

TYPE 2 SILVICULTURE ANALYSIS
Tree Farm Licence 41

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Prepared for

West Fraser Timber Ltd.

by

Sterling Wood Group Inc.

Victoria BC

www.sterlingwood.com

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1.0 INTRODUCTION

Forest management is the practical application of science, technology and economics to a forest estate for the production of designed results. Producing the desired flows of timber is achieved through the process of **Harvest Regulation** and **Silvicultural Investment**.

The aim of harvest regulation is to provide for orderly harvest and renewal of our timber stocks. The aim of silviculture is to renew the forest after logging and to increase the economic value of the forest. The biological principles that silvics imposes upon silvicultural practice must be considered in conjunction with forest management. The two must work together.

Harvesting a forest may be planned independently for each forest stand or may be co-ordinated for all stands in the forest. The first method is often called **stand level management** and the second **forest level management**.

1.1 STAND LEVEL MANAGEMENT

As Clutter et al (1983) define it, stand level management is where each individual stand is independently treated in the way that best fits the desires of the forest owner. If the owner's goal is profit maximization, each stand would probably be managed to maximize the present value of future cash flows produced by the stand. If all stands in the forest can be managed in this way, the economic benefits to the owner will be greater than those possible under any other plan that can be devised. Yet, there are forests that cannot be operated with stand level management because the resulting overall forest plan is not feasible, regardless of its apparent economic desirability. As an example, these authors imagine a forest that has been acquired or established to provide raw material for several mills. In this case, significant year-to-year variations in harvest volumes would simply be unacceptable. Similarly, a forest landowner without processing facilities but whose total income is derived from timber harvests may also be unable to operate when revenues produced by the forest fluctuate wildly from year-to-year. Operational stability may be required in forests, which support their own work force. In this case, a small harvest in one year leads to a shortage of labour for any expansion of the cut in the next year. Where stable short-term patterns of harvest volume, area or income are important then stand level management will usually be rejected. Often, stand level management is rejected without sufficient thought. Some of the literature in timber management seems to assume that foresters should always practice forest-level management planning. Clutter et al (1983) based on their experience with privately held timberlands do not support the assumption that forest level management should always be applied to forest estates. Brasnett (1953) refers to an earlier German example of stand level management. In 1860 Judeich, a forestry Professor, drew attention to the frequency and the serious results of accidents caused by wind and snow in the forests. He developed stand management based on the conditions of individual crops. He selected and listed the stands which, irrespective of age, he thought should be felled and replaced in the ensuing regeneration period. He then applied an age class check. If this check indicated that some of his proposed feelings would cause serious fluctuations in future forest level yields, he revised the stand list. These revisions were repeated until a satisfactory compromise between stand and forest level requirements was reached.

1.2 FOREST LEVEL MANAGEMENT

Forest level management is required when some kind of regulated timber supply is required. Any kind of forest level regulation will have economic costs. If one were only to consider log supply, the most profitable management plan may simply be a consolidation of the best stand level plans for all stands in the forest. Any change in this consolidated plan to provide consistent annual yields or revenues could mean that some stands will no longer be managed to their economically best strategies.

Managers of large tracts of forest land are usually concerned with the production of timber harvests that are relatively stable from year-to-year as these generally maximize profits at the corporate level.

Forest level management has traditionally been called **forest regulation**. Traditional forest regulation procedures were based on the existence of some “target forest” structure. Attainment and subsequent maintenance of this structure were assumed to be important management objectives.

This document describes a “Type 2 Silvicultural Analysis” for Tree Farm Licence 41 (TFL 41). The analysis contains 12 parts:

- background,
- timber harvesting land base,
- timber supply issues,
- silviculture history,
- opportunities to increase timber supply,
- potential treatments,
- potential strategies,
- improving timber value,
- financial analysis of potential treatments,
- timber supply analysis,
- incremental silviculture program,
- job outcomes, income and revenue.

2.0 BACKGROUND

TFL 41 was granted to Eurocan Pulp and Paper Co. Ltd. in December 1966 in order to provide a secure timber supply for the unbleached kraft pulp and paper mill, which the company was building at Kitimat. Since that time there have been changes in the ownership of Eurocan and the name of the licence holder. Figure 1 is a key map showing the location of TFL 41.

Originally Eurocan was a joint-venture company between two major Finnish forest companies, Enso Gutzeit Oy and UPM Kymmene Group. In 1981, West Fraser Mills Ltd. acquired a major share in Eurocan by purchasing UPM Kymmene's holdings. West Fraser subsequently purchased Enso Gutzeit's shares and in 1993 the name of the licensee was changed from Eurocan to West Fraser Mills Ltd.

The original area of TFL 41 was 1,019,740 hectares. It excluded fee simple land owned by Aluminum Company of Canada Ltd. (Alcan) at Kemano and their powerline transmission corridor from Kemano to the aluminum smelter at Kitimat as well as Indian Reserves. Two major area revisions recently have reduced the gross area to approximately 70% of the original. These revisions were:

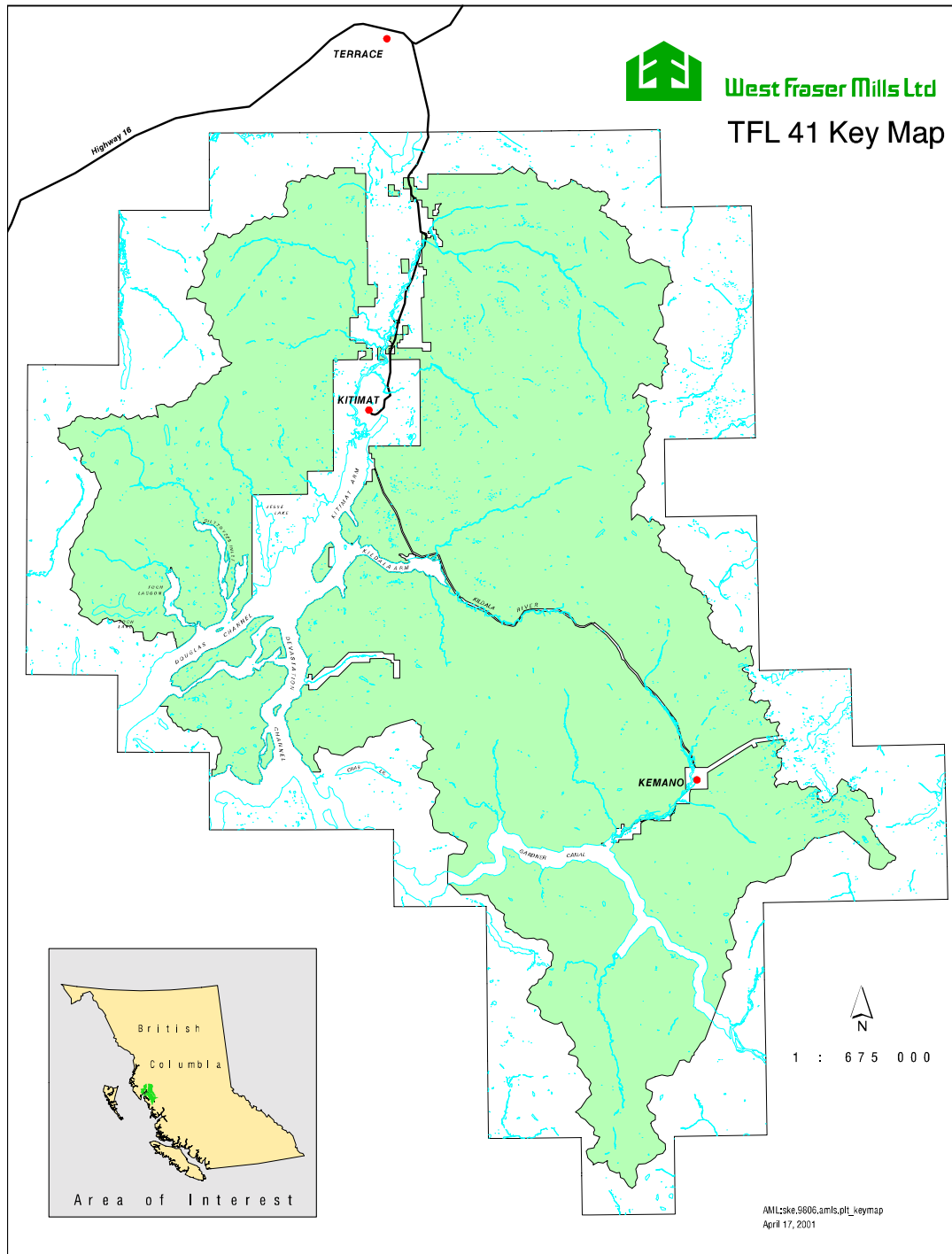
- removal of the Kitlope drainage in 1996 to create the Kitlope Heritage Conservancy area. (321,120 hectares),
- removal of Lots 305 and 306 for transfer to the Haisla Band Kitimat Indian Reserve in 1997. (139.5 hectares),
- addition of expired timber licence, TO 991, in the Kitimat valley as Schedule A land (906.4 hectares) and Schedule B (176.5 hectares) land.

Prior to creation of the TFL some logging had taken place south of Kitimat along the shoreline of Douglas Channel and the inlets. Initial logging began on TFL 41 in 1970 and the first plantations were established in 1973.

West Fraser Timber Co. Ltd. began operations in 1955 in British Columbia and in Alberta in 1989. West Fraser Mills Ltd. (West Fraser) is the wholly owned principal operating subsidiary. The company has become a major integrated forest products company in Canada producing dimension lumber and speciality wood products: medium density fibreboard, pulp, linerboard, kraft paper and newsprint. Most of the forest products manufactured by West Fraser are sold worldwide as commodities. West Fraser holds Crown timber tenures in British Columbia and Alberta and has forest products divisions in both provinces. West Fraser's share of the current annual capacities of its wholly-owned and joint venture manufacturing facilities is approximately 1600 MMfbm of lumber, 210 MMsf of MDF, 450,000 tonnes of linerboard and kraft paper, 325,000 tonnes of BCTMP (bleached chemi-thermomechanical pulp) and 125,000 tonnes of newsprint.

In north-western British Columbia, West Fraser operates a dimension sawmill at Terrace and a pulpmill at Kitimat. Logs and fibre for these facilities are supplied from TFL 41 (47%) and from two forest licences in the Kalum and Nass timber supply areas. The combined allowable annual cut (AAC) of these licences is 638,465m³. TFL 41 is managed by Skeena Sawmills Division from its woodlands office in Terrace.

Figure 1: Key Map



2.1 COMMUNITY DEPENDENCE

Communities associated with the TFL are Terrace (population 13,372), Kitimat (population 11,700) and Kitimaat Village (population 676).

The local economy of these communities is resource dependent: there is an aluminum smelter, pulp and papermill and a methanol and ammonia production plant at Kitimat. Terrace is the service sector for the northwest communities and has a more diversified economic base than Kitimat. In normal times direct employment generated by West Fraser's business is 850; employing approximately 221 people at its woodlands and sawmilling operations, and approximately 611 people at the Eurocan pulp and paper mill in Kitimat. The contract work force in woodlands provides about 400 direct jobs in logging, road construction, trucking and silviculture operations. The estimated gross annual income from these operations is \$270 million. West Fraser makes donations and supports local events that young people participate in, such as sports teams, social events, cultural events and education scholarships.

3.0 TIMBER HARVESTING LAND BASE

The gross area of TFL 41 is 703,745 hectares. This is derived from the TRIM map base provided by the MoF. The cadastral information is not considered to be entirely accurate by the MoF as the boundaries of the Kitimat Municipality and the Kitimat Provincial forest were plotted as a best fit. The MoF has undertaken to update the cadastral base when new TRIM files are available, although the timing is not known. Also the Claque Mountain Park reserve (1,514 hectares), which was under a 15-year lease to the Kitimat Municipality, expired in 1984 and is now assumed to be part of the gross area. Prior to these changes, the gross area was 1,019,739 hectares.

As Table 1 shows, a high proportion of TFL 41 is either non-forest alpine area, or not suitable for timber harvesting. Only 21% of the productive forest area is classified as net operable and used as the net harvesting land base for the AAC determination.

Table 1: TFL 41 Land base (hectares)

Gross Area	703,745
Non forest	333,833
Non productive forest (alpine, swamp)	36,988
Productive forest	332,924
Reduction for inoperable ESAs, riparian, roads, etc.	264,837
Net timber harvesting land base	68,087

Removal of the Kitlope reserve resulted in a loss of 8,960 hectares net operable. However, the revised operability mapping increased the net conventional area by 8,866 hectares and added a net non-conventional area of 5,161 hectares.

A new timber inventory was completed in 1998 to MoF standard inventory specifications. The graphics and database files are loaded on an ARC/INFO GIS digital system. The new inventory has improved the stratification and classification of productive forest at higher elevations and has completely updated the classification of regenerated stands less than 40 years old. The inventory consists of:

- 82 forest cover maps (48 full equivalent mapsheets at 1:20,000 scale),
- 37,394 forest cover polygons with attributes,
- 2,506 typed aerial photos (902 in 1996 and 1,606 in 1997),
- 1,176 field samples (900 aircalls and 476 ground plots),
- gross area and volume statistics by planning cell.

Tables 2 and 3 summarize the productive forest area.

Table 2: Productive Forest Area by Age Class (hectares)

Type Group	1	2	3	4	5	6	7	8	9	Other	Total
Hemlock	13,440	6,990	2,922	3,032	4,719	6,937	4,745	25,115	162,901	0	230,801
Balsam	1,647	746	191	311	352	550	428	4,103	16,314	0	24,641
Cedar	455	62	14	14	73	157	151	1,909	16,969	0	19,805
Spruce	493	443	112	59	153	552	297	1,618	1,467	0	5,195
Douglas-fir		20				19	4		76	0	119
Pine	290	46			2	21	138	156		0	652
Deciduous	412	1,039	951	519	413	363	190	113		0	4,000
NSR	351	18					2		22	2,054	2,447
NC-Br										45,265	45,265
Total	17,088	9,365	4,190	3,935	5,713	8,599	5,955	33,014	197,748	47,319	332,924

Table 3: Productive Forest Volume by Age Class (m³)

Type Group	1	2	3	4	5	6	7	8	9	Total
Hemlock	4,363	155,281	221,521	367,256	323,440	1,323,448	1,142,436	7,216,847	63,476,132	74,230,724
Balsam	20	8,821	24,897	74,601	65,676	148,668	171,363	1,536,595	7,808,633	9,839,274
Cedar	16	23	112	3,138	5,033	32,378	30,880	535,603	5,864,418	6,471,599
Spruce	3673	19,667	41,111	24,226	74,555	297,713	160,135	1,168,171	1,294,018	3,083,269
Douglas-fir		25				2,650	1,197		35,140	39,014
Pine	7	157			100	3,303	39,443	46,227		89,237
Deciduous	12,289	113,342	200,723	130,155	106,212	111,615	50,166	33,647		758,148
NSR	79	44					233		3,495	3,851
Total	20,448	297,359	488,362	599,376	575,016	1,919,774	1,595,854	10,537,089	78,481,836	94,515,114

Table 4 summarizes the timber harvesting land base for TFL 41.

Table 4 includes the areas for conventional and non-conventional timber harvesting land base. Skeena Sawmills identified the non-conventional land base. A subset of this non-conventional area totalling 5,161 hectares is included in the timber harvesting land base. This area represents 7.6% of the initial timber harvesting land base. The volume reductions have also been calculated and presented in the Table 4. The netdown sequence is the same as the sequence shown in the Table 4.

Table 4: Timber Harvesting Land base

Description	Area Schedule A	Area Schedule B	Total Area	Volume Schedule A	Volume Schedule B	Total Volume
Total Land base	906	702,838	703,745	214,583	98,080,745	98,295,328
Non-Forest	0	333,833	333,833	0	1,402,262	1,402,262
Non-Productive Forest	0	36,988	36,988	0	2,377,942	2,377,942
Total Productive Forest	906	332,018	332,924	214,583	94,300,541	94,515,124
Less:						
Inoperable/Inaccessible	66	240,170	240,236	22,704	59,440,423	59,463,126
NC (Non Commercial)	0	236	236	0	0	0
Low Site	0	68	68	0	7,449	7,449
Deciduous	2	2,824	2,826	41	533,528	533,569
Non-merchantable	3	1,176	1,178	901	311,020	311,922
ESAs	35	11,346	11,381	6,503	5,006,878	5,013,381
Riparian Reserves	23	4,128	4,151	6,230	1,949,041	1,955,271
Specific Geographically Defined Area	0	13	13	0	4,554	4,554
Unclassified Roads, Trails, Landings	24	1,258	1,281	7	8,327	8,334
NSR	32	1,568	1,600	0	11	11
Wildlife Tree Patch	33	1,834	1,867	8,555	468,665	477,220
Total Current Reduction	218	264,619	264,837	44,940	67,729,896	67,774,836
Initial Timber Harvesting Land base	688	67,398	68,086	169,643	26,570,645	26,740,288
Additions:						
NSR	32	1,568	1,600	0	0	0
Total Additions	32	1,568	1,600	0	0	0
Current Timber Harvesting Land base	721	68,966	69,686	169,643	26,570,645	26,740,288
Future Reductions:						
Future Roads, Trails, Landings	22	3,011	3,033	0	0	0
Future Timber Harvesting Land base	699	65,954	66,653	169,643	26,570,645	26,740,288

3.1 AREAS BY LEADING SPECIES AND SITE CLASS

The areas in the harvesting land base by leading species are shown in Table 5. Site classes are defined as:

Productive site class 1	BH50 SI > 35
Productive site class 2	25 < BH50 SI ≤ 35
Productive site class 3	15 < BH50 SI ≤ 25
Productive site class 4	3 < BH50 SI ≤ 15

Table 5: TFL 41 Timber Harvesting Land base by Leading Species and Site Class

Leading Species	Site Class	Hectares
Hemlock & Cedar	1 & 2	2,899
	3	33,253
	4	<u>20,562</u>
	Sub total	56,714
Balsam	2	370
	3	5,828
	4	<u>2,991</u>
	Subtotal	9,189
Spruce	1 & 2	375
	3 & 4	<u>1,524</u>
	Sub total	1,899
Lodgepole pine	3&4	<u>284</u>
Sub total		284
Grand Total		68,086

Within the total productive TFL 41, 13,443 hectares are forest stands between the ages of ten and 110 years.

Table 6 below shows these areas by ten-year age class and leading species.

**Table 6: Hectares by Leading Species and Age Class;
Timber Harvesting Land base TFL 41**

%	Age Class	Hemlock	Balsam	Spruce	Cedar	Pine	Douglas-fir	Total
53	11 - 20	6,076	440	262	72	216	0	7,066
29	21 - 30	3,070	539	295	50	40	17	3,966
7	31 - 40	879	35	6	24	0	17	945
3	41 - 50	286	39	26	1	0	0	352
1	51 - 60	164	0	10	19	0	0	193
2	61 - 70	194	48	9	0	0	0	250
1	71 - 80	156	22	4	1	0	0	183
1	81 - 90	89	4	5	3	0	0	98
1	91 - 100	66	35	29	4	1	0	135
2	101 - 110	175	7	69	5	0	0	256
Total		11,154	1,169	714	132	257	17	13,443

Table 7 shows the areas of productive forest by biogeoclimatic zone.

**Table 7: Hectares by Leading Species and Biogeoclimatic Zone;
Productive Forest Land base TFL 41**

Zone	Species	Area (ha)	Zone	Species	Area (ha)
AT		1,165	ESSF		25
AT	B	63	ESSF	B	78
AT	H	2,174	ESSF	H	111
CWH		20,326	MH		25,800
CWH	B	19,209	MH	B	5,301
CWH	CW	14,328	MH	CW	171
CWH	YC	4,591	MH	H	74,533
CWH	FD	119	MH	PL	16
CWH	H	154,278	MH	S	770
CWH	PL	638	MH	YC	723
CWH	S	4,446	MH	Deciduous	237
CWH	Deciduous	3,822			
Total Area			332,924		

Table 8 below shows the definition of the analysis units used in this project.

Table 8: TFL 41 Analysis Units

Analysis Unit	Leading Species	Inventory Type Group	Productivity Site Class	Age Range	Net Area (ha)
1	Hemlock & Cedar	9 – 17	1,2	All	2,899
2	Hemlock & Cedar	9 – 17	3	0 - 140	13,766
3	Hemlock & Cedar	9 – 17	4	0 - 140	454
4	Hemlock & Cedar	9 – 17	3	140+	19,487
5	Hemlock & Cedar	9 – 17	4	140+	20,108
6	Balsam	18 - 20	2	All	370
7	Balsam	18 - 20	3	All	5,828
8	Balsam	18 - 20	4	All	2,991
9	Spruce	21 - 26	1,2	All	375
10	Spruce	21 - 26	3,4	All	1,524
11 ³	Lodgepole Pine	28 - 31	3,4	All	284
Total					68,086

4.0 TIMBER SUPPLY ISSUES

The following issues affect timber supply on TFL 41.

1. Poor profitability and return on investment has resulted from high logging costs due to a combination of expensive offshore operations and average to poor quality timber stands. The economics of operating in remote locations continues to be marginal and is exacerbated during periods of low lumber commodity prices.
2. The weakening of traditional markets on the US eastern seaboard for green hemlock lumber during 1998 is not easily replaced. Stumpage charged by government for Crown timber is not market-driven and logging costs have increased considerably due to the Code.
3. The majority of the merchantable timber is more than 140 years old. The age class distribution and imbalance constrains the flexibility to maintain even-flow harvesting levels through the mid-term. A case can be made for a declining harvest level until a significant volume of second growth timber becomes available.
4. Government land use allocation strategies and aboriginal land claims have created a level of uncertainty concerning the long-term security and integrity of the TFL land base. Deletion of the Kitlope drainage was a major reduction in timber supply. Any further significant land withdrawals from the TFL would seriously affect the productive harvest level and undermine the economic log supply available for the company's manufacturing facilities.
5. The recently completed Kalum LRMP process will remove areas from the current timber harvesting land base. These removals will exert downward pressure on the AAC.
6. Road access and deactivation is an issue with some recreationists and local people who want to have logging roads maintained and kept driveable rather than being deactivated.
7. There is considerable scope for operational flexibility and administration by the MoF without compromising forestry practices and environmental standards. Approval procedures could be streamlined for a number of activities, e.g., timber cruising, road construction standards, road permit amendments, deactivation, windthrow, salvage applications and waste assessments.
8. Planning for biodiversity including retention of old-growth management areas should be focussed at the landscape level. Outside of critical habitat for identified species, the attendant issues of forest connectivity and wildlife habitat protection should be dealt with at this level.
9. The visual sensitivity ranking of the forest landscape advocated by the MoF takes a conservative approach and assumes a high degree of visibility and a large viewing public. West Fraser contends that the remote location of much of the operating area warrants a strategy that enables more merchantable timber to be available for harvesting than a visual constraint allows.

The age class imbalance listed in issue #3 above is shown below in Table 9.

Table 9: Age Class Distribution – TFL 41 Timber Harvesting Land base

	Age Class									Total
	1	2	3	4	5	6	7	8	9	
Hectares	12,593	5,065	705	535	221	799	765	4,735	42,669	68,087
Cubic Metres	6,426	129,735	182,432	255,186	125,119	486,653	398,777	2,518,287	22,637,673	26,740,288

4.1 TIMBER QUALITY

Variation in tree or log quality is very important in attaining maximum net revenues from the timber resource. Apart from rot and decay, neither tree nor log grade have a very significant effect on cost, but the effect on revenue is pronounced. Where timber is decadent so that the useable volume recovery is reduced by breakage and high waste, then logging costs will also be significantly increased by poor timber quality tree.

The characteristics most likely to affect the quality of timber products are:

- tree size,
- tree straightness,
- tree taper,
- freedom from knots,
- annual ring width.

In TFL 41 the timber quality in old growth stands is generally poor. In second growth stands the timber is sound and, for the same sized tree, is of better quality than the decadent old growth.

Old Growth Stands

The high pulpwood content in the over-mature hemlock and balsam stands in TFL 41 means that log quality is a key factor in determining operability and logging chance. Estimating log quality from diameter and external pathological indicators, as is done in inventory and timber cruising, is unreliable due to hidden internal defect.

In this report for TFL41, the term ‘standard sawlogs’ has been used for higher quality lots. The term ‘gang sawlogs’ has been used for average and lower quality logs. Local forestry staff at West Fraser estimate that 60% of the old growth volumes is sawlog and 40% is pulpwood.

Species

Of the 47,000 hectares of forest stands in the timber harvesting land base that are 141 years or older, 79% have hemlock as the leading species. Balsam is the leading species in 13% of the old growth stands. Most of the remaining 8% are cedar-leading.

Volumes of rot and decay are consistently high in the old growth. Spruce weevil occurs in spruce plantations and has curtailed the planting of this species.

