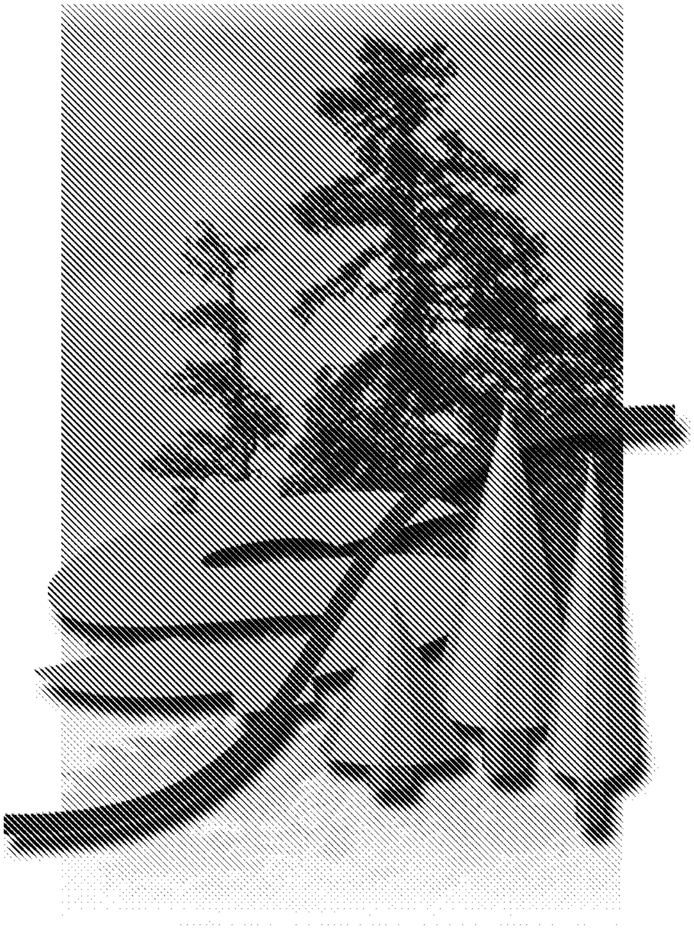

Arrow Lakes Tree Farm Licence 23

Silviculture Strategy (Interim)

Version 1.1 – March 99

Pope & Talbot Ltd.

[inside cover]

L.P. Atherton and Associates and Cortex Consultants Inc. prepared this report.

Forest Renewal BC funded the project under a contract between Pope and Talbot Ltd. and Cortex Consultants Inc.

Chris Shelley of Pope and Talbot Ltd. managed the project.

The participation of representatives of the following organizations at the strategy workshop is gratefully acknowledged:

Pope and Talbot Ltd.
Arrow Forest District, B.C. Ministry of Forests
Nelson Forest Region, B.C. Ministry of Forests.

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Strategy at a Glance

Purpose

This strategy is intended to help optimize the funding available for silviculture activities to improve the future quantity and quality of both habitat and timber supply. The strategy will be considered as one of several inputs in decisions on funding allocations and treatment activities.

Primary Objectives

The primary objectives of the silviculture strategy are to

eliminate the mid term timber supply shortfall indicated by the MP #9 base case harvest forecast; and

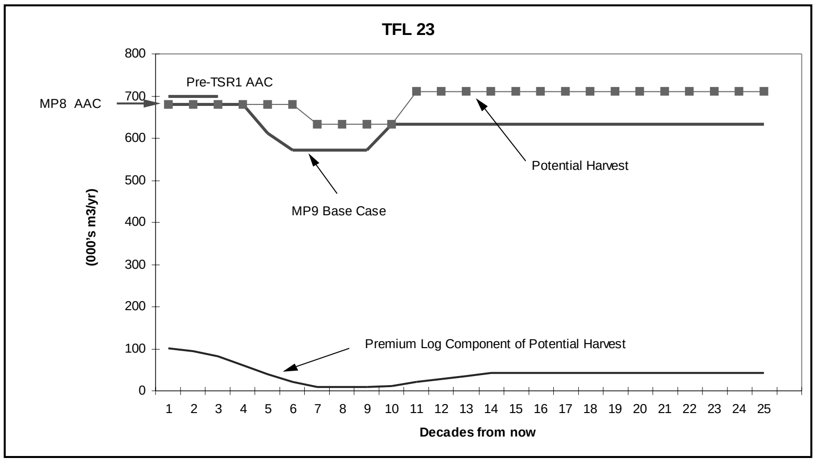
substantially increase the volume and quality of future regenerated stands.

Accomplishing this strategy requires a program substantially above historic levels as well as pre free growing activities above basic silviculture.

Working Targets

Quantity:	Maintain the current harvest level of 0.68 million m3/yr for six decades, and manage mid and long term timber supply to yield harvest levels of 0.64 and 0.71 million m3/yr, respectively.
Quality:	Manage regenerated stands to yield at least 6% (by volume) premium large logs, with most of the remainder being sawlog quality.

The following chart illustrates the working targets. They represent the plausible high end of the potential of the timber resource relative to the MP #9 base case. Changes to the base case would also change the potential forecast. These forecasts are interim and require confirmation through analysis and modelling.



Log Quality Objectives

The following are log quality objectives for TFL 23.

Quality class	Species	Characteristics
Premium log	All, except white pine & red cedar	45+ cm dbh
	white pine & red cedar	30+ cm dbh
	All, except white pine & red cedar	30+ cm dbh, 25+ % clear lumber production, min 5 m log
Sawlog	All, except white pine & red cedar	30+ cm dbh

Silviculture Strategies

The following strategies are those considered in the workshop and follow-up analysis to be appropriate towards achieving the working targets. Other strategies that were considered but had no opportunity area are documented in the report.

Timber Quantity

Some of the following practices are pre free growing and are unlikely to be undertaken without funding assistance if free growing obligations can be achieved without them.

No.	Strategy	Priority
General		
	Conduct silviculture surveys to support all strategies.	1
Short Term		
	No short term silviculture actions identified.	
Mid Term		
MT 2	For existing managed stands aged 1–25 yrs, lower the minimum harvest age 25 yrs (to age 80 for all species except age 70 for Pl) and maximize stand volumes at that age by:	
ii)	brushing an additional 500 ha/yr above basic silviculture levels for growth enhancement and increased survival;	8
iii)	spacing 1200 ha/yr to advance technical rotation ages;	5
iv)	managing approximately 50 000 ha under a 15 yr cycle repeat fertilization regime of 3300 ha/yr to obtain a 10% volume gain at the stand level (shared objective with MT 3 viii);	11
MT 3	For about-to-be regenerated stands, lower the minimum harvest age 25 yrs (to age 80 for all species except age 70 for Pl) and maximize stand volumes at that age by:	
i)	site preparing 200 ha/yr more than current levels;	6

No.	Strategy	Priority
ii)	using improved seed for 90% of planted areas (1800 ha/yr);	3
iii)	using larger planting stock on 80% of planted areas (1600 ha/yr);	7
vi)	brushing an additional 500 ha/yr above basic silviculture levels for growth enhancement and increased survival (continuation of MT 2 ii);	8
vii)	spacing 1200 ha/yr (continuation of MT 2 iii);	5
viii)	managing approximately 50 000 ha under a 15 yr cycle repeat fertilization regime of 3300 ha/yr (shared objective with MT2 iv);	11
MT 4	Fertilize 400 ha/yr 15 yrs prior to harvest beginning 60 years from now on stands that have not been under repeat fertilization program.	9
MT *5*	For the white pine component of mixed stands, first lift prune 225 ha/yr and second lift prune 75 ha/yr (total 300 ha/yr, 225 ha/yr under management) to retard blister rust development and to capture, through later commercial thinning, volumes that would otherwise be lost to mortality (approximately 2.25% of annual harvest volume).	4
Long Term		
LT 1	Brush 500 ha/yr of existing backlog plantations.	2
LT 3	Continue MT 3 activities into the long term (except spacing), but with the objective changed from harvesting at age 80 to harvesting at an average stand diameter of 30 cm.	same as MT 3

Timber Quality

No separate strategies to increase the quality of future timber supply were identified in the workshop. Strategies for increasing quality are interwoven with those for increasing quantity.

Habitat Supply

No separate strategies to increase the quantity or quality of future habitat supply were identified in the workshop. Rather, needs for further research and information for caribou habitat management were identified

Silviculture Regimes and Investment Priorities

The following table summarizes the anticipated costs and benefits of each silviculture treatment. Investment priorities are ranked across all treatments. “Risk” reflects the confidence level of workshop participants in the probability of attaining the estimated outcomes for a treatment, particularly for timber supply effects.

Regimes		Strategy	Opportunity Area (Ha/Yr)	Risk	Timber Supply Effects			Quality	Habitat Caribou	Jobs Days/ha	Cost $/ha[1]	Wkshp Rank
					Short	Medium	Long					
Survey												
1			12,000							0.1	30	1
Backlog												
2	Brushing	L1	500	L			+			2	500	2
Pre FTG												
3	site prepare more areas	M3i, L3	200	L-M		+	+		-	0.5	700	6
4	improved seed	M3ii, L3	1800	L		+++	+++	++			80	3
5	larger planting stock	M3iii, L3	1400	L-M		+	+			0.5	168	7
6	fertilize at time of planting	M3iv, L3	1600	M		+	+			0.5	150	10
7	manage voids	M2i,M3v, L3	0	-		+	+				0	
8	brush for growth	M2ii,M3vi, L3	500	M-H		+	+			2	500	8
Post FTG												
9	spacing stands (30-year window)	M2iii, M3vii	1200	M		++		+	+	2.7	800	5
10	repeat fertilize on 15 year cycle	M2iv, M3viii	3300	M		+	+	+		0.1	200	11
11	Fertilize late rotation (begin in 45 yrs)	M4	400	M		++				0.1	200	9
12	CT capture mortality (pruned, 20 yrs)	M5	0			+			+			
13	CT create old seral structure	M5	0			+			++			
14	Prune Pw to 3m (blister rust, CT later) 1st lift	M5	225	L		++		++		0.8	250	4
15	2nd lift	M5	75	L		+		+++		0.8	250	4

Incremental Silviculture Program (ha)

The following annualized program will contribute to achieving the above goals and strategies. This program is considerably above historic levels and some activities may require phasing in.

Year	Surveys*	Backlog Brushing	Brushing for Growth	Enhanced Establishment	Space	Prune	Fertilize
1	12,000	500	500	5,000	1,200	300	3,700
2	12,000	500	500	5,000	1,200	300	3,700
3	12,000	500	500	5,000	1,200	300	3,700
4	12,000	500	500	5,000	1,200	300	3,700
5	12,000	500	500	5,000	1,200	300	3,700
Subtot Yr 1 - 5	60,000	2,500	2,500	25,000	6,000	1,500	18,500
6 - 10	60,000	-	2,500	25,000	6,000	1,500	18,500
Total Yr 1 - 10	120,000	2,500	5,000	50,000	12,000	3,000	37,000
* Includes prescription and layout							
Unit cost ($/ha)	30	500	500	152	800	250	200

Program Table - $ 000s, TFL 23, March 1999

Year	Surveys*	Backlog Brushing	Brushing for Growth	Enhanced Establishment	Space -	Prune -	Fertilize -	Total
1	360	250	250	759	960	75	740	3,394
2	360	250	250	759	960	75	740	3,394
3	360	250	250	759	960	75	740	3,394
4	360	250	250	759	960	75	740	3,394
5	360	250	250	759	960	75	740	3,394
Subtot Yr 1 - 5	1,800	1,250	1,250	3,796	4,800	375	3,700	16,971
6 - 10	1,800	-	1,250	3,796	4,800	375	3,700	15,721
Total Yr 1 - 10	3,600	1,250	2,500	7,592	9,600	750	7,400	32,692

Job Creation

The following are the anticipated job outcomes associated with the preceding program, assuming the program is maintained into the future as necessary to achieve the working targets.

Short term *employment associated with undertaking the silviculture activity, in person years*

Year	Surveys*	Backlog Brushing	Brushing for Growth	Enhanced Establishment	Space -	Prune -	Fertilize -	Total
1	6.0	5.0	5.0	8.0	16.2	1.2	1.9	43.3
2	6.0	5.0	5.0	8.0	16.2	1.2	1.9	43.3
3	6.0	5.0	5.0	8.0	16.2	1.2	1.9	43.3
4	6.0	5.0	5.0	8.0	16.2	1.2	1.9	43.3
5	6.0	5.0	5.0	8.0	16.2	1.2	1.9	43.3
Subtot Yr 1 - 5	30.0	25.0	25.0	40.0	81.0	6.0	9.3	216.3
6 - 10	30.0	-	25.0	40.0	81.0	6.0	9.3	191.3
Total Yr 1 - 10	60.0	25.0	50.0	80.0	162.0	12.0	18.5	407.5

Note: Assumes 200 days of harvesting, silviculture work, and timber processing = 1 job

Long term *employment associated with improved quality and quantity of the timber resource*[1]

Decade	Harvest Increment ('000 m3)	Incremental Jobs per year Region[2]	Incremental Jobs per decade Region[2]
1	-	-	-
2	-	-	-
3	-	-	-
4	-	-	-
5	68	267	2,672
6	108	424	4,244
7	62	244	2,437
8	62	244	2,437
9	62	244	2,437
10	-	-	-
11	76	299	2,987
12	76	299	2,987
13	76	299	2,987
14	76	299	2,987
15	76	299	2,987
16	76	299	2,987
17	76	299	2,987
18	76	299	2,987
19	76	299	2,987
20	76	299	2,987
21	76	299	2,987
22	76	299	2,987
23	76	299	2,987
24	76	299	2,987
25	76	299	2,987
Total			59,029

Notes:

1. Assumes continuation of the silviculture program beyond the first 10 years, in accordance with the strategy. The total harvest increment is associated with all the silvicultural practices documented in the "Opportunities" section and is only partly attributable to spacing and fertilization practices. Some of the increase may be associated with pre-free growing silviculture that was not current practice at the time of strategy development.

2. Assumes 3.93 TSA level direct (harvesting, silviculture, processing), indirect and induced (PYs) per 1000 cubic metre. (Source: TFL 23 MP #9 Timber Supply Analysis Report, p.39)

Further Information and Research Needs

During the assessment process, the following needs for further information and research became apparent. The outcome of these have implications for further strategy development. Bracketed numbers refer to the strategy numbers under which the need is identified (see tables in "Workshop Review of Potential Strategies," page 36.

1. Determine the current status of time until green-up (Reickenback (1996) has shown that green-up ages may be lower than estimated for TFL 23) and re-run the sensitivity analyses using revised green-up ages for:
   a) the combined IRM, caribou and ungulate winter range zones; and
   b) VQO zone. (ST 1)
2. Assess the stocking and height status of existing age class 30 stands (26--35 years). This age class is critical to mid term timber supply and it should be surveyed to determine if the stands are tracking as managed or unmanaged stands and whether volumes should be calculated at 17.5 cm dbh (as at present) or at 12.5 cm dbh utilization standard. (MT 1)
3. The TIPSY OAF 1 factor of 15% requires confirmation. Survey techniques are available. Use of a different OAF1 in AAC determination requires statistical validity at the management unit level. (MT3 v)
4. Further study of root rot management techniques and options is needed., Presence of root rot can limit commercial thinning options (MT6). Need to determine if TIPSY OAF2 allowance of 5% is an adequate estimate of losses (LT4).
5. Assess the extent and dynamics of age class 1 deciduous stands for their potential to be added to the THLB. (LT2 a)
6. Old growth site index estimation studies require completion. It is anticipated that site indexes may be underestimated. Sensitivity analysis of the MP #9 shows that OGSI adjustments may increase long term timber supply substantially. (LT7)
7. Silviculture activities, particularly commercial thinning, can be used to create old-growth tree attributes at earlier ages. Further study is required to determine if CT can achieve these attributes earlier, particularly enhanced lichen production for caribou. (LT8)
8. Check that caribou constraints were modelled properly with respect to other factors, particularly biodiversity. Remodel caribou constraints once MoELP objectives (amount, where, timing) for caribou and better info on silviculture management options are available. (LT 8)

Introduction

About the Interim Strategy

This strategy is intended to help optimize the funding available for silviculture activities to improve the future quantity and quality of both habitat and timber supply. The strategy will be one of several inputs in decisions on funding allocations and treatment activities.

Because of limited time, budget, and available information this first version of the strategy consentrates on the future quantity of the timber resource. As the strategy develops and as better and more information becomes available, the strategy will focus more on future timber quality and the future quantity and quality of habitat supply.

To achieve optimization, the opportunities evaluated here are not limited by factors such as the availability of funding, funding source (e.g., public vs. private), or the ability to deliver a program. Therefore, the strategy illustrates the plausible high end of the potential of the timber resource. After considering cost-effectiveness, available treatments, and operational realities – all of which were explored in the workshop – potential treatment activities were ranked. The end result should point to the most effective and efficient means of partially achieving the working targets. The success of the overall strategy will ultimately depend on how well the expressed targets will be achieved. The strategy, of course, could also be affected by unknowns, such as major changes in forest policy, land base available for timber production, or market demand.

Although this strategy focuses primarily on silviculture, silviculture is one part of many potential strategies which may influence the future quality and quantity of habitat and timber supply.

This strategy should not be confused with the allowable annual cut (AAC)[1] determination process. The AACs are based on actual practice and current information at the time of the determination. This strategy, on the other hand, is about creating a future state of our forests. The strategy may influence future, but not necessarily present, AAC determinations.

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

Methodology

This strategy was prepared as follows:

1. Prior to the workshop, L. P. Atherton & Associates prepared a preliminary draft of this document (version 1.0), summarizing all available information relevant to a strategy and identifying opportunities to improve the future quantity and quality of timber supply.

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[1] See "Abbreviations" for a list of abbreviations used in this report.

2. A workshop was held March 22 and 23, 1999, in Nakusp, attended by representatives of Pope and Talbot Ltd. (P&T) and the Ministry of Forests (MoF). Larry Atherton of L. P. Atherton & Associates, and Doug Williams of Cortex Consultants Inc. led the session. Participants reviewed the potential opportunities listed in the draft document and identified others. The outcome of the session was a regime table, complete with priorities.
3. The consultants incorporated the results of the workshop into a revised draft document (version 1.1), analyzed further as appropriate, and added forecasts of future harvest quantity and quality and of job outcomes.
4. After client review, the consultants submitted a completed strategy to Pope & Talbot in electronic format as version 1.2. P&T will assign higher version numbers (e.g., 1.3, 1.4) as the strategy evolves.

Structure of This Document

This document generally reflects the flow of the methodology: pre-workshop preparation, workshop findings and outcomes, and post-workshop analysis and review. A key objective of the process is to have a documented rationale to the strategy. For clarity and ease of reading, workshop information and additional information on document development are in the appendices.

Higher Level Goals and Objectives

This section documents higher level goals and objectives relevant to an incremental silviculture strategy for the timber supply area (TSA).

Provincial Goals

Government's goals can be characterized as:

- sustainable use;
- community stability; and
- a strong forest sector (B.C. Ministry of Forests, 1998a).

Provincial Objectives

Until provincial targets for timber quantity and quality are established, management unit strategies are to consider the following interim provincial strategic objectives (B.C. Ministry of Forests, 1998a).

Objective 1: Maintain current harvest levels as long as possible without creating disruptive shortfalls in future timber supply.

Objective 2: Create a long term timber supply capable of supporting a steady long term provincial harvest level similar to current levels.

Objective 3: Minimize the interim shortfall in provincial harvest anticipated before a steady long term timber supply is achieved.

Objective 4: Create a long term timber supply which will enable the timber quality profile of future harvests to be the same or better than the current profile.

Not every management unit can contribute to these interim objectives. Further, these objectives may not be attainable at current funding levels. Their purpose is to guide to the application of available funds. Incremental silviculture strategies must also be in keeping with higher level plans under the Forest Practices Code.

