TFL 6
Tree Farm License

Type II Incremental Silviculture Strategy

Prepared for
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TFL 6 INCREMENTAL SILVICULTURE STRATEGY (TYPE II)

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EXECUTIVE SUMMARY

This report describes a "Type 2" incremental silviculture strategy for TFL 6 which is held by Western Forest Products Limited. (WFP). This strategy utilized the results of a "Type 1" project (an interim strategy) completed in July, 2001.

The "Type 2" focused on stand and forest-level growth and yield and financial analysis of short-term (next 5 years) incremental programs and some key basic reforestation strategies. TIPSY and TASS were used for stand-level growth and yield analysis and COMPLAN was used for forest-level analysis. The net present value approach to stand-level financial analysis was used assuming static, current conditions for log values and treatment costs. Scenario planning and sensitivity analysis were used to address future un-certainty with respect to relative timber values and treatment costs.

The key timber supply and quality issues identified for TFL 6 are:

- Policies developed over the last two decades to ensure multi-resource sustainability limit the timber supply in the short to medium-term. Reductions in the amount of old forest available for harvest result in the annual allowable cut (AAC) being stepped down over the next 50 years. In the mid to long term, as more second growth becomes merchantable, the AAC slowly recovers until it reaches a long-term sustainable level higher than the current harvest rate.

- Unlike most timber supply management units on the coast, the minimum harvest ages for timber supply analysis (TSA) for TFL 6 are set based on the achievement of target diameters rather than maximization of mean annual increment (MAI). This strategy generally results in higher harvest ages than would occur using biological criteria.

- The TFL 6 AAC is very sensitive to minimum harvest ages over the next 100 years. For example, if minimum harvest ages were set at 95% of culmination ages, there would virtually be no short to mid-term fall-down in supply. On the other hand this strategy would result in a smaller average harvested log size (diameter). Therefore assumptions about future merchantability, as represented by target average diameters or diameter distributions, can significantly impact timber supply assessments and therefore strategic silvicultural planning for TFL 6.

- Existing second growth stands in TFL 6 are dominated by Hw. If the current depressed market demand (price) for Hw relative to other primary coastal species continues, this lack of species diversification will limit the economic returns from harvesting in TFL 6.

- Past silviculture efforts have softened the effects of recent harvesting restrictions. Aggressive basic reforestation and intensive treatments such as tree improvement and fertilization have been included in the current management option (CMO). According to the current timber supply analysis (TSA), future intensive treatments, of the magnitude assumed in the CMO, account for between 5 and 20% of the projected AAC after about 2140.

Several scenarios were developed to evaluate assumptions in the current management option (CMO), strategies to increase timber volume and strategies to improve timber quality. Based on the potential significance of a lack of species diversification in the second growth, a priority was the assessment of ecologically-viable regimes for growing alternatives to Hw.

Analysis confirmed that SCHIRP fertilization and use of genetically improved stock positively impact long-term timber supply and are financially viable. Juvenile spacing was not found to be an effective tool for improving timber supply and was not economically justifiable. Pruning of Hw was not found to be financially viable.

Of the alternative reforestation species analyzed, increasing the use of Cw on S1ha sites was identified as the most promising. The benefit of increasing the use of Cw would be higher harvest log values (assuming current log prices), however harvest levels may be decreased. In addition there are un-certainties about the impacts of competition from Hw natural in-fill on the growth of Cw on some sites.

Analysis showed that on sites which will regenerate naturally to Hw, planting genetically improved Hw seedlings is not cost effective.

Based on the results of the analysis and WFP's current philosophy and understanding of the key issues effecting timber supply, quality and habitat the key silviculture strategies are:

Strategies to Increase the Quantity of Future Timber Supply:

Short-term:	1. Reduce regeneration delay on salal sites by continuing to fertilize at the time of planting. 2. Increase the short-term AAC by harvesting alder.
Mid-term:	1. Increase the AAC in the 2041 to 2060 "trough" by looking at establishing alder plantations on ecologically-suitable currently harvested areas. 2. If non-SCHIRP Hw fertilization response can be demonstrated, the mid-term AAC could be significantly increased by fertilization. 3. If commercial thinning can be proved to be viable, a program starting in about 2030 could be used to increase the AAC in the 2041 to 2060 "trough."

Long-term:	1. Increase long-term AAC by continuing to aggressively fertilize and monitor treatment response under SCHIRP. 2. Reduce long-term minimum harvest ages by continuing to use genetically improved seed. 3. Increase the long-term AAC by converting un-managed alder-leading stands to managed coniferous stands. 4. Increase the long-term AAC and forestry land base by draining wet, low productivity sites. 5. Increase the long-term AAC with an aggressive road rehabilitation program.

Strategies to Increase the Quality of Future Timber Supply:

Short-term:	1. Increase product diversification by harvesting alder.
Mid-term:	1. Increase product diversification and recover logs with some clear cuttings by growing alder. 2. Juvenile spacing to promote Cw and Yc. 3. If commercial thinning can be proved to be viable, a program starting in about 2030 could be used to increase the quality of the final harvest.
Long-term:	1. Increase value by modification/ diversification of the species mixes used in reforestation.

Strategies to Increase the Quantity or Quality of Future Habitat Supply:

Long-term:	1 Density management and conversion of alder-leading stands in riparian management zones to mixed to deciduous-coniferous stands will improve long-term fish and riparian habitat.

The fundable treatment priorities are:

1) SCHIRP fertilization,
2) Backlog brushing,
3) Riparian restoration,
4) Juvenile spacing and,
5) Pruning

Finally a recommended silviculture program for 2002 to 2006 is outlined which is based on a funding level of slightly more than $1,000,000 per year. This program supports a timber supply which is similar to the CMO of the current TSA. This program allocates up to 10% of the total budget to “experimental” or innovative projects such as the further analysis of the impacts of using alternative species, the viability of commercial thinning and fertilization responses.

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1. INTRODUCTION

The terms of a service agreement between Forest Renewal BC (FRBC) and the BC Ministry of Forests (MoF) require the MoF to develop, and FRBC to fund, what is essentially a "Type 2" incremental silviculture strategy. This document addresses the contractual requirement for Tree Farm License (TFL) 6, which is held by Western Forest Products Limited (WFP).

Incremental silviculture (treatments that are beyond a licensee's reforestation responsibilities) is part of a suite of strategies, which can have a significant influence on the future quality and quantity of habitat and timber supply. A "Type 2" strategy uses stand and forest-level computer modeling to analyze potential silvicultural strategies and choose a preferred plan. A "Type 1" strategy uses the most recent timber supply analysis and other existing data to develop an interim incremental silvicultural. A "Type 1" project was completed for TFL 6 in July, 2001.

An incremental silviculture strategy should not be confused with the Allowable Annual Cut (AAC) determination process. AAC's are based on actual practice and current information at the time of the determination. This strategy, on the other hand, is about creating a future state of our forests. The degree to which the strategy proves appropriate and is achieved may influence future, but not necessarily current, AAC determinations.

Although the intention of "Type 2" strategies is to focus primarily on developing short-term (ie: next 5 years) incremental silviculture programs, it is recognized that basic silviculture strategies can have a significant impact on medium to long-term (ie: >10 years) enhanced silviculture programs. As a result, this project included review and analysis of some key basic reforestation strategies.

2. METHODOLOGY

Using the "Type 1" project as a starting point this "Type 2" strategy was prepared through the following process:

1. Clarifying WFP's objectives relative to silvicultural strategies for TFL 6.
2. Further analysis of timber supply, quality and habitat issues and potential treatments.
3. Development of the key scenarios to review through stand and forest level analysis.
4. Research and development of potential strategies and treatment regimes.
5. Stand-level growth and yield and financial analysis of the different regimes to determine the most viable options.
6. Forest-level analysis to evaluate the impacts of the most viable regimes on the key scenarios.
7. Evaluation of the key scenarios and selection of a preferred strategy.
8. Development of a 5 year incremental silviculture program.

Following preliminary completion of steps 1 through 6, a field tour of selected sites within the Port McNeill Operation was carried out in February 2002.

In March 2002 Jeff McWilliams of B. A. Blackwell and Associates Ltd. led a workshop at WFP's Port McNeill office. This workshop was attended by WFP staff from TFL 6, TFL 19 and head office, Larry Sigurdson of the MoF Regional Office and a representative of the Port McNeill MoF district office. Participants reviewed the preliminary stand and forest-level analysis and provided feedback to guide the rest of the project. Following the workshop revisions/additions to stand and forest-level analysis were completed and a draft report produced. After WFP and MoF review, a completed strategy document was submitted.

2.1 Growth and Yield

Stand-level

This project utilized stand-level data generated by WFP from the Table Interpolation Program for Stand Yields (TIPSY) version 2.1 during the Timber Supply Analysis (TSA) for Management Plan (MP) 9. In addition new yield curves and log outturns were generated from TIPSY version 3.0 and by Ken Polsson of the MoF Research Branch from the Tree and Stand Simulator (TASS). Input specifications and assumptions for the yield curves and log outturns generated for this project are included in the appendices[1].

Forest-level

This project utilized the proprietary forest estate simulation model COMPLAN. COMPLAN was used by WFP in the most recent TSA (for more information on COMPLAN see the Timber Supply Information Package for MP 9). Many of the timber supply runs from the recent TSA have been utilized for this project. In addition several runs were generated by Jerry Miehm and Dwight Crouse of Olympic Resource Management. As COMPLAN is a simulation model it cannot be used to conduct optimization analysis.

2.2 Financial Analysis

For stand-level analysis the net present value (NPV) approach was used. The NPV of a treatment regime is the sum of its discounted revenues minus the sum of its discounted costs. By calculating NPV's, treatment regimes with costs and revenues at different points in time can be compared. For this project a customized spreadsheet was developed to facilitate financial analysis. This spreadsheet incorporates the use of sensitivity analysis by allowing cost, revenue and discount rate assumptions to be varied. The appendices include this spreadsheet and an explanation of the key formulas and assumptions. A CD has been included which contains the spreadsheet and brief instructions for its use.

For this project stand-level financial analysis was used primarily to rank the potential treatment regimes.

[1] TASS outputs for the alder regimes are not included as this data is considered experimental.

For forest-level analysis the potential recommended treatment regimes were applied to all suitable stands in the inventory and the costs and responses were recorded.

2.3 Analysis Assumptions

Assumed log grades and values, treatment costs and employment criteria used in the analysis are listed in the appendices.

2.4 Use of Scenario Planning

There are many uncertainties that may affect the development of a strategic silvicultural plan. Some examples of key unknowns or risks over an extended time horizon include the following.

- What if market demand and hence price of a particular species significantly increases relative to other species? or,
- What if a significant technological breakthrough creates new processing opportunities for particular timber grades? or,
- What if new substitutes significantly depress the demand and hence price of different species and/or timber grades?

There are also uncertainties in treatment responses to some silvicultural regimes. In many cases, these uncertainties cannot be eliminated. But they can greatly affect the ultimate value of different silvicultural strategies. Scenario planning helps to understand the significant issues that control future outcomes related to stated objectives by simplifying the complex interactions.

The basic steps involved in scenario planning are:

1. Identify the focal issues and key decisions to be made. Develop alternative management strategies and appropriate outcome indicators.
2. Identify the driving forces that shape future outcomes along with key uncertainties. Develop a range of scenarios along different “themes” that reflect meaningful combinations of key uncertainties.
3. Evaluate outcome indicators against each scenario to help develop and refine an optimal strategy.

For this project scenario planning was used to develop a range of different forest-level outcomes for which management regimes were designed. These scenarios were evaluated and used to determine a preferred option. The actual final strategy may be composed of portions of several scenarios.

In developing potential strategies to address key forest-level issues the following factors were considered:

- Uncertainty over relative future log prices was dealt with by developing different sets of prices to reflect increased future premiums for larger logs and relatively flat log prices versus increasing log size.
- Log prices were separated by species with the allowances for differential premiums to be placed on selected species.
- Ranges of silviculture and harvesting costs were used to allow for sensitivity analysis of the effect of varying current costs and uncertainty over future costs.

3. SUMMARY OF BASIC DATA, TIMBER SUPPLY AND SILVICULTURAL HISTORY

3.1 Basic Data

(Source for this Section: Timber Supply Analysis Information Package for Management Plan 9 for TFL 6, WFP)

The following figures and table summarize some of the key basic data for TFL 6. Forests on the timber harvesting land base (THLB) are dominated by western hemlock with lesser components of western red cedar and balsam. The age class distribution is unbalanced with significant components of old and young forest but a relative lack of mature stands. Ecosystems are classified using the Lewis Ecosystem Units and are dominated by S1hemlock-amabalis (roughly equivalent to site series 01 in the MoF biogeoclimatic system). Site indices have been assigned by productivity group based on recent sampling and statistical analysis.

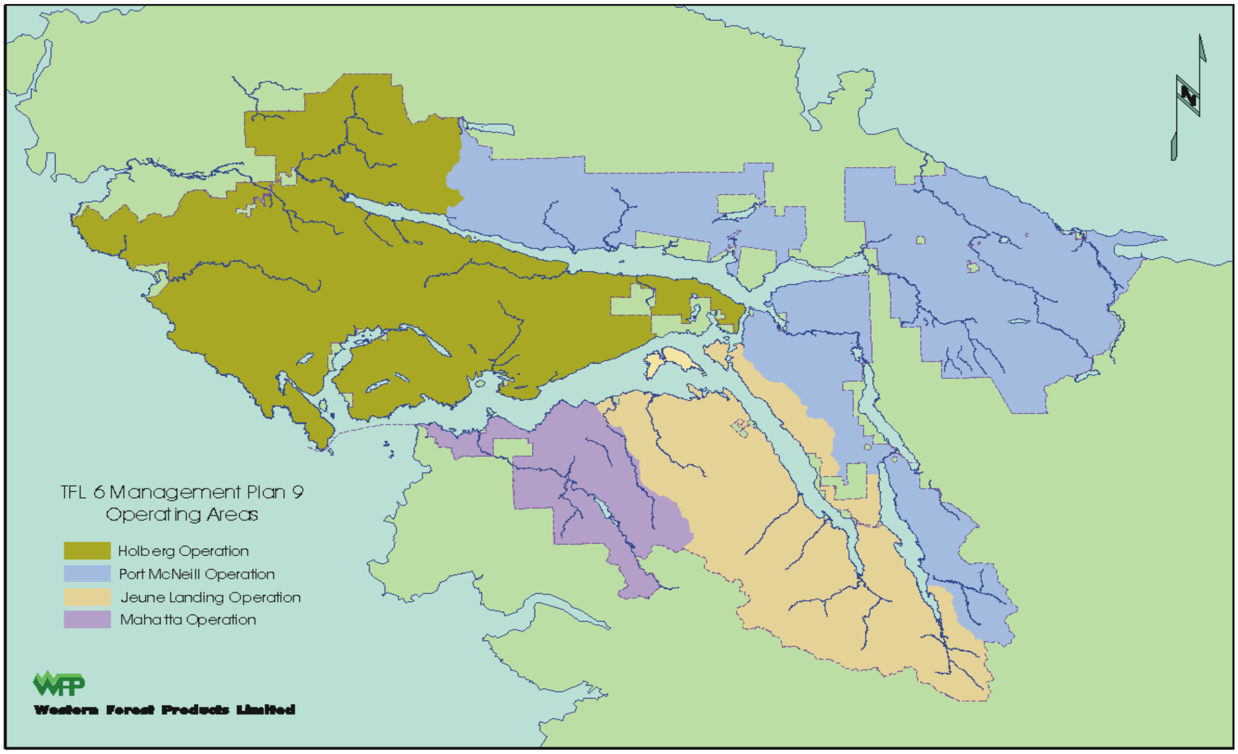

Figure 1. Overview of TFL 6

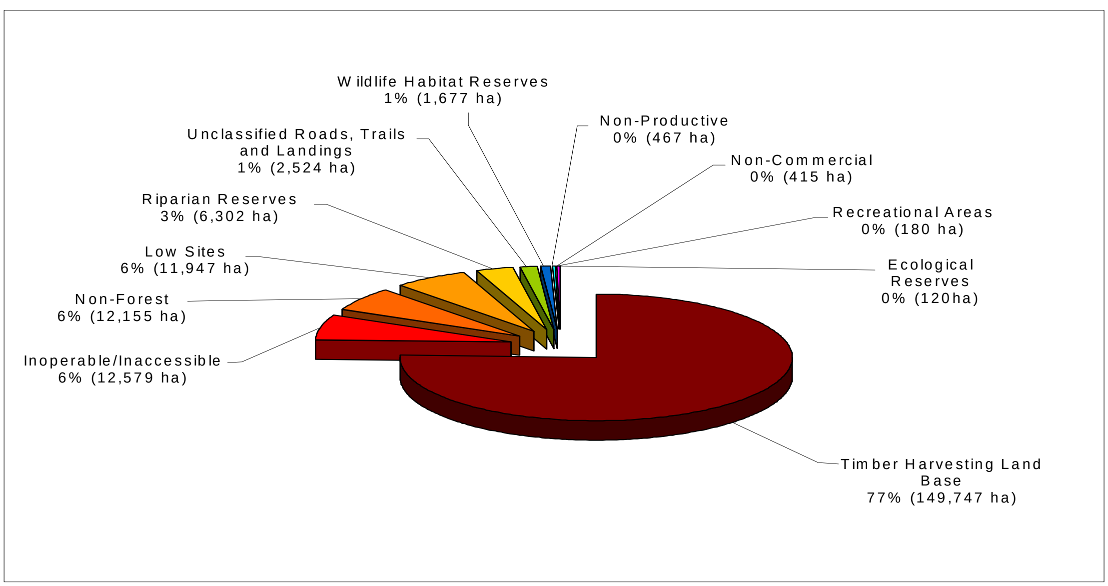

Figure 2. Breakdown of Productive Forest Land

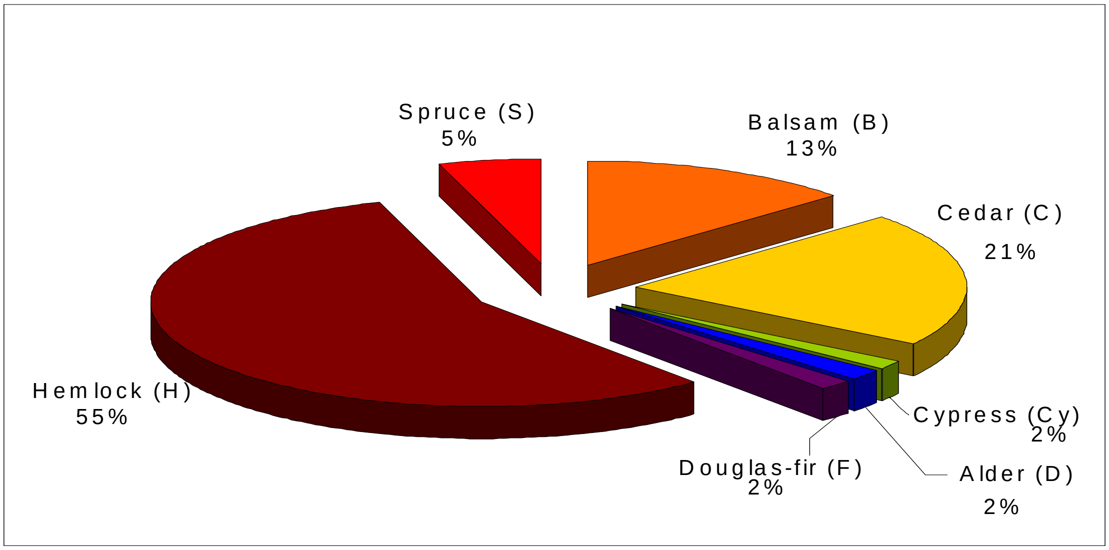

Figure 3. **Distribution of Tree Species by leading species area on the THLB**

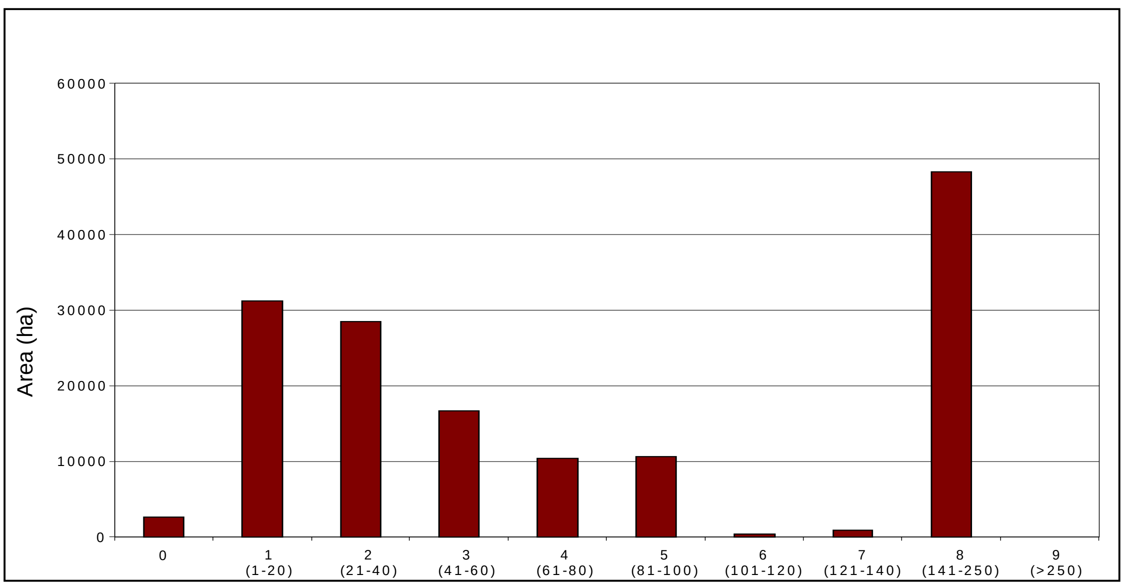

Figure 4. **Age Class Distribution on the THLB**

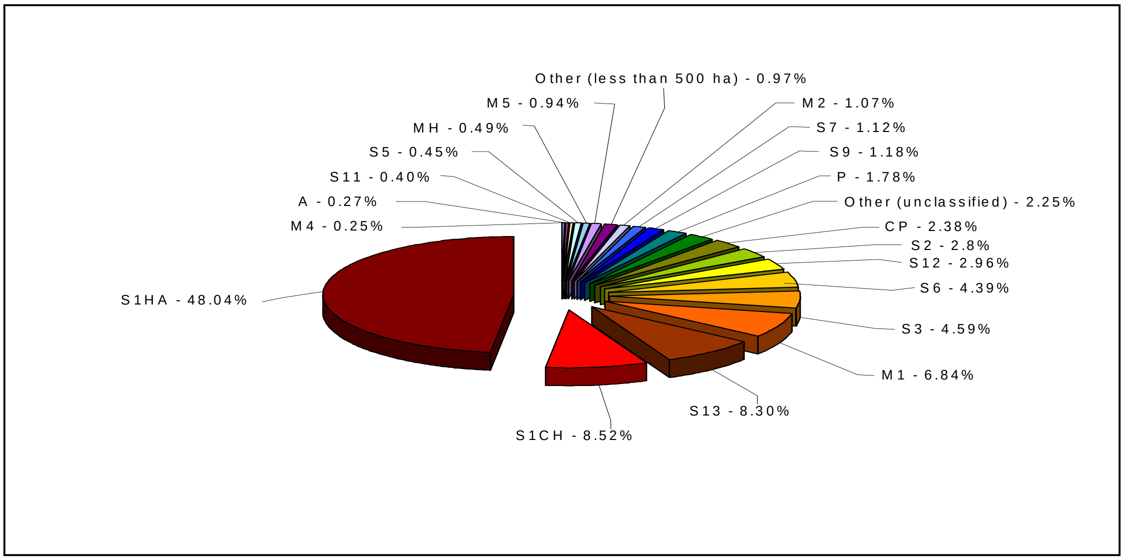

Figure 5. Lewis Ecosystem Unit Distribution on the THLB

3.2 Timber Supply

(Source for this Section: TSA for MP 9 for TFL 6, WFP)

History of the AAC

The AAC for TFL 6 is currently 1,469,900 m^3 /year. This reflects a reduction of about 1.2% from the previous period (1996 to 2000). For about the past 30 years annual harvesting levels in the TFL have been relatively constant at about 1,400,000 m^3 /year. Note however that during this period there have been additions and deletions to the TFL and inventory and yield estimates have improved.

Timber Supply Analysis Results for MP 9

The following figures summarize the AAC forecast for the Current Management Option[2] (CMO) (Figure 6) and show the impacts of this forecast on annual harvested area, average harvested diameter, volume per hectare and harvested age (Figures 7 and 8). These figures show a step down in the harvest from now until about 2050 as the remaining non-constrained old-growth is harvested. From about 2020 to 2050 there is a shift in harvesting to second growth. After about 2050 the harvest is entirely from second growth and the AAC recovers slowly until about 2140. As a result of past and projected future silviculture treatments and the use of diameter targets to set minimum harvest ages, the second growth volumes at the projected harvest ages tend to be higher than for the currently harvested old-growth and lead to a “fall up” in harvest levels.

[2] See the appendices for the assumptions which are included in the CMO

Figure 9 shows the impact of the CMO on the distribution of growing stock and Figure 10 shows the effect of the CMO on age class distribution over the simulation period.