Second Growth Stands

On TFL 41, because of past logging and regeneration, and to a lesser extent natural disturbances, a vibrant second growth forest is emerging. On TFL 41, 21,000 hectares of forest in the timber harvesting land base are younger than 141 years. Of these, 81% have hemlock as their leading species and 11% are balsam leading.

Most stands younger than 140 years are between the ages of 1 and 40. In fact, 94% of this area is occupied by hemlock leading and balsam leading stands aged 1-40. Only 7% of the area younger than 140 supports forest stands that are 100-140 years old.

Hemlock and Balsam stands regenerated after logging on TFL 41 are densely stocked. Natural regeneration occurs on logged sites including those planted after logging. Stems per hectare in very young stands may be as high as 10,000 and are typically about 6,000 stems per hectare. One consequence of high initial densities is second growth stands that have high fibre volumes and many small-diameter trees. These stand structures will produce relatively low volumes of sawlogs.

Juvenile spacing treatments that reduce stand densities will increase average tree diameter, sawlog volumes and stand value relative to untreated stands, without losing volume. In dense untreated stands, the age at which a commercial thinning is feasible is higher than in stands that have been previously spaced.

The Terrace area is one of the very few places in BC where the second growth will be better than the old growth. In particular, the second growth will be much sounder than the old growth. Currently over 60% of the fibre ends up at the pulpmill (40% in logs, 20% in residual chips). In managed second growth stands, a lower proportion of the fibre should end up as pulp.

Recent ongoing productivity studies have shown that the second growth is more productive than indicated by previous estimates.

Harvest Costs and Markets

Harvesting the old growth stands on TFL 41 is expensive. Steep slopes, rockwork, large bridge structures, the required logging systems, and low quality decadent timber, combine to produce high timber recovery costs.

The pulp component of the old growth stands is currently directed to the pulp mill in Kitimat. Some of the old growth logs from TFL 41 are exported.

The downturn in the Asian economies has resulted in the introduction of cheaper substitutes. Those have become popular with consumers, reducing the demand for high end products. They have also fundamentally changed the Asian markets. Traditionally, green hemlock markets have been replaced by Kiln dried SPF or Russian Red Pine. Markets for the wood products produced from TFL 41 are very weak.

The existing sawmills in the Terrace area were designed to manufacture large logs. In the future, as second growth stands form a bigger part of the timber harvest, the average log size will be smaller. To process the changing log profile, mills will have to be re-tooled. Part of the required processing capability will probably be something like a merchandiser and the ability to cut very small logs. There may be a requirement for value added facilities such as chop plants and finger jointing.

Other Resource Issues

Non-timber resource issues may impact potential silvicultural programs on TFL 41. The recently completed Kalum Land and Resource Management Plan (LRMP) contains features that might be considered in future silvicultural investment decisions.

Habitat supply

The discussion of habitat supply is based on extracts from the Kalum LRMP. In the LRMP habitat for grizzly bears, ungulate winter range, and other wildlife is discussed.

For grizzly bears, the objective is to provide an adequate supply of berry feeding. Application of mitigation measures to managed forests is aimed at achieving and maintaining natural levels of forage supply (as present in old growth forests). Mitigation measures will be applied on the pure, rich and wetter sites (on operationally feasible treatment units of no less than one hectare in size) to offset the need for the seral stage restriction. The mitigation measures will also be applied on complexes that include rich and wet site series. In these situations, the treatment units will be as small as is practicable, readily identifiable after harvesting, and be a minimum of 0.1 hectares. The rich and wetter sites are defined in CWHWS 1 and CWHWS 2 as 06, 07, 08, 09 and 11 site series; in the CWHVM 1 as 05, 07, 08, 09, 10 and 14 site series; and in the CWHVM 2 as the 05, 08 and 11 site series. Examples of mitigation measures include:

- harvest at age class 4 (60-80 years),
- pre-commercial thinning,
- commercial thinning,
- group selection,
- cluster planting,
- selection harvesting,
- variable retention,
- pruning,
- prescribed fire,
- managing to lower stocking standards.

Table 10 below shows the stocking levels recommended for key grizzly bear habitat areas.

Table 10: Recommended Stocking Standards for Key Grizzly Bear Habitat

Subzone variant	Site association ¹	Target	Free growing stocking standards ² (stems/ha)	
			Minimum	Maximum ³
vm1 and vm2	BaCw – Foamflower	600	400	660
	BaSs – Devil’s club			
ws1 and ws2	BaCw – Devil’s club	600	400	660
vm1 and vm2	CwSS – Skunk	400	200	440
ws1 and ws2	Cabbage			
vm1 and vm2	Ss – Salmonberry	500	200	550
ws1 and ws2	Ac – Red-osier dogwood			

¹ Stocking levels for low bench floodplain site associations are not listed; site-specific prescriptions should be developed that account for the naturally low density of microsites appropriate for crop tree growth and high shrub cover.

² The “well spaced” clause does not apply to forage gaps when stems are clustered as part of the silvicultural prescription. Crop tree size vs. competing brush standards are unchanged from existing regional guidelines. When determining the number of crop trees, minimum inter-tree distances, as stated in the silviculture prescription, still apply to trees within the cluster.

³ If stand exceeds maximum density set in the prescription at free growing, these guidelines recommend spacing back to this stocking level.

On TFL 41 two ungulate species, mountain goat and moose have winter ranges that require special management. The quality and quantity of forage available in winter influences how quickly summer reserves are depleted and affects chances of survival and reproduction.

Thermal or heat regulating cover, in the form of conifers with canopy structures, which intercept snowfall and reduce snow accumulations below, is a critical component of ungulate winter range. Thermal cover provides shade to reduce stress in the warmer days of early and late winter and shelter from mid-winter cold temperatures and heavy snowfalls. It helps conserve energy or calorie requirements during extreme environmental conditions. Road access to winter ranges is a concern because of increased disturbance and poaching when ungulates are concentrated on winter range. Disturbances on the winter range often results in animal displacements to less suitable habitat, increased vulnerability to predators and reduced survival rates.

The LRMP and riparian management provisions of the *Forest Practices Code of BC Act* provide direction for incremental silviculture activities with respect to ungulate winter range.

For all wildlife the intent of the LRMP is to maintain the quantity and quality of wildlife populations and habitats, including plant communities.

Visual Management

Visual management is important along highway and other travel corridors. Harvest blocks planned within visually sensitive areas are subjected to visual impact assessments. Cut block boundaries in visually sensitive areas are designed to blend into the viewed landscape.

5.0 SILVICULTURE HISTORY

A silviculture program has been maintained on TFL 41 since 1973, when the first plantations were established. The program has emphasized prompt reforestation of all logged cutblocks and stand tending to maintain highly productive growth of the regenerated forest areas. It has not been difficult to successfully reforest most logged areas, either by planting or from natural regeneration. By the mid-1980s, plantations of Sitka spruce were found to be susceptible to terminal weevil damage so planting of this species is now restricted to a small percentage of the total seedlings planted. As shown in Table 11 reforestation of TFL 41 has been kept in balance with the area harvested or burnt by wildfire so that backlog of not sufficiently restocked (NSR) area is minor.

Table 11: Reforestation Performance

	Activity	1994-98	1976-98
Basic	Planted	3,708	13,856
	Natural	1,690	8,684
	<i>Subtotal</i>	5398	22540
	Site Prep.	0	180
	Broadcast Burnt	0	865
	Brushed	1,836	3,976
Intensive	Juvenile Spaced	1,813	2,470
	Pruned	28	47
Logged	Logged	3,217	20,649
	Wildfire	143	3,249
	<i>Subtotal</i>	3,360	23,898

The overriding goals of the silviculture program are to:

- maintain the forest productivity of all harvested areas through prompt reforestation with ecologically suitable species,
- manage and tend regenerated forests to realize the biological growth potential,
- enhance where appropriate the economic value of forest products.

Planting is completed in spring and summer. Approximately 700,000 seedlings are planted each year. Species used are: western hemlock 40%; *amabilis* fir 35%; western red cedar 12%; Sitka spruce, 10%; other species 3%. Generally, stock types are PSB 313 styroplugs of similar size with a portion of larger plugs, PSB 415, used for planting on brush hazard sites.

5.1 SEED SUPPLY

Conifer seed for the reforestation program is provided from cone collections made from natural stands within the licence area. Cone collections are made in accordance with the *Tree Cone, Seed and Vegetative Material Regulation*.

The goal is to maintain sufficient seed inventory of each species to supply projected seedling requirements for a 10-year period. As shown in Table 12 the total seed inventory at August 1998 was equivalent to approximately 17 million seedlings in two seed zones.

Cone collection in any given year will depend on seed needs for specific species and the quality of the cone crop. There are no seed orchards established for coastal species in the seed planning zones that cover the licence area.

Table 12: Seed Inventory

Seed Zone	Species	# of Seedlots	Seeding potential
Submaritime			(000's)
Ba	Amabilis fir	4	1,410
Cw	Western red cedar	3	1,310
Fd	Douglas-fir	1	50
Hw	Western hemlock	3	1,690
Ss	Sitka spruce	1	2,400
Pl	Lodgepole pine	1	190
Subtotal			7,050
Maritime			
Ba	Amabilis fir	7	1,725
Cw	Western red cedar	3	2,790
Hm	Mountain hemlock	2	2,000
Hw	Western hemlock	3	1,575
Ss	Sitka spruce	4	2,325
Cy	Yellow cedar	2	13
Subtotal			10,428

5.2 INCREMENTAL SILVICULTURE

Incremental silviculture is any stand level treatment designed to maintain increased timber value sometime in the future. Potential treatments on TFL 41 are juvenile spacing, pruning and fertilization during the next five years. Commercial thinning could begin in approximately 10-15 years. The scope for a large incremental silviculture program on TFL 41 during Management Plan 6 (MP6) is limited due to the relatively young age of the regenerated stands.

Initially, the juvenile spacing program began in the early 1980's, funded by various provincial and federal government programs. Approximately 2,500 ha have been spaced since 1983. The forecasted activity goals for the next five years in Table 13 are dependent on continued funding by Forest Renewal BC or other sources. These treatments are labour intensive and provide jobs for local silviculture workers.

Table 13: Silviculture Activity Forecast (hectares)

Activity	1999		2000		2001		2002		2003	
	WF	FRBC	WF	FRBC	WF	FRBC	WF	FRBC	WF	FRBC
Surveys	1,000	900	1,000	300	1,000	200	1,000	100	1,000	100
Site Preparation	0	0	0	0	0	0	0	0	0	0
Planting	650	15	650	10	650	10	650	5	650	0
Brushing	200	100	200	50	200	50	200	20	200	0
Free Growing Surveys	1,000	--	1,000	--	1,000	--	1,000	--	1,000	--
Spacing	--	500	--	500	--	500	--	500	--	500
Pruning	--	50	--	50	--	50	--	50	--	50

The goals of the incremental silviculture program are to:

- maintain productive, healthy regenerated stands,
- increase recoverable merchantable volume of sawlogs at final harvest,
- increase piece size and value at final harvest,
- meet stand level biodiversity objectives,
- shorten rotation length.

Approximately 14% of the productive land base (47,829 hectares) is a defined enhanced management zone. This zone has the best growing sites and access, and has the most promising potential for an economic return from silviculture investments. However, not all areas within this zone would receive treatments.

The underlying rationale is for an enhanced silviculture program to improve the value and shorten the merchantable rotation age. Treatments will help mitigate the age class imbalance and increase the timber supply availability in 40-60 years. This approach will broaden fibre supply options in the future and provide an opportunity to recover volumes from commercial thinnings.

Potential benefits from an enhanced silviculture program could be:

- improvement in the quality and volume yield,
- increase in stand value,
- shorter rotation ages,
- bridging the forest age class imbalance by improving availability of merchantable timber in 40-60 years,
- creating silviculture employment opportunities,
- enhancing and maintaining biodiversity over the landscape.

Pre-Commercial Thinning

West Fraser expects to juvenile space approximately 2,500 hectares of western hemlock/*amabilis* fir stands during MP 6. Stands are assessed for juvenile spacing once they have reached sufficient age and height. Potential candidate stands would have the following attributes:

Site Index	> 20 m
Age	15-20 years
Height	5-8 metres
Density	> 3500 sph
Health	Low incidence of insects, fungi or mammal damage

The thinning regime is designed to maintain growing space for crop trees, while leaving enough stems to allow an opportunity for commercial thinning. Post-spacing density is in the 800-1200 sph range. Species selection order in preference is Ba, Hw and Cw. Western red cedar is left, as it generally makes up a small component of the species in regenerated stands.

Pre-standing surveys will be completed for candidate stands. These are predominantly mixed hemlock/balsam stands on undulating terrain, benches and lower slopes up to 50%. Stands should possess average or better productivity and be exhibiting signs of stand competition for growing space. Stand management prescriptions are prepared for selected stands.

Pruning

A limited amount of pruning has been completed since 1993. Hemlock/*amabilis* fir stands of above average productivity, i.e., $\geq$ SI 27 m, are considered to be suitable candidates. The purpose is to produce high quality knot-free wood in the first log length (up to 6 m).

Stands are selected and prioritized in accordance with the *Pruning Guidebook* (1995). Pruning of the bottom log is scheduled in two stages:

- first lift 0-3 m when average stand height is 6-8 m,
- second lift 3-6 m when average stand height is 10-12 m.

Fertilization

To date no operational fertilization has occurred on the TFL. A fertilization trial was established in 1996 and covered seven sites. Re-measurement is scheduled for each year for the next four years to 2000.

Commercial Thinning

Second growth stands in the enhanced management zone will be tended and spaced with regimes designed to allow an opportunity for commercial thinning in the future. This opportunity will not be available for another 10-15 years at minimum. By that time there will be approximately 2,700 hectares of second growth hemlock stands on the onshore area that are about 40-45 years old. Those stands on flat to moderate topography could have a first entry commercial thinning. These stands have regenerated from some of the first logging on the TFL in the 1970s.

There are approximately 830 hectares of age class 2 stands in the offshore area that originated from A-frame logging along the Douglas Channel shoreline in the 1950's. Although these stands could be thinned, any operation would be uneconomic at current log prices. Prior to any actual thinning these stands would be surveyed to provide data for assessing the economic feasibility of any commercial thinning.

6.0 OPPORTUNITIES TO INCREASE TIMBER SUPPLY

Timber supply can be increased in four ways by:

- increasing market demand,
- increasing fibre production from the fixed land base,
- more accurate estimates of productivity that are higher than previous estimates,
- re-arranging the harvest schedule and flow of harvested timber over time.

Increasing market demand causes marginal timber to become economic. Timber is a commodity whose price is determined in global markets. No single producer can affect these prices so this factor is outside the scope of this study.

Cultural techniques exist for growing more fibre on a fixed land base. These techniques are fertilization, irrigation/drainage and the use of genetically improved stock. Any given site provides finite amounts of the factors affecting fibre production. These are water, nutrients, sunlight and temperature. The moisture regime may be changed by irrigation or its reverse, drainage. The nutrient regime may be changed by fertilization. In TFL 41 irrigation and drainage are not practical, economically feasible or even desirable techniques. In hemlock stands, the application of fertilizer produces variable and unpredictable results. To date, fertilizer trials in hemlock stands have not produced effective operational procedures.

For a given set of site conditions some genotypes will produce more fibre than others. Improved genotypes are produced from seed orchards. Usually, seed from second-generation orchards produce more than trees grown from wild seed. In the Terrace area, there are currently no seed orchards for hemlock. Therefore yield gains from genetically improved seed are not available at this time.

By lowering rotations, or otherwise changing the harvest schedule over time, some silvicultural treatments may improve timber supply in periods of scarcity. In this project, juvenile spacing is a case in point.

6.1 POTENTIAL TREATMENTS

Potential treatments on TFL 41 are:

- spacing (pre-commercial thinning),
- pruning,
- fertilization,
- commercial thinning,
- use of genetically improved planting stock.

Limited local research into fertilization combined with other studies show that fertilization of amabilis fir is warranted. These studies also suggest that results with hemlock are inconclusive. Accordingly, only fertilization treatments in balsam leading stands were included at the stand and forest level.

At this time, genetically improved seed is not available from seed orchards. Past experience with first generation hemlock seed orchards suggest a genetic gain of about 2.0 %.

Pre-commercial thinning

On TFL 41 stocking levels of young stands are high. Whether planted or naturally regenerated, continued natural invasion of hemlock and balsam tree produces young stands with high densities up to 10,000 stems per hectare. Densities of about 6,000 stems appear commonly. Reducing stand densities by pre-commercial thinning is an important treatment option on TFL 41. Pre-commercial thinning may be applied with or without a later commercial thinning.

West Fraser is currently following the spacing regimes shown below.

Table 14: Current West Fraser Spacing Regimes

Species	Treatment Age	Residual sph	BH50SI
HW	15	800	20, 25, 30
HW	15	1,000	20, 25

Effect of Initial Density on Stand Volume

Smith and Massie (1987) discussed some fundamental principles of growth and yield. The following sections on spacing and fertilization are based on their discussion. Every forest site has a fixed innate productive capacity because a given area of land provides just so much soil moisture, soil nutrients, carbon dioxide and sunlight for plant growth. Classical experimental work in agriculture and forestry (Kira et al 1953, 1956; Pienaar and Turnbull, 1973) showed that the same final yield is reached over a considerable range of initial densities. For example, using data for *Pinus Elliotti*, Pienaar and Turnbull (1973) found that initial densities of 2964 stems per hectare, down to 494 could ultimately sustain an equal amount of live basal area. One of their conclusions was stands with initial stocking densities above a certain lower limit will converge towards an identical amount of basal area per hectare, determined by the productive capacity of the given site.

This conclusion agrees with the well known forestry doctrine of “trend towards normality”. Stands with low initial densities take longer to reach the final yield but grow more steadily than high density stands. High density stands grow at a fast early rate which peaks at a younger age than low density stands and then falls off rapidly.

The total stand includes all live trees, from ground to tip. The merchantable stand includes the wood between a specified stump height and a minimum top diameter in all live trees bigger than a specified diameter at breast height.

This report used merchantable volumes for all stand and forest level analyses. Merchantable volume was the volume in all trees with a dbh of at least 17.5 centimetres, between a 30 centimetre stump and a 10 centimetre top diameter inside bark.

Even though the principle of constant final yield is true for a wide range of densities on a given site, some densities are too low to take full advantage of the productive capacity of the site. These stands are called **understocked stands**. A **fully stocked stand** is one which is fully using the productive capacity of the site.

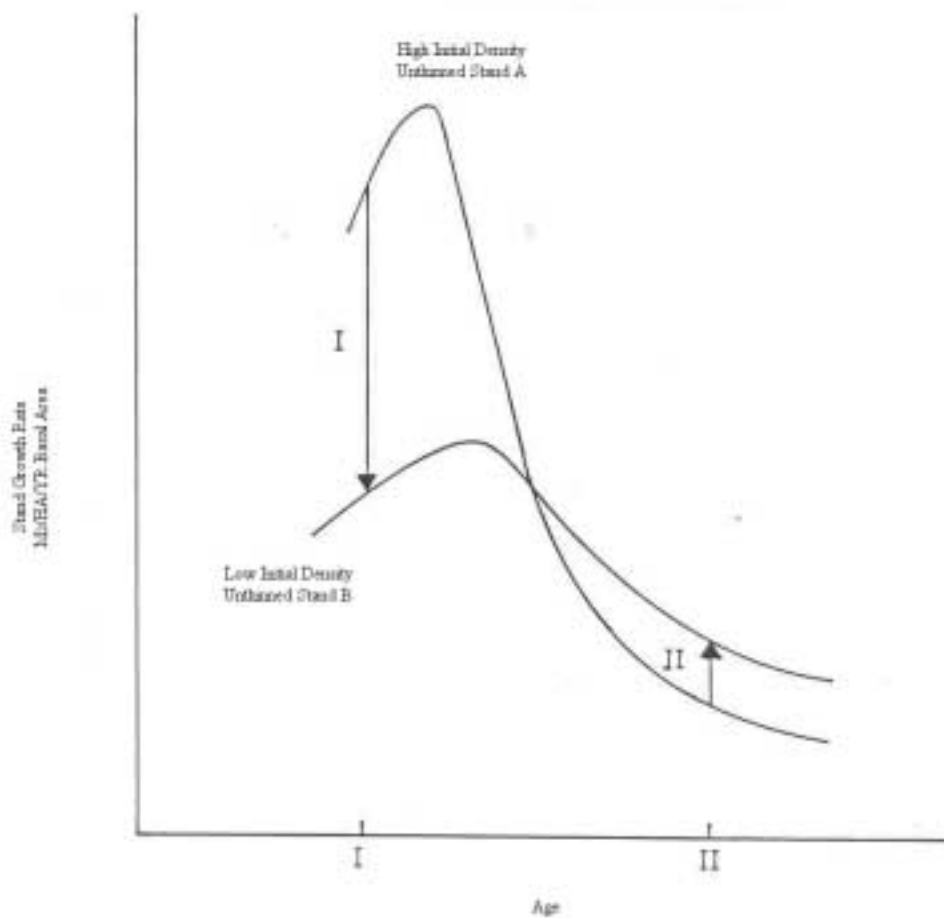
Stand Growth and Thinning Treatments

Removal of stems by thinning or spacing immediately reduces stand density, basal area and volume per hectare. The growth rate after thinning is different from what it would have been in the unthinned state.

Pienaar and Turnbull (1973) suggested that for a wide range of thinning regimes, the total stand growth in a thinned stand (after thinning 'shock') is identical with that of an unthinned stand of the same age and the same basal area as the thinned stand. Their data from permanent sample plots directly supported this suggestion. Later work by Pienaar et al (1985) suggested that the growth rate of the thinned stand is slightly greater than an unthinned stand of the same basal area and age. Nevertheless, the expectation is a good working rule.

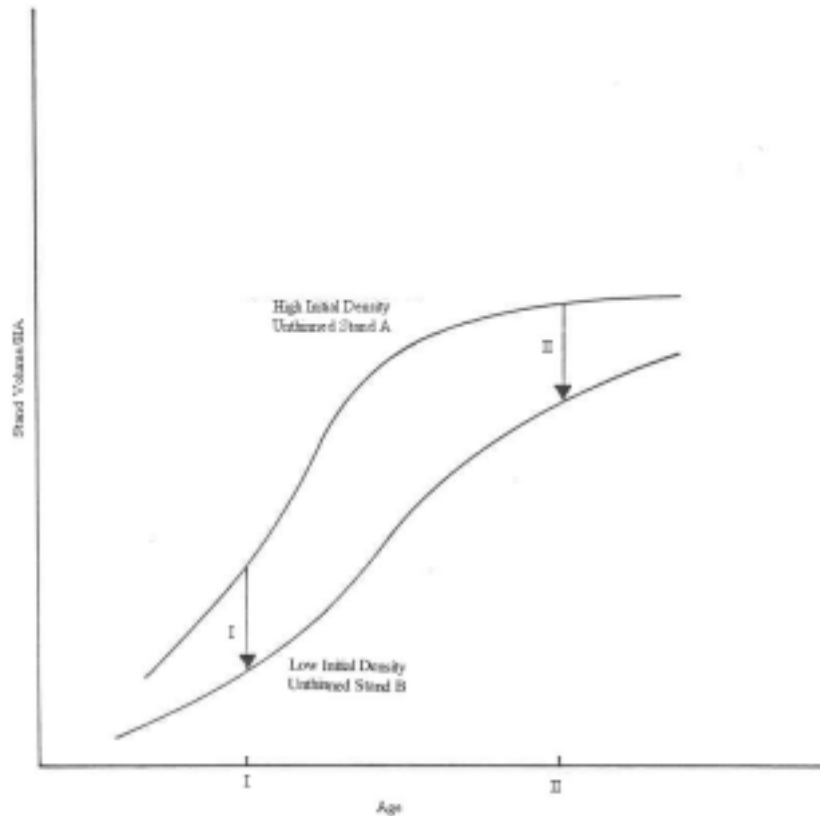
Supposing a stand established at a high initial density is thinned, what growth responses would growth and yield theory predict? Figure 2 shows that the response depends upon the stage of development at which thinning takes place. Figure 2, from Pienaar and Turnbull (1973), shows a growth curve current annual increment (CAI) for an unthinned stand, 'A', established at a high initial density and an unthinned stand, 'B', established at a low initial density. Arrow #I represents a thinning of the high density stand to a basal area equal to that of the low density unthinned stand. Thinning takes place before the CAI of either stand has reached its peak. The thinned stand now follows or slightly exceeds the growth of an unthinned stand having the same basal area, i.e., the growth of stand 'B'.

Figure 2: The Growth Response of a Thinned Stand



Arrow #II represents a thinning of stand 'A' at an age well past the peak CAI. Once more, for basal area growth, stand 'A' will be transformed to stand 'B'. This time, however, the growth rate after thinning will be increased. Figure 2 predicts that a juvenile spaced stand will have a decreased stand basal area growth rate after spacing but commercial thinning of a well stocked 60-year old stand will result in an increased growth rate after thinning. Total stand basal area and total stand volume behave in the same way. Figure 3 repeats the pattern shown in Figure 2 in terms of stand volume yield rather than stand basal area growth.

