000 sph, space to 750 sph, CT
N30S75-TF	Natural regen 3000 sph, space to 750 sph, CT, fertilized
N30S75--F	Natural regen 3000 sph, space to 750 sph, fertilized
N30S85	Natural regen 3000 sph, space to 850 sph
eA12	Existing managed, plant to 1600, space to 750, prune
eA16	Existing managed, Planted 1600 sph



Table B-1. State codes (*continued*)

Code	Treatment state
Existing managed stands created by future management actions on existing states	
eA12S75	Existing managed, plant to 1200, space to 750
eA12S75F	Existing managed, plant to 1200, space to 750, fertilize
eA12S75-P	Existing managed, plant to 1200, space to 750, prune
eA12S75FP	Existing managed, plant to 1200, space to 750, fertilize, prune
eA12S75-PT	Existing managed, plant to 1200, space to 750, prune, CT
eA12S75FPT	Existing managed, plant to 1200, space to 750, fertilize, prune, CT
eA12S75--T	Existing managed, plant to 1200, space to 750, fertilize, CT
eA12S75F-T	Existing managed, plant to 1200, space to 750, fertilize, CT
eA16S90	Existing managed, Planted 1600 sph, space to 900 sph
eA16S90F	Existing managed, Planted 1600 sph, space to 900 sph, fertilized
eA16S90-P	Existing managed, Planted 1600 sph, space to 900 sph, pruned
eA16S90FP	Existing managed, Planted 1600 sph, space to 900 sph, fertilized, pruned
eA16S90-PT	Existing managed, Planted 1600 sph, space to 900 sph, pruned, CT
eA16S90FPT	Existing managed, Planted 1600 sph, space to 900 sph, fertilized, pruned, CT
eA16S90--T	Existing managed, Planted 1600 sph, space to 900 sph, CT
eA16S90F-T	Existing managed, Planted 1600 sph, space to 900 sph, fertilized, CT
Future managed states	
A12	Planted 1200 sph
A12----F	Planted 1200 sph, fertilized
A1210	Planted 1200 sph, ingrowth to 10000 sph
A1210S10	Planted 1200 sph, ingrowth to 10000 sph, space to 1000 sph
A1230	Planted 1200 sph, ingrowth to 3000 sph
A12S75	Planted 1200 sph, space to 750
A12S75F	Planted 1200 sph, space to 750, fertilized
A12S75-P	Planted 1200 sph, space to 750, pruned
A12S75FP	Planted 1200 sph, space to 750, fertilized, pruned
A12S75-PT	Planted 1200 sph, space to 750, pruned, CT
A12S75FPT	Planted 1200 sph, space to 750, fertilized, pruned, CT
A12S75--T	Planted 1200 sph, space to 750, CT
A12S75F-T	Planted 1200 sph, space to 750, fertilized, CT
A16	Planted 1600 sph
A1630	Planted 1600 sph, ingrowth to 3000 sph
A1630S85	Planted 1600 sph, ingrowth to 3000 sph, space to 850
A16S80	Planted 1600 sph, space to 800 sph
A16S80-P	Planted 1200 sph, space to 800 sph, pruned
A16S90	Planted 1600 sph, space to 900 sph



A16S90F	Planted 1600 sph, space to 900 sph, fertilized
A16S90-P	Planted 1600 sph, space to 900 sph, pruned
A16S90FP	Planted 1600 sph, space to 900 sph, fertilized, pruned
A16S90-PT	Planted 1600 sph, space to 900 sph, pruned, CT
A16S90FPT	Planted 1600 sph, space to 900 sph, fertilized, pruned, CT
A16S90--T	Planted 1600 sph, space to 900 sph, CT
A16S90F-T	Planted 1600 sph, space to 900 sph, fertilized, CT
A08	Planted 800 sph

Table B-2. Activity codes.

Code	Activity Description
CLC	Clearcut
PI nn	Plant nn stems per hectare
Js age nn	Juvenile space to nn stems per hectare at age
Pr	Prune to specifications noted in Table B-3
Fert	Fertilization
CT	Commercial thin to specifications noted in Table B-3



Table B-3. Specifications for TASS runs to create volume tables for regenerated development types, Strathcona TSA

1 Utilization levels

	min dbh	max stump	min top dib
all types	12.5	30	10

Note: all figures in centimetres.

2 Operational adjustment factors

OAF 1	15
OAF 2	5

3 Juvenile spacing

- leave well-spaced trees, favouring tallest

4 Commercial thinning

- thin from below: removing shortest, and leaving well-spaced trees, favouring fattest
- CT stems leave takes precedence over volume remove

5 Pruning

- retain 30% live crown on first lift
- retain 40% live crown on second lift

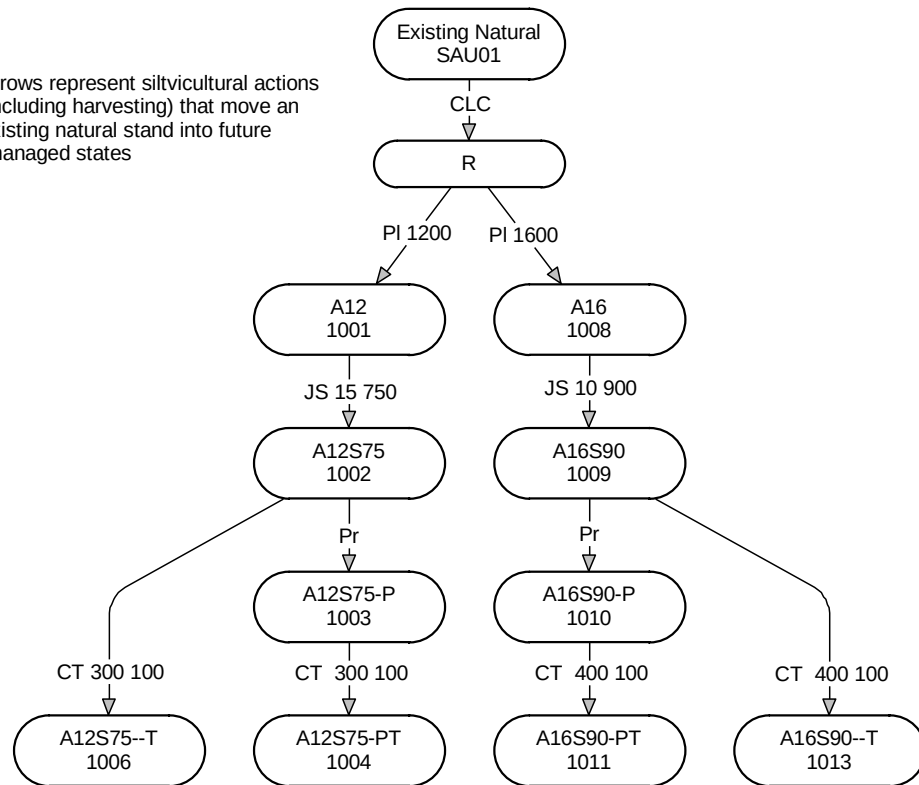
up to the max number specified in the spreadsheet. For example, the "best 300"

Alternate Development Pathways for Existing Natural and Existing Managed Stands

Strathcona TSA

SAU01 Fd (1-5,8), SI>=32, WSI = 35.2, 6.1% THLB

Arrows represent silvicultural actions (including harvesting) that move an existing natural stand into future managed states



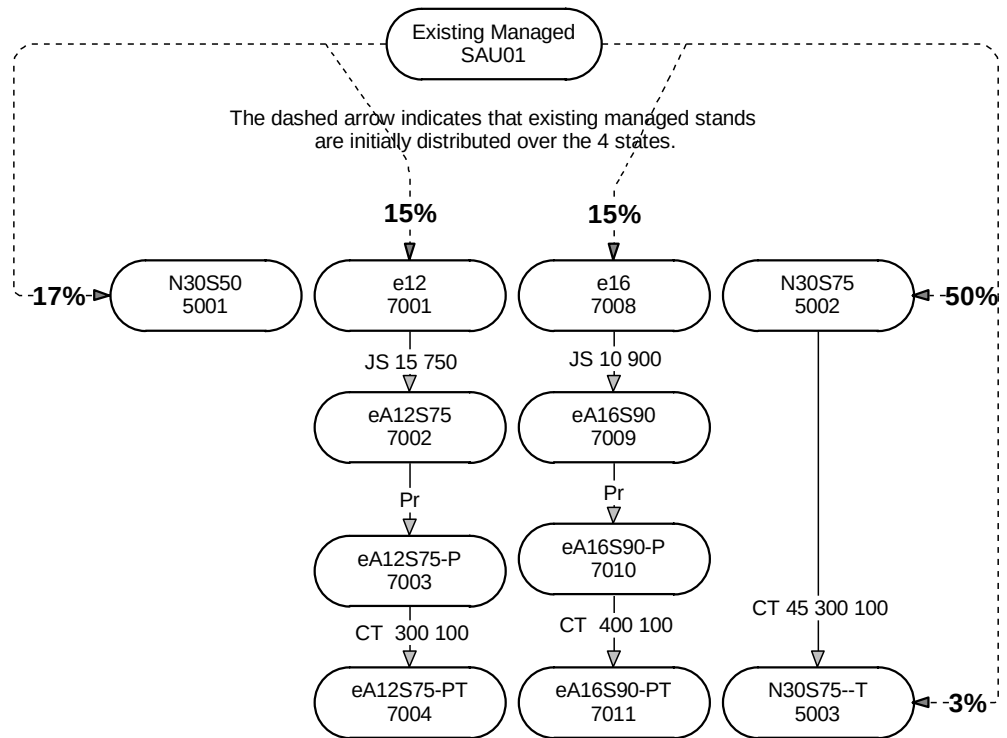
Existing Natural and Future Managed Stands

All spacing, pruning, and CT actions occur only in conventional areas.