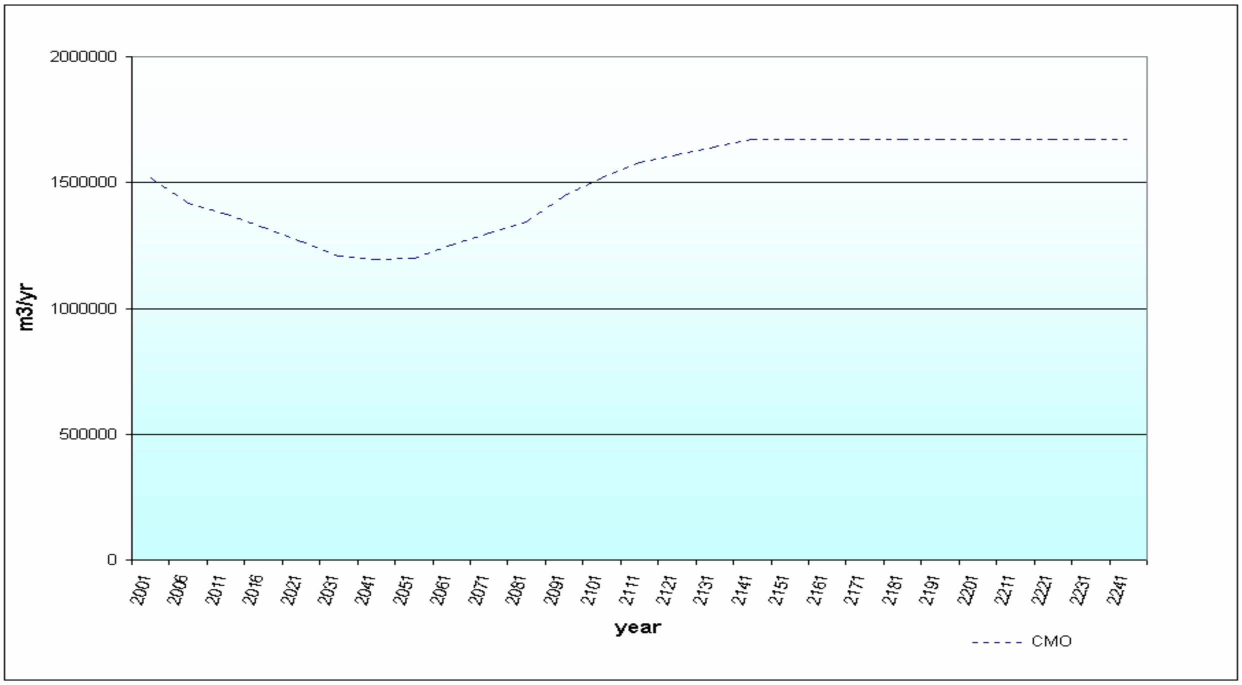

Figure 6. Current Management Option (CMO)

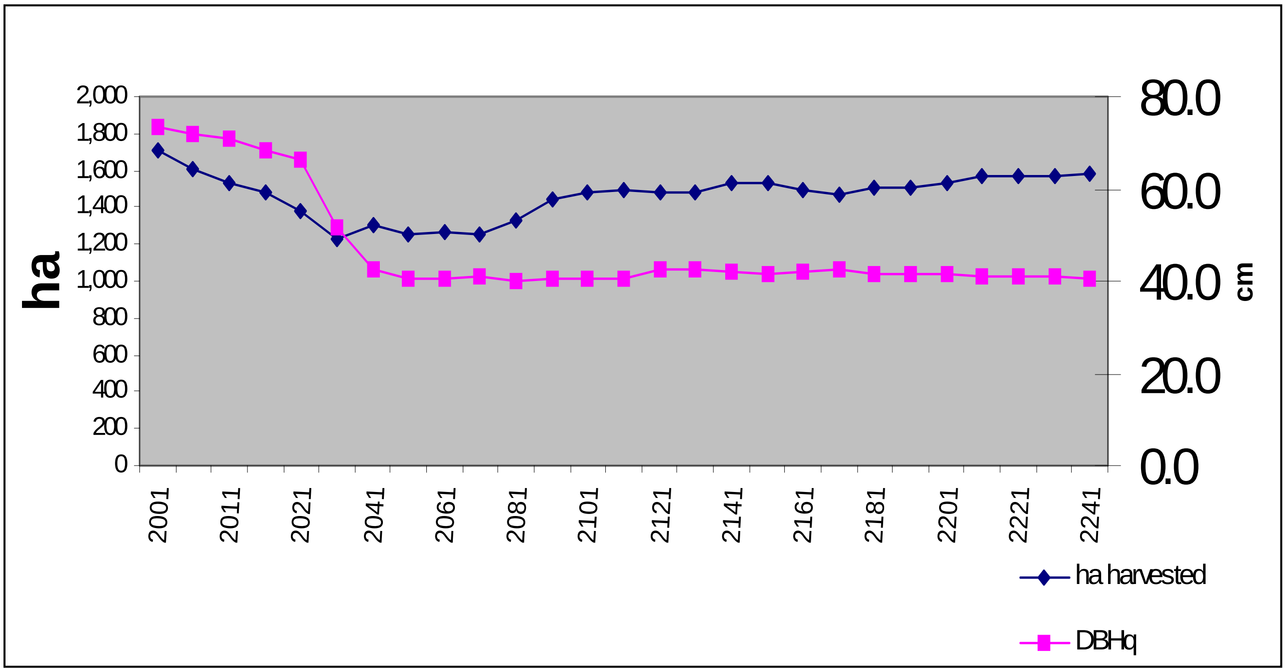

Figure 7. Annual Area Harvested and Average Diameter Harvested under the CMO

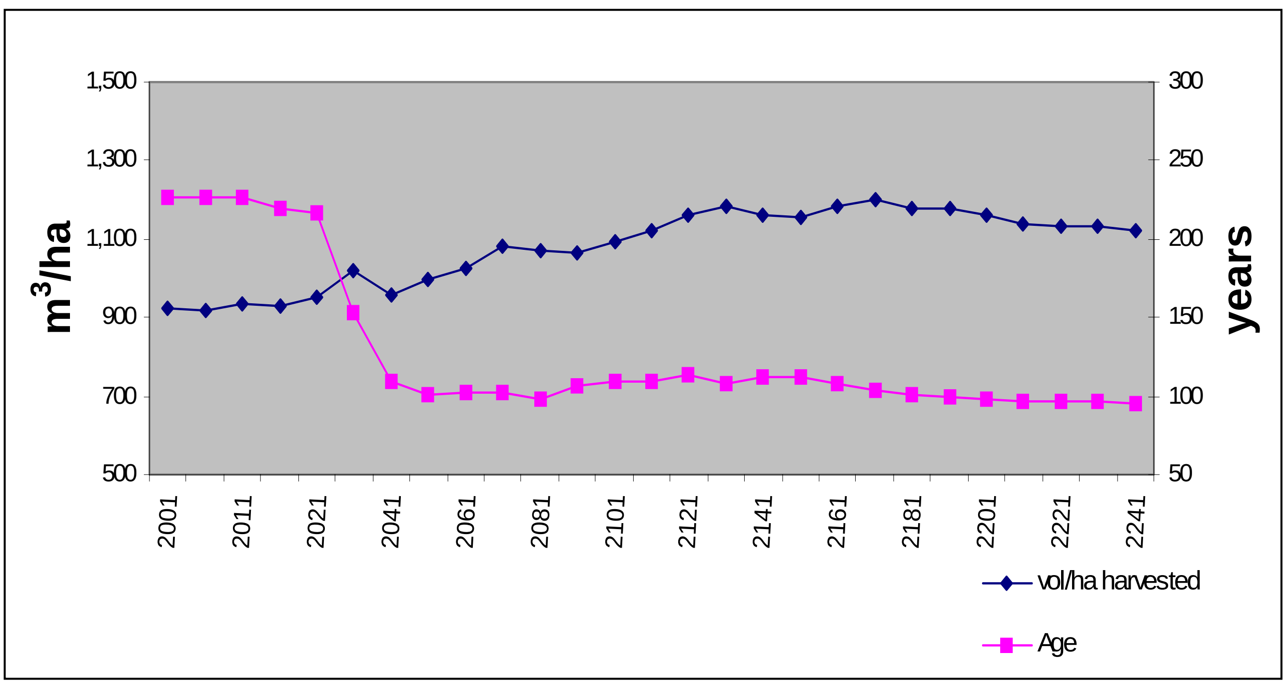

Figure 8. Annual Volume/ha and Age Harvested under the CMO

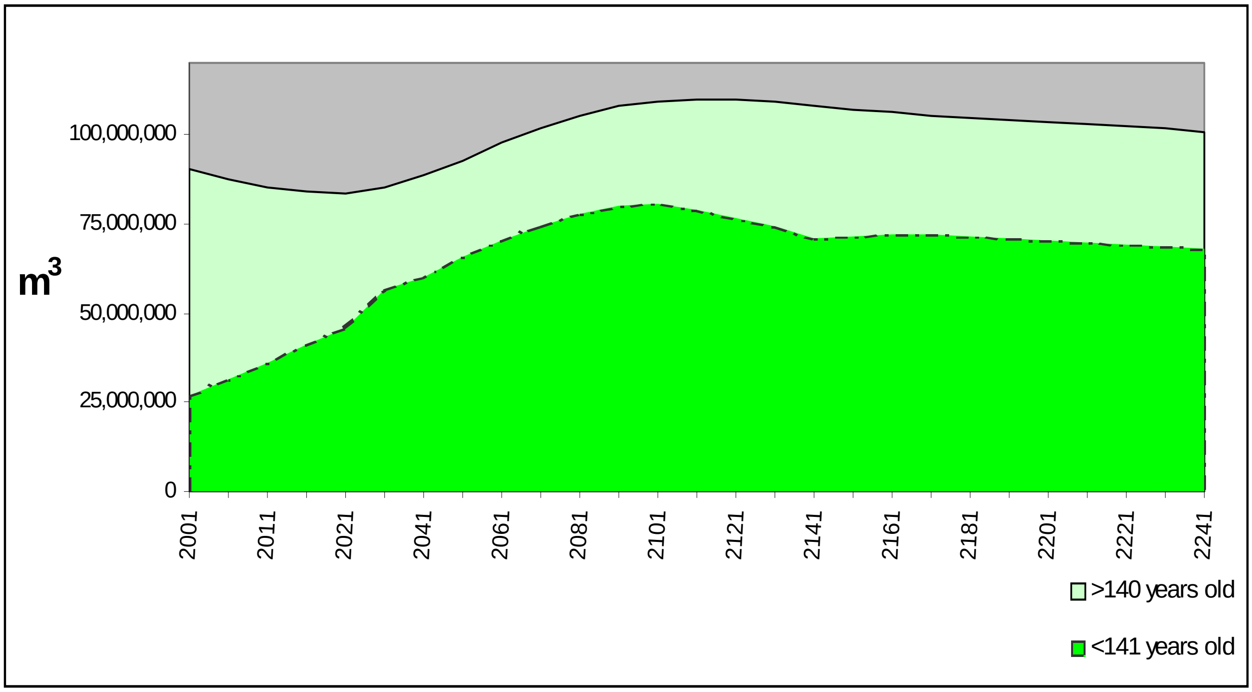

Figure 9. Growing Stock Distribution on the TFL 6 land base under the CMO

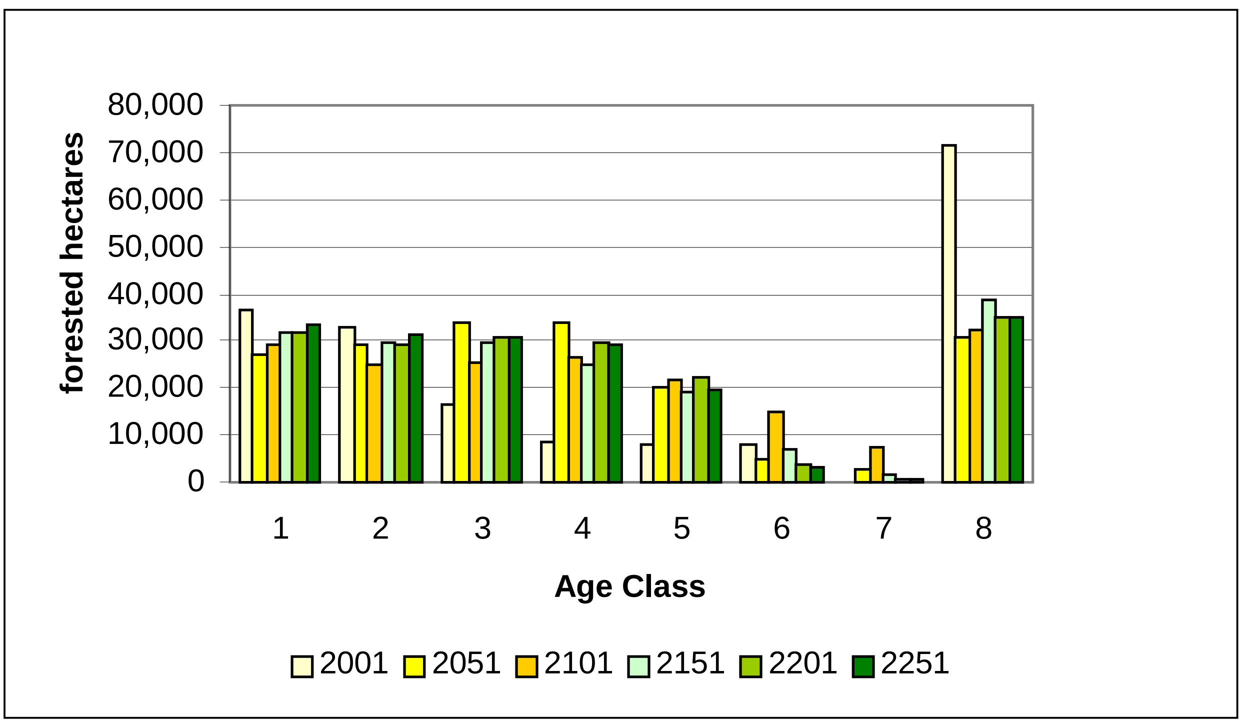

Figure 10. Age Class Distribution on the TFL 6 land base under the CMO

3.3 Silvicultural History

WFP has consistently carried out aggressive basic and enhanced silviculture programs on TFL 6. Currently, almost all of the harvested area is planted within 3 years of harvest and the majority of planted seedlings are from genetically improved seed. There is virtually no backlog "not satisfactorily restocked" (NSR) area. To date the vast majority of free growing obligations due have been met according to management plan standards.

Since 1965 almost 11,000 hectares (ha) have been juvenile spaced and about 10,000 ha have been fertilized. Most of this fertilization has occurred within the last five years and has been primarily on salal sites. Since 1984 almost 2,800 ha have been pruned. Since 1981 several small commercial thinning trials have been done.

WFP has been a leader on the Salal Cedar Hemlock Integrated Research Program (SCHIRP) research team for over 10 years. Results from this program have shown that crop tree growth on salal-dominated (CH) and transitional CH – non salal sites can be improved through fertilization and that responses are long-lasting.

Recent Incremental Silviculture History

Table 1 shows the last 3 years of incremental silviculture activity in TFL 6. Over this period annual Forest Renewal British Columbia (FRBC) expenditures have averaged approximately $1,846,000/yr for the backlog and enhanced programs. However over the last 2 years the expenditures have averaged about $1,278,000/yr. The Forest Investment Account (FIA) will succeed FRBC in April 2002.

Table 1. Summary of 1999 to 2001 Expenditures for Backlog and Enhanced Silviculture

Treatment	Actual 1999		Actual 2000		Plan or Actual 2001	
	(ha)	($ 000s)	(ha)	($ 000s)	(ha)*	($ 000)*
Surveys	1,141	36	361	12	211	7
Site Rehabilitation	0	0	?	33		
Planting	5	5	13	13		
Spacing	318	662	69	175	166	306
Pruning	185	428	374	797	172	376
Fertilization	3,416	1,466	59	46	637	314
Conifer Release /Cleaning	538	385	589	302	438	262
Habitat	0	0	15	66	67	170
Plans and Prescriptions	0[3]	0[3]	0[3]	0[3]	1076	5
Totals	5,603	2,982	1,480	1,444	3425	1,111

*estimated

4. SUMMARY OF ISSUES AFFECTING TIMBER SUPPLY AND QUALITY[4]

4.1 Non-Timber Resources

Period(s) Effected[5]	Key Issues
Short to Long-term	Policies developed over the last two decades to ensure multi-resource sustainability limit the timber supply in the short to medium-term. Reductions in the amount of old forest available for harvest result in the AAC being stepped down over the next 50 years. During this period these policies are the primary factors affecting timber supply.

[3] Included within accomplishments for the individual treatments or administration
[4] For more detailed information, including selected timber supply sensitivities, see the “Type 1” report.
[5] Short term is 1 to 20 years, Mid-term is 21 to 70 years and Long-term is >70 years.

4.2 Timber Resources

Period(s) Effected	Key Issues
Short to medium-term	**Age Class Distribution:** An age class gap created by the loss of old forest from the THLB is the key reason which leads to the step down in the AAC through ~2050 (corresponds to the liquidation of the remaining available old forest). From about 2020 to 2040 the harvest shifts to second growth. After 2040 the entire AAC is from second growth. **Minimum Harvest Criteria:** Minimum harvest ages are set based on achievement of target diameters (DBHq). Minimum target DBH's have been set by productivity group. The AAC is very sensitive to minimum harvest criteria between 2010 and 2100. This system is based on economic operability and generally results in harvest ages which are > biological rotations. **Deciduous-leading stands:** There are about 2700 ha of deciduous-leading stands on the THLB. The deciduous volumes from deciduous-leading stands have not been included in the TSA. Analysis shows that if the deciduous volumes were included there is potential for a modest increase in the AAC. **Operability and Utilization of stands on Low Sites:** Recently harvesting from stands growing on lower site classes has exceeded AAC requirements. Continuation of this performance could lead to a modest increase in AAC. Helicopter logging has been ongoing for the last few years improving operability. Mapping of operability has recently been updated.
Mid to long-term	**Species Composition and Timber Quality:** Existing second growth stands are dominated by Hw. If the current depressed market demand (price) for Hw relative to other species continues into the future, this lack of species diversification will limit the economic returns from harvesting in TFL 6. The second growth log profile should be relatively uniform and will yield mostly construction grades of lumber. However, using target DBH's to set minimum harvest ages should result in second growth piece sizes which are relatively larger than log profiles from similar timber supplies with harvesting based on biological culmination. Some clear cuttings should come from pruned second growth stands which are harvested after about 2070.
Period(s) Effected	**Key Issues**
Long-term	**Intensive Silviculture:** Past silviculture (basic and intensive) efforts have softened, and will continue to soften, the effects of recent harvesting restrictions. Modeling indicates that past silviculture treatments will augment the AAC between ~2021 to 2091 by about 8%. According to the TSA, future intensive silviculture treatments such as juvenile spacing, fertilization and tree improvement do not impact the timber supply until the long-term (ie: after ~2140). After this time future intensive treatments, of the magnitude assumed in the CMO, potentially account for between 5 and 20% of the projected AAC.

4.3 Other Timber Supply Issues by Period

Short-Term

- Potential inaccuracies in the old growth inventory.
- Reductions to the THLB which involve mature timber.
- Changes in the regulations governing forest practices that involve mature timber (ie: maximum opening sizes, green-up, biodiversity, OGMAs, implementation of "higher level plans" such as Landscape Unit Plans, and the VILUP Enhanced Forestry Zones, and Special Management Zones).Changes to harvesting techniques and/or markets which cause changes in physical and economic operability

Mid-Term

- Potential inaccuracies in the managed stand inventory and growth projections.Reductions to the THLB which involve immature timber.
- Changes in technology which affect operability and markets.Improved silvicultural opportunities/returns through research.

Long-Term

- Short and medium term changes and
- Global warming.

5. OBJECTIVES OF THE SILVICULTURE PROGRAM

5.1 TFL 6 Objectives

The primary objectives of WFP's silviculture plan are to ease the transition to the long-term harvest level (LTHL) and to maintain or increase the LTHL and/or increase the harvested value. A secondary objective is to create job opportunities through a period of declining harvest-related employment.

As well as improving timber supply and quality, silviculture activities can enhance habitat values. Where funding is available, treatment of areas otherwise reserved from harvesting can enhance habitat values by accelerating succession and development of structures.

5.2 Provincial Objectives

Until provincial targets for timber quantity and quality are established, management unit strategies are to consider the following interim provincial strategic objectives (MoF, 1998a):

- Maintain current harvest levels as long as possible without creating disruptive shortfalls in future timber supply.

- Create a long-term timber supply capable of supporting a steady long-term provincial harvest level similar to current levels.
- Minimize the interim shortfall in provincial harvest anticipated before a steady long-term timber supply is achieved.
- Create a long-term timber supply, which will enable the timber quality profile of future harvest to be the same or better than the current profile.

It is recognized that not every management unit has the same capability to contribute to these interim objectives. Further, it is recognized that these objectives may not be attainable at current funding levels. Their purpose is to provide general guidance to the application of available funds.

5.3 Regional Objectives

The objectives of the regional incremental silviculture strategy (MoF, 1998b) are to:

- Ensure a long term sustainable harvest, which approximates the current harvest value and volume levels and that produces a diversified mix of products necessary to create and maintain sustainable forest employment.
- Balance treatments that enhance growth and yield such as fertilizing, spacing and forest health activities with those that increase the value of the wood such as spacing and pruning.
- Utilize incremental silviculture treatments to contribute to sustainable management of non-timber values at the landscape level.

6. SUMMARY OF IDENTIFIED STRATEGIES TO INCREASE TIMBER SUPPLY, QUALITY AND HABITAT

Potential strategies identified in the "Type 1" report include:

Strategies to Increase the Quantity of Future Timber Supply

Short-term:	1. Reduce regeneration delay on salal sites by continuing to fertilize at the time of planting. 2. Increase the short-term AAC by harvesting alder.
Mid-term:	1. Reduce the minimum harvest age (eg. faster diameter growth to accelerate achievement of operable diameter assumptions) and thereby increase the AAC in the 2041 to 2060 "trough" by maintaining or increasing current spacing levels and modifying residual densities and/or, if viable, starting an "Early" commercial thinning program. 2. If commercial thinning can be proved to be viable, a program starting in about 2030 could be used to increase the AAC in the 2041 to 2060 "trough." 3. Increase the AAC in the 2041 to 2060 "trough" by looking at establishing alder plantations on ecologically-suitable currently harvested areas. 4. If non-SCHIRP fertilization response can be demonstrated, the mid-term AAC could be significantly increased by fertilization.
Long-term:	1. Increase long-term AAC by continuing to aggressively fertilize and monitor treatment response under SCHIRP. 2. Reduce long-term minimum harvest ages by continuing to use genetically improved seed. 3. Increase the long-term AAC with an aggressive road rehabilitation program. 4. Increase the long-term AAC by converting un-managed alder-leading stands to managed coniferous stands. 5. Increase the long-term AAC and forestry land base by draining wet, low productivity sites.

Strategies to Increase the Quality of Future Timber Supply

Short-term:	1. Increase product diversification by harvesting alder.
Mid-term:	1. Increase mid-term clear recovery by continuing or increasing the current pruning program. 2. Improve mid-term sawlog quality by continuing or increasing current juvenile spacing levels and/or, if viable, starting an "Early" commercial thinning program. 3. If commercial thinning can be proved to be viable, a program starting in about 2030 could be used to increase the quality of the final harvest. 4. Increase product diversification and recover logs with some clear cuttings by growing alder.
Long-term:	1. Diversification / refinement of the species mixes used in reforestation can be used to diversify the mix of species harvested in the long-term.

Strategies to Increase the Quantity or Quality of Future Habitat Supply

Long-term:	1 Density management and conversion of alder-leading stands in riparian management zones to mixed to deciduous-coniferous stands will improve long-term fish and riparian habitat.

7. ANALYSIS OF THE KEY TIMBER SUPPLY AND QUALITY ISSUES

As a starting point for discussions and analysis of timber value Figure 11 shows the approximate species profile of the CMO harvest after 2041 when harvesting is from predominantly second growth stands. This figure shows that, based on past reforestation strategies, existing second growth will yield a harvest profile which is dominated by Hw. Subsequently if future reforestation strategies mimic the past (as is assumed in the CMO) the predominance of Hw will continue. With the current challenges in economically kiln drying Hw and the difficulties in marketing green Hw solid wood products, the high component of Hw in the timber supply may limit future economic returns from harvesting in TFL 6. In addition, based on current log prices and demand for other species, there may be opportunities to diversify the species profile. As a result species profile together with harvest log size distribution, were important indicators of quality used in this project. Manipulation of these quality parameters was a key consideration when developing scenarios for analysis.