Regional Objectives

The Nelson Forest Region has not set out formal regional incremental silviculture objectives. In the interim, the provincial objectives are accepted as broadly applicable within the region.

Higher Level Plans

Formal higher level plans are strategic plans defined by the Forest Practices Code. Currently, no approved higher level plans cover (TFL) 23. The Kootenay Boundary Land Use Plan has been approved but the decision whether to make it a higher level plan has not been finalized. Until that time it guidesmanagement practices.

Other plans exist at a higher level; there plans are strategic (policies and guidelines) or operational and provide direction to any lower level plans, prescriptions, or forest practices. These, however, are not higher level plans as defined under the Code.

Basic Data

Table 1. Land area

Description	Area (ha)	Area %
Total area of TFL 23	556 900[a]	100
Total productive Crown forest	371 800	67
Net THLB	224 700	40

Source: Pope and Talbot (1998b:2) 4–5: rounded to nearest 100 ha.

[a] Includes 6800 ha of Schedule A land.

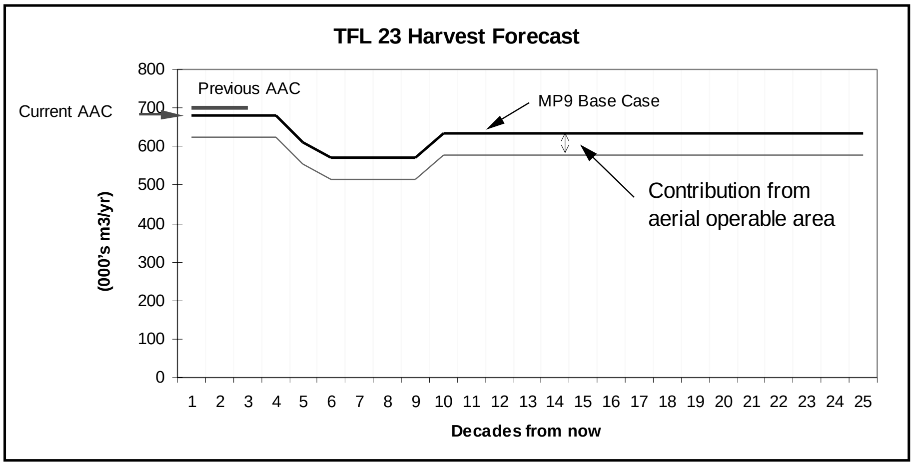
Table 2. Allowable Annual Cut

AAC type	Pre-TSR (m^3)	TSR1[a] (m^3)	Change (%)
Conventional	700 000	555 000	-20.7
Deciduous	-	-	
Insect/disease	-	-	
Marginal	-	125 000	∝
Total	700 000	680 000	-2.9
SBFEP AAC	80 700	80 700[b]	

[a] Effective September 1994.

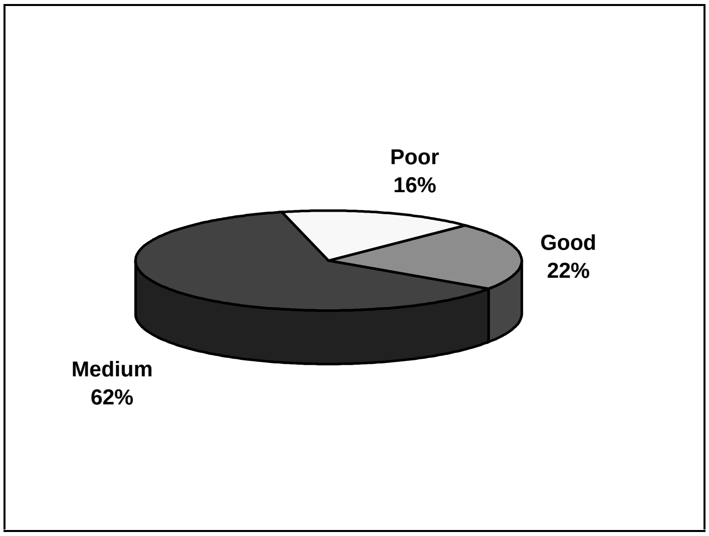
[b] Source: Pope and Talbot (1997:1)

Figure 1. Base case harvest forecast.



Source for base case: Pope and Talbot (1998b:12, Table 1, scenario 3).

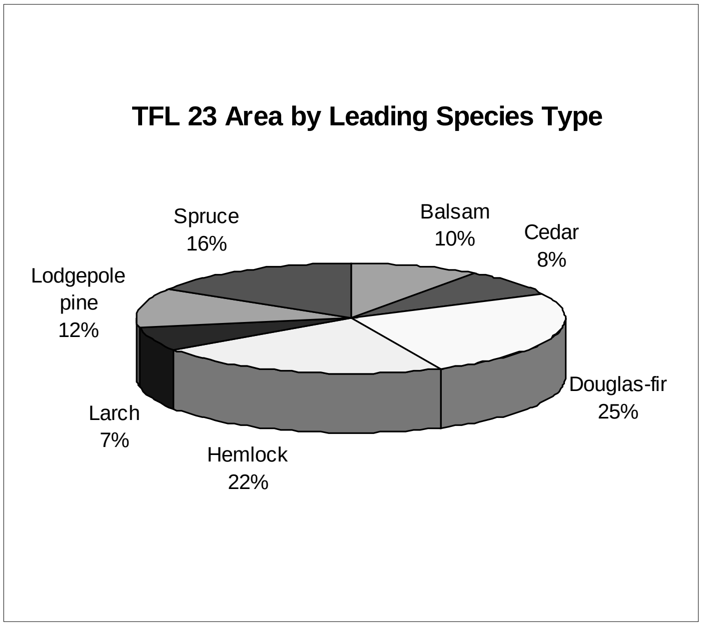
Figure 2. Site class distribution, THLB only.



Source: Pope and Talbot (1998b:8) Figure 9b data (with OGSI adjustment).

Note: Site class assignment is a general description of the relative productivity of stands and is not the same as the old MoF system (Pope and Talbot 1998a:29).

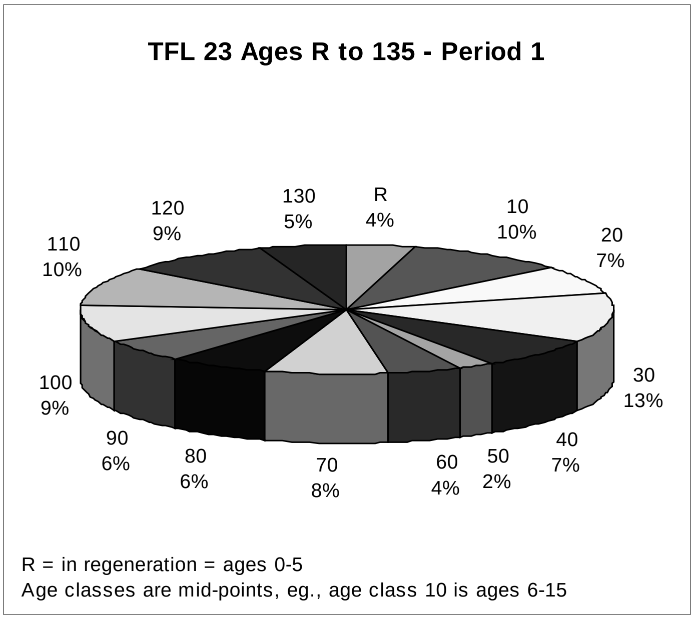
Figure 3. Tree species distribution, THLB only.



Source: Pope and Talbot (1998b:7) Figure 8 data merged to major leading species.

distribution, THLB only, all ages

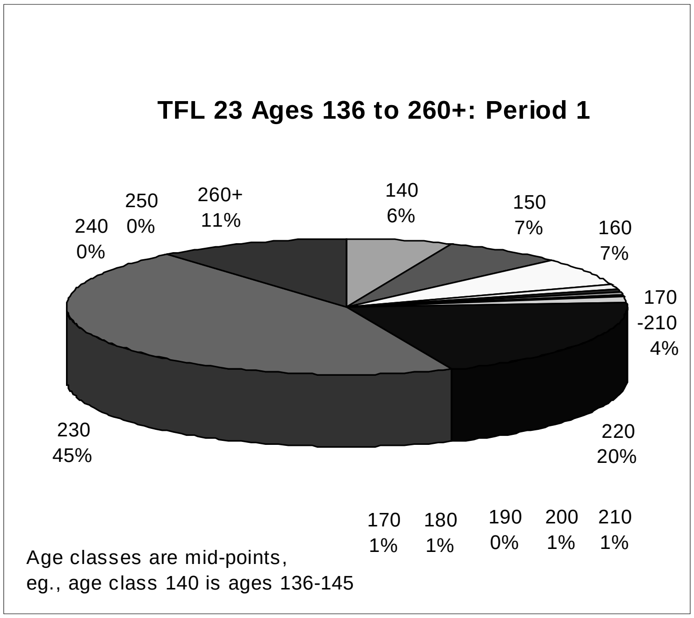
Figure 4. Age class distribution, ages R to 120, THLB only


TFL 23 Ages R to 135 - Period 1

R = in regeneration = ages 0-5
Age classes are mid-points, eg., age class 10 is ages 6-15

Source: Pope and Talbot (1998b:15); Figure 14 data.

Figure 5. Age class distribution, ages 136 to 260+, THLB only


TFL 23 Ages 136 to 260+: Period 1

Age classes are mid-points, eg., age class 140 is ages 136-145

Source: Pope and Talbot (1998b:15); Fig 14 data.

Incremental Silviculture History

Timber harvesting began on a large scale within the TFL in the 1950s. Approximately 2600 ha were harvested annually in the first two decades, falling to a level of about 2000 ha/yr starting in decade 6 (Pope and Talbot, 1998b:14).

Treatment	**Management Plan #9 status (1998)**		**Current status (1999)**
	Incorporated in timber supply analysis	**Not incorporated in timber supply analysis**	Source: P&T
Backlog	Eliminated		Eliminated
Conversion			None
Commercial thin			No CT history
Space	TIPSY used for stands regenerated over the past 25 years. Assumes stocking control on these stands to keep them in the range assumed by TIPSY with a stand establishment of 1600 sph		Currently averages about 200 ha/yr; maximum past level about 350 ha/yr
Prune			380 ha/yr of pathological pruning (includes first and second lift); not done for value
Fertilize			No fertilization history

Issues and Silviculture Opportunities

Silviculture planning has not yet been modelled. Therefore, sensitivity analyses from the MP # 9 timber supply analysis report are the best source of information about opportunities for silviculture to increase future timber supply. For detailed issues and opportunities analysis, see Appendix B.

The following are selected sensitivity analysis charts from the analysis report, with added opportunity information. The consultants prepared some additional charts based on information in the report or additional information supplied by Timberline forest inventory consultants. Detailed analyses are required to confirm the indicated effects.

Figure 6 Alternative harvest forecasts. LRSY = Long run sustained yield. LTHL = Long term harvest level.

The alternative chosen as the base case allows the initial harvest level to be maintained for four decades, but at the expense of a lower mid term level than if harvest levels were reduced after one decade (scenario 2). Silviculture treatments can be used to eliminate the indicated base case mid term shortfall.

Figure 7 Changeover from existing to managed stands.

Managed stands begin to be harvested by the model in decade 8 of the base case. By decade 10, managed stands form well over 50% of the harvest.

Figure 8 Current age of stands modelled to be harvested in the later mid term period.

Stands presently 30 years of age figure prominently in harvests in the latter half of the mid term shortfall period. The volumes of these stands are calculated using natural stand yield tables (which have lower volumes than managed stands) and to a 17.5 cm dbh utilization standard (vs. 12.5 cm for managed stands).

Figure 9 Sensitivity to changes in minimum harvest ages

Reducing minimum harvest ages 10 years enables the initial harvest level to be maintained for two decades longer than the base case and the mid term shortfall is almost eliminated. The lower ages make younger existing, as well as soon-to-be-regenerated stands, available for harvest 10 years sooner than in the base case. (Figure 8 shows these stands figure prominently in the mid term shortfall period.) This releases some older existing stands for earlier harvest because they do not have to be held as long. Spacing and fertilizing suitable stands could lower harvest ages.

If minimum ages are increased 10 years, the converse is true.

Figure 10 Changes in existing stand volumes.

Harvest forecasts are very sensitive to changes in the estimates of existing stand volumes. However, a recently completed inventory audit shows current estimates are reliable.

Suitable existing stands could be fertilized to raise their volumes.

Figure 11 Changes in managed stand yields.

Increasing managed stand yields by 10% raises the long term harvest level by the same percentage and has a minor effect in the mid term. Many silviculture practices can be used to increase managed stand yields.

Figure 12 Harvest forecast after OGSI adjustment.

Oldgrowth types are known to incorporate a negative site productivity bias. After such stands are harvested the newly regenerated stands will grow faster than currently predicted. Changing the site indices of these stands to their expected true productivity significantly increases mid and long term harvest levels. Combining increased site productivity with increased managed stand volumes (Figure 11) can be expected to substantially increase yield.

Figure 13 Potential to increase timber supply in decade 5.

Several sensitivity analyses indicate a similar response in decade 5 when forest cover requirements are relaxed. This result indicates some flexibility in timber supply in this time period. Commercial thinning or partial harvesting can allow access to some stands which otherwise would be unavailable for harvest.

Figure 14 Changes in green-up and adjacency.

As noted, relaxation of various forest cover constraints makes addtional timber supply available in decade 5. The same result can be achieved through reduced green-up ages. Silviculture practices can be used to achieve green-up at younger ages.

Figure 15 Reduction in allowable disturbance levels in IRM and wildlife zones.

Second decade harvests are at significant risk if allowable disturbance levels in the IRM and wildlife zones are reduced. Partial harvesting or commercial thinning may allow access to stands that otherwise would be unavailable. Silviculture practices could be used to achieve faster green-up in newly regenerated stands. (Workshop participants, however, believed that green-up and adjacency were not significant issues in this time period.)

Figure 16 Effect of log diameter on harvesting cost and log value.

Generally, log value has historically increased with diameter, up to about 40 cm. Logging costs for all types of harvesting systems are very high below 19 cm diameter and, other than for harvesting systems using log forwarders, do not change significantly above about 28 cm log diameter.

Figure 17. Impact of piece size and lumber recovery.

A similar trend to that of log value exists in the relationship between log diameter and lumber recovery factor (LRF). Lumber recovery significantly increases with log size up until about 30 cm top diameter, after which only slight increases occur.

Summary of Issues: Timber Quantity

General

The MP #9 base case harvest forecast holds the initial harvest level (current AAC) for four decades. This results in insufficient timber supply from existing natural stands to span the mid term, with a consequent 10% shortfall below the long term harvest level (LTHL). An alternative harvest forecast indicates that only a slight shortfall (2% below eventual LTHL) would exist if harvest levels were lowered by 9% after only one decade. In light of this alternative, the base case forecast could be seen to represent a "borrowing" of timber from the future to maintain the present harvest level. This scenario may prove unacceptable to the provincial Chief Forester in the next or a future AAC determination.

The overall silviculture strategy, therefore, should be to begin silviculture (and other) actions over the next decade that will at least eliminate the base case mid term shortfall. This strategy needs to be in effect no later than the MP #11 timber supply analysis, which is about when the alternative harvest forecast indicates harvest levels would have to drop to avoid the more serious mid term shortfall associated with the MP #9 base case.

Short Term (1–20 years)

The short term is defined as the first two decades.

Generally, the base case forecasts that the initial harvest level can be maintained at the current AAC throughout the short term. Harvesting in the short term occurs only in existing mature natural stands.

Modelling convention typically applies any increases in available timber supply from sensitivity analysis to extending the initial harvest level into the future rather than increasing short term harvest levels. Therefore, the *relaxation* of harvesting constraint generally does not increase timber supply in the short term. The two exceptions to this are the P&T caribou habitat option and an increase to the operable land base by the addition of mature harvestable timber.

Modelling convention also tries to prevent the short term harvest level from dropping, without causing undue disruption to future harvest levels. Increasing constraints, therefore, will generally affect the mid term before the short term is affected, unless the transition from existing to managed stands occurs in the short term.

In TFL 23, increasing constraints related to older forests does not affect short term harvest levels. This is because the relatively large area of older existing timber both within and outside the THLB can readily satisfy increased requirements for older timber in this time period. (This is not the case in the mid term, when fewer older stands exist.)

While increasing older forest requirements does not affect short term harvest levels, lowering the limit on the area not required to be greened up (from 25 to 20%) in the IRM, caribou, and ungulate winter range zones (in total, 78% of the THLB) causes the harvest level to drop by 12% in the second decade. Because the area not greened up is already close to its limits in the base case, making the requirement more restrictive immediately puts it over the second decade limit. To mitigate this risk, silviculture actions could focus on achieving green-up as soon as possible in this period.

Either decreasing the timber harvesting land base 10% or removing the aerial operable area from the THLB can result in a need to lower the initial harvest level below that of the base case (the current AAC). However, silviculture can not affect these factors.

Mid Term (21–100 years)

The mid term is the time from year 21 until the time at which the harvest is predominantly in managed stands.

In the MP #9 base case, the first two decades of the mid term (i.e., decades 3 and 4) are held at the initial harvest level. After the fourth decade, the base case falls over two decades until a level below the long term harvest level is reached at decade 6. (For discussion, these first three decades (i.e., 3–5) are referred to as the *early mid term*.) The level below the LTHL is held for three decades (from decades 6–9) and is referred to as the *mid term shortfall*. The base case then rises in one decade to the LTHL in decade 10. The end of the mid term period is therefore defined as 100 years from now, the end of decade 10. At this point about two thirds of harvesting is in managed stands (Figure 7).

In management units having a mid term shortfall, as in TFL 23, factors affecting the harvest forecast fall into two broad categories:

1. those that affect the availability or volume of existing natural timber stands, which must be rationed until secondgrowth managed stands become available; and
2. those that affect the availability or volume of managed secondgrowth stands, which must take over the harvest from the diminishing stock of existing stands as soon as possible.

Factors Affecting Existing Natural Stands

In the mid term, factors that affect the availability or volume of existing natural stands greatly affect the ability to maintain the initial harvest level for longer or shorter than in the base case.

Applying full old-seral biodiversity requirements in the low-biodiversity emphasis landscape units, lowering existing stand yields 10%, removing mature stands having marginal site productivity, or increasing caribou thermal and oldgrowth objectives reduces the availability of mature and old forests. These actions cause harvest levels to start the transition period sooner because there are now fewer stands available to bridge the gap until managed stands are available. Conversely, improving timber volumes or relaxing constraints tends to lengthen the time until the transition to lower levels because these actions increase the ability of existing stands to bridge or even fill the gap.

In TFL 23, the greatest of these factors is the estimate of existing stand volumes. Confidence in the current estimates was increased by a recent inventory audit, so management efforts could focus on silviculture opportunities to increase the volumes of existing stands above present estimates. Sensitivity testing indicates that increasing volumes by 10% extends the initial harvest level (IHL) to the 10th decade, eliminating the mid term shortfall.

Little can be done to increase the volume of older, mature existing stands. However, opportunities may exist to increase the volumes of, or recovered from, thrifty existing natural stands. Commercial thinning may capture volumes that would otherwise be lost to mortality. Fertilization could increase existing stand volumes. Of particular importance is increasing the volumes of existing natural stands that are currently 26 to 44 years of age (i.e., age classes 30 and 40). Applying the right set of silviculture practices to stands now can not only increase their volumes, but also make them harvestable sooner.

Adjacency forest cover constraints have a lesser but significant effect on timber supply in the mid term. Sensitivity analyses indicate harvest levels could be increased in the early mid term if regeneration delay were reduced, or if green-up could be achieved earlier. Relative to its size (only 7% of the THLB), the mid term harvest forecast shows particular sensitivity to changes in constraints in the VQO zone. Silviculture practices can affect both of these constraints. In TFL 23, these constraints would not only affect both the availability of existing mature timber but also the timing of the transition to managed stands.

