Weyerhaeuser Company Ltd.

Tree Farm License # 44

Type 1 Incremental Silviculture Strategy

February 2001

Funded by
Forest Renewal BC

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Sincere thanks are expressed to the participants at the workshop held December 13, 2000 at the Sproat Lake Division offices of Weyerhaeuser, for their time and valuable input. The following people attended the workshop:

Erin Badesso	Weyerhaeuser
Derek Ferguson	Renewal Investment Corp.
Rod Hillyard	Olivotto Timber
Glen Johnson	Ministry of Environment, Lands and Parks
Peter Kofoed	Weyerhaeuser
Diane Medves	Weyerhaeuser
Norm Nallewag	Ministry of Forests
Gerrard Olivotto	Olivotto Timber
Rick Player	Weyerhaeuser
Larry Sigurdson	Ministry of Forests
Dean Stewart	Ministry of Forests
Cees van Oosten	Renewal Investment Corp.

Preface

The terms of a service agreement between Forest Renewal BC (FRBC) and the BC Ministry of Forests (MOF) requires the MOF to develop, and FRBC to fund, the development of a rationalized incremental silviculture strategy. This document is partial fulfillment of the contractual requirement.

Incremental silviculture is part of a group of strategies that together may influence the future quality and quantity of habitat and timber supply. This strategy document broadly analyzes the full potential range of silviculture activities, in order to create a context for an incremental strategy.

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

This strategy is founded upon readily available information and the knowledge of forestry professionals. It is intended as an interim strategy until a more in-depth, analysis-based review is completed.

Strategy Summary

The focus of the incremental silviculture strategy in TFL 44 is to ensure rapid early growth of young stands, and increased volume production from older second growth stands. The strategy also enhances wildlife habitat values in second-growth stands, and includes some treatments to increase log size and quality.

Major silviculture strategies:

Quantity
1. Brushing young stands to remove salmonberry and salal competition for moisture and nutrients.
2. Fertilization at planting for Douglas-fir and SCHIRP fertilization of young cedar-hemlock stands.
3. Aerial fertilization of Douglas-fir stands 40–60 years old.

Quality
1. Juvenile spacing – limited to areas of very high density, or for species choice or forage production.
2. Pruning and spacing for clear wood production – again very limited, used in high-site Douglas-fir and redcedar stands, and control of White Pine Blister Rust.

Habitat
1. Variable density spacing in second-growth reserved areas (generally riparian zones) to meet old seral targets in landscape units that are currently short.

Summary of areas (ha) proposed for treatment under the silviculture program

Year	Surveys	Brushing	Fertilize young	Fertilize pre-harvest	Space	Prune	Total
1	4,000	400	800	1,000	150	50	2,400
2	4,000	400	800	1,000	150	50	2,400
3	4,000	400	800	1,000	150	50	2,400
4	4,000	400	800	1,000	150	50	2,400
5	4,000	400	800	1,000	150	50	2,400
Subtotal 1-5	20,000	2,000	4,000	5,000	750	250	12,000

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1.0 INTRODUCTION

TFL 44 held by Weyerhaeuser Company Ltd. is located in the west-central Vancouver Island area and encompasses the communities of Port Alberni, Tofino, Ucluetet and Bamfield (Figure 1). The TFL is administered from the South Island Forest District as part of the Vancouver Forest Region. Logging, forestry and processing operations (as of 1997) employ more than 3,000 individuals making a significant socio-economic impact on the Alberni region.

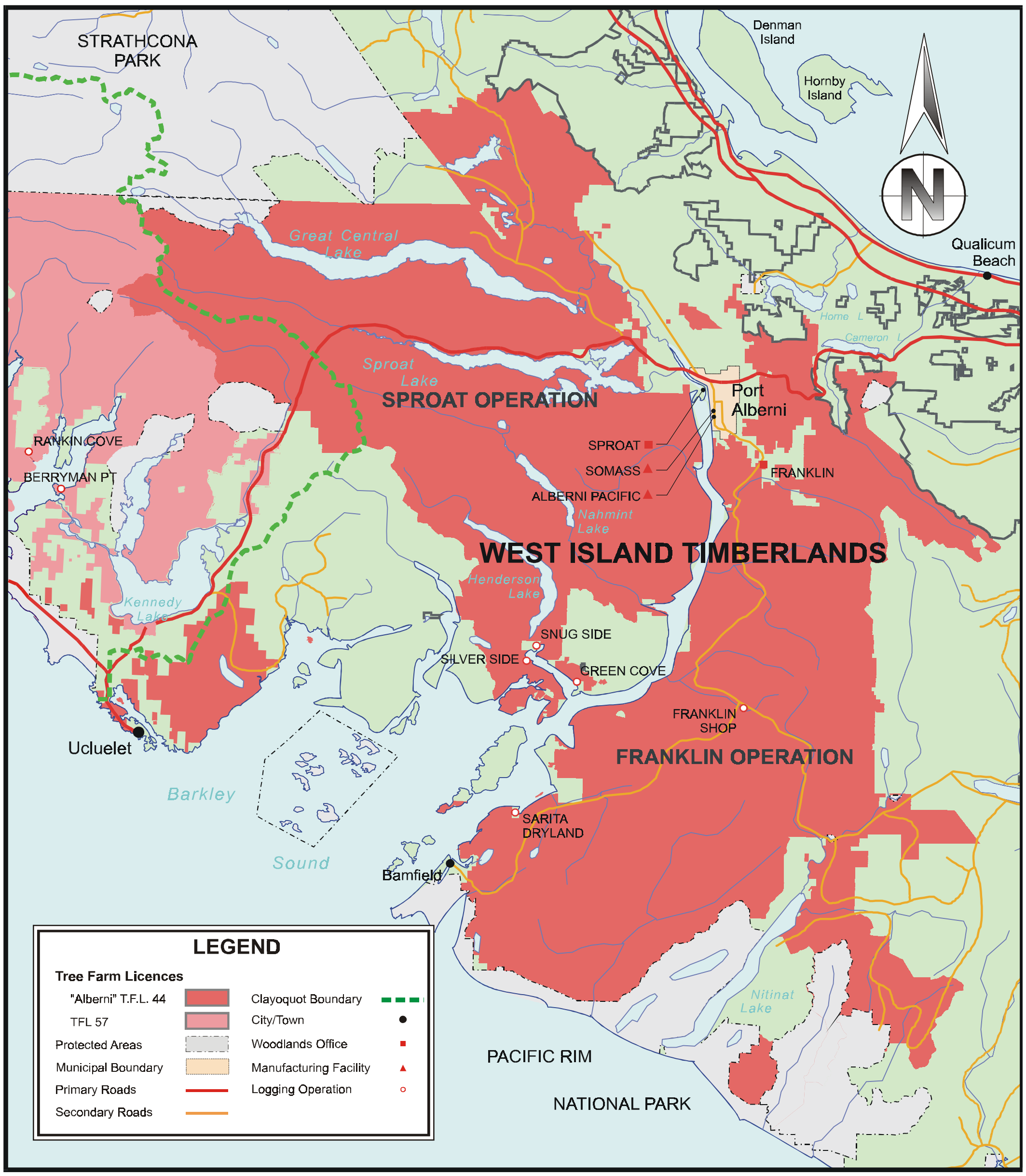


Figure 1. Key map to TFL 44.

Within TFL 44 there are four working circles, Alberni East, Alberni West, Ucluelet and Clayoquot Sound. The Clayoquot Sound circle has largely been removed to become TFL 57. This report does not address Clayoquot Sound as it was not considered in the Timber Supply Analysis for MP#3.

The Alberni East working circle is comprised of Blocks 1 and 2 and has a timber harvesting land base (THLB) of 99,911 ha. Alberni West includes Block 3 (except compartment 10E) and Block 4. Alberni West has a THLB of 70,208 ha which makes it the second largest working circle. The smallest working circle is Ucluelet. Ucluelet has a THLB of 6,938 ha which is found in the portion of Block 5 that is not held by the Clayoquot Sound working circle.

Methodology

The first step of this project was to review Weyerhaeuser Company Ltd.'s and MoF's documentation of recent timber supply and silviculture scenario analyses for TFL 44. Upon completion of the review a preliminary draft document was produced that summarized available information relevant to the timber supply situation in TFL 44, and potential opportunities to improve timber quantity and quality. A workshop was held at Sproat Lake Division offices on December 13, 2000 with representatives from MoF, Weyerhaeuser, MELP, and FRBC to review the potential opportunities, discuss the merits of each opportunity, and identify those opportunities best suited to the forest management goals of Weyerhaeuser. The information provided at the workshop was incorporated into this document and forecasts and changes in future harvest quantity, quality and job outcomes were added. After Weyerhaeuser reviews the document, a complete final version will be prepared for submission to the planning committee.

1.1 TFL Issues Impacted by Silviculture

Timber issues

Weyerhaeuser's main emphasis is on volume production. The company believes that good timber quality will be ensured by maintaining full stocking. Trees in well-stocked stands typically have higher wood density, less juvenile wood, tighter grain, smaller knots and straighter form than trees in open stands. For most stands, strategies to add value by juvenile spacing to increase piece size are viewed as unattractive. Costs are high, losses in volume production are likely, piece size gains appear less than previously estimated, and intrinsic wood quality factors are compromised by significantly faster stem growth. The company expects that technology (both products and processes) will over time reduce the current value premiums due to larger piece sizes.

Habitat issues
Variable retention (VR) is a major component of Weyerhaeuser BC Coastal Group's strategy for both stand-level and landscape-level biodiversity. It is envisioned that VR will complement Old Growth management areas and Wildlife Tree Patches. The different growing site conditions, and longer rotations in areas with non-timber forest cover requirements also adds diversity to the forest landscape. In addition, the company recognizes that silviculture options including variable density and wide or patch spacing in riparian reserves and other suitable reserve areas may promote early provision of old-growth habitat characteristics in variants short of old seral age classes. Wide spacing and some pruning may be useful to promote spring forage values.

Employment issues
Harvesting and attendant processing of the harvest from TFL 44 supports over 3000 jobs in the Alberni region. Increases above current incremental silviculture levels will create further employment, both at time of treatment and over time as harvest levels respond to the treatments. Incremental silviculture is important to first nations members, who are trained and employed on silviculture activities, and are now developing sustainable businesses based on those skills.

1.2 Objectives of the Silviculture Program

This section documents higher level goals and objectives relevant to an incremental silviculture strategy for the TFL.