Note that fertilization, originally specified for this SAU, has been eliminated due to lack of modelled response.

Commercial thinning will only be undertaken if
 residual sph >= 300 sph (A12) or 400 sph (A16)
 removed >= 100 m3 at dbh >= 22.5 cm

The development of these stands will be modelled (e.g., TIPSy) as planted managed stands.



Existing Managed Stands

All spacing, pruning, and CT actions occur only in conventional areas.

The development of these stands will be modelled (e.g., TIPSy) as natural (not planted) managed stands.

Commercially thinned stands will be modelled as:
 residual >= 300 sph
 removed = 150 m, dbh >= 22.5

Alternate Development Pathways for Existing Natural and Future Managed Stands

Strathcona TSA

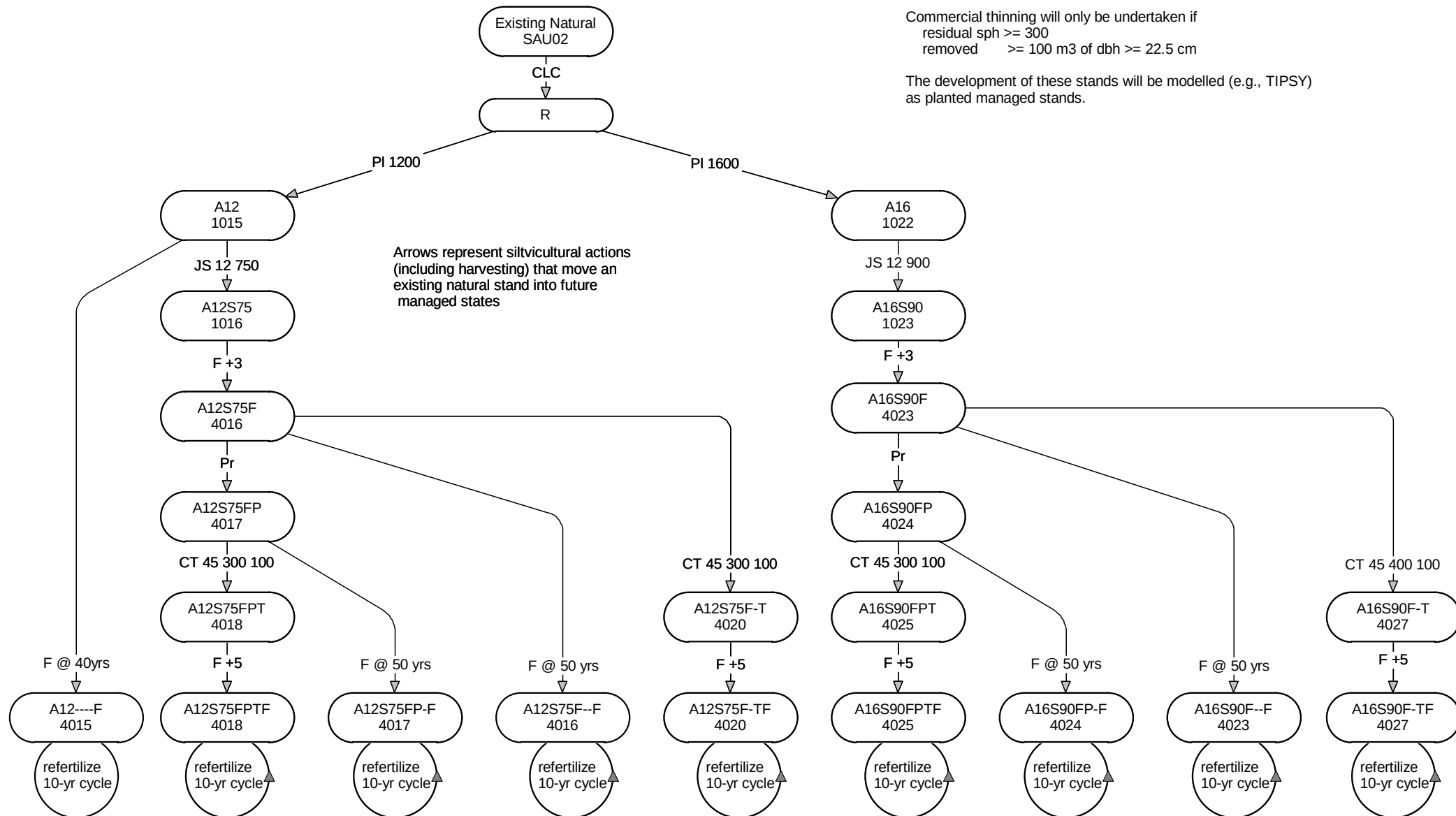
SAU02 Fd (1-5,8), $27 \leq SI < 32$, WSI = 28.3, 11.2% THLB

Existing Natural and Future Managed Stands

Fertilization after juvenile spacing occurs 3 years after the event.
Fertilization after commercial thinning occurs 5 years after the event.
Subsequent fertilization is undertaken on a 10 year cycle, until clearcut.

Commercial thinning will only be undertaken if
residual sph ≥ 300
removed ≥ 100 m³ of dbh ≥ 22.5 cm

The development of these stands will be modelled (e.g., TIPSY) as planted managed stands.



Alternate Development Pathways for Existing Managed Stands

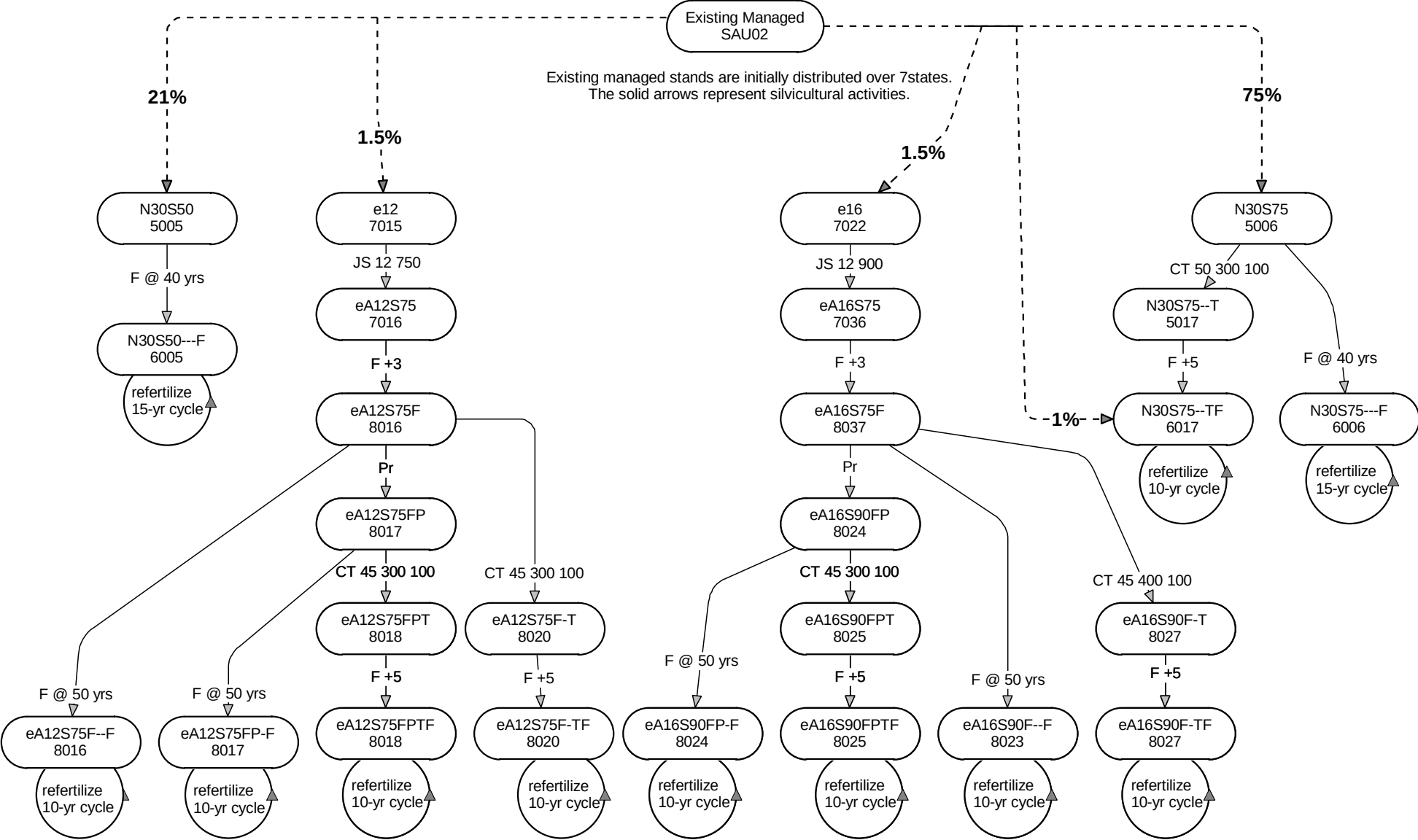
Strathcona TSA
SAU02 Fd (1-5,8), 27<= SI <32, WSI = 28.3, 11.2% THLB

Existing Managed Stands

All spacing, pruning, and CT actions occur only in conventional areas.