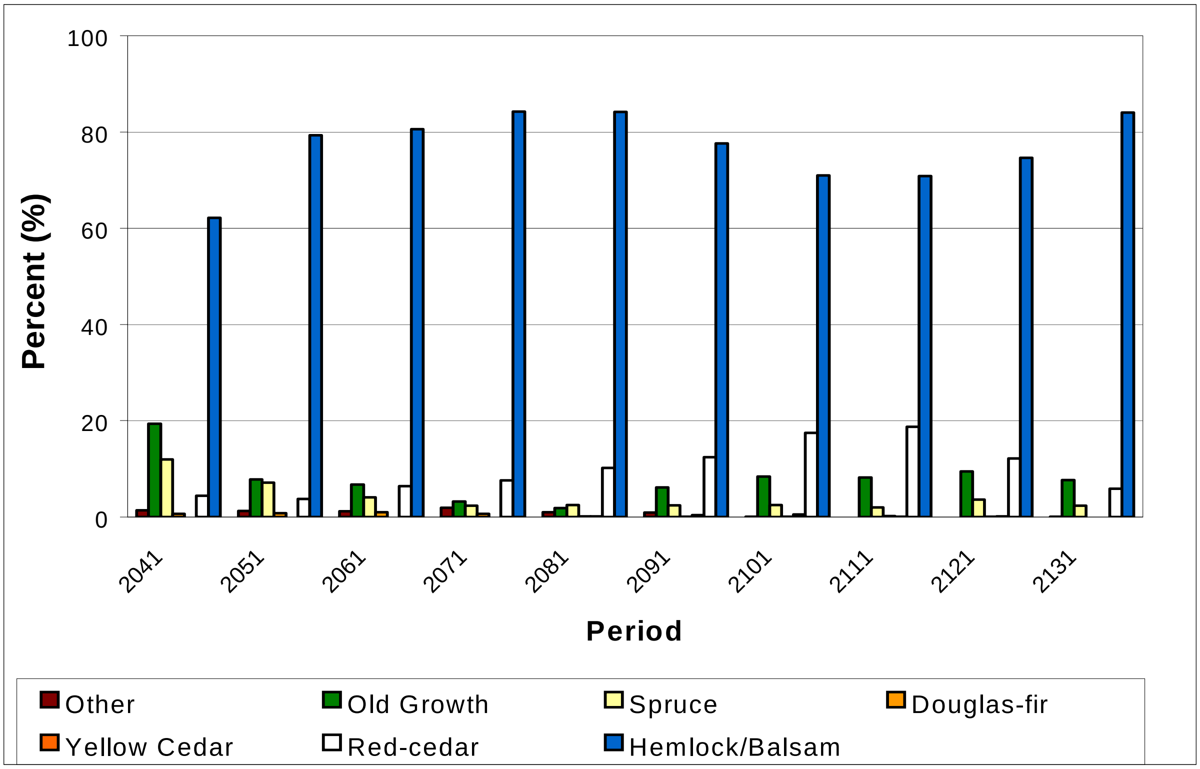

Figure 11. Forecast species composition with CMO.

Unlike most timber supply areas on the coast, for TFL 6 minimum harvest criteria have been set based on achievement of target DBH's. More commonly timber supplies are based on rotation ages which are set at biological culmination with provisions for minimum harvest ages which are based on a percentage of culmination age (commonly 90 or 95%) or threshold ages and/or minimum volumes per hectare. In all cases the intention is for minimum harvest criteria to reflect the minimum conditions necessary to allow for potentially profitable harvesting (operability). With the current targets of 42 cm on the best sites, 37 cm on the average sites and 35 cm on the poor sites, minimum harvest ages in TFL 6 are greater than if criteria from other similar timber supplies had been used.

According to WFP staff, historically minimum target DBH's have been set conservatively to reflect uncertainty with the economic viability of harvesting small diameter, hemlock-dominated, second growth stands on the north end of Vancouver Island. At the other end of the spectrum, in the last TSA, WFP completed a simulation using minimum harvest ages based on achievement of 95% of maximum mean annual increments for each growth curve (CMO+95% MaxMAI).

Figure 12 compares the CMO harvest rate with a harvest flow using CMO+95% MaxMAI for each growth curve. This graph shows that using CMO+95% MaxMAI criteria virtually eliminates the short to mid-term falldown in supply.

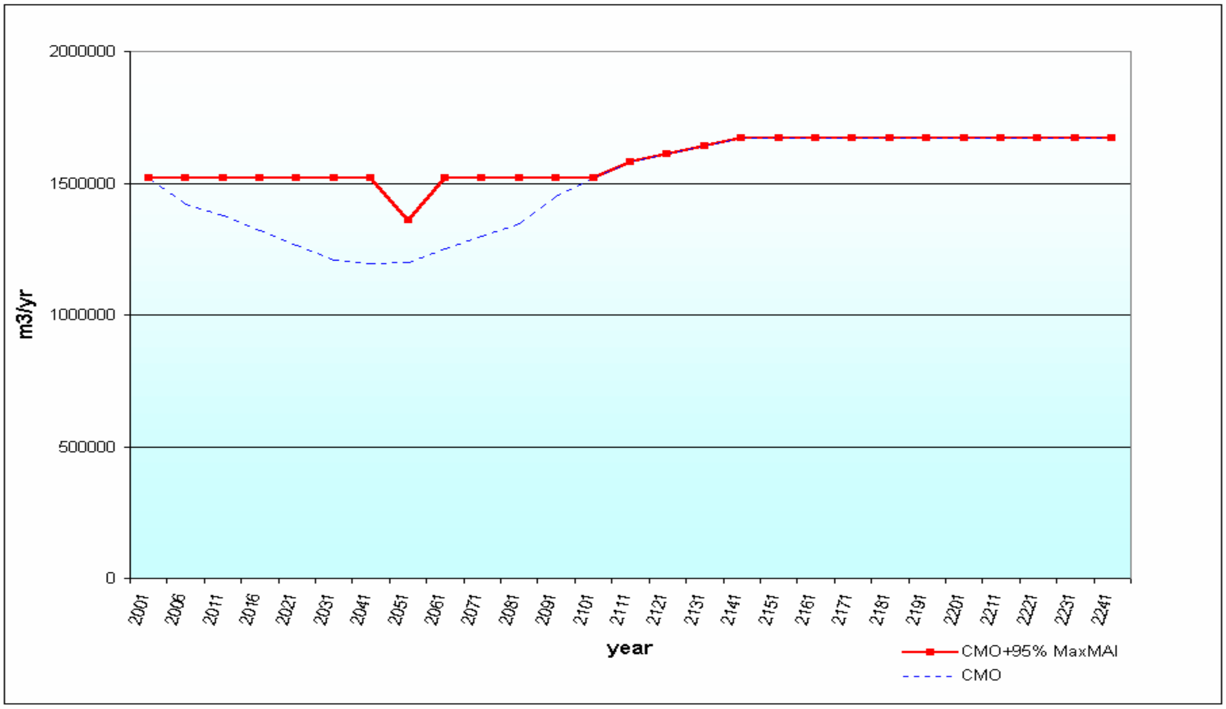

Figure 12. Comparison of CMO and CMO+95% MaxMAI

However assuming the use of CMO+95% MaxMAI criteria has other effects on the timber value and non-timber forest attributes. Figures 13 to 16 compare the impacts on harvested area, average harvested diameter, volume per hectare and harvested age between the CMO and the CMO+95% MaxMAI forecasts. As can be seen, harvesting according to CMO+95% MaxMAI would be a much more aggressive strategy with average rotation ages of less than 80 years and average stand diameter at harvest of about 35 cm. In addition increased annual harvest areas would lead to reductions in old-forest proportion and reduce the potential for future recruitment.

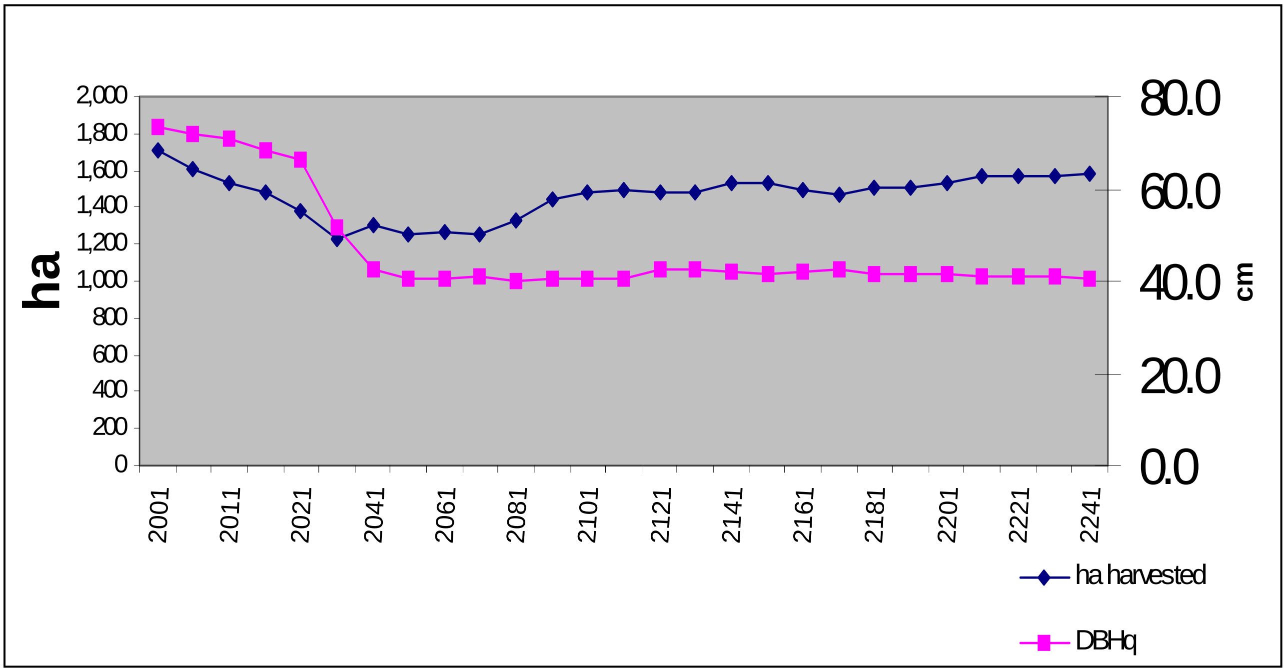

Figure 13. CMO Annual Area Harvested and Average Diameter Harvested

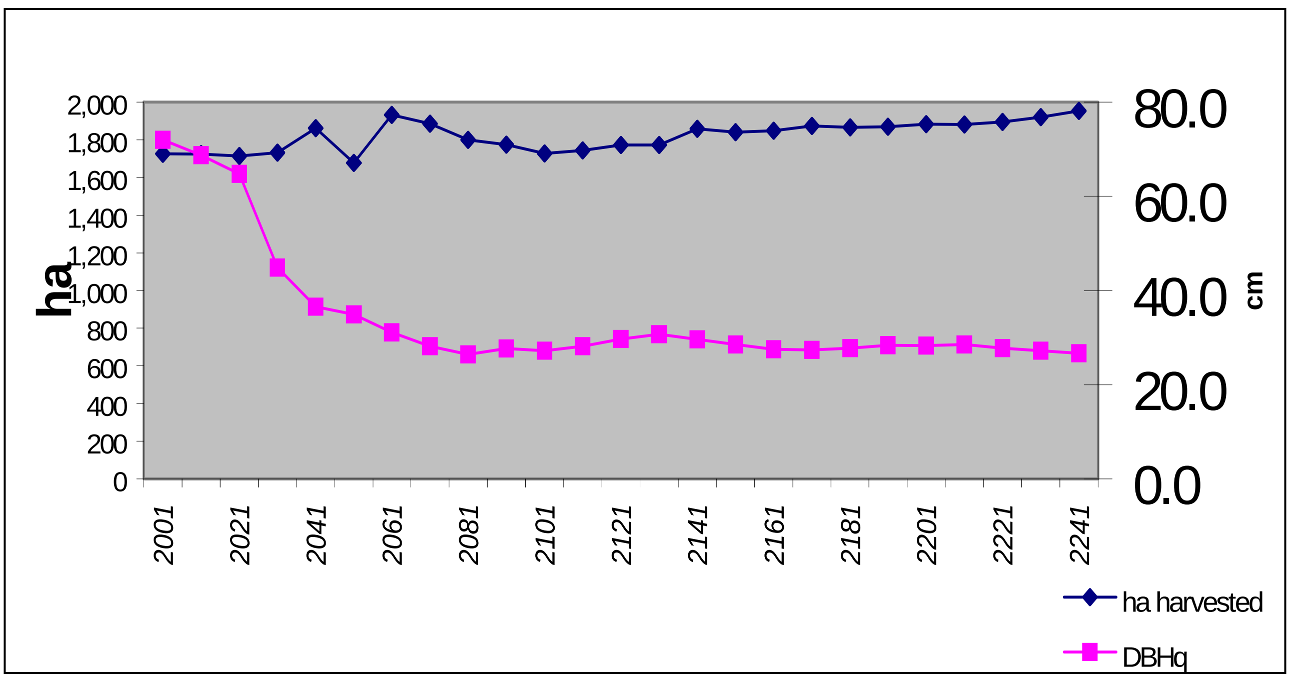

Figure 14. CMO+95% MaxMAI Annual Area Harvested and Average Diameter Harvested

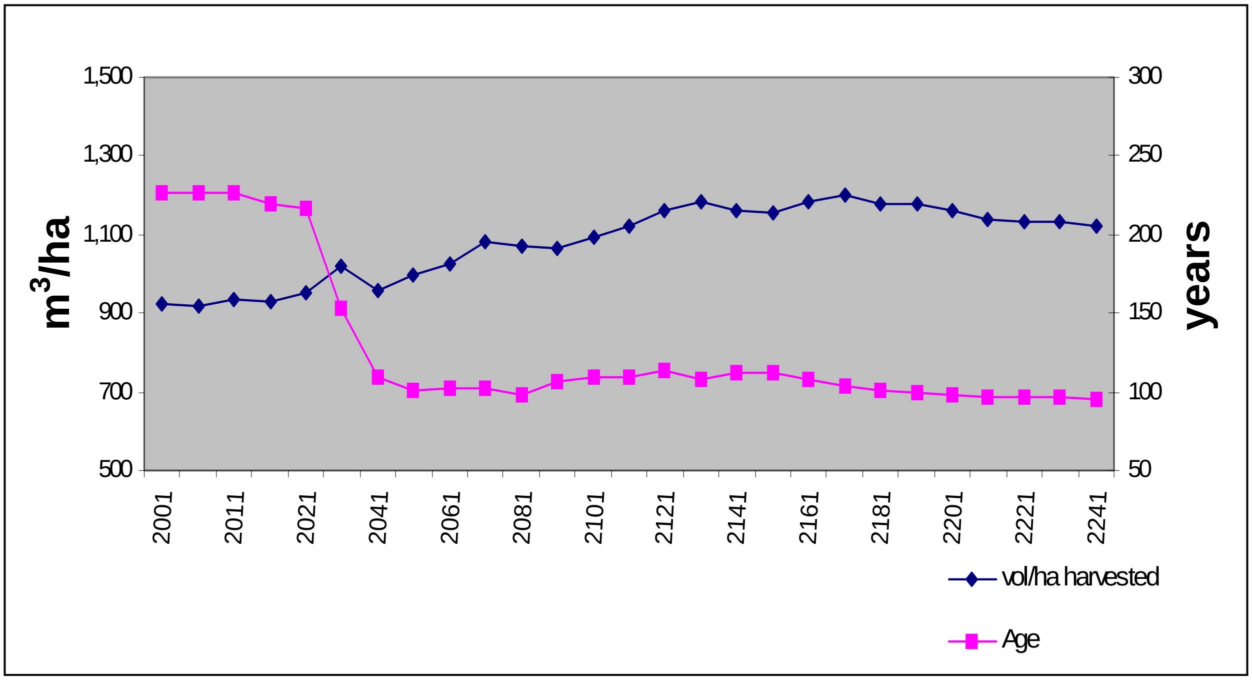

Figure 15. CMO Annual Volume/ha and Age Harvested

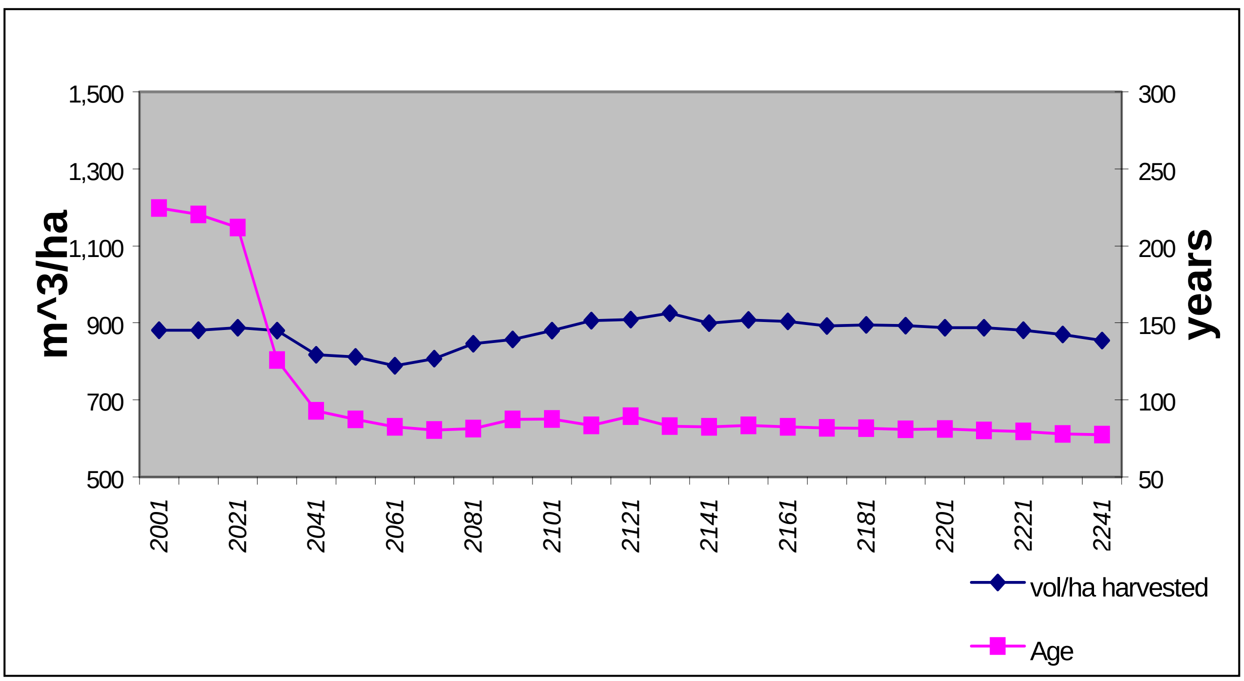

Figure 16. CMO+95% MaxMAI Annual Volume/ha and Age Harvested

As a further comparison between the effects of the CMO and the CMO+95% MaxMAI forecasts on timber quality, figures 17 to 19 illustrate the impacts of the different strategies on harvest log grade outturns and average log prices after 2041. These graphs show the second growth grade breakdowns and average log prices for each forecast are relatively unchanged during this period. However, the CMO forecast averages about 40% of the log profile in the largest grades (H and I) versus about 30% in the same grades for the CMO+95% MaxMAI forecast. As expected, this trend reflects the difference in average harvested diameter between the two forecasts (Figures 13 and 14). Figure 19 shows that up to about 2091, using current log prices (Base Log Prices), the difference in log grade outturns results in the CMO forecast having about a $4 per cubic meter (about 6.2%) increased log price over the CMO+95% MaxMAI forecast.

Figure 20 compares the harvest revenue generated for the two strategies after 2041. Prior to about 2071 the CMO+95% MaxMAI forecast has higher revenues as a result of a higher AAC. For about the next 10 years the strategies have similar revenues although the CMO+95% MaxMAI forecast continues to have a higher AAC. After 2101 the CMO forecast results in higher revenues despite similar harvest levels.

Figure 21 shows the impacts on the two strategies of assuming increased future premiums for larger logs (Steep Log Prices which assume a 45% price increase for H and I grade logs with no price changes for the other grades).

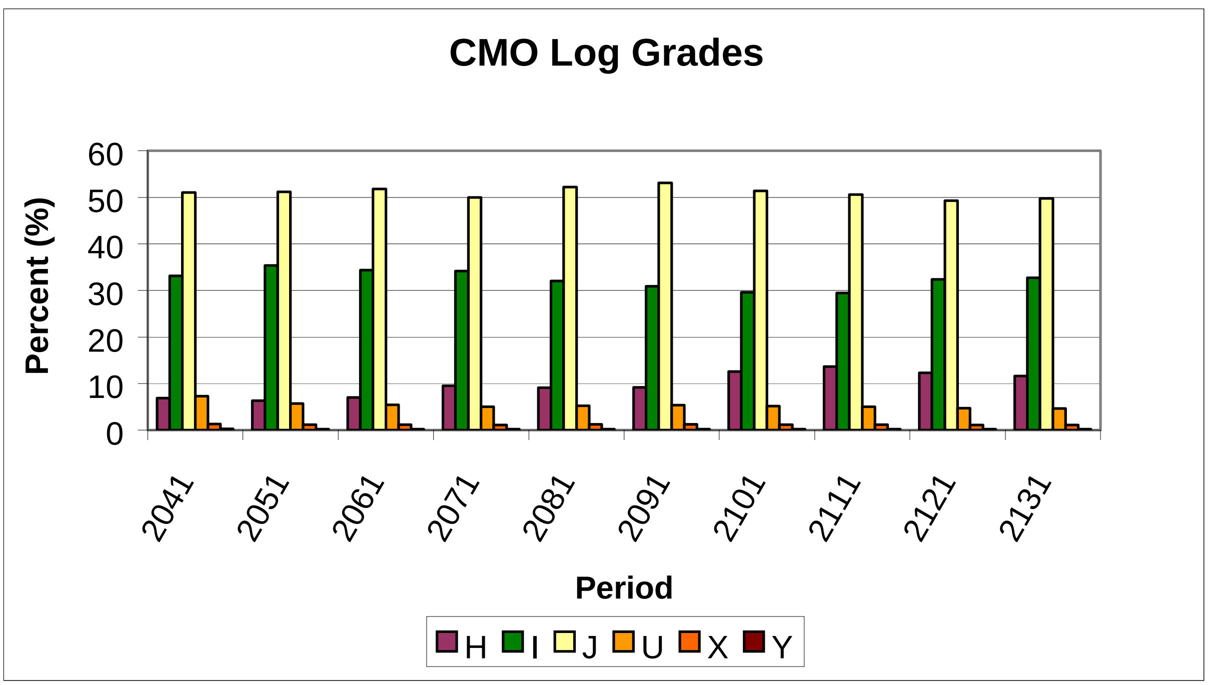

Figure 17. Second growth log grade profile for CMO

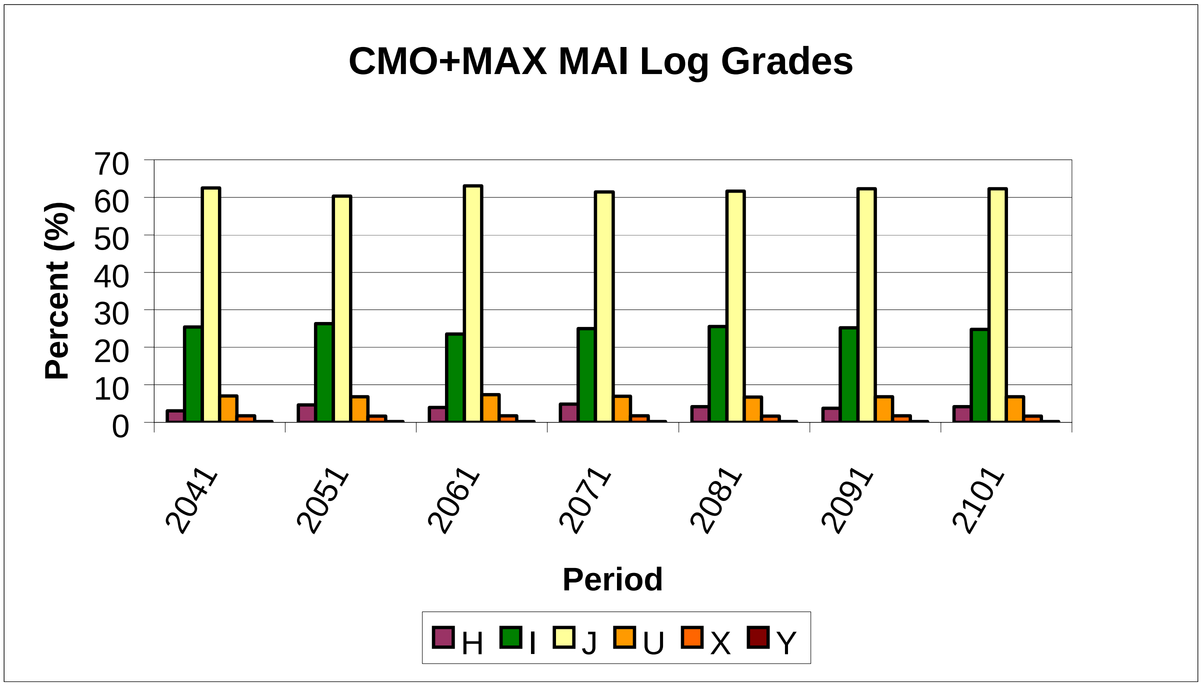

Figure 18. Second growth log grade profile for CMO+95% MaxMAI

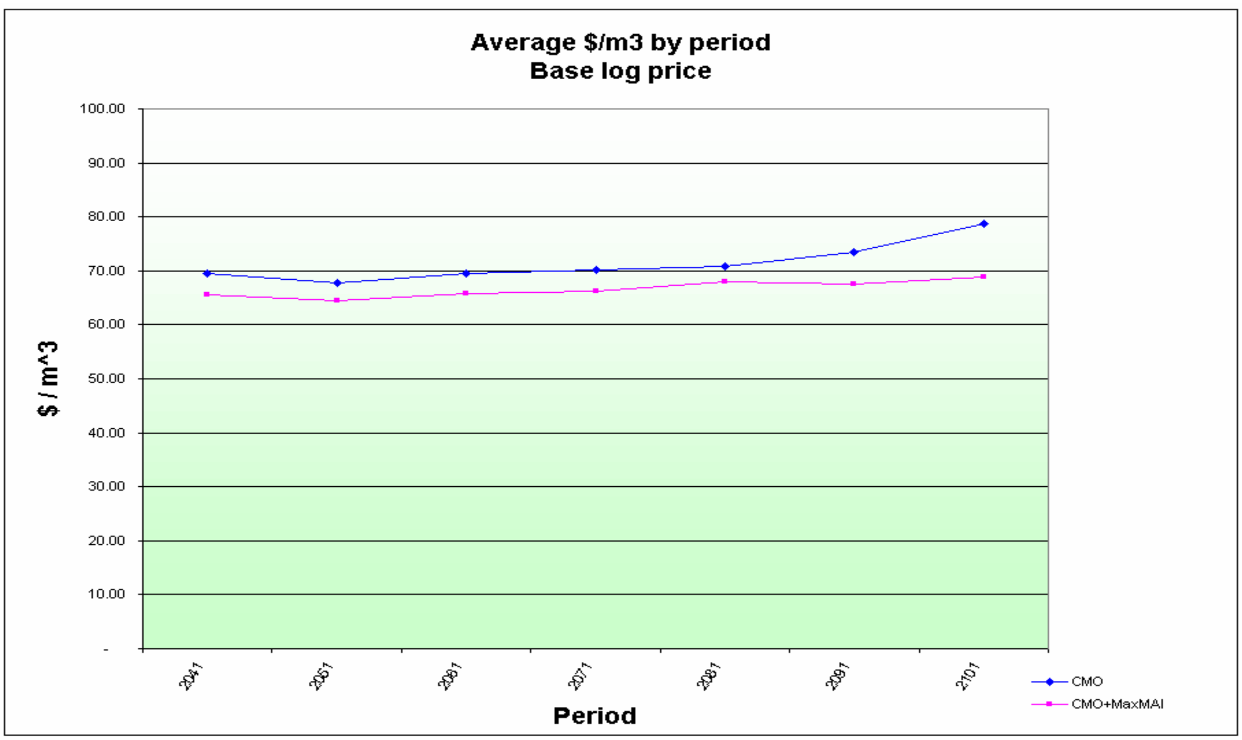

Figure 19. CMO vs CMO+95% MaxMAI comparison of second growth harvest base average log prices