TFL 44 objectives
The objective of Weyerhaeuser's TFL 44 silviculture plan is to minimize the currently predicted medium-term shortfall in timber supply, to ease the transition to the long-term harvest level (LTHL) and to increase the LTHL. Weyerhaeuser also wants to provide employment opportunities that are related to silviculture activities.

Weyerhaeuser recognizes that silviculture activities can enhance habitat values. Treating areas otherwise reserved, according to the availability of government funding, can enhance habitat values while also being positive to timber supply by releasing other areas that may be temporarily reserved.

Provincial goals
Government's goals can be characterized as:
- Sustainable use;
- Community stability; and
- A strong forest sector. (MoF, 1998a)

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). Incremental silviculture strategies must also be in keeping with higher level plans under the Forest Practice Code.

- Maintain current harvest levels as long as possible without 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 supply is achieved.
- Create a long term timber supply which will enable the timber quality 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.

Regional objectives
The objectives of the Vancouver Forest Region incremental silviculture strategy (MoF 1998c) 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 and forest health activities with those that increase the value and/or reduce harvest and processing costs 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.

2.0 RESOURCE DYNAMICS

2.1 Synopsis of the land base

The most recent timber supply analysis for TFL 44 was completed in 1997 in support of Management Plan #3 (MP#3). The analysis included a data package, and was followed by an AAC rationale document by the Chief Forester. The following tables and figures, derived from the analysis, provide qualitative and quantitative description of important land base attributes for TFL 44.

Table 1. THLB (ha) after net down procedure for the Working Circles.

Netdown category	Alberni East	Alberni West	Ucluelet	Total
Total TFL landbase	153,385	145,267	10,946	309,598
Less non-forest	(9,659)	(26,034)	(824)	(36,517)
	143,726	119,233	10,122	273,081
Les nonproductive	(4,383)	(8,394)	(281)	(13,059)
	139,342	110,839	9,841	260,022
Less physically inoperable	(2,094)	(6,512)	-	(8,606)
	137,248	104,327	9,841	251,416
Less sensitive sites & non-timber values	(25,424)	(18,617)	(1,635)	(45,676)
	111,824	85,710	8,206	205,740
Less deciduous	(1,448)	(485)	(53)	(1,986)
	110,376	85,225	8,153	203,754
Less currently uneconomic	(936)	(4,713)	(271)	(5,920)
	109,440	80,512	7,882	197,834
Less FEN links	(8,708)	(9,386)	(908)	(19,002)
	100,732	71,126	6,974	178,832
Less additional old-growth reserves	(821)	(918)	(36)	(1,775)
Resultant net landbase	**99,911**	**70,208**	**6,938**	**177,057**

Table 2. Harvest levels modelled in the MP#3 analysis

Working Circle	MP#3 Base Option
Alberni East	1,203,000
Alberni West	521,000
Ucluelet	36,000
Total	**1,760,000 m3/yr**

* The TFL 44 AAC is 1,766,200 m3/yr
(includes 6,200 m3/yr in Clayquot)

Alberni West does not produce the same ratio of harvest to land base as Alberni East. Two reasons that may cause this difference are the amount of net mature volume available and percent of net area in retention and partial retention VQO's. Alberni West has 29.7% of the TFL 44 net mature volume compared to Alberni East which has 67.9%

of the TFL 44 net mature volume. The percentage of net area in retention and partial retention VQO's are 5.8% in Alberni East and 22.7% in Alberni West.

Age classes
Figure 2 illustrates the distribution of area by ten-year age class in the productive forest. Reserved area includes both old and young forest, although the Forest Ecosystem Network (FEN) links are concentrated in older timber.

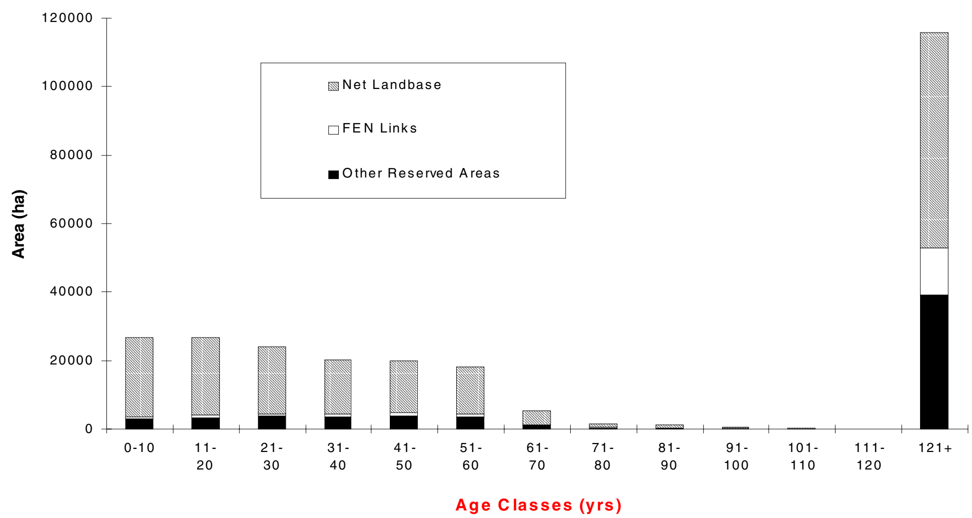


Figure 2. Age class distribution within the productive forest

Figure 3 illustrates the distribution of regenerated area by age and species within the timber harvesting land base (THLB). Approximately 33% of the timber harvesting land base is covered by stands more than 250 years old and 5% in stands between 70 to 250 years old (not shown). In the regenerated area, 26% of the THLB area is covered in stands between 30 to 70 years old, and 36% in stands between 0 to 30 years old. Older second-growth stands are mainly Douglas-fir leading, while stands younger than 25 years are mainly hemlock-leading. The species difference will become apparent after a two or three decades of harvesting reliance on second-growth timber.

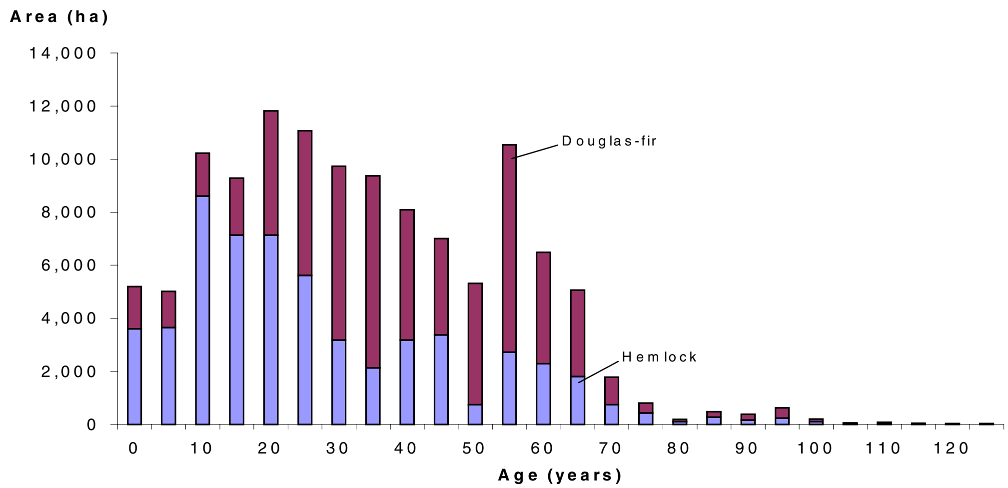


Figure 3. Age class distribution on regenerated THLB areas

Growing site quality

Site index is expressed as the height a stand is expected to reach by 50 years breast height age. Figure 4 illustrates the distribution of THLB area by species and site index. Approximately two-thirds of the land base is site index 27+, suitable for regeneration management that includes spacing treatments according to foresters at the workshop. Approximately 14% of the area is greater than site index 35, suitable for pruning, and another 16% is site index 33, suitable for pruning with fertilization according to foresters at the workshop. Actual stands presently suitable for these treatments will be a subset of the area, because many stands are already beyond treatment age.

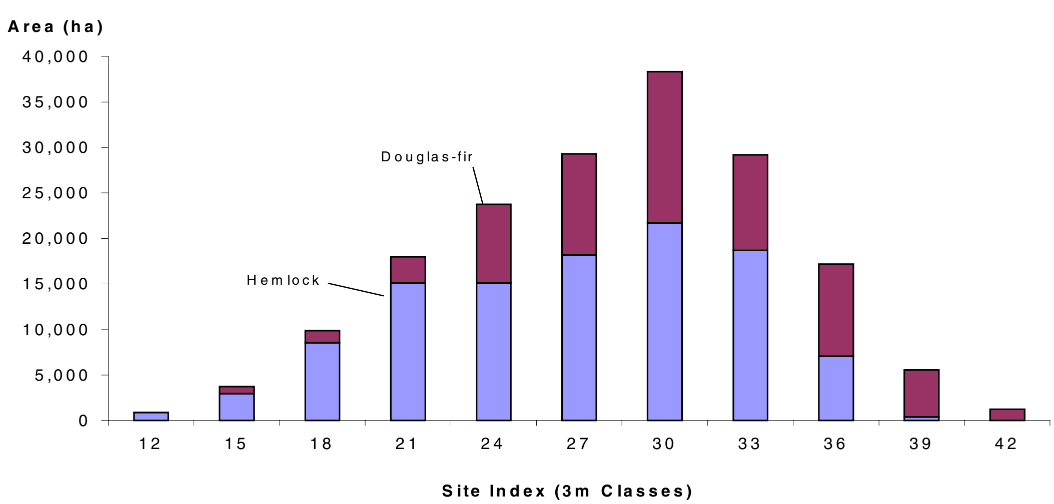


Figure 4. Area by species and site index class

Stand densities

Weyerhaeuser has developed a regeneration model that predicts species and densities regenerated by planting and natural means, according to stand location in the landscape. The model assigns regenerating stands fractionally among establishment density classes.

The assignment is recorded in the inventory file. The Ministry of Forests Table Interpolation Program for Stand Yields (TIPSY) provides information about competitive exclusion density reductions over time for a specified establishment density and growing site/species combination. These two sources of information were combined to develop estimates of present stand density conditions in TFL 44. Figure 5 illustrates the derived distribution of area by density class for regenerated stands (those presently less than 120 years old).