The development of these stands will be modelled (e.g., TIPSy) as natural (not planted) managed stands.

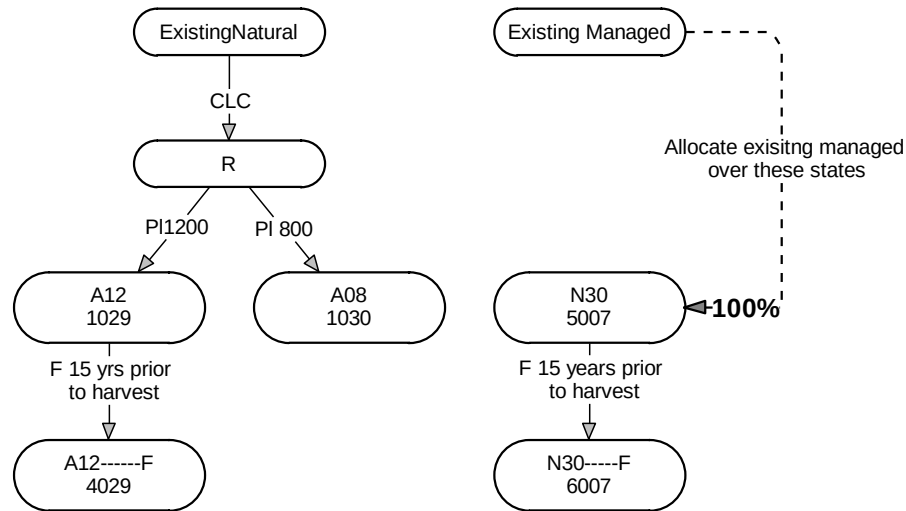
Commercially thinned stands will be modelled as:
residual >= 300 sph
removed = 125 m, dbh >= 22.5



Alternative Development Pathways

Strathcona TSA

SAU03 Fd (1-5,8), SI<27, WSI=21.0, 7.2% THLB



Existing Natural Stands

All spacing, pruning, and CT actions occur only in conventional areas.

After harvesting (CLC) these stands will be planted to 1200 sph or 800 sph.. The higher established density (1200) will be fertilized 15 years prior to harvest. The development of these stands will be modelled (e.g., TIPSy) as planted to 1200 and 800 sph, respectively, and the higher density stand will be fertilized 15 years prior to (unfertilized)culmination age.

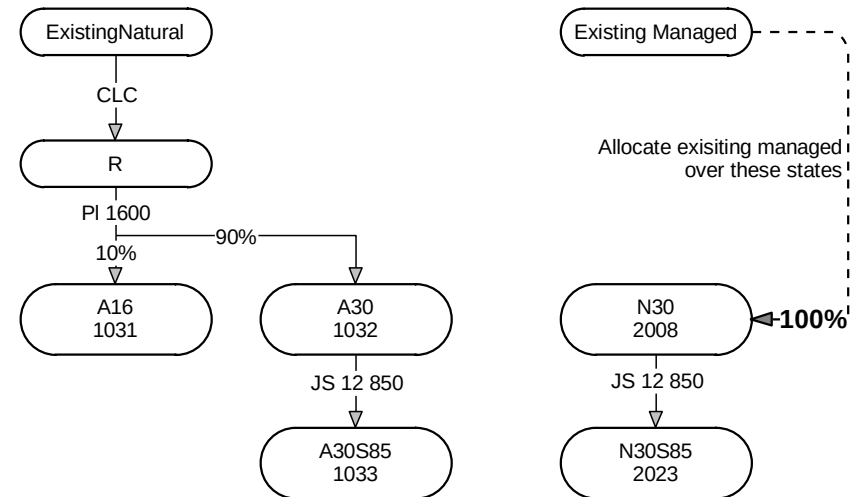
Existing Managed Stands

All spacing, pruning, and CT actions occur only in conventional areas.

All existing managed stands are assumed to be established at 3000 sph. Some have been fertilized. The development of these stands will be modelled (e.g., TIPSy) as natural (not planted) stands established at 3000 sph, and fertilized 15 years prior to (unfertilized) culmination age.

Strathcona TSA

SAU04 Hw (12-14,16,17), SI>=27, WSI=29.9, 6.9% THLB



Existing Natural Stands

All spacing, pruning, and CT actions occur only in conventional areas.

After harvesting (CLC) these stands will be fill planted to 1600 sph. Planting will vary from 0 - 1600 trees planted, and will average about 500 trees. At free growing, 10% will be 1600 sph and 90% will have ingressed to 3000 sph The development of these stands will be modelled (e.g., TIPSy) as planted to 1600 and 3000 sph, respectively. Note that the future managed stand is modelled a planted stand due to the superior site occupancy of the stand (source: JI)

Existing Managed Stands

All spacing, pruning, and CT actions occur only in conventional areas.

All existing managed stands are assumed to be established at 3000 sph. Some have been spaced to 850 sph and some (very few) have been subsequently pruned. The development of these stands will be modelled (e.g., TIPSy) as natural (not planted) stands established at 3000 sph.

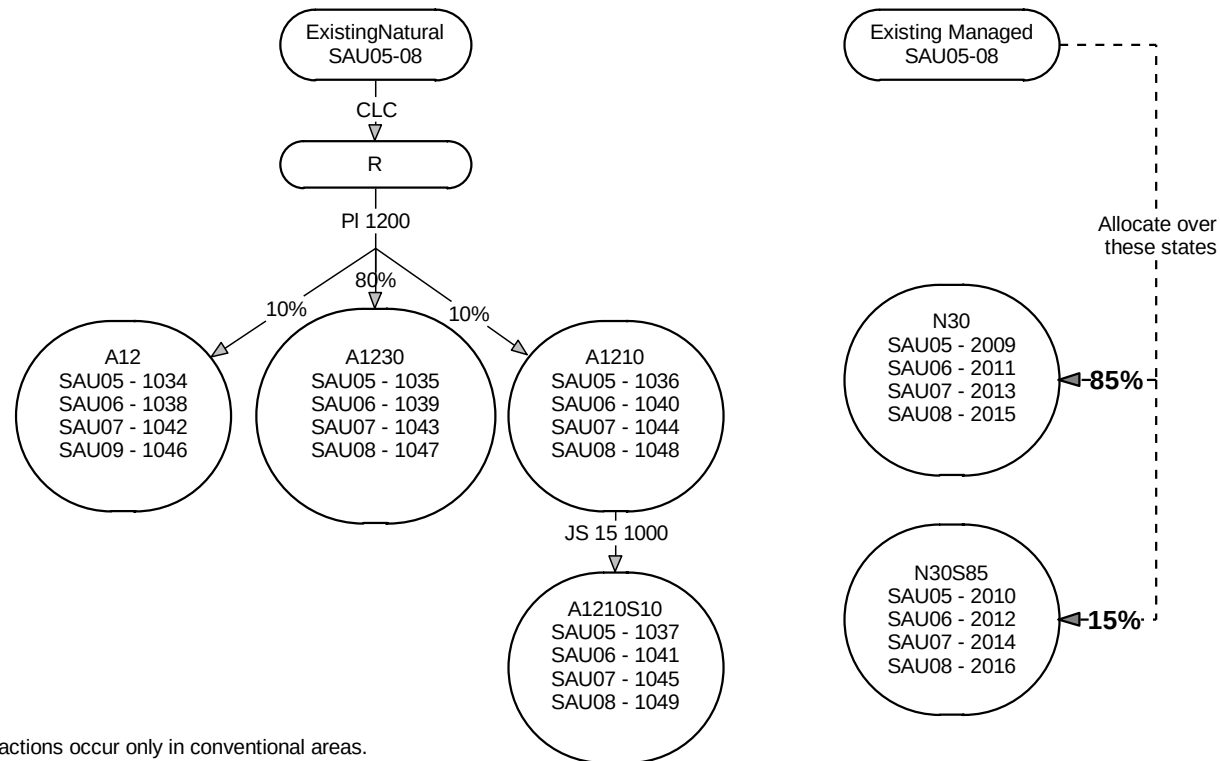
Alternative Development Pathways for Existing Natural and Existing Managed Stands

SAU05 Hw (12-14,16,17), 22=<SI<27, WSI=22.4, 21% THLB

SAU06 Hw (12-14,16,17), SI <22, WSI=15.7, 14.6% THLB

SAU07 HemBal (15, 18-20, 9-11,21-26), SI>=22, WSI=23.9, 11.9% THLB

SAU08 HemBal (15, 18-20, 9-11,21-26), SI < 22, WSI=16.2, 18% THLB



Existing Natural Stands

All spacing, pruning, and CT actions occur only in conventional areas.

After harvesting (CLC) these stands will be planted to 1200 sph.