Figure 3: The Yield Response of a Thinned Stand



In Figure 3 the stand with the high initial density, stand 'A', increases rapidly in volume with the peak growth rate, or steepest part of the curve, occurring early. Thereafter the growth rate drops off rapidly and the stand slowly approaches the final yield. The low initial density stand, 'B', grows slowly at first, its peak growth rate occurring later and the maximum slope of the curve is lower than that of stand 'A'. Both stands are converging toward an identical final yield.

Arrow #I represents a thinning of stand 'A' to the same volume as an unthinned stand 'B'. The thinning takes place before the CAI has reached its peak. The thinned stand now follows, or slightly exceeds, the growth of the unthinned stand 'B'. As far as volume growth goes, stand 'A' has been transformed to stand 'B'. The thinned stand 'B' regains the volume lost in thinning and grows toward the final yield at a lower but steadier rate than stand 'A'.

Arrow #II represents a late thinning of stand 'A'. In this thinning the volume growth rate increases after thinning.

Pruning

Pruning is carried out to produce high value stands through the production of a significant component of clear wood. There are two kinds of pruning: high and low. High pruning is done on older trees often using ladders. In BC, low pruning is practiced. This is done in young trees, usually removing branches to a height of six metres in two successive lifts. Low pruning must be carried out in a very narrow window of opportunity. After each pruning lift, half the height of the tree remains in live crown. Due to the high cost of two treatments, single lift pruning and more cost effective treatment approaches are now being investigated.

Pruning has been applied for many years outside BC. For example, on private land in the UK, Hiley (1956) suggested that pruning is likely to pay with heavy thinning, to be a doubtful risk with moderate thinning, and to be uneconomic with light thinning. The reason for Hiley's suggestion was that heavily thinned trees reached sawlog size much sooner than moderately or lightly thinned trees. Therefore, the cost of pruning was compounded for a shorter period. In the heavily thinned trees, stand volume at the merchantable size would be reduced, but for the pruned trees the increased volume of clear timber would more than repay the compounded cost.

West Fraser is currently following the pruning regime shown below.

Table 15: Current West Fraser Pruning Regimes

Leading Species	Age Prune 1	Age Prune 2	BH 50 SI	Stand Type
HW/Ba	15	20	20, 25, 30	Spaced to 800 sph

Fertilization

Fertilizer responses in hemlock have proven to be extremely variable and are, for practical purposes, unpredictable. Responses in amabilis fir are thought to be more consistent and similar to those found in Douglas fir. In this project it was assumed that fertilization of balsam leading stands would produce a volume gain at harvest of 30 cubic metres per hectare.

Commercial Thinning

The following section describes the development of a complete set of potential treatments.

West Fraser does not currently commercial thin on TFL 41. However, the dense second growth stands are candidates for commercial thinning.

An analysis of these regimes has been completed. The subset of treatments giving the best return while minimizing risk has been identified. Within this subset, individual treatments have been ranked using their risk/reward ratio. The financial criterion used in the analysis was present net worth (PNW).

7.0 DETERMINING POTENTIAL TREATMENTS

At the time of harvest the structure of each second growth stand will have a big impact on its net value. Here, net value is defined to be the difference between the value of the logs in a stand less the costs of felling and moving to roadside.

When harvested, each stand will produce a mix of pulplogs and sawlogs. The exact mix will depend on average piece size and the level of utilization applied to the stand. A given hectare of forest can be made to yield saw logs and pulplogs in varying proportions.

In TFL 41 the base case is assumed to produce the maximum long term harvest level. The base case includes basic silviculture treatments that produce prompt restocking of logged areas and uses planting to ensure full stocking of regenerated areas. The standard MoF yield prediction model for stands regenerated after logging, TIPSy, generates higher merchantable timber volumes at rotation age from unspaced stands than from spaced stands.

To develop a complete set of potential treatments we have:

1. started with the current treatments,
2. determined which second growth stand structures maximize net stand value,
3. discovered treatment regimes that produce the target stand structures,
4. developed a set of benchmark or “do nothing” regimes,
5. added all the regimes in (1), (3) and (4) together to make the complete set.

7.1 TARGET STAND STRUCTURES

There are economic techniques for determining which second growth stand structures will maximize net value. These techniques are called “marginal analysis”. The technique requires the development of three components:

- ISO cost curves,
- ISO revenue curves,
- the expansion path.

ISO Cost Curves

Stand structure is described by two variables, volume per hectare and average volume per tree. Then it can be determined which combinations of the two variables produce stands, which can be felled and brought to roadside for a fixed cost, say \$15.00 per cubic metre. The exercise can be repeated to find out which stand structures can be logged and brought to roadside for \$20.00 per cubic metre and so on.

Using a mathematical equation based on the interior appraisal manual and a research paper by Holtzschler and Lanford (1997), we produced the set of ISO-cost lines shown in Figure 3. The

mathematical derivation of the equation is given in Appendix I. A three dimensional version of Figure 4 is presented as Figure 5.

Figure 4: ISO-Cost Curves

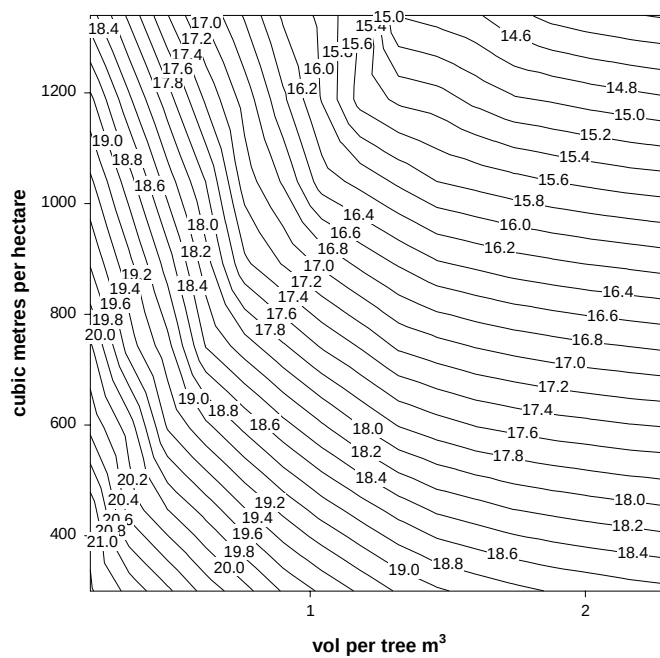


Figure 5: ISO-Cost Surface

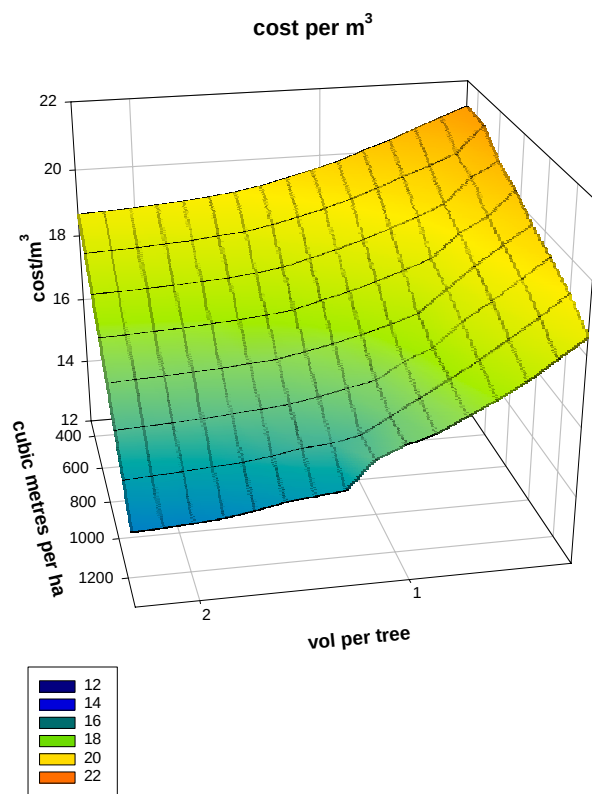


Figure 4 shows that there are many different stand structures that can be logged at the same cost per cubic metre. For example, a stand whose average volume per tree is 1.1 cubic metres and whose volume per hectare is 420 cubic metres costs the same per cubic metre as a stand whose average piece size is 0.6 cubic metres and whose volume per hectare is 620 cubic metres. In both cases we estimate the cost per cubic metre to be \$19.00.

Figure 4 also shows us that when volume per hectare is kept constant, but piece size increases, the logging cost per cubic metre decreases. For example, if we keep volume per hectare at 620 cubic metres but increase piece size from 0.6 to 1.7 cubic metres then logging cost drops from \$19.00 to \$17.50 per cubic metre.

ISO-Revenue Curves

Using the TIPSy stand model and assumptions about current (low market) log values we were able to determine the different stand structures that produce the same gross log value per cubic metre. These curves are shown in Figure 6. Figure 6 is drawn as a three-dimensional surface in Figure 7. Our log value assumptions are documented in Appendix II.

Figure 6: ISO-Revenue Curves – Low Market

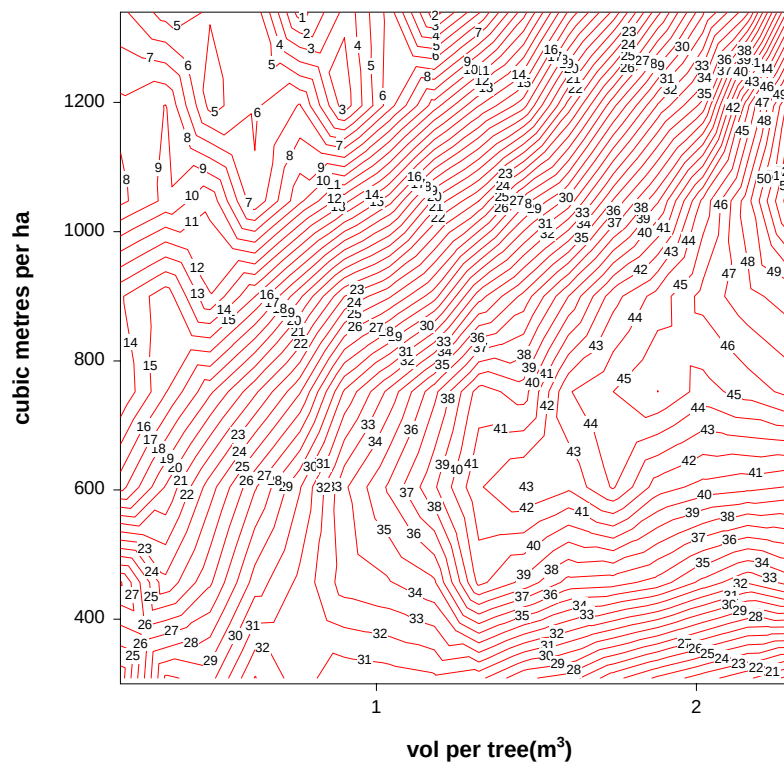
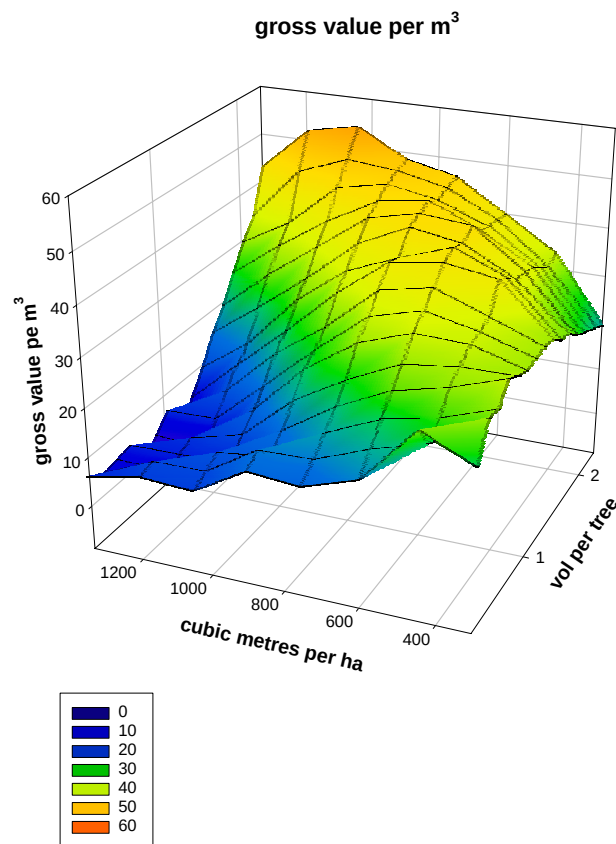


Figure 7: ISO-Revenue Surface – Low Market



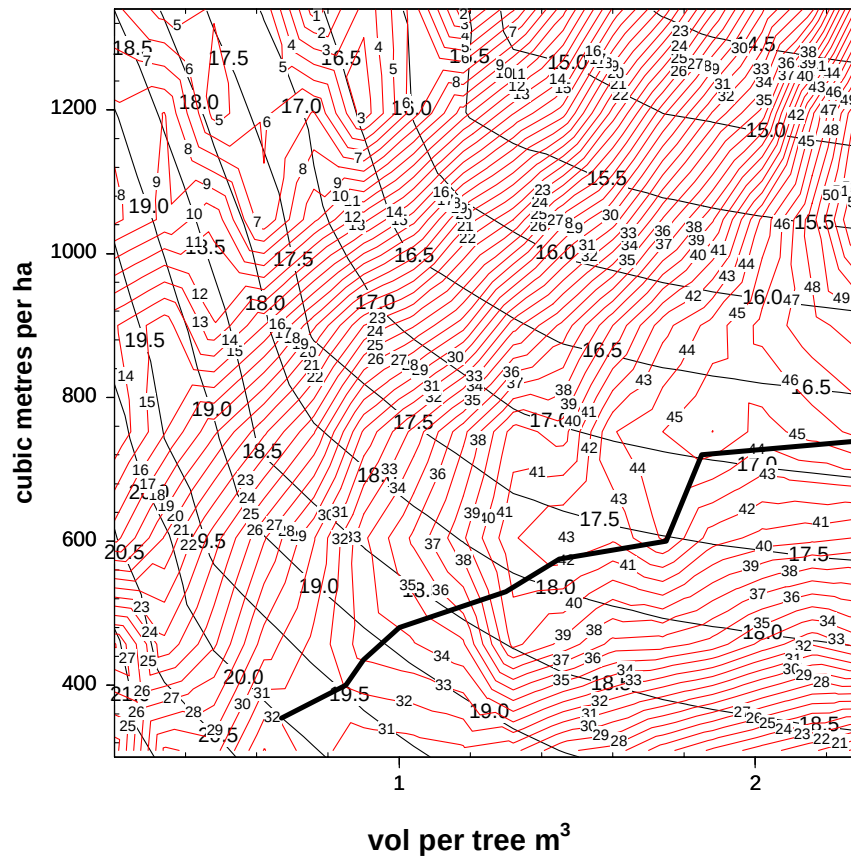
Figures 6 and 7 show that many different stand structures have the same average value per cubic metre. For example a stand of 620 cubic metres per hectare with an average piece size of one cubic metre has a gross value of \$35.00 per cubic metre in low markets. The same average value of \$35.00 is achieved by a stand with only 400 cubic metres per hectare and a piece size of about 1.5 cubic metres.

Finding the Expansion Path

For each ISO-cost line in Figure 4 there is a single stand structure which produces the maximum net value. This point is where one of the ISO-revenue lines in Figure 6 is **tangent** to the ISO-cost line.

If this point is defined for every ISO-cost line, then the point can be joined together to form the **expansion path**. The expansion path shows those stand structures that produce the maximum net value. Figure 8 shows the expansion path obtained by overlaying Figures 4 and 6 and identifying the relevant tangent points.

Figure 8: Expansion Path Showing the Stand Structures, which Maximize Net Value



The expansion path in figure 8 shows that for a tree-to-truck cost of \$18.00 a stand with an average piece size of 1.2 cubic metres and 5500 cubic metres per hectare will maximize net roadside value at \$23.50 per cubic metre. This also means that under the conditions assumed for TFL 41, the average tree-to-truck logging cost for this stand structure is \$34.00 per cubic metre.

We repeated this exercise for high market values and produced an expansion path very similar to the one in Figure 8. The average expansion path over high and low markets is shown in Table 16.

Table 16: Stand Structures that Maximize Net Stand Value for TFL 41

Piece size (m ³)	Vol/ha (m ³)	% Pulp	% Sawlog	Net value \$/ m ³	
				Low market	High market
0.7	350	37	63	14	56
1.0	420	21	69	17	60
1.3	485	26	74	20	63
1.6	460	23	77	21	66
1.9	725	21	79	23	68
2.2	740	18	82	24	69

The stand structures in Table 16 apply to all sites. The time taken to reach each stand structure will be longer on poorer sites and the higher volume/higher piece size structures will never be reached on the poorer sites.

7.2 THE POTENTIAL TREATMENTS

A set of 112 different silviculture treatments was developed for financial analysis. This set had four components.

First, for site indices 15, 20 and 25 we determined a set of treatments that will produce the target stand structures shown in Table 16. This was done by trial and error using the TASS model. To these we added existing treatment regimes. We also built a set of benchmark “do nothing” treatments. The total set of 112 potential treatments is shown in Table 17. These treatments were subjected to a financial analysis using present net worth (PNW) as the investment criterion. The financial analysis is described in Section 8 of this report.

The second component of the treatment set was treatments for existing stands that did not produce the target stand structures. These treatments resulted in commercial stands at minimum cost.

The third component was a set of existing regimes that are in use on the TFL, and some regimes that maximize volume yield.

The fourth component was a set of benchmark ‘do nothing and harvest at culmination age’ regimes. These provided the benchmark against which the silvicultural investments were compared.

The complete set of 112 potential treatments is shown in Table 17. The treatments were subjected to a financial analysis that included an assessment of market risk, using present net worth as the criterion of success and were done at two real discount rates (2% and 4%).

The potential treatments include many that are not applied by West Fraser in their current silviculture program. Because many of the potential treatments are based on producing the most profitable stand structures, on the lower sites commercial thinning entries would have to be made at advanced ages to produce these structures. It is important to realize that the potential treatments are not the same as recommended treatments. By showing the implications of different treatments, Table 17 shows why some potential treatments would never be chosen.

Table 17: The List of Potential Treatments

Treat- ment #	Post JS density	CT year	CT vol removed m ³ /ha	Harvest year	Harvest volume m ³ /ha	SI	Final piece size	
1				134	454	15	0.35	benchmark-culmination stand
2				110	633	20	0.61	benchmark-culmination stand
3				98	852	25	1.0	benchmark-culmination stand
4	800	60	111	73	420	25	1.0	
5	800	60	128	80	485	25	1.3	
6	800	60	133	88	560	25	1.6	
7	800	60	106	100	725	25	1.9	
8	800	60	127	105	740	25	2.2	
9	1,200	60	139	73	420	25	1.0	
10	1,200	60	156	80	485	25	1.3	
11	1,200	60	161	88	560	25	1.6	
12	1,200	60	134	100	725	25	1.9	
13	1,200	60	155	105	740	25	2.2	
14	660			132	350	15	0.7	
15	560			164	420	15	1.0	
16	500			193	485	15	1.3	
17	645			85	350	20	0.7	
18	540			100	420	20	1.0	
19	480			113	485	20	1.3	
20	458			126	560	20	1.6	
21	515			148	725	20	1.9	
22	450			157	740	20	2.2	
23	635			62	350	25	0.7	
24	535			73	420	25	1.0	
25	475			80	485	25	1.3	
26	448			88	560	25	1.6	
27	500			100	725	25	1.9	
28	435			105	740	25	2.2	
29	800	135	100	164	420	15	1.0	
30	800	160	123	193	485	15	1.3	
31	800	80	105	100	420	20	1.0	
32	800	95	138	113	485	20	1.3	
33	800	105	149	126	560	20	1.6	
34	800	130	120	148	725	20	1.9	
35	800	135	152	157	740	20	2.2	
37	800	65	137	80	485	25	1.3	
38	800	70	153	88	560	25	1.6	
39	800	85	129	100	725	25	1.9	
40	800	90	160	105	740	25	2.2	
41	1,200	135	128	164	420	15	1.0	

Treat- ment #	Post JS density	CT year	CT vol removed m ³ /ha	Harvest year	Harvest volume m ³ /ha	SI	Final piece size	
42	1,200	160	147	193	485	15	1.3	
43	1,200	80	135	100	420	20	1.0	
44	1,200	95	162	113	485	20	1.3	
45	1,200	105	175	126	560	20	1.6	
46	1,200	130	140	148	725	20	1.9	
47	1,200	135	167	157	740	20	2.2	
49	1,200	65	164	80	485	25	1.3	
50	1,200	70	179	88	560	25	1.6	
51	1,200	85	151	100	725	25	1.9	
52	1,200	90	182	105	740	25	2.2	
53		100	74	132	350	15	0.7	
54		135	122	164	420	15	1.0	
55		160	143	193	485	15	1.3	
56		65	73	85	350	20	0.7	
57		80	125	100	420	20	1.0	
58		95	158	113	485	20	1.3	
59		105	171	126	560	20	1.6	
60		130	136	148	725	20	1.9	
61		135	166	157	740	20	2.2	
62		45	54	62	350	25	0.7	
63		60	131	73	420	25	1.0	
64		65	157	80	485	25	1.3	
65		70	173	88	560	25	1.6	
66		85	147	100	725	25	1.9	
67		90	178	105	740	25	2.2	
68	600			121	998	25	2.5	JS @ 15 yrs, prune @ 15 and 20 yrs, harvest at culmination
69	800			107	919	25	1.8	JS @ 25 yrs, harvest at culmination
70	800			136	780	20	1.4	JS @ 25 yrs, harvest at culmination
71	1200			102	886	25	1.4	JS @ 25 yrs, harvest at culmination
72	1200			134	783	20	1.2	JS @ 25 yrs, harvest at culmination
73	1200	65	81	85	350	20	0.7	
74	600			70	476	25	1.02	JS @ 15 yrs, prune @ 15 and 20 yrs
75	600			80	590	25	1.29	JS @ 15 yrs, prune @ 15 and 20 yrs
76	1600			85	468	20	0.45	
77	1600			62	460	25	0.46	
78	800			85	476	20	0.79	AU 7, fertilize 10 years before harvest
79	800			62	459	25	0.74	AU 6, fertilize 10 years before harvest
80	1200			85	495	20	0.63	AU 7, fertilize 10 years before harvest
81	1200			62	477	25	0.60	AU 6, fertilize 10 years before harvest
82				132	446	15	0.35	No treatment, clear cut
83				85	455	20	0.36	No treatment, clear cut
84				62	448	25	0.34	No treatment, clear cut
85	800			85	476	20	0.79	AU 7, fertilize @ 75yrs
86	800			62	459	25	0.74	AU 6, fertilize @ 55yrs
87	1200			85	495	20	0.63	AU 7, fertilize @ 75yrs
88	1200			62	477	25	0.60	AU 6, fertilize @ 55yrs
89	1000			132	766	20	1.26	

Treat- ment #	Post JS density	CT year	CT vol removed m ³ /ha	Harvest year	Harvest volume m ³ /ha	SI	Final piece size
90	1000			102	881	25	1.51
91	1000			85	443	20	0.63
92	1000			62	436	25	0.62
93	1000	60	89	100	420	20	1.0
94	1000	60	98	113	485	20	1.3
95	1000	60	100	126	560	20	1.6
96	1000	60	85	148	725	20	1.9
97	1000	60	96	157	740	20	2.2
98	1000	70	107	100	420	20	1.0
99	1000	70	121	113	485	20	1.3
100	1000	70	123	126	560	20	1.6
101	1000	70	101	148	725	20	1.9
102	1000	70	117	157	740	20	2.2
103	1000	60	119	73	420	25	1.0
104	1000	60	135	80	485	25	1.3
105	1000	60	141	88	560	25	1.6
106	1000	60	115	100	725	25	1.9
107	1000	60	135	105	740	25	2.2
108	1000	70	134	73	420	25	1.0
109	1000	70	152	80	485	25	1.3
110	1000	70	158	88	560	25	1.6
111	1000	70	127	100	725	25	1.9
112	1000	70	151	105	740	25	2.2

Some treatments will maximize volume and some will maximize value. As explained in section 7.2, the criterion of value used in this report is present net worth. Figure 8 shows the results of several TIPSy runs for different spacing treatments. For pure natural hemlock stands with a starting density of 600 stems per hectare, site index 20, five different TIPSy runs were made:

- no spacing,
- space to 500, 800, 1200 and 1600 stems per hectare.