Ungulate management is a significant factor within the TFL, particularly for caribou in the Shelter Bay block. However, changing the associated forest cover requirements has relatively minor effects on the harvest forecast because the ungulate and old-seral biodiversity guidelines overlap; therefore, both must be satisfied for a significant wood flow impact.

Factors Affecting Existing and Future Managed Stands

Because of the nature of the mid term, factors that affect the timing at which managed stands become available can also significantly affect mid term timber supply. The greatest of these factors is minimum harvest age. Increasing minimum ages 10 years means it takes the younger thrifty existing stands as well as the managed secondgrowth stands 10 years longer before they are available for harvest. To stretch the existing timber supply over this longer period, harvests must be reduced from the initial level two decades earlier than in the base case.

Conversely, if these stands are available for harvest 10 years earlier than in the base case, the existing harvest level can be maintained for 20 more years (until decade 6) and the mid term shortfall below LTHL is nearly eliminated. However, commensurate with decreasing ages are decreasing tree sizes, which may not be desirable. Average stand diameter at breast height(dbh) at the base case minimum ages is in the low 20 cm range, at a 12.5 cm utilization standard. Silviculture practices can be used to reduce harvestable ages while maintaining stand diameters and volumes above those of unmanaged stands.

Factors Affecting All Stands

The choice of the breakpoint between managed and unmanaged existing stands is highly relevant because of the timber yield assumptions that go with each. Managed existing stands are currently aged 0–25 years, to which TIPSY managed stand yields are calculated at a 12.5 cm dbh utilization standard. Existing stands currently aged 26+ years are assigned considerably lower variable density yield projection (VDYP) calculated at a 17.5 cm dbh utilization standard. Given the importance in the mid term shortfall period of stands currently in age classes 30–40 years, stand yield assumptions for them are particularly significant. (In the workshop P&T staff stated current practice is to utilize all logs with a minimum 10cm top diameter and 3m length.)

Long Term (101+ years)

The long term is the remainder of the planning horizon, usually characterized by a steady state harvest level.

Long term harvesting is primarily in managed stands. While forest cover constraints affect the availability of these stands, by the long term the base case constraints have much less overall impact. Forest cover constraints generally only affect the long term harvest level when they cause a long delay in the average harvest age. This is because the long term harvest level depends primarily upon the productivity of managed stands at the time of harvesting. If harvesting is delayed for a significant portion of the land base, productivity falls.

Otherwise, the long term is affected mainly by the size of the timber harvesting land base and by the volume of stands when harvested. Some silviculture activities such as stand rehabilitation or conversion can be used to bring non-productive area or unmerchantable stands into the land base.

Many silviculture activities are appropriate to increasing the growth of forests and therefore the volume of stands at harvest. In most management units, the long term is sensitive to changes in regenerated stand volumes. A 1% increase or decrease in volume results in an equal 1% increase or decrease to LTHL.

Potential for Change in the Shape of the Harvest Forecast

The shape of the harvest forecast must be confirmed because different silviculture opportunities arise in association with different shapes.

For TFL 23, two shapes are feasible shapes to a status quo harvest forecast (see Figure 6). As additional timber supply becomes available and is applied towards each alternative forecast, both forcasts would ultimately merge to a similar shape. For the adopted base case, additional supply would first be applied towards eliminating the mid term shortfall. For scenario 2, where the mid term shortfall is already minimal, additional timber supply would be applied towards maintaining the initial harvest level. Either way, the end result would be a harvest forecast similar to that of the base case without a mid term shortfall. The silviculture practices to increase timber supply would be valid either way as well.

Possible increases to the LTHL are a 12% increase from higher site indices and a further 15–20% increase if regenerated stand volumes are increased by this amount. Offsetting these might be some reduction due to modelling the stands outside the THLB without regeneration, but this amount (if any) is not presently quantified. When possible increases and decreases are combined, a substantial rise to the LTHL can be anticipated. This rise enables some of this volume to be brought forward in time to fill the mid term harvest shortfall. Decreasing minimum harvest ages and commercial thinning are two ways of achieving this.

Future land base reductions could change the profile of the harvest forecast if a substantial area of younger or middleaged forests are removed. This possibility suggests silviculture strategies appropriate to the existing land base and forest profile may not be robust against future change in the TSA land base. However, this uncertainty is true of most TSAs and should not cause inaction; rather, when choices between strategies or actions are to be made, this factor should be kept in mind.

Summary of Issues: Timber Quality

The timber supply analysis for MP #9 does not address the future quality of the timber resource (its primary purpose is to provide information for an allowable annual cut determination). However, the reports present some information on harvested stand ages and dbh which can be used as a broad surrogate for timber quality. Within limits, the older the stand and/or the larger the dbh, the higher the timber quality.

The average harvested age over time is not included in the analysis reports. However, harvesting in the short and early mid term periods is projected to be mostly in older existing stands. In the latter mid term and long term, harvesting will be in younger secondgrowth managed stands at ages close to their minimum harvest ages.

Changes to minimum harvest ages substantially impact the harvest forecast (see Appendix B: Detailed Issues and Silviculture Opportunities Analysis: minimum harvest ages, and Figure 9).

Harvesting future stands at or near minimum ages indicates future timber quality will be much lower than today's. Timber will have much smaller diameter, stem taper will tend to be greater, ring widths will be wider, juvenile wood content will be higher and little clear wood will be produced.

Because lowering minimum ages 10 years extends the current harvest two decades, timber quantity strategies will focus on lowering minimum ages, and may lower the overall quality of the timber resource (unless lower ages are compensated by strategies to maintain average tree sizes).

Maintaining timber harvest volumes during the mid term may occur at the expense of profitability. Generally, at lower diameters harvesting costs increase and mill recovery decreases (Figure 16 and Figure 17).

Requiring more of the old-seral biodiversity requirement to be met from within the THLB would lengthen the harvest ages of some stands considerably. This would increase the average quality content of future harvests when some of these areas are harvested. However, these stands may tend to occupy poorer quality growing sites, and once set aside old-seral biodiversity, may be held for longer. Tracking these stands through modelling would help improve understanding of howdifferent management scenarios affect future harvest quality profile.

Maintaining a strictly volume-oriented focus at the expense of overall quality has risks. Future markets must be such that a full diet of small diameter wood can be profitable. Secondary manufacturing opportunities, as well as manufacturing of high quality products, will become more limited.

The dilemma presented is choosing between volume and value. *However, some choices do not necessarily have to be made today.* Stands can be spaced now to reduce minimum ages or to increase stand value. *Future* markets and forest management policies will decide the ultimate allocation between quantity and quality. More attention likely is required for pruning decisions.

Modelling is required to have a better grasp of future timber quality scenarios.

White Pine

Western white pine has a limited range in British Columbia and perhaps grows best in the area of TFL 23. Its wood is highly valued and commands a premium price. An introduced blister rust, however, has killed most of the older trees. "Cankers are produced on branches and stems, usually within 2.5 m of the ground. Thus, initial infection occurs mainly on younger trees with branches close to the ground." (Finck et al. undated:75)

Silviculture Opportunities

Planted white pine seedlings are rust resistant, having been bred for this characteristic, although are not 100% so. Naturally regenerated young trees can be pruned to reduce the incidence of infection.

Pruning stands can produce a clear wood component for future harvests. Spacing can be used to increase the average diameters of some stands (this strategy would also enable harvesting at younger ages).

Opportunities to Increase Timber Supply

Potential Silviculture Strategies

Before the workshop, information in the previous sections and from the detailed issue analysis in Appendix B was used to identify the following potential silviculture strategies. These strategies could either maintain or increase future timber supply at the TSA level. Each of these was discussed in detail in the district working session, the results of which are recorded in Appendix XX; along with additional strategies that arose during the meeting. Strategies that are ultimately adopted are noted in "Silviculture Strategies."

Short Term (1–20 years)	
ST 1	Determine the current status of time until green-up and re-run the: a) IRM, caribou and ungulate winter range; and b) VQO sensitivity analysis using revised green-up ages. (maintain)[2]
ST 2	If, after ST 1 analysis, the short term still shows sensitivity to green-up ages, depending on the assessed risk: (maintain) a) further analyze to determine the LU/REA combinations that are constraining and the location of potentially treatable existing or about to be regenerated stands; b) reduce the area not greened-up in decade 2 in those zones where green-up is 2m by accelerating the growth of young stands by: i) on about-to-be-regenerated stands, using aggressive stand establishment and tending practices (see MT 3); and ii) on existing stands below green-up, fertilizing and/or brushing for growth enhancement; c) Reduce the area not greened-up in decade 2 in those zones where green-up is 5–6 m by spacing and fertilizing free growing (FG) stands (fertilizer may not be acceptable in watershed zone).
ST 3	Alternatively, or with ST 2, partial harvest or commercial thin in decade 2 as necessary to overcome adjacency limitations. (maintain)
ST 4	Fertilize all suitable stands scheduled for harvest in the second decade. (increase)[3]
Mid Term (21–100 years)	
MT 1	Assess the stocking and height status of existing age class 30 stands to determine: a) whether they are tracking as natural stands (VDYP) or managed stands (TIPSY); and/or (increase) b) whether a 12.5 cm dbh utilization standard should apply. (increase)

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[2] (maintain) means oriented to maintaining the harvest level in the TSR 2 base case.

[3] (increase) means oriented to increasing harvest levels above those in the TSR2 base case.

MT 2	For existing managed stands (1–25 years) and natural stands in the 30-and 40-year age classes, (increase) (a) reduce minimum harvest ages 10 years while (b) maintaining the base case volume by, as appropriate: i) managing stocking so voids do not account for more than 10% of the area; ii) brushing for growth enhancement (i.e., not only for survival); (increase) iii) spacing stands; (maintain) and iv) repeat fertilize suitable stands on a 15-year return cycle.
MT 3	For about-to-be-regenerated stands: a) reduce minimum harvest ages 10 years (MT impact), (b) increase the volume of regenerated stands by 10% over those used at the base case minimum harvest age (LT impact), and (c) achieve green-up 3–5 years earlier (ST impact) by: i) site preparing more areas; (increase) ii) using improved seed; (increase) iii) using larger planting stock; (increase) iv) fertilizing at the time of planting; (increase) v) managing stocking so voids do not account for more than 10% of the area; (increase) vi) brushing for growth enhancement (i.e., not only for survival); (increase) vii) spacing stands; (maintain) and viii) repeat fertilizing suitable stands on a 15-year return cycle.
MT 4	Repeat fertilize all suitable existing stands scheduled for harvest 20 to 80 years from now to achieve the same harvested volumes as modelled in the base case but at lower min harvest ages. (increase)
MT 5	Commercially thin stands to: a) recover volumes lost to mortality; b) create old-seral attributes earlier; or c) bring forward volumes from the long term. (increase)
MT 6	Implement partial harvesting (CT?) regimes in all zones (particularly the VQO zone) to overcome adjacency limitations. (increase)
Long Term (100+ years)	
LT 1	Brush___ ha of existing backlog plantations. (maintain)
LT 2	Increase the THLB by: a) converting/rehabilitating deciduous stands; (increase) b) converting/rehabilitating non-merchantable hemlock stands; (increase) c) assessing low-site stands for proper classification; or d) improving the site productivity of low-site stands by (fertilization?). (increase/maintain)
LT 3	Continue MT 3. (increase)
LT 4	Reduce losses to root rot by: a) pushover logging/stumping; b) planting alternate/mixed species;

	c) pop-up spacing. (maintain)
LT 5	Continue MT 5 (except item c). (increase)
LT 6	a) Model regenerating stands outside the THLB. b) Depending on the outcome of (a), plant areas outside of the THLB to increase the area in an old-seral state in 100 to 200 years. (maintain)
LT 7	Confirm OGSI adjustments.

Workshop Review of Potential Strategies

Each of the potential strategies listed in the preceding section was examined in a two-day workshop. This section documents workshop discussion and conclusions as well as related follow-up analysis.

The response time frame (i.e., the short, mid or long term) in the following subsections is the period in which the anticipated result is expected, *not* the period in which actions must necessarily begin. The harvest forecast for each period uses the MP #9 base case as the starting level. The harvest forecast column was not thoroughly reviewed during the workshop. *Results are largely conjecture and are meant to illustrate the potential of the strategies.*

Explanatory notes about the following tables.

Column number	Note
1 & 2	Strategy numbers correspond with the numbers recorded earlier in “Potential Silviculture Strategies”. Items followed by an asterisk (*) were added during the workshop.
3	Information is largely from a meeting of P&T and MoF personnel held March 22 and 23, 1999, in Nakusp (the “workshop”), combined with information presented earlier in this document.
4	Anticipated results are typically calculated using the timber supply response indicated by the MP #9 timber supply analysis sensitivity tests.

Short Term (1–20 years)

Number	Potential strategy/action	Discussion/current status	Anticipated result
♦ **ST 1**	1. Determine the current status of time until green-up and re-run the a) integrated resource management (IRM), caribou and ungulate winter range; and b) VQO sensitivity analysis; using revised green-up ages. (maintain)[4]	1. This defensive strategy is oriented to maintaining the base case harvest forecast. Sensitivity analysis indicates second decade harvest levels would drop dramatically were the allowable area < two metres in height to drop from 25 to 20%. There is some expectation that green-up will not be an issue. A new definition of green-up has recently been issued that effectively lowers green-up ages. (New or old def'n used in analysis?), Reichenback (1996) shows that actual green-up ages are likely lower than the estimates used in the timber supply analysis. Improved stock and higher actual site productivity than currently used in projections will also shorten time to green-up. Lastly, field experience is generally that green-up/adjacency constraints are not a problem. P&T has submitted a 20 yr operating plan that has been accepted by the MoF. Therefore, the logical first step is to re-examine information and assumptions.	1. Action added to "Summary of Information and Research Needs."
♦ **ST 2**	If, after ST 1 analysis, the short term still shows sensitivity to green-up ages, depending on the assessed risk: (maintain) a) further analyze to determine the LU/REA combinations that are constraining and the location of potentially treatable existing or about to be regenerated stands; b) reduce the area not greened-up in decade 2 in those zones where green-up is 2 m by accelerating the growth of young stands by: i) on about-to-be-regenerated stands, using aggressive stand establishment and	2. Depending on the outcome of ST 1, these potential strategies could be pursued. Not explored further in the workshop because expectation is that green-up is not/will not be an issue.	2. No action at this time.

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[4] (maintain) means oriented to maintaining the harvest level indicated by the TSR 2 base case.

Number	Potential strategy/action	Discussion/current status	Anticipated result
	tending practices (see MT3); and ii) on existing stands below green-up, fertilizing and/or brushing for growth enhancement; a) Reduce the area not greened-up in decade 2 in those zones where green-up is 5–6 m by spacing and fertilizing free growing (FG) stands (fertilizer may not be acceptable in watershed zone).		
◆ **ST 3**	3. Alternatively, or with ST2, partial harvest or commercial thin in decade 2 as necessary to overcome adjacency limitations. (maintain)	3. Same as for ST 2. These actions will be largely driven by factors of timber supply and market demand. If supply is tight and market is high, then partial harvesting or CT might occur if there are no other viable means of harvesting. Risk level at this time does not warrant silviculture actions.	3. Not applicable.
◆ **ST 4**	4. Fertilize all suitable stands scheduled for harvest in the second decade. (increase)	4. Inventory audit indicates volume estimates for existing stands are accurate. Any gain in existing volumes would therefore increase harvest levels above the base case. There are likely few suitable stands for fertilizing. The two main reasons are (1) currently harvesting old-growth cedar/hemlock stands and (2) current planning and approval processes are inadequate to identify stands that will be harvested in a decade or longer.	4. No opportunity.
	Short Term Harvest Forecast Summary	The workshop review of the above potential strategies indicated no immediate opportunities for increasing the short term harvest level above the MP #9 base case. The following summarizes the short term findings of a potential harvest forecast for the period. **(000s m^3/yr)** 680 1st decade (same as base case) 680 2nd decade green-up fertilization 680 Total	

Mid Term (21–100 years)

Number	Potential strategy/action	Discussion/current status	Anticipated result
♦ **MT 1**	1. Assess the stocking and height status of existing age class 30 stands to determine: a) whether they are tracking as natural stands (VDYP) or managed stands (TIPSY); (increase) and/or b) whether a 12.5 cm dbh utilization standard should apply. (increase)	1. Age class 30 stands are scheduled for harvest in the timber supply model immediately before the transition to managed stands. If the volume estimates of these stands are low, then higher corrected volumes would increase harvest levels towards that indicated by the sensitivity test of higher existing stand volumes (Figure 10). Higher volumes could result in two ways: 1. A change in the utilization level to which the yields are calculated, based on the current harvesting practice (i.e., from 17.5 cm dbh to 12.5 cm dbh). This can be done using either VDYP or TIPSY. 2. A change in assumptions about stocking levels in these stands. This is best done using TIPSY which has a high flexibility in setting stocking levels. A statistically sound estimate of the stocking levels of age class 30 stands would be necessary to successfully argue for using TIPSY vs VDYP in AAC determination. Depending on the outcome for age class 30, a similar approach could be progressively applied to higher age classes.	1. Action added to “Summary of Information and Research Needs.”
♦ **MT 2**	2. For existing managed stands (1–25 yrs) and natural stands in the 30- and 40-year age classes, (increase) (a) reduce minimum harvest ages 10 years while, (b) maintaining the base case volume by, as appropriate:	2.	2.
♦ **MT 2**	i) managing stocking so voids do not account for more than 10% of the area;	i) See MT 3 (v).	i) See MT 3 (v).
♦ **MT 2**	ii) brushing for growth enhancement (i.e., not only for survival); (increase)	ii) See MT 3 (vi).	ii) See MT 3 (vi).
♦ **MT 2**	iii) spacing stands; (maintain) and	ii) See MT 3 (vii).	ii) See MT 3 (vii).
♦ **MT 2**	iv) repeat fertilize suitable stands on a 15 yr return cycle.	iv) See MT 3 (viii).	iv) See MT 3 (viii).

Number	Potential strategy/action	Discussion/current status	Anticipated result
♦ **MT 3**	3. For about-to-be-regenerated stands: (a) reduce minimum harvest ages ~~10~~ 25 years (MT impact), (b) increase the volume of regenerated stands by ~~10~~ 50% over those used at the base case minimum harvest age (LT impact), and (c) achieve green-up 3–5 years earlier (LT impact) by:	1. The actions listed below (items i to viii) can influence both the mid and long term harvest levels depending upon the degree to which the objectives (a–c) are attained. To avoid duplication, they are all evaluated together in this section. In the workshop, the target for (a) reduced ages, was changed from 10 to 25 years to reflect a target harvest age of 80, vs. approx. 105 years used in the analysis; and for (b) increased volumes, from 10 to 50%. The revised (lower) age target is the avg. used for the OGSI sensitivity test and reflects the objective of lower minimum ages. The revised (higher) volume change is based on increasing avg. dbh from 22 cm (MP #9 avg. dbh for managed stands) to 30 cm (target sawlog stand) at age 80 and 1600 sph (same initial stocking used in the MP #9). Objective (c) is not applicable. The timber supply analysis does not contain a sensitivity test for green-up ages. See ST 1 about changes to the area allowed to be below green-up. See MT 6 for changes to green-up ages in the VQO zone.	3. (i) See "Summary" below.
♦ **MT 3**	i) site preparing more areas; (increase)	i) Currently about 15% of harvested areas are broadcast burned and 15% site prepared mechanically. This equals 600 ha/yr (30% X 2 000 ha logged/yr). An additional 200 ha/yr (10% of annual area harvested) could be site prepared, mainly in the Engelmann spruce – subalpine fir (ESSF) ecological zone. Workshop participants estimated this could achieve a 5 yr reduction in minimum and/or rotation ages at the same volumes. [how? by releasing nutrients? reducing brush?] A 5-year reduction in ages equates to a 5% volume increase, assuming the same volume is harvested 5 yrs earlier. (Getting the same volume 5 yrs earlier, e.g., at age 100 vs. age 105, on a multiple rotation basis equates to a 5% volume gain. Across the entire harvested area this equates to a 0.5 yr age reduction (10% area X 5 yr age reduction). At $700/ha, total cost = 200 ha X $700 = $140,000/yr.	3.(i) 0.5 yr reduction in minimum ages. Cost: $140,000/yr See "Summary" below.