With ingress, at free growing 10% will be 1600 sph, 80% will be 3000 sph, and 10% will >10,000 sph
Stands in state A1210 (>10,000 sph at free growing) may be spaced to 1000 sph

Existing Managed Stands

All spacing, pruning, and CT actions occur only in conventional areas.

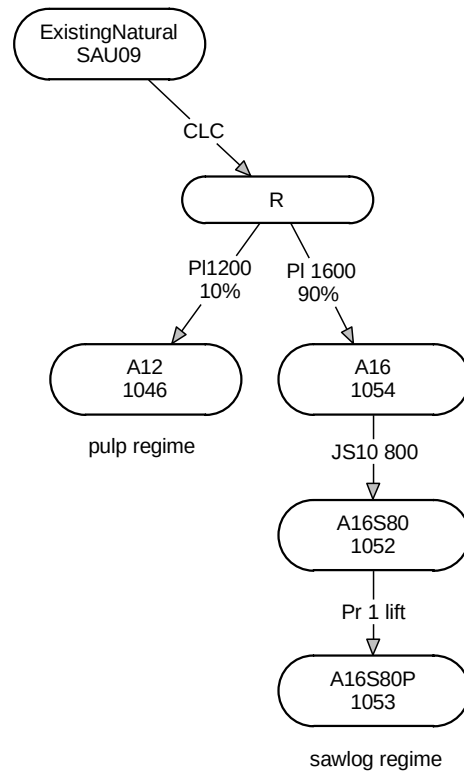
These are stands where the year of establishment is known. Some of these stands will have been treated (spaced) and will be recored in ISIS. It is assumed that all untreated stands (80%) are >3,000 sph and spaced stands (20%) are 850 sph. The existing managed stands identified in the inventory and ISIS will be allocated over these two states.

Untreated existing managed (N30) stands will not be treated (i.e., JS) in the future.

Alternative Development Pathways

Strathcona TSA

SAU09 Deciduous SI= 30, 3.1% THLB



Existing Natural Stands

All spacing, pruning, and CT actions occur only in conventional areas.

10% will be planted to 1200 sph and 90% will be planted to 1600 sph. The stands planted to 1600 sph may be subsequently spaced to 800 sph and pruned.



Appendix C — Genetic Gain

The seed zones and elevation breaks (Table C-1) and the forecast gain in volume from improved seed (Table C-2) for the Strathcona TSA were obtained from the Forest Genetics Council. The gain forecast for 2007–2008 was assumed to be applicable out to the planning horizon of this study (25 decades) and was prorated over the planting mixes identified by the district and the proportion of the TSA in each elevation.

Table C-1. Class "A" Seed Zones related to each TSA by species, Strathcona TSA.

TSA	Fd	Class "A" Seed Zones by species				
		Hw	Cw	Ba	Yc	Ss
Strathcona	M, GL	M	M	M	M	M

Table C-2. Forecast gain in volume from improved seed, Strathcona TSA.

TSA	Species & Seed Zone	Elevation (m)	Gain from Improved Seed (%)		
			99-00	04-05	07-08
Strathcona	Fd M Low	<700	8.0	12.2	14.0
	Fd M High	>700	2.0	5.0	5.0
	Hw M Low	<700	15.0	15.0	15.0
	Hw M High	>700	2.0	2.0	2.0
	Cw M Low	<700	2.5	11.6	11.6
	Ba M SM Low	<700	2.0	2.0	2.0
	Bg M Low	<700	2.0	2.0	2.0
	Ss M Low	<700	3.0	4.0	4.9
	Yc M	400-1200	5.1	10.5	20



Appendix D – Analysis Method

The key component of the analysis method the development a silvicultural planning model that is consistent with the TSR model and base case for the Strathcona TSA, and also fully represents the additional forest-level objectives and silvicultural activities required for silvicultural planning in a multiple resource planning context. The model will then emulate the TSR base case if incremental silviculture activities are turned off (i.e., the silviculture budget is constrained to \$0). As the budget is increased, the model will select silviculture activities that maximize its objectives. In essence, the model devises a silvicultural strategy that is consistent with the analyst's objectives for the TSA from the silviculture treatments specified for each SAU.

D.1 Develop a LP Model of the TSR Base Case

One of the major differences between this analysis and the TSR is the choice of the forest estate model. While the TSR uses FSSIM, a forest-level simulator, this analysis casts the silviculture planning problem as an linear model, solvable by linear programming (LP). Woodstock™ (Remsoft, 1997) was used to create the LP model and two optimization codes (C-Whiz™ and XA™) were used to solve it¹.

The first step in the analysis is to develop an LP model formulation of the TSR base case. An LP model represents the forest and its management as a series of linear equations, which can be arranged in a matrix. One equation, the objective function, expresses the forest-level objective (e.g., maximize volume production). Other equations represent the forest management rules such as limits on harvest fluctuation and forest cover constraints. The LP solution software finds the set of management activities (e.g., harvesting) that best meet the objective.

D.2 Implement Silviculture Activities in the Forest-Level Model

The regime diagrams (Appendix B) are implemented in the silviculture planning model as activities, transitions, inputs and outputs.

Actions are defined in the model to represent each silvicultural activity listed or implied in the regime diagram for each SAU. Transitions map the flow of land between states. For example, a spacing action moves land from a regenerated state to a spaced state and a pruning action moves spaced land to a post-first-lift state.

Costs are incurred and outputs generated with each transition initiated by an action. Costs are summed by regime, by strategy, and in total, and are constrained by budget. Other outputs, such as employment, volume harvested,

¹ C-WHIZ *Linear Programming Optimizer*, Ketron Management Science, July 1994
XA/LP, Sunset Software Technology, San Marino, CA



quality and value measures, are summed to the appropriate objective functions in the model.

D.3 Implement Forest Level Objectives

Each forest-level objective must be implemented in the silviculture planning. The current version of the silviculture planning model has seven objectives implemented:

- maximize short-term timber harvest (decades 1-2)
- maximize mid-term timber harvest (decades 3-10)
- maximize long term timber supply (decades 11-20)
- maximize a priority-structured timber supply
- maximize volume harvested with dbh $\geq$ 65cm
- maximize volume harvested of solid-clear
- maximize financial efficiency

The priority-structured objective maximizes the harvest over the entire 25-year planning horizon but puts the highest priority on maximizing harvest levels in decade 2, the second priority in the mid term (decades 3-14), and the lowest priority in the long term (decades 15-25).

Only one of the forest-level objectives can be active at a time and the other rows are described as non-constraining. These non-constraining rows calculate the contribution of harvesting and silvicultural activities to each forest level objective and are referred to as objective tracking rows.

D.4 Implement Management Rules as LP Constraints

Forest cover constraints, as specified in TSR1, are represented explicitly in the LP model of the base case.

TSR harvest forecasts are shaped in part by harvest-flow guidelines. When using a simulation model such as FSSIM, harvest-flow guidelines are implemented by the modeller during the search for the best harvest schedule. However, with an LP model, the harvest flow guidelines must be implemented explicitly in the model as constraints.

To model the TSR1 base case, the following constraints were added to the model.

- decade 1: annual harvest = the current AAC
- decade 2: annual harvest $\leq$ annual harvest decade 1
- decade 3-5: annual harvest $\geq$ 88% of annual harvest previous decade
- decade 6 -25: annual harvest $\geq$ annual harvest of previous decade



Constraints on the area disturbed (not “greened up”) are specified for each of the eight management zones recognized in the TSR.

Other forest management rules may be added as constraints. In order to ensure that the long-term harvest is sustainable in decades 26 and beyond, the growing stock (total inventory volume) in decade 25 is constrained equal or exceed the average growing stock of decades 21-25.

The first-decade harvest profile (Section 2.4) for clear cutting and commercial thinning are implemented in the LP model as constraints.

D.5 Analyze Scenarios

The silvicultural planning problem expands the timber supply problem by adding silvicultural activities, constraints on silviculture expenditures, and the objective function rows required to calculate contributions to forest-level objectives.

Silviculture scenarios are constructed in a manner that the benefits from specific silvicultural practices can be identified in terms of the models objectives, e.g., the impact (benefit) of fertilization on mid-term timber supply.

The LP solver finds both the harvest area and the level of silvicultural activity for each of the time periods represented in the model. Silvicultural expenditures are constrained and shadow prices (sensitivity coefficients) associated with each constraint are calculated as part of the solution process.

The scenarios developed for this analysis are:

S01: TSR1 Base Case – This scenario reproduces the TSR2 base case in order to validate the data and model. The management objective is to maximize priority-structured timber supply.

S02: Revised Base Case (RBC)– This scenario will reflect changes since the last TSR, and will include the OGSi/SIBEC adjustments described in the document Adjusting the Site Indices of the Strathcona TSA.

S03: Basic Silviculture Plus Improved Seed – This scenario demonstrates the incremental benefit of improved seed. Genetically improved seedlings are assumed planted but ingress is of natural origin. This assumption will be implemented by reducing the forecast gain by the ratio of the planted sph to total sph after ingress. For example, if Hw SI=30 is planted to 1600 sph, and ingresses to 3000 sph, the gain from improved seed will be reduced to $(1600/3000=)$ 52% of its original value. This scenario will be called the Silviculture Base Case (SBC) and will be the basis of comparison for subsequent scenarios.