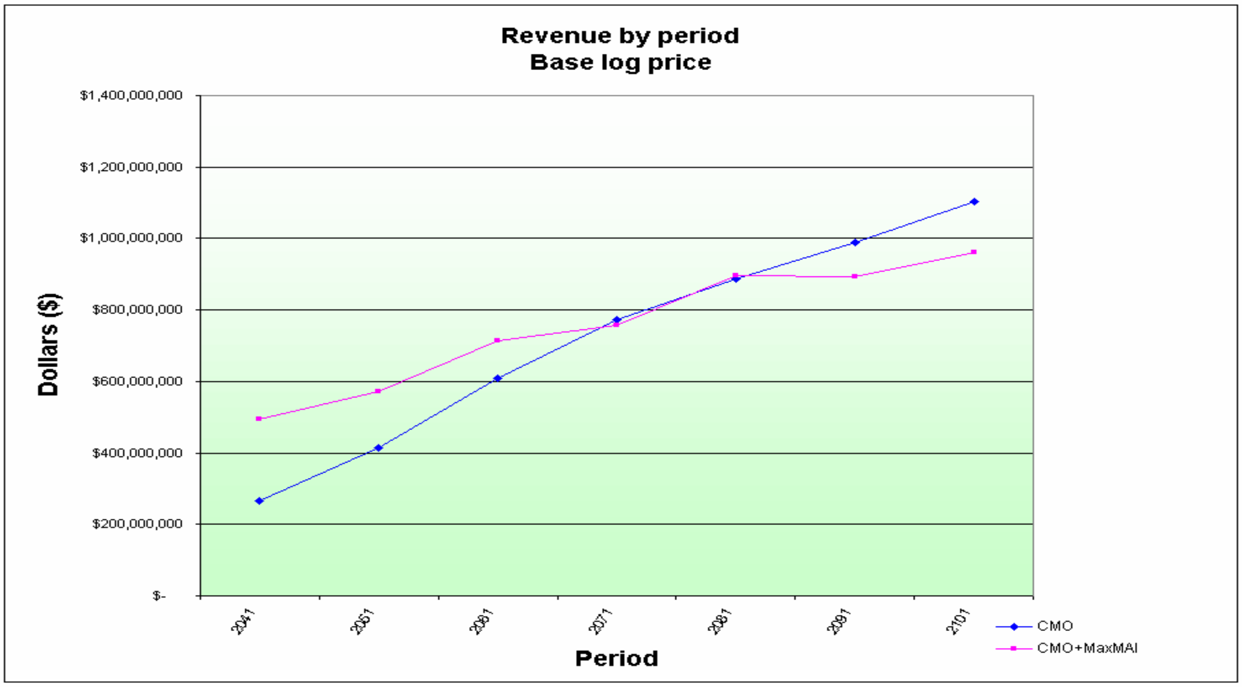

Figure 20. CMO vs CMO+95% MaxMAI comparison of second growth harvest base revenue forecasts

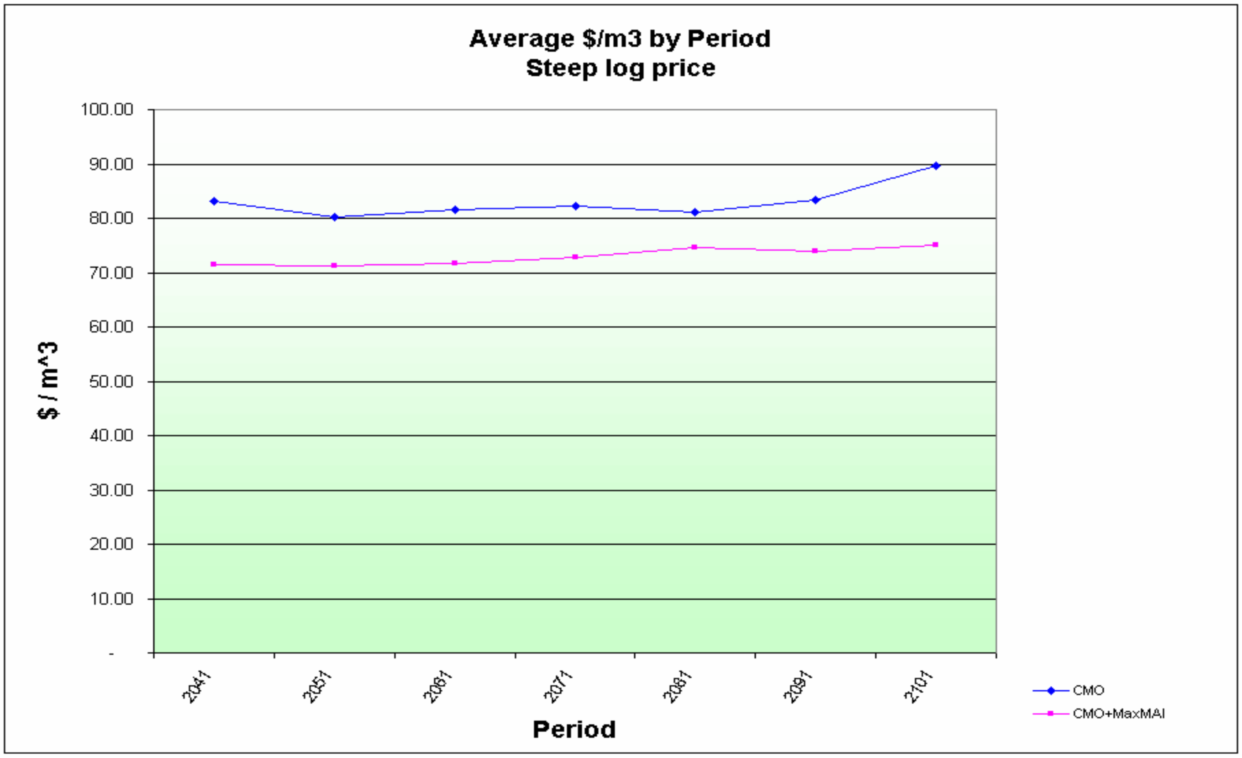

Figure 21. CMO vs CMO+95% MaxMAI comparison of second growth harvest steep average log prices

Without presuming that WFP would, or should, change their current approach of using target DBH's to set minimum harvest ages, for the purposes of this project, comparisons of conditions using CMO and CMO+95% MaxMAI were used as opposite ends of a framework for comparing potential future conditions and their impacts on silviculture strategies. The CMO forecast can be described as a starting point for a value oriented strategy with the CMO+95% MaxMAI forecast representing a volume maximization strategy.

Setting minimum harvest ages based on dbh targets also theoretically creates the potential for timber supply effects from density management treatments such as juvenile spacing. Potential impacts can occur because spacing generally removes the smaller trees which effectively increases the average stand diameter. As a result the minimum harvest age is theoretically reduced, albeit with a corresponding reduction in stand volume. To illustrate this point the forest-level supply and quality implications of different spacing regimes was evaluated in this project.

8. DEVELOPMENT OF KEY SCENARIOS

Evaluation of CMO Stand-level Assumptions

Effects of Natural Ingress on Genetically Improved Plantations

Some growth curves for future stands do not account for natural in-fill. This analysis evaluates the effects of ingress on volume and diameter growth of stands planted with genetically improved stock.

Due to the large number of potential issues which could be analyzed it was necessary to limit the number of scenarios reviewed. Based on review and discussion of the results of the "Type 1" report and subsequent analysis of key timber supply and quality issues, the following scenarios were developed for analysis:

Timber Volume Strategies:

Scenario #1 Impacts of Genetic Improvement and SCHIRP fertilization

This scenario evaluates the effects of the use of genetically improved seed and fertilization on timber supply.

Scenario #2 Impacts of Juvenile Spacing

As harvest ages are based on target DBH's, density management could have a timber supply effect. This scenario evaluates the effects juvenile spacing on timber supply and quality.

Timber Quality Strategies:

Scenario #3 Pruning

This strategy analyzes the impacts of creating clear wood by pruning.

Reforestation Strategies; Impacts of Changing Species Mixes:

The following strategies review the impacts of varying the species used in reforestation of harvested sites on timber quality, supply and potential future incremental silviculture programs. These strategies are designed to diversify the species profile of the future timber supply by reducing the reliance on Hw.

Scenario #4 Cw versus Hw

Scenario #5 Ss/Hw versus Hw

Scenario #6 Fd/Hw versus Hw

Scenario #7 Dr versus Hw

Other Strategies:

Scenario #8 Planting with Genetically Improved Stock Versus Natural Regeneration

This strategy compares the timber supply and economic implications of natural versus artificial regeneration strategies on S1ha sites.

Other Strategies

This section covers other strategies identified during the "Type 1" project.

9. STAND-LEVEL STRATEGIES FOR KEY SCENARIOS

Based on the requirements for analysis of the key scenarios, stand-level regimes were developed and modeled with TIPSY or TASS. For a complete listing of TIPSY and TASS regime inputs and outputs see the appendices.

As a starting point for regime development, the inventory aggregation results for the current management plan were reviewed. This information was used to focus regime development around the most significant analysis units (AU's). Manipulation of the largest AU's provides the key opportunities for forest-level silvicultural intervention. Table 2 lists the largest AU's and their key stand and site attributes. This information confirms the predominance of Hw-leading stands in the timber supply and shows that most stands are in Productivity Group (PG)[6] 2. PG 2 is dominated by the S1ha which is the most significant ecosystem unit for future management. As a result the initial regimes were designed for the S1ha ecosystem unit.

Table 2 Summary of Largest Analysis Units by Stand Type

Stand Type	AU	Productivity Group (PG)[7]	Leading Species	Age Class	Treatment	% of Total THLB
Managed	15	2	H	1-2	None	17.6
Managed	7	4	C	1-2	None	3.5
Managed	13	2	H	1-2	Spaced	3.3
Managed	5	2	C	1-2	None	2.7
Managed	19	4	H	1-2	None	2.5
					Managed Subtotal	29.6
Natural Immature	52	2	H	3-7	None	20.4
Mature	73	2	H	8-9	None	17.0
Mature	70	2	C	8-9	None	6.0
Mature	71	4	C	8-9	None	5.0
					Mature Subtotal	28.0
					Total	**78.0**

Similarly, the TSA harvest data was used to show when impacts of silviculture treatments on future stands would start to have significant effects on the timber supply for the CMO and CMO+95% MaxMAI forecasts (see Figure 22).

[6] These are groups of statistically-similar Lewis Ecosystem Units based on site indices.
[7] For PG 2 the site index for Hw is 28 and for Cw is 24. For PG 4 the site index for Hw is 20 and for Cw is 19.

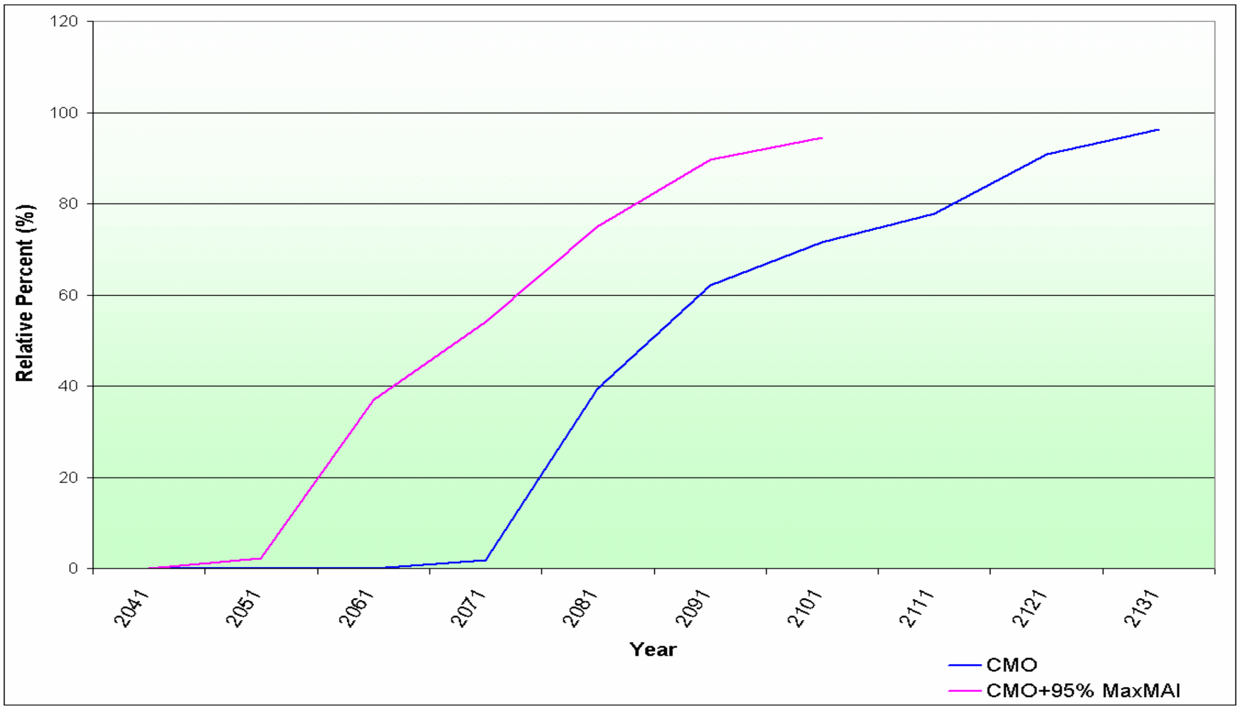

Figure 22. Percent of Total volume harvested from future managed stands (AUs 120-138)

10. RESULTS AND EVALUATION OF STAND AND FOREST-LEVEL ANALYSIS OF THE KEY SCENARIOS

A significant amount of stand-level growth and yield and financial analysis was completed for this project. The complete results are included in the appendices and are included on a CD. The spreadsheet model used for the financial analysis is also available on the CD. A brief set of instructions for use of this spreadsheet is included.

Revised CMO

During forest-level analysis it was discovered that spacing regimes, which were assumed to be incorporated in the CMO supply forecast, were not fully functioning. As a result, for this project, the CMO forecast was assumed to not include any future spacing[8].

Effects of Natural Ingress on Genetically Improved Plantations

In TFL 6 natural regeneration of Hw on sites such as the S1ha can be significant. WFP's current management practice on these sites is to plant primarily Hw, grown from genetically improved seed, at about 1100 stems per hectare (SPH) within 2 years of harvest. In the TSA AU 121 was the growth curve designed for future stands established on S1ha sites to mimic current management practices. As AU 121 was modeled with TIPSY no natural in-fill was assumed to

[8] The CMO assumed future spacing levels of 300 ha/yr.

occur[9]. Given the uncertainty over the potential influences of natural in-fill on the growth of genetically improved stock, several TASS runs were completed with varying levels of natural regeneration, genetic improvement and, with and, without future spacing. Ingress levels between 2000 and 10000 sph were modeled assuming a normal distribution of ingress over time (with a mean of 2 years and a standard deviation of 1.5 years). This pattern of ingress assumes naturals start seeding in immediately after harvest, with the largest amount of in-fill in the 4th year after harvesting, and all the seedlings are established by the 6th year after logging.

Analysis of the results showed that AU 121 achieved a dbh of 37 cm (target criteria for the CMO forecast) about 11 to 14 years before the TASS simulations. Interestingly the TASS output indicates that ingress densities of between 2000 and 8000 have little impact on average dbh after about age 60. In addition, after about age 70 AU 121 forecasts about 10 to 15% more merchantable volume than the TASS simulation with 2000 sph of ingress and about 2 to 5% more merchantable volume than the TASS run with 8000 sph of ingress.

These results were somewhat suprising as it was expected that natural ingress within several years after plantation establishment with genetically superior trees would not have a significant effect on harvest yields. According to the MoF[10] most of the differences in the merchantable volume estimates for scenarios involving ingress results from comparing TIPSY to TASS output with TIPSY output being not as precise.

Given the sensitivity of the timber supply to minimum harvest criteria and second growth yield, these results indicate that the CMO supply forecast may be overstated in the medium to long term. However an in-depth review of the impacts of ingress on genetically improved plantation yields was beyond the scope of this project. As a result it is recommended that actual ingress patterns and stand-level modeling of this ingress be reviewed in the next timber supply analysis.

Timber Volume Strategies:

Scenario #1 Impacts of Genetic Improvement and SCHIRP fertilization

The CMO assumes that all stands established on SCHIRP (primarily S1ch) sites will be fertilized. In the TSA fertilization is assumed to increase the Productivity Group from 4 to 2/3 which effectively results in an increase in the Cw site index from 19m to 24m. Results of ongoing research indicate that these assumptions are achievable and perhaps understated. In addition stand-level financial analysis done as part of the SCHIRP research trials shows potentially positive returns on investment with this fertilization. Therefore additional stand-level analysis was not done for this project.

The CMO also assumes that future planting with Hw, Yc, Cw and Ss will use stock grown from genetically improved seed. The assumed gains range from 3% for Cw and Ss to 15% for Hw and Yc established after 2010. These assumptions are likely conservative as geneticists feel that third generation gains may be even better.

[9] TIPSY does not allow for manipulation of natural in-fill with planted stands.
[10] Email correspondence with Ken Polsson

The forest-level impacts of genetic improvement and SCHIRP fertilization on the CMO and the CMO+95% MaxMAI forecasts are shown in figures 23 and 24. For the CMO, fertilization of about an average of 200 ha/year results in an AAC increase of about 86,145 m3. For the CMO+95% MaxMAI, fertilization of about an average of 280 ha/yr results in an AAC increase of about 116,625 m3. As expected the relative impact of fertilization is about the same for each forecast (ie: each hectare treated results in an increase in the long run harvest of about 431 m3 for the CMO forecast and about 416 m3 for the CMO+95% MaxMAI forecast). However, the larger harvest area required to support the CMO+95% MaxMAI forecast results in more area available for fertilization with this strategy.

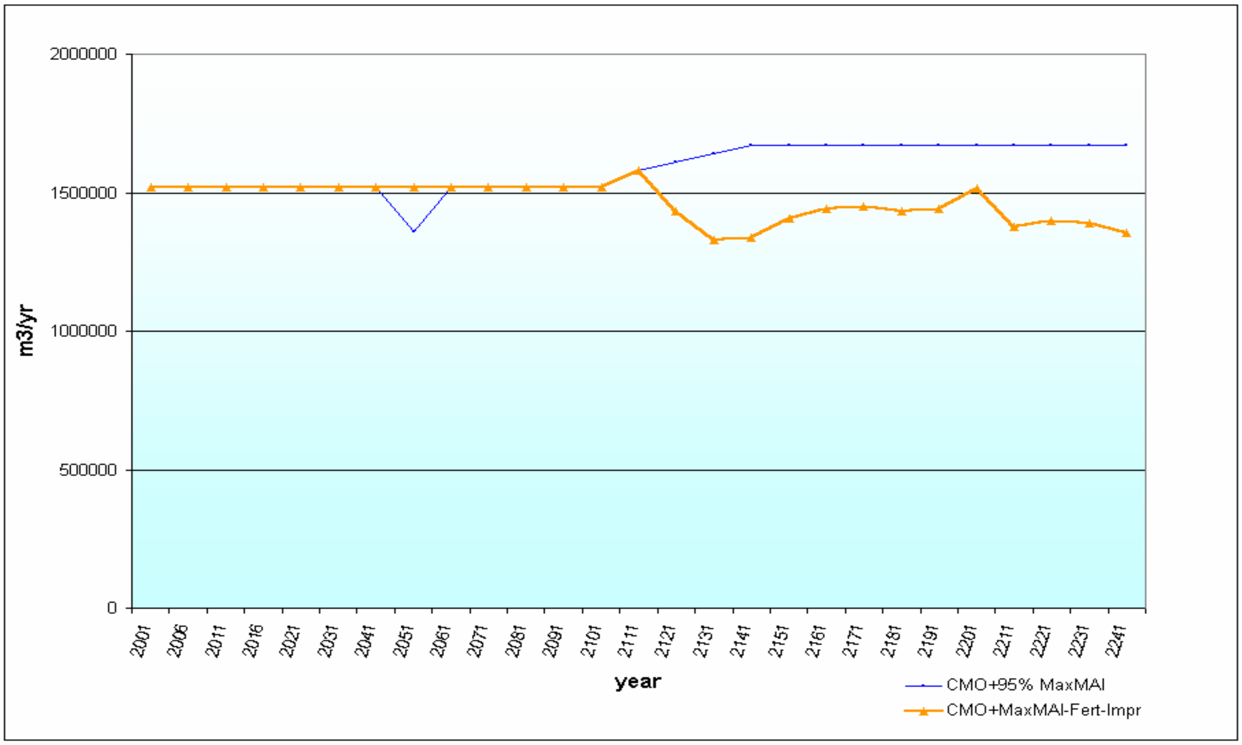

Figure 23. Sensitivity Analysis- CMO+95% MaxMAI less fertilization and tree improvement

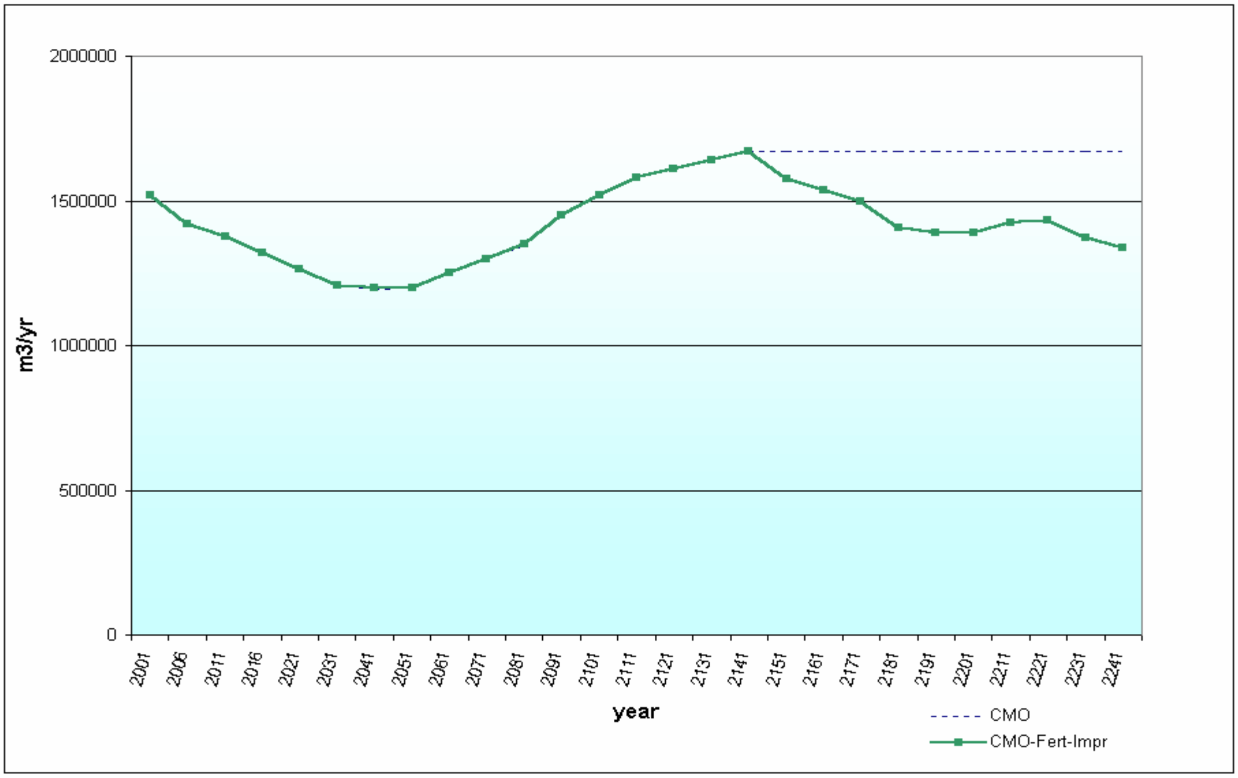

Figure 24. Sensitivity Analysis- CMO less fertilization and tree improvement

Scenario #2 Impacts of Juvenile Spacing

Juvenile spacing has been done in TFL 6 to improve timber quality and merchantability and habitat while creating employment. Recently, spacing for timber benefits has been carried out on about 150 to 500 ha/year of moderately dense to dense Hw-dominated stands to a residual density of about 850 sph. WFP is aware of the tradeoffs between timber volume and size and quality when manipulating stand density. In summary, within the range of rotation ages discussed in this report and the naturally occurring densities on S1ha sites, juvenile spacing results in these general effects:

- as residual density decreases harvested merchantable volume decreases and average DBH increases (as juvenile spacing primarily removing a high proportion of the smaller trees) and,
- as residual density decreases, branch size, taper and the proportion of juvenile wood increases. Juvenile spacing can also improve stand quality by selecting the best trees.