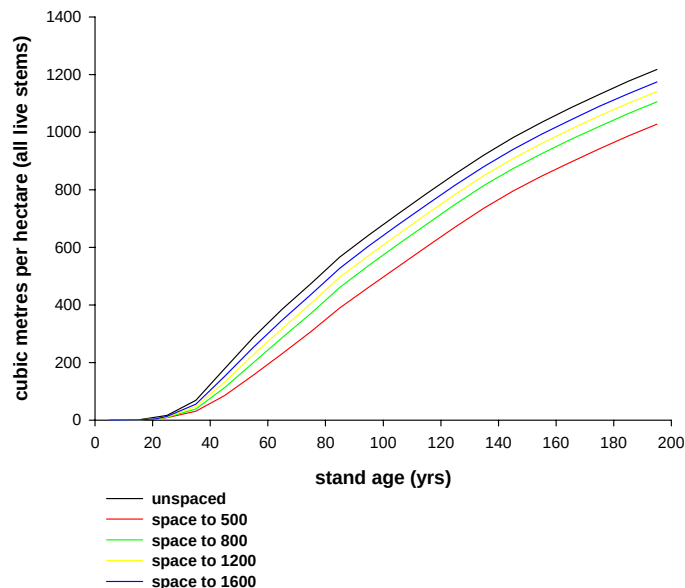
As Figure 8 shows, TIPSy produces the highest merchantable volume when no spacing is applied. Projected timber volumes from TIPSy decrease systematically as the stems left after spacing drops from 1600 to 500 per hectare. These treatments correspond to treatments 2, 19, 70, 72 and 76 in Table 16, and Appendix IV.

The spacing treatments result in a bigger average piece size at the same age as the untreated stand, or a reduced harvest age. Countering this there is a loss in volume and a spacing expense that must be carried to rotation age. The financial analysis showed that spacing did not increase the PNW of the stand relative to no treatment harvested at or close to one of the target stand structures. In this case, based on TIPSy output, the highest volume and highest investment value resulted from no spacing. In treatment 76, a natural stand is spaced to 1600 stems per hectare and evaluated at an 85 year rotation. This is 25 years shorter than the untreated natural stand harvested at culmination age (treatment 2). The PNW of this investment is also lower than that of the untreated stand.

The same conclusion is reached when a natural stand is spaced to 1000 stems per hectare (treatment #91).

Figure 9: Hemlock SI 20

TIPSy merchantable volume per hectare at different spacing densities



8.0 IMPROVING TIMBER VALUE

Timber value in second growth stands can be improved in three ways by:

- manipulating stand structure to increase the percentage of sawlog volume, and piece size,
- producing stand structures which maximize net revenue,
- increasing the percentage of clear wood on sawlog grades.

Often, measures that increase timber value decrease the volume of fibre available for harvest. For example, stand structures that maximize net revenue often have a lower volume per hectare than other stands.

9.0 FINANCIAL ANALYSIS OF POTENTIAL TREATMENTS

Section 7 previously described a procedure for determining those second growth stand structures, which maximize net revenue. The same section listed a comprehensive set of 112 candidate treatments for financial analysis. The tables in Appendix IV provide a summary of revenues, volumes and products to be expected from the 112 treatments.

The procedures used to carry out the stand level financial analyses are summarized below.

First, a set of potential treatments was developed. This included spacing and commercial thinning treatments designed to maximize undiscounted operating profit; a set of spacing treatments representing current practices; a set of controls using natural, untreated stands harvested at culmination age; and a set of possible treatments using fertilization and pruning that are not part of current practices. In total, 112 potential treatments were developed and subjected to financial analysis. These are listed with their resulting volumes by log grade in Appendix IV.

The financial analysis used Present Net Worth (PNW) as the investment criterion. PNW was calculated for two discount rates, 2% and 4%. Market uncertainty was incorporated into the PNW calculation by calculating a risk adjusted, or expected, PNW over the complete market cycle. For each discount rate those treatments whose PNW was greater than or equal to zero were selected and ranked with the largest PNW value ranked highest.

This process is explained in more detail in sections 9.1 to 9.6.

9.1 SECOND GROWTH STANDS

In our financial analysis we have recognized and accounted for the different pay back periods for investments made in existing stands. From the comprehensive list in Table 17, the treatments appropriate to existing stands of different ages have been applied.

Each existing second growth forest stand will be a candidate for some of the 88 treatments depending on its age and site class. None of the stands in the 41-60 year-old range are candidates for juvenile spacing. No site class 15 stands are considered to be candidates for fertilization. In TFL 41, when the available treatments were listed for the existing stands in each age range, the number of potential treatments is expanded. In this project, all potential treatments that would be applied for each age class were identified and a PNW value calculated. The method used to label these age specific treatments is shown in Table 18 using treatment # 63 from Table 17 as an example.

Table 18: Labelling Age Specific Treatments

Age Class	Treatment	Age Specific Label
1 – 20	63	63
21 – 40	63	63 – 2
41 – 60	63	63 – 3
61 – 80	n/a	n/a
81 – 100	n/a	n/a
101 – 120	n/a	n/a

Treatment 63 is a treatment where no juvenile spacing is applied, commercial thinning at age 60 is carried out, followed by a final felling at age 73. Only high sites (average SI 25) are eligible. As Table 15 shows, this treatment can only be applied to existing stands that are 60 years or younger. The treatments 63, 63-2 and 63-3 are considered separately because the period over which revenues and costs are discounted is different for a stand currently aged ten and another aged 50. The shorter the discount period, the higher the present net worth. As Table 18 shows, the single potential treatment #63 expanded into six PNW calculations because it was applied to six specific age classes of existing stands.

9.2 TREATMENT COSTS

Local treatment costs for spacing and pruning are averages derived from local experienced costs. These costs are:

spacing – \$1100 per hectare
pruning – \$1300 per hectare per lift

Commercial thinning costs and the cost of final felling were derived from mathematical equations developed by the consultants for this project. These equations were based on the Interior Appraisal Manual and a research paper by Holtzscher and Lanford (1997). Their study examined and measured the different costs of operating cut-to-length logging equipment over a range of average stand diameters at breast height. Systems included:

1. feller buncher/manual forwarder,
2. feller buncher/processor/forwarder,
3. swing-to-tree harvester/forwarder.

Each individual system followed different cost trends, but for all systems, tree size had a significant effect on the unit cost of wood produced. As tree size increased, the unit cost of wood produced decreased. In stands whose average diameter was above 20 cm, the costs for all three systems were similar. Below 20 cm, the swing-to-tree harvester system was more expensive than the other two. In this study the consultants used data from Holtzscher and Lanford for the first two systems.

The cost equations are shown in detail in Appendix I. Different relationships were apparent for stands with average tree volume less than 0.8 cubic metres and those equal to or greater than 0.8 cubic metres. The consultants developed a different cost equation for each size range and used a mathematical spline method to join them. In these equations, tree-to-truck logging cost was a function of:

- stand volume per hectare,
- average volume per tree removed during harvesting,
- percentage of stand volume removed.

9.3 REVENUES

For each stand three products were defined:

- pulplogs,
- gang sawlogs,
- standard sawlogs.

Using TIPSy output describing log volumes by letter grade, the three products were defined as follows:

pulplogs = 30% J and 100% U,X,Y logs,
gang sawlogs = 60% of non-pulp volume,
standard sawlog = 40% of non-pulp volume.

Log price assumptions were:

	High <u>Market</u>	Low <u>Market</u>
pulplogs/m ³	\$60	\$28
gang sawlogs/m ³	\$90	\$50
standard sawlogs/m ³	\$140	\$80

9.4 FINANCIAL CALCULATIONS

The QUICKSILVER model was used to calculate Present Net Worth (PNW) for each treatment at discount rates of zero, two, four, six, and eight percent. These calculations were done three times for:

- high markets,
- low markets,
- average markets.

These calculations were applied to every age specific treatment including the control, or do nothing treatments. Bullard and Straka (1993, 1998) state that the appropriate rate of interest to use in forestry often depends on who owns the land. This report presents results for 2% and 4% discount rates.

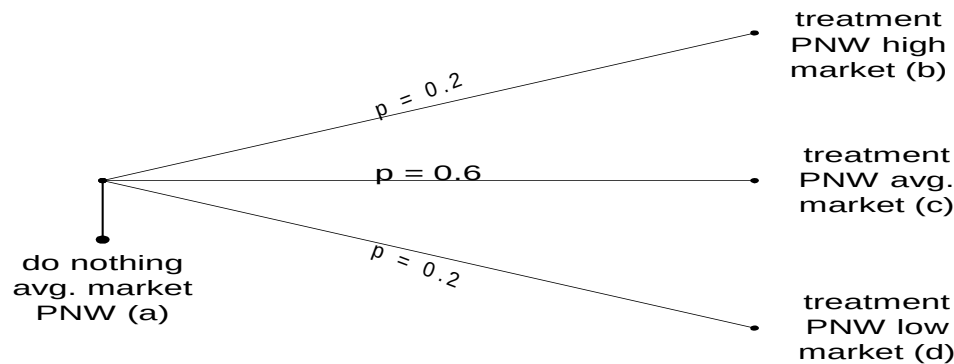
9.5 INCLUDING MARKET RISK

For every treatment the 'Mark to Future' method of Dembo and Freeman (1998) was applied. This produced a PNW value for every treatment that was adjusted for market risk and therefore was valid over a complete market cycle.

The framework used to calculate market risk was developed as follows:

1. From inspection of long-term commodity futures charts, the probability of high and low market prices was estimated to be 20% for each. The probability of average market prices was estimate to be 60%.
2. The mark to future diagram shown in Figure 10 was constructed.

Figure 10: Mark to Future Diagram for Market Risk, for a Single Treatment



3. From Figure 10 these quantities were calculated:
 - $b-a$,
 - $c-a$,
 - $d-a$.
4. The upside for a treatment was calculated as:

$$0.2(b-a)+0.6(c-a)+0.2(d-a)$$
 for those values of $(b-a)$, $(c-a)$ and $(d-a)$ that were greater than zero.
5. The downside for a treatment was calculated as:

$$0.2(b-a)+0.6(c-a)+0.2(d-a)$$
 for those values of $(b-a)$, $(c-a)$ and $(d-a)$ that were less than zero.
6. For each treatment an upside (U) and a downside (R) calculated which included market risks.
7. Finally a market risk adjusted value was calculated for each treatment from the quantity $U - R$

This risk adjusted value is the premium (or penalty) that should be added to or subtracted from the PNW for the do nothing treatment. This value per hectare gives the dollars per cubic metre that are available for spending on loading, unloading, trucking, overheads, etc. The size of this amount suggests how far away from Terrace a treatment could be applied.

The PNW, upside, downside and risk adjusted values are all different for different discount rates. In the analysis a discount rate of 0, 2, 4, 6 and 8% was used at the stand level.

Real Price Increases

From the various historical data, it can be shown that the value of wood products has increased more than the rate of inflation. There are different opinions as to the size of this 'real price increase'. For private corporations the consultants have used a range between 1 and 2.5 percent, usually in conjunction with deferred discount rate assumptions. In this way, a matrix of net present values is produced for

different discount rate/real price increase combinations. In any event, assuming a real price increase in the future reduces the effective discount rates by the real price increase assumption.

In this study, the consultants were asked to use the combination of a 4% discount rate with an assumption that future wood product prices will show a 2% real price increase. The result is an effective discount rate of 2%.

9.6 FINDING TREATMENTS THAT MINIMIZE RISK

For both discount rates, a scatter plot was constructed. These are shown in Figures 11 and 12. The Y-axis measures the downside risk. The X- axis measures the upside potential. The units on both axes are PNW in dollars, per hectare.

Figure 11: TFL 41 Silviculture Risk Frontier – 2% Real Discount Rate

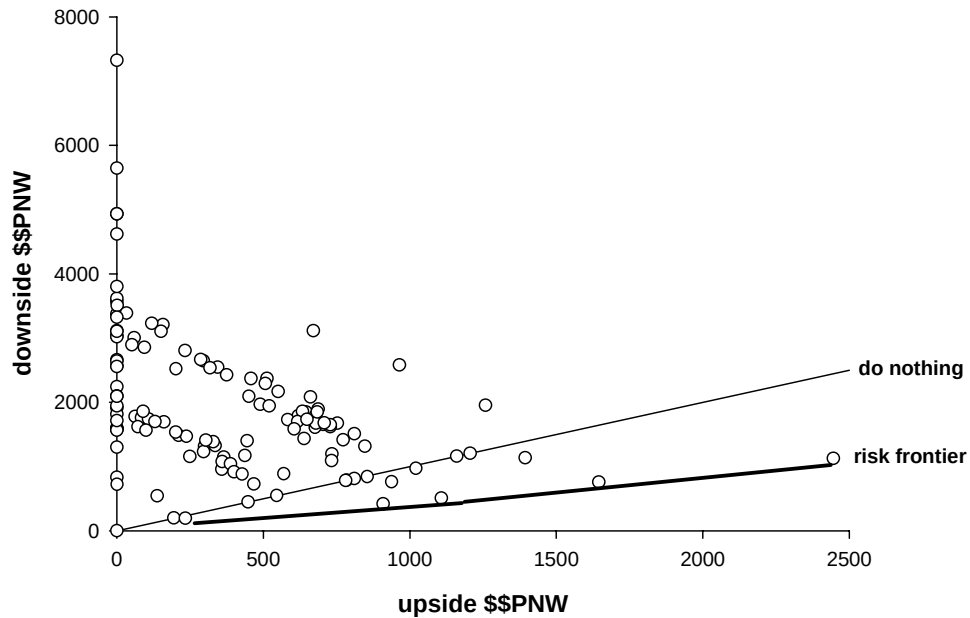
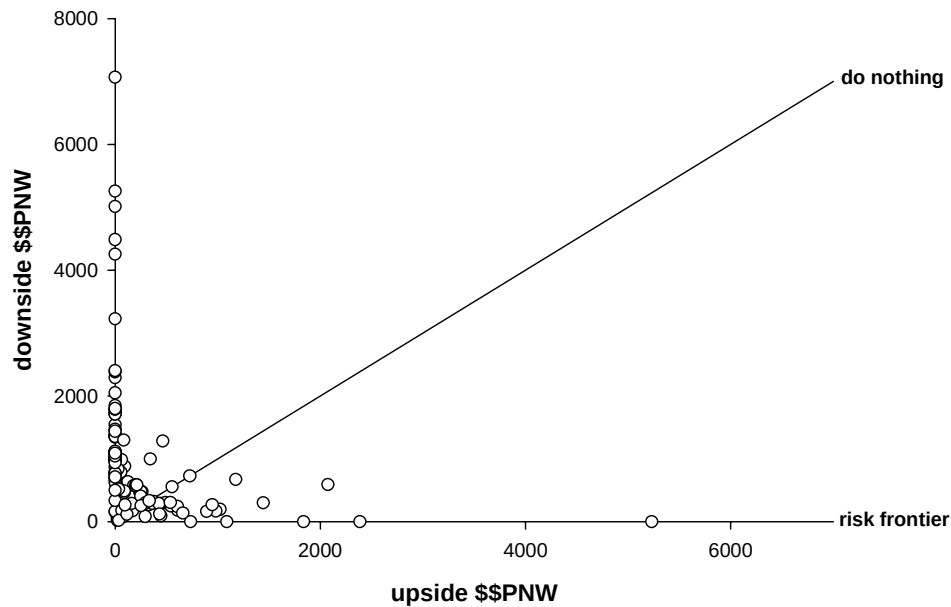


Figure 12: TFL 41 Silvicultural Risk Frontier – 4% Real Discount Rate



In Figures 11 and 12, the treatments that minimize market risk for a given return lie along the risk frontier. The do-nothing control treatments lie along the 45-degree line. Treatments to the left of and above the 45 degree are worse than doing nothing. Treatments to the right of and below the 45-degree line are better than doing nothing.

It is from this latter group that a portfolio of financially efficient investments can be developed.

There are three ways of ranking the investments that fall to the right of the 45-degree line:

1. rank by risk/reward ratio,
2. rank by risk adjusted return,
3. rank by risk adjusted PNW.

Ranking Investments by Risk/Reward Ratio

The treatments on the risk frontier are those that minimize risk for a given upside potential. Choosing these treatments produces a portfolio that **minimizes risk relative to rewards**.

Ranking Investments by Risk Adjusted Return

The treatments on the risk frontier may not maximize risk adjusted return. Ranking those treatments to the right of and below the 45-degree line by risk-adjusted return will produce a portfolio that is low risk (not minimal risk). The risk-adjusted value of this portfolio will usually be higher than the minimal risk portfolio. This portfolio **maximizes risk-adjusted returns at low risk**.

Ranking Investments by Risk Adjusted PNW

The treatments to be right of, and below the 45 degree line that minimize risk or maximize risk adjusted returns, may not maximize the risk adjusted PNW. For example, an investment on SI 15 land may produce a risk adjusted return of \$500 per hectare compared to an investment on SI 20 land, which returns \$400 per hectare. In our framework, both of these returns are risk adjusted and are relative to the do nothing benchmark. But the PNW of the SI 15 benchmark may be \$2,500 and that of the SI 20 benchmark may be \$7,000. The risk adjusted PNW for the SI 15 investment would then be \$3,000 compared with a value of \$7,400 for the more productive SI 20 land.

Choosing a Ranking Method

All three ranking methods described here are valid. If the objective is a portfolio of investment that minimizes risk, then ranking by risk/reward ratio is appropriate. When the objective is to keep risks low but to maximize returns on investment, then ranking by the risk adjusted value is preferable. If maximizing asset values is the dominant objective, then ranking by risk adjusted PNW is the criterion to use.

For the type 2 analyses, the consultants chose the third method. Ranking by PNW is a conventional choice in silvicultural investment analysis where risk is not incorporated. The objective of maximizing asset values is commonly implied by existing silvicultural programs in BC for public lands. Tables 19 and 20 rank the treatments to the right of and below the 45-degree line that are shown in Figures 11 and 12.

Financially Efficient Investment Portfolios

Table 19 shows the efficient silvicultural investment portfolio for TFL 1, ranked by risk adjusted PNW at a 2% discount rate. Table 20 shows the portfolio for a 4% discount rate.

Table 19: TFL 41 Risk Adjusted Investment Portfolio at 2% Real Discount Rate

Rank	Treatment label	SI	Existing Age	Risk Adjusted PNW \$/ha
1	87-4	20	61-80	16,084
2	2-4	20	61-80	14,763
3	86-6	15	101-120	13,699
4	1-6	15	101-120	13,437
5	87-3	20	41-60	10,823
6	75	25	1-20	10,247
7	71	25	1-20	10,207
8	3	25	1-20	10,195
9	2-3	20	41-60	9,935
10	86-5	15	81-100	9,219
11	1-5	15	81-100	9,043
12	87-2	20	21-40	7,284
13	2-2	20	1-20	6,685
14	87	20	1-20	5,975
15	2	20	1-20	5,484
16	86	15	1-20	2,304
17	1	15	1-20	2,260

Table 20: TFL 41 Risk Adjusted Investment Portfolio at 4% Real Discount Rate

Rank	Treatment Label	SI	Existing Age	Risk adjusted PNW \$/ha
1	87-4	20	61-80	12,020
2	86-6	15	101-120	8,936
3	1-6	15	101-120	8,431
4	57-4	20	61-80	8,276
5	2-4	20	61-80	6,789
6	87-3	20	41-60	5,485
7	56-3	20	41-60	4,244
8	86-5	15	81-100	4,079
9	88	25	1-20	4,078
10	1-5	15	81-100	3,847
11	57-3	20	41-60	3,776
12	2-3	20	41-60	3,098
13	62	25	1-20	3,069
14	63	25	1-20	3,054
15	64	25	1-20	2,970
16	65	25	1-20	2,665
17	92	25	1-20	2,606
18	90	25	1-20	2,536
19	87-2	20	21-40	2,503
20	90	25	1-20	2,441
21	9	25	1-20	2,429
22	4	25	1-20	2,404
23	77	25	1-20	2,402
24	81	25	1-20	2,380
25	79	25	1-20	2,309
26	5	25	1-20	2,305
26	10	25	1-20	2,305
26	106	25	1-20	2,305
29	23	25	1-20	2,298
30	49	25	1-20	2,248
31	3	25	1-20	2,241
31	96	25	1-20	2,241
31	107	25	1-20	2,241
34	56-2	20	21-40	1,936
35	57-2	20	21-40	1,724
36	87	20	1-20	1,690
37	92	25	1-20	1,632
38	2-2	20	21-40	1,413
39	56	20	1-20	1,308
40	57	20	1-20	1,164
41	91	20	1-20	961
42	2	20	1-20	954
43	86	15	1-20	261
44	1	15	1-20	246

In Table 20, eight treatments include commercial thinning without any previous juvenile spacing. Local foresters have not found this to be operationally feasible. It may be that the TIPSy model used to predict stand yields is indicating higher, more valuable volumes from commercial thinning of unspaced stands than are realistic.

The treatments listed in Tables 19 and 20 should be viewed as an efficient set around which the preferred management scenario can be developed. Although treatments that include commercial thinning appear in Table 24, in poor market conditions commercial thinning is very unlikely to be applied. This is because it represents an operating loss in low markets.

In this project we have included market risk in the valuation of silvicultural investments. First, we calculated a risk-adjusted or expected present net worth over all market conditions. Second, we calculated a risk/reward ratio for each investment. Only investments whose risk/reward ratio is less than or equal to 1.0 were accepted. These investments were then ranked by risk adjusted PNW.

The risk/reward ratios had an interesting interaction with discount rates. Risk/reward ratio was calculated from dividing the downside for a treatment by the upside of a treatment. Upside and downside were calculated by the process described in section 9.5, and are relative to the PNW of the do-nothing benchmark treatment. One result of this process is that any treatment whose risk/reward ratio is less than one, provides a return that is less than doing nothing. A second result is, that at lower discount rates more treatments provide a return that is less than do nothing, than is the case at higher discount rates. This happens because the risk-adjusted PNW relative to the PNW of the do-nothing base changes as discount rates increase. The changes relative to the base cause some risk/reward ratios that are less than one at low discount rates to become greater than one at higher rates.

For these reasons, more investments have a risk/reward ratio greater than one at a 4% discount rate than at a 2% discount rate. More risk-adjusted investments at 4% are better than doing nothing than is the case at 2%. These investments are listed in tables 19 and 20.

There are seven feasible investments whose rewards are greater than the risk and who also appear in both Tables 19 and 20. These treatments are shown in Table 21 below.

Table 21: Comparison of Selected Investments at 2% and 4% Discount Rates

Label	Treatment	Existing Age	Risk Adjustment 2%	PNW \$/ha 4%	Site Index
2-4	Clear-cut existing stand at age 10	61-80	14,763	6,789	20
1-2	Clear-cut existing stand at age 134	81-100	9,043	3,847	15
2-3	Clear-cut existing stand at age 98	40-60	9,935	3,098	20
87-2	Stand previously spaced, clear-cut at age 85	21-40	7,284	2,503	20
2-2	Clear-cut existing stands at age 110	21-40	6,685	1,413	20
2	Clear-cut existing stands at age 110	1-20	5,484	954	20
86	Space to 800 sph clear- cut at age 62	1-20	2,304	261	25
1	Clear-cut at age 134	1-20	2,260	246	15

In all cases, the PNW values at a 2% discount rate are higher than at a 4% discount rate. Incorporating risk into the calculation causes slight changes in the ranking. For example, treatment 2-3 ranks ahead of 1-5 at a 4% discount rate but their positions are reversed at a 2% rate. As Table 21 shows, treatments applied to older existing stands tend to rank ahead of treatments applied to young stands. This is because of the shorter period to final yield in the older stands and the associated discounting period.

10.0 TIMBER SUPPLY ANALYSIS

In TSA's the government sells timber in various licences and it is therefore obliged to make these volumes available. In TFL's the management of a fixed area has been delegated to the licensee by the government. The licensee, with government approval, projects harvest rates in the short, medium and long term.

10.1 GOVERNMENT PRINCIPLES

In 1999, the government prepared an Incremental Silviculture Strategy for British Columbia. This strategy included seven working papers. Working Paper 3 is entitled 'Government's Goals, Proposed Guiding Principles'. This paper does not provide a list of government's goals but it does list a set of guiding principles. Among these is a set from Forest Renewal BC's (FRBC) 1997/1998 Land-Based Handbook. FRBC guiding principles help in identifying enhanced forestry program priorities and developing investment plans. Three guiding principles relevant to this study are repeated below.

Timber Supply Considerations

Management unit priorities should address Timber Supply Review (TSR) needs and considerations, and silvicultural activities should be designed to ensure that management assumptions are met.

Stand Treatment

Stand-level treatments should be clearly linked to TSA and TFL objectives or regional/subregional silviculture strategies, as appropriate. They should be selected to meet local economic, social and environmental objectives while adhering to sound biological principles. Stand Management Prescriptions (SMP's) should reflect, as nearly as possible, the future objective of the forest management unit, within the parameters of local site and stand conditions.