S04: Partial Harvesting – This scenario demonstrates the incremental benefit over the SBC of partial harvesting in appropriate stands to improve short-term harvest levels.

S06: Maximum Volume Scenario– This scenario demonstrates the combined effects of all incremental silviculture activities and partial harvesting (S04). The silviculture activity levels will be determined such that the forest-level objectives



are met and that timber flow and other management constraints are also met. The silviculture planning model will determine the combination and intensities of silviculture activities that meet the forest-level objectives.

S08: Maximum Quality – Solid Clears-- This scenario is identical to S06 except that the objective is to maximize the volume of clear wood produced in the long term. The harvest flow (compiled at TSR2 utilization levels) is constrained to the harvest flow achieved in S06 so loss of timber supply is avoided.

S09: Maximum Quality – Dimension – This scenario is identical to S06 except that the objective is to maximize the harvest volume compiled at a utilization level of 65 cm dbh. The harvest flow (compiled at TSR2 utilization levels) is constrained to the harvest flow achieved in S06 so loss of timber supply is avoided.

S10: Maximum Financial Efficiency (Discounted Net Revenue) – This scenario maximizes the discounted net revenue. The harvest flow constrained $\geq$ S03 harvest levels and $\leq$ S06 harvest levels and all incremental silviculture activities (spacing, pruning, fertilization and commercial thinning) were permitted.



Appendix F – Adjusting the Site Indices

F-1.0 Introduction

The objective of this procedure is to incorporate site index estimates from OGSi surveys and SIBEC into the Strathcona silviculture analysis (Type 2).

The AAC Rationale report for the unit (B.C. Ministry of Forests, 2000) describes the potential for inaccurate site indices in general in BC, and on the Strathcona TSA specifically:

In general, in British Columbia, site indices determined from younger stands (i.e. less than 31 years old), and older stands (i.e. over 150 years old) may not accurately reflect potential site productivity. In young stands, growth often depends as much on recent weather, stocking density and competition from other vegetation, as it does on site quality. In old stands, which have not been subject to management of stocking density, the trees used to measure site productivity may have grown under intense competition or may have been damaged, and therefore may not reflect the true growing potential of the site. This has been verified in several areas of the province where studies – known as the old-growth site index or OGSi project – suggest that actual site indices may be higher than those indicated by existing data from mature forests. In recent years it has been concluded consistently from such studies that site productivities have generally been underestimated; managed forest stands tend to grow faster than projected by inventory-based site index estimates from mature and old-growth stands. In the Strathcona TSA, site productivity estimates for almost one quarter of the timber harvesting land base are based on old-growth stands.

For the purposes of the Strathcona Silviculture Analysis (Type 2) site indices were adjusted by using OGSi survey results to modify the sites of existing mature inventory (i.e. stands over 150 years old) and to adjust the sites of existing managed stands (less than 31 years old) using SIBEC.

F-2.0 Treatment of Site Indices in TSR2

Before proceeding to describe the method for accomplishing these adjustments, it will be useful to consider the Chief Forester's comments on site index and OGSi in particular, as recorded in the AAC Rationale Report.

OGSi adjustments were examined in a sensitivity analysis of the base case of the most recent timber supply analysis:

To test the sensitivity of the harvest forecast for the Strathcona TSA to changes in site indices for old-growth stands, OGSi adjustments based on the 'maximum' results described in the 1998 BCFS Research Branch Working Paper No. 36 were applied. These adjustments reflect the maximum site potential (productivity) given ideal management and stocking conditions. Managed stand volume estimates, green-up ages and minimum harvestable ages were also redefined, based on the site index adjustments. This resulted in a mid-term harvest level 100 000 cubic metres or 10 percent higher than in the base case, and a long-term level 14 percent higher, and achieved one decade earlier, than in the base case.



However, he noted that the inventory audit had found that older mature stands on the east side of the TSA were, in fact, significantly overestimated.

The general cautions recommended in the OGSi reports are reinforced by results of the inventory audit related to both immature and mature stands. The audit suggested that while site indices derived for stands under 45 years appear to have been underestimated, the opposite is the case for stands older than 45 years. Further, the overestimation of heights and ages for older mature stands on the east side of the TSA led to an implicit upward site index adjustment for those stands. That is, if the inventory had reflected actual heights and ages, the site indices would have been lower than derived for the analysis. At this time, the precise degree to which the inventory errors and the OGSi results overlap one another is uncertain.

The report concludes that results of the inventory audit will reduce the positive impact of OGSi adjustments and called for further study of site indices in the Strathcona.

Research has demonstrated clearly that in general, productivity of sites currently occupied by mature or old-growth stands will most likely be higher than currently estimated. However, uncertainties related to the applicability of province-wide study results to the Strathcona TSA, to the inventory, and to the degree to which full site potential will be achieved, mean that I cannot reasonably assume that timber supplies will be as high as shown in the sensitivity analysis employing OGSi adjustments.

Thus while the sensitivity analysis indicates substantially higher timber supply projections for the mid and long terms, it is reasonable to expect that the projection in the sensitivity analysis would represent maximum anticipated increases, and that the actual response would likely be more moderate. In my determination I have therefore accepted the potential for increases of something less than 10 and 14 percent in the mid and long terms respectively, as noted in "Reasons for Decision". If funds could be made available, a study to resolve the appropriate adjustments to make to site indices in the Strathcona TSA could potentially indicate significant future timber supply benefits.

To date, studies have not been undertaken specific to the Strathcona TSA that resolve this issue, i.e., estimation of appropriate adjustments to site indices.

The Chief Forester's other major reservation was whether OGSi adjustments should be applied without also adjusting the site indices for the inventory audit results. District staff considered this issue and suggested that the area of mature timber in question was relatively small.

F-3.0 Method for Adjusting Site Indices in the Inventory File

1. Add a new site index field to the Strathcona inventory file, ADJ_SI. The original site index is in field SI.
2. For older stands (i.e. over 140 years old) set $ADJ_SI = a_0 + a_1SI$ where a_0 and a_1 are from Table F-1.



Table F-1. Coefficients for the old-growth site index adjustment equation.

Leading Species	a ₀	a ₁
Fd	8.883	0.8688
Cw		1.326
Hw	15.47	0.7144

Source: Nigh, G. 1998

3. For stands age 31-140, set ADJ_SI = SI, i.e. the current site index
4. For existing managed stands (1-30 years) set ADJ_SI = SIBECtab(LS, BECVAR) where LS is leading species, BECVAR is the BEC variant, and SIBECtab is the table derived below. These 3 steps will be repeated for each of three leading species group represented in the model (Fd, Cw and other conifers).
 - 4.1. The inventory is categorized by 6 BEC variant codes, including “none”. The first step is to run a query on the Cortex ISIS tables to tabulate the area planted by BEC variant and site series.
 - 4.2. The second step is to assign site indices from the SIBEC tables (B.C. Ministry of Forests, 1998) for each BEC variant site series combination with hectares recorded in the first table.
 - 4.3. The table SIBECtab is created with the area weighted averages of the site indices tabulated in the second table.

F-4.0 Results

Table 2 contains the area-weighted site indices for the BEC variant and leading species combinations determined in step 4 (4.1-4.3) in previous section. In some cases district staff have adjusted the site index and the area-weighted average is included in parentheses

Table F-2. Area-weighted site indices by BEC variant and leading species.

BEC var	Leading Species:					
	Ba	Cw	Fd	Hw	PI	Ss
CDF mm		28.00	36.32		32.00	
CWH MM1			30.45	28 (24)		
CWH MM2	24.00		26.15	25 (23)		24.00
CWH vh1	23.50	15.98		18.69	27.38	
CWH vm1	26.81	23.02	33 (35)	28.5 (27)		
CWH vm2	27.42	19.67	26 (24)	27.28		
CWH xm		24.00	32.69	24.00		



Table F-3. Definition of silvicultural analysis units based on inventory site indices.

Table F-4. Definition of silvicultural analysis units with SIBEC and OGSi adjustments to site indices.

Figure F-1. Area of silvicultural analysis units using inventory SI and SIBEC/OGSi adjusted site indices.

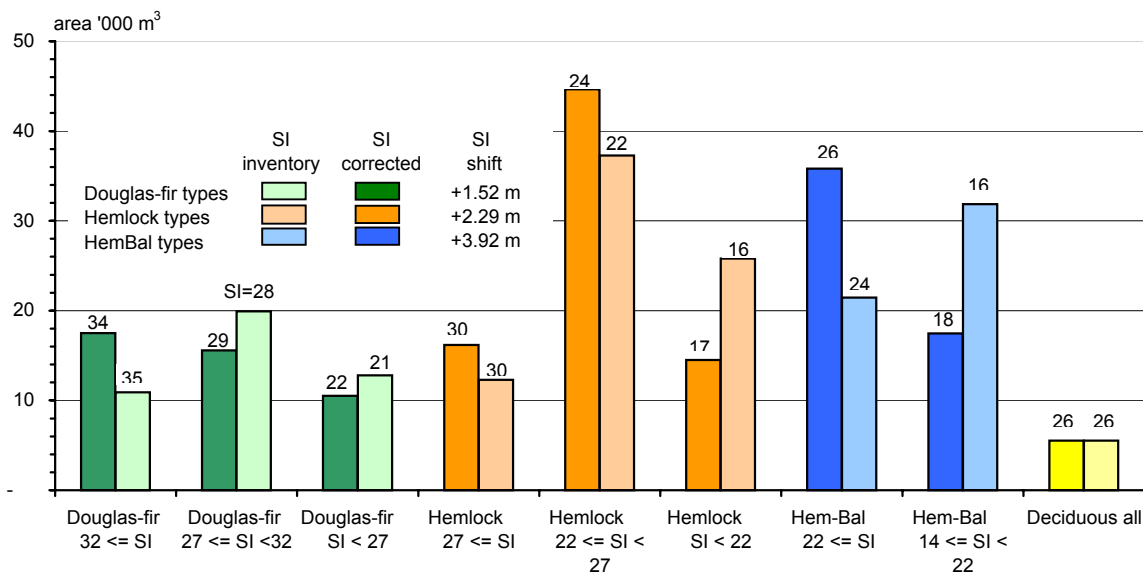
Table F-3. Definition of silvicultural analysis units based on inventory site indices.