Recently the amount of juvenile spacing done in TFL 6 (and in the rest of the Vancouver Forest Region) has been decreasing as a result of uncertainties over the economic benefits and a reduction in the number of stands requiring treatment.

In addition increasing concerns have been raised over the effects of reducing stand densities on wood quality. A 2002 FORINTEK study, "Second Growth Western Hemlock Product Yields and Attributes Related to Stand Density" found that lumber from Hw stands spaced to 580 sph had lower proportions of high grade structural lumber, lower wood densities, lower modulus-of-elasticities and lower modulus-of-ruptures than stands spaced to 930 sph.

However as the TSA assumes harvest ages are based on target DBH's, it was felt that density management could have a timber supply effect. In addition the idea that future log markets could provide increased premiums for larger logs was found to be of interest. As a result several TASS runs were completed with varying densities and varying juvenile spacing regimes.

Figures 25 to 28 summarize the growth and yield and log grade comparisons between different juvenile spacing regimes (including no treatment) carried out on a stand with a total initial density of about 5100 sph of Hw (1100 sph planted and 4000 sph of natural ingress) on a S1ha site (Hw SI of 28m) (typical stand and site conditions with TFL 6).

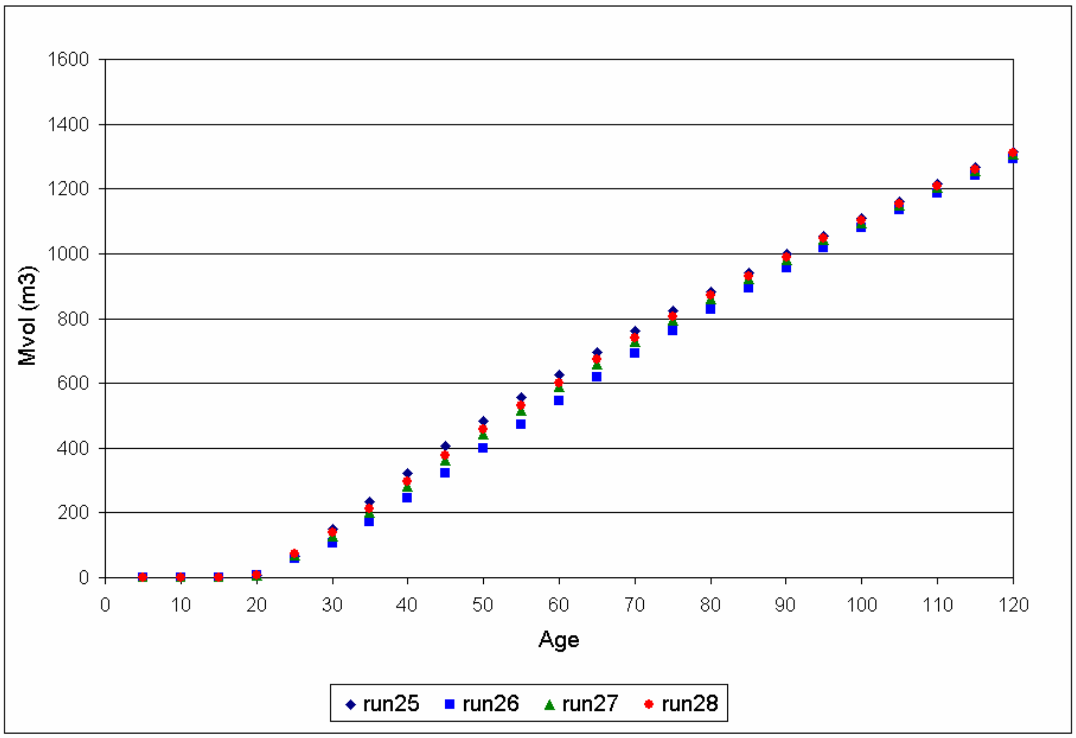

Figure 25. MVol vs Age (Run 25: No Treat; Run 26: JS600; Run 27: JS850; Run 28: JS1000)

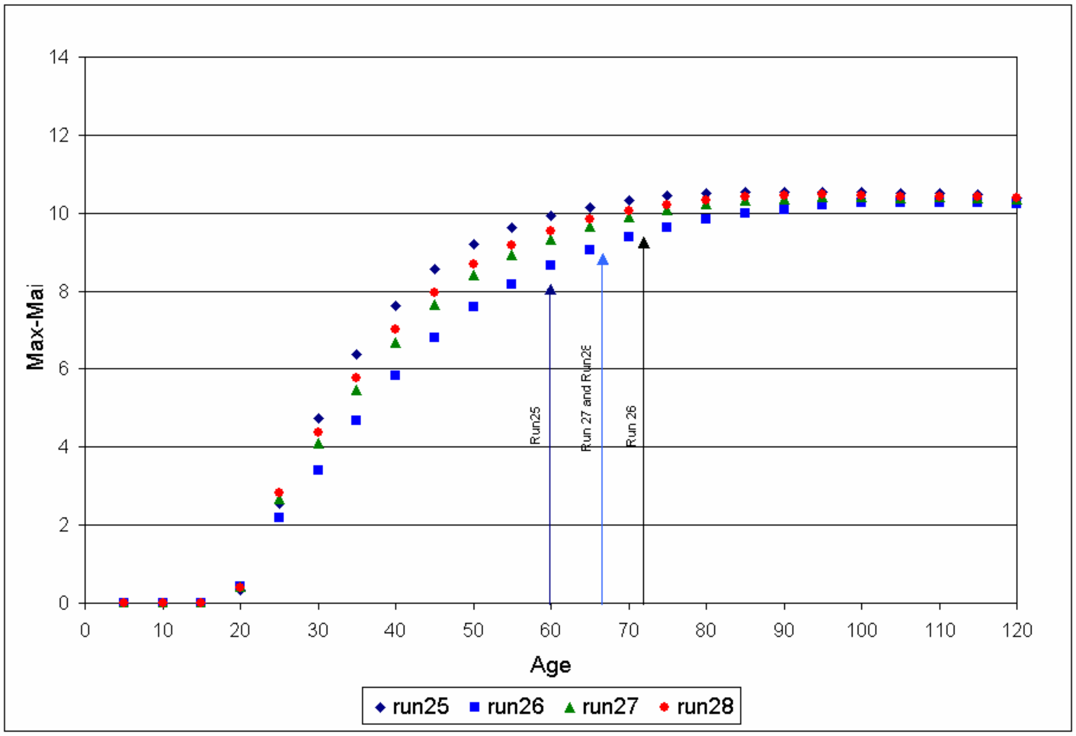

Figure 26. MAI vs Age (Run 25: No Treat; Run 26: JS600; Run 27: JS850; Run 28: JS1000) with 95% MaxMAI ages for each run highlighted

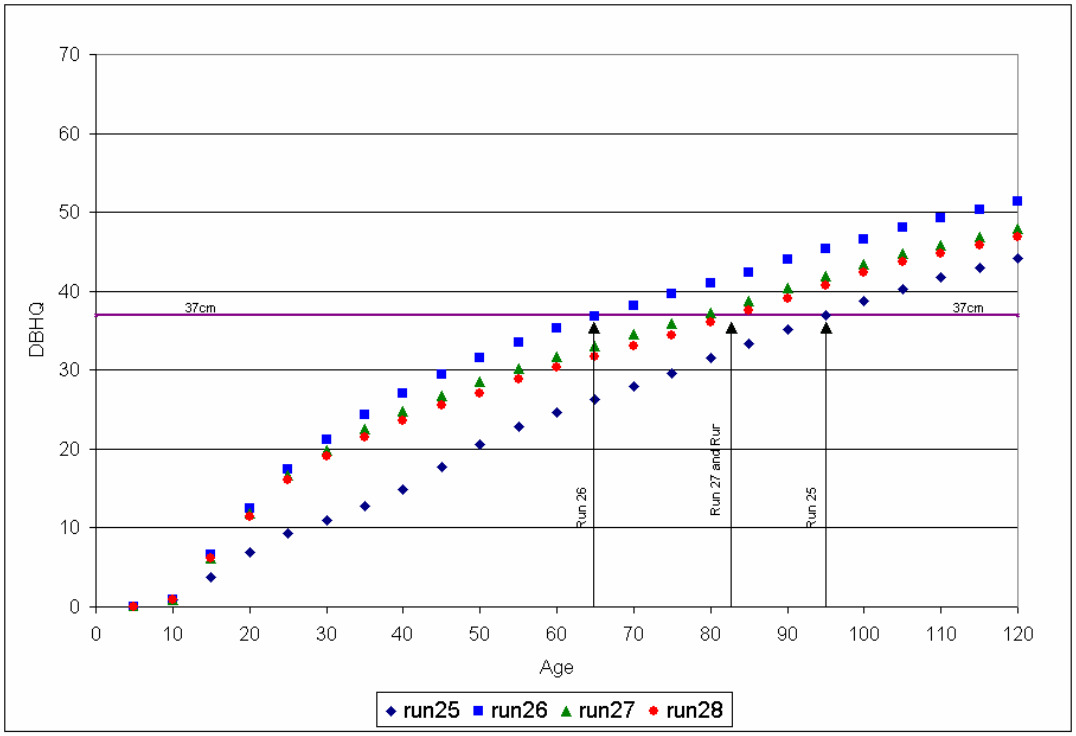

Figure 27. DBHq vs Age (Run 25: No Treat; Run 26: JS600; Run 27: JS850; Run 28: JS1000) with the CMO min. harvest ages to achieve 37 cm DBH highlighted

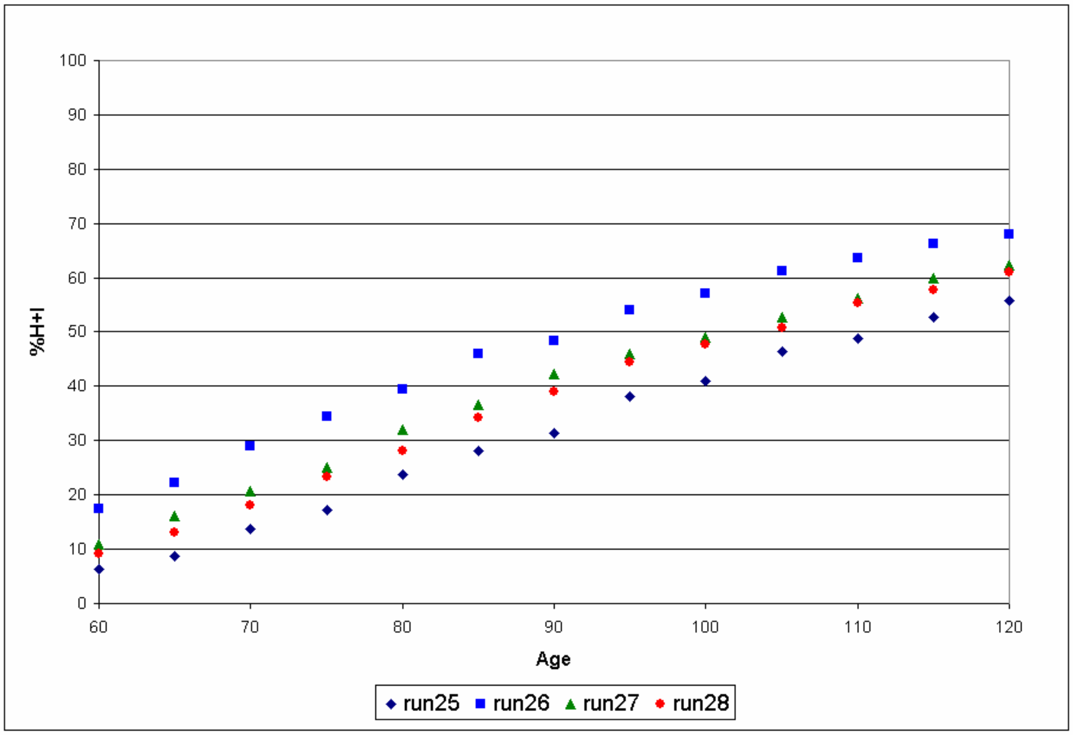

Figure 28. % H+I Logs vs Age (Run 25: No Treat; Run 26: JS600; Run 27: JS850; Run 28: JS1000)

These figures show that spacing can have a significant effect on DBH and the relative proportion of larger logs (H and I grades) produced but has little effect on merchantable volume. In addition spacing can have a significant effect on minimum harvest ages. For example with the CMO forecast, spacing to 600 sph (Run 26) theoretically reduces the minimum harvest age by about 30 years relative to the un-treated (Run 25). On the other hand with the CMO+95% MaxMAI forecast spacing to 600 sph theoretically increases the minimum harvest age by about 12 years relative to the un-treated.

Figure 29 shows that the influence of spacing on DBH and log grade distribution does not translate into a significant impact on average log values using current log prices (Note: this also assumes, for example, that an H grade log harvested from a stand spaced to 600 sph has the same value as a log with the same grade harvested from an un-spaced stand. As the FORINTEK report noted earlier shows this may not be true).

Figure 30 shows that with current log prices and treatment costs of between $1,300 and $1,700/ha (Low JS Costs), the three spacing regimes analyzed are not profitable.

Figure 31 shows the impacts of assuming increased future premiums for larger logs (Steep Log Values which assume a 45% price increase for H and I grades log with no price changes for the other grades) on the NPV’s for the different spacing regimes.

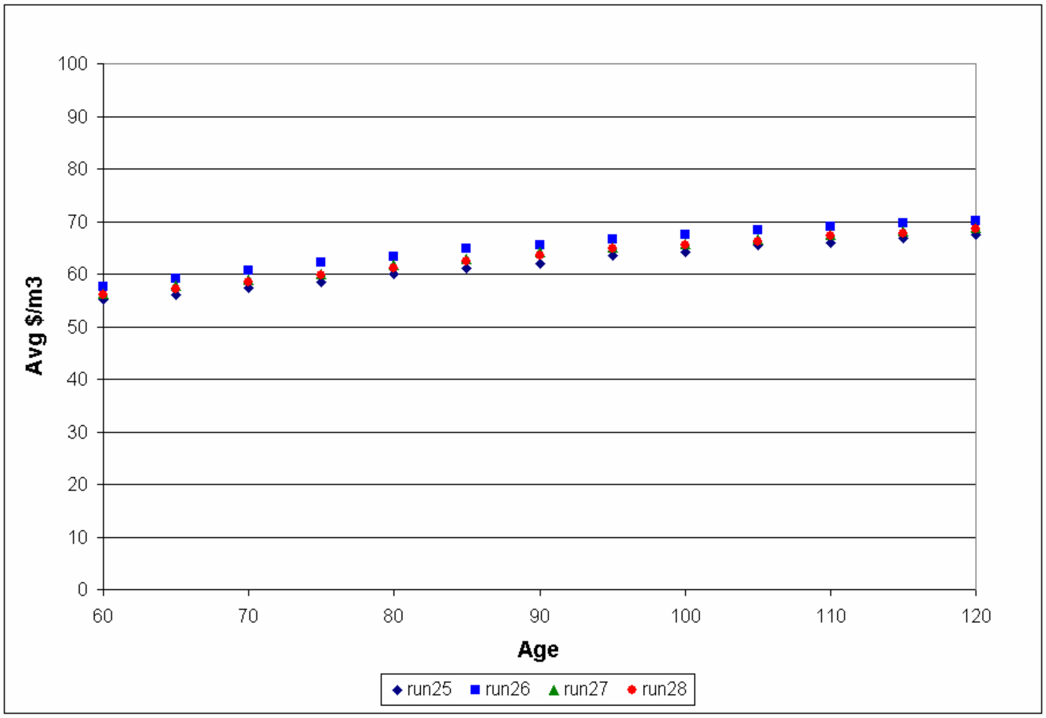

Figure 29. Base Log Value, $/m3 vs Age (Run 25: No Treat; Run 26: JS600; Run 27: JS850; Run 27: JS1000)

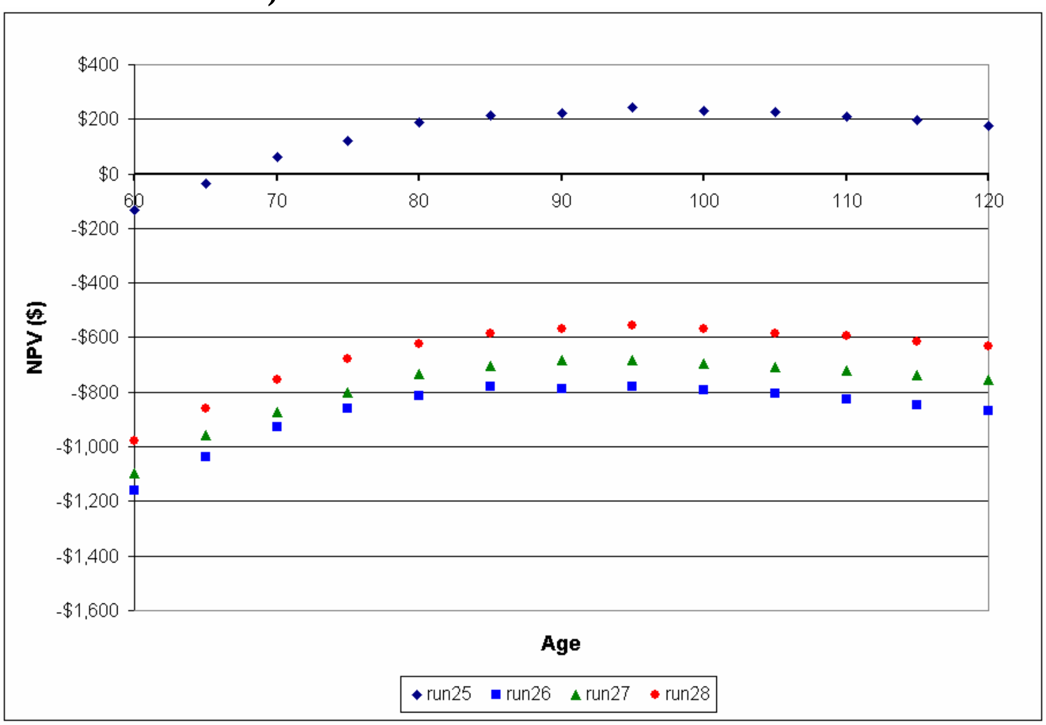

Figure 30. Low JS Costs and Base Log Values, Age vs NPV (Run 25: No Treat; Run 26: JS600; Run 27: JS850; Run 28: JS1000)

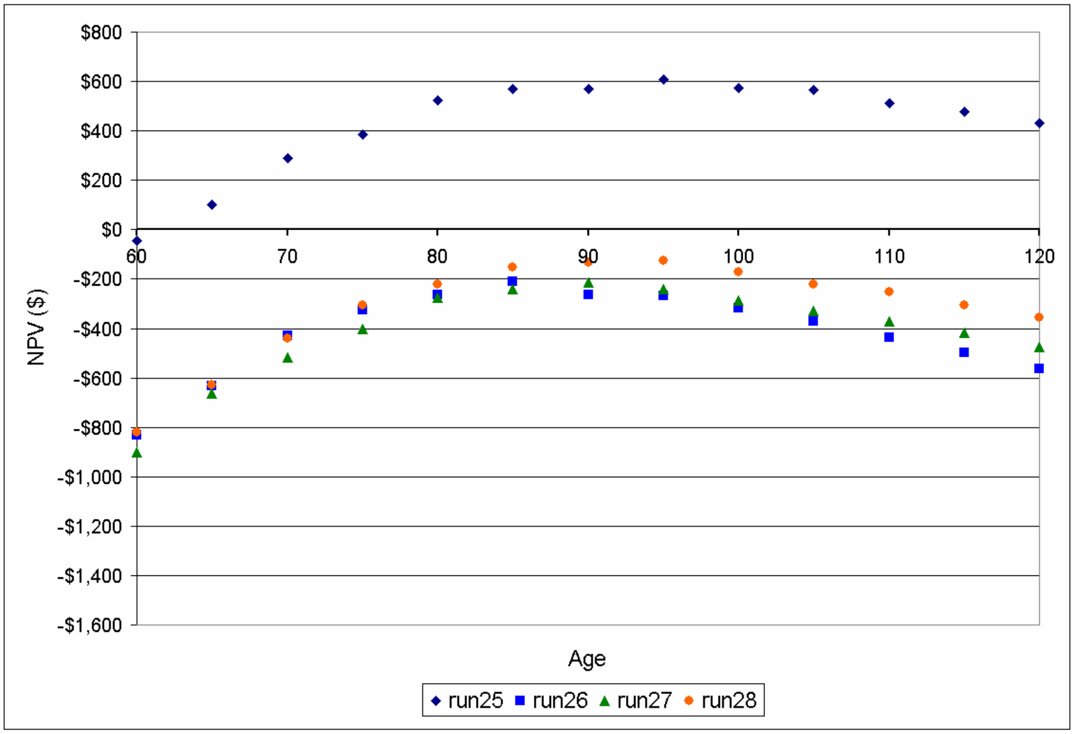

Figure 31. Low JS Costs and Steep Log Values, Age vs NPV (Run 25: No Treat; Run 26: JS600; Run 27: JS850; Run 27: JS1000)

In an attempt to create a timber supply effect by spacing, a forest-level simulation was done with the following regime; juvenile spacing of up to 1000 ha/yr to a residual density of 600 sph for the next 30 years (CMO +1-15JS600+Future10yrsJS600). The intention of this simulation was to attempt to fill a portion of the timber supply "trough" between 2021 and 2061. Figure 32 shows the results of this run against CMO. This run was not done with CMO+95% MaxMAI criteria as it was felt there would be little chance of a positive supply effect.

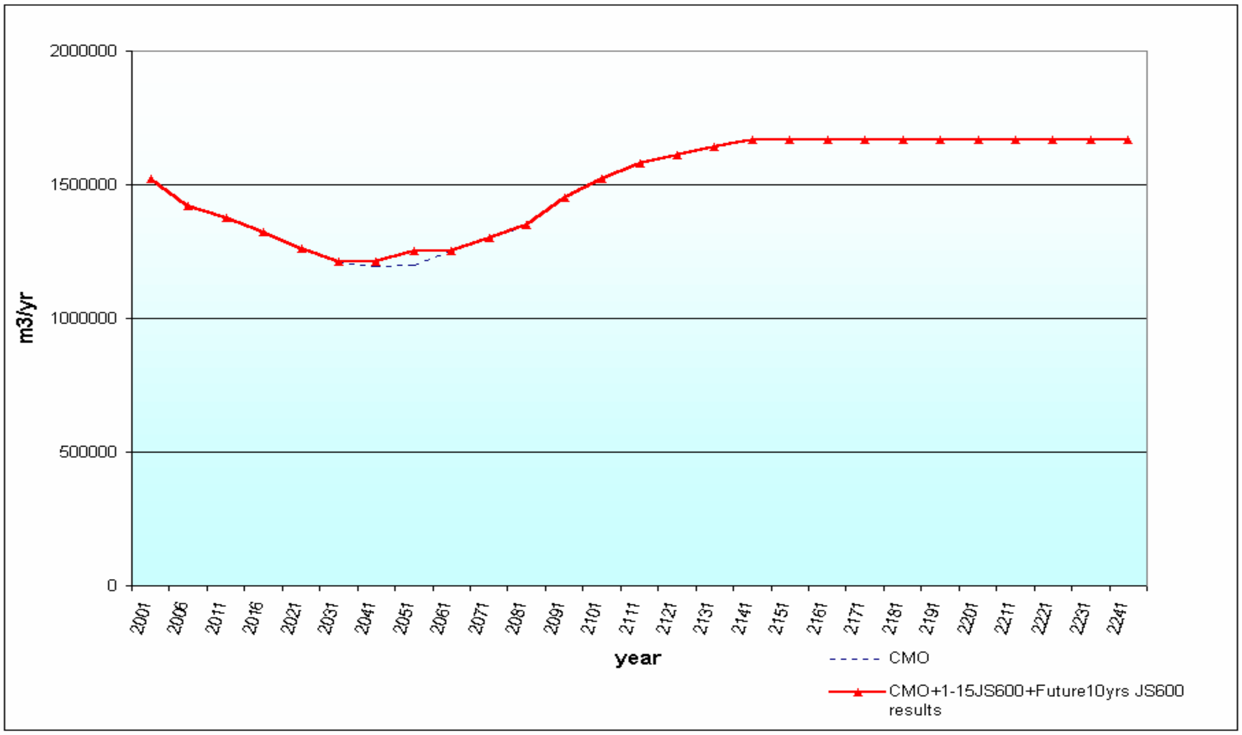

Figure 32. Sensitivity Analysis- CMO +1-15JS600+Future10yrsJS600

For the CMO, spacing an average of 1050 ha/yr for 30 years results in a short-term AAC increase of about 8,615 m3. Clearly, for TFL 6, spacing does not appear to be an effective or economic tool for minimizing the timber supply shortage in the "trough".