Forest Structure

The density management regimes and forest structure necessary to achieve TSA and TFL objectives should be defined. In the absence of specified management objectives, the stand density in managed and unmanaged second growth stands should vary widely, in order to ensure adequate diversity in future forest structures and habitat conditions.

10.2 TIMBER SUPPLY CONTEXT FOR TFL 41

The base case of the timber supply analysis forecasts timber supply subject to current administrative constraints. It is based upon several assumptions about timber growth and yield, and the technical availability of current mature timber stands. The constraining mechanisms and 'pinch points' that shape the timber supply forecast for TFL 41 are identified in the following section.

Base Case Forecast

The base case harvest forecast is included in the 1999 Timber Supply Analysis that was part of the current Management Plan 6 for TFL 41.

The initial harvest level in the base case harvest forecast is 400,000 cubic metres per year, and is the current allowable annual cut (AAC). After three decades the harvest must be reduced by about 10% per decade until decade nine. The reduction is the result of the deletion of the Kitlope TFL 41. From decade 10 onward, the long term harvest level immediately increases to 510,500 cubic metres per year.

The approved 20-year plan using current green-up and adjacency rules indicate about 24 years for harvest at the present allowable rate of 400,000 cubic metres per year. This agrees with the base run for the timber supply analysis.

Figure 13 shows the base case harvest flow over time.

Figure 13: TFL41 Base Harvest Forecast

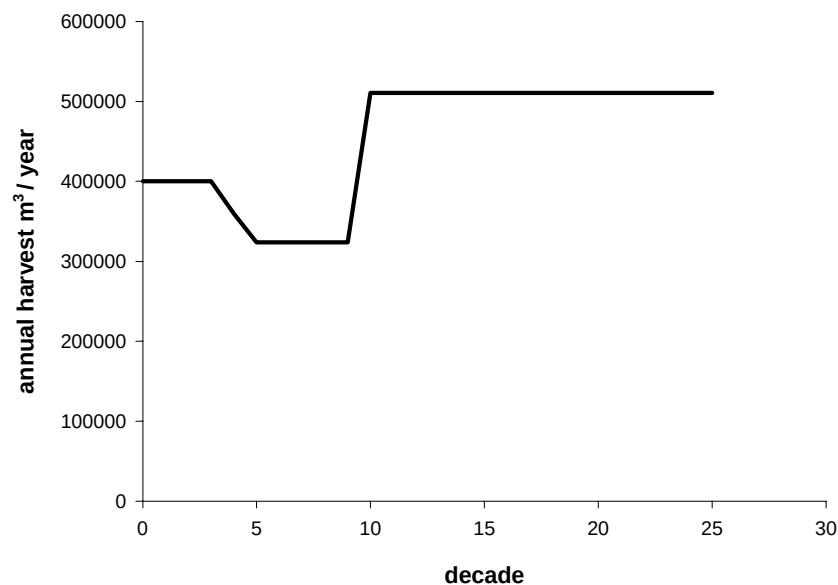


Figure 14 shows the forecasted harvest areas for the base case. Figure 15 projects the per hectare volumes expected to be harvested over time.

Figure 14: Base Case: Areas Harvested Over Time

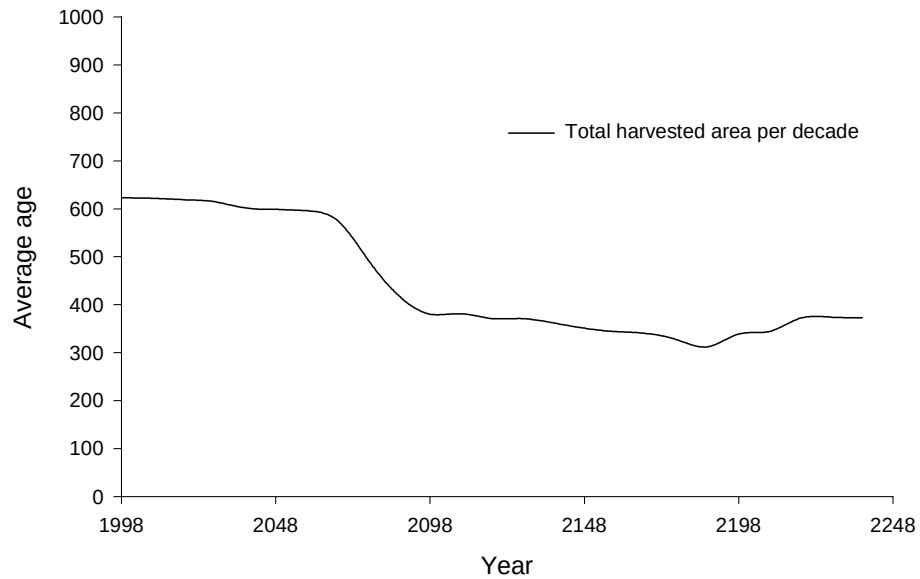
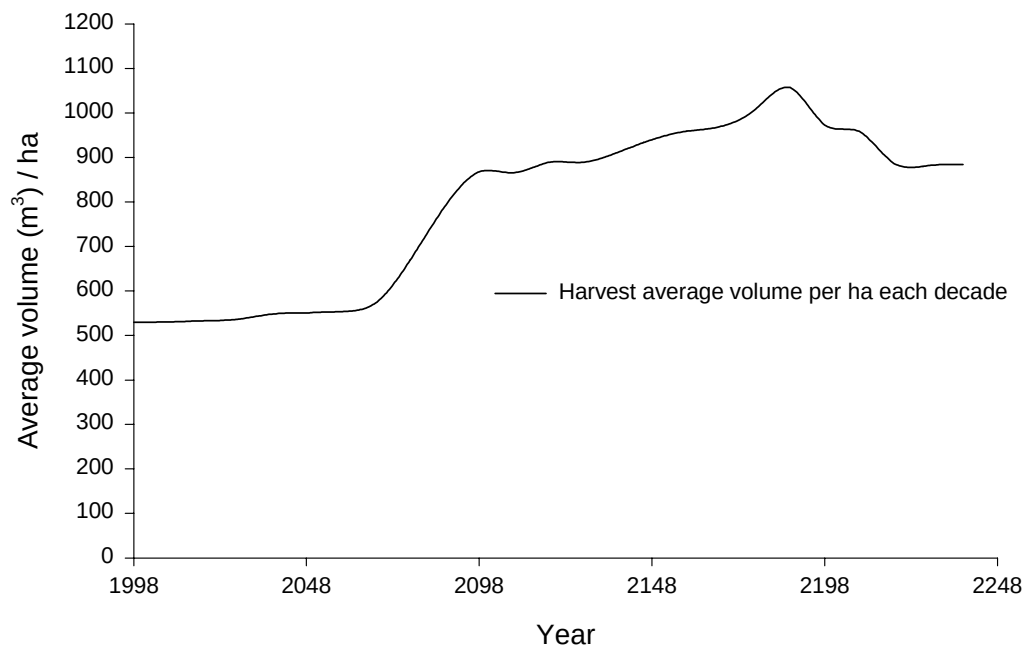


Figure 15: Base Case: Volume per hectare Harvested Over Time



Over the planning horizon the average area harvested annually ranges from about 620 hectares in the first three decades to about 350–375 hectares at the long-term harvest level. After 100 years, new stands regenerated after logging begin to appear in the harvest. These regenerated stands are expected to have higher volumes than existing stands at the same age. Consequently harvest levels go up while the harvested area stays relatively low.

In TFL 41 there will be a transition period during which the present emphasis on harvesting old growth forests will shift to a future emphasis on harvesting forests regenerated after logging. In the base case the transition from old growth to second growth forests is expected to take about 90 years to complete. Old growth timber produces higher grades and values in present markets than second growth timber. Offsetting this difference is the relative logging costs in current old growth stands, versus expected lower logging costs in the accessible second growth stands regenerated after early logging in old growth. As old growth timber becomes more scarce, and manufactured wood products become more prevalent, the relative value of second growth timber may increase. But, if timber prices do increase over the long run, demand for wood products may shift to products that are substitutes for wood. Because of all the shifting economic factors, and the long transition period, no definite statements can be made about future timber values for TFL 41.

Key Features of the Base Case

Two key features of the base case for TFL 41 were:

- site index assumptions for regenerated stands,
- volume adjustments for existing old growth.

Estimates of site productivity have traditionally been made using site index, which is subsequently used to drive growth and yield predictions. The Site Productivity Working Group identified problems with traditional site index curve applications in old growth stands. Subsequently the BC Ministry of Forests (MoF) derived a set of interim adjustment equations for old growth site indices; Nussbaum and Nigh (1997) and also Site Index Adjustment for Old-Growth Coastal Western Hemlock Stands in the Kalum Forest District; Nigh and Love (1998).

In the base case for TL 41 the site index of all hemlock leading stands regenerated after logging existing old growth was adjusted by adding ten metres for stands with an old growth site index between eight and 18 metres. This method is described by the MoF by Nigh and Love (1998) in the paper referred to above. Old growth site index adjustments for other species were obtained from MoF Research Working Paper 36 and applied to the base case. The old growth site index (OGSI) adjustments were applied after the net down procedure to ensure that the timber harvesting land base was not changed. These adjustments did not change in any way the existing timber volume assigned to each old growth polygon.

For the base case, and all other analyses, localized volumes were used for existing stands 141 years or older. A re-inventory of TFL 41 was completed prior to the management plan. The results of this inventory were used to localize the old growth volumes obtained from VDYP applied to the old growth polygon attributes. Application of these factors to the VDYP derived yield curves ensured that estimates of existing timber volumes in the forest estate model closely matched the localized old growth

volumes from the inventory polygon database. Table 22 shows the old growth volume localization factors.

Table 22: VDYP Volume Localization Factors for Existing Old Growth Stands

Leading Species	Age Class	Localization Factor
Hemlock	8, 9	0.8057
Balsam	8, 9	0.7170
Cedar	8, 9	0.8446

Table 22 shows that in the re-inventory of TFL 41 actual old growth volumes averaged about 80% of those predicted by VDYP from inventory polygon attributes.

Sensitivity Analyses

In the management plan timber supply analysis sensitivity analyses showed that harvest forecasts were most sensitive to changes in:

- OGSi conversions,
- regenerated stand volumes,
- minimum harvest ages,
- land base assumptions.

Changing cover constraints, green-up heights and visual zone areas produced very small changes in harvest forecasts.

Making OGSi conversions in hemlock leading stands only did not affect short and medium term harvest levels but had some effect on long term levels. Making any OGSi adjustments at all resulted in the AAC being achieved for two instead of three decades because existing timber stocks were needed to maintain mid term harvest levels. Without any OGSi adjustments the minimum harvest level fell to two thirds that of the base case and the long term harvest level was cut in half to about 235,000 cubic metres per year. Table 23 summarizes the results of 15 sensitivity analyses around the base case.

Table 23: TFL 41 Base Case Plus 15 Sensitivity Analyses

Decade	Base case	OGSI adjusted Hemlock only	No OGSI Adjustment	Existing stand volume +10%	Existing stand volume -10%	Regen stand volume +10%	Regen stand volume -10%	95% CMAI min_harvestable age	Minimum harvest age +10 years	Minimum harvest age -10 years	Land base +10%	Land base 10%	Green-up Height+ 2m	Green-up Height- 2m	No Visual Zone	No Wildlife Tree Patch
1	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000
2	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000
3	400,000	400,000	359,800	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	359,800	400,000	400,000	400,000	400,000
4	359,800	359,800	323,620	400,000	359,800	400,000	359,800	359,800	359,800	400,000	400,000	323,620	359,800	359,800	359,800	400,000
5	323,620	323,620	291,058	400,000	323,620	359,800	323,620	323,620	323,620	400,000	400,000	291,058	323,620	323,620	323,620	359,800
6	323,620	323,620	261,752	359,800	323,620	323,620	323,620	323,620	323,620	400,000	400,000	291,058	323,620	323,620	323,620	323,620
7	323,620	323,620	235,377	359,800	323,620	323,620	323,620	323,620	323,620	400,000	400,000	291,058	323,620	323,620	323,620	323,620
8	323,620	323,620	211,639	323,620	147,982	323,620	323,620	323,620	323,620	357,893	359,800	291,058	323,620	323,620	323,620	323,620
9	323,620	323,620	211,639	323,620	238,482	323,620	314,273	274,541	142,475	350,198	359,800	246,207	287,604	323,620	323,620	323,620
10	510,500	448,840	211,639	510,500	470,598	523,803	424,802	400,572	82,882	510,500	534,754	416,365	486,161	511,500	511,800	523,500
11	510,500	505,160	211,639	510,500	508,220	548,833	503,319	506,028	224,831	510,500	550,096	439,978	510,500	511,500	511,800	523,500
12	510,500	510,500	211,639	510,500	510,500	550,200	510,500	510,500	483,604	510,500	550,200	440,200	510,500	511,500	511,800	523,500
13	510,500	510,500	211,639	510,500	510,500	550,200	510,500	510,500	510,500	510,500	550,200	440,200	510,500	511,500	511,800	523,500
14	510,500	510,500	235,377	510,500	510,500	550,200	510,500	510,500	510,500	510,500	550,200	440,200	510,500	511,500	511,800	523,500
15	510,500	510,500	235,377	510,500	510,500	550,200	510,500	510,500	510,500	510,500	550,200	440,200	510,500	511,500	511,800	523,500
16	510,500	510,500	235,377	510,500	510,500	550,200	510,500	510,500	510,500	510,500	550,200	440,200	510,500	511,500	511,800	523,500
17	510,500	510,500	235,377	510,500	510,500	550,200	510,500	510,500	510,500	510,500	550,200	440,200	510,500	511,500	511,800	523,500
18	510,500	510,500	235,377	510,500	510,500	550,200	450,389	510,500	510,500	510,500	550,200	440,200	510,500	511,500	511,800	523,500
19	510,500	510,500	235,377	510,500	510,500	550,200	219,894	510,500	510,500	510,500	550,200	440,200	510,500	511,500	511,800	523,500
20	510,500	455,711	235,377	510,500	510,500	550,200	204,440	510,500	510,500	510,500	550,200	440,200	510,500	511,500	511,800	523,500
21	510,500	478,747	232,497	510,500	510,500	550,200	479,798	510,500	510,500	510,500	550,200	440,200	499,960	511,500	511,800	523,500
22	510,500	510,500	235,377	510,500	510,500	550,200	510,500	510,500	510,500	510,500	550,200	440,200	510,500	511,500	511,800	523,500
23	510,500	510,500	235,377	510,500	510,500	550,200	510,500	510,500	510,500	510,500	550,200	440,200	510,500	511,500	511,800	523,500
24	510,500	510,500	235,377	510,500	510,500	550,200	510,500	510,500	510,500	510,500	550,200	440,200	510,500	511,500	511,800	523,500
25	510,500	510,500	235,377	510,500	510,500	550,200	510,500	510,500	510,500	510,500	550,200	440,200	510,500	511,500	511,800	523,500
Total	11,345,900	11,192,358	6,363,085	11,534,840	11,042,942	12,029,716	10,556,195	11,182,421	10,424,572	11,676,091	12,307,250	9,913,002	11,275,005	11,361,900	11,366,700	11,630,280
Avg % diff*		-1.4	-43.9	1.7	-2.7	6.0	-7.0	-1.4	-8.1	2.9	8.5	-12.6	-0.6	0.1	0.2	2.5

Of particular interest in the sensitivity analyses shown in Table 27 is the dramatic improvement to the mid-term timber supplies caused by reducing the minimum harvest age by ten years. In this case, the current harvest level of 400,000 cubic metres per year could be maintained for 70 years compared with 30 in the base case.

10.3 TIMBER SUPPLY WITH BASIC SILVICULTURE

In the yield analysis for the management plan, the base run assumed basic silviculture only. This simplification was due to the tight deadlines that were imposed by the schedule for renewal of the management plan.

Genetic Improvement

There are currently no seed orchards that produce genetically improved hemlock or balsam seed for the Terrace area. Nonetheless, the required simulation run was completed which assumed a 2% generic gain from a first generation orchard on 75% of the timber harvesting land base. The harvest forecast was the same as the base except the long run harvest level rose from 515,500 to 518,000 cubic metres per year.

10.4 TIMBER SUPPLY WITH INCREMENTAL SILVICULTURE

For this project two runs were completed for TFL 41, which included basic silviculture plans:

- 100% of current incremental silviculture,
- 300% of current incremental silviculture.

100% and 300% Incremental Silviculture

In TFL 41 current levels of incremental silviculture were defined at spacing 500 hectares per year from suitable hemlock and balsam leading stands, site index 20 or better. The 300% incremental strategy attempted to space 1500 hectares each year, tripled the pruning budget and set a target of fertilizing all balsam leading second growth stands site index 15 or higher, ten years before the final felling. The effects of tripling the incremental silviculture budget are shown in Figure 15.

The consultants were asked by the MoF to simply triple the current incremental silviculture expenditures for this run. Activities to be included were the existing activities of spacing and pruning and the potential activity of fertilization in Balsam leading stands. Pruning has no effect on future timber volumes. Fertilization increases volume. Spacing allows stands to be harvested sooner, but does not increase volume yields. Of the three activities, spacing has the largest impact on future harvest flows because it allows a re-scheduling that ameliorates the 'pinch points' in mid-term timber supplies.

Figure 16: TFL41 Comparison of Base Case and 300% Incremental Silviculture

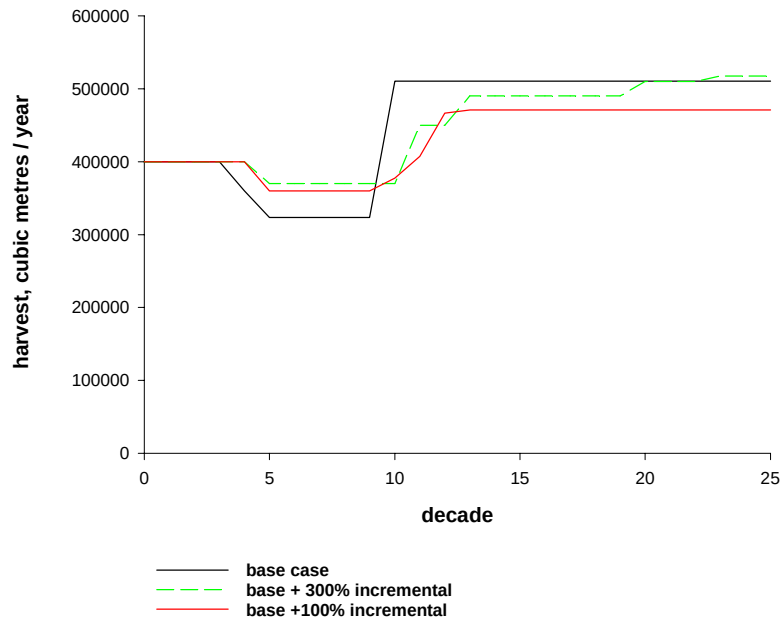


Figure 16 shows that increased levels of incremental silviculture improve short and medium term harvest levels compared with the base case.

The 100% of the current incremental silviculture extends the present harvest level for one decade and also improves the lowest level of harvest in decades five to nine from 324,000 cubic metres to about 360,000 cubic metres per year.

The 300% incremental silviculture regime also extends the present harvest level to the end of the fourth decade. In addition, the harvests in decades five to ten are increased from 324,000 to 370,000 cubic metres per hectare, compared with the base. Beyond decade ten the 300% incremental program projects lower harvests than the base until decade 20. From then on, the 300% incremental long term harvest level meets or exceeds the harvest levels projected for the base run.

The opportunities and areas of stands suitable for juvenile spacing are finite. These opportunities are in hemlock and balsam leading stands of site index 20 and above, in the age range 15 – 25 years. The dynamics of the spacing program in TFL 41 are also complicated by the pattern of harvesting from previously spaced stands. In TFL 41 spacing opportunities will be cyclical.

As the forest stands age, there may not always be enough stands to space. The dynamics of the forest estate are further complicated by the pattern of harvesting from previously spaced stands; their regeneration and subsequent second spacing.

Figure 17 shows the actual spacing achievements over time for both silvicultural programs. The larger program has a target that is three times the smaller. However, due to a limited availability of stands to space, the achieved targets of the 300% program are not three times that of the 100% program.

Figure 17: TFL 41 Spacing Activity Over Time

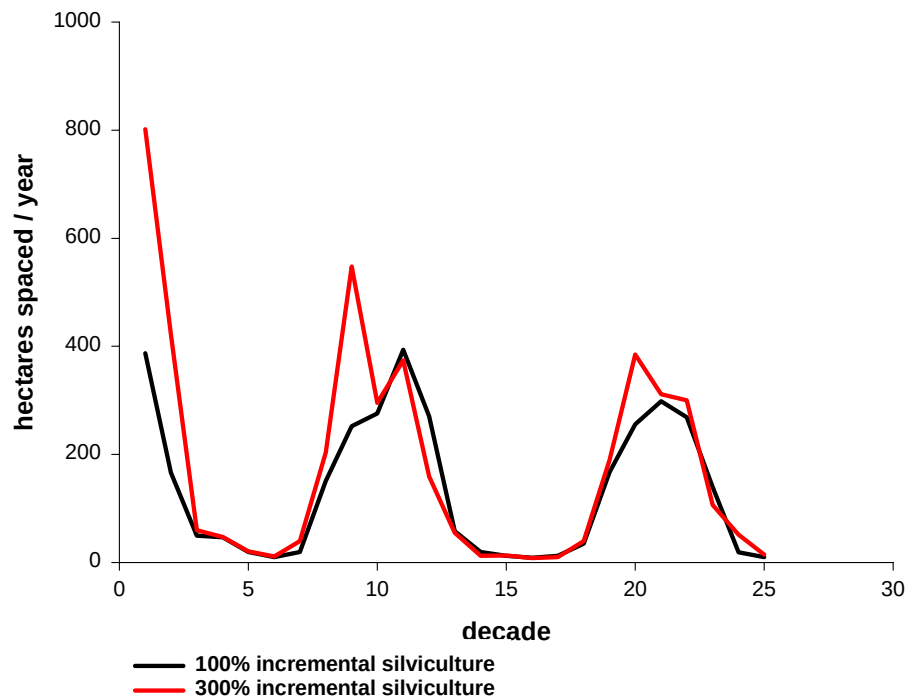


Figure 18 shows the expansion of the spaced component of the forest estate after harvests have been taken from spaced stands.

Figure 18: TFL 41 Changes in Spaced Areas Over Time

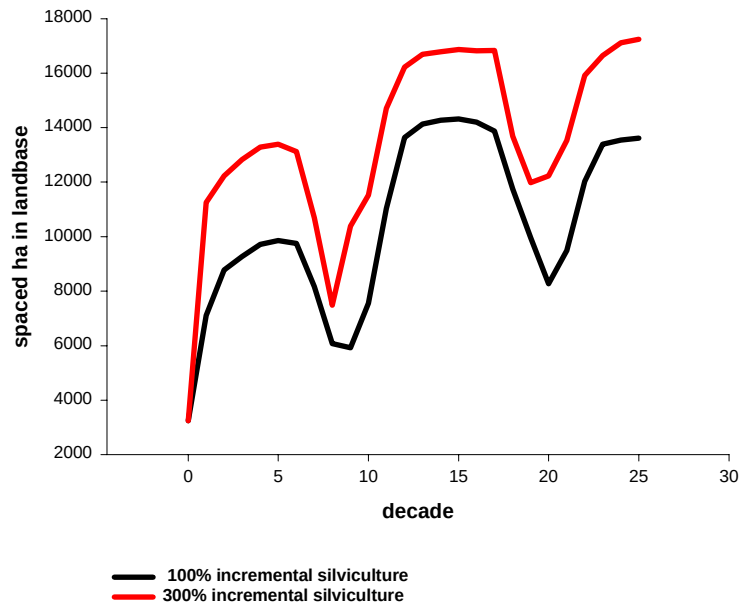
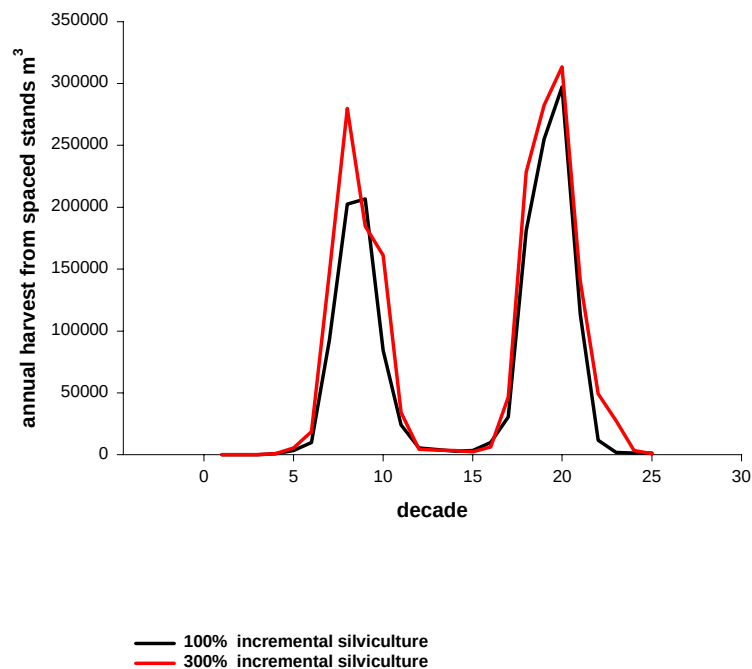


Figure 19 shows that pattern of harvests from spaced stands.