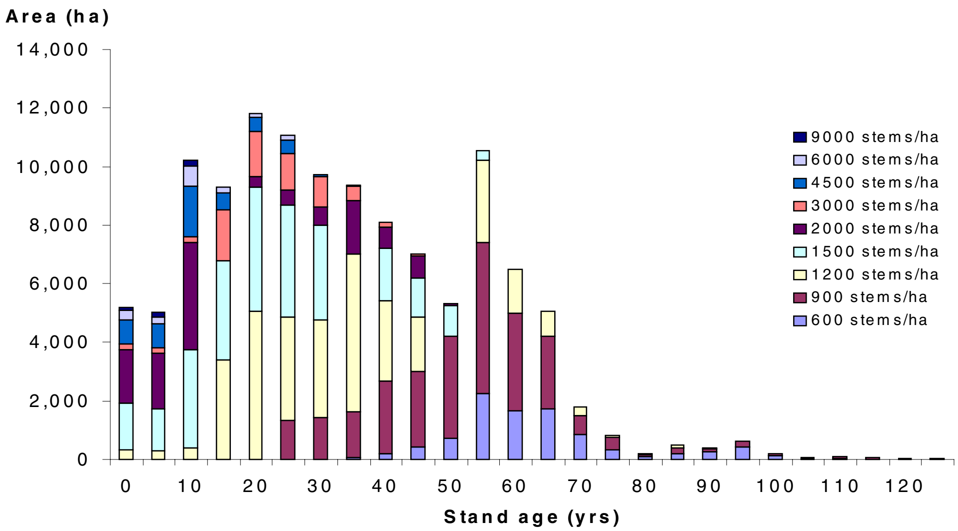


Figure 5. Area by age and stand density class

2.2 Timber Supply Dynamics

The following section is a review of the Timber Supply Analysis Report developed by Weyerhaeuser Ltd. for TFL 44 in support of MP#3 in 1997. Base case harvest levels are presented, followed by a discussion of the sensitivity tests undertaken in the analysis.

Current harvest forecast

The harvest level (excluding Clayoquot Sound) for the period 1997-2001 is 1,760,000 m^3/year as projected by the current timber supply analysis. The AAC was determined by the Chief Forester at that level, which is 2.5% below the previous AAC (excluding Clayoquot Sound). The next 25 years are expected to have a decreasing timber supply in five-year increments of 5.3%, 5.0%, 3.2%, 3.3% and 1.3% respectively. The lowest point in the timber supply occurs in the period 2022-2026 when it reaches a projected low of 1,464,000 m^3/year. The analysis projects a rebound in harvest levels by one decade later, and a long-term harvest level (LTHL) that is 7.3% higher then the 2022-2026 dip. (MB 1997c, p49; MoF 1997, p6)

The figures on the two following pages illustrate the base case harvest forecast for each working circle and for TFL 44 according to the MP#3 timber supply analysis.