<table>
<tr><th>Number</th><th>Potential strategy/action</th><th>Discussion/current status</th><th>Anticipated result</th></tr>
<tr>
<td>♦ MT 3</td>
<td>ii) using improved seed; (increase)</td>
<td>
<p>3. (ii) 100% of areas are planted. Of this, about 90% will be genetically improved stock with an average volume gain of 15%. Latest estimates of yield gains are:</p>
<table>
<tr><th>Species</th><th>Cur %</th><th>Future %</th><th>1st gen % gain</th><th>2nd gen % gain</th></tr>
<tr><td>Fd/L</td><td>30</td><td>55</td><td></td><td></td></tr>
<tr><td>Cw/Hw</td><td>30</td><td>5</td><td></td><td></td></tr>
<tr><td>S/B</td><td>25</td><td>25</td><td></td><td></td></tr>
<tr><td>Pl</td><td>15</td><td>15</td><td>—</td><td></td></tr>
<tr><td></td><td></td><td></td><td>15 avg</td><td></td></tr>
</table>
<p>A 3% yield gain for <i>all</i> newly regenerated managed stands was included in the MP #9 timber supply analysis. A 15% gain on 90% of stands is a net effect of ((0.9 X 15) -3 =) 10.5% gain over volumes used in the MP#9 analysis.</p>
<p>For Fdi, sit index (SI) 23, establishment of 1600 sph, age 80 (target age), TIPSY indicates a 15% volume gain equates to a 1.3 m SI increase. (Note: an SI increase is used here as a means to measure the dbh effect of improved trees while holding age and stocking constant). The dbhg difference for all stems is approx. 1.5 cm (from 23.6 to 25.1). This equates to 0.9 X 1.5 = 1.4 cm dbh gain over THLB (estimated at 4% in the workshop) and is about a 7 yr reduction in age. (dbh gain may be slightly overstated data not available on how dbh may have been adjusted to reflect the 3% gain used in the timber supply analysis.)</p>
<p>Tree improvement could also significantly reduce green-up ages.</p>
</td>
<td>
<p>3.(ii) Current practice. Volume gain over that already included in base case = 10.5% and 1.4 cm dbh at age 80. These are achieved 7 yrs earlier than TIPSY (base case).</p>
<p>Cost: indirect.</p>
<p>See “Summary” below.</p>
</td>
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<tr>
<td>♦ MT 3</td>
<td>iii) using larger planting stock; (increase)</td>
<td>
<p>(iii) Pre free growing item. Larger stock could be used but not likely in current economic conditions. Upper bound of opportunity area is 80% of planted area = 0.8 X 2000 = 1600 ha/yr.</p>
<p>Mostly now plant 1+0 PSB 415B stock. Larger stock would be PSB 415D which would cost $0.12 more per tree. Increased cost for larger stock would be (1600 ha/yr X 1400 trees/ha X $0.12/tree =) $272,000/yr. Could reduce green-up ages and minimum ages 1–2 yrs. Prorated over THLB, this equals (0.8 X 1.5 ≅) 1 yr reduction in ages and 1% vol increase.</p>
</td>
<td>
<p>3. (iii) 1 yr reduction in min. ages; 1% vol increase.</p>
<p>Cost: $272,000/yr</p>
<p>See “Summary” below.</p>
</td>
</tr>
<tr>
<td>♦ MT 3</td>
<td>iv) fertilizing at the time of planting; (increase)</td>
<td>
<p>(iv) Pre free growing item. Not presently eligible for Forest Renewal BC funding and not likely to be voluntarily undertaken unless necessary to achieve FG.</p>
<p>Experience elsewhere shows fertilizing at time of planting can give similar early results as using larger planting stock. Opportunity area assumed to be 80% of area planted (0.8 X 2000 =) 1600 ha/yr. Assume 1% volume gain or 1 yr reduction in min ages.</p>
<p>Experienced cost elsewhere is $150/ha, but this may go down if done on a large scale. Fertilizer may also soon be available in the plug medium, which would eliminate the labour cost in the plantation. Assume cost in this case would be $50/ha. Total cost may range from ($50 X 1600 ha =) $80,000 to ($225 X 1600 ha =) $225,000/yr.</p>
<p>Note: Workshop follow-up by Ivan Listar of the MoF indicates that results elsewhere are</p>
</td>
<td>
<p>3. (iv) 1 yr reduction in min. ages.</p>
<p>Cost: $80–$225,000/yr</p>
<p>High risk rating.</p>
<p>See “Summary” below.</p>
</td>
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</table>

Number	Potential strategy/action	Discussion/current status	Anticipated result
		inconclusive. One trial found a generally favourable response, but also that certain formulations and certain species had a negative response. Fertilization did not prevent a brushing on brush sites. In the workshop, a medium risk was assigned to this activity. Based on the new information, the risk is reassessed as high.	
♦ **MT 3**	v) managing stocking so voids do not account for more than 10% of the area; (increase)	(v) TIPSY standard OAF1 factor for voids is 15%. Objective is to reduce this to 10%. Current free growing requirements will result in <15% in voids; however, the actual amount is unknown. Surveys of stands close to free growing (not many stands are at FG ages yet) are coming out close to minimum requirements. This is a function of age and survey methodology, not mortality. Total stocking is higher, and in a few years more stems will cross the minimum ht requirements. Approximately 40% of the total land area of the TFL is within the THLB. This estimate implies relatively moderate terrain, so an OAF1 of 15% may be high. On the other hand, approx. one third of harvested areas have brush competition, which may increase stand voids or impede growth. *Surveys for voids must be completed to get a measure of the actual area in voids*. Voids can be desirable for wildlife habitat, so intensive void management may not be practicable on all areas.	3. (v) Action added to "Summary of Information and Research Needs," page 68. See "Summary" below.
♦ **MT 3**	vi) brushing for growth enhancement (i.e., not only for survival); (increase)	(vi) Of the 2000 ha/yr harvested about 600 ha/yr require brushing to ensure free growing (hts are 1.4 m for Fdi and 2 m for Lw, Pl, Pw). About half of these require a second brushing, for a total program of about 900 ha/yr. Brushing for growth opportunities are: 200 ha of second brushing of already brushed sites + <u>300</u> ha of new areas 500 ha total. Cost at $500/ha = $250,000. In the Golden TSA strategy, brushing for growth was estimated to have a 4–5% volume impact; 4% from increased survival and 1% from reduced growth impedence. Assuming a 5% benefit, 500 ha/2000 ha total X 5% = 1.25% long term harvest level increase. Workshop notes in the summary show the benefit as 0.25. Recall this is cm, but notes give no indication how this number was derived. Because volume effect is largely due to increased survival, more stems will slightly lower avg. dbh, if anything. Changed post-workshop to indicate a volume rather than dbh effect. Brushing for growth could also reduce green-up ages.	(vi) 1.25% volume increase. Cost: $250,000/yr Med–high risk rating. See "Summary" below.

Number	Potential strategy/action	Discussion/current status	Anticipated result
♦ **MT 3**	vii) spacing stands; (maintain) and	(vii) Virtually no basic spacing is necessary. Timber supply analysis assumes stocking control in the form of spacing for over-stocked stands (TIPSY yields based on establishment at 1600 st/ha – 1400 planted + 200 ingress). Typical stocking history on about 60% of THLB is: establishment 1400 sph peak stocking w ingrowth 3000 stocking at free growing 2000 [Check. Is this total stocking or acceptable, well-spaced?] post spacing at 15–20 yrs 1200 2000 ha/yr X 0.6 = 1 200 potential ha/yr spacing X $750/ha = $960,000/yr. [Check, at 600 ha of basic brushing + 300 more for brushing for growth + 1200 spacing, we have accounted for 2100 ha. This means some areas that are brushed will later have to be spaced and that there is no area that would not benefit from either brushing or spacing. Is this correct?] Using Fdi, SI 23, natural establishment of 3000 sph [Check, should this be run at 2 000?], age 80 (target age), TIPSY indicates spacing to 1200 sph has negligible volume impact at 12.5 cm utilization (367 m3/ha unspaced vs 351 spaced), but increases dbhg for all stems by 3.6 cm (estimated at 4 cm in the workshop) from 22.8 to 26.4 cm (see Table 4, row vii). This equates to (0.6 X 3.6 ≅) 2.2 cm dbh gain over THLB. The unspaced stand reaches a (22.8 + 2.2 =) 25 cm dbhg at roughly age 90, indicating a 10 yr harvest age reduction when spacing is prorated across the entire THLB . If stands were spaced to 900 sph, TIPSY indicates a slightly greater volume difference at 12.5 cm utilization (367 m^3/ha unspaced vs. 340 spaced), but dbhg increases by 5.77 cm to 28.5 at 80 yrs. This equates to 0.6 X 5.7 = 3.4 cm across the entire THLB and a 15 yr reduction in harvest age. Spacing and harvesting at an early age has a cost, however. Culmination age of the unspaced stand is 96 yrs with an MAI of 4.81 m^3/ha/yr. When the same stand is spaced to 1200 sph and harvested at age 80, MAI drops to 4.38 m^3/ha/yr, almost 10% lower than that of the unspaced stand. If stands were repeatedly spaced and harvested at age 80, this reduction in MAI would translate to almost a 10% reduction in LTHL.	vi) 15–20 yr reduction in min. ages. 2.8–4.2 cm dbh increase. Yields 110 m^3/ha below that of age 100 culmination Cost: $960,000/yr Med risk rating. See "Summary" below.
♦ **MT 3**	viii) repeat fertilizing suitable stands on a 15 year return cycle.	(vii) Area available for repeat fertilization management can be roughly calculated as follows: • 70% of the species are suitable for fertilization (based on expected future leading species - see MT 3(i) above); • 70% of the site classes are suitable; • 90% of fertilizable stands are available for treatment (i.e., are not restricted due to watershed or social considerations); and • about 50% of fertilizable stands are economically treatable, largely related to accessibility. This nets to (0.7 X 0.7 X 0.9 X 0.5 =) 22% of the total THLB potentially being suitable for repeat fertilization. This equals 0.22 X 225 000 ha or 49 500 ha under a repeat fertilization regime. *On a 15 yr return cycle, this equates to a program of 3300 ha/yr* at a cost of $200/ha or $660 000/yr. A 10% volume gain would increase long term harvest levels (0.22 X .1 =) 2.2%. Cost works out roughly to $55/$m^3$ of wood produced. Fertilization improves site productivity and can be represented as an SI shift. For Fdi, SI 23, plant	(viii) Increase LTHL 2.2% Cost: $660,000/yr or $55/$m^3$. Med risk rating. See "Summary" below.

Number	Potential strategy/action	Discussion/current status	Anticipated result
		1600 sph, 12.5 cm util., std OAFs, a 10% volume gain ≅ a 1 m SI increase. The age 80 vol. and diameters at SI 23 are reached at age 75 with an SI of 24, indicating a 5 yr reduction in min ages at the stand level and a 1 yr reduction across the entire THLB.	
♦ **MT 3**		*Summary* Current min. ages and weighted avg. dbh for existing stands (not incl. Pl) are about 105 yrs and 30 cm dbh, respectively. Projected is 105 yrs at 22 cm. In the workshop, a target of 30 cm QMD 80 yrs was proposed. Meeting the target requires a 25 yr reduction in min ages and an 8 cm increase in dbh. Table 4 and Table 5, summarize as well as contain further post-workshop analysis of the MT 3 workshop conclusions. Table 4 shows the effects of the individual MT 3 treatments and presents a combination stand at the bottom (referred to as the “MT 3 stand”). Table 5 compares this MT3 stand with the base stand under a variety of benchmarks. Both tables use Fdi, SI 23 as a base stand. The use of SI 23 is based on the weighted avg SI of Martin’s (1999) analysis of ISIS data of TSAs near TFL 23, and include an OGSI adjustment. The use of Fdi is based on the expectation that this species will be 55% of future leading species. In both Table 4 and Table 5, the “base stand” is a TIPSY stand and is not necessarily representative of the TFL 23 profile. This stand falls between the medium to good Fdi analysis units 341 and 342 used in the MP #9 timber supply analysis. In Table 4, the “risk” measure reflects the confidence of participants in the indicated effects of each practice. For each activity, the first line is stand level effect and the second line (*in italics*) is forest level effects after pro-rating the opportunity area across the entire THLB. Because the results of the individual treatments are not necessarily cumulative, a combination stand is formulated at the bottom of Table 4. Stands that are brushed are not likely to require spacing. If improved stock significantly outperforms natural ingrowth, then spacing may not be required if the improved stock overtops the natural stock early in stand development. Improved stock could be planted at lower densities (e.g., 1200 sph) to grow larger target diameters. On the other hand, higher densities enable a commercial thinning option. From the analyses in Table 4 and Table 5, the following broad conclusions are drawn. With reference to target age 80, excluding fertilization at planting and reduction in voids (both of which were inconclusive): • Every MT 3 treatment increases dbhg at age 80 over the base stand. The most significant of these is spacing, which raises dbhg 3.6 cm when a 3000 sph stand is spaced to 1200 sph or 5.7 cm when spaced to 900 sph. • Except for larger stock and spacing, all treatments raise the productivity of the stand to the extent that the MAI at age 80 of the treated stand is greater than the MAI of the base stand at culmination. This would indicate that these practices could not only increase dbh but also increase the LTHL. • Spacing significantly reduces MAI at age 80 vs. MAI of the base stand at culmination age. This	

Number	Potential strategy/action	Discussion/current status	Anticipated result
		indicates that while spacing can be used to substantially advance the technical rotation age, harvesting stands at this early age is also significantly in advance of the stand culmination. Spacing can be used to advantage in the critical midterm period, but continued spacing and early harvest, by itself, would result in about a 10% lower LTHL. • Final stocking level is the greatest determinant of dbh. Strategies should therefore focus on final stocking objectives, not initial stocking. • Improved stock is likely to also improve stocking control. The improved trees are more likely to exert early dominance of both brush and natural tree competition. Thus, the need for future spacing is uncertain. The treated MT3 stand is predicated on the concept that initial stocking will prove dominant. • The treated MT3 stand cannot meet both the target of 30 cm dbhg$_{all}$ at age 80. Planting at 1200 sph yields a dbhg of 27.6 cm at age 80. However, MAI is raised considerably, indicating approximately a 10% rise in LTHL. • *The age 80 target* is 16 years earlier than the culmination age of the base stand. At 1600 sph initial stocking, the MT3 dbhg$_{all}$ at age 80 is 1.2 cm below that of the base stand at culmination (Box 2, Table 5). However, at 1200 sph initial stocking, the MT 3 dbhg$_{all}$ is about 1 cm greater, suggesting a lower initial stocking level would be appropriate to achieving the objective (Box 8, Table 5). At either stocking level, although the merch volume of the base stand at culmination is higher than the MT3 stands, at age 80 the MAI of the MT 3 stand is higher than the base stand, indicating LTHL would also rise even with advancing the harvest age to 80 years. • *The 30 cm target* can also be more readily met at lower initial (and therefore final) stocking levels. At 1600 sph initial stocking it takes 103 years for the MT3 dbhg$_{all}$ to reach 30 cm, whereas this size can be reached 10 years earlier at 1200 sph (Boxes 5 and 11, Table 5). The tradeoff is in MAI, it being about 1% lower at 1200 sph. At 1200 sph, the 30 cm target can be reached at age 93, 3 years sooner than the culmination of the base stand. Extending the harvest age so that it is closer to culmination age not only allows achievement of the larger piece size target but also increases MAI by a further 2.5% over that of the increase of the MT 3 stand over the base stand (i.e., from 11.6 (Box 8) to 14.1% (Box 11)).	

Number	Potential strategy/action	Discussion/current status	Anticipated result
♦		*MT 3 Conclusions:* • Assuming no commercial thinning, a lower final stocking of 750–800 sph (associated with 1200 sph initial stocking) is more conducive to achieving both the minimum age and diameter targets than the current approx 880 sph (based on initial stocking of 1400 sph + 200 sph ingrowth, OAF 1 of 15%). • In the late mid term period, where lower minimum ages is a governing factor in the harvest forecast, the focus should be on this aspect (i.e., harvest at age 80) of the target. • In the long term, where quality and higher harvest levels are the governing factors in the harvest forecast, the focus should be on the target dbh (i.e, harvest at 30 cm dbhg) aspect of the target. Regardless of the focus, the activities and their priorities are likely the same, except that spacing will be prominent in the later mid term, whereas it is assumed not required in the long term when stands will have improved stock and greater initial stocking control. <u>Time Frame:</u> — <u>Target Focus</u> — <u>Activities</u> 70–100 yrs from now — Harvest at age 80 — Space over-stocked existing managed stands 101–120 — Transition period 121+ yrs from now — Harvest at 30 cm dbhg — Manage stocking to final target of 750800 sph for those stands not planned for CT. (a) The target of harvesting existing managed and about-to-be-regenerated stands at age 80 appears achievable, with the most impact being achieved through spacing and tree improvement, respectively. Spacing may only be necessary in existing managed stands that are over-stocked. Further evaluation of the effects of spacing on the LTHL is needed. Sensitivity analysis indicates a 10 yr reduction in min. harvest ages will extend the initial harvest level to decade 6 and results in a mid term trough only 2% below LTHL. A mid term rise in harvest levels results because less mature timber has to be held throughout this time period. (b) An 11% gain in regenerated stand volumes appears achievable at slightly below existing culmination ages (Box 11, Table 5). Sensitivity analysis indicates a 10% increase in regen volumes results in a 1% increase in mid term harvest levels. (c) N/A. See ST1 and MT6.	*MT 3 Conclusions:* (a) Extend the initial harvest level to decade 6 and raise mid term trough to 2% below LTHL. (b) Further raise mid term trough to only 1% below LTHL. (c) N/A

Table 4. Effects of individual MT 3 silviculture practices on dbhg and MAI using Fdi, SI 23, age 80

Practice	Effect Level	Expected effect (workshop)	Oppor-tunity Area	Oppor-tunity Area Factor (area /2000)	Base stand vol - age 80, SI 23	Volume change (%)	Net Vol-ume	Age change (yrs)	Net age	OAF 1 change	Net OAF1	Adjusted SI to get increased vol at net age at net OAF1	Adjusted SI to get base vol at net age	DBHg, age 80, - adjusted SI / net OAF1 / spaced	Base stand DBHg, age 80 SI 23	DBHg change at age 80	MAI at age 80, adjusted SI /OAF 1 /spaced	Base stand cul. MAI (age 96)	MAI change	% Change in MAI (stand) LTHL (forest) age 80 vs base stand cul. age	$/ha $/year	Risk
MT 3		Avg annual area harvested:		2000																		
i) Site preparation	stand level	reduce cul age 5 yrs, same vol.			367			-5	75				24.0	24.7	23.6	1.1	5.05	4.81	0.24	4.8	700	L-M
	forest level		*200*	*0.1*												*0.1*				*0.5*	*140,000*	
ii) Tree improvement	stand level	increase volume 15% at culmin.			367	+15.0	422	0	80			24.5		25.3	23.6	1.7	5.27	4.81	0.46	8.7	indirect	L
	forest level		*1800*	*0.9*		*+10.5*										*1.5*				*7.9*	*indirect*	
iii) Larger stock	stand level	reduce cul age 1-2 yrs, same vol.			367			-2	78				23.4	24	23.6	0.4	4.77	4.81	-0.04	-0.8	170	L-M
	forest level		*1600*	*0.8*												*0.3*				*-0.7*	*272,000*	
iv) Fertilize at planting	stand level	reduce cul age 1-2 yrs, same vol.			367										23.6				variable		50-150	H
	forest level		1600	*0.8*															n/a		75-225,000	
v) Voids	stand level	increased vol, lower OAF1 factor.			367										23.6				measure			n/a
	forest level		2000	*1*																		
vi) Brush for growth	stand level	increased vol, 5% lower OAF1 factor.			367					-5	10			23.6	23.6	0	4.85	4.81	0.04	0.8	500	M-H
	forest level		500	*0.25*												*0.0*				*0.2*	250,000	
vii) Spacing																						
(3000 to 1200sph)	stand level	lower technical rotation age			367									26.4	22.8	3.6	4.38	4.81	-0.43	-9.8	750	M
(3000 to 900 sph)	stand level	lower technical rotation age			367									28.5	22.8	5.7	4.25	4.81	-0.56	-13.2	750	M
(3000 to 1200 sph)	*forest level*		*1200*	*0.6*												*2.2*				*-5.9*	*960,000*	
(3000 to 900 sph)	*forest level*		*1200*	*0.6*												*3.4*				*-7.9*	*960,000*	
viii) Repeat fertilizatior	stand level	increase volume 10% at culmin.			367	+10.0	404	0	80	0	15	24		24.7	23.6	1.1	5.05	4.81	0.24	4.8	200	M
	forest level		22% THLB	0.22												*0.2*				*1.0*	660,000	
Totals (space to 1200)	stand level															7.9				8.4		
	forest level															4.4				3.0	2,505,000	
Combination MT3 stand																						
no spacing/plant 1600	forest level		2000	1	367	12.5	413	-2	78	-1	14	24.7		25.5	23.6	1.9	5.29	4.81	0.48	9.1		
no spacing/plant 1200sph			2000	1	367	12.5	413	-2	78	-1	14	24.7		27.6	23.6	4	5.37	4.81	0.56	10.4		

Estimates for individual activities based on TIPSY Fdi, SI 23, plant 1600, 12.5 cm utilization, standard OAF's (base stand - 55% of future species profile), except spacing which is based on 3000 natural.
Combination stand based on combined forest level effects, i.e.,12.5% larger vol from tree improv+fert, 2 yr lower ages from SP + larger stock and a 1% lower OAF 1 from brushing. Spacing assumed not req'd in the expectation improved as well as highly managed trees will significantly outperform and overtop any natural ingrowth. Factoring in other species will change the results to some degree.