Timber Quality Strategies:

Scenario #3 Pruning

Pruning has been occurring on spaced stands of predominantly Hw in TFL 6 to create a component of clear wood and to create employment. WFP's current regime is to first lift prune about two thirds of the spaced stand and to second lift prune the majority of the originally pruned stems. Pruning is assumed to have an insignificant impact on tree growth, therefore no stand or forest-level growth and yield modeling was done. As a basis for discussion stand-level financial analysis of pruning Hw was completed.

Figure 33 shows the trend in the average stand profit increase required from pruning to break even based on financial analysis. As expected, the longer the pruning investment is carried the higher profits which are required to break even.

However, although Figure 33 shows there is a financial incentive to harvest pruned stands as soon as possible, it should be noted the clear shells on the pruned logs must become large enough to produce the amount of clear lumber required to make the pruning financially viable.

For example the expected profit required to break even at a harvest age of 80 years is about $38/m3 (about a 63% increase on a stand with an average log value of $60). This means that the average value of all of the volume in the stand (pruned and unpruned logs) must increase by $38/m3 to cover the cost of the pruning. Given that about 40% of trees in the stand are pruned to 5.5m (assume about 40% of tree volume) and about 26% are pruned to 3m (assume about 22% of tree volume), the value of the wood from pruned logs needs to increase by $38/(40% x 40%)+(26% x 22%) = $175/m3 to result in an average increase of $38 for all of the volume in the stand. With current log prices, this would mean that pruning would have to increase the value of an H grade log by about two times.

As a comparison, work by the Forest Practices Branch using TASS simulations with current market prices for clear and non-clear lumber suggests that a pruned stand will be 40% more valuable than an un-pruned stand at a harvest age of about 80 years[11]. In the same report the MoF compared recent clear and non-clear lumber prices and found that clear Hw 2x4's were about 4 times as valuable as non-clear grades of the same size. However, it is unclear from this MoF report whether the prices being compared were for products from second growth or old growth logs (currently, clear Hw prices for lumber from fast-grown (<8 rings/inch) second growth is worth about half of similar-sized lumber from old growth[12]).

According to this analysis and other similar studies, assumptions about huge premiums for clear versus non-clear wood must be forecast before significant pruning programs can be justified. In addition, in order to maximize pruning benefits, pruned stands must be harvested within a narrow range of ages. This inflexibility in harvest scheduling increases the risks of not maximizing pruning benefits.

It should also be noted that continuation of a Hw pruning program likely requires maintaining a significant spacing program.

[11] From the report, Clear Wood Values from Pruning, Silviculture Practices Branch, MoF, December, 2000
[12] Personal communication with Jim McWilliams, Forest Products Consultant.

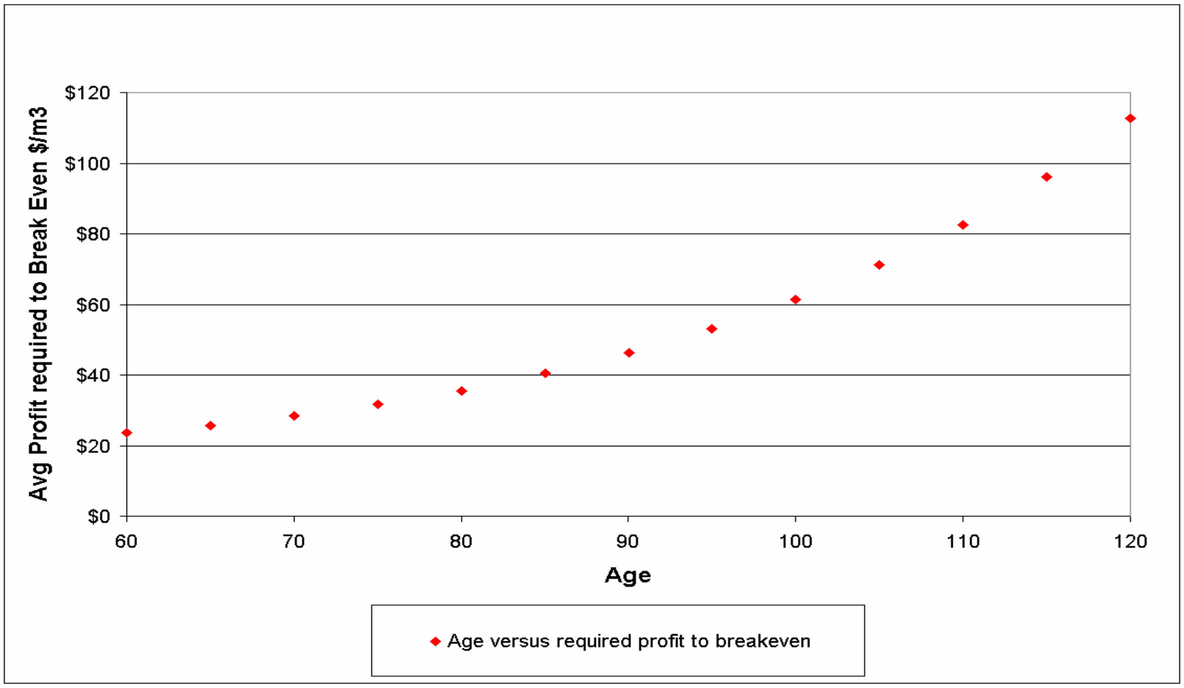

Figure 33. Age vs. Required Profit Increase Required to Break Even

Reforestation Strategies; Impacts of Changing Species Mixes:

The following strategies are based on attempting to diversify the long-term species profile. In all cases this involves substituting alternative species for Hw. Initially these strategies were targeted for the S1ha as manipulation of this ecosystem unit offers the greatest potential for forest-level impacts. However some of the regimes are appropriate for other ecosystem units as well. While these strategies are felt to be ecologically feasible over small to large portions of the TFL and broad opportunity areas are listed for each regime, further study and refinement would be required prior to implementation. Significant pros and cons for each strategy have been included.

Scenario #4 Cw versus Hw

This strategy is based on managing all or significant portions of the S1ha for Cw[13]. Cw is also ecologically suitable on many other non-salal dominated ecosystems in TFL 6. Therefore a Cw strategy could be applicable to a significant portion of TFL 6.

[13] This strategy would also be similar for Yc management, although there may be fewer sites where Yc would be ecologically preferable to Cw.

The potential benefits from growing Cw are:

- based on today's log prices, average log values for second growth Cw are significantly higher than for Hw. Significantly, this differential exists for the smaller logs which will be the dominant products of the second growth harvest and,
- the potential for future Cw prices and markets to remain strong relative to other species is realistic as few other jurisdictions in the world are growing significant amounts of Cw. Significantly the second growth Cw log market is relatively mature, where several mills in the Pacific Northwest of the United States have been cutting mostly second growth Cw into the siding market for the last decade and,
- as a result of the higher log values, especially for small logs, it may be economically viable to invest in significant enhanced silviculture treatments such as density management, pruning and fertilization.

The potential risks of growing Cw are:

- the site productivity (as measured by site index) for Cw is apparently lower than for Hw (24m at 50 years for Cw versus 28m for Hw). As a result, growing a significant amount of Cw may result in a long-term reduction in the AAC. In addition, on sites where Hw natural regeneration is abundant and occurs soon after harvest, the relative reduced productivity of Cw versus Hw may lead to a requirement to "clean out" the competing Hw and,
- ungulate browse can have a significant impact on early stand performance of Cw

Several regimes were developed to simulate potential Cw management regimes for comparison with a currently used Hw regime (Run 25; plt 1100 sph of Hw (with low gain genetic improvement) with natural infill of 4000 sph with a site index of 28m). Run 105 simulates planting 1100 genetically improved (low gain) Cw (site index 24m) per hectare with an ingress of 4000 sph of Hw (site index 28m). Run 151 simulates planting a higher density of Cw (1800 sph with low gain genetic improvement with site index 24m) (or assuming natural ingress of Hw) and spacing to 1000 sph.

Figures 34 and 35 show the growth and yield comparisons. The results for Run 105 should be considered with the following rider; either the growth and yield estimations are accurate but are reflecting a stand dominated by Hw (this was not the intention but is likely what happened) or if you assume a significant Cw component at harvest, the yield estimates are overstated. A more realistic, conservative Cw scenario is Run 151 where spacing or cleaning of competing conifers (likely Hw) is required to assure a Cw crop at rotation. Figure 34 shows that Run 151 results in a merchantable volume reduction of about 190 m3/ha or 19% as compared with the Hw run at about the minimum harvest age (CMO scenario with a target DBH of 37 cm). This volume difference is significant.

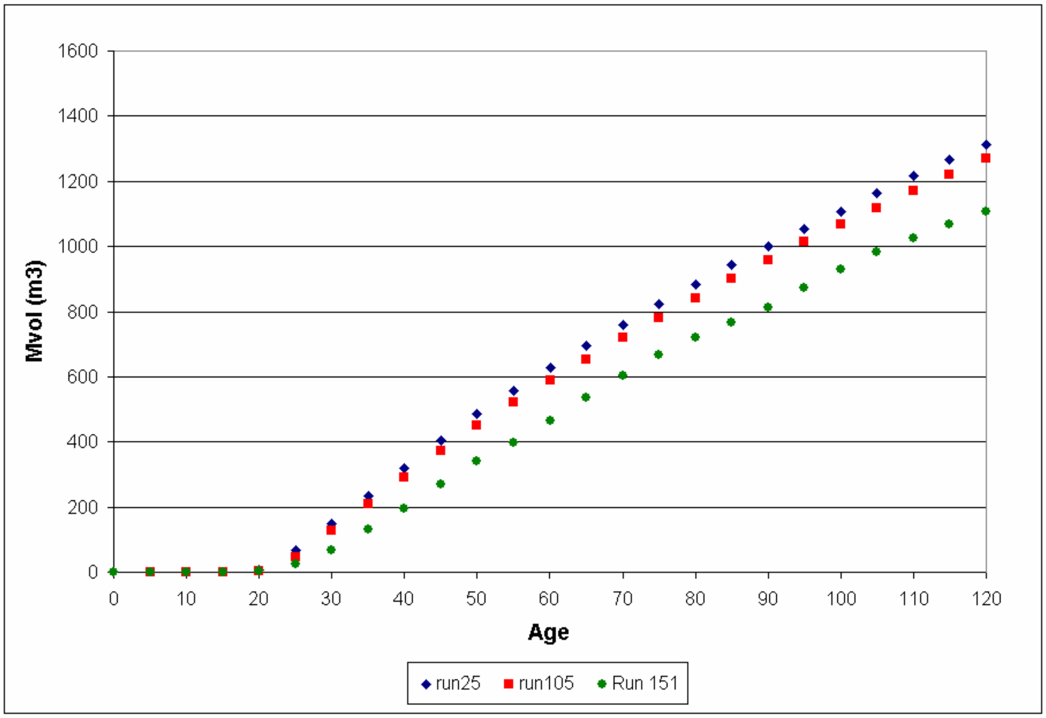

Figure 34. MVol vs Age (Run 25: No Treat; Run 105: pltCw, No Treat.; Run 151: pltCw, JS1000)

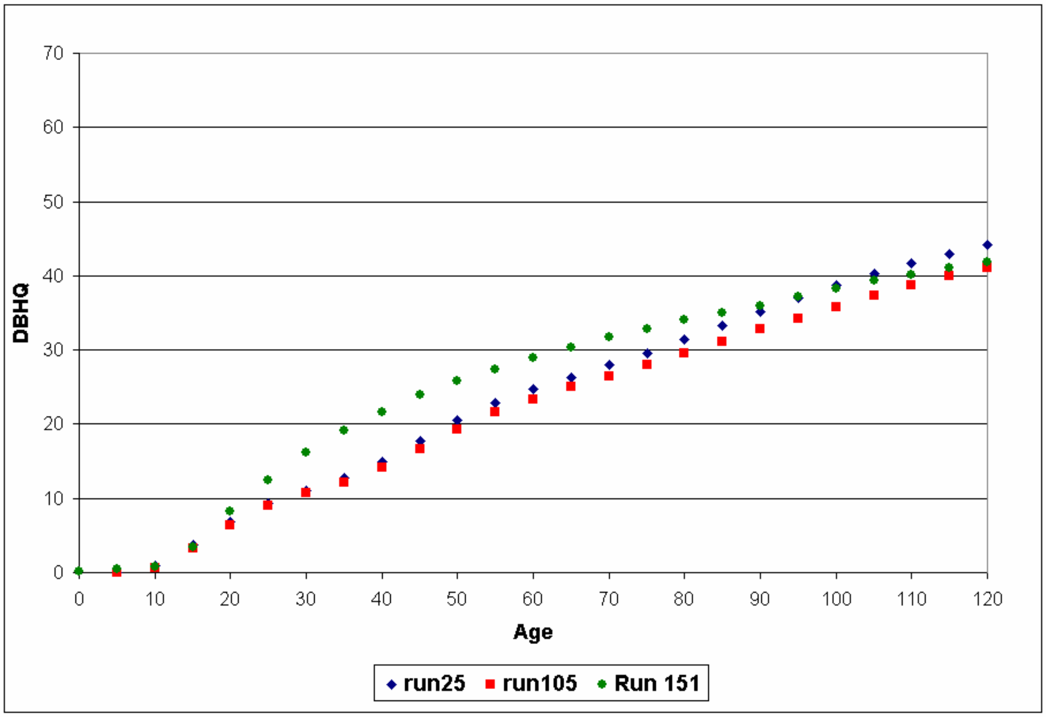

Figure 35. DBHq vs Age (Run 25: No Treat; Run 105: pltCw, No Treat.; Run 151: pltCw, JS1000)

Figure 36 shows the comparison between average log values for the different strategies using current second growth log prices. The results for Run 105 assume a 50% Cw component at harvest, which as mentioned previously, may be optimistic. As Run 151 was spaced to Cw the harvest is assumed to consist of 100% Cw. Comparing Runs 25 and 151 show the significant value improvement of the Cw versus the Hw strategy.

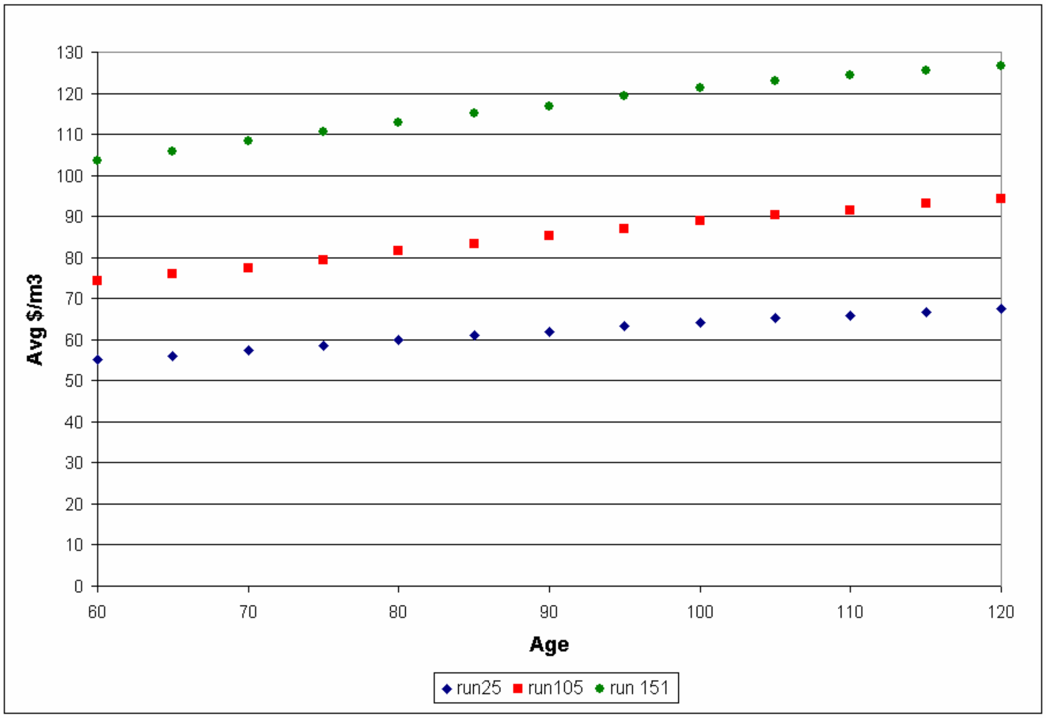

Figure 36. Base Case Avg $/m3 vs Age (Run 25: No Treat; Run 105: pltCw, No Treat.; Run 151: pltCw, JS1000)

Figure 37 compares the NPV's of the different strategies. This figure shows that, despite the extra spacing costs incurred ($1,300/ha) and the reduced volume available for harvest, the Run 151 Cw strategy is financially preferred over the Hw strategy. Given these results implementing a Cw strategy could have significant impacts on future harvest levels, profitability and the magnitude of an economically-viable incremental silviculture program in TFL 6. As a result, additional stand-level analysis (financial and growth and yield sensitivities) and forest-level timber supply and quality analysis is warranted.

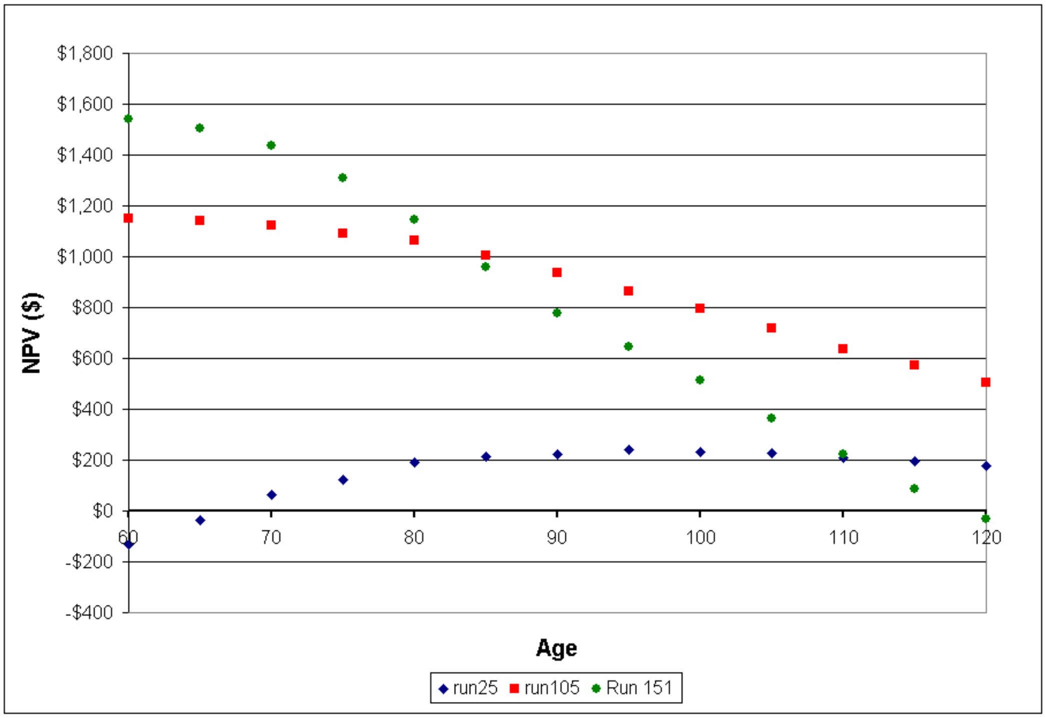

Figure 37. Base Case Age vs. NPV (Run 25: No Treat; Run 105: pltCw, No Treat.; Run 151: pltCw, JS1000)

Scenario #5 Ss/Hw versus Hw

This strategy is based on managing a portion of the S1ha for a component of Ss. Ss is also ecologically-suitable on the S12ha, S13 and S3 ecosystem units.

The potential benefits from growing Ss are:

- based on today's log prices, average log values for second growth Ss are somewhat higher than for Hw (although lower than for Cw and Fd or similar grades) and,
- the site productivity (as measured by site index) for Ss is somewhat higher than for Hw (31m at 50 years for Ss versus 28m for Hw). As a result, growing a significant amount of Ss may result in a long-term increase in the AAC and,
- Ss and Hw are known to grow well together in mixed stands and,
- Ss responds to nitrogen fertilization leading to future opportunities for incremental silviculture investments.

The potential risks of growing Ss are:

- Ss plantations on northern Vancouver Island are known to be susceptible to terminal weevil. Incidence of attack has varied from high to low depending on the location and biogeoclimatic variant. Recently, genetically improved, weevil-resistant Ss seed has become available for TFL 6. While the effectiveness of this seed is unknown, it is currently estimated that with its use weevil attack incidence can be reduced to acceptable levels of impact and,
- The second growth Ss log market is currently small and immature. Currently, the prognosis for future uses of Ss second growth are un-certain. Therefore, future log values relative to other species are un-certain.

For this analysis a planted Ss (50%)/Hw(50%) regime (Run 65; plt 550 sph of Hw (with low gain genetic improvement and site index 28m) and 550 sph of Ss (with low gain genetic improvement and site index 31m) with natural infill of 4000 sph of Hw with a site index of 28m) was compared with a Hw regime (Run 25; plt 1100 sph of Hw (with low gain genetic improvement) with natural infill of 4000 sph with a site index of 28m) on S1ha sites.

Figures 38 to 40 show the growth and yield and log grade outturn benefits of the Ss/Hw mix.

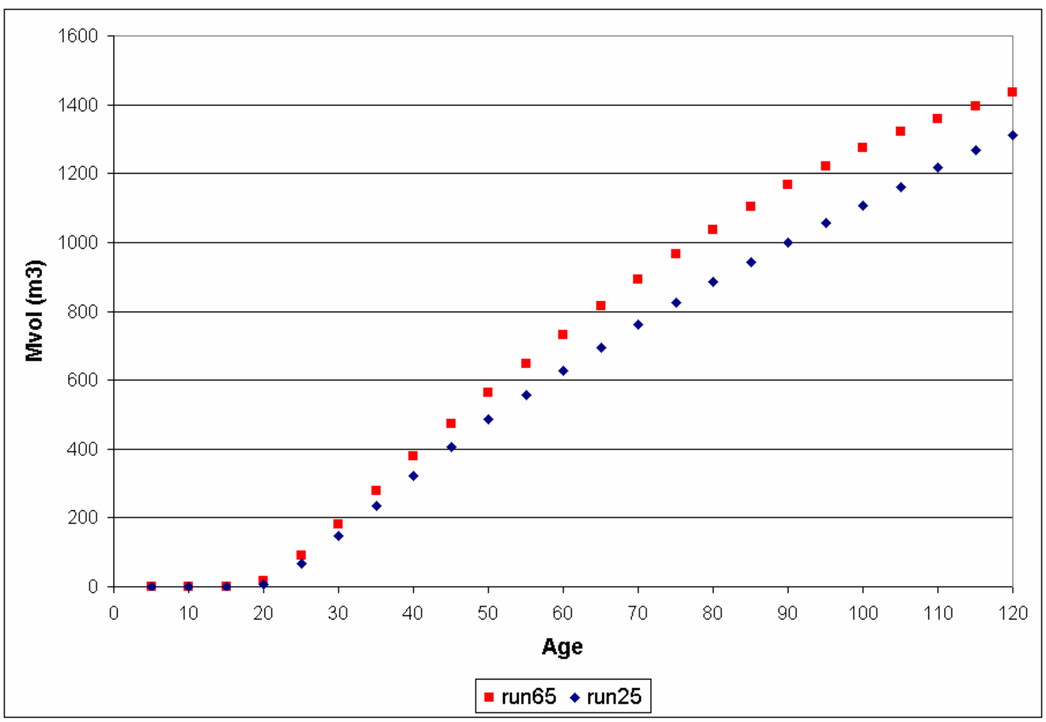

Figure 38. MVol vs Age (Run 65; Ss/Hw, Run 25; Hw)

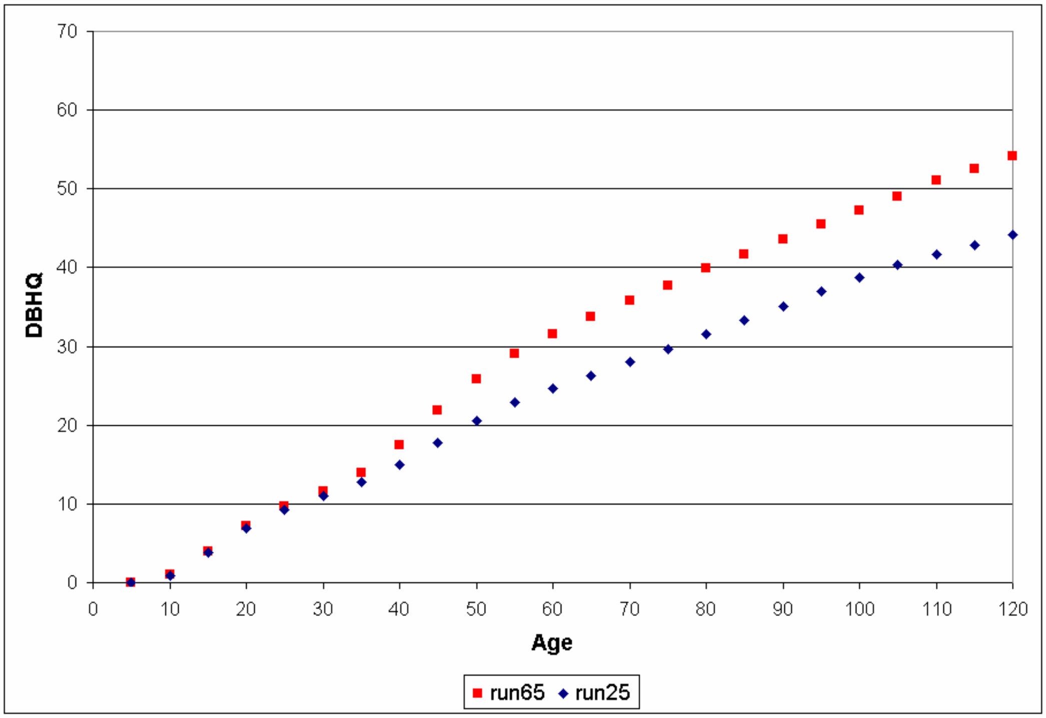

Figure 39. DBHq vs Age (Run 65; Ss/Hw, Run 25; Hw)

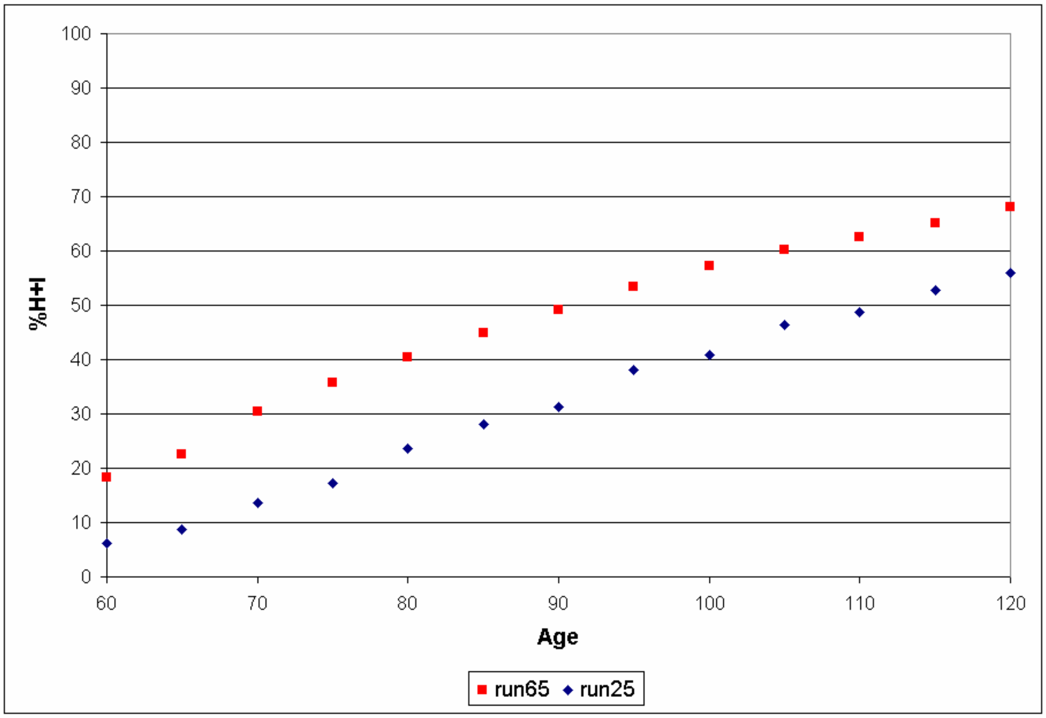

Figure 40. Percent H+I Log grade outturn vs Age (Run 65; Ss/Hw, Run 25; Hw)

Based on a cursory review of TFL 6 using ecological attributes that are favorable for Ss, about 40,000 ha could be reforested to components of Ss (see the appendices for ecological attributes which were used for these queries). Therefore, keeping in mind the uncertain future risks of the weevil, growing increased components of Ss has a modest potential to improve timber supply and quality (average log price). In addition, the use of Ss could allow for significant economically-viable future fertilization opportunities.