Silviculture Analysis Units	Type Group	Leading Species	Site Index Range	Total Area	Weighted Average SI	% THLB	SI by LS
1	1-5, 8	Douglas-fir	32 <= SI	10,893	35.2	6.1%	27.9
2	1-5, 8	Douglas-fir	27 <= SI < 32	19,929	28.3	11.2%	
3	1-5, 8	Douglas-fir	SI < 27	12,801	21.0	7.2%	
4	12-14,16,17	Hemlock	27 <= SI	12,296	29.9	6.9%	21.4
5	12-14,16,17	Hemlock	22 <= SI < 27	37,293	22.4	21.0%	
6	12-14,16,17	Hemlock	SI < 22	25,788	15.7	14.5%	
7	15, 18-20, 9-11,21-26	Hem-Bal	22 <= SI	21,438	23.8	12.1%	19.2
8	15, 18-20, 9-11,21-26	Hem-Bal	14 <= SI < 22	31,843	16.2	17.9%	
9	37-39	Deciduous	all	5,517	26.4	3.1%	
subtotal:				177,797		100.0%	

Table F-4. Definition of silvicultural analysis units with SIBEC and OGSi adjustments to site indices.

Silviculture Analysis Units	Type Group	Leading Species	Site Index Range	Total Area	Weighted Average SI	% THLB	SI by LS	SI Diff
1	1-5, 8	Douglas-fir	32 <= SI	17,509	34.4	9.8%	29.4	1.52
2	1-5, 8	Douglas-fir	27 <= SI < 32	15,585	28.9	8.8%		
3	1-5, 8	Douglas-fir	SI < 27	10,529	21.9	5.9%		
4	12-14,16,17	Hemlock	27 <= SI	16,186	29.8	9.1%	23.7	2.29
5	12-14,16,17	Hemlock	22 <= SI < 27	44,670	23.5	25.1%		
6	12-14,16,17	Hemlock	SI < 22	14,520	17.2	8.2%		
7	15, 18-20, 9-11,21-26	Hem-Bal	22 <= SI	35,803	25.6	20.1%	23.2	3.92
8	15, 18-20, 9-11,21-26	Hem-Bal	14 <= SI < 22	17,477	18.1	9.8%		
9	37-39	Deciduous	all	5,517	26.0	3.1%		
subtotal:				177,797		100.0%		

Figure F-1. Area of silvicultural analysis units using inventory SI and SIBEC/OGSi adjusted site indices.





Appendix G — Sayward Landscape Unit Harvest Analysis

During the course of this study, the Campbell River Forest District requested that the maximum sustainable (non-declining) harvest be determined for the Sayward landscape unit. The goal of the District is to obtain a harvest of $\geq 300\,000\text{ m}^3/\text{year}$ in the mid and long term

Figure G-1
Harvest forecast

Figure G-1 illustrates the forecast harvest for the Sayward landscape unit for three scenarios, all driven by the management objective of maximizing timber supply.

- S01b** Scenario S01b is the base case and excludes OGSi/SIBEC and genetic gain. A harvest level of $295\,301\text{ m}^3/\text{year}$ is maintained out to the planning horizon (250 years).
- S03** Scenario S03 is S01b plus OGSi/SIBEC correction and genetic gain. The S03 forecast harvest begins at $280\,000\text{ m}^3$ in decades 1 and 2, then rises 23% to $362\,100\text{ m}^3/\text{year}$ in decade 3. This harvest level is maintained out to the planning horizon.
- S06** Scenario S06 is scenario S03 plus incremental silviculture activities and commercial thinning. Scenario S06 follows the same pattern as S03 with a harvest level of $284\,600\text{ m}^3/\text{year}$ in decades 1 and 2, then rising 28% in decade 3 to $392\,250\text{ m}^3/\text{year}$. This harvest level is maintained out to the planning horizon.

All other Figures in Appendix G were created from data obtained in scenario S06. Comparisons of figures made in Appendix G are between S06 data for the Sayward landscape unit and S06 data for the entire TSA (Figures 3-15 to Figure 3-25).

Figure G-2
Harvest by leading species

The majority of the harvest for the Sayward landscape unit is from Douglas-fir (Figure G-2). In periods 2-4 over 90% of the harvest is from Douglas-fir.

Figure G-3
Transition to managed stands

The transition from natural stands to managed stand is almost complete by period 8 (Figure G-3). The harvest from hemlock stands increases once managed stands become operable in period 8.

Figure G-4
Volume per ha harvested

Figure G-4 represents the harvest forecast by volume per unit area. Over 80% of the harvest is from stands with a volume $> 450\text{ m}^3$. This is not surprising given that a majority of the harvest in the landscape unit is from high yielding Douglas-fir and hemlock stands which have volumes $> 450\text{ m}^3$ by age 6 for SAU01 and SAU04, age 7 for SAU02 and SAU05, and age 11 for SAU03 and SAU06. When fertilization regimes are applied to these analysis units, the age at which the stand reaches 450 m^3 decreases by 1 or more decades.



Figure G-5
Composition of
harvest by age

The composition of the forecast harvest by age is illustrated in Figure G-5. As future managed stands become operable, the age at harvest decreases. The majority of stands harvested in periods 8 to 25 are younger than 91 years of age. In the mid to long term the harvest is dependent on high yielding, fast growing managed stands.

Figure G-6
Clearcut vs.
commercial thinning

Figure G-6 shows the area harvested by clearcutting and commercial thinning. The rate of commercial thinning over periods 1 to 3 substantially exceeds the average for the remainder of the 25 decade planning period as the model brings forward in the harvest queue volume from stands that are scheduled for harvest in decades 4-7, decades in which a surplus (relative to the rate of harvest) of timber becomes available for harvest.

Figure G-7
Composition of
harvest by grade

Figure G-7 shows the composition by grade of the harvest from managed stands. Comparing this figure with the equivalent figure for the total TSA (Figure 3-21), there is a significant improvement in grade distribution for the Sayward landscape unit, with an increased proportion of harvest from grades C through I.

Figure G-8
Composition of
harvest by diameter
limit

Figure G-8 shows the composition of the harvest by diameter limit from managed stands. As with the distribution of grade, the distribution of harvest by diameter limit for the Sayward is superior to the TSA as a whole (Figure 3-22), with a noticeable increase in volume compiled with a diameter of >45 cm. The mean DBHq for the entire TSA is 29 cm as compared to 36 cm for the Sayward landscape unit.

Figures G-9, G-10, and G-11 plot the area by treatment, treatment costs, and direct silviculture employment benefits, respectively, for the harvest maximization scenario.

Figure G-9
Treatment area

Figures G-9 shows that the fertilization program (including repeats) increases in size from 58 ha per year in decade 1 to an average of 1085 ha per year in decades 6-25. The area juvenile spaced per year also increases in size from 159 ha spaced per year in decade 1 to an average of 375 ha spaced per year in decades 6-25.

Figure G-10
Treatment area

The cost of spacing and fertilization (Figures G-10) and the silviculture employment outputs of these programs (Figures G-11) follow a similar pattern.

Figure G-11
Employment

The average cost of spacing and fertilization over the planning horizon is \$282 134 per year. This figure makes up 33% of the total average cost of spacing and fertilization for the entire TSA.

Figure G-1. Impact of commercial thinning, spacing and fertilization on the forecast harvest, Sayward Landscape Unit.