Table 5. Comparison of MT 3 stand management objectives and results using Fdi, SI 23

1600sph both

	Base Stand	**MT3 Stand**	MT3 - base	
initial stocking	1600	1600		
Box 1	**age 80**	**age 80**	difference	
final stocking	993	936	-57	
age	80	80	0	
MAI	4.58	5.43	0.85	18.6%
$DBHg_{all}$	23.6	25.5	1.9	
DBH_{250}	35.4	38.2	2.8	
merch vol	367	434	67	
Box 2	**cul age**	**age 80**	difference	
final stocking	879	936	57	
age	96	80	-16	
MAI	4.81	5.43	0.62	12.9%
$DBHg_{all}$	26.7	25.5	-1.2	
DBH_{250}	39.9	38.2	-1.7	
merch vol	462	434	-28	
Box 3	**cul age**	**98% cul MAI (pre)**	difference	
final stocking	879	936	57	
age	96	80	-16	
MAI	4.81	5.43	0.62	12.9%
$DBHg_{all}$	26.7	25.5	-1.2	
DBH_{250}	39.9	38.2	-1.7	
merch vol	462	434	-28	
Box 4	**cul age**	**cul age**	difference	
final stocking	879	803	-76	
age	96	100	4	
MAI	4.81	5.55	0.74	15.4%
$DBHg_{all}$	26.7	29.4	2.7	
DBH_{250}	39.9	43.5	3.6	
merch vol	462	555	93	
Box 5	**cul age**	**30cm targt**	difference	
final stocking	879	786	-93	
age	96	103	7	
MAI	4.81	5.55	0.74	15.4%
$DBHg_{all}$	26.7	30.0	3.3	
DBH_{250}	39.9	44.2	4.3	
merch vol	462	571	109	
Box 6	**cul age**	**98% cul MAI (post)**	difference	
final stocking	879	730	-149	
age	96	113	17	
MAI	4.81	5.43	0.62	12.9%
$DBHg_{all}$	26.7	31.6	4.9	
DBH_{250}	39.9	46.0	6.1	
merch vol	462	613	151	

1600sph base, 1200 sph MT3

	Base Stand	**MT3 Stand**	MT3 - base	
initial stocking	1600	1200		
Box 7	**age 80**	**age 80**	difference	
final stocking	993	788	-205	
age	80	80	0	
MAI	4.58	5.37	0.79	17.2%
$DBHg_{all}$	23.6	27.6	4	
DBH_{250}	35.4	38.9	3.5	
merch vol	367	429	62	
Box 8	**cul age**	**age 80**	difference	
final stocking	879	788	-91	
age	96	80	-16	
MAI	4.81	5.37	0.56	11.6%
$DBHg_{all}$	26.7	27.6	0.9	
DBH_{250}	39.9	38.9	-1.0	
merch vol	462	429	-33	
Box 9	**cul age**	**98% cul MAI (pre)**	difference	
final stocking	879	781	-98	
age	96	82	-14	
MAI	4.81	5.41	0.6	12.5%
$DBHg_{all}$	26.7	28.0	1.3	
$DBHg_{250}$	39.9	39.6	-0.3	
merch vol	462	444	-18	
Box 10	**cul age**	**cul age**	difference	
final stocking	879	703	-176	
age	96	102	6	
MAI	4.81	5.52	0.71	14.8%
$DBHg_{all}$	26.7	31.6	4.9	
$DBHg_{250}$	39.9	446	406.1	
merch vol	462	563	101	
Box 11	**cul age**	**30cm targt**	difference	
final stocking	879	741	-138	
age	96	93	-3	
MAI	4.81	5.49	0.68	14.1%
$DBHg_{all}$	26.7	30	3.3	
DBH_{250}	39.9	42.5	2.6	
merch vol	462	511	49	
Box 12	**cul age**	**98% cul MAI (post)**	difference	
final stocking	879	661	-218	
age	96	113	17	
MAI	4.81	5.41	0.6	12.5%
$DBHg_{all}$	26.7	33.3	6.6	
DBH_{250}	39.9	46.6	6.7	
merch vol	462	611	149	

Number	Potential strategy/action	Discussion/current status	Anticipated result
♦ **MT 4**	4. Late rotation fertilize all suitable existing stands scheduled for harvest 20 to 80 years from now to achieve the same harvested volumes as modelled in the base case but at lower min harvest ages. (increase)	4. Note: strategy wording corrected from that in the initial strategy list. Because of current stand age and structure, the potential for late rotation fertilization may *start in about 60 years from now* for stands to be harvested starting about 75 years from now (i.e., in decade 8). This could be an effective strategy to ensure stands targeted for harvesting at lower minimum ages have the minimum volumes required. If logging 2000 ha/yr at that time and assuming logging areas follow the species/site class profile (see MT 3 vii), then fertilization *program would be 2 000 X 22% = 400 ha/yr.* If a 5% vol. gain is achieved would equal 400 ha/yr X 5% gain X 400 m^3/ha = 8000 m^3/yr harvest level gain. This is roughly 1% of current AAC. Stands to be fertilized may require stocking control to ensure they can respond to the fertilizer.	4. Fertilization may commence in about 60 years. No current action necessary. 1% gain in decades 8–10
♦ **MT 5**	5. Commercially thin stands to: (a) recover volumes otherwise lost to mortality; (b) create old-seral attributes earlier; or (c) bring forward volumes from the long term. (increase)	5. (a) White pine (Pw) makes up about 15% of the volume of many stands. Due to blister rust, only about one third of this would survive to harvest age. The other two thirds would die, which equals 10% of the total harvest volume. Pruning lower branches is successful in prolonging the life of susceptible trees. From 1994, all planted Pw (about 15% of total planting) has been rust resistant and does not require pruning. However, natural ingrowth, which can be up to 30% of a stand, requires pruning to survive. The pruning objective is to keep trees alive until harvestable at about 50-60 years of age. *Requires an annual pruning program of 300 ha–225 ha first lift and 75 ha second lift*. Previous program level was higher in order to catch up on the backlog of required pruning. Cost is $250/ha X 300 ha = $75,000/yr. Cost recovery is in about 40 years to which the entire stem contributes, so probably is a very good financial return. Pw that is currently aged < 20 years is expected to survive the full rotation and be harvested along with the entire stand. Pw currently aged >20 years has a higher component of natural as well as unpruned stems and is planned for earlier harvest than the remainder of the stand through commercial thinning. Pw has not been separated into its own analysis units in the timber supply analysis, nor is it subtracted from the stand volume through a higher OAF2 factor. Pruning and commercial thinning therefore serve to maintain the base case harvest forecast. (b) Due to modelling methodology, the contribution of areas outside the THLB to meet requirements was possibly overstated. However, the impacts of fire control on the aging of stands outside the THLB and their subsequent contribution to biodiversity requirements are unknown. For now, no action is needed.	5. (a) Maintain the base case forecast.

Number	Potential strategy/action	Discussion/current status	Anticipated result
		See LT 8 re caribou habitat.	
		(c) Bringing forward volumes is better accomplished through reducing minimum harvesting ages and harvesting the whole stand. CT would only be practiced where clearcutting is constrained, which at this point is not seen as the case. (Note: MT #5 is reworded in the strategy section to reflect workshop discussion.	
♦ **MT 6**	6. Overcome adjacency limitations in the VQO zone by (increase):	6. Note: MT #6 is reworded to reflect workshop discussion.	
	(a) reducing green-up ages; and	(a) The VQO zone is broken into east and west sides of the Arrow Lakes. The west side, about 65% of the VQO zone, has a maximum limit of 25% of the area allowed to be below 5m green-up. The east side maximum is 15% allowed below 5m green-up. Green-up age is 24 years which workshop participants considered to be quite conservative. Reichenback (1996) showed current practice for Nelson Region for F, L, Pw to range from 17 to 22 years. The first step is to refine green-up ages based on actual practice. Sensitivity tests indicate a 5 yr reduction in green-up ages in the VQO zone will increase the fifth decade harvest level by 6% (to almost the IHL) and the sixth decade by 2% and re-run the timber supply model. A 10 yr reduction does not further increase timber supply. Although unlikely, if actual green-up ages do not prove to be 5 yrs less than used in the base case, the next step would be to evaluate the potential for partial harvesting or commercial thinning in the VQO zone and to determine the need for a spacing program to prepare stands in advance.	(a) Reassess 5 m green-up ages. Assume 5 yr age reduction will be proven. Raises fifth decade 6% and sixth decade 2%.
	(b) implementing partial harvesting/CT regimes.	(b) VQO zone is 7% of THLB. There is a need for visual rehabilitation of past harvesting in the VQO zone. Partial harvesting or commercial thinning may have a role in this. Currently there is no CT occurring (see MT #5 re planned Pw CT). Because of a lack of candidate stands, CT is not a short term option. Also, log products from thinning are very sensitive to market prices. CT will likely only occur when necessary to access timber. Root rot can limit CT options. Further study of root rot management techniques and options are needed. (Noted under "Summary of Information and Research Needs,") If CT is to be an option in the later mid term, young existing or newly regenerated candidate stands must have appropriate stocking. On the one hand, this may mean brushing to keep stocking up; on the other, spacing may be required to reduce over-stocking. These activities must occur now to ensure the candidate stands will be ready. A study of partial cutting in 3 TSAs (Wang and Pollack 1998) indicates that a global program of partial harvesting throughout a TSA can actually reduce harvest levels in early time periods, whereas a directed effort in a small portion of a management unit, particularly in VQO zones can increase the overall harvest level (a 3% rise in Golden). This is due to a harvest scheduling effect; total stand volume from both partial harvesting and final harvest was by and large unchanged. (CT may offer up to 10% additional volume through recovery of timber that would otherwise be lost through mortality.)	(b) No opportunity at present. Dependent upon outcome of (a).

Number	Potential strategy/action	Discussion/current status	Anticipated result
	Mid Term Harvest Forecast Summary	*Summary* of potential mid term strategy anticipated results: Potential strategy No. — Anticipated result MT 3 (a) — Extend IHL to decade 6 MT 3 (a) — Raise MT shortfall level to 2% below IHL MT 3 (b) — Raise MT shortfall level by 1% MT 4 — 1% gain in decades 8–10 MT 5 — Maintain the base case (salvage Pw mortality). MT 6 (a) — Raise decade 5 by 6% and decade 6 by 2% (could be reallocated across decades 7–9 (Base case not adjusted for OGSI. If appropriate, adjustments should be made in accordance with CF MP #9 determination.)	*Conclusion* Mid term shortfall below the base case LTHL eliminated. (A shortfall remains, however, because the LTHL can be raised above the base case; see the next section.)

Long Term (101 + years)

Number	Potential Strategy/Action	Discussion / Current Status	Anticipated Result
♦ **LT 1**	1. Brush 500 ha/yr of existing backlog plantations. (maintain)	1. All backlog has been reforested. About _____ ha of backlog requires brushing to free growing. *A program of 500 ha/yr over the next 5 years is needed.*	1. Maintain base case LTHL.
♦ **LT 2**	2. Increase the THLB by:	2. — Area (ha) — % tot area — % prod area — % THLB (a) Decid — 5800 — — — 3 (b) Non-merch — 4000 — — — 2 (c/d) Low site — 1700 — — — 0.7 (e) Roads/Ldgs — 5300 — — — 3 (f) OTTs/ buy — 5000 — — — 2	
♦ **LT 2**	(a) converting/ rehabilitating deciduous stands; (increase)	(a) Many deciduous areas are young regenerated stands and are a normal part of natural succession, having conifer below. The extent and dynamics of such stands need further investigation. Few, if any, large contiguous areas of mature deciduous suitable for harvest or stand conversion. Further analysis required to determine how much is age class 1 deciduous that may be able to be part of the managed THLB.	(a) Assess extent/dynamics of age class 1 decid for potential to add to THLB. (Noted under “Summary of

Number	Potential Strategy/Action	Discussion / Current Status	Anticipated Result
			Information and Research Needs.")
♦ **LT 2**	(b) converting/ rehabilitating non-merchantable hemlock stands; (increase)	(b) Most of the non-merch H/B stands are on steep slopes. These stands contribute to biodiversity. Rehabilitating them might require setting aside higher timber quality stands to meet biodiversity requirements. No opportunity.	(b) No opportunity.
♦ **LT 2**	(c) assessing low-site stands for proper classification; (d) improving the site productivity of low-site stands by (fertilization?); (increase/maintain)	(c/d) No opportunity.	(c) No opportunity.
♦ **LT 2**	(e) rehabilitate roads/landings (added in workshop); or	(e) Potential unknown.	(c) No opportunity?
♦ **LT 2**	(f) acquire old temporary tenures, buy land (added in workshop).	(f) Old temporary tenures (OTTs) that lie within the boundaries of the TFL revert to the TSA after harvest. This is a policy issue which P&T is pursuing with the province. Because these areas will have young stands on them when they revert, LTHL may not go up proportionately or may even go down if they contribute to the area not greened-up. Policy issue being pursued.	(f) Not a silviculture issue.
♦ **LT 3**	3. Continue MT 3. (increase)	3. See MT 3 above. Assume: (a) target stand $dbhg_{all}$ of 30 cm met at age 93 (essentially at culmination age - see Box 11 Table 5); (b) a 12% gain on regen stand volumes (allowing for 3% increase for TI already included in the base case); and (c) green-up ages commensurate with ST1.	3. (a) Increased timber quality. (b) Sensitivity analysis indicates a 10% increase in regen stand volumes will result in a 10% increase in long term harvest levels. (c) N/A
♦ **LT 4**	4. Reduce losses to root rot by: (a) pushover logging/stumping; (b) planting alternate species; and (c) pop-up spacing.	4. A 2% reduction in LTHL can be estimated as follows. Significant root rot occurs primarily in the ICH zone (60% of THLB). About 70% of this area has susceptible species and of this about 25% has serious problems. This nets to (0.6 X 0.7 X 0.25 =) 10% of THLB. If these stands lose 20% volume, TSA level loss amounts to (0.10 X 0.20 =) 2%. TIPSY OAF2 of 5% used in base case managed stand yields. Expectation is that this could adequately reflect current losses to root rot. The need for further study of root rot management and associated harvest level impacts noted under "Summary of Information and Research Needs."	4. Managed as part of basic obligation. Losses are within the range of TIPSY OAF 2.

Number	Potential Strategy/Action	Discussion / Current Status	Anticipated Result
	(maintain)	(a) Not reviewed in workshop. (b) Current practice. Typically Pw, and Lw are planted as alternates. See MT 3 for projected species changes. (c) This is expensive and only suitable for heavily infected areas. Plans include 20 ha this fall as part of basic obligation.	
♦ **LT 5**	5. Continue MT 5 (except item c). (increase)	5. See MT 5. No immediate opportunity.	5. See MT 5.
♦ **LT 6**	a) Model regenerating stands outside the THLB. b) Depending on the outcome of (a), plant areas outside of the THLB to increase the area in an old-seral state in 100 to 200 years. (maintain)	6. (a) Not considered a priority. (b) This opportunity was not discussed during the workshop. Not likely to be practiced in the foreseeable future.	6. N/A
♦ **LT 7**	7. Confirm OGSI adjustments.	7. Not discussed during the workshop.	6. Noted under "Summary of Information and Research Needs."

Number	Potential Strategy/Action	Discussion / Current Status	Anticipated Result
♦ **LT 8**	8. Caribou management: create old seral attributes earlier. (added during workshop)	8. The caribou and ungulate winter range zones do not exhibit a significant response to relief of constraints. This is possibly because the underlying old-seral biodiversity constraints immediately become binding. Need to check that caribou constraints were modelled properly with respect to other factors (particularly biodiversity) noted under "Summary of Information and Research Needs."). Need info from MoELP on where and how much range, together with the timing of the need (i.e., what decades have tight supply) before can determine size, timing, and location of silviculture program. Next step is a zonation exercise to identify core habitat, peripheral/potential areas close to the core and areas not used at all. Potential to innovate in peripheral areas. Some generalized info can be used from provincial studies but some needed info is subspecies specific and can't be transferred from/to other areas. Rather than using age as an indicator of suitability, we should try to identify other stand attributes that work better. Silviculture activities, particularly commercial thinning, can be used to create old-growth tree attributes at earlier ages, thereby enhancing lichen production. However, some other biological requirements may not be met. Analysis is required to determine if CT can achieve these attributes earlier (noted under "Summary of Information and Research Needs."). Once the above info is known (or better estimates available) can more precisely model age constraints as surrogates for seral attributes as well as the silviculture management opportunities.	8. More info, modelling required. Noted under "Summary of Information and Research Needs."