Scenario #6 Fd/Hw versus Hw

This strategy is based on managing portions of the S1ha for a component of Fd. Within the majority of TFL 6, Fd is on the edge of its natural distribution therefore this strategy would only be applicable to portions of the TFL.

The potential benefits from growing Fd are:

- based on today's log prices, average log values for second growth Fd are higher than for Hw. However, in order to achieve this premium for Fd logs the rate of growth cannot be excessive. On the S1ha this should not be a problem as the natural in-fill of Hw should maintain relatively dense stands (as long as spacing is not done) which will moderate radial growth once the stands achieve canopy closure and,
- the site productivity (as measured by site index) for Fd is somewhat higher than for Hw (31m at 50 years for Fd versus 28m for Hw). Although, in this case, this improvement in relative productivity will not likely translate into a long-term increase in the AAC (see below) and,

- Fd responds to nitrogen fertilization leading to future opportunities for incremental silviculture investments.

The potential risks of growing Fd are:

- Some Fd plantations established in, and adjacent to TFL 6 have been observed to have undesirable growth characteristics that could lead to reductions in log values. Therefore, while it is felt that portions of the S1ha are suitable for Fd management, site selection will be very important and,
- Fd and Hw grown together are known to be relatively incompatible due to their spatial needs.

For this analysis a planted Fd regime (Run 125; plt 1100 sph of Fd (with low gain genetic improvement and site index 31m) with natural infill of 4000 sph of Hw with a site index of 28m) was compared with a Hw regime (Run 25; plt 1100 sph of Hw (with low gain genetic improvement) with natural infill of 4000 sph with a site index of 28m) on S1ha sites.

Results of this analysis were that the Fd regime had significantly less volume at the minimum harvest age but similar average diameters. As expected average log values for the Fd regime were much higher than for the Hw that resulted in the Fd regime being financially superior (see the analysis results in the appendices).

Based on a cursory review of TFL 6 using ecological attributes that are favorable for Fd, about 10,000 to 15,000 ha could be reforested with components of Fd (see the appendices for ecological attributes which were used for these queries). Therefore, keeping in mind the risks of establishing poor quality Fd stands, growing increased components of Fd has the potential to improve quality (average log price) but may cause a decrease in timber supply. In addition, the use of Fd could allow for significant economically-viable late rotation future fertilization opportunities.

Scenario #7 Dr versus Hw

This strategy relates to establishing alder on currently harvested areas. Starting with the “Type 1” project, alder reforestation strategies were developed as a species diversification strategy and to potentially improve medium-term timber supply. This project continued this process by researching and developing different potential management regimes, identifying the most favourable ecosystem units for treatment and reviewing marketing opportunities and constraints. Summaries of the results of these processes are included in the appendices.

Currently interest in utilizing existing alder and managing for future alder is increasing on the coast. Weyerhaeuser, on their private lands in the USA have been managing for alder for over 10 years. Weyerhaeuser on the coast are currently investigating alder management strategies for their BC private land and crown tenures.

The benefits of managing for alder in TFL 6 are:

- on ecologically-suitable sites, alder has a higher site index than most coniferous species except possibly Ss,

- alder matures at a relatively early age relative to coniferous species. Culmination of MAI can occur at 25 to 30 years on the best sites,
- with intensive silvicultural regimes, significant components of high quality clear wood can be grown with relatively short rotations and,
- currently value-added alder markets are already in place

Challenges to managing for alder in TFL 6 are:

- no significant processing facilities are in close proximity to TFL 6 lands. Logging and milling alder have time sensitive requirements which cause logistical and cost problems as distances to mills increase,
- currently Weyerhaeuser controls the majority of the coastal alder market which may make it difficult for other companies to get fair market prices and,
- based on a cursory review, TFL 6 does not appear to have a large area of ecologically-preferable sites.

Adaptation of TASS to alder is currently under development. As a result it was not possible to complete "accurate" stand-level modeling for this project. Some TASS runs were performed but the results are considered experimental and will not be released with this project. However, figures 41 to 45 show some growth and yield comparisons between selected alder and Hw regimes. These graphs are not to be used to finalize alder management regimes or be used for business decision-making.

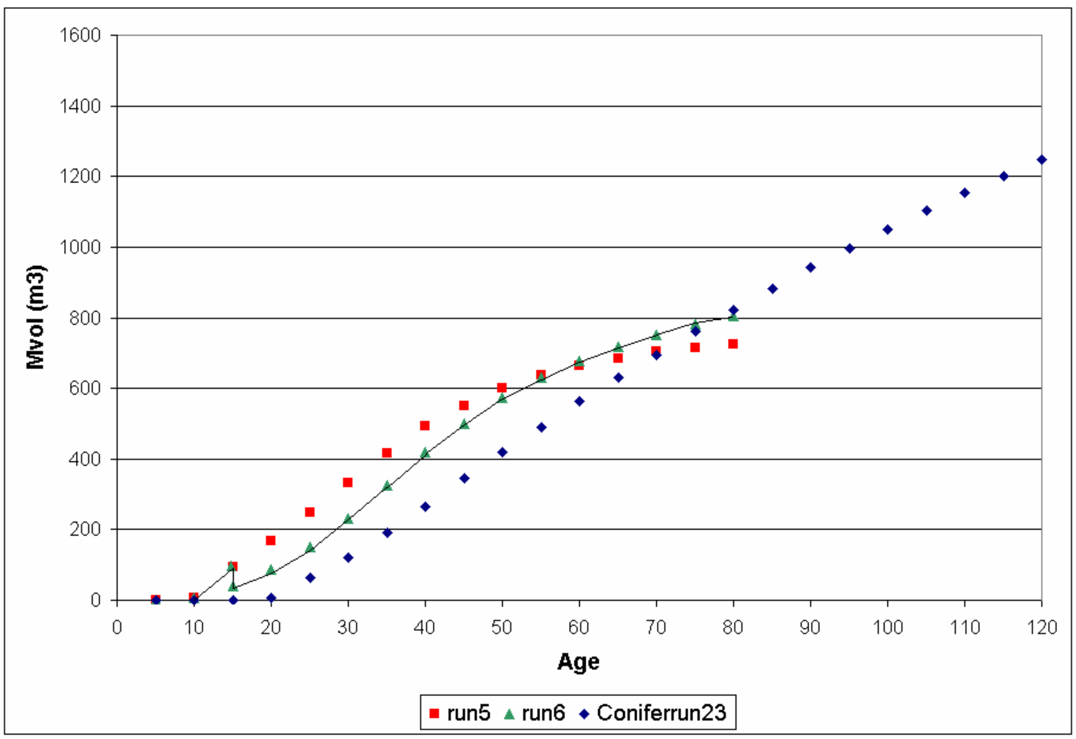

Figure 41. MVol vs Age on better S1ha (Run 5; DrJS850, Run 6; DrJS850CT275, Run 23; HwJS850)

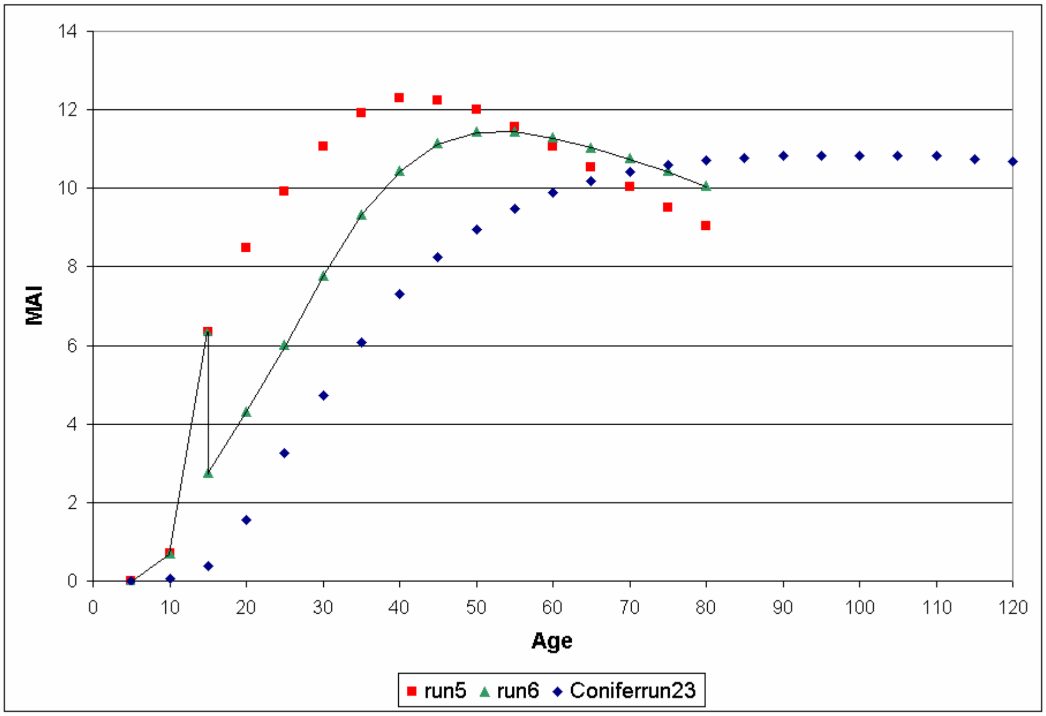

Figure 42. MAI vs Age on better S1ha (Run 5; DrJS850, Run 6; DrJS850CT275, Run 23; HwJS850)

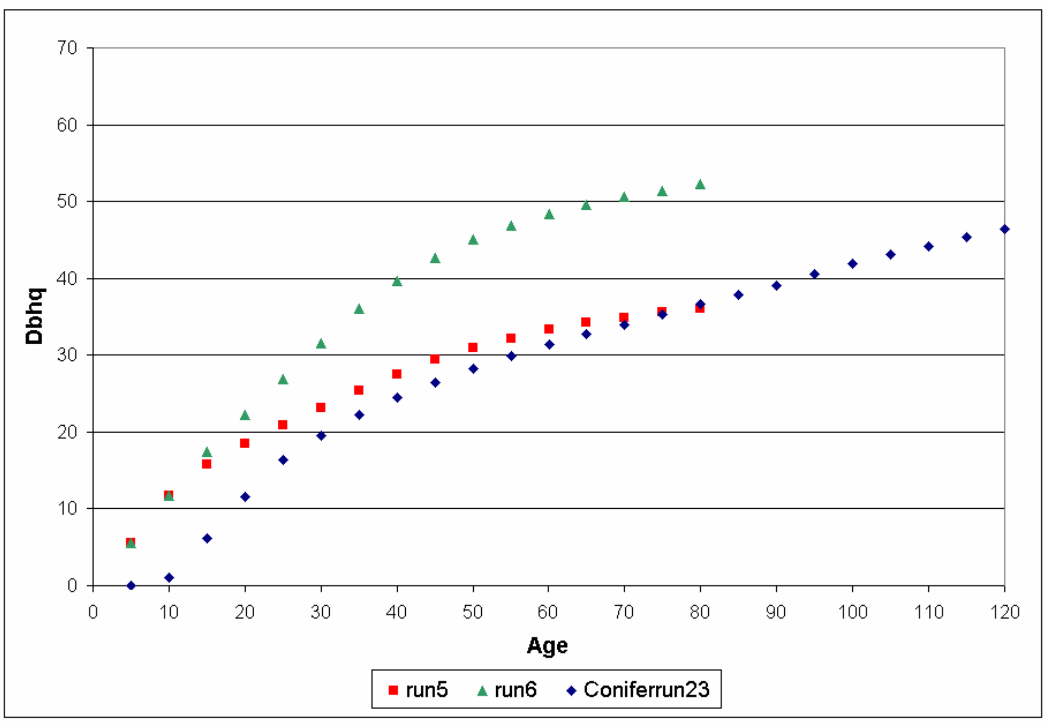

Figure 43. DBHq vs Age on better S1Ha (Run 5; DrJS850, Run 6; DrJS850CT275, Run 23; HwJS850)

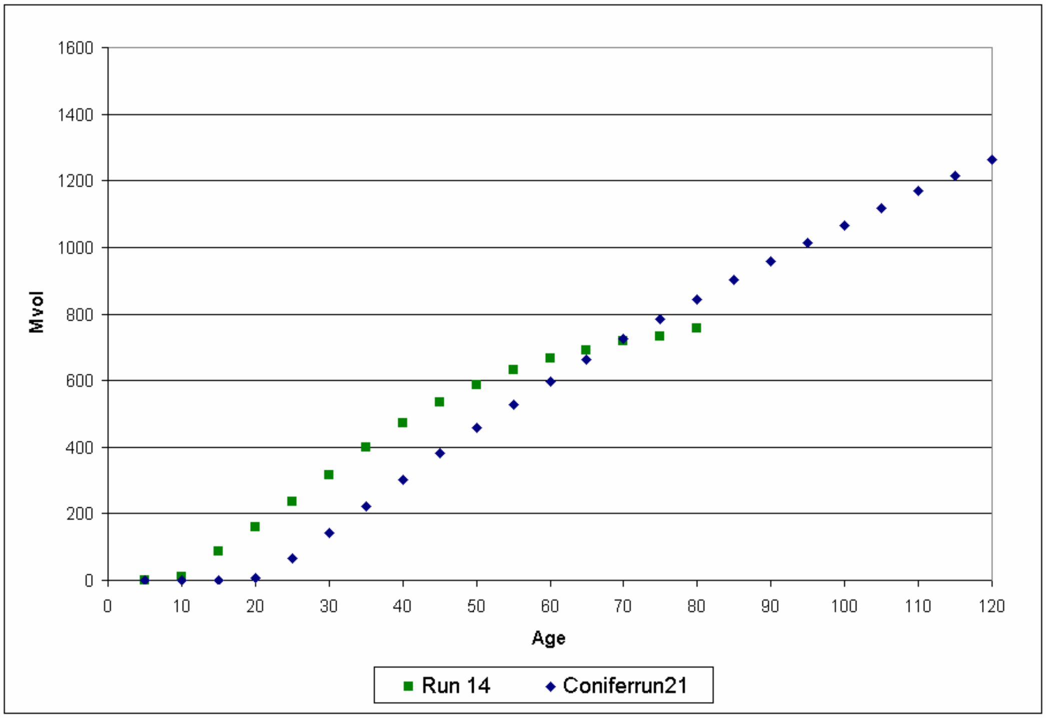

Figure 44. MVol vs. Age on better S1ha (Run 14; Dr Plt1100, Run 21; Hw Plt1100 5%GI+2000 Infill)

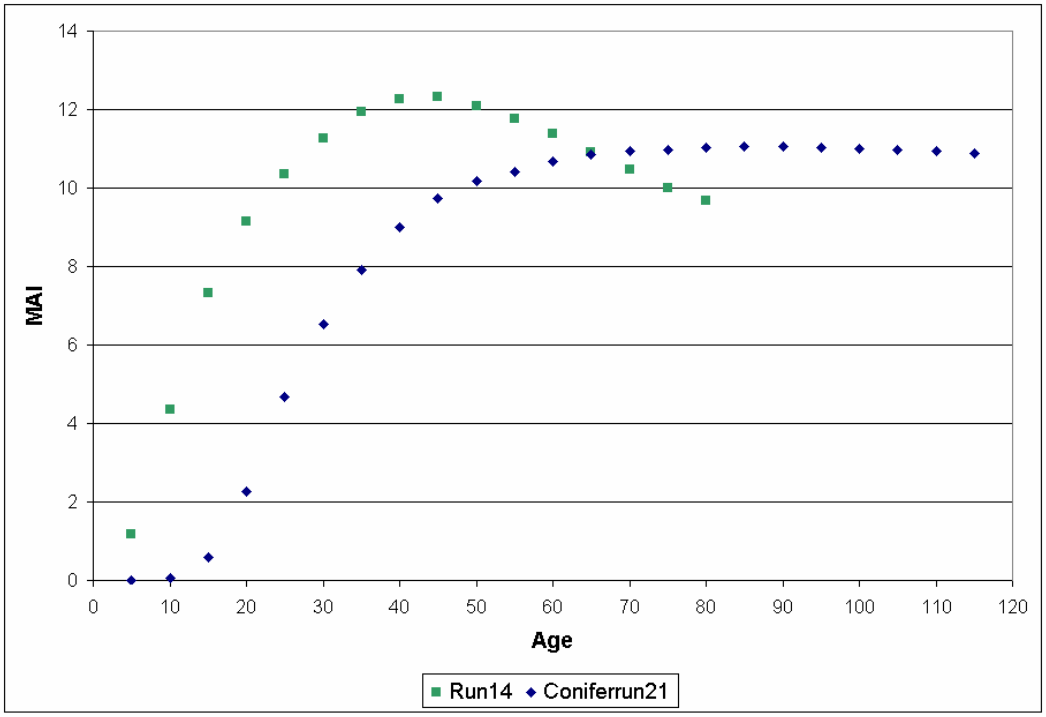

Figure 45. MAI vs Age (Run 14; Dr Plt1100, Run 21; Hw Plt1100 5%GI+2000 Infill)

These figures show that at a stand-level there is potential for developing viable alder strategies that could improve medium to long-term timber supply and quality.

Figures 46 to 49 compare the financial analysis results of the selected regimes. These figures also show that alder strategies could be financially viable especially relative to Hw strategies.

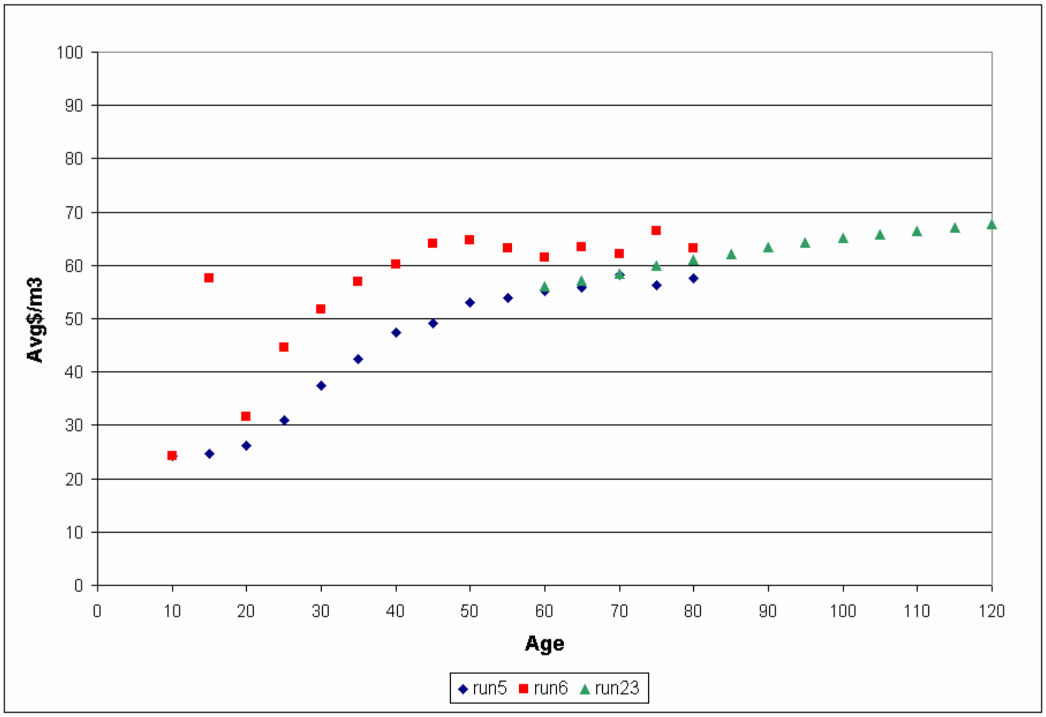

Figure 46. Base Case Avg $/m3 vs. Age (Run 5; DrJS850, Run 6; DrJS850CT275, Run 23; HwJS850)

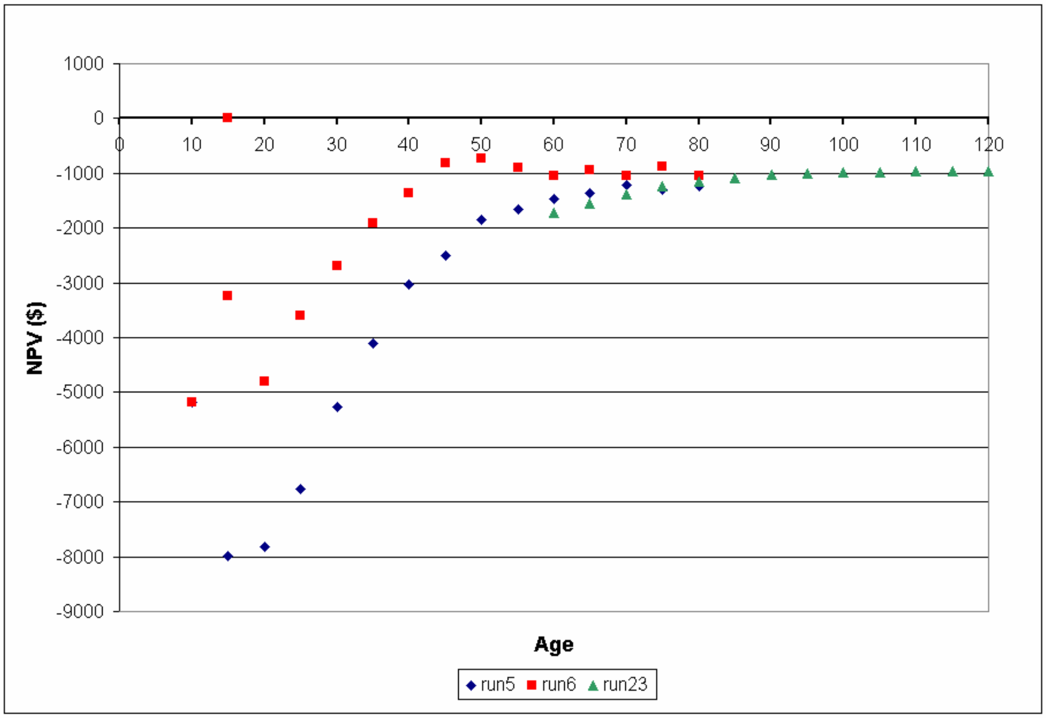

Figure 47. Base Case Age vs. NPV (Run 5; DrJS850, Run 6; DrJS850CT275, Run 23; HwJS850)