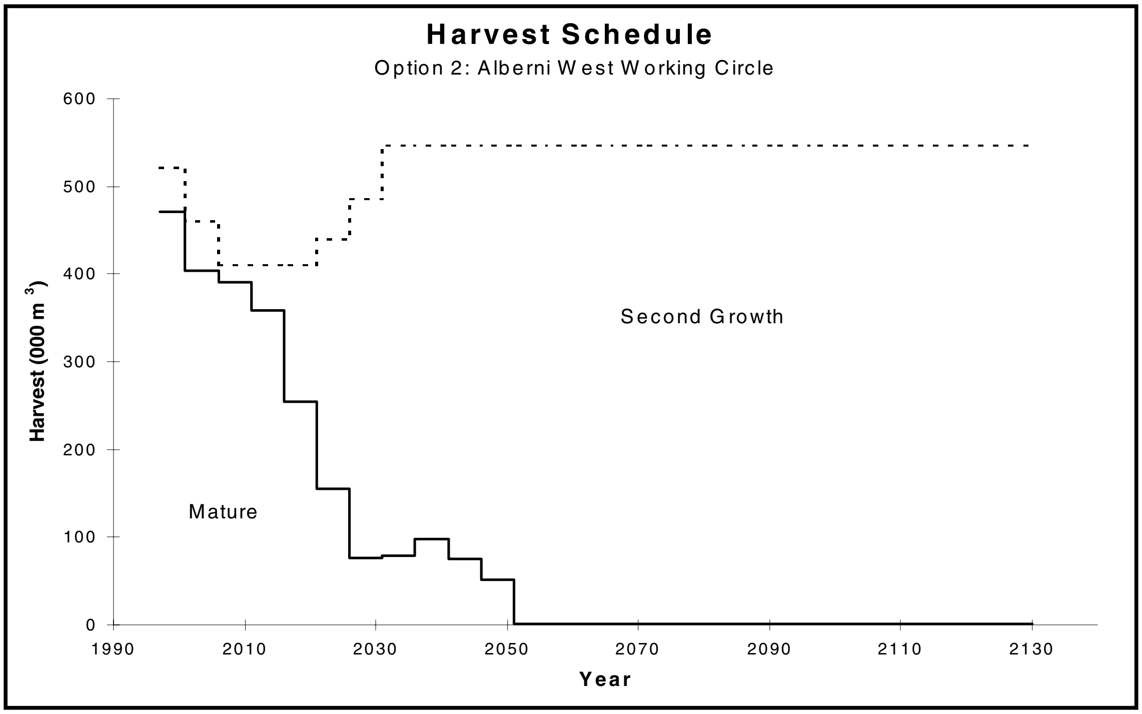


Figure 6. Harvest forecast for Alberni West

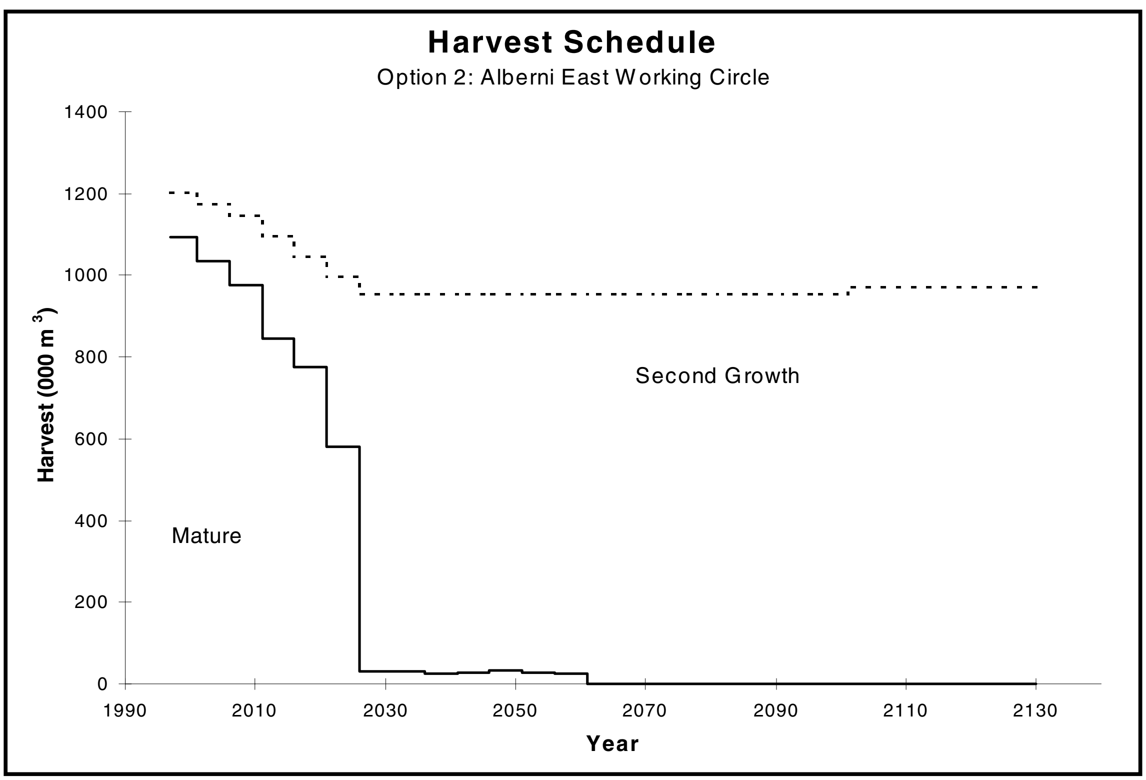


Figure 7. Harvest forecast for Alberni East

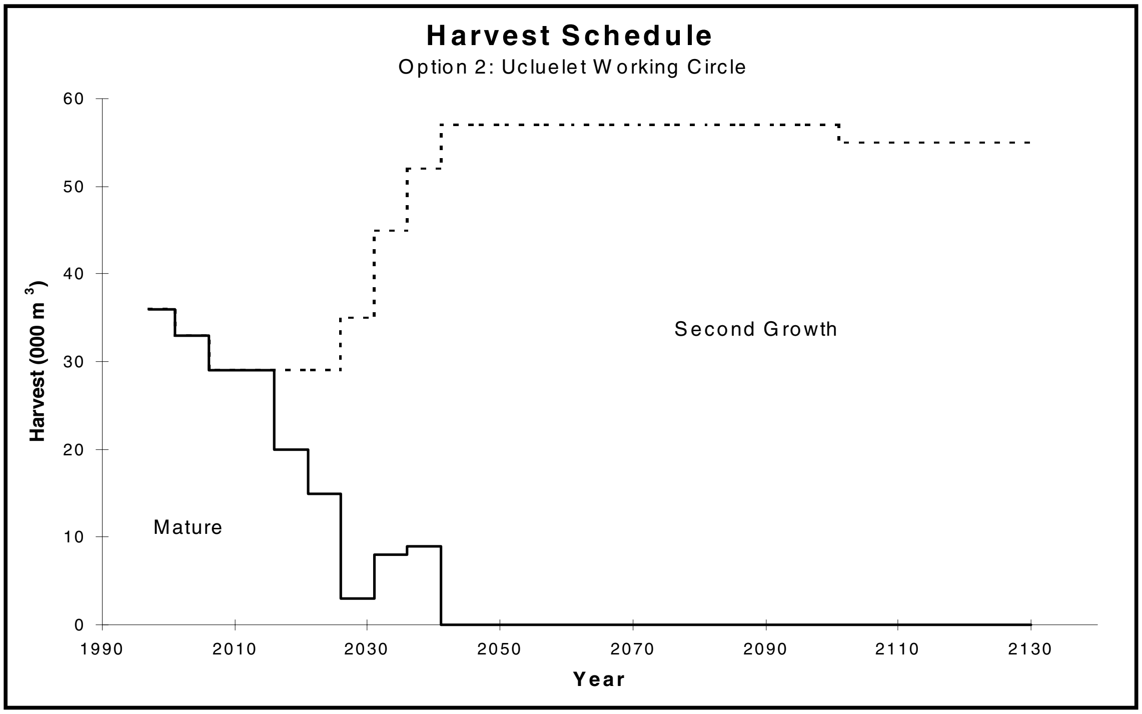


Figure 8. Harvest forecast for Ucluelet

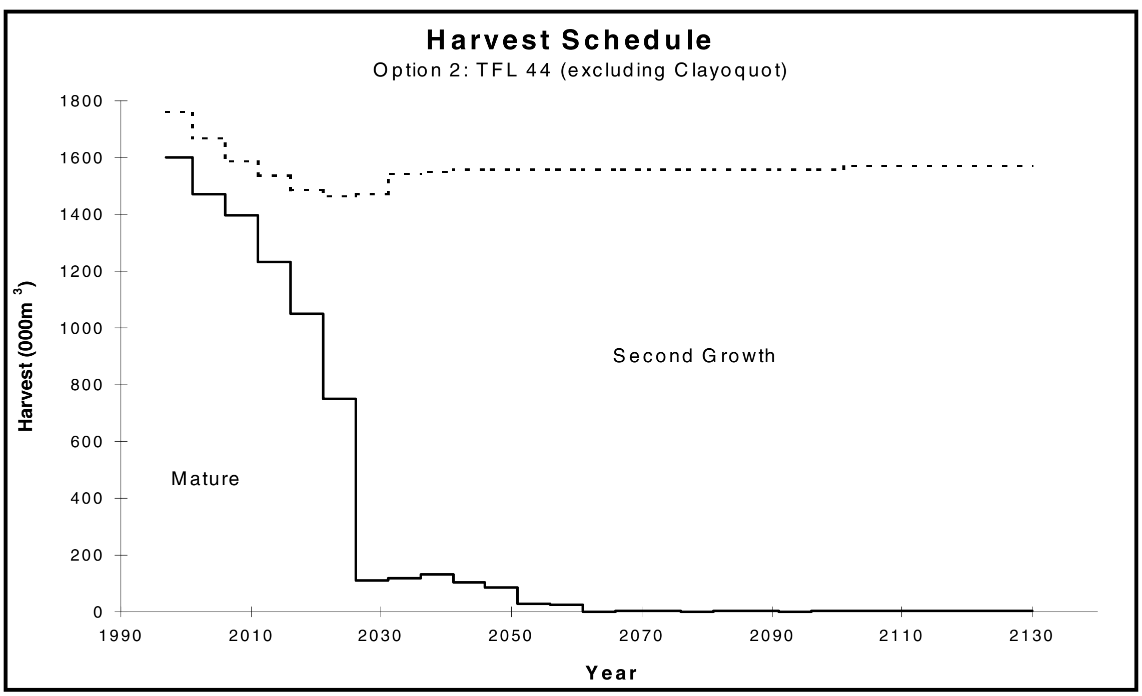


Figure 9. Combined TFL 44 harvest forecast

Forest cover requirements for visually sensitive areas

In visually sensitive areas regenerating stands must achieve 5m height to be considered greened-up. In the base case this height is met in 13-16 years. Reducing the time to visually effective green-up (VEG) by silviculture methods can increase the harvest flow, especially in the mid-term, due to increased flexibility in harvest scheduling.

The analysis tested reducing and increasing the VEG age by four years. A four-year reduction in the VEG age increased the mid-term and long-term harvest flow compared to the base case. The greatest increase is in the mid-term where the dip is reduced by a 4.1% increase in timber supply over the base case. The LTHL is increased by 1.4% above the base case. VEG may be reduced by prompt establishment and fertilization of appropriate sites.

A four-year increase in the VEG age, from 13-16 years to 17-20 years, decreased the harvest flow for the entire harvest projection. The short-term and mid-term harvest levels decreased by approximately 2.5%, and the LTHL decreased by 1.2%.

There are three visual quality objective (VQO) classes identified for forest cover requirements. The VQO classes are Retention, Partial Retention, and Modification. Base case requirements (dependent on working circle) are that at most 1-2% of the area be non-VEG in Retention, 7-8% be non-VEG in Partial Retention and 20-22% be non-VEG in Modification. The THLB area effected by these constraints is 30.8% (MB 1997c, p.18)

The analysis tested increasing and decreasing the area permitted to be non-VEG by five percentage points. With tightened alteration constraints there are negative effects on the harvest level of 5.0% in the short term, 7.1% in the mid term, and 5.7% in the long term.

Relaxed alteration constraints have a positive effect on harvest levels of 3.5% in the short term, 4.4% on average through the mid term, and 2.0% in the long term. The main increase is in the early mid-term (2017-2031) where the dip in harvest levels shown in the base case is eliminated. The increased harvest level is 6.3% above the base case for that time frame. Weyerhaeuser expects that improved design of cutblocks, and reserved variable retention patches, will effectively shift present alteration constraints toward the upper end of the stated ranges.

Older forest

The base case included requirements for old growth and biodiversity. The Chief Forester (MoF 1997) considered the modelled reductions appropriate for the time, and agreed that the analysis was completed correctly for the information available. The analysis modelled protection of older forest by making reductions of 19,002 ha of Forest Ecosystem Networks (FENs), plus an additional reduction of 1,755 ha of mature timber. Refer to Table 1.

The analysis tested a decrease in land base reductions. Adding the FENs back into the THLB has a positive impact on the timber supply. The short term harvest level is increased by 6% at initial commencement followed by a 10% decline over 25 years to a LTHL that is 12% higher than the base case. If regenerating forest can attain the structure of mature stands and older forest habitat conditions earlier, then a portion of the otherwise reserved older forest might come available for harvest.

Minimum harvest ages (MHA)
The minimum harvest age for the base case was established using two criteria. The first criterion was the age at which a stand's annual growth is within 0.2 cubic meters per hectare per year of its culmination of mean annual increment. The second criterion is that the stand volume must be at least 250 cubic meters per hectare with the trees that make up the stand having, on average, a minimum diameter at breast height of 25 centimeters. Using these criteria the average MHA for TFL 44 is 78 years. The culmination age requirement is the most constraining. For example a planted good-site Douglas-fir stand with 1200 stems/ha using these criteria has a MHA of 85yrs with an average diameter of 35 cm and a volume of 861 m^3/ha at that age.

The second-growth harvest strategy in MP#3 promotes flexibility in determining MHA for first-pass harvesting. Stands are harvested at younger ages than in the base case, according to a financial rotation assessment. The result is that some harvest volume is moved forward to fill the predicted mid-term dip in timber supply, particularly in the Alberni West and Ucuelet working circles.

Changing the MHA effects when second growth will be available for harvest and, accordingly, how quickly existing mature stands may be harvested. The analysis tested increasing and decreasing the minimum harvest age by ten years. A reduction in MHA causes an increase in the short-term and early mid-term harvest levels by allowing earlier access to the second-growth forest. However, harvest levels are reduced in the long term because the stands are harvested before culmination age.

A ten-year increase in the MHA causes harvest levels in the short term and early mid term to be severely reduced (1997-2041 - 14.6% reduction). The long-term harvest level is slightly improved (+1.5%) relative to the base case. The short-tem effect is due to a limited supply of presently mature volume, which is then required to sustain the harvest level for an additional ten years. MHA would be reduced by tree improvement, rapid establishment activities and late rotation fertilization.

The MHA would be reduced by tree improvement, rapid establishment activities and late rotation fertilization. This is in addition to the increased harvest flexibility provided by the second-growth harvest strategy.

Silviculture systems
The predominant silviculture system for TFL 44 outside of Clayoquot Sound is clearcutting. There is some clearcutting with reserves and the Chief Forester strongly

recommends continued exploration of alternative silviculture systems. Under current practices Weyerhaeuser Company Ltd. has introduced variable retention harvesting. Variable retention (VR) will be the main harvesting system by the year 2003. The 1997 analysis does not include VR. The expected effect of VR would be a lower harvest level in future years (offset somewhat by the positive effect of increased visual cover), and increased stocking levels in regenerating stands due to a more abundant seed source.

Regeneration delay

The timber supply analysis assumed an average two-year regeneration delay for all regenerated stands. The current trend is toward reduced (less then two year) regeneration delay. Decreased regeneration delay could effect the short-term harvest flow by requiring the current mature inventory to be spread over a shorter period until second growth comes available. Also, it would impact the long term due to a higher overall MAI and decreased average rotation length to achieve equal stand volumes.

The mature volume harvested for the next 30 years is 80% of the total volume harvested. A 2-year decrease in regeneration delay (from 2 to 0 years) could therefore cause a short-term harvest level increase of approximately 5% (2/30*80) and a long term harvest level increase of 2.5% (78 vs. 80 years to MHA). Reduced regeneration delays also result in shorter periods to achieve green-up for adjacency and in visual landscapes resulting in further timber supply benefits.

Estimates of second growth timber volume

Y-XENO, Weyerhaeuser's yield projection model, was used to develop yield projections for the timber supply analysis. Douglas-fir yield estimates were adjusted to closely approximate MoF TIPSY yield estimates. The analysis tested a comparison of Y-XENO versus TIPSY estimates of volume for second-growth Douglas-fir. The use of Y-XENO without reductions to match TIPSY yield estimates shows that the harvest level is not sensitive in the short term but it is moderately sensitive in the mid and long term. The long-term harvest level is increased by 3.4%.

The analysis also tested increasing and decreasing all second-growth volumes by 10%. Increasing second-growth volumes by 10% has an impact on the mid- and long-term harvest flows. The mid-term dip becomes non-existent and the LTHL is increased by 9.9%. The short term was unaffected.

A 10% decrease in the second-growth volumes impacts the mid- and long-term harvest levels. The LTHL drops 10.1% compared to the base case. The short term was unaffected.

Estimates of existing mature timber volumes

Mature volumes are not responsive to intensive silviculture treatments, but the harvest flow is constrained by mature volumes. The analysis tested increasing and decreasing estimates of existing mature volumes by 10%. A 10% mature volume increase and a harvest flow strategy to harvest the extra volume over the first 4-5 decades increases the short-term and early mid-term harvest levels enough to fill the projected timber supply dip. The increased supply is 5% above the base case for 1997-2046.

A 10% decrease in mature volume estimates, with a harvest flow strategy to take the loss in the short term, leaves the harvest flow in the short and early mid term 4.7% below the base case with an unchanged LTHL.