Long Term Harvest Forecast Summary

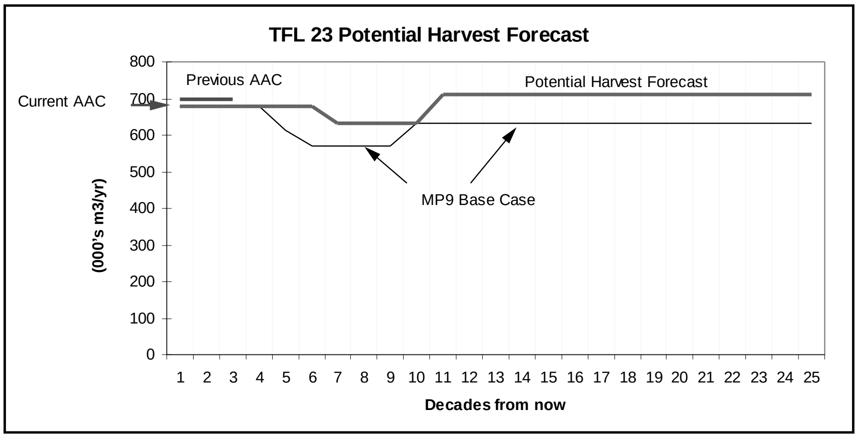
('000 m^3/yr)

634	base case
0	backlog brush
0	increase THLB
0	min ages
76	increase regenerated stand volumes (12%)
0	green-up
0	commercial thin
0	model/plant areas outside THLB
0	root rot
0	caribou
710	Total

Potential Harvest Forecast

Figure 18 graphs the harvest level that may be attained through implementation of the silviculture strategies in the preceding section. This forecast is highly speculative and must be confirmed through computer-based modelling and analysis. It generally indicates the plausible high end of the potential of the timber resource. Modelling may indicate more precise timing, targeting and program levels associated with silviculture activities than could be developed in this interim strategy.

Figure 18 Potential harvest forecast.



Note that when this strategy was prepared, the Chief Forester had not yet made the MP #9 AAC determination, so it was not known how he would view the base case harvest forecast. Consequently, Figure 18 contains no adjustments to the base case. In any event, the difference between the two forecasts illustrates the potential outcome of the strategy. This difference would likely remain the same even if the base case is amended.

Opportunities to Improve Timber Quality

The effects of silviculture on the future quality of the timber resource are not analyzed in the timber supply analysis. Information in this section was gathered during the workshop.

Product Objectives

The following are log quality objectives for TFL 23.

Quality class	Species	Characteristics
Premium log	All, except white pine & red cedar	45+ cm dbh
	white pine & red cedar	30+ cm dbh

Quality class	Species	Characteristics
	All, except white pine & red cedar	30+ cm dbh, 25+ % clear lumber production, min 5 m log
Sawlog	All, except white pine & red cedar	30+ cm dbh

Potential Strategies by Response Time Frame

The following strategies have potential to increase timber quality. These were identified in the workshop. The response time frame is the period in which the anticipated result is expected, not the period in which actions must necessarily commence.

Response Time Frame	Potential Strategy/Action	Discussion / Current Status	Anticipated Result	Premium Log Forecast
Short Term (1--20 yrs)	None	Short term harvests will come from existing older stands which are not treatable to improve quality.	Quality profile of existing old growth will prevail. Assume this is equal to a recent coast-wide estimate of 15%. Estimate could be improved by analyzing cruise or sawmill data for the past several years.	15%?
Mid Term (21--100 yrs)	. See MT 5	The current Pw pruning program is for the purpose of ensuring survival from the blister rust and therefore is a quantity objective rather than quality. Requires an annual pruning program of 300 ha - 225 ha first lift and 75 ha second lift. Net result is 150 ha/yr of 1 lift and 75 ha/yr of 2-lift pruned area. See MT 5. The following evaluates the secondary benefit of the clear wood component produced. [Can't figure out workshop notes, so have done evaluation below.] 150 ha/yr 1st lift = (150/2000=) 7.5% THLB. Pw = about 15% of stands overall, but assume pruned stands have a higher than average component of 20%. For simplicity, assume all survive to final harvest and are not CT'd at younger age, therefore pruned Pw = .20 X .075 = 1.5% of future harvests. If 3.1 m = 10% of tree vol, (.015 X .1 =) 0.15%/yr of future harvest volume will be clear logs resulting from 1st lift pruning. 75 ha/yr 2 lift to 5.5 m would yield approximately the same result (half the area, but double the pruning ht) and would double the pruned log volume total to 0.3%. [workshop notes indicate a total of 3%]		0.3% of future harvest volumes will be Pw clear log.
Long Term (101 + yrs)	Manage stands to a 30 cm dbhg as per the strategies to increase the quantity of future timber supply.	See the "Quantity" strategies.		6% large log.

Large Premium Log Analysis

Two large log analyses are reported below, both based on an annual spacing program of 1200 ha. Table 6 shows the results of the long term strategy of harvesting stands at a target 30 cm dbh. This table is based on the expected future species mix and incorporates gains from stand management activities under strategy MT 3 (a 20% MAI gain is assumed) on top of base site indices that include an OGSI adjustment. Under these assumptions, 6% of annual harvested volumes in the long term will be large premium logs.

Table 7 shows the results of the strategy of harvesting stands at 80 years of age (70 for lodgepole pine) in the later mid term, at SIs that can be considered inclusive of OGSI adjustments. This table is based on the expected future species mix but *does not* incorporate gains from stand management activities under MT 3, other than spacing. Most of the stands to be harvested in this period will not come from improved stock, and will not be managed as under strategy MT 3. Under these assumptions, only 1.6% of annual harvested volumes in the later mid term will be large premium logs.

Assumptions	Avg. annual area harvested = 2000 ha Utilization std = 12.5 cm dbh for all species TIPSY ver 2.1d OAF1 = 15% OAF2 = 5% Ages in 1 yr steps All areas planted. large log calculation for all species is to to 45+ cm large log, except Pw and Cw which are to 30+ cm. Because TIPSY table dbh classes are mid-points, this translates to 42.5 + and 27.5 + cm, respectively. Bottom 5 m log = 25% of tree vol. % large of total annual harvest volume = (area/2000) X (% vol ≥ 30 or 45 cm, as appropriate) X (25% of tree vol.) Assume 1200 ha are spaced, of this 1100 ha in Fdi, 100 ha in Pl, none in Sx or Cw.

Table 6. Large log analysis: target 30 cm dbhg

Target - 30 cm DBHg

									Total		Largest 250		DBH class[1]													5m large log - % tot hrvst vol
Species	%inv	SI	Space frm/to:	Area	DBHg -all	Harv Age	MAI	LRF bf/m3	Vol (12.5cm util)	Trees	Vol	DBHg	0 - 10 cm		15 - 25 cm				30 - 40 cm				45+ cm			
													# trees	% tot trees	# trees	% tot trees	vol	% tot vol	# trees	% tot trees	vol	% tot vol	# trees	% tot trees	vol	% tot vol	
Fd/L[2]	**55**	**25**	**3000/1200**	**1100**	**30.0**	**89**	**5.60**	**257**	**499**	**709**	**374**	**41.8**	**21**	**3**	**340**	**48**	**81**	**16**	**270**	**38**	**273**	**55**	**78**	**11**	**146**	**29**	**4.0**
alternative			3000/900	N/A	30.0	78	5.41	251	421	636	308	39.4	13	2	279	44	71	17	304	48	282	67	40	6	68	16	N/A
comparison			1600/unspaced	N/A	30.0	101	5.61	264	566	776	442	44.2	23	3	419	54	95	17	227	29	244	43	107	14	227	40	N/A
comparison			3000/unspaced	N/A	30.0	110	5.50	265	606	782	479	44.9	66	8	368	47	83	14	227	29	255	42	121	15	265	44	N/A
Sw/Bl[3]	**25**	**18**	**1600/unspaced**	**500**	**30.0**	**139**	**3.50**		**487**	**718**	**304**	**38.8**	**0**	**0**	**327**	**46**	**116**	**24**	**360**	**50**	**299**	**61**	**31**	**4**	**61**	**13**	**0.8**
Pl	**15**	**24**	**4000/1200**	**100**	**30.0**	**76**	**5.71**	**251**	**434**	**680**	**248**	**36.4**	**0**	**0**	**275**	**40**	**99**	**23**	**392**	**58**	**314**	**72**	**13**	**2**	**19**	**4**	**0.1**
			1600/unspaced	**200**	**30.0**	**93**	**5.05**	**256**	**470**	**665**	**277**	**36.6**	**0**	**0**	**261**	**39**	**108**	**23**	**389**	**58**	**335**	**71**	**15**	**2**	**28**	**6**	**0.1**
comparison			4000/unspaced	N/A	28.7[4]	95	4.84	258	459	653	277	35.2	0	0	332	51	151	33	314	48	296	64	7	1	13	3	N/A
alternative			4000/900	N/A	30.0	64	5.78	245	370	641	216	36.0	1	0	238	37	77	21	395	62	282	76	7	1	9	2	N/A
Cw_6Hwi_4	**5**	**20**	**1600/unspaced**	**100**	**30.0**	**116**	**5.76**		**668**	**948**	**457**	**44.8**	**23**	**2**	**502**	**53**	**119**	**18**	**317**	**33**	**308**	**46**	**105**	**11**	**239**	**36**	**1.0**
comparison			3000/900	N/A	30.1	80	5.21		417	683	278	38.6	18	3	275	40	72	17	356	52	286	69	35	5	59	14	N/A
Total				**2000**																							**6.0**

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[1] Actual ranges are 0 - 12.5 cm, 12.6 - 27.5 cm, 27.6 - 42.5 cm, and 42.6 + cm

[2] Plant 1200 FLPw. Hemlock natural ingrowth takes stocking up to 3000. Hw is cut out during spacing, leaving the planted trees. Modeled as all planted Fdi due to TIPSY limitations.

[3] Modeled as all planted Sw due to TIPSY limitations.

[4] TIPsy database for Pl 4 000 unspaced reaches its limits at age 95.   DBHg at this age is 28.7.

Table 7. Large log analysis: target harvest at age 80 (Pl – 70)

Target - Harvest at age 80 (Pl - 70)

Species	%inv	SI	Space frm/to:	Area	DBHg -all	Harv Age	MAI	LRF bf/m3	Total Vol (12.5cm util)	Total Trees	Largest 250 Vol	Largest 250 DBHg	DBH class[1]												5m large log - % tot hrvst vol
													0 - 10 cm		15 - 25 cm				30 - 40 cm				45+ cm				
													# trees	% tot trees	# trees	% tot trees	vol	% tot vol	# trees	% tot trees	vol	% tot vol	# trees	% tot trees	vol	% tot vol	
Fd/L[2]	**55**	**23**	**3000/1200**	**1100**	**26.2**	**80**	**4.76**	**239**	**381**	**795**	**260**	**36.7**	**55**	**7**	**431**	**54**	**101**	**27**	**293**	**37**	**254**	**67**	**16**	**2**	**26**	**7**	**0.9**
alternative			3000/900	N/A	28.7	80	4.68	244	375	647	267	37.4	19	3	303	47	78	21	306	47	264	70	19	3	32	9	N/A
comparison			1600/unspaced	N/A	24.0	80	4.75	237	380	977	252	36.0	108	11	587	60	127	33	266	27	227	60	15	2	26	7	N/A
comparison			3000/unspaced	N/A	21.7	80	4.80	231	384	1217	246	35.1	302	25	637	52	136	35	271	22	236	61	7	1	13	3	N/A
Sw/Bl[3]	**25**	**16**	**1600/unspaced**	**500**	**21.0**	**80**	**3.17**	**202**	**254**	**1187**	**116**	**29.1**	**100**	**8**	**965**	**81**	**189**	**74**	**121**	**10**	**64**	**25**	**1**	**0**	**1**	**0**	**0.0**
Pl	**15**	**22**	**4000/1200**	**100**	**26.9**	**70**	**5.05**	**235**	**354**	**779**	**188**	**33.7**	**4**	**1**	**449**	**58**	**133**	**38**	**323**	**41**	**217**	**61**	**3**	**0**	**4**	**1**	**0.0**
			1600/unspaced	**200**	**24.2**	**70**	**5.11**	**224**	**358**	**1013**	**167**	**31.7**	**9**	**1**	**780**	**77**	**210**	**59**	**223**	**22**	**145**	**41**	**2**	**0**	**3**	**1**	**0.0**
comparison			4000/unspaced	N/A	21.7	70	4.98	220	349	1139	162	29.8	62	5	924	81	242	69	152	13	107	31	0	0	0	0	N/A
alternative			4000/900	N/A	29.3	70	4.91	241	343	649	200	35.2	2	0	265	41	82	24	379	58	256	75	4	1	6	2	N/A
Cw$_6$Hwi$_4$	**5**	**18**	**1600/unspaced**	**100**	**23.0**	**80**	**4.54**	**233**	**363**	**1133**	**190**	**33.0**	**117**	**10**	**765**	**68**	**182**	**50**	**246**	**22**	**173**	**48**	**5**	**0**	**8**	**2**	**0.6**
comparison			3000/900	N/A	27.7	80	4.25	249	340	695	214	35.3	29	4	331	48	90	26	324	47	234	69	11	2	17	5	N/A
Total				2000																							1.6

[1] Actual ranges are 0 - 12.5 cm, 12.6 - 27.5 cm, 27.6 - 42.5 cm, and 42.6 + cm

[2] Plant 1200 FLPw. Hemlock natural ingrowth takes stocking up to 3000. Hw is cut out during spacing, leaving the planted trees. Modeled as all planted Fdi due to TIPSY limitations.

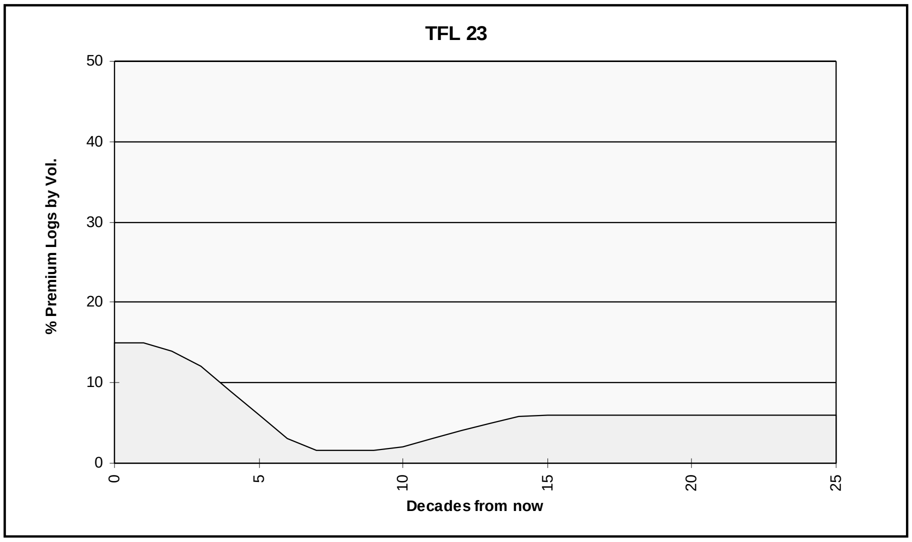
[3] Modeled as all planted Sw due to TIPSY limitations.

Timber Quality Forecast

The foregoing analysis indicates the premium log content of harvests in the mid and long term will be lower than today's levels (assumed current estimate of 15%). In the long term, harvesting at a target of 30 cm dbhg will result in 6% of harvest volumes being in 5 m premium logs. This estimate is below the provincial target of 10%.

Postponing harvest to past culmination age would increase the large dimension component of premium logs. However, this scenario is unlikely, given the need to maintain sawlog volumes.

Figure 19 Potential quality forecast.



Large logs could form 6% of future harvests (based on spacing 1200 ha/yr). Without pruning, few logs would meet the clear log criterion of 25% lumber content.

Silviculture Strategy

This section synthesizes the preceding background information and analysis into a silviculture strategy for the TFL.

Objectives

The primary objectives of the silviculture strategy are to

- eliminate the mid term timber supply shortfall indicated by the MP #9 base case harvest forecast; and
- substantially increase the volume and quality of future regenerated stands.

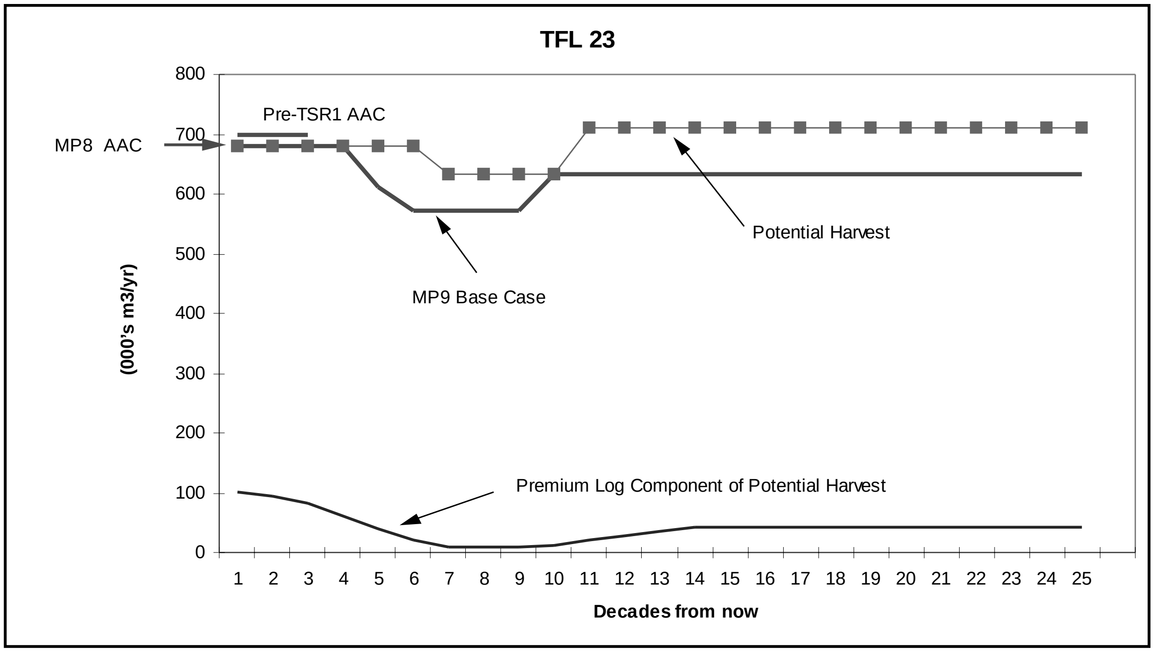
Accomplishing this strategy requires a program substantially above historic levels as well as pre free growing activities above basic silviculture.

Working Targets

The preceding analysis indicates the following working targets (WT) are attainable. Figure 20 illustrates these.

WT 1 (Quantity):	Maintain the current harvest level of 0.68 million m^3/yr for six decades, and manage mid and long term timber supply to yield harvest levels of 0.64 and 0.71 million m^3/yr, respectively.
WT 2 (Quality):	Manage regenerated stands to yield at least 6% (by volume) premium large logs, with most of the remainder being sawlog quality.

Figure 20 Combined potential quantity and quality harvest forecasts.



Log Product Objectives

The following are log quality objectives for TFL 23.

Quality class	Species	Characteristics
Premium log	All, except white pine & red cedar	45+ cm dbh
	white pine & red cedar	30+ cm dbh
	All, except white pine & red cedar	30+ cm dbh, 25+ % clear lumber production, min 5 m log
Sawlog	All, except white pine & red cedar	30+ cm dbh

Silviculture Strategies

The following strategies have potential to maintain and/or increase the quantity and quality of the timber supply of TFL 23. Strategy numbers correspond with those recorded earlier.

Strategies to Increase the Quantity of Future Timber Supply

The following strategies are those determined in the workshop as necessary to maintain the base case harvest forecast or as having potential to increase the quantity of the future timber supply. Some strategies are restated as appropriate to the findings of the workshop or of the post-workshop analysis. In such cases, the original strategy number is maintained to maintain the rationale for each strategy item.

Some potential strategies were determined in the workshop to require additional research or information before the role or need for a silviculture action could be confirmed. These additional needs are listed under "Summary of Information and Research Needs."

Some of the following practices are pre free growing and are unlikely to be undertaken without funding assistance if free growing obligations can be achieved without them.

These strategies are supported by specific silviculture regimes, listed in Table #, along with investment priorities.