Figure 19: TFL 41 Annual Harvest from Spaced Stands



From Figure 19 it can be seen that the contribution of harvested timber from spaced stands in decades five to 12 makes more harvestable timber available than from basic silviculture. It should be noticed how the harvest peaks in Figure 19 coincide with the two low points in Figure 17. That is, when harvests from spaced stands are high, the area of spaced stands in the forest estate is low. It should also be noticed that, in Figure 16, increased spacing activity follows increased harvesting from spaced stands, with a lag of about two decades.

10.5 THE PREFERRED MANAGEMENT SCENARIO

The preferred management scenario was developed from the results of the stand level financial analysis, but tempered by the experience and local knowledge of the MoF and West Fraser silvicultural staff.

For example some treatments that included commercial thinning of existing second growth stands that were never spaced, rated highly in the financial analysis. The experience to-date in the Terrace area suggests this is not operationally feasible. The existence of many small stems in the unspaced stands significantly increases the cost of commercial thinning, making it uneconomic. Even in previously spaced stands, commercial thinning will only be done when wood supplies are tight and pulp log prices are high enough to produce an operation profit from commercial thinning.

After discussion, the following preferred management scenario was developed:

1. for existing second growth stands 30 years or older, leave to grow and clear-cut at 62 years for site index 25, 85 years for site index 20, and 130 years for site index 15,
2. on 50 hectares per year, site index 25, space to 600 stems per hectare, prune twice and clear-cut at 80 years,
3. apply no commercial thinning without previous juvenile spacing,
4. on site index 20 and above, commercial thin a maximum of 300 hectares per year in stands that have previously been spaced,
5. in all stands whose site index is 20 and above, space to between 800 and 1,200 stems per hectare; clear-cut at 73 years on site index 25 and at 85 years on site index 20.

In TFL 41 the areas of suitable balsam leading stands available for fertilization are too small to support an operationally feasible program. For this reason, fertilization of balsam leading stands was not included in the preferred scenario.

Timber Supply Analysis of the Preferred Scenario

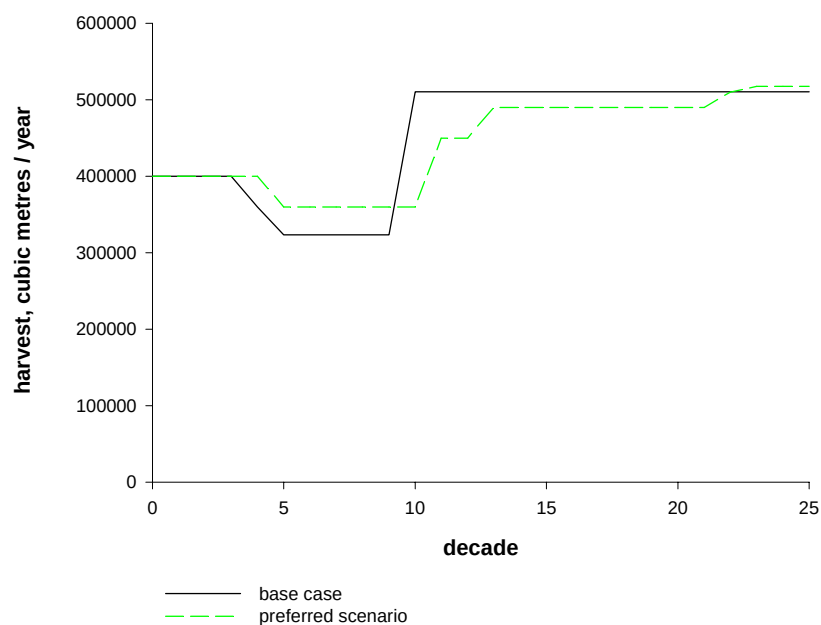
In TFL 41 the preferred scenario consists of basic silviculture plus juvenile spacing and commercial thinning in analysis units 1, 2, 6 and 7. Fertilization of balsam leading stands on site indexes 20 and better was assumed. Pruning was assumed for 50 hectares per year. The preferred scenario assumes that all of the stands are first spaced to between 800 and 1,200 stems per hectare. In the Forest Estate Model, for site index 25 and better, commercial thinning entries are made at age 65 and a final felling can be made at age 75 or later. On site 20, commercial thinning entries are made at age 65 and a final felling can be made at age 85 or later. In the financial analyses, the entry ages for commercial thinning were 60 and 65 for site index 25 and 20 respectively. In the estate model, because 10-year age

classes are used, the model applies commercial thinning in both stand types at age 65. For the same reason, the final felling for site index 25 takes place at 75 years or later, instead of 73.

For example, treatment #56 for site index 20 in Table 17 is juvenile space to 1200 stems, commercial thin at age 65 with a final felling at age 85. At a 4% discount rate this treatment produced a risk-adjusted PNW of \$1,308 per hectare (see Table 24).

During the simulation runs, the final felling of stands that were previously commercially thinned took place at the earliest possible age. Stands that were previously spaced were also harvested as soon as possible at rotations consistent with forest level supply requirements.

Figure 20: TFL 41 Comparison of Base Case and Preferred Scenario



The preferred scenario makes timber available sooner than the base case in the computer simulation model. In particular, the present harvest level can be maintained for 20 years longer than the base case. As Figure 20 shows this shifting forward of available timber has a consequence after 90 years, when projected harvests climb back up to the long-term level more slowly than the base case.

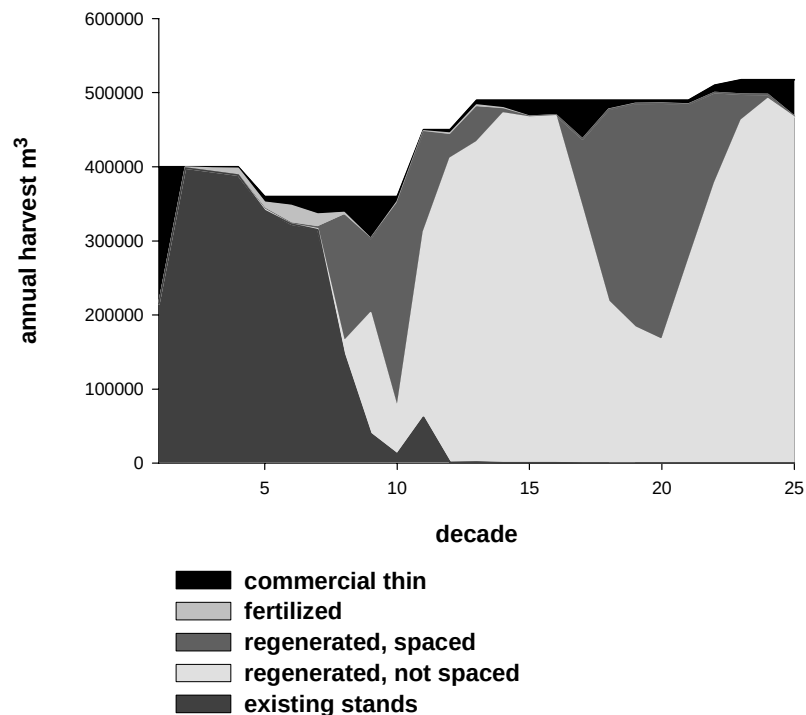
Details of the Preferred Scenario

The projected harvests in the preferred scenario will be made up of timber cut from:

- existing stands,
- spaced and commercially thinned stands,
- other stands naturally regenerated and planted after logging but not spaced or commercially thinned.

Figure 21 shows the harvest contribution from different parts of the forest estate in the preferred scenario.

Figure 21: TFL 41 Harvest Contribution from Different Parts of the Forest Estate



At first, future harvests will come mainly from existing stands. Then, starting in the second decade, stands that were previously spaced will be entered for a commercial thinning. Later, these stands will receive a final felling. Starting in the ninth decade unspaced plantations will begin to contribute to the timber harvest. Finally, unspaced naturally regenerated stands contribute to the harvest 100 years from now. After 120 years, the harvests from existing stands cease because they have all been replaced. From this point on, the timber harvests come from regenerated stands.

Figure 20 shows that the harvest contribution from spaced and commercially thinned stands is important in decade seven.

Part of the timber harvest in Figure 21 comes from commercially thinned areas. In the commercial thinning simulation, the final felling volumes for stands that were previously commercially thinned were reduced by exactly the amount removed in the commercial thinning. This reduction was applied for 50 years after the commercial thinning. In the simulation, the final entry was forced to occur 30 years after thinning for SI 25 and 40 years after for SI 20. This ensured that the total harvest from thinning and final felling was approximately equal to the harvest from stands that were not commercially thinned. Four TASS runs support this strategy. Figure 22 shows that for site 25, a commercially thinned stand yields 91% of the unthinned stand volume 50 years after a commercial thinning. For site 20, the

equivalent number is 88%. When the volume removed by TASS in the commercial thinning is added to the standing timber, 50 years after thinning, the result is approximately equal to the merchantable yield of the untreated stand.

Figure 22: TFL 41 Projected Yields from Commercial Thinning

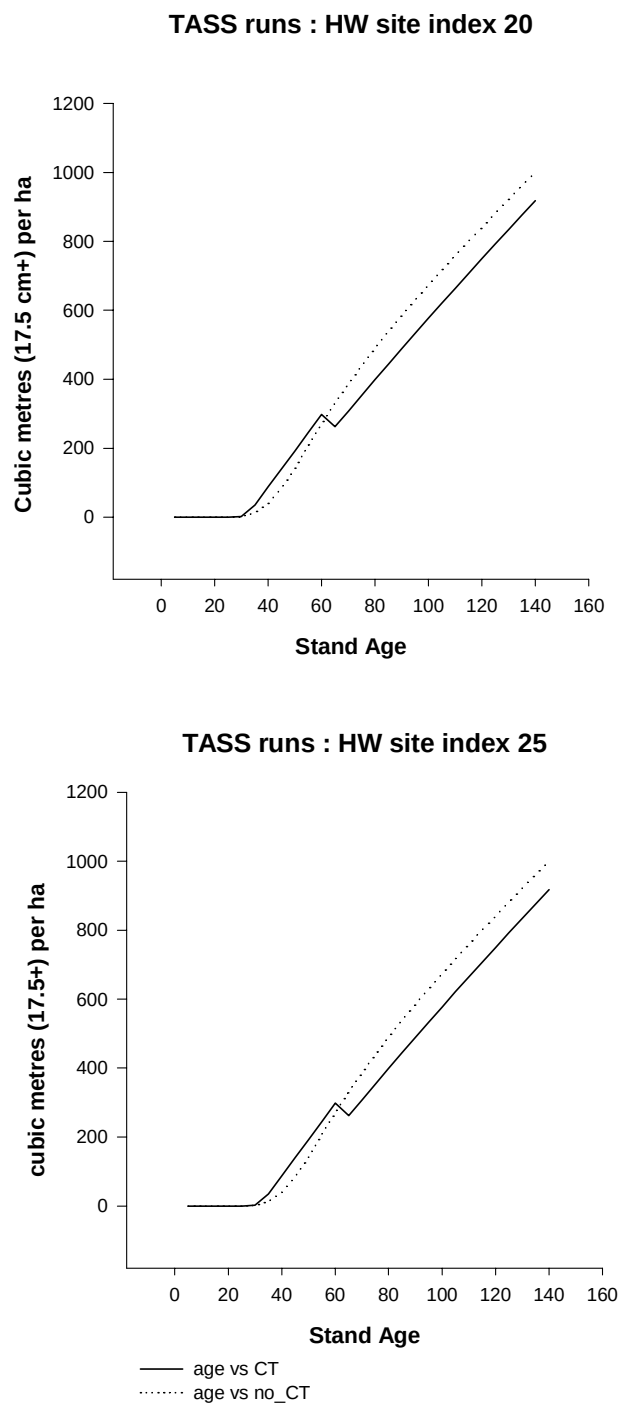
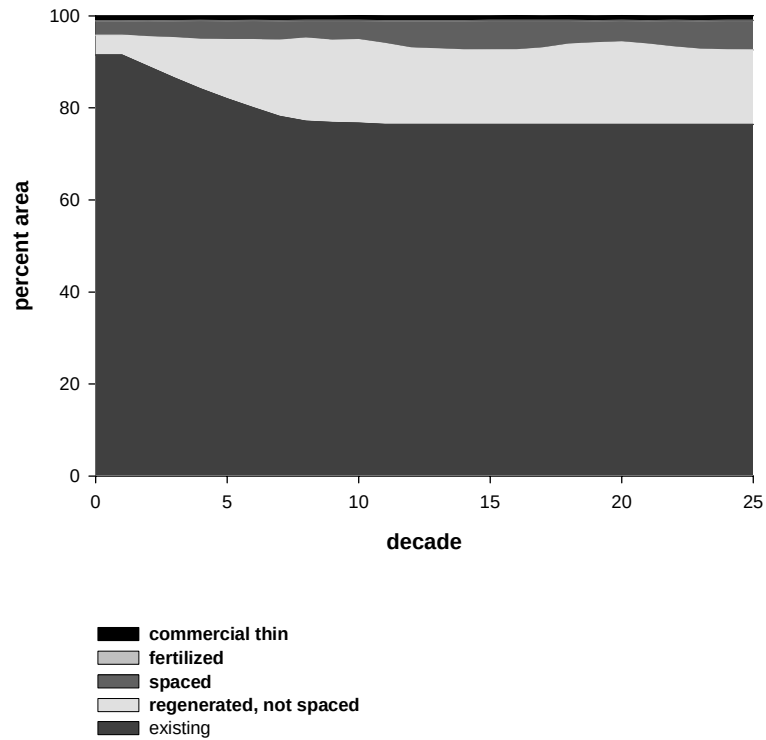


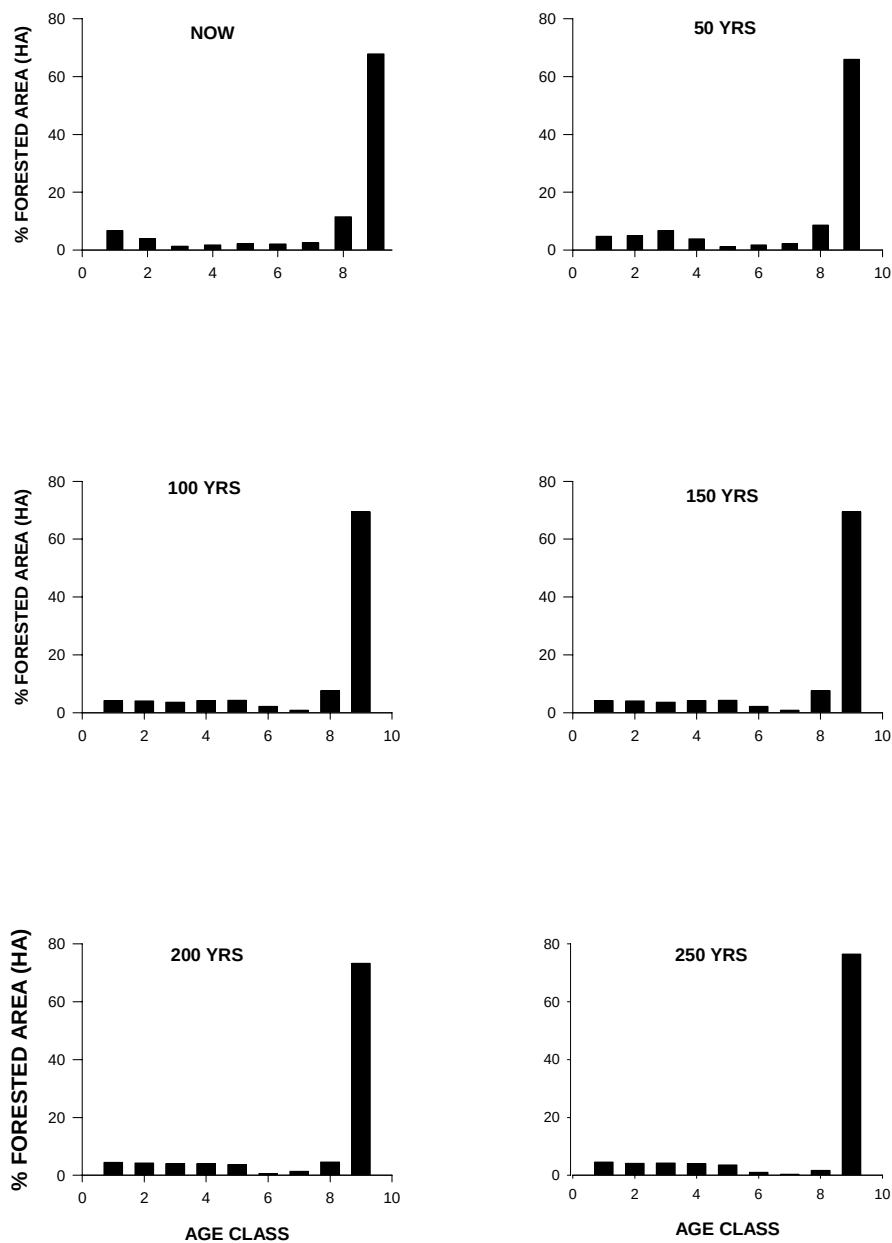
Figure 23 is complimentary to Figure 20 because it shows the projected composition by treatment type of the total productive green forest left after each decade's harvest. The large areas of existing stands in Figure 23 are a reflection of the high proportion of productive forest on TFL 41 that is not included in the timber harvesting land base.

**Figure 23: TFL 41 Total Productive Forest
by Projected Treatment Types**



As time goes by, the age class structure of TFL 41 is projected to change. Figure 24 shows the projected area distributions on TFL 41 and the present age class distribution. Projected distributions are shown at 50, 100, 150, 200 and 250 years from now.

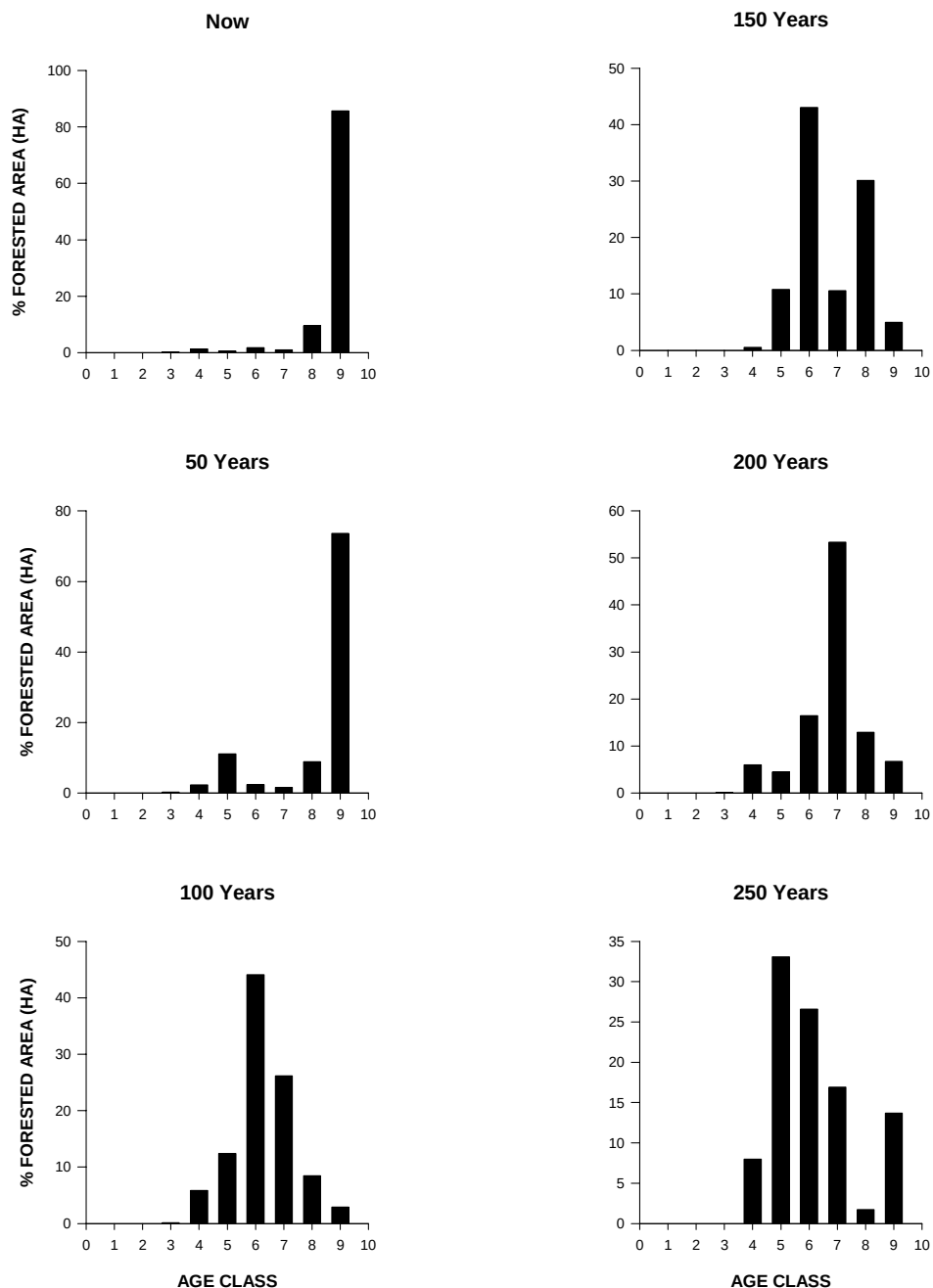
Figure 24: TFL 41 Preferred Scenario – Projected Age Class Distributions of Total Productive Forest



In Figure 24 there is always a large old growth component. This is because the timber harvesting land base is only 20% of the total productive forest. Therefore, about 80% of the productive forest just

gets old and is never harvested or is reserved from harvesting. Figure 25 shows the projected age class distributions for the operable land base. The operable land base shows a transition from mainly old growth to a more even age class distribution. The projected age class distribution 250 years from now shows about 33% of the area in the 80-100 year age class and about 12% of the area supports stands that are at least 250 years old.

**Figure 25: TFL 41 Preferred Scenario –
Projected Age Class Distributions of Operable Forest**



The Profile of Fibre, Sawlogs and Premium Logs over Time

In the timber harvest the total volume can be divided into pulp logs and sawlogs. In this project we have divided the sawlogs into gang sawlogs and higher value standard sawlogs.

For the preferred management scenario the proportions of pulplogs, gang sawlogs and standard sawlogs were estimated. Based on the stand level financial analysis the proportion of pulplogs was estimated for each analysis unit and age class. These estimates were then applied to the harvests projected by the Forest Estate Model. In the stand level analysis the sawlog volume was allocated to gang and standard categories by assuming a 60/40 split by volume. The same assumptions were applied to the forest level results. These assumptions were based on estimates from knowledgeable Skeena Cellulose and West Fraser Staff. Table 24 shows the estimates for the preferred scenario. The volumes in Table 24 have not been reduced for non-recoverable losses, which are estimated at 2,000 cubic metres per year.

Table 24: Preferred Scenario Projected Volume Profile of Log Products

	Harvest Volume (m ³ per year)		
	Gang	Standard	Pulp
Totals			
143861	95907	160232	400000
143649	95766	160586	400000
143126	95418	161456	400000
142795	95197	162008	400000
127712	85141	147147	360000
126168	84112	149720	360000
126157	84105	149738	360000
119391	79594	161015	360000
128594	85730	145676	360000
132272	88182	139546	360000
176614	117742	155644	450000
163230	108820	177950	450000
179196	119464	191340	490000
174475	116317	199208	490000
174155	116104	199741	490000
174306	116204	199490	490000
175811	117208	196981	490000
175852	117325	196913	490000
175150	116767	198083	490000
173818	115879	200303	490000
173143	115429	201428	490000
184004	122670	203326	510000
188485	125657	203358	517500
183788	122526	211186	517500
182941	121960	212599	517500

Job Outcomes, Income and Revenue

Table 25 below identifies forest-based employment multiples recognized by the Ministry of Forests. These multiples may be aggregated to describe the full extent of employment derived through a combination of timber harvesting, primary timber processing and secondary or value-added manufacturing.