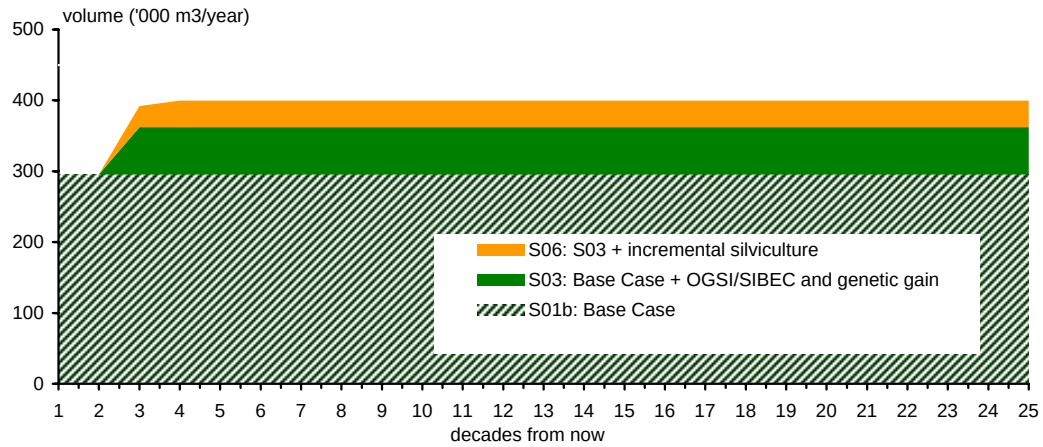


Figure G-2. Composition of the harvest by leading species, Sayward Landscape Unit, maximum harvest volume scenario (S06)

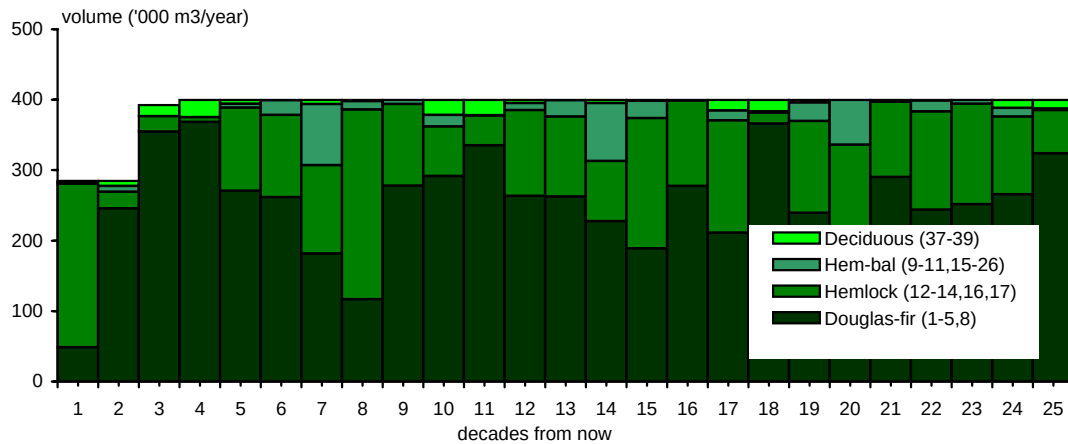


Figure G-3. Composition of the harvest by existing natural and managed stands, Sayward Landscape Unit, maximum harvest volume scenario (S06)

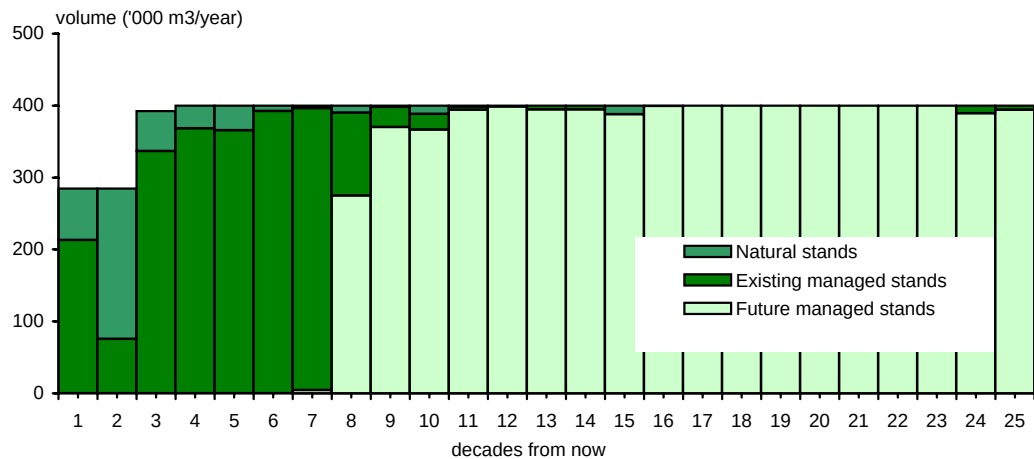


Figure G-4. Composition of forecast harvest by volume per unit area, Sayward Landscape Unit, Sayward Landscape Unit.

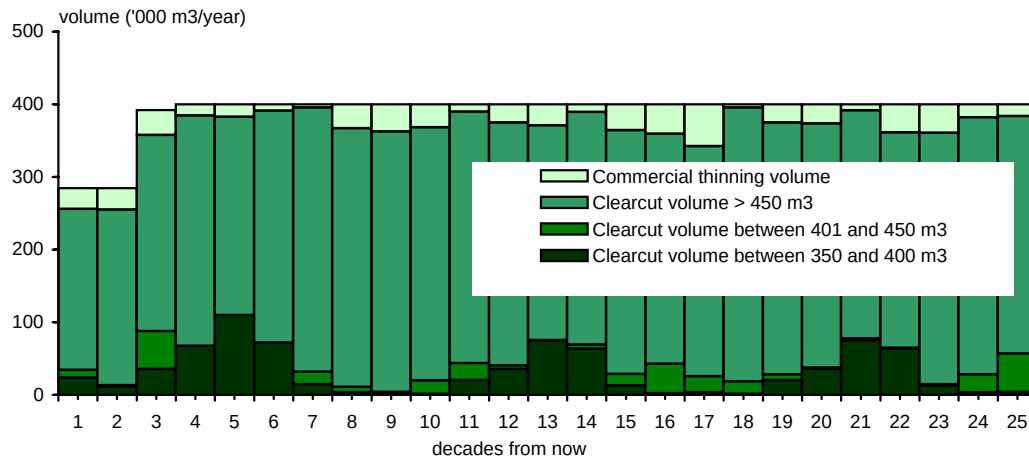


Figure G-5. Composition of the harvest by age class, Sayward Landscape Unit, maximum harvest volume scenario (S06)

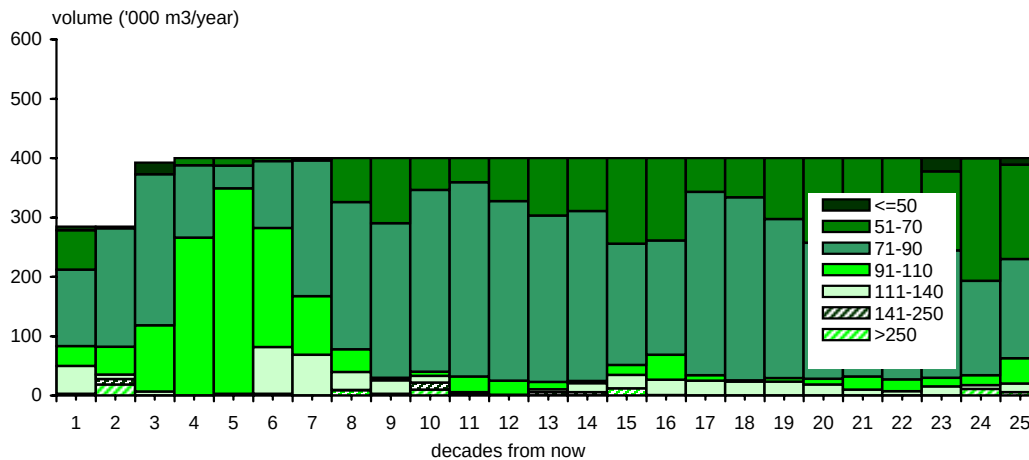


Figure G-6. Total area and volume per unit area of the forecast harvest, Sayward Landscape Unit, maximum harvest volume scenario (S06)

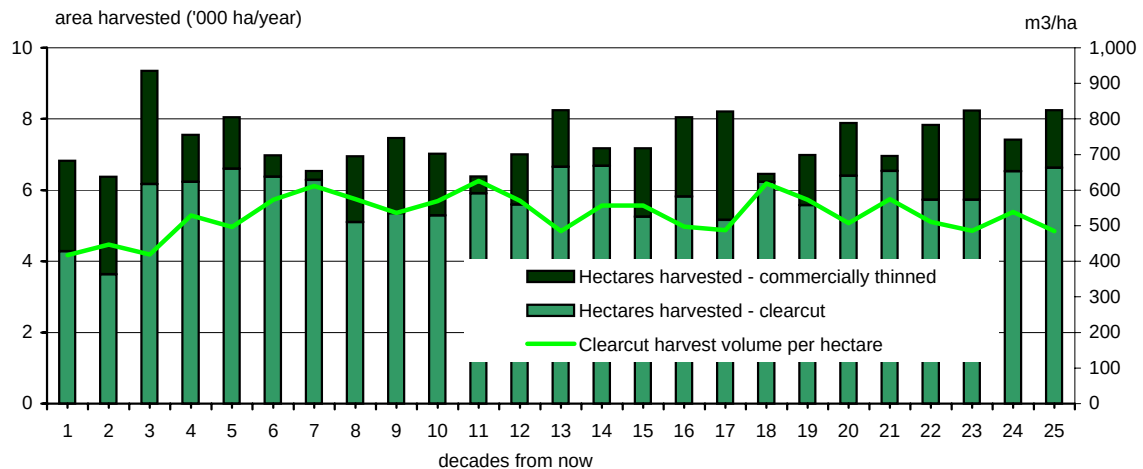


Figure G-7. Composition of forecast harvest by grade, Sayward Landscape Unit, maximum harvest volume scenario (S06)