No.		Strategy	Priority
General			
		Conduct silviculture surveys to support all strategies.	1
Short Term			
		No short term silviculture actions identified.	
Mid Term			
MT 2		For existing managed stands aged 1–25 yrs, lower the minimum harvest age 25 yrs (to age 80 for all species except age 70 for Pl) and maximize stand volumes at that age by:	
	ii)	brushing an additional 500 ha/yr above basic silviculture levels for growth enhancement and increased survival;	8
	iii)	spacing 1200 ha/yr to advance technical rotation ages;	5
	iv)	managing approximately 50 000 ha under a 15 yr cycle repeat fertilization regime of 3300 ha/yr to obtain a 10% volume gain at the stand level (shared objective with MT 3 viii);	11
MT 3		For about-to-be regenerated stands, lower the minimum harvest age 25 yrs (to age 80 for all species except age 70 for Pl) and maximize stand volumes at that age by:	
	i)	site preparing 200 ha/yr more than current levels;	6
	ii)	using improved seed for 90% of planted areas (1800 ha/yr);	3
	iii)	using larger planting stock on 80% of planted areas (1600 ha/yr);	7
	vi)	brushing an additional 500 ha/yr above basic silviculture levels for growth enhancement and increased survival (continuation of MT 2 ii);	8
	vii)	spacing 1200 ha/yr (continuation of MT 2 iii);	5
	viii)	managing approximately 50 000 ha under a 15 yr cycle repeat fertilization regime of 3300 ha/yr (shared objective with MT2 iv);	11

No.	Strategy	Priority
MT 4	Fertilize 400 ha/yr 15 yrs prior to harvest beginning 60 years from now on stands that have not been under repeat fertilization program.	9
MT *5*	For the white pine component of mixed stands, first lift prune 225 ha/yr and second lift prune 75 ha/yr (total 300 ha/yr, 225 ha/yr under management) to retard blister rust development and to capture, through later commercial thinning, volumes that would otherwise be lost to mortality (approximately 2.25% of annual harvest volume).	4
Long Term		
LT 1	Brush 500 ha/yr of existing backlog plantations.	2
LT 3	Continue MT 3 activities into the long term (except spacing), but with the objective changed from harvesting at age 80 to harvesting at an average stand diameter of 30 cm.	same as MT 3

Strategies to Increase the Quality of Future Timber Supply

No separate strategies to increase the quality of future timber supply were identified in the workshop. Strategies for increasing quality are interwoven with those for increasing quantity.

Strategies to Increase the Quantity or Quality of Future Habitat Supply

No separate strategies to increase the quantity or quality of future habitat supply were identified in the workshop. Rather, needs for further research and information for caribou habitat management were identified (see____________).

Silviculture Regimes and Investment Priorities

The following table indicates silviculture regimes that are suitable to attaining the previous working targets and strategies.

Regimes	Strategy	Opportunity Area (Ha/Yr)	Risk	Timber Supply Effects Short	Medium	Long	Quality	Habitat Caribou	Jobs Days/ha	Cost $/ha[1]	Wkshp Rank
Survey											
1		12,000							0.1	30	1
Backlog											
2 Brushing	L1	500	L			+			2	500	2
Pre FTG											
3 site prepare more areas	M3i, L3	200	L-M		+	+		-	0.5	700	6
4 improved seed	M3ii, L3	1800	L		+++	+++	++			80	3
5 larger planting stock	M3iii, L3	1400	L-M		+	+			0.5	168	7
6 fertilize at time of planting	M3iv, L3	1600	M		+	+			0.5	150	10
7 manage voids	M2i,M3v, L3	0	-		+	+				0	
8 brush for growth	M2ii,M3vi, L3	500	M-H		+	+			2	500	8
Post FTG											
9 spacing stands (30-year window)	M2iii, M3vii	1200	M		++		+	+	2.7	800	5
10 repeat fertilize on 15 year cycle	M2iv, M3viii	3300	M		+	+	+		0.1	200	11
11 Fertilize late rotation (begin in 60 yrs)	M4	400	M		++				0.1	200	9
12 CT capture mortality (pruned, 20 yrs)	M5	0			+			+			
13 CT create old seral structure	M5	0			+			++			
14 Prune Pw to 3m (blister rust, CT later) 1st lift	M5	225	L		++		++		0.8	250	4
15 2nd lift	M5	75	L		+		+++		0.8	250	4

Silviculture Program

The following annualized silviculture program will contribute to achieving the above goals and strategies. This program is considerably above historic levels and some activities may require phasing in. Spacing and fertilization goals represent an anticipated upper bound. Lesser program levels should be oriented to specific target stands as shown in the regime table.

Year	Surveys*	Backlog Brushing	Brushing for Growth	Enhanced Establishment	Space	Prune	Fertilize
1	12,000	500	500	5,000	1,200	300	3,700
2	12,000	500	500	5,000	1,200	300	3,700
3	12,000	500	500	5,000	1,200	300	3,700
4	12,000	500	500	5,000	1,200	300	3,700
5	12,000	500	500	5,000	1,200	300	3,700
Subtot Yr 1 - 5	60,000	2,500	2,500	25,000	6,000	1,500	18,500
6 - 10	60,000	-	2,500	25,000	6,000	1,500	18,500
Total Yr 1 - 10	120,000	2,500	5,000	50,000	12,000	3,000	37,000

* Includes prescription and layout

Unit cost ($/ha)	30	500	500	152	800	250	200

Program Table - $ 000s, TFL 23, March 1999

Year	Surveys*	Backlog Brushing	Brushing for Growth	Enhanced Establishment	Space -	Prune -	Fertilize -	Total
1	360	250	250	759	960	75	740	3,394
2	360	250	250	759	960	75	740	3,394
3	360	250	250	759	960	75	740	3,394
4	360	250	250	759	960	75	740	3,394
5	360	250	250	759	960	75	740	3,394
Subtot Yr 1 - 5	1,800	1,250	1,250	3,796	4,800	375	3,700	16,971
6 - 10	1,800	-	1,250	3,796	4,800	375	3,700	15,721
Total Yr 1 - 10	3,600	1,250	2,500	7,592	9,600	750	7,400	32,692

Job Outcomes

The following are the anticipated job outcomes associated with the preceding program, assuming the program is maintained into the future as necessary to achieve the working targets.

Short term *employment associated with undertaking the silviculture activity, in person years*

Year	Surveys[*]	Backlog Brushing	Brushing for Growth	Enhanced Establishment	Space -	Prune -	Fertilize -	Total
1	6.0	5.0	5.0	8.0	16.2	1.2	1.9	43.3
2	6.0	5.0	5.0	8.0	16.2	1.2	1.9	43.3
3	6.0	5.0	5.0	8.0	16.2	1.2	1.9	43.3
4	6.0	5.0	5.0	8.0	16.2	1.2	1.9	43.3
5	6.0	5.0	5.0	8.0	16.2	1.2	1.9	43.3
Subtot Yr 1 - 5	30.0	25.0	25.0	40.0	81.0	6.0	9.3	216.3
6 - 10	30.0	-	25.0	40.0	81.0	6.0	9.3	191.3
Total Yr 1 - 10	60.0	25.0	50.0	80.0	162.0	12.0	18.5	407.5

Note: Assumes 200 days of harvesting, silviculture work, and timber processing = 1 job

Long term *employment associated with improved quality and quantity of the timber resource*[1]

Decade	Harvest Increment (’000 m3)	Incremental Jobs per year Region[2]	Incremental Jobs per decade Region[2]
1	-	-	-
2	-	-	-
3	-	-	-
4	-	-	-
5	68	267	2,672
6	108	424	4,244
7	62	244	2,437
8	62	244	2,437
9	62	244	2,437
10	-	-	-
11	76	299	2,987
12	76	299	2,987
13	76	299	2,987
14	76	299	2,987
15	76	299	2,987
16	76	299	2,987
17	76	299	2,987
18	76	299	2,987
19	76	299	2,987
20	76	299	2,987
21	76	299	2,987
22	76	299	2,987
23	76	299	2,987
24	76	299	2,987
25	76	299	2,987
Total			59,029

Notes:

1. Assumes continuation of the silviculture program beyond the first 10 years, in accordance with the strategy. The total harvest increment is associated with all the silvicultural practices documented in the "Opportunities" section and is only partly attributable to spacing and fertilization practices. Some of the increase may be associated with pre-free growing silviculture that was not current practice at the time of strategy development.

2. Assumes 3.93 TSA level direct (harvesting, silviculture, processing), indirect and induced (PYs) per 1000 cubic metre. (Source: TFL 23 MP #9 Timber Supply Analysis Report, p.39)

Summary of Information and Research Needs

During the assessment process, the following needs for further information and research became apparent. The outcome of these have implications for further strategy development. Bracketed numbers refer to the strategy numbers under which the need is identified (see tables in "Workshop Review of Potential Strategies," page 36.

1. Determine the current status of time until green-up (Reickenback (1996) has shown that green-up ages may be lower than estimated for TFL 23) and re-run the sensitivity analyses using revised green-up ages for:
   a) the combined IRM, caribou and ungulate winter range zones; and
   b) VQO zone. (ST 1)

2. Assess the stocking and height status of existing age class 30 stands (26--35 years). This age class is critical to mid term timber supply and it should be surveyed to determine if the stands are tracking as managed or unmanaged stands and whether volumes should be calculated at 17.5 cm dbh (as at present) or at 12.5 cm dbh utilization standard. (MT 1)

3. The TIPSY OAF 1 factor of 15% requires confirmation. Survey techniques are available. Use of a different OAF1 in AAC determination requires statistical validity at the management unit level. (MT3 v)

4. Further study of root rot management techniques and options is needed., Presence of root rot can limit commercial thinning options (MT6). Need to determine if TIPSY OAF2 allowance of 5% is an adequate estimate of losses (LT4).

5. Assess the extent and dynamics of age class 1 deciduous stands for their potential to be added to the THLB. (LT2 a)

6. Old growth site index estimation studies require completion. It is anticipated that site indexes may be underestimated. Sensitivity analysis of the MP #9 shows that OGSI adjustments may increase long term timber supply substantially. (LT7)

7. Silviculture activities, particularly commercial thinning, can be used to create old-growth tree attributes at earlier ages. Further study is required to determine if CT can achieve these attributes earlier, particularly enhanced lichen production for caribou. (LT8)

8. Check that caribou constraints were modelled properly with respect to other factors, particularly biodiversity. Remodel caribou constraints once MoELP objectives (amount, where, timing) for caribou and better info on silviculture management options are available. (LT 8)

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Abbreviations

The following abbreviations are used:

AAC	allowable annual cut
CF	chief forester
CT	commercial thinning
dbh	diameter at breast height
ESSF	engelmann spruce - subalpine fir (ecological zone)
FCC	forest cover constraints
FG	free growing
FRBC	Forest Renewal BC
ICH	interior cedar-hemlock (ecological zone)
IHL	initial harvest level
IRM	integrated resource management
KBLUP	Kootenay-Boundary Land Use Plan
LRSY	long run sustained yield
LT	long term
LTHL	long term harvest level
LU	landscape unit
MoF	Ministry of Forests
MS	montane spruce (ecological zone)
MSYT	managed stand yield table
MT	mid term
NCBr	non-commercial brush
NSR	not satisfactorily restocked
NSYT	natural stand yield table
OAF	operational adjustment factor
OGSI	old growth site index (project)
OLB	operable land base
P&T	Pope and Talbot Ltd.
PH	partial harvesting

SBFEP	small business forest enterprise program
SI	site index
SPH	stems per hectare
ST	short term
TFL	tree farm licence
THLB	timber harvesting land base
TIPSY	table interpolation program for stand yields
TSA	timber supply area
TSR	timber supply review
VDYP	variable density yield projection
VQO	visual quality objective
WT	working target

Species abbreviations: B or Ba - balsam fir; Cw - western redcedar; Fd - Douglas-fir; Fdi - interior Douglas-fir; Hw - western hemlock; Pl - lodgepole pine; S - spruce species.

Site class abbreviations: G - good; M - medium; P - poor.

Appendix A: Additional Document Detail

Section	**Source**	**Prepared**
Strategy at a Glance	Executive Summary - captures the essence of the final silviculture strategy.	Post - workshop.
Higher Level Goals and Objectives	Ministry of Forests documents - see references	Pre-workshop.
Basic Data	MP #9 timber supply analysis reports.	Pre-workshop.
Incremental Silviculture History	Past history - MP #9 timber supply analysis reports. Current history - workshop participants.	Pre-workshop, workshop.
Issues		
- Individual Issue Analysis (Appendix B)	Consultant's review and analysis of available documentation, mostly MP #9 timber supply analysis reports, in advance of preparing potential strategies for workshop discussion.	Pre-workshop.
- Illustration of Issues and Silviculture Opportunities	Charts - MP #9 timber supply analysis reports, prepared pre-workshop as a Powerpoint presentation to facilitate workshop discussion of issues and opportunities. Commentary - added post workshop but largely illustrates the findings of the individual issue analysis. May incorporate some workshop findings.	Pre-workshop, workshop, post-workshop.
- Summary of Issues by Period	Prepared in advance of the workshop as a summary of the timber supply dynamics of the management unit, to facilitate development of potential strategies for workshop discussion. May be amended post-workshop to incorporate new insights, findings resulting from the workshop review.	Mostly pre-workshop. Some post-workshop.
Opportunities to Increase Timber Supply		
- Potential Strategies	Consultant's proposals, based on the issue analysis, to facilitate workshop discussion. Strategy numbers are carried throughout the documentation for tracking purposes. Potential strategies can be related back to the Silviculture Opportunities columns of the issue analysis.	Pre-workshop.

Section	**Source**	**Prepared**
- Workshop Review of Potential Strategies	Documentation of the workshop session.	Workshop
- Potential Harvest Forecast	Consultant's illustration of strategy potential based on workshop results.	Post workshop.
Opportunity to Improve Timber Quality	Note: The lack of available information on timber quality and habitat supply limited pre-workshop development of these aspects of the strategy.	
Product Objectives	Workshop discussion.	Workshop.
Potential Strategies	Partially consultant's proposals to facilitate workshop discussion. Mostly developed in the workshop. Strategy numbers are carried throughout the documentation for tracking purposes.	Some pre-workshop, mostly workshop.
Large Premium Log Analysis	Prepared by consultant in advance of workshop to facilitate workshop discussion. Modified afterwards to reflect workshop strategies.	Pre-workshop, workshop, post-workshop.
Potential Quality Forecast	Consultant's illustration of strategy potential based on workshop results and post-workshop analysis.	Post workshop.
Opportunities to Improve Habitat Supply	Proposed by workshop participants.	Workshop, post-workshop.
Silviculture Strategy	Summation of the findings of the workshop, translated into a strategy. Only those potential strategies deemed feasible by workshop participants are kept. Strategy numbers correspond with those initially proposed for tracking purposes (which are founded in the issue analysis). Strategies are ranked in keeping with the treatment rankings of the regime table.	Post workshop.
Silviculture Regimes and Investment Priorities	Prepared during the workshop. Recorded here as part of the final strategy (rather than under the workshop) to avoid unnecessary duplication.	Workshop.
Silviculture Program	Basic program elements prepared during the workshop. Program developed later by the consultants.	Workshop, post workshop.
Job Outcomes	Basic factors from workshop participants. Calculations performed later by consultants.	Workshop, post workshop.

Appendix B: Detailed Issues and Silviculture Opportunities Analysis

Timber Quantity Issue Analysis

The following information is primarily from two sources: the *Timber Supply Analysis Information Package* ("P&T, 1998a")and the *Timber Supply Analysis Report* ("P&T, 1998b"). These were both prepared jointly by Pope & Talbot and Timberline Forest Inventory Consultants Ltd. in support of Management Plan #9. Sources are noted, with full references given on page 68. Only information which is relevant to a silviculture strategy is recorded. Key statements are bolded.

Issue	Description	Discussion	Silviculture Opportunities	
			Increase Over Base Case	Maintain Base Case
Harvest Forecast	Harvest forecast scenario 3 adopted as the base case. The initial harvest level of 680 000 m^3/yr (current AAC) can be maintained for 4 decades, followed by successive decadal declines of 10% and 6.5% over 2 decades to a mid term low of 572 000 m^3/yr. This low lasts for 3 decades followed by an 11% rise to a long term harvest level of 634 000 m^3/yr (7% below the current AAC) reached in decade 10. (P&T, 1998b:12) Harvest volumes in the first 7 decades are virtually all from existing natural stands. In decade 8 about half of the harvest is from existing managed stands (ie. currently aged R–25 yrs). From decade 9 onwards, harvesting comes largely from managed stands. Available growing stock minimizes at decade 8 (decade 9 according to P&T, 1998b:13–Fig 11). The harvest flow over decades 1-9 is largely controlled by this minimum. (P&T, 1998b:13) LTHL is approx. 8% below the long run sustained yield (LRSY) (P&T, 1998b:v).		Increasing the growing stock in decades 6 – 9 would allow higher harvest levels in the mid term.	
Age Class	Existing stands are relatively well distributed in 10 year age classes between ages R and 135, except stands aged 25–35 years occupy virtually twice the area of those in the age classes immediately before and after it. (P&T, 1998b:15 Fig 14, p) See Figure 4, page 14. Stands over 136 years of age (i.e., age class 140+) are only 31% of the THLB. However, there are almost no stands aged 166–215 yrs, while almost half of the older stands (15% of all stands) are aged 226–235 (age class 230). (P&T, 1998b:15–Fig 14) See Figure 5, page 14. Non-harvestable forests are aged but not regenerated. In 250 years the bulk of them are aged over 260 yrs with virtually none below 240 years of age (P&T, 1998b:17–Fig 19).	The large proportion of stands aged 26–35 is significant in that natural stand yield table (NSYTs) are applied to them. High concentration of stands in age class 230 due to inventory methodology? Not regenerating	Can anything be done to bring stands aged 26–35 yrs under management, so that managed stand yield table (MSYTs) would apply? Are they under-stocked? Are they fertilizable? Where are they located?	

Issue	**Description**	**Discussion**	**Silviculture Opportunities**	
			Increase Over Base Case	Maintain Base Case
		stands outside the THLB may cause LTHL to be overestimated.		
Silv. Systems	Silviculture systems are not explicitly stated. Assume clearcut harvesting system. All areas are planted (P&T 1998a:32). Base case employs an avg. 2 yr regen delay (P&T, 1998b:29). Existing stands are regenerated to species mixes that are representative of current silviculture objectives for the TFL. (P&T, 1998a:25–26) All managed stands are regenerated to the same MSYT at 1 600 sph, including ingress (P&T, 1998a:33)			
Backlog NSR	TSR1 AAC rationale (p 4) indicates 5 311 ha of backlog to be restocked by end of 1995. SMOOP indicates backlog reforestation is complete (P&T, 1997:3). Harvestable landbase includes 6 165 ha of current not satisfactorily restocked (NSR) lands, scheduled to be restocked (P&T, 1998b:4).	Appears to be no backlog NSR.		
Land Base	Approx. 100 000 ha (27%) of productive forest is classed as inoperable and 18 600 ha (5%) as unharvestable and are not included in the THLB. (P&T, 1998b:5). After OGSI adjustment, a high proportion of these stands are classified as good and medium site (P&T, 1998b:8). *NC Brush* 198 ha of NC Brush removed from the THLB. (P&T, 1998a:7) *Low Productivity stands* 1 680 ha (equiv to 0.7% of THLB) removed from the THLB, after allowance for other netdown factors (gross area 180 338 ha). (P&T, 1998a:7) 4 461 ha (equiv to 2% of THLB) of low productivity forest types (SI 8.0 to 8.9 – mostly S/B types > age 140, subject to OGSI bias) were included in the THLB. Sensitivity test of removal of this area from the THLB resulted in lowering harvest levels in the 4th through 9th decades by 2% and in the 10th and subsequent decades by 1%. (P&T, 1998b:24) *Overmature Hemlock and Balsam* 4 071 ha (equiv to 2% of THLB) of overmature hemlock and balsam stands deducted from THLB as non-merchantable, after allowance for other netdown factors (gross area 28 024 ha). (P&T, 1998a:7) After allowing for other constraints, 3 660 ha (equiv. to 1.6% of THLB) could be added back. Sensitivity analysis indicates this has no effect on the short and early mid term periods but could add 1% to the base case starting in decade 5. (P&T, 1998b:21)	OGSI bias affects existing older stands with SI 8.0 – 8.9 only after regeneration. More relevant is what are the merch vol's of these stands. If they cannot be harvested, OGSI benefit would not appear.	OGSI adjustment shows significant shift in area from poor site to medium site. Would there also be a shift from low site (assume classed as NP) to poor?	Removal of marginal site productivity forests lowers the harvest forecast during its most sensitive period.