2.3 Summary of TFL-level Issues by Period

Short term (1-20 years)
The short term is always the hardest to change due to the lag that is introduced by the growth rate of trees. Previous harvesting has moved a large portion of older stands to younger stands. Presently 62% of the TFL 44 land base is below the average minimum harvest age of 78 yrs. There is just enough remaining mature and available timber to sustain the current harvest level until developing stands will be ready for harvest. The analysis illustrates this by showing a highly sensitive short-term harvest level when minimum harvest ages are increased by ten years. An increase in the estimated volume of mature stands has a positive impact on the short-term timber supply, which is another indicator that the mature volume is a constraint on supply.

Mid term (21-50 years)
The mid term is also effected by the presence of an initial young age class distribution. The mid term is relatively sensitive to changes in visual quality requirements, both the VEG age and the percent alteration. With a decrease of 4 years in VEG age the supply dip in the mid term is reduced significantly. With an increase in the maximum modelled alteration of 5% the mid-term supply dip is eradicated. A mature volume increase of 10% eliminates the dip. An increase in second-growth volume reduces the dip but not to the same extent. Reductions in mature area withdrawals for FENs would also serve to fill the mid-term timber supply deficit. Additionally, the second-growth harvest strategy illustrates the dip can be reduced by shifting ahead volume from future periods. This flattens the dip – it is less steep but lasts longer.

Long term (51+ years)
The long-term harvest level will not respond positively to commercial thinning or partial harvesting if volume is the main objective. The long-term harvest level is sensitive to the modelled increase in regenerated volumes. The analysis shows a proportional gain in volume when second-growth volumes are increased by 10%. When volume is removed before the minimum harvest age via thinning or early second-growth harvesting the long-term harvest level is lower than the base case.

2.5 Opportunities to Increase Timber Supply

Opportunities indicated through TSR sensitivity analysis

The timber supply analysis included one intensive silviculture scenario that combined several treatments, and other sensitivity tests that may be interpreted to gain understanding of the timber supply effects of particular silviculture treatments.

The intensive silviculture scenario included:

- Prompt establishment and fertilization at planting (regeneration delay reduced by two years)
- 1,182 ha of deciduous forest converted to coniferous forest over first 20 years
- Medium-site Douglas-fir stands are fertilized within 10 years of harvesting (2% increase modelled starting 2007)

Figure 10 shows that the scenario results in harvest level gains commencing within ten years, and significant gains after 30 years from now. This scenario includes the same 3% volume increase for tree improvement (based on first generation progeny testing) as applied in the base case. The Chief Forester (MoF 1997) notes that a 3% increase for genetic gain appears to be low compared to currently experienced yield gains of 10-15% for current second-generation progenies. Harvest levels projected for the intensive silviculture scenario may be considered conservative. The short-term harvest flow is not impacted by the specified treatments because of the lag in treatment effects.

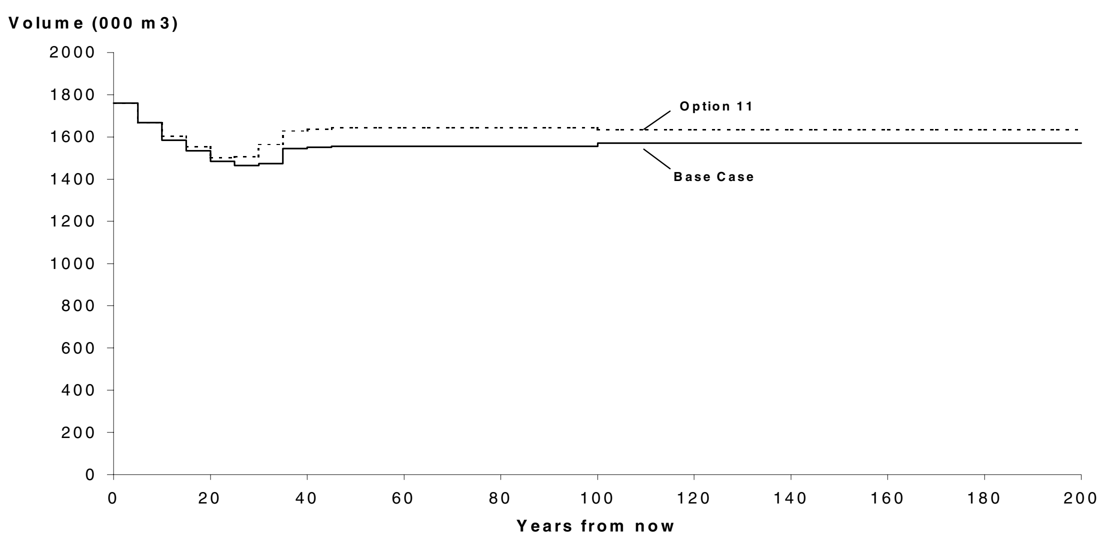


Figure 10. Harvest flow with the intensive silviculture option

Prompt stand establishment, fertilization at planting, vegetation management and use of large and/or genetically selected stock will improve mid- and long-term harvest levels. Treatments that occur early in the life of a stand are especially beneficial in reducing spatial constraints, for example adjacency and visual impacts. Figure 11 illustrates the impact on visually sensitive areas. Prompt green-up raises the mid-term harvest level almost up to the base case LTHL.

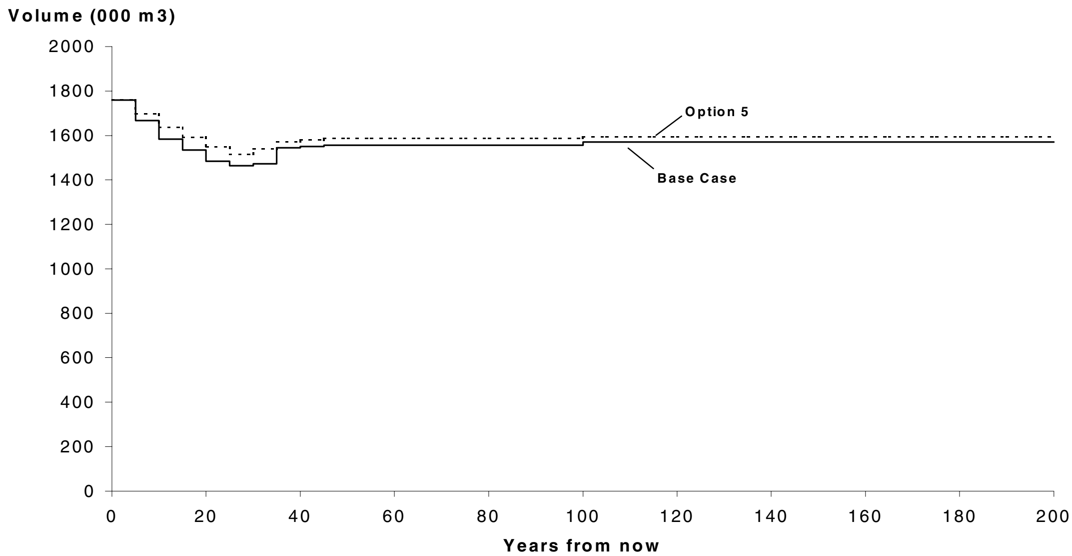


Figure 11. Harvest flow with visually effective green-up decreased by 4 years

Active management of areas currently classified as deciduous would add both short- and long-term timber supply. Weyerhaeuser is developing a management strategy that will recognize growing alder on some of these sites. The potential increment in long-term timber supply is between 10,000 and 20,000 m^3/yr.

Incremental silviculture treatments such as spacing with fertilization, fertilization alone and genetic gain can all help reduce stand minimum harvest ages (MHA). The MHA was set in the MP#3 base case to the combined criteria of when the stand's annual growth is within 0.2 m^3/ha of culmination mai, a minimum stand average dbh of 25 cm and a minimum stand volume of 250 m^3/ha. This was reduced for the first pass in the second-growth harvesting strategy. Y-XENO results for Douglas-fir, site index 27, for alternative spacing regimes are summarized in Table 3.

Table 3. Y-XENO modelled treatments and how they effect MHA

	Minimun Harvest Age (yrs)				
MHA Criteria	Ct 400 stems	JS 400 stems	JS 800 stems	JS150 stems CT80 stems	No Treatment
0.2 of Culmination, >250m3/ha, >25cm dbh	90	90	85	115	80
>250 m3/ha >25cm dbh	40	45	40	75	40
>350m3/ha >25cm dbh	65	50	50	90	45

* JS = juvenile spacing at age 15, CT = commercial thinning at age 60

The harvest level is reduced by an increase in the MHA. Table 3 shows that some treatments have a negative impact on the MHA. These treatments may reduce the TFL 44 harvest level if applied to a large enough land base. Table 3 also illustrates that the culmination criteria was the constraining attribute for the base case.

Decreasing the MHA by 10 years has an immediate short-term effect as seen in Figure 12. The LTHL is reduced slightly because harvesting at the lower MHA means harvesting below culmination age and the stand does not reach its full volume production potential.

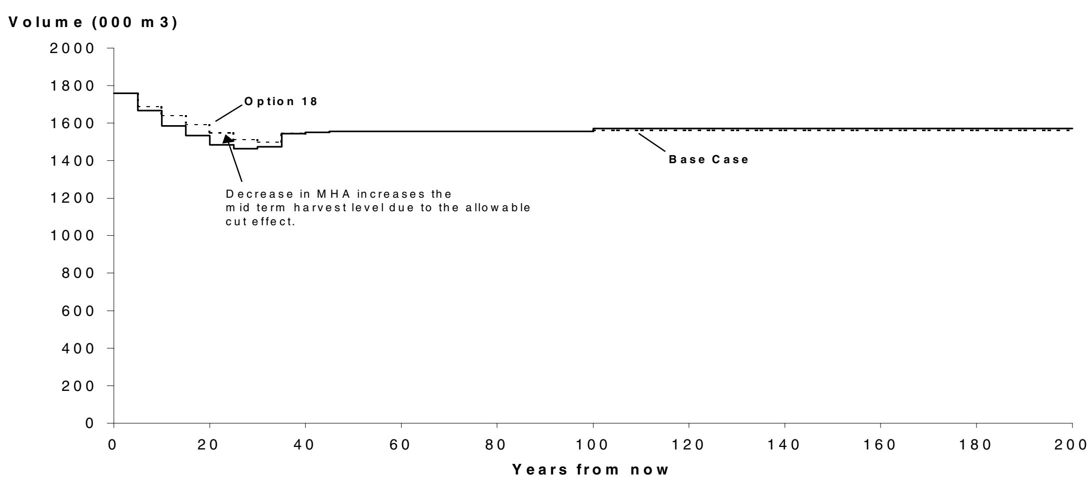


Figure 12. Harvest flow with MHA reduced by 10 years.