Table 25: Employment Multiples

Employment Multiples	Coast Jobs/000 m³	Interior Jobs/000 m³
Woodlands ¹	0.45	0.27
Primary Manufacturing ²	0.62	0.34
Secondary Manufacturing ³	1.00	1.00

¹ A provincial Impact Estimation Procedure for the British Columbia Forest Sector. Staff Discussion Paper. Analysis and Evaluation Branch. Treasury Board Staff. Ministry of Finance and Corporate Relations. February 1996

² Derived through four studies: (1) Lumber Remanufacturing in British Columbia. Select Standing Committee to the Legislature (1993 finding 1.1 jobs/000m³); (2) A snapshot of the British Columbia Value-Added Industry. Fraser et. al. (1996) finding 0.92 jobs/000m³; (3) Structure and Significance of the Value-Added Industry in B.C., FRDA (1993 finding 1.73 jobs/000m³); (4) Ministry of Forests, Internal analysis of twenty bid proposal competitions (1996 finding 0.95 jobs/000m³).

³ Ibid.

For TFL 41 the Coast multiplier from Table 25 for woodlands and primary manufacturing are appropriate. Applying these to the projected harvests for the preferred management scenario produces the estimated job outcomes shown in Table 26.

Table 26: Projected Job Outcomes for the Preferred Scenario (FTE's)

Direct Employment (FTE's)				Direct Employment (FTE's)			
Decade	Woodlands	Manufacturing	Total	Decade	Woodlands	Manufacturing	Total
1	179	247	426	14	220	303	522
2	179	247	426	15	220	303	522
3	179	247	426	16	220	303	522
4	179	247	426	17	220	303	522
5	161	222	383	18	220	303	522
6	161	222	383	19	220	303	522
7	161	222	383	20	220	303	522
8	161	222	383	21	220	303	522
9	161	222	383	22	229	315	544
10	161	222	383	23	232	320	552
11	202	278	479	24	232	320	552
12	202	278	479	25	232	320	552
13	220	303	522				

For each 1000 cubic metres direct jobs are assumed to guarantee \$18,000 federal and provincial income tax. An average income tax rate of 35% implies a before tax income of \$51,000 for 1000 cubic metres of wood harvested.

Applying our employment income assumptions to projected harvests net of non-recoverable losses for the preferred scenario produces the estimates shown in Table 27.

Table 27: Projected Employment Income from the Preferred Scenario

Employment Income		Employment Income	
Decade	\$\$ Millions	Decade	\$\$ Millions
1	20.3	14	24.9
2	20.3	15	24.9
3	20.3	16	24.9
4	20.3	17	24.9
5	18.3	18	24.9
6	18.3	19	24.9
7	18.3	20	24.9
8	18.3	21	24.9
9	18.3	22	25.9
10	18.3	23	26.3
11	22.8	24	26.3
12	22.8	25	26.3
13	24.9		

Applying the gross revenue values for pulp, gang and standard sawlogs from the stand level financial analysis produces the projected revenue estimates shown in Table 28 for the preferred scenario.

Table 28: Projected Gross Revenues from the Preferred Scenario

Decade	Gross Log Value (Total \$ Millions/year)	Revenues to Govt. (\$ Millions/year)	Decade	Gross Log Value (Total \$ Millions/year)	Revenues to Govt. (\$ Millions/year)
1	31.4	24.7	14	35.1	30.3
2	31.0	24.7	15	34.9	30.3
3	31.0	24.7	16	34.9	30.3
4	31.3	24.7	17	35.2	30.3
5	28.2	22.2	18	35.0	30.3
6	27.9	22.2	19	34.9	30.3
7	27.3	22.2	20	34.9	30.3
8	25.7	22.2	21	34.9	30.3
9	26.2	22.2	22	38.0	31.5
10	26.2	22.2	23	37.4	32.0
11	33.9	27.8	24	36.8	32.0
12	32.5	27.8	25	37.1	32.0
13	35.3	30.3			

In Table 28 revenues to government were based on 'The BC and Coast Forest Sector Employment and Economic Contribution Facts for 1999' produced by the Coast Forest and Lumber Association. For coastal BC this estimates all revenues to Government at \$76.40 per cubic metre. For the Terrace area we assumed a long run average stumpage rate of \$4 per cubic metre. This reduced the estimated revenue to government from \$76.4 to \$62 per cubic metre. Gross log values in Table 28 include the effect of harvesting 50 ha/per year pruned stands which have a 38% higher value than unpruned stands

Preferred Management Program

The preferred management scenario can be expressed as a five-year program of activities. This program consists of basic silvicultural activities plus juvenile spacing and some pruning. In the future, commercial thinning of previously spaced stands is expected to take place.

Table 29 presents the five-year preferred management program for TFL 41, based on the results of the forest estate model simulation.

Table 29: TFL 41 Five-Year Preferred Management Program

Activity	Annual Hectares	\$/ hectares	Annual Budget (\$)	Annual Employment (FTE's)
Spacing	800	1100	880000	7.1
Pruning	50	1300	65000	0.7
Total	850	2686	945000	7.8

The computer simulation run fertilized only 148 hectares in the first two decades. This represents 7 hectares per year, which is too small an area to include in a silvicultural program. For this reason, fertilization was omitted from the preferred five-year program for TFL 41.

To calculate the annual employment generated by the preferred silviculture plan the following assumptions were used. For spacing we used a Figure quoted by Laing & Mculloch and Nawitka Consultants in a 1992 study. They estimated that one person-year of employment will be created for every 50 – 175 hectares spaced. We have assumed one person-year of employment created for 112 hectares spaced. We assumed that one hectare of pruning generates three days of work. The small fertilization program is estimated to generate two days of work each year.

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APPENDIX I

Prediction Equations For Tree To Truck Logging Costs

1.0 INTRODUCTION

Tree to truck logging costs include the costs of felling and forwarding trees to roadside. They do not include loading.

This appendix describes the derivation of equations to predict tree to truck costs for clear cutting and commercial thinning.

In these equations the two most important variables are stand volume per hectare and average volume per tree.

2.0 DEVELOPMENT OF EQUATIONS

The MoF Interior Approval Manual (July 1999) contains the following equation in section 4.4.3 for ground skidding methods.

$$\begin{aligned} \frac{\$}{m^3} = & K + 7.18(slope\%/100) - 7.85(volha/1000) \\ & + 4.33BD\% + 6.14DPCUT \\ & - 5.46(PCUT/100) + 0.77(ds - 50)/100 \\ & + 1.92(ds - 150)/100 \end{aligned} \quad (1)$$

where K = a constant dependent on region and biogeoclimatic zone.

$slope\%$ = slope percentage

$volha$ = cubic metres per hectare removed

$BD\%$ = percent blowdown

$DPCUT = 1$ if partial cut percent is less than 90

$DPCUT = 0$ otherwise

$PCUT$ = percent volume removed in partial cut to a maximum value of 90

DS = distance to delivery point in KM.

if $DS \geq 50$ then $DS - 50 = 0$

if $DS > 50$ then $DS - 50 = 100$

For the investment analysis for second growth stands, we made the following assumptions:

$BD = 1\%$

$DS < 50$ KM

slope percent = 25

constant = 22.64 (from interior appraisal manual)

Equation (1) does not account for changes in logging cost due to average tree size. These changes were modeled as described in the next section.

2.1 MODELLING THE EFFECT OF TREE SIZE

If the volume removed during logging is the same in two stands, but the average tree size in one stand is one cubic metre and half that in the second stand then tree to truck costs/cubic metre will be higher in the second stand. Holtzcher and Lanford (1997) in a paper presented in the Forest Products Journal a graph which produces the following data for tree to truck costs of logging forest stands with different average diameters at breast height.

Table 2.1: Tree to Truck Costs and Stand dbh

dbh (in)	\$ US/cord
4.0	114
5.0	69
6.0	47
7.0	40
8.0	29
9.0	28
10.0	24
11.0	19

A standard cord is 128 cubic feet but stacked cords contain less than 128 cubic feet of solid wood. A common percentage of solid wood is 60 percent, but according to Avery (1975), it may vary from 50 to 75 %. In this study we assumed 62.5% of a stacked cord is solid wood. Using an exchange rate of \$1.56 Canadian to \$1.00 US and 60 % solid content we converted Table 1 to Table 2 below.

Table 2.2: Tree to Truck Costs and Stand dbh and Average Tree Volume

Dbh (cm)	\$ c/m³ Solid Wood
10.2	77.0
12.7	46.6
15.2	31.7
17.8	27.0
20.3	1.9
22.9	18.9
25.4	16.2
27.9	12.8

Table 3 shows the relationship between stand dbh and average volume per tree in selected stand structures produced by the TIPSy stand model, for natural hemlock stands starting at 6000 stems per hectare.

Table 2.3: Average dbh and Average Volume per Tree, from TIPSy

Dbh (cm)	Avg Vol/tree (m³)
21.1	0.2
24.4	0.3
26.7	0.4
30.6	0.6
34.1	0.8
35.9	1.0
38.7	1.2
41.6	1.4
45.4	1.6

Cost per Cubic Metre as a Function of DBH

A non-linear, exponential decline function was fitted to the data in Table 2 using the statistical software package, SYSTAT.

The function obtained relating tree to truck cost and stand dbh was,

$$\text{cost}/m^3 = 6.747 + 250e^{-0.183dbh} \quad (2)$$

This function had a corrected R-square value of 0.983. It was high because the data in Table 2 are smoothed by the source graph.

DBH as a Function of Average Tree Volume

Two non-linear quadratic function was fitted to the data in Table 3 using the statistical software package SYSTAT. Scatter plots showed that the relationship between DBH and average tree volume is different below and above an average tree volume of 0.8 cubic metres. Equation (3) shows the relationship below 0.8 cubic metres; equation (4) shows the relationship above 0.8 cubic metres.

$$\text{stand} = 34.82 + 4.3ha(\text{vol} / \text{tree})^2 \quad (3)$$

dbh

where $\text{vol} / \text{tree} < 0.8m^3$

$$\text{stand} = 30.157 + 5.91(\text{vol} / \text{tree})^2 \quad (4)$$

dbh

where $\text{vol} / \text{tree} > 0.8m^3$

Equation (3) had an adjusted R-square value of 0.998. The R-square value for equation (4) was also 0.998. These values are very high because the MoF smoothed the data determining them during the development of TIPSy.

Cost per Cubic Metre as a Function of Average Tree Volume

The consultants combined equations (2), (3) and (4) by substituting the last two equations into equation (2).

This produced equations (5) and (6) which describe the relationship between logging cost per cubic metre and average tree volume.

$$\text{cost}/m^3 = 6.747 + 250e^{-6.323 - (0.787 \text{ ha}(\text{vol}/\text{tree})^2)} \quad (5)$$

where

re $\text{vol} / \text{tree} < 0.8m^3$

$$\text{cost}/m^3 = 6.747 + 250e^{-5.519 - 1.082(\text{vol}/\text{tree})^2} \quad (6)$$

where $\text{vol} / \text{tree} < 0.8m^3$

Combining the Appraisal Manual and Piece Size Equations

The relationships in equations (5) and (6) were applied to equation (1) as cost multipliers taking account of the effect of average volume per tree. In the process, these equations and equation (1) were calibrated to local data provided by the licensee.

For final felling or clear cutting, equation (1) for tree to truck logging before adding the piece size multiplier became:

$$\text{cost}/m^3 = 29.5 - 0.00785(\text{vol} / \text{ha}) \quad (7)$$

Equation (7) does not have the required multiplier to account for cost effect of different average tree volumes. After initial calibration the cost multipliers for piece size became:

$$\begin{aligned} \text{cost multiplier} &= 0.544 + 20.16e^{-6.323 - (0.787 \text{ ha}(\text{vol}/\text{tree})^2)} \\ &\text{for vol} / \text{tree} \end{aligned} \quad (8)$$

for $\text{vol} / \text{tree} < 0.8m^3$

$$\begin{aligned} \text{cost multiplier} &= 0.544 + 20.53e^{-5.519 - 1.082(\text{vol}/\text{tree})^2} \\ &\text{for vol} / \text{tree} \end{aligned} \quad (9)$$

for $vol / tree \geq 0.8m^3$

Combining equations (7), (8) and (9) and calibrating to local data provided by the licensee produced the final tree to truck cost equations shown below.

Clear -cutting Tree to Truck Cost

$$cost/m^3 = 5.0 + [[24.5 - 0.00785(vol / ha)] * S] \quad (10)$$

$$\text{where } S = 0.544 + 20.16e^{-6.323 - (0.787ha(vol/tree)^2)} \quad (11)$$

when $vol / tree < 0.8m^3$

$$\text{and } S = 0.554 + 20.53e^{-5.519 - 1.082(vol/tree)^2} \quad (12)$$

when

$vol / tree \geq 0.8m^3$

Commercial Thinning Tree to Truck Cost

When the stand has been previously spaced:

$$cost/m^3 = 20.0 + [[24.5 - 0.00785(vol / ha)] * S] \quad (13)$$

where $S =$ equation (11)

when

$vol / tree \leq 0.8m^3$

and where $S =$ equation (12)

when

$vol / tree > 0.8m^3$

When the stand has not been previously spaced:

$$cost/m^3 = 27.0 + [[24.5 - 0.00785(vol / ha)] * S] \quad (14)$$

where $S =$ equation (11)

when

$vol / tree \leq 0.8m^3$

and where $S =$ equation (12)

when

$vol / tree > 0.8m^3$

Application of these Equations

The relationships in equations (10) to (14) were used to generate the ISO-cost and ISO-revenue lines in the analysis, which developed, target stand structures for the final felling as a function of volume per hectare and volume per tree.

For example, when average volume per tree is one cubic metre and volume per hectare is 450, then equation (10) produces a tree to truck cost of \$21.3 per cubic metre for clear cutting. If the volume per hectare remains at 450 but the average volume per tree drops to 0.2 cubic metres then the tree to truck cost for clear cutting increases to \$33 per cubic metre.

APPENDIX II

Products By Stand Age

Preferred Scenario				
AU's 1,6,9,14,21,24				
Age	% Standard	% Gang	% Pulp	Total
30	0.08	0.13	0.79	1
40	0.17	0.26	0.57	1
50	0.21	0.32	0.47	1
60	0.24	0.35	0.41	1
70	0.25	0.38	0.37	1
80	0.27	0.40	0.33	1
90	0.28	0.42	0.30	1
100	0.29	0.44	0.27	1
110	0.30	0.46	0.24	1
120	0.31	0.47	0.21	1
130	0.32	0.48	0.19	1
140	0.33	0.49	0.18	1
150	0.34	0.50	0.16	1
160	0.34	0.51	0.15	1
170	0.34	0.52	0.14	1
180	0.35	0.52	0.13	1
190	0.35	0.53	0.12	1
200	0.35	0.53	0.12	1

Preferred Scenario			
Age	% Standard	% Gang	% Pulp
30	0.00	0.00	0.00
40	0.11	0.17	0.72
50	0.16	0.24	0.60
60	0.19	0.29	0.52
70	0.21	0.32	0.47
80	0.23	0.34	0.43
90	0.24	0.36	0.40
100	0.25	0.37	0.38
110	0.26	0.39	0.35
120	0.27	0.40	0.33
130	0.28	0.41	0.31
140	0.28	0.43	0.29
150	0.29	0.44	0.27
160	0.30	0.45	0.26
170	0.30	0.45	0.24
180	0.31	0.46	0.23
190	0.31	0.47	0.22
200	0.32	0.48	0.21

Preferred Scenario				
AU's 3,8,10,11,12,13,16,23,26,28,29,30				
Age	% Standard	% Gang	% Pulp	Total
30	0.00	0.00	0.00	0
40	0.00	0.00	0.00	0
50	0.10	0.15	0.75	1
60	0.12	0.19	0.69	1
70	0.15	0.23	0.61	1
80	0.18	0.27	0.56	1
90	0.19	0.29	0.52	1
100	0.20	0.30	0.49	1
110	0.21	0.31	0.48	1
120	0.22	0.33	0.45	1
130	0.23	0.34	0.43	1
140	0.23	0.35	0.42	1
150	0.24	0.36	0.41	1
160	0.24	0.36	0.40	1
170	0.25	0.37	0.39	1
180	0.25	0.38	0.37	1
190	0.25	0.38	0.36	1
200	0.26	0.39	0.36	1

APPENDIX III

Forest Cover Constraints and Harvesting Rules Applied in this Analysis

EXISTING STAND YIELDS

For the yield analysis, existing volumes were obtained from VDYP generated yield curves, except for stands 141 years or older. In these ages the localized inventory database volumes were used where available. Application of these factors to VDYP derived yield curves ensured that the existing timber volumes available to the forest estate model closely matched those found in the inventory database. Table 1 shows mature volume adjustment factors derived from the re-inventory report and the average mature volumes per hectare in the database, after localization of VDYP volumes.

**Table 1: VDYP Localization Factors
for Existing Stands 140 Years or Older**

Leading Species	Age Class	Adjusted Factors	Localized avg VDYP vol/ha
Hemlock	8, 9	0.8057	526
Balsam	8, 9	0.7170	536
Cedar	8, 9	0.8446	467

The derivation and application of these factors was presented in detail in the TFL 41 re-inventory report.

OLD GROWTH SITE INDEX ADJUSTMENTS

Estimates of site productivity have traditionally been made using site index which is subsequently used to drive growth and yield predictions. The Site Productivity Working Group identified problems with traditional site index curve applications in old growth stands and recommended the initiation of projects to improve them. The objective was to develop adjustments for short-term application in Timber Supply Planning. Subsequently the Ministry of Forests (MoF) derived a set of interim adjustment equations for old growth site indices, Nussbaum and Nigh (1997) and Site Index Adjustment for Old-growth Coastal Western Hemlock Stands in the Kalum Forest District, Nigh, G. and B. Love, March 3, 1998. They also developed the following application guidelines for Timber Supply Analysis:

1. Adjustment equations apply only to age class 8 and 9 stands following clearcut harvest regeneration.
2. Adjustment of old growth polygons must be applied on a polygon basis before regenerated stand analysis units are formed.
3. The site index of the old growth polygon must be within the range of site index sampled to build the interim adjustment equation.
4. Old growth site index must be:
 - derived from the same species as the adjustment equation;
 - derived from the same site curves used to develop the adjustment equations,
 - derived from the height and age of the old growth polygon.

In this timber supply analysis, the SI of all Hemlock stands was adjusted by adding 10 meters for any old growth derived SI between 8 meters and 18 meters. This method is presented by the MoF in "Site Index Adjustment for Old-Growth Coastal Western Hemlock Stands in the Kalum Forest District." by G. Nigh and B. Love, March 3, 1998 (MoF Research Working Paper 27).

Site index adjustment equations for other leading species stands such as Cedar and Balsam leading were obtained from MoF Research Working Paper 36. This adjustment was applied after the net down procedure to ensure that the timber harvesting landbase was not changed. This adjustment did not change in any way the existing timber volume assigned to each old growth polygon. In the computer model, after an existing old growth stand was harvested, the new regenerated stand was assigned the adjusted site index. Future regenerated stand volumes were assigned using the adjusted site index.

HARVESTING ASSUMPTIONS

TFL 41 lies inside the coastal biogeoclimatic zones. Almost all logging is done using the clearcut system. Adjacency and green-up requirements, and stand level and landscape level biodiversity requirements were modeled in the timber supply analysis using the rules shown in tables 2 and 3. Riparian reserve and management zone requirements were also met in the analysis, by using a GIS exercise to record the area of reserve and management zone to be found in each polygon. Riparian reserve areas were allowed to contribute to wildlife tree patches. The details of the allowances for stand level biodiversity are shown in the data package, table 36.

Table 2: Area Percentage for Old Growth Seral Stage (table 34b in data package)

Group No	Landscape Unit	Biogeoclimatic			NDT	BEA	Minimum Retention Area (%)		Minimum Age
		Zone	Subzone	Variant			L45%I45%H10%	BEA	
1	Dala	CWH	vm		1	L	13.6	13	250
2	Dala	CWH	ws	2	2	L	9.4	9	250
3	Dala	MH	mm	1	1	L	19.9	19	250
4	Falls	CWH	vm		1	L	13.6	13	250
5	Falls	CWH	vm	1	1	L	13.6	13	250
6	Falls	MH	mm	1	1	L	19.9	19	250
7	Foch	CWH	vh	2	1	H	13.6	19	250
8	Foch	CWH	vm		1	H	13.6	19	250
9	Foch	MH	mm	1	1	H	19.9	28	250
10	Gilttoeyes	CWH	vh	2	1	I	13.6	13	250
11	Gilttoeyes	CWH	vm		1	I	13.6	13	250
12	Gilttoeyes	MH	mm	1	1	I	19.9	19	250
13	Hawkesbury Island East	CWH	vh	2	1	L	13.6	13	250
14	Hawkesbury Island East	CWH	vm		1	L	13.6	13	250
15	Hawkesbury Island East	MH	wh	1	1	L	19.9	19	250
16	Hawkesbury Island West	CWH	vh	2	1	I	13.6	13	250
17	Hawkesbury Island West	CWH	vm		1	I	13.6	13	250
18	Hawkesbury Island West	MH	wh	1	1	I	19.9	19	250
19	Horetzky	CWH	ws	2	2	L	9.4	9	250
20	Horetzky	MH	mm	2	1	L	19.9	19	250
21	Hot Springs	CWH	ws	1	2	L	9.4	9	250
22	Hot Springs	CWH	ws	2	2	L	9.4	9	250
23	Hot Springs	MH	mm	2	1	L	19.9	19	250
24	Jesse - Bish	CWH	vm		1	L	13.6	13	250
25	Jesse - Bish	MH	mm	1	1	L	19.9	19	250
26	Kemano - Kildala	CWH	vm		1	I	13.6	13	250
27	Kemano - Kildala	CWH	vm	1	1	I	13.6	13	250
28	Kemano - Kildala	CWH	ws	2	2	I	9.4	9	250
29	Kemano - Kildala	MH	mm	1	1	I	19.9	19	250
30	Kemano - Kildala	MH	mm	2	1	I	19.9	19	250
31	Kitimat	CWH	vm		1	L	13.6	13	250
32	Kitimat	CWH	ws	1	2	L	9.4	9	250
33	Kitimat	CWH	ws	2	2	L	9.4	9	250
34	Kitimat	MH	mm	1	1	L	19.9	19	250
35	Kitimat	MH	mm	2	1	L	19.9	19	250
36	Kowesas	CWH	vm		1	L	13.6	13	250
37	Kowesas	CWH	vm	1	1	L	13.6	13	250
38	Kowesas	CWH	vm	2	1	L	13.6	13	250
39	Lakelse	CWH	ws	1	2	I	9.4	9	250
40	Lakelse	CWH	ws	2	2	I	9.4	9	250
41	Lakelse	MH	mm	2	1	I	19.9	19	250
42	Wedeene	CWH	vm		1	I	13.6	13	250
43	Wedeene	CWH	ws	1	2	I	9.4	9	250
44	Wedeene	CWH	ws	2	2	I	9.4	9	250
45	Wedeene	MH	mm	1	1	I	19.9	19	250
46	Wedeene	MH	mm	2	1	I	19.9	19	250

Table 2 shows two sets of parameters. One was created by assuming an area distribution rule of 45 % for both low (L) and intermediate (I) Biodiversity Emphasis Area (BEA) and 10 % for high (H) BEA, and another using the actual Biodiversity Emphasis Area distribution found in each landscape unit on the TFL. In our analyses we used the 45/45/10 split.

Table 3. Area Percentage for Green-up
(table 34a in data package)

Group No	SWG Mgmt Zone	VQO	Green-up Height (meters)	Current Operable Landbase Green-up Area %	Productive Landbase Green-up Area %
47	General		3	35	4.01
48	Enhanced		3	35	28.05
49	Visual	R	5	5	1.51
50	Visual	PR	5	15	14.73
51	Visual	M	5	25	11.05
52	Riparian		5	25	3.47
53	Wathl watershed		9	25	9.10

WILDLIFE TREE PATCHES

Table 20(a) in the biodiversity guidebook is the correct one to apply because landscape units have been designated. Table 4 is calculated by interpolating the data from the Table 20(a) in the Biodiversity Guidebook that is based on the two entry points: % of the area available for harvesting that has already been harvested without wildlife tree retention, and % available for harvest. This has been done for each landscape unit (LU) and the results are shown in Table 4. The percentages in Table 4 have not been reduced to include the contribution of riparian reserves and management zones. In the landbase netdown, contributions to wildlife tree patches from inoperable, low site, environmentally sensitive and other areas which have been removed from the timber harvesting landbase, are accounted for.