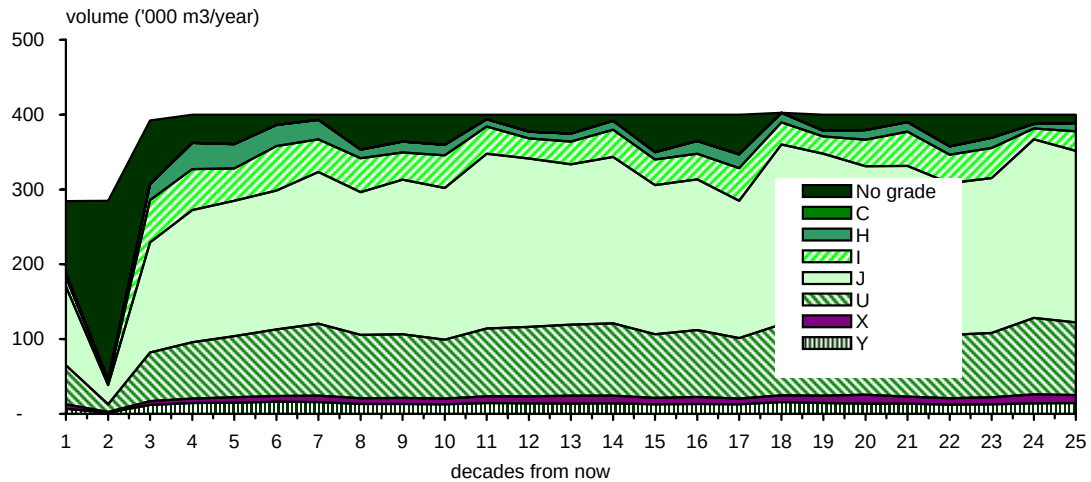


Figure G-8. Composition of the harvest by dimension, Sayward Landscape Unit, maximum harvest volume scenario (S06)

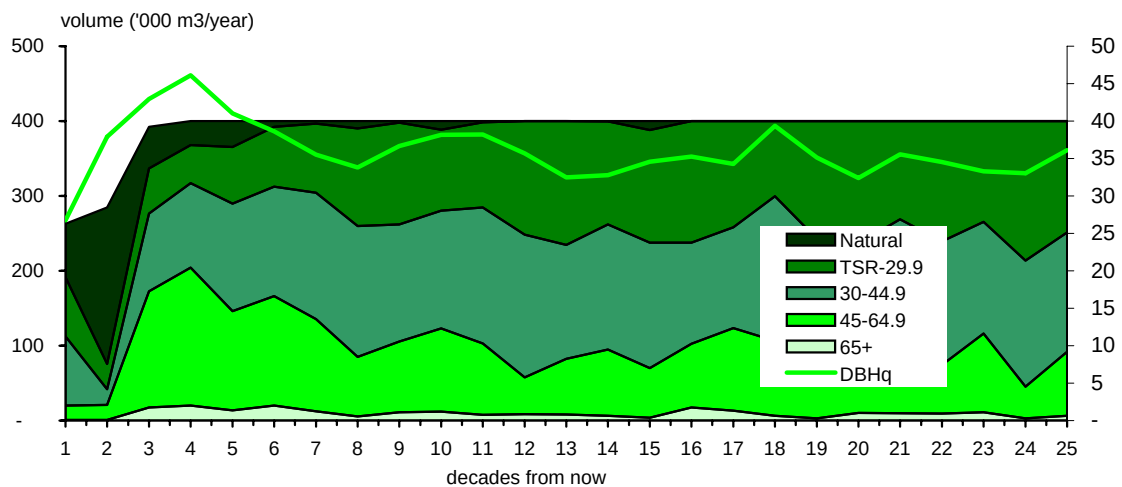


Figure G-9. Treatment area forecast, Sayward Landscape Unit, maximum harvest volume scenario (S06)

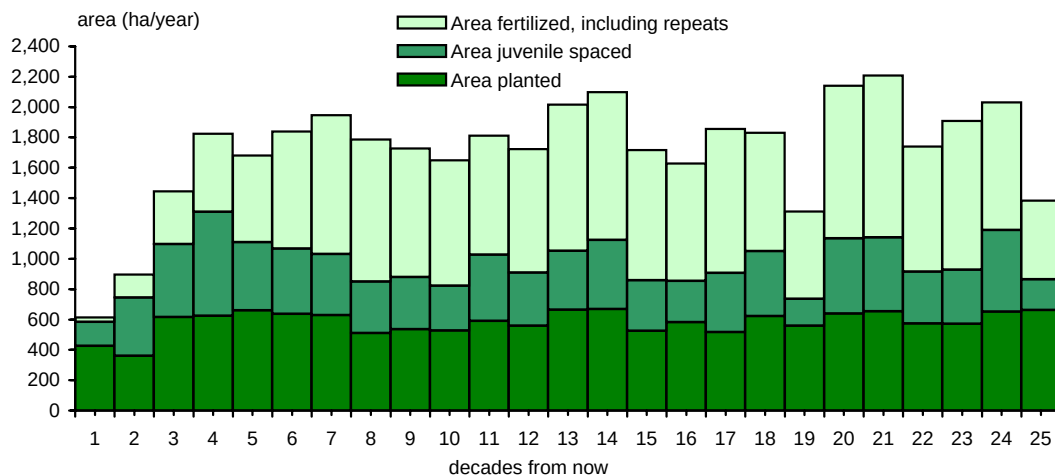


Figure G-10. Treatment cost forecast, Sayward Landscape Unit, maximum harvest volume scenario (S06)

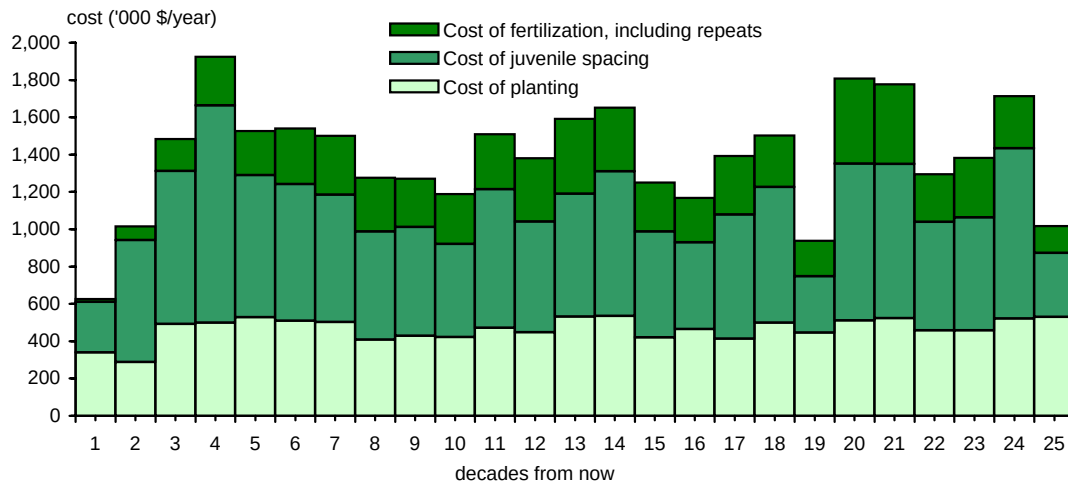
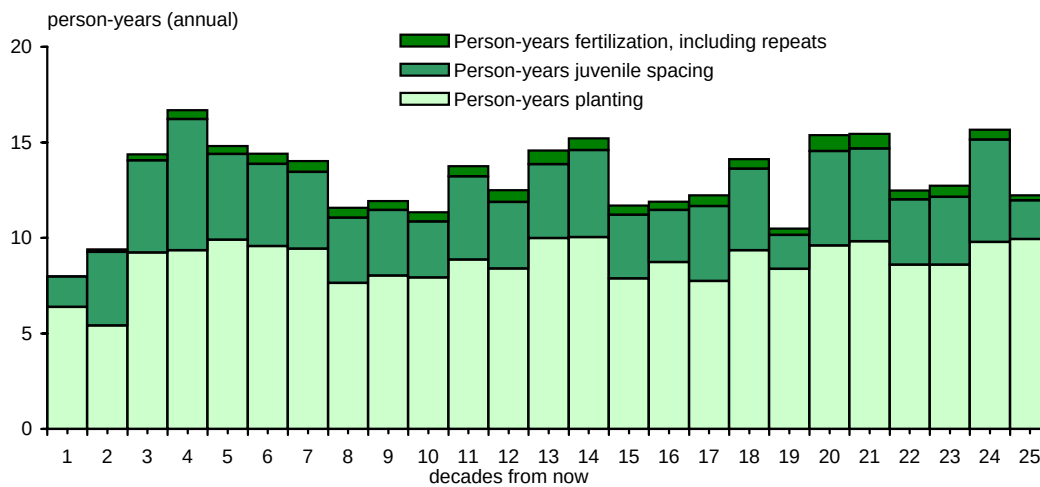


Figure G-11. Silviculture direct employment forecast, Sayward Landscape Unit, maximum harvest volume scenario (S06)





Appendix H– MoF Guidelines for Deviating from the Silviculture Strategy

Ministry of Forests

File: 22130-20/SILV STRATEGY

Date: October 24, 2001

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

1. Objectives

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

2. Inventory and yield predictions

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

3. Budgets

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

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