Fertilization treatments and improved genetic quality will increase modelled second-growth volumes. Figure 13 illustrates the timber flows achievable with a 10% increase in second-growth stand volumes. The treatments result in increased harvest levels by 20 years from now, as shown in Figure 13. Note that the sensitivity test did not reduce MHA with the greater volume production.

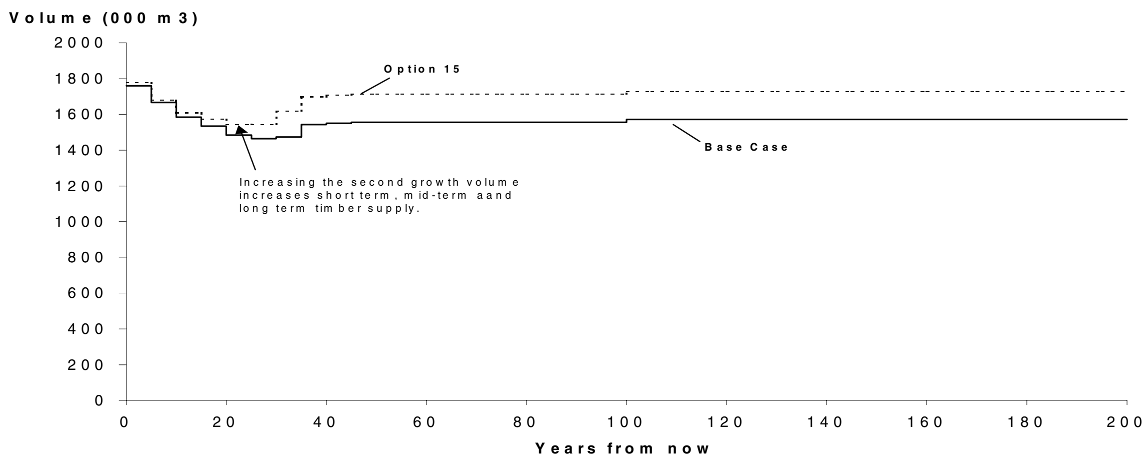


Figure 13. Harvest flow with second-growth volume estimates increased by 10%

2.6 Stand-level analysis

Diameter and volume impact of alternative spacing densities

Using TIPSY, several generic runs were completed to evaluate the trade-off in volume as a result of improved timber quality. The improved quality (larger piece size) was accomplished by thinning the stand to various densities. Table 4 shows the results of this test for Coastal Douglas-fir. Premium logs for this experiment are considered to be 55cm+ dbh. TIPSY indicates that it is necessary to thin stands to below 800 sph before seeing significant volume losses and diameter gains. The average diameter at 80 years is influenced by the removal of the smaller stems, which instantly increases the average stand diameter.

TABLE 4. TIPSY yield estimates for production of premium logs

Coastal Douglas-fir Site Index 27							
Original Density (stems/ha)	Thinning Density (Stems/ha)	Stems per Ha. @ 80yrs		Vol/ha @ 80yrs		Avg. diameter @ 80yrs of age	
		# Stems	% change from Base Case	m^3/ha	% change from Base case	DBH @ 80 yrs	m^3/ha of volume >55 cm dbh
2000	n/a	965	0.0	554	0.0	28.4	28
2000	1200	769	-20.3	547	-1.3	31.0	31
2000	1000	678	-29.7	541	-2.3	32.7	32
2000	800	585	-39.4	535	-3.4	34.8	35
2000	600	451	-53.3	508	-8.3	38.5	38
2000	400	308	-68.1	464	-16.2	44.5	44

Spacing and commercial thinning

The harvest age data in Table 3 and the TIPSY diameter information in Table 4 indicate that spacing and commercial thinning will have a negative impact on final accumulated volume, but will increase the average diameter. Will premiums for larger logs more than compensate for the volume lost and cost of treatments? Figures 14 and 15 illustrate Y-XENO yield projections for Douglas-fir, site index 27, for a range of spacing and commercial thinning treatments. The commercial thinning occurs at 60 years of age, and the spacing at 15 or 40 years. The variable density treatment proposed for riparian reserves is the JS 150/CT 80 line with low volume production in Figure 15. Treatments that provide greater diameter effect generally have a larger negative impact on volume per hectare.

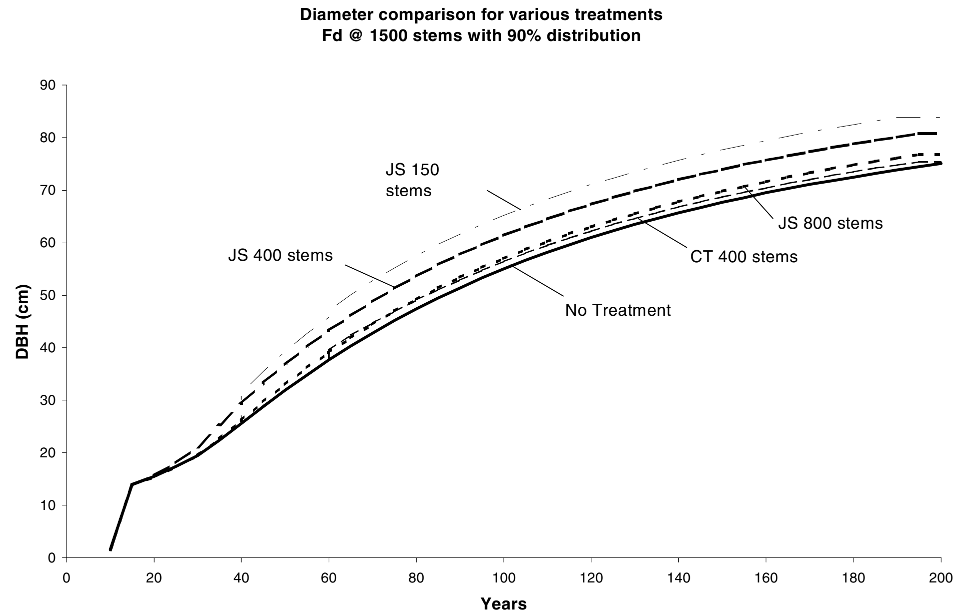


Figure 14. Diameter comparisons for candidate treatments.

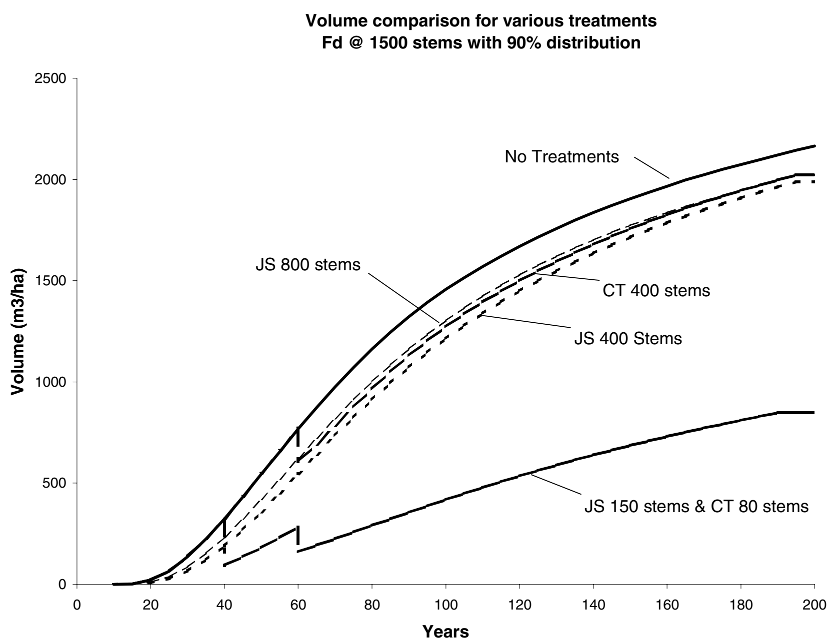


Figure 15. Volume comparisons for candidate treatments.

Species Conversion
The following discussion refers to species conversion after harvest of an existing stand. This is an important part of the silviculture strategy for TFL 44, but may be considered a basic rather than an incremental strategy.

Figures 16 and 17 illustrate Y-XENO estimates of the different development pathways for Douglas-fir and western hemlock, growing on site index 29 for each species. Often Douglas fir will grow at 2 – 4 m higher apparent site index than hemlock, which would raise the Douglas-fir curves in the figures. Workshop participants discussed converting regenerating stands of natural hemlock to either Douglas-fir or western redcedar. The wood from these species presently carries a 40% value premium.

The treatment regime requires planting, followed by a spacing treatment that favors those species. However, concerns were raised about investing in treatments that reduce land base productivity. Figures 16 and 17 illustrate that the total volume produced by growing hemlock on repeated short rotations (55-65 years), especially at high densities, exceeds the volume that can be expected growing Douglas-fir on the same value site index. This volume gap is closed, or reversed on many sites suited for Doouglas-fir where the site index for Douglas-fir exceeds that of hemlock.

However, both western redcedar stands (which grow on a pathway similar to hemlock) and Douglas-fir stands may contribute superior wildlife habitat attributes when placed in a mainly hemlock mosaic The workshop did not discuss possible habitat benefits of the species conversion.

Additionally, note that the Douglas-fir stands eventually and inevitably produce greater standing volumes than hemlock. The species conversion may therefore be most beneficial if undertaken in areas expected to be managed on rotations longer than approximately 100 years. This would include Partial Retention areas as modelled in the base case.

The workshop discussed pruning of Douglas-fir and redcedar stands on site index 35+, and on site index 32-35 with fertilization. Species conversion at regeneration on these higher sites would be a first priority, to establish stands that are suitable for the later treatments.