Table 4: Wildlife tree patches

Landscape Unit	Biogeoclimatic		Guidebook table 20a row	Guidebook table 20a col.	Reduction Area %	Area Reduction
	Zone	Subzone				
Dala	CWH	vm	3.54	48.91	1.63	90
Dala	CWH	ws	2.80	35.31	0.62	8
Falls	CWH	vm	11.42	30.47	1.19	42
Hawkesbury Island East	CWH	vh	2.24	35.09	0.54	2
Hawkesbury Island West	CWH	vh	0.57	15.71	0.02	0
Horetzky	CWH	ws	11.79	37.46	1.92	8
Hot Springs	CWH	ws	52.44	54.68	7.71	84
Jesse - Bish	CWH	vm	1.03	27.57	0.09	1
Kemano - Kildala	CWH	vm	18.89	16.63	0.92	8
Kemano - Kildala	CWH	ws	16.73	16.02	0.74	14
Kitimat	CWH	vm	39.62	79.33	8.90	25
Kitimat	CWH	ws	37.17	45.44	5.26	744
Kitimat	MH	mm	10.76	3.27	0.01	0
Lakelse	CWH	ws	58.08	33.09	6.12	31
Lakelse	MH	mm	100.00	2.62	7.52	1
Wedeene	CWH	vm	59.39	34.01	6.34	376
Wedeene	CWH	ws	77.89	46.94	9.48	431
Wedeene	MH	mm	25.85	3.88	0.31	2
Total						1,867

* Reduction Area % is zero for other landscape units which BEC zones, subzones and variants are not shown.

TIMBER HARVESTING

Minimum Merchantability Standards

In the timber supply analysis a stand must satisfy all the minimum volume, DBH and age requirements before it can be harvested. Table 5 shows minimum harvest rules that will be used for each analysis unit. These minimums may not be reached until several decades from now. Even then, only some stands will be harvested at minimum volume, DBH and age. The minimum ages for natural and planted in Table 5 were calculated from old growth SI adjusted yield tables.

Table 5: Minimum harvest volume and age

Analysis Unit	Existing			Natural			Planted		
	Min Age	Min DBH	Min Vol	Min Age	Min DBH	Min Vol	Min Age	Min DBH	Min Vol
1	46	30	300	47	30	300	43	30	300
2	64	30	300	61	30	300	57	30	300
3	147	30	300	122	30	300	116	30	300
4	91	30	300	53	30	300	49	30	300
5	135	30	300	59	30	300	55	30	300
6	51	30	300	46	30	300	43	30	300
7	90	30	300	59	30	300	55	30	300
8	149	30	300	60	30	300	56	30	300
9	37	30	300	44	30	300	40	30	300
10	52	30	300	61	30	300	56	30	300
11	68	30	300	68	30	300	65	30	300

Operability

New operability mapping of TFL 41 was undertaken during 1998. The classification was completed under a terms of reference approved by the district manager on March 5, 1998. An operability report including a composite map was submitted to the district manager December 18, 1998. It describes the three categories that are based on a combination of harvesting system, stand quality and economic criteria.

Table 6 presents three categories of the operability.

Table 6: Three categories of the operability

Categories	Criteria	Productive		Net		Descriptions
		Area (ha)	Volume (m ³)	Area (ha)	Volume (m ³)	
Conventional	OPER =C	85,489	31,225,581	62,925	24,077,667	includes ground-based, grapple and highlead cable and A-frame to the ocean
Non- conventional	OPER = A and Height Class > 3 and SI > 10 and Hemlock species <= 50 %	7,199	3,826,412	5,161	2,760,495	includes helicopter yarding, skyline cable and other systems not included in the conventional
Inoperable	OPER = I or OPER = N or any area not in conventional and non-conventional landbases	240,236	59,463,131			includes timber either physically inaccessible or marginally economic to log in the foreseeable future

APPENDIX IV

TFL 41 Product Summary for Treatments 1 – 112

TFL 41 Product Summary for Treatments 1 – 35

#	SI	final piece size m3	age	vol	rev-low \$/ha	rev-med \$/ha	rev-high \$/ha	unit value low \$/m3	unit value med \$/m3	unit value high \$/m3	revised cost \$/m3	revised net rev-L \$/m3	revised net rev-M \$/m3	revised net rev-H \$/m3	H, I m3/ha	J m3/ha	U,X,Y m3/ha	total vol m3/ha	sawlog m3/ha	pulp m3/ha
1	15	0.35	134	final	21501.00	30833.00	40165.00	47.36	67.91	88.47	20.30	27.06	47.61	68.17	10	355	89	454	258.5	195.5
2	20	0.61	110	final	31276.40	44593.20	57910.00	49.41	70.45	91.48	18.95	30.46	51.50	72.53	57	488	88	633	398.6	234.4
3	25	1.0	98	final	44052.00	62436.00	80820.00	51.70	73.28	94.86	17.20	34.50	56.08	77.66	181	590	81	852	594.0	258.0
4	25		60	CT	5273.80	7559.40	9845.00	47.51	68.10	88.69	39.02	8.49	29.08	49.67		91	20	111	63.7	47.3
4		1.0	73	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
5	25		60	CT	6106.80	8748.40	11390.00	47.71	68.35	88.98	38.39	9.32	29.96	50.59		106	22	128	74.2	53.8
5		1.3	80	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
6	25		60	CT	6342.00	9086.00	11830.00	47.68	68.32	88.95	38.24	9.44	30.08	50.71		110	23	133	77.0	56.0
6		1.6	88	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
7	25		60	CT	5038.60	7221.80	9405.00	47.53	68.13	88.73	39.26	8.27	28.87	49.47		87	19	106	60.9	45.1
7		1.9	100	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
8	25		60	CT	5951.40	8528.20	11105.00	47.23	67.68	88.13	38.39	8.84	29.29	49.74		103	22	126	72.1	52.9
8		2.2	105	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4
9	25		60	CT	6224.40	8997.20	11770.00	44.78	64.73	84.68	40.63	4.15	24.10	44.05		98	41	139	68.6	70.4
9		1.0	73	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
10	25		60	CT	6938.40	10039.20	13140.00	44.48	64.35	84.23	39.79	4.69	24.56	44.44		108	48	156	75.6	80.4
10		1.3	80	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
11	25		60	CT	7221.20	10435.60	13650.00	44.85	64.82	84.78	39.57	5.28	25.25	45.21		114	47	161	79.8	81.2
11		1.6	88	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
12	25		60	CT	5965.40	8630.20	11295.00	44.52	64.40	84.29	40.85	3.67	23.55	43.44		93	41	134	65.1	68.9
12		1.9	100	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
13	25		60	CT	6910.40	9995.20	13080.00	44.58	64.49	84.39	39.84	4.74	24.65	44.55		108	47	155	75.6	79.4
13		2.2	105	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4
14	15	0.7	132	final	17280.00	24640.00	32000.00	49.37	70.40	91.43	20.00	29.37	50.40	71.43	31	270	49	350	220.0	130.0
15	15	1.0	164	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
16	15	1.3	193	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
17	20	0.7	85	final	17280.00	24640.00	32000.00	49.37	70.40	91.43	20.00	29.37	50.40	71.43	31	270	49	350	220.0	130.0
18	20	1.0	100	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
19	20	1.3	113	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
20	20	1.6	126	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
21	20	1.9	148	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
22	20	2.2	157	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4
23	25	0.7	62	final	17280.00	24640.00	32000.00	49.37	70.40	91.43	20.00	29.37	50.40	71.43	31	270	49	350	220.0	130.0
24	25	1.0	73	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
25	25	1.3	80	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
26	25	1.6	88	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
27	25	1.9	100	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
28	25	2.2	105	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4
29	15		135	CT	4846.80	6928.40	9010.00	48.47	69.28	90.10	38.67	9.80	30.61	51.43		86	14	100	60.2	39.8
29		1.0	164	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
30	15		160	CT	5871.60	8410.80	10950.00	47.74	68.38	89.02	36.99	10.75	31.39	52.03		102	21	123	71.4	51.6
30		1.3	193	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
31	20		80	CT	5010.60	7177.80	9345.00	47.72	68.36	89.00	39.40	8.32	28.96	49.60		87	18	105	60.9	44.1
31		1.0	100	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
32	20		95	CT	6529.60	9364.80	12200.00	47.32	67.86	88.41	36.95	10.37	30.91	51.46		112	26	138	78.4	59.6
32		1.3	113	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
33	20		105	CT	7099.40	10172.20	13245.00	47.65	68.27	88.89	36.18	11.47	32.09	52.71		123	26	149	86.1	62.9
33		1.6	126	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
34	20		130	CT	5763.80	8249.40	10735.00	48.03	68.75	89.46	35.42	12.61	33.33	54.04		101	19	120	70.7	49.3
34		1.9	148	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
35	20		135	CT	7302.40	10451.20	13600.00	48.04	68.76	89.47	34.65	13.39	34.11	54.82		128	24	152	89.6	62.4
35		2.2	157	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4

TFL 41 Product Summary for Treatments 37 – 63

#	SI	final piece size m3	age	vol	rev-low \$/ha	rev-med \$/ha	rev-high \$/ha	unit value low \$/m3	unit value med \$/m3	unit value high \$/m3	revised cost \$/m3	revised net rev-L \$/m3	revised net rev-M \$/m3	revised net rev-H \$/m3	H, I m3/ha	J m3/ha	U,X,Y m3/ha	total vol m3/ha	sawlog m3/ha	pulp m3/ha
37	25		65	CT	6501.60	9320.80	12140.00	47.46	68.04	88.61	37.44	10.02	30.60	51.17		112	25	137	78.4	58.6
37		1.3	80	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
38	25		70	CT	7211.40	10348.20	13485.00	47.13	67.64	88.14	36.62	10.51	31.02	51.52		123	30	153	86.1	66.9
38		1.6	88	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
39	25		85	CT	6182.40	8851.20	11520.00	47.93	68.61	89.30	35.70	12.23	32.91	53.60		108	21	129	75.6	53.4
39		1.9	100	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
40	25		90	CT	7693.00	11009.00	14325.00	48.08	68.81	89.53	34.77	13.31	34.04	54.76		135	25	160	94.5	65.5
40		2.2	105	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4
41	15		135	CT	5749.80	8307.40	10865.00	44.92	64.90	84.88	40.11	4.81	24.79	44.77		91	37	128	63.7	64.3
41		1.0	164	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
42	15		160	CT	6686.40	9643.20	12600.00	45.49	65.60	85.71	38.04	7.45	27.56	47.67		108	39	147	75.6	71.4
42		1.3	193	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
43	20		80	CT	5969.60	8644.80	11320.00	44.22	64.04	83.85	40.90	3.32	23.14	42.95		92	43	135	64.4	70.6
43		1.0	100	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
44	20		95	CT	7344.40	10597.20	13850.00	45.34	65.41	85.49	38.00	7.34	27.41	47.49		118	44	162	82.6	79.4
44		1.3	113	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
45	20		105	CT	7946.40	11463.20	14980.00	45.41	65.50	85.60	36.85	8.56	28.65	48.75		128	47	175	89.6	85.4
45		1.6	126	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
46	20		130	CT	6419.00	9247.00	12075.00	45.85	66.05	86.25	35.99	9.86	30.06	50.26		105	35	140	73.5	66.5
46		1.9	148	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
47	20		135	CT	7793.80	11199.40	14605.00	46.67	67.06	87.46	35.21	11.46	31.85	52.25		131	36	167	91.7	75.3
47		2.2	157	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4
49	25		65	CT	7376.60	10655.80	13935.00	44.98	64.97	84.97	38.53	6.45	26.44	46.44		117	47	164	81.9	82.1
49		1.3	80	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
50	25		70	CT	8082.20	11668.60	15255.00	45.15	65.19	85.22	37.47	7.68	27.72	47.75		129	50	179	90.3	88.7
50		1.6	88	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
51	25		85	CT	6917.40	9966.20	13015.00	45.81	66.00	86.19	36.37	9.44	29.63	49.82		113	38	151	79.1	71.9
51		1.9	100	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
52	25		90	CT	8404.20	12094.60	15785.00	46.18	66.45	86.73	35.30	10.88	31.15	51.43		139	43	182	97.3	84.7
52		2.2	105	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4
53	15		100	CT	3071.60	4490.80	5910.00	41.51	60.69	79.86	64.74	-23.23	-4.05	15.12		42	32	74	29.4	44.6
53		0.7	132	final	17280.00	24640.00	32000.00	49.37	70.40	91.43	20.00	29.37	50.40	71.43	31	270	49	350	220.0	130.0
54	15		135	CT	5296.20	7690.60	10085.00	43.41	63.04	82.66	53.09	-9.68	9.95	29.57		79	43	122	55.3	66.7
54		1.0	164	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
55	15		160	CT	6336.40	9173.20	12010.00	44.31	64.15	83.99	48.77	-4.46	15.38	35.22		98	45	143	68.6	74.4
55		1.3	193	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
56	20		65	CT	3043.60	4446.80	5850.00	41.69	60.92	80.14	66.47	-24.78	-5.55	13.67		42	31	73	29.4	43.6
56		0.7	85	final	17280.00	24640.00	32000.00	49.37	70.40	91.43	20.00	29.37	50.40	71.43	31	270	49	350	220.0	130.0
57	20		80	CT	5332.60	7763.80	10195.00	42.66	62.11	81.56	46.73	-4.07	15.38	34.83		77	48	125	53.9	71.1
57		1.0	100	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
58	20		95	CT	6970.60	10097.80	13225.00	44.12	63.91	83.70	48.82	-4.70	15.09	34.88		107	51	158	74.9	83.1
58		1.3	113	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
59	20		105	CT	7596.40	10993.20	14390.00	44.42	64.29	84.15	46.77	-2.35	17.52	37.38		118	53	171	82.6	88.4
59		1.6	126	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
60	20		130	CT	6069.00	8777.00	11485.00	44.63	64.54	84.45	45.05	-0.42	19.49	39.40		95	41	136	66.5	69.5
60		1.9	148	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
61	20		135	CT	7504.00	10832.00	14160.00	45.20	65.25	85.30	43.55	1.65	21.70	41.75		120	46	166	84.0	82.0
61		2.2	157	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4
62	25		45	CT	2249.80	3287.40	4325.00	41.66	60.88	80.09	76.99	-35.33	-16.11	3.10		31	23	54	21.7	32.3
62		0.7	62	final	17280.00	24640.00	32000.00	49.37	70.40	91.43	20.00	29.37	50.40	71.43	31	270	49	350	220.0	130.0
63	25		60	CT	5619.60	8174.80	10730.00	42.90	62.40	81.91	54.20	-11.30	8.20	27.71		82	49	131	57.4	73.6
63		1.0	73	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1

TFL 41 Product Summary for Treatments 64 – 90

#	SI	final piece size m3	age	vol	rev-low \$/ha	rev-med \$/ha	rev-high \$/ha	unit value low \$/m3	unit value med \$/m3	unit value high \$/m3	revised cost \$/m3	revised net rev-L \$/m3	revised net rev-M \$/m3	revised net rev-H \$/m3	H, I m3/ha	J m3/ha	U,X,Y m3/ha	total vol m3/ha	sawlog m3/ha	pulp m3/ha
64	25		65	CT	6895.00	9995.00	13095.00	43.92	63.66	83.41	50.11	-6.19	13.55	33.30		105	52	157	73.5	83.5
64		1.3	80	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
65	25		70	CT	7628.60	11051.80	14475.00	44.10	63.88	83.67	47.99	-3.89	15.89	35.68		117	56	173	81.9	91.1
65		1.6	88	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
66	25		85	CT	6543.60	9466.80	12390.00	44.51	64.40	84.29	45.75	-1.24	18.65	38.54		102	45	147	71.4	75.6
66		1.9	100	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
67	25		90	CT	8030.40	11595.20	15160.00	45.11	65.14	85.17	43.86	1.25	21.28	41.31		128	50	178	89.6	88.4
67		2.2	105	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4
68		2.47	121	final	56198.00	78814.00	101430.00	77.71	108.98	140.25	15.60	62.11	93.38	124.65	537	420	41	998	831.0	167.0
69	25	1.76	107	final	49923.00	70319.00	90715.00	54.32	76.52	98.71	16.15	38.17	60.37	82.56	358	505	56	919	711.5	207.5
70	20	1.42	136	final	41533.60	58656.80	75780.00	53.18	75.10	97.03	16.95	36.23	58.15	80.08	241	482	58	781	578.4	202.6
71	25	1.41	102	final	47135.80	66565.40	85995.00	53.20	75.13	97.06	16.50	36.70	58.63	80.56	278	541	67	886	656.7	229.3
72	20	1.19	134	final	40926.60	57925.80	74925.00	52.27	73.98	95.69	17.35	34.92	56.63	78.34	197	517	69	783	558.9	224.1
73	20		65	CT	3648.40	5269.20	6890.00	45.04	65.05	85.06	45.08	-0.04	19.97	39.98	0	58	23	81	40.6	40.4
73		0.70	85	final	17280.00	24640.00	32000.00	49.37	70.40	91.43	20.00	29.37	50.40	71.43	31	270	49	350	220.0	130.0
74	25	1.02	70	final	24422.20	34648.60	44875.00	70.80	100.45	130.10	18.80	52.00	81.65	111.30	89	339	48	476	326.3	149.7
75	25	1.29	80	final	31126.40	44003.20	56880.00	72.80	102.92	133.04	17.90	54.90	85.02	115.14	165	378	47	590	429.6	160.4
76	20	0.45	85	final	22301.00	31953.00	41605.00	47.65	68.28	88.90	20.00	27.65	48.28	68.90	15	365	88	468	270.5	197.5
77	25	0.46	62	final	21876.40	31353.20	40830.00	47.56	68.16	88.76	20.05	27.51	48.11	68.71	14	358	88	460	264.6	195.4
78	20	0.79	85	final	23704.80	33762.40	43820.00	49.80	70.93	92.06	19.20	30.60	51.73	72.86	49	366	61	476	305.2	170.8
79	25	0.74	62	final	22688.20	32346.60	42005.00	49.43	70.47	91.51	19.60	29.83	50.87	71.91	38	359	62	459	289.3	169.7
80	20	0.63	85	final	24243.60	34606.80	44970.00	48.98	69.91	90.85	19.65	29.33	50.26	71.20	38	382	75	495	305.4	189.6
81	25	0.60	62	final	23209.20	33159.60	43110.00	48.66	69.52	90.38	19.65	29.01	49.87	70.73	28	374	75	477	289.8	187.2
82	15	0.35	132	final	21076.40	30233.20	39390.00	47.26	67.79	88.32	20.30	26.96	47.49	68.02	9	348	89	446	252.6	193.4
83	20	0.36	85	final	21518.80	30864.40	40210.00	47.29	67.83	88.37	20.25	27.04	47.58	68.12	9	356	90	455	258.2	196.8
84	25	0.34	62	final	21132.40	30321.20	39510.00	47.17	67.68	88.19	20.40	26.77	47.28	67.79	9	348	91	448	252.6	195.4
85	20	0.79	85	final	23704.80	33762.40	43820.00	49.80	70.93	92.06	19.20	30.60	51.73	72.86	49	366	61	476	305.2	170.8
86	25	0.74	62	final	22688.20	32346.60	42005.00	49.43	70.47	91.51	19.60	29.83	50.87	71.91	38	359	62	459	289.3	169.7
87	20	0.63	85	final	24243.60	34606.80	44970.00	48.98	69.91	90.85	19.65	29.33	50.26	71.20	38	382	75	495	305.4	189.6
88	25	0.60	62	final	23209.20	33159.60	43110.00	48.66	69.52	90.38	19.65	29.01	49.87	70.73	28	374	75	477	289.8	187.2
89	20	1.26	132	final	40202.40	56871.20	73540.00	52.48	74.24	96.01	17.20	35.28	57.04	78.81	203	498	65	766	551.6	214.4
90	25	1.51	102	final	47169.20	66559.60	85950.00	53.54	75.55	97.56	16.45	37.09	59.10	81.11	295	524	62	881	661.8	219.2

TFL 41 Product Summary for Treatments 91-112

#	SI	final piece size m3	age	vol	rev-low \$/ha	rev-med \$/ha	rev-high \$/ha	unit value low \$/m3	unit value med \$/m3	unit value high \$/m3	revised cost \$/m3	revised net rev-L \$/m3	revised net rev-M \$/m3	revised net rev-H \$/m3	H, I m3/ha	J m3/ha	U,X,Y m3/ha	total vol m3/ha	sawlog m3/ha	pulp m3/ha
91	20	0.63	85	final	21618.00	30874.00	40130.00	48.80	69.69	90.59	19.70	29.10	49.99	70.89	26	350	67	443	271.0	172.0
92	25	0.62	62	final	21211.20	30305.60	39400.00	48.65	69.51	90.37	19.80	28.85	49.71	70.57	24	344	68	436	264.8	171.2
93	20		60	CT	3943.80	5709.40	7475.00	44.31	64.15	83.99	41.44	2.87	22.71	42.55	0	61	28	89	42.7	46.3
93		1.0	100	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
94	20		60	CT	4314.80	6252.40	8190.00	44.03	63.80	83.57	41.74	2.29	22.06	41.83	0	66	32	98	46.2	51.8
94		1.3	113	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
95	20		60	CT	4418.40	6399.20	8380.00	44.18	63.99	83.80	41.91	2.27	22.08	41.89	0	68	32	100	47.6	52.4
95		1.6	126	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
96	20		60	CT	3760.40	5445.20	7130.00	44.24	64.06	83.88	40.98	3.26	23.08	42.90	0	58	27	85	40.6	44.4
96		1.9	148	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
97	20		60	CT	4211.20	6105.60	8000.00	43.87	63.60	83.33	41.72	2.15	21.88	41.61	0	64	32	96	44.8	51.2
97		2.2	157	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4
98	20		70	CT	4852.40	7001.20	9150.00	45.35	65.43	85.51	39.38	5.97	26.05	46.13	0	78	29	107	54.6	52.4
98		1.0	100	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
99	20		70	CT	5458.60	7881.80	10305.00	45.11	65.14	85.17	39.19	5.92	25.95	45.98	0	87	34	121	60.9	60.1
99		1.3	113	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
100	20		70	CT	5562.20	8028.60	10495.00	45.22	65.27	85.33	39.32	5.90	25.95	46.01	0	89	34	123	62.3	60.7
100		1.6	126	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
101	20		70	CT	4565.40	6590.20	8615.00	45.20	65.25	85.30	39.17	6.03	26.08	46.13	0	73	28	101	51.1	49.9
101		1.9	148	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
102	20		70	CT	5275.20	7617.60	9960.00	45.09	65.11	85.13	39.28	5.81	25.83	45.85	0	84	33	117	58.8	58.2
102		2.2	157	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4
103	25		60	CT	5569.20	7999.60	10430.00	46.80	67.22	87.65	38.09	8.71	29.13	49.56	0	94	25	119	65.8	53.2
103		1.0	73	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
104	25		60	CT	6302.80	9056.40	11810.00	46.69	67.08	87.48	37.88	8.81	29.20	49.60	0	106	29	135	74.2	60.8
104		1.3	80	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
105	25		60	CT	6589.80	9467.40	12345.00	46.74	67.14	87.55	37.84	8.90	29.30	49.71	0	111	30	141	77.7	63.3
105		1.6	88	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
106	25		60	CT	5362.00	7706.00	10050.00	46.63	67.01	87.39	38.07	8.56	28.94	49.32	0	90	25	115	63.0	52.0
106		1.9	100	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
107	25		60	CT	6302.80	9056.40	11810.00	46.69	67.08	87.48	37.88	8.81	29.20	49.60	0	106	29	135	74.2	60.8
107		2.2	105	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4
108	25		70	CT	6274.80	9012.40	11750.00	46.83	67.26	87.69	36.42	10.41	30.84	51.27	0	106	28	134	74.2	59.8
108		1.0	73	final	21616.60	30655.80	39695.00	51.47	72.99	94.51	19.10	32.37	53.89	75.41	82	297	41	420	289.9	130.1
109	25		70	CT	7159.60	10274.80	13390.00	47.10	67.60	88.09	36.36	10.74	31.24	51.73	0	122	30	152	85.4	66.6
109		1.3	80	final	25721.40	36338.20	46955.00	53.03	74.92	96.81	18.40	34.63	56.52	78.41	145	303	37	485	357.1	127.9
110	25		70	CT	7446.60	10685.80	13925.00	47.13	67.63	88.13	36.27	10.86	31.36	51.86	0	127	31	158	88.9	69.1
110		1.6	88	final	30368.00	42784.00	55200.00	54.23	76.40	98.57	17.80	36.43	58.60	80.77	215	310	35	560	432.0	128.0
111	25		70	CT	5959.80	8557.40	11155.00	46.93	67.38	87.83	36.56	10.37	30.82	51.27	0	101	26	127	70.7	56.3
111		1.9	100	final	39867.00	56071.00	72275.00	54.99	77.34	99.69	16.95	38.04	60.39	82.74	320	365	40	725	575.5	149.5
112	25		70	CT	7107.80	10201.40	13295.00	47.07	67.56	88.05	36.37	10.70	31.19	51.68	0	121	30	151	84.7	66.3
112		2.2	105	final	41276.40	57953.20	74630.00	55.78	78.32	100.85	16.80	38.98	61.52	84.05	368	338	34	740	604.6	135.4