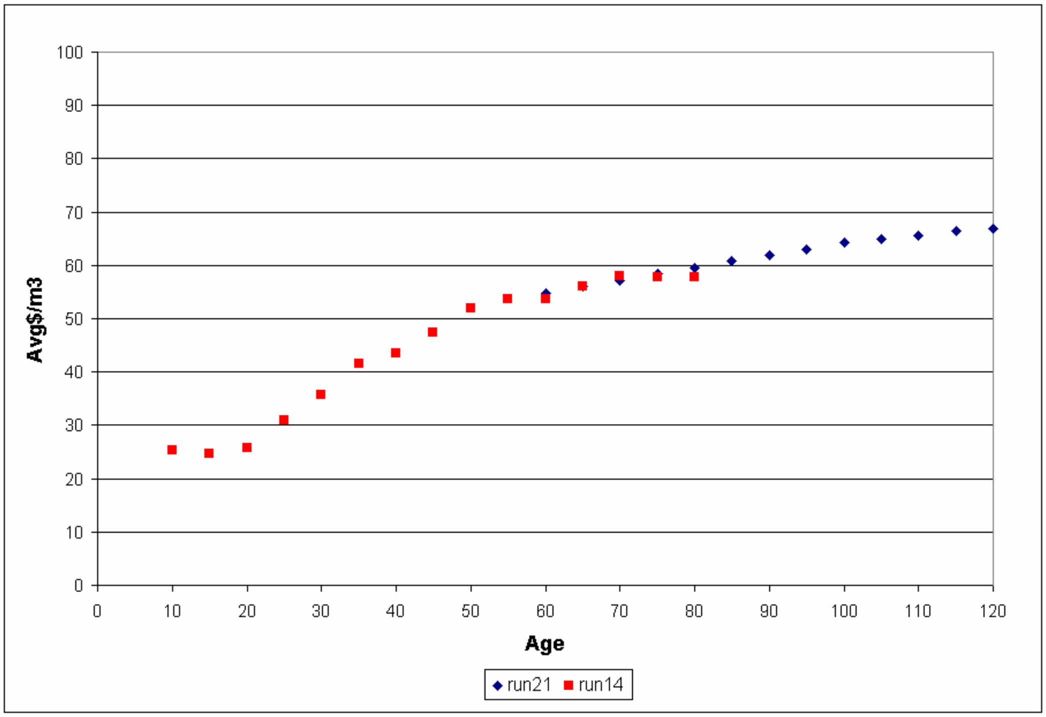

Figure 48. Avg $/m3 vs Age (Run 14; Dr Plt1100, Run 21; Hw Plt1100 5%GI+2000 Infill)

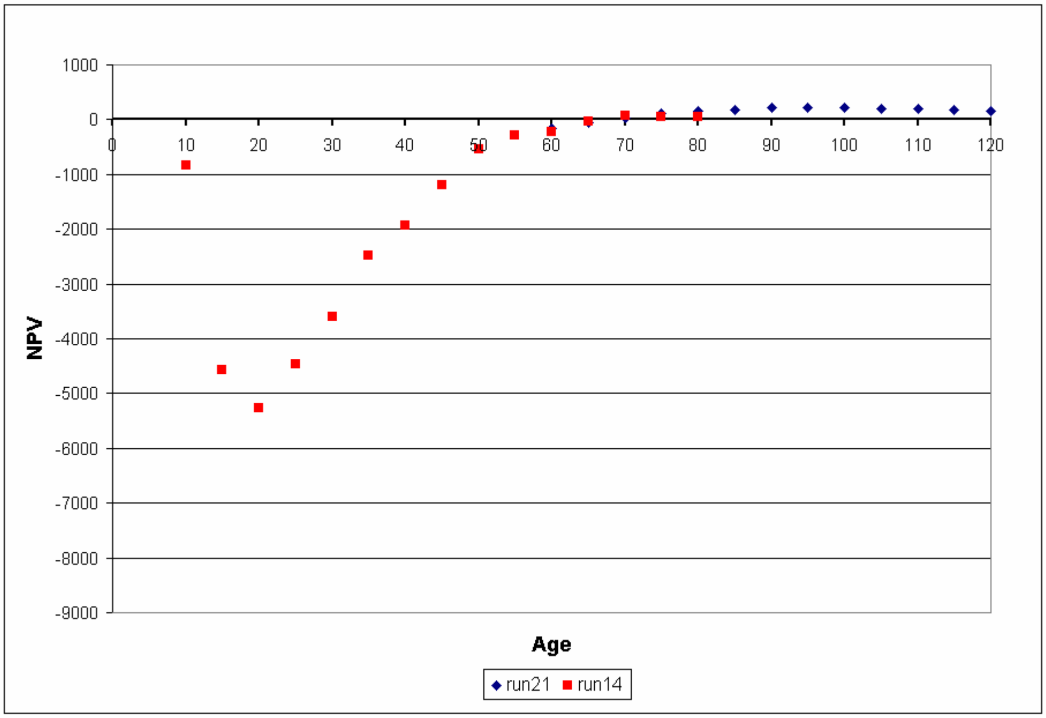

Figure 49. Base Case Age vs. NPV (Run 14; Dr Plt1100, Run 21; Hw Plt1100 5%GI+2000 Infill)

Based on a cursory review of TFL 6 using ecological attributes which are preferable for Dr, only about 3,100 ha could be reforested to Dr. (see the appendices for ecological attributes which were used for these queries). However, based on further analysis and knowledge about growth and yield of alder relative to different sites, there may be a larger potential than is currently estimated. Based on the small area estimated to be available for treatment, it is unlikely that an alder management strategy would have a significant impact on timber supply and/or quality.

Other Strategies:

Scenario #8 Planting with Genetically Improved Stock Versus Natural Regeneration

This strategy compares the growth and yield and financial implications of allowing S1ha sites to regenerate naturally to Hw-dominated stands or planting with genetically improved Hw. Currently the predominant treatment for S1ha sites is to plant about 1100 sph genetically improved Hw per hectare within 2 years of harvest.

The potential benefits of this strategy are:

- improved growth, and hopefully better quality, of the improved trees versus the natural stock,
- minimization of regeneration delay which positively effects timber supply,

- reduced risks of fill planting which can be costly and may result in stocking standards not being achieved and,
- reduced possibility that spacing to control density will be required where natural infill rates are high

On the other hand planting is expensive relative to natural regeneration.

For this analysis regimes were developed to compare the growth of stands planted with low and high gain genetic stock with naturally regenerated stands at various densities and with no spacing and various spacing densities. Financial analysis was also used to compare selected regimes. For the base case no filling planting was assumed to be required for the naturally regenerated regime. Variation 1 included a low probability that fill planting would be required.

Figures 50 and 51 show the growth and yield comparisons. As expected the genetically improved stock improves yields at about the minimum harvest ages by about their assumed genetic worths (5 or 15%). As mentioned earlier, according to TASS, genetic improvement has virtually no impact on DBH development.

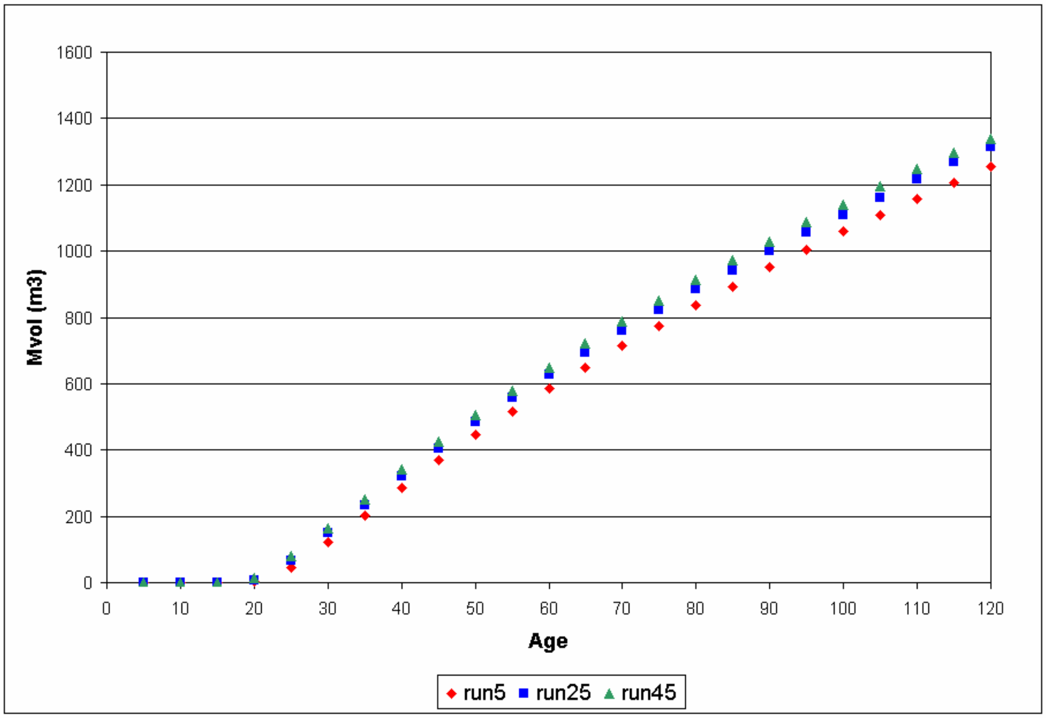

Figure 50. MVol vs Age with 4000 sph infill (Run 5; Nat, Run 25; Plt5%; Run 45; Plt15%GI)

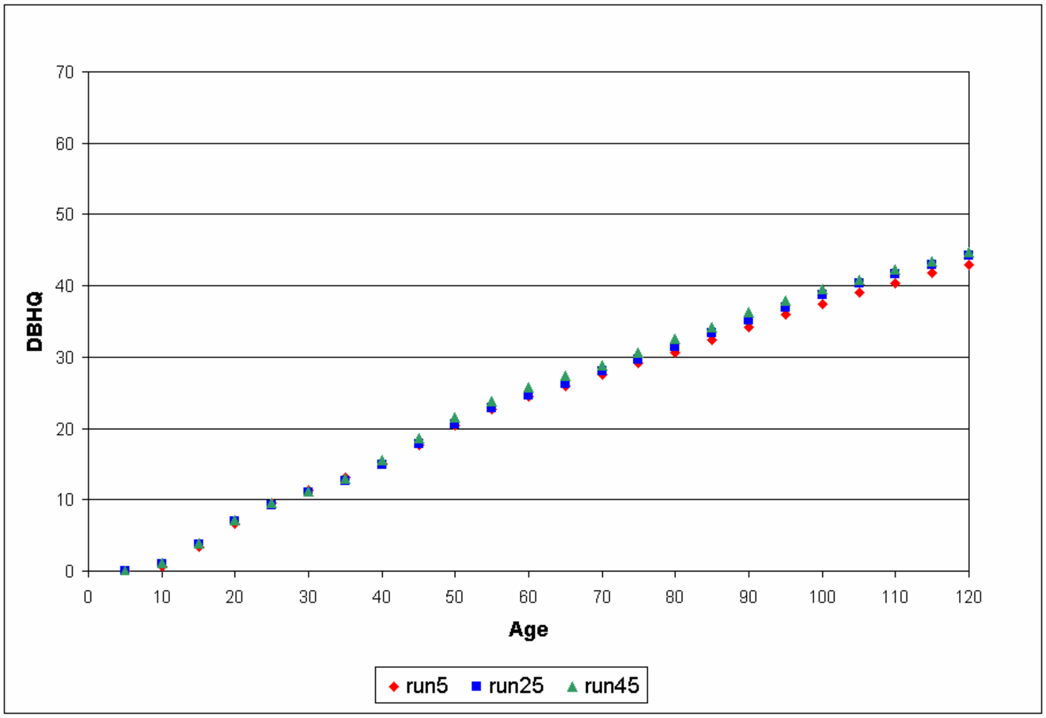

Figure 51. DBHq vs Age with 4000 sph infill (Run 5; Nat, Run 25; Plt5%; Run 45; Plt15%GI)

Figure 52 compares the NPV's for the different regimes. For this analysis there was assumed to be no increases in log quality with the use of genetically improved stock. Figure 53 compares the NPV's for the genetically improved regimes with the naturally regenerated regime assuming that some fill planting would be required. This analysis shows that, at the stand-level, use of genetically improved stock does not appear to be cost effective when natural regeneration is likely.

Scenario #1 showed that use of genetically improved stock accounts for about a 5 to 10% improvement in timber supply under the CMO forecast. An additional timber supply consideration for relying on natural regeneration is that effective regeneration delays may increase. In addition, there are some financial and administrative risks to not achieving reforestation requirements within the limits prescribed.

Forest-level financial analysis comparing the use of genetically improved stock versus natural regeneration was not done for this project. However, in general, unless there are significant opportunities for an allowable cut effect, treatments that are not financially beneficial at the stand-level do not pay at the forest level.

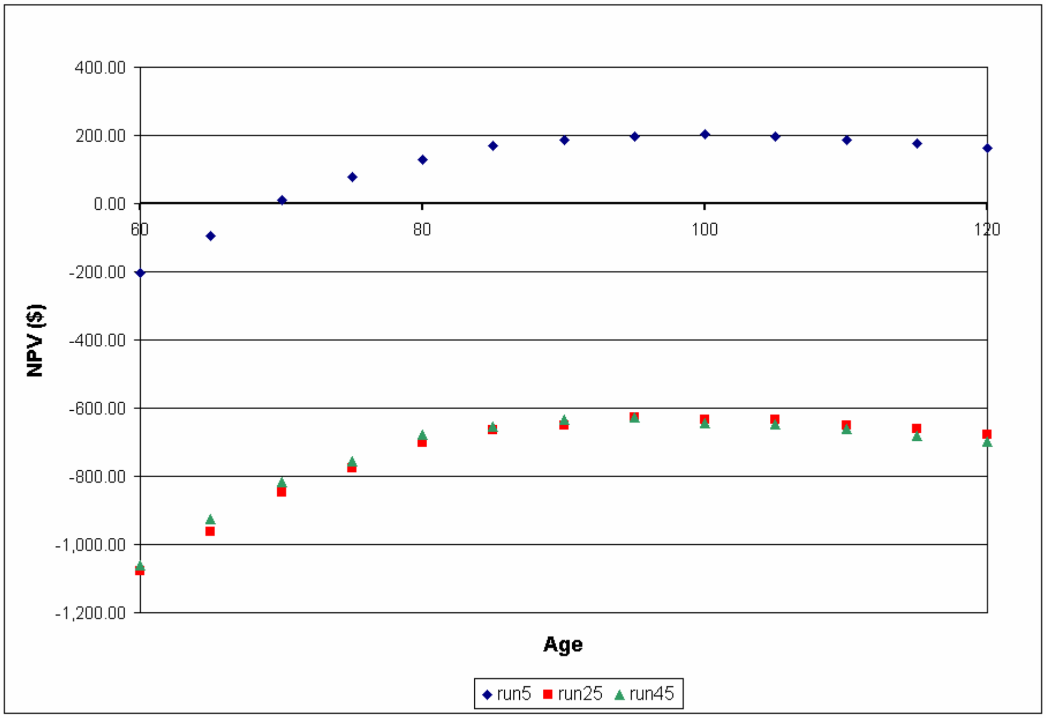

Figure 52. Base Case Age vs NPV with 4000 sph infill (Run 5; Nat, Run 25; Plt5%; Run 45; Plt15%GI)

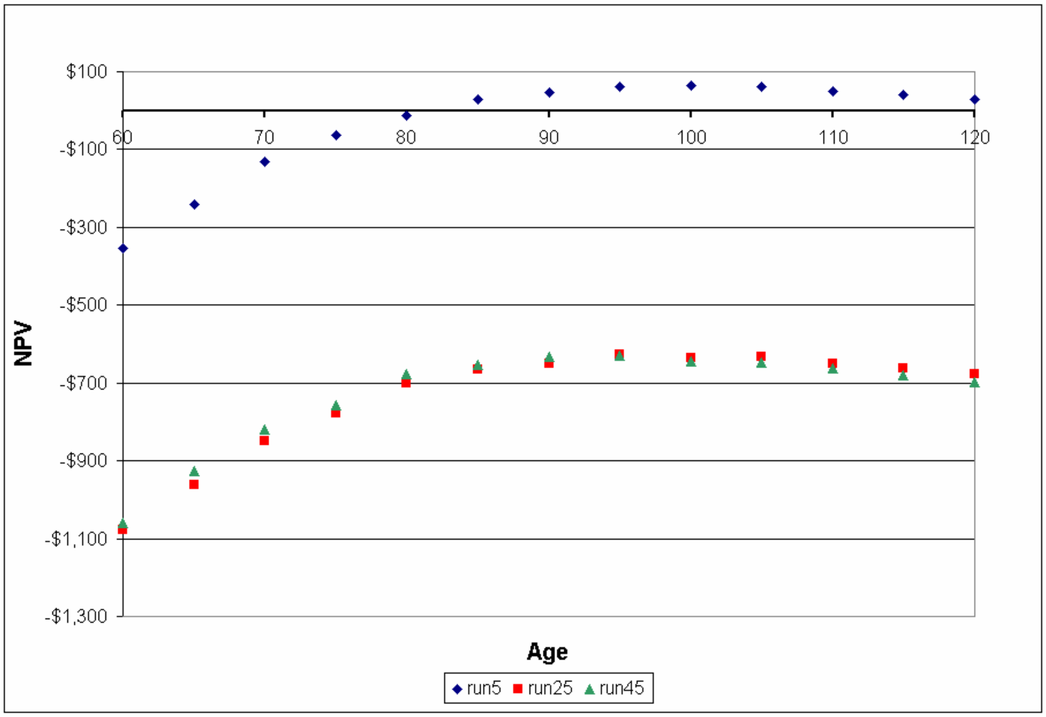

Figure 53. Variation 1Age vs. NPV with 4000 sph infill (Run 5; Nat with fill plant, Run 25; Plt5%; Run 4515%GI)

Other Strategies

The “Type 1” project identified timber supply and quality opportunities from harvesting existing alder stands. Since the “Type 1” project some alder harvesting has been done. This is expected to continue as long as suitable stands are found and log prices and demand remain firm. As identified in the “Type 1” project, utilization of these stands will have positive short and long-term timber supply effects. As harvesting and basic reforestation activities are not fundable by FIA and analysis of the utilization of deciduous-leading stands falls within the scope of timber supply analysis, this project did not deal with the stand and forest level impacts of harvesting the existing alder inventory.

Over the last few years WFP has been conducting aggressive alder control programs along roadsides and within older plantations. These treatments are designed to release coniferous crop trees from competition. The preliminary Silviculture Investment Plan in the “Type 1” report shows that WFP plans to treat about 300 ha/year for the next 5 years. Despite the size of this program, neither this project or the “Type 1” project tackled the stand and forest-level growth and yield and financial impacts of this program. Therefore, if this program continues to be sizeable, it is recommended that a separate analysis be conducted to support the planned expenditures.

11. HABITAT

Based on results of the “Type 1” a review of opportunities for treatments to increase habitat quantity and quality was completed. While WFP remains committed to continue with identified, feasible treatments, inventories and studies with available funding no significant habitat-enhancing treatments identified which were deemed worthy of stand or forest-level analysis.

Currently, priorities are continuing with density management treatments in riparian areas. With the small areas currently being treated, it was determined that forest-level timber supply effects ould be minimal. In future broader scale treatments may be considered.

12. DETERMINATION OF THE PREFERRED SILVICULTURE STRATEGY

Summary of Timber Supply, Quality Issues and General Silviculture Strategies:

Policies developed over the last two decades to ensure multi-resource sustainability limit the timber supply in the short to medium-term. Reductions in the amount of old forest available for harvest result in the annual allowable cut (AAC) being stepped down over the next 50 years. In the mid to long term, as more second growth becomes merchantable, the AAC slowly recovers until it reaches a long-term sustainable level higher than the current harvest rate.

Unlike most timber supply management units on the coast, the minimum harvest ages for the TSA for TFL 6 are set based on the achievement of target diameters rather than maximization of mean annual increment (MAI). This strategy generally results in harvest ages that are higher than would occur using biological criteria, particularly on certain sites.

The TFL 6 AAC is very sensitive to minimum harvest ages over the next 100 years. For example, if minimum harvest ages were set at 95% of culmination ages, there would virtually be no short to mid-term fall-down in supply. On the other hand this strategy would result in a smaller average harvested log size (diameter). Therefore assumptions about future merchantability, as represented by target average diameters or diameter distributions, can have a significant impact timber supply assessments and therefore on strategic silvicultural planning.

Hw dominates existing second growth stands in TFL 6. If the current depressed market demand (price) for Hw relative to other primary coastal species continues, this lack of species diversification will limit the economic returns from harvesting in TFL 6. As a result, the “Type 2” project focused on assessment of ecologically-viable regimes for growing alternatives to Hw. Of the alternatives analyzed, increasing the use of Cw on S1ha sites was identified as the most promising. The benefits of increasing the use of Cw would be higher harvest values (assuming current log prices), however harvest levels may be decreased. Given the importance of strategic decisions such as this, it is recommended that additional analysis be done prior to potential implementation of significant changes in species management.

Past silviculture efforts have softened, and will continue to soften, the effects of recent harvesting restrictions. Aggressive basic reforestation and intensive treatments such as tree improvement and fertilization have been included in the CMO. According to the TSA, future intensive treatments, of the magnitude assumed in the CMO, potentially account for between 5 and 20% of the projected AAC after about 2140.

Otherwise, most of the additional suggested treatments are considered “experimental” and require further study or research prior to implementation.

Silviculture Strategies:

The “Type 1” project included an evaluation process to rank the identified silviculture treatment options. This evaluation process was completed by WFP foresters and used to develop a preliminary 5-year tactical plan.

Primarily as a result of the relative importance placed on creating short-term silviculture employment, the “Type 1” project evaluation process resulted in the following treatment rankings for the main silviculture treatments:

Treatment	Rank
Juvenile spacing	1
Pruning	2
Backlog brushing	3
SCHIRP fertilization	4
Use of genetically improved stock	5
Fertilization at time of planting	6

Subsequently the FRBC's priorities and WFP's objectives for TFL 6 have changed. Currently WFP's focus is on treatments that improve timber supply, quality or habitat and are financially viable. As a result the FIA fundable treatment priorities have been re-prioritized to:

Treatment	Rank
Juvenile spacing	4
Pruning	5
Backlog brushing	2
SCHIRP fertilization	1
Riparian Restoration	3

In addition, based on the results of the "Type 2" project the silviculture strategies have been amended to:

Strategies to Increase the Quantity of Future Timber Supply

Short-term:	1. Reduce regeneration delay on salal sites by continuing to fertilize at the time of planting. 2. Increase the short-term AAC by harvesting alder.
Mid-term:	1. Increase the AAC in the 2041 to 2060 "trough" by looking at establishing alder plantations on ecologically-suitable currently harvested areas. 2. If non-SCHIRP Hw fertilization response can be demonstrated, the mid-term AAC could be significantly increased by fertilization. 3. If commercial thinning can be proved to be viable, a program starting in about 2030 could be used to increase the AAC in the 2041 to 2060 "trough."

Long-term:	1. Increase long-term AAC by continuing to aggressively fertilize and monitor treatment response under SCHIRP. 2. Reduce long-term minimum harvest ages by continuing to use genetically improved seed. 3. Increase the long-term AAC by converting un-managed alder-leading stands to managed coniferous stands. 4. Increase the long-term AAC and forestry land base by draining wet, low productivity sites. 5. Increase the long-term AAC with an aggressive road rehabilitation program.

Strategies to Increase the Quality of Future Timber Supply

Short-term:	1. Increase product diversification by harvesting alder.
Mid-term:	1. Increase product diversification and recover logs with some clear cuttings by growing alder. 2. Juvenile spacing to promote Cw and Yc. 3. If commercial thinning can be proved to be viable, a program starting in about 2030 could be used to increase the quality of the final harvest.
Long-term:	1. Increase value by modification/ diversification of the species mixes used in reforestation.

Strategies to Increase the Quantity or Quality of Future Habitat Supply

Long-term:	1 Density management and conversion of alder-leading stands in riparian management zones to mixed to deciduous-coniferous stands will improve long-term fish and riparian habitat.

13. INCREMENTAL SILVICULTURE PROGRAM

This section outlines and summarizes a recommended incremental program. This program is based on a funding level of $1, 045,000 which is slightly lower than was planned for 2001-02. This plan reflects WFP’s current philosophy and understanding of the key issues effecting timber supply and quality and habitat. Table 3 summarizes the recommended program for 2002 to 2006 and estimates the resultant employment creation.

Table 3: 2002 to 2006 Recommended Incremental Silviculture Program

Treatment	Rank	% of Annual Budget	Total Opportunity Area (end of 2001) (ha)	Annual Treatment Area (ha)			Cost/ha ($/ha)	Annual Cost ($)	Employment	
				Low	High	Average			MD/ha	Annual MD
Main										
Juvenile Spacing	4	0 to 20	3,000	0	800	45	2,000	90,000	6.5	292.5
Pruning	5	0 to 10	500	0	450	10	3,000	30,000	7.5	75
SCHIRP Fert.	1	50 to 80	2,700	800	1200	1000	600	600,000	0.2	200
Backlog Brushing	2	10 to 30	1500	100	500	250	700	175,000	1	250
Riparian Restoration	3	10 to 20	300	30	50	40	2,800	112,000	7.6	304
Totals:			*8,000*	*930*	*3,000*	*1345*		*1,007,000*		
Other Projects		3 to 10						38,000		
Cw, Dr Silv. Strategies										
CT										
Non-SCHIRP Hw fertilization										
Grand Totals:								*1,045,000*		

The recommended program allocates up to 10% of the budget to studying "experimental" or innovative projects which will contribute to decision-making on potentially important future treatment opportunities.

Timber supply analysis of the recommended program was not required as the main treatments were included within the CMO of the last TSA.

14. REFERENCES

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