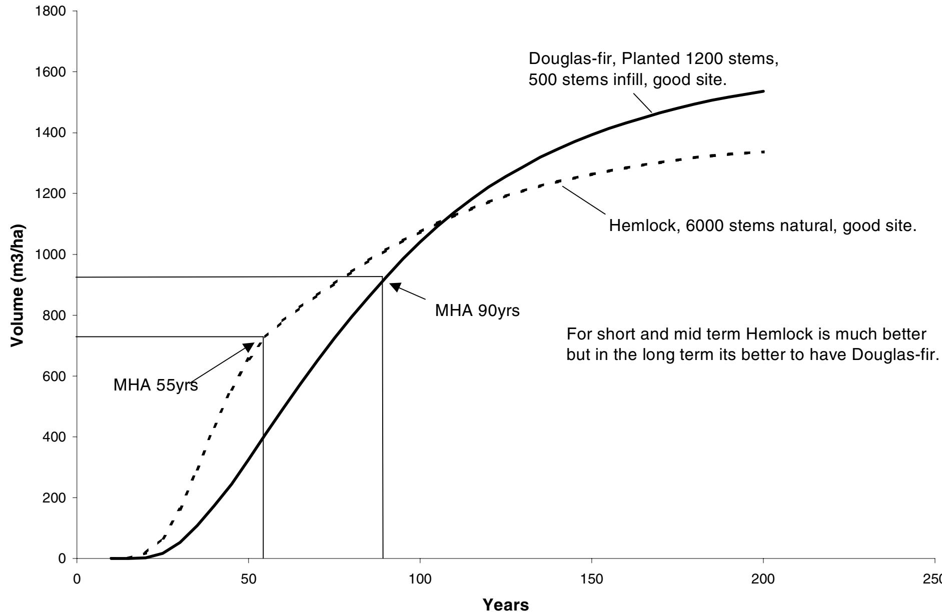


Figure 16. Hemlock 6000 natural stem/ha vs. planted Douglas-fir

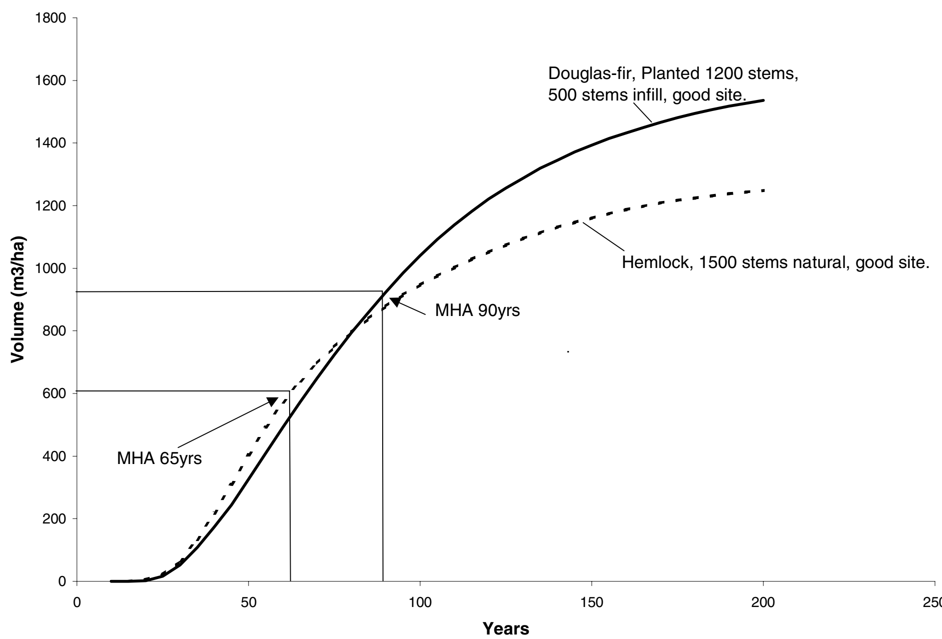


Figure 17. Hemlock 1500 natural stem/ha vs. planted Douglas-fir

2.7 Incremental Silviculture History

Table 5 summarizes recent silviculture activities in TFL 44, and activity planned for the current year. Area treated, total budgets, and average costs per hectare are presented. The total budget last year, and the budget projected for the current year, are approximately $1.75 million, or close to $1 per cubic metre of allowable annual cut. Over half the budget is allocated to brushing treatments, and an increasing emphasis is being placed on fertilization.

TABLE 5. Current silviculture activity in TFL 44

	ha.			
	Actual	Actual	Plan	
Treatment	1998/99	1999/00	2000/01	Total
Brushing	834.50	684.60	905.00	2,424.10
Pruning	75.20	36.10	-	111.30
Juvenile spacing	220.10	202.50	-	422.60
Planting	30.00	65.60	-	95.60
Surveys	7,744.00	4,745.00	3,800.00	16,289.00
Space and prune	-	-	34.00	34.00
Fertilize	-	53.00	1,425.00	1,478.00
FHT	-	-	60.00	60.00

	$			
	Actual	Actual	Plan	
Treatment	1998/99	1999/00	2000/01	Total
Brushing	1,179,790.00	901,367.00	1,026,754.00	3,107,911.00
Pruning	288,653.00	95,206.00	-	383,859.00
Juvenile spacing	613,098.00	457,960.00	-	1,071,058.00
Planting	30,994.00	76,601.00	-	107,595.00
Surveys	324,766.00	210,011.00	145,943.00	680,720.00
Space and prune	-	-	121,137.00	121,137.00
Fertilize	-	25,328.00	362,785.00	388,113.00
FHT	-	-	86,001.00	86,001.00

	$/ha			
	Actual	Actual	Plan	
Treatment	1998/99	1999/00	2000/01	Total
Brushing	1,413.77	1,316.63	1,134.53	1,282.09
Pruning	3,838.47	2,637.29	-	3,448.87
Juvenile spacing	2,785.54	2,261.53	-	2,534.45
Planting	1,033.13	1,167.70	-	1,125.47
Surveys	41.94	44.26	38.41	41.79
Space and prune	-	-	3,562.85	3,562.85
Fertilize	-	477.89	254.59	262.59
FHT	-	-	1,433.35	1,433.35

3.0 SILVICULTURE STRATEGIES

Table 6 illustrates the impacts some incremental silviculture treatments may have when used on appropriate stands. This is a general table adapted from Gordon Weetman (SIBC 1992). Specific outcomes may change depending upon the situation.

Table 6. General effects of various silviculture treatments.

Silviculture Actions	accelerated availability	mean growth	Accumulated yield	productivity	average diameter	quality	biological diversity
Basic Silviculture	+	+	+	+	+	+	±
Spacing	++	+	-	±	+	±	±
CT	+	0	-	+	+	-	+
Fertilization	+	+	+	+	+	+	0
Pruning	0	0	0	0	0	++	0
Tree improvement	+	+	+	+	+	+	±

Source: Adatpted from G. Weetman, SIBC 1992

The following section summarizes issues and observations discussed at the workshop held December 13, 2000. Treatments, expected gains, and rankings are summarized in Tables 7-9 at the end of the section.

3.1 Timber quantity strategies

Strategies to improve the quantity of timber produced from TFL 44 were discussed at the workshop according to phases in the development of young stands. Prompt early establishment, planting with economically preferred and ecologically suited species, fertilization at planting, aggressive vegetation management on better sites and use of genetically improved stock ranked together as a high priority.

Vegetation management (brushing) in recent years has largely been to remove competition from alder. Interest in utilizing and managing for alder has increased significantly with Weyerhaeuser's purchase of Coast Mountain Hardwoods. A management policy on managing for alder is scheduled by the end of 2001. It is expected that less emphasis will be directed towards removal of alder, particularly in accessible areas near roads.

Emphasis has been on treatments (prompt planting, seedling stock type, brushing) to ensure trees are not overtopped and to get them to Free Growing. There is now an opportunity to focus on vegetation management that is not required to achieve Free Growing but will provide substantial growth gains by reducing below-ground competition for moisture and nutrients from species such a salmonberry and salal. Potential treatment options include mechanical and bioherbicides. High sites will be priority areas for treatment.

In the southern (Sarita) portion of the Alberni East working circle salal is a fierce competitor on cedar-hemlock sites. Results from the Salal-Cedar-Hemlock Integrated

Resource Project (SCHIRP) show that fertilization with nitrogen and phosphorus is effective at giving redcedar and hemlock a competitive advantage over the salal.

Weyerhaeuser recognizes the critical impact of regeneration delay and early tree growth on timber supply. The company is working toward a one-year or less effective regeneration delay (considering the age of planted seedlings) and plants improved seedlings where possible.

In addition, fertilization has been applied at time of planting in recent years. It is expected that this treatment will become more focussed on sites that offer value gains as experience is gained and results from plot measurements are analyzed. It is suggested that most of the fertilization at time of planting is not a basic treatment (not required to meet Free Growing). Instead it is incremental as it provides gains, primarily in meeting adjacency and visual landscape green-up requirements more quickly and secondarily in increasing long-term forest growth and hence timber supply.

Aerial fertilization of older second-growth Douglas-fir stands ranked second as a treatment at the workshop. The practice is to provide good and high site Douglas-fir stands with up to three applications of fertilizer prior to final harvest. Stands would be fertilized at intervals of around 7 years with the last application 7–10 years prior to scheduled harvest. Stands in the current inventory that are scheduled for earlier harvesting (within 7–15 years) could be fertilized with only one or two applications. Fertilization is considered an attractive investment, capable of producing wood volume of approximately 50 m^3/ha from three applications. In undiscounted dollars this equates to a cost of less than $14 per cubic meter. Fertilization also increases piece sizes, since the volume is added to a relatively static number of stems.

3.2 Timber quality strategies

Juvenile spacing ranked as a lower priority at the workshop. Benefits of juvenile spacing that were identified included diameter increment, an ability to select crop tree species, and the establishment of windfirm stands that will be suitable for later variable retention harvesting. Participants stated that it was difficult to find areas appropriate for spacing based on high stem density and lack of expressed dominance. The conclusion was that future spacing programs would be relatively small and based on site specific requirements for windfirm boundaries, species selection, density control and production of forage.

Pole thinning (at age 40) and commercial thinning (at ages 50-60) were discussed at the workshop. These treatments may move volume ahead in the harvest queue. Candidate stands would be close to a mill and have road access in place. However, treatments that earn revenue do not qualify as incremental silviculture under present FRBC funding guidelines.

Pruning was also ranked as a low priority at the workshop. Pruning occurs in stands aged 10 to 18 years, generally in two lifts of 3m each, that result in a 5.5m (16 feet) clear butt log. By harvest age the clear lumber produced is approximately 15% of the standing wood volume. If clear lumber continues its premium of 3 to 4 times the value of knotty lumber, then a pruning treatment will increase the future value of a stand by approximately 40% (FPB 2000).

At the workshop it was noted that pruned logs will only be marketable if approriate processing facilities exist, and that a processing facility would need a large supply of this material. Therefore pruning, if judged viable, should be undertaken as a comprehensive program. Species suitable for pruning include both Douglas-fir and redcedar.

3.3 Habitat strategies

Wildlife habitat considerations occupied a significant portion of the workshop. Weyerhaeuser recognizes that provision of suitable habitat may make presently reserved timber more available for harvesting. Weyerhaeuser is implementing variable retention harvesting throughout its coastal operations, including TFL 44. Portions of old forest will remain throughout the regenerating landscape.

Incremental silviculture treatments to change the uniform structure of regenerating stands are being designed. The focus is on improving diversity (horizontal and vertical structure) in riparian reserves. This includes creating old-growth characteristics including snags, variable density and large woody debris and openings for forage and browse. An important element is to ensure that the adjactent Riparian Management Zone transforms into a structurally sound stand that is windfirm. Dense, uniform hemlock and/or Douglas-fir stands up to 40 years of age are candidate for this treatment. There may be salvage opportunities for larger piece sizes.

Another habitat enhancement treatment discussed was wide spacing and pruning to maintain or create spring forage near known ungulate winter ranges. The forage value would last for 15 to 20 years, before the canopy closes again.

Discussion at the workshop considered the benefits of using variable density spacing of young upland stands to provide habitat connectivity. Emphasis should be on treating already reserved areas otherwise the low rate of volume development (Figure 15) in these stands would eventually reduce the LTHL. An additional benefit of wide spacing treatments within reserved areas would be increased harvest availability of older forests, as the treated stands develop old forest attributes. Over 10% of the net THLB area was removed from harvesting in the MP#3 analysis due to FEN linkages, and including these areas in the harvestable forest raises short- and mid-term harvest levels by 5%.

Table 7. Summary of treatments and candidate stands

Treatment	Site index (m@50yrs)	Stand density (sph)	Age (yrs)	Species (fir, cedar, hemlock)
Brushing			3 to 6	F, C & H
GU Reduction *fert @ planting* *Genetically improved stock* *Planting quickly*	All	All	0	F, C & H
SCHIRP	Low sites	All	0 to 4	C & H
Variable density spacing	21+	>3000	13 to 40	F, C & H
Juvenile spacing	27+	varies	15	F, C & H
Pruning and spacing	32+	>2000	10 to 18	F & C
Aerial fertilization	21+	600-2000	40 to 60	F

4.0 SILVICULTURE PRIORITIES

Table 8. Summary of treatment effects and rankings discussed at the workshop

	Forest level objective						Ranking
Treatment	**Reduce green-up**	**Reduce MHA**	**Increase volumes**	**Increase diameters**	**Increase value**	**Increase habitat**	
Brushing	X	X	X				High
GU Reduction *fert @ planting* *Genetically improved stock* *Planting quickly*	X	X	X				High
SCHIRP	X	X	X				High
Variable density spacing			-	X	-	X	Medium
Juvenile spacing				X	X	X	Low
Pruning and spacing				X	X	X	Low
Aerial fertilization		X	X	X			High

5.0 SILVICULTURE PROGRAM

5.1 Working targets

Working targets are a set of specified objectives relative to the production potential of the management unit. Targets might include statements about the quantity of premium log size, or clear logs, to be produced over time. Targets might also specify a certain quantity of high-value wildlife habitat and recreation potential.

The workshop resulted in one main working target – volume production. The highest priority treatments are those which will increase timber harvest levels above the base case. Most interest is focussed on treatments that will serve to fill the dip in supplies anticipated 20-40 years from now. An additional criterion is that the treatments raise the LTHL. Treatments such as pole and commercial thinning that simply shift harvest volume from a later to an earlier date to fill the dip are low priority.

Volume production requires maintaining well-stocked stands, which is also consistent with a target of high wood quality as noted in Section 1.1.

5.2 Program costs and benefits

The incremental silviculture budget (FRBC) for TFL 44 the past two years is approximately $1.75 million per year (Table 5). Table 9 summarizes the candidate areas suitable for treatment in the short term, budgets needed to undertake the work, and employment benefits associated with the incremental silviculture treatments listed in Tables 7 and 8. This table only applies to silviculture treatments on Crown lands within TFL 44.

Table 9. Budget and employment estimates for the silviculture program

Treatment	Area (ha/yr)	Cost ($/ha)	Budget ($/yr)	Employment (days/ha)	Annual Jobs
Brushing	400	1,316	526,400	2.40	4.80
Fert at planting	500	180	90,000	0.25	0.63
SCHIRP	300	487	146,100	0.28	0.42
Variable density spacing	100	2,485	248,500	7.00	3.50
Juvenile spacing	100	2,262	226,200	5.40	2.70
Prune and space	50	3,563	178,150	13.00	3.25
Aerial fertilization	1,000	255	255,000	0.15	0.75
Surveys	4,000	40	160,000	0.20	4.00
Other			100,000		2.00
Total			1,930,350		22.05

Notes to Table 9:

Brushing: During the next few years there will be a transition from brushing pre-1987 stands to achieve Free Growing to vegetation management on higher sites as an incremental activity. Maintenance of this FRBC program the next 2–3 years depends upon implementing the incremental program.

Fertilization at planting: It is recommended that fertilization at time of planting is defined as an incremental treatment (as defined in the silviculture prescription objectives). It is expected that the choice of sites for this treatment will be fine tuned and 500 ha/yr is a current best estimate.

SCHIRP: Additional inventory analysis is required to confirm the 300 ha/yr figure. It assumes that there are 1000–2000 ha of backlog areas that could be treated. Some areas will be treated twice and 100–200 ha of these sites are harvested each year.

Variable density spacing: This program will largely depend on outcomes of the landscape unit planning process. It is an option for managing recruitment to meet old seral targets in variants that are currently short. It is expected that this program will be small; hence the inclusion of 100 ha/yr.

Juvenile spacing: There are relatively few high stocking (poor expression of dominance) sites in TFL 44. Spacing will be for a variety of objectives including very high density areas, species choice, forage production, and development of windfirmness in specific areas. In total the juvenile spacing program is expected to be small, on the order of 100 ha/yr.

Pruning and spacing: Again, not expected to be a large program. Limited to very high Douglas-fir and redcedar sites and to some forest health issues (i.e. White Pine Blister Rust).

Aerial fertilization: There is substantial area of 40–60 year old Douglas-fir stands in TFL 44. Inventory numbers suggest the potential for a fertilization program of 1,000 ha per year.

Surveys: These numbers are based on the results for recent years.

Other: Includes treatments such as stand rehabilitation and planting of restored and rehabilitated sites.

6.0 CONCLUSION

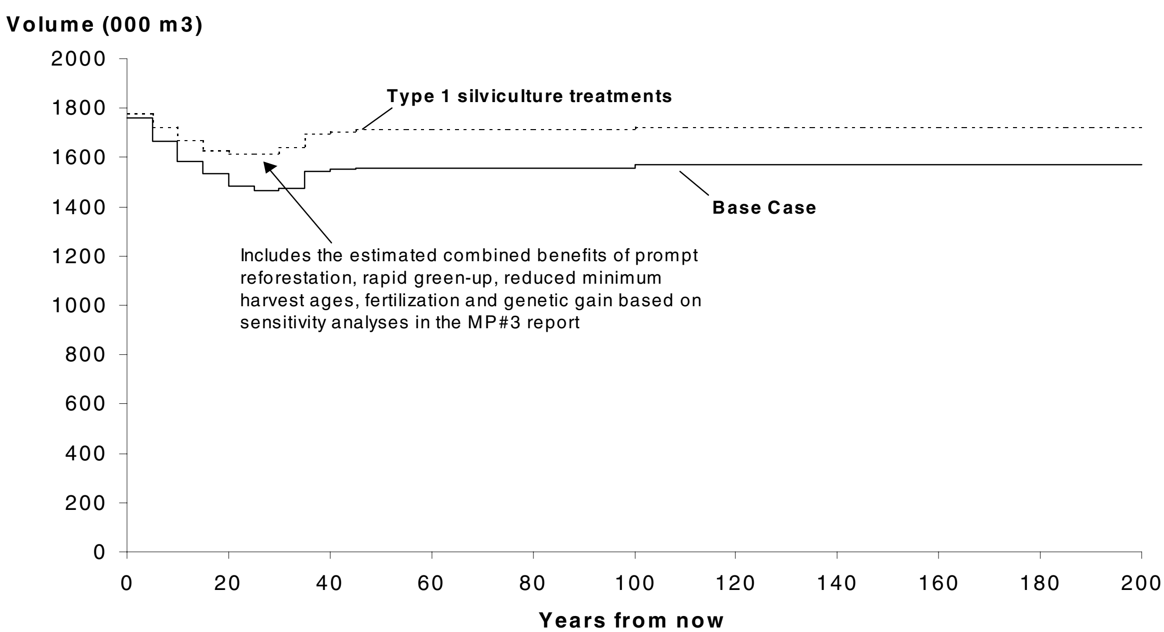
The FRBC budget analysis in Table 9 may be compared with current FRBC budgets (e.g. the last two years, 1999/00 and 2000/01, in Table 5). The major change is a shift from brushing treatments to fertilization. If an average of two years is used then the budget for brushing almost halves from $964,000 to $526,000. The fertilization budget more than doubles from an average of $194,000 to $491,000, if fertilization at time of planting and treatment of SCHIRP sites are included. These treatments ranked as high priority at the workshop.

Variable density spacing is the other major new treatment. The objective is to enhance habitat values with also potentially positive impacts on timber supply by treating areas that are otherwise reserved. The size and application of this program is largely contingent on landscape unit planning and the need to recruit additional old-growth to meet old seral targets. An expenditure of around $250,000/yr is suggested and was ranked a medium priority at the workshop.

Juvenile spacing and spacing plus pruning were identified as low-priority investments at the workshop. They are expected to continue at relatively low levels and a cost of $400,000/yr.

Summarizing the budget analysis, high-priority incremental silviculture investments in brushing and fertilization might be accomplished with an expenditure of approximately $1.0 million. To this is added the estimated cost of $260,000 for surveys and miscellaneous treatments. Medium-priority treatments (variable density spacing) and lower priority treatments (juvenile spacing and pruning plus spacing) add another $250,000 and $400,000 respectively to the budget. The total for all the treatments identified here is $1.93 million, only slightly higher than the budget level of the last two years.

Figure 18. Estimated harvest flow with high-priority incremental silviculture treatments



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