Issue	**Description**	**Discussion**	**Silviculture Opportunities**	
			Increase Over Base Case	Maintain Base Case
	Deciduous leading stands and deciduous minor species 5 845 ha (equiv. to 3% of THLB) of deciduous-leading stands removed from the THLB, after allowance for other netdown factors (gross area 7 407 ha). (P&T, 1998a:7) No deciduous volumes are included in the volumes reported for conifer leading stands (P&T, 1998a:32) *Sensitivity test for removal of Aerial Harvesting stands* Approx. 19 500ha (equiv to 9% of THLB) of land suitable to aerial harvesting was included within the net harvestable area. Removing this area results in the need to lower harvest levels by 56 000 m^3/yr over the entire planning horizon. This equates to the current AAC aerial partition of 50 000 m3 of aerial volume plus 6 000 m3/yr attributable to the MoF small business program. (P&T, 1998b:22)] *General sensitivity test* Sensitivity test ± 10% of THLB. [Area in all stand types and ages both increased and decreased?] Non-harvestable, productive area adjusted accordingly Harvest forecasts parallel the base case and are shifted ± 10% from base case along entire planning horizon. (Appears in the -10% scenario that no attempt was made to maintain the IHL.) (P&T, 1998b:23)			
Site Productivity	Old growth types aged >140 years are known to incorporate a negative bias. (P&T, 1998b:25) Site index change simulated by changing regen stand volumes and green-up ages based on MoF approved interim adjustment factors. Min. harvest ages unchanged. (SI changes given in P&T, 1998a:30–31). <u>SI underestimated</u>: (P&T, 1998b:25) 1st 5 decades unchanged. **Raises mid term shortfall level by 7%**. LTHL reached 1 decade earlier (in decade 9 vs base case decade 10) and **12% above base case**. MAI of whole forest increases from 3.2 to 3.6 m^3/ha/yr.	Green-up ages are changed at the same time, although amount of changes not specified. Not possible to tell the proportion of effect attributable to this.	Has implications for bringing forward volumes from LT to MT. Spacing, fertilizing, CT activities (MT) could help accomplish this.	

Issue	**Description**	**Discussion**	**Silviculture Opportunities**	
			Increase Over Base Case	Maintain Base Case
Timber Volume Estimates	*Existing stands aged 26+ yrs*: Natural stand yield tables (NSYT) were prepared using the MoF's Variable Density Yield Projection (VDYP) system used for existing stands aged 26+ years. Utilization to 17.5 cm dbh, except 12.5 cm for Pl (P&T, 1998a:32) Sensitivity test for ± 10% in volume. Short and long terms insensitive to either increase or decrease. (P&T 1998b:26) Increase: (+10%) **Highly sensitive in the mid term**. IHL can be maintained 10 decades, 6 longer than the base case. Harvest level then drops to an unchanged LTHL. Decrease: (-10% - alternative 1) **Highly sensitive in the mid term**. IHL can only be maintained 2 decades (2 less than base case) before falling to a shortfall level 12% below the LTHL, rising to an unchanged LTHL in decade 11.	A recently completed inventory audit found no statistical difference between inventory and audit volume estimates, although audit volumes were slightly below inventory volumes (MoF, 1998b). Increasing vol's of existing stands would enable extending current harvest levels.	Species, ages and stocking levels might be appropriate for a substantial fertilization program (MT). Intensively survey and analyze 30 and 40 year old stands for stocking, c/c and yield forecasting. Are these NSYT or MSYT? Perhaps MSYT with a higher OAF? (MT) See also min harvest ages. CT program in close in, good-site stands to recover volumes lost to mortality? (MT) CT could also be used to bring fwd vol's from LT (MT).	
	Existing managed stands aged ≤ 25 yrs and future managed (regenerated) stands: Existing managed stands includes all stands regenerated since 1972 (both natural and planted) and presently occupy 37 600 ha (17% of THLB). These stands are regenerated to the same analysis units following harvest (P&T, 1998a:25, 33). Managed Stand Yield Tables (MSYT) were prepared using the MoF's Table Interpolation Program for Stand Yields (TIPSY Ver 2, Beta 5) for all regenerated stands and existing managed stands aged 25 or less. (P&T 1998b:2). Utilization to 12.5 cm dbh for all species (P&T, 1998a:31). TIPSY operational adjustment factor 1 (OAF1) - 15%; OAF 2 – 5% applied to all managed stands (P&T, 1998a:31). All yields of future managed stands increased 3% to account for tree improvement program. (P&T, 1998a:34). Sensitivity tests for ± 10% in volume. Short term insensitive to either. Slight sensitivity to both in the mid term and h**ighly sensitive to both in long term**. (P&T, 1998b:27)	Armillaria root rot present? May reduce yields in some regenerated stands by 20%. This may prolong green-up or create gaps in free growing stands.	Possibilities to increase regen vol's: Improved seed. Larger planting stock. Reduce voids (OAF1). Fertilization at planting. Brushing for growth. (LT) Combined effect of increasing regen	Management for root rot to limit losses. (LT)

<table>
<tr><th rowspan="2">Issue</th><th rowspan="2">Description</th><th rowspan="2">Discussion</th><th colspan="2">Silviculture Opportunities</th></tr>
<tr><th>Increase Over Base Case</th><th>Maintain Base Case</th></tr>
<tr><td></td><td><u>Increase</u>: (+10%) Short term insensitive. 1% rise mid term. LTHL 10% higher than base case, starting in decade 10.

<u>Decrease</u>: (-10%) Mid term shortfall level 1% lower than base case. LTHL 10% below base case.</td><td></td><td>stand vol's and OGSI could be substantial.

Challenge is to move volumes forward to fill mid term shortfall - see min harvest ages. (MT)</td><td></td></tr>
<tr><td>Min. Harvest Ages</td><td>Minimum ages based on age before which a further increase to MAI would be less than 0.05 m3/ha/yr. This approach avoids excessively high culmination ages resulting from small increases in MAI. (P&T, 1998a:42) Minimum harvest ages for existing mature natural stands (aged 141+ yrs) do not affect timber supply because virtually all stands are already above the specified ages. Avg minimum age for existing thrifty natural stands (currently aged 26–140 yrs) and for managed stands are highly relevant because these are the stands being harvested in the shortfall period, decades 5–10.
<table>
<tr><th></th><th><u>Min Age</u></th><th><u>dbh</u></th><th><u>Est.Volume</u></th></tr>
<tr><td>Existing mature natural stands - all</td><td>110</td><td>29</td><td>220 (17.5)</td></tr>
<tr><td>Existing thrifty natural stands -all (incl Pl)</td><td>100</td><td>30</td><td>260 (17.5)</td></tr>
<tr><td>Existing thrifty natural stands -Pl</td><td>80</td><td>22</td><td>220 (12.5)</td></tr>
<tr><td>Existing managed stands - all (incl Pl)</td><td>100</td><td>23</td><td>340 (12.5)</td></tr>
<tr><td>Existing managed stands - Pl</td><td>85</td><td>21</td><td>250 (12.5)</td></tr>
<tr><td>Future managed stands - rgen frm mat all</td><td>110</td><td>21</td><td>340 (12.5)</td></tr>
<tr><td>Future managed stands - rgen frm thrft all</td><td>100</td><td>22</td><td>310 (12.5)</td></tr>
<tr><td>Future managed stands - rgn frm thrft -Pl</td><td>80</td><td>22</td><td>280 (12.5)</td></tr>
<tr><td>Future managed stands
rgen frm mat + OGSI - all</td><td>80</td><td>23</td><td>320 (12.5)</td></tr>
</table>
Sensitivity analysis of ± 10 yrs. (P&T, 1998b:28) Very sensitive.

<u>Decrease</u>: (- 10 yrs) IHL is extended 2 decades longer than the base case (6 vs 4) followed by a decline of 10% to a mid term level only 2% below LTHL. Rises to same LTHL as base case in decade 10. Lowering min ages 10 years allows both the tail end of the thrifty existing stands and the first of the managed stands to be available sooner, thus freeing up mature timber that is being held to fill in in the shortfall period.</td><td>No long term sensitivity to a 20 yr spread in age changes (i.e., ± 10 yrs) indicates min ages are probably close to true culmination ages.

Must use caution when comparing existing natural stand diameters and yields to those of managed stands because of the different utilization stds.

Maintaining stocking is critical to the mid/long term forecast. Lower stocking levels will result in lower volumes.

Increasing volumes at the same minimum age would be same as increasing regen stand vol's & will result in higher LTHL.

Reducing ages 10 years removes substantial volume</td><td>There is a potential for a trade-off between increasing volumes of regenerated stands and reducing min ages. Target sharing of these effects; e.g., lower min ages 10 yrs (allowing maintenance of IHL for 2 more decade) and increase regen volumes 10%? (MT, LT)</td><td></td></tr>
</table>

Issue	**Description**	**Discussion**	**Silviculture Opportunities**	
			Increase Over Base Case	Maintain Base Case
	Increase: (+10 yrs) IHL can be maintained only 2 decades, 2 less than the base case. Timber supply in the mid term period is slightly reduced. The first of the second growth managed stands, which are critical to timber supply during the transition of harvesting from old growth to second growth, must age an additional decade before they are considered merchantable. Some existing stands must be held longer to avoid even more serious timber supply disruptions.	**from the harvest schedule in the early mid term which does not reappear.** Possibly is parceled out very slowly over the long term to maintain LTHL at base case.		
Forest Cover	*Integrated Resource Management (IRM), Caribou, & Ungulate Winter Range (UWR) Zones*: Zones are 55%, 12%, and 11% of THLB (78% total) and 52%, 17% and 9% of productive land base (78% total) respectively (P&T, 1998b:7 - Fig 7 data). Base case requirement of at most 25% of the net harvestable land base permitted to be < green-up ht (2 m in all zones (P&T, 1998a:39) which equates to a 15 yr age (Wang, pers comm.)). Sensitivity tests of ± 5% of area allowed to be not greened up. (P&T, 1998b:30) Relax Constraint: (+5% to 30%) 1st 4 decades insensitive. **Decade 5–6 harvest levels 3–7% above base case**. Same as base case thereafter. Increase Constraint: (-5% to 20%) Highly sensitive in the **second decade - harvest level falls 16% below base case**.	On a global basis, at the end of periods 1 & 2 about 21% and 26% of THLB area is < 15 yrs old, respectively. Changing the allowable level to 20% (from 25%) in the 2nd decade immediately puts the harvest over this limit. Timberline report Table A3 (P&T, 1998b:43) can be used to pinpoint LU's that are limiting. Relaxing the constraint does not increase ST timber supply because next most constraining factor is the need to hold timber to fill the mid term period.		The second decade harvest level is at serious risk should there be an increase in forest cover constraints (FCC's). 1. Determine actual time to green-up under current practice and model. (ST) 2. If timber supply is still sensitive at this age, accelerate green-up using enhanced silv practices (ST) (these are the same stands that come into play in the mid term harvest), or 3. use PH or CT to access timber if this becomes necessary (ST) (**probably more costly than silv activities**).

Age	Period 1	Period 2
R	26 000	27 000
1–5	6 165	26 000
6–15	15 080	6 165
Total	47 245	59 165
% THLB	21%	26%

Issue	**Description**	**Discussion**	**Silviculture Opportunities**	
			Increase Over Base Case	Maintain Base Case
	Caribou Thermal and Old Growth Objectives Base case requirement of at least 30% of ESSF and 40% of ICH caribou habitat zone area be in stands > 140 years and at least 10% be in stands > 250 years of age (including operable, but non-harvestable forests). Also, at least 70% of the productive inoperable forest (i.e., outside the THLB) in the caribou zone must be in stands >140 years. (P&T, 1998a:37–40) Sensitivity tests of ± 5% of area required to be above specified ages. (P&T, 1998b:31) <u>Relax Constraint</u>: (5% less area required to be above specified ages) Same as base case in all periods except d**ecade 6 harvest level 7% above base case**. <u>Increase Constraint</u>: (5% more area required to be above specified ages) IHL can only be maintained 3 decades, 1 less than base case. Mid term level 2% above base case. LTHL basically unchanged.	Decade 6 harvest level increase is also freed up in IRM/wildlife and Regen delay sensitivity tests. These effects are probably not cumulative, but free up the same timber, probably up to the min age limit. Because min ages are more limiting, better to target them.	Target min ages.	
	Ungulate Winter Range Thermal Objectives			
	Caribou Habitat Option			
	Visual Quality Zones: 7% of THLB (P&T, 1998b:7 - Fig 7 data). Base case requirement of at most 25% (west side) and 15% east side (partial retention visual quality objective (VQO)) to be < 5 m tall (P&T, 1998a:39). This equates to a 24 yr age (Wang, pers comm.)). Sensitivity test of ± 5% of area. (P&T, 1998b:33) <u>Relax Constraint</u>: (+5% to 20% east and 30% west) - same as IRM) Very sensitive only in decades 5 & 6, given this zone is only 7% of THLB. **Raises** d**ecades 4 & 5, 9% & 4% respectively above base case**. <u>Increase Constraint</u>: (-5% to 10% east and 20% west) Very sensitive - initial harvest level can be maintained only 2 decades (vs base case 4), falling thereafter to the mid term shortfall level which it reaches 1 decade earlier. Same as base case thereafter.	Responses are very significant given VQO zone is only 7% of THLB.	Increasing harvests from the VQ zones offers potential to have higher harvests in decades 5 & 6. Two avenues: CT to increase vol. or brush/fertilize regen stands to reach 5 m green-up sooner. (MT, LT)	**Decade 3–5 harvest levels are at significant risk to a relatively minor reduction in the area allowed not greened-up.** (MT)
	Green-up: Green-up ages used in the TFL 23 analysis are shown in the table below (Eric Wang, per comm.). These ages do not include regen delay (2 yrs on the TFL and 2–4 yrs in Nelson FR) which is added to get total green-up time. The table	Ages used in the TFL analysis appear high for 2 m green-up, close for 5 & 6 m	Targeting reduction in time until green-up by no more than 5 years in VQ and watershed	

<table>
<tr><th rowspan="2">Issue</th><th rowspan="2">Description</th><th rowspan="2">Discussion</th><th colspan="2">Silviculture Opportunities</th></tr>
<tr><th>Increase Over Base Case</th><th>Maintain Base Case</th></tr>
<tr>
<td></td>
<td>
<p>includes comparisons with data from Reichenback, 1996, without regen delay (2m green-up ht = 2.5 m top ht.).</p>
<table>
<tr><th></th><th><i><u>2m</u></i></th><th><i><u>5m</u></i></th><th><i><u>6m</u></i></th><th><i><u>9m</u></i></th></tr>
<tr><td><u>TFL 23 - all</u></td><td>15</td><td>24</td><td>27</td><td>36</td></tr>
<tr><td><u>Current Nelson FR (Reichenback, 1996)</u></td><td></td><td></td><td></td><td></td></tr>
<tr><td>F, L, Py, (Pw)-g</td><td>8</td><td>17</td><td>-</td><td>29</td></tr>
<tr><td>F, L, Py, (Pw)-m</td><td>8</td><td>18</td><td>-</td><td>33</td></tr>
<tr><td>F, L, Py, (Pw)-p(l)</td><td>8</td><td>22</td><td>-</td><td>47</td></tr>
<tr><td>H, C (all)</td><td>8</td><td>19</td><td>-</td><td>33</td></tr>
<tr><td>S,B-g,m</td><td>12</td><td>24</td><td>-</td><td>38</td></tr>
<tr><td>S,B-p</td><td>15</td><td>39</td><td>-</td><td>64</td></tr>
<tr><td>Pl,(Pa)-g,m</td><td>8</td><td>18</td><td>-</td><td>31</td></tr>
<tr><td>Pl,(Pa)-p(l)</td><td>9</td><td>24</td><td>-</td><td>51</td></tr>
<tr><td><u>Enhanced Nelson FR</u></td><td></td><td></td><td></td><td></td></tr>
<tr><td>F, L, Py, (Pw)-g</td><td>6</td><td>12</td><td>-</td><td>20</td></tr>
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<tr><td>H, C (all)</td><td>7</td><td>16</td><td>-</td><td>27</td></tr>
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</table>
<p>At the request of Cortex/Atherton, Timberline performed additional sensitivity tests of separately reducing green-up ages in the domestic watershed (6 m ht; 13% of THLB) and VQO zones (5 m ht; 7% of THLB) and of increasing the area allowed to be not greened-up in the domestic watershed zone by 5%. (Hts source - P&T, 1998a:39 / zone % source - P&T 1998b:7)</p>
<p>Reducing <u>either</u> the VQO or the domestic watershed green-up ages 5 years produces the same effect. In both cases IHL is maintained one decade longer than in the base case (5 vs 4) and the harvest level in decade 6 is increased by 7%. (No test done with both reduced at the same time.) Reducing either by 10 years does not increase harvest levels further. This indicates a maximum sensitivity of 5 years lower ages; it could be less.</p>
<p>Allowing 5% more area to be not greened-up in the watershed zone produces a lesser effect than reducing green-up ages.</p>
</td>
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<p>green-up and close for 9 m good and med. sites but low for 9 m poor sites.</p>
<p>Enhanced silviculture practices offer considerable opportunity to reduce time to green-up for all target hts. For TFL 23 these appear to avg. reductions of about 8 yrs for both 2 and 5 m, and 6–16 yrs for 9 m, except for SB-p which would still be higher than the current green-up age.</p>
<p>Both the regen delay and the OGSI sensitivity tests also indicate green-up age is a controlling factor in the mid term shortfall period.</p>
<p>See also regen delay sensitivity test and min ages.</p>
</td>
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<p>zones offers potential to increase decade 5 & 6 harvests. (MT)</p>
<p>See increase managed stand vol’s for list of practices. Add site prep.</p>
</td>
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</tr>
</table>

Issue	**Description**	**Discussion**	**Silviculture Opportunities**	
			Increase Over Base Case	Maintain Base Case
	Aerial fertilization would not likely be acceptable in the watershed zone. Perhaps at planting?			
	Regeneration Delay Base case uses avg 2 yr delay. Sensitivity test of ± 1 yr. (P&T, 1998b:29) <u>Shorter Delay</u>: (1 yr) Unchanged over 1st 4 decades. Slight increase in decade 5, but **decade 6 harvest level 7% above base case**. Decades 7–9 1% above base case and 3 000 m^3/yr above base case thereafter. <u>Longer Delay</u> (3 yr) Insensitive.	The sensitivity to a 1 yr reduction in regen delay likely linked to green-up delay in VQO and domestic watershed zones. However, doing a green-up age reduction in IRM zone might be useful.		
Bio-diversity	*Full Biodiversity Objectives in Low Emphasis Landscape Units* Base applied only one third of old growth seral stage requirements in the low-emphasis landscape units, gradually increasing this over 3 rotations so that the full requirements were met in 240 years. Sensitivity test of application in full at the beginning of the planning horizon. Result is that IHL can be maintained for only 2 decades vs 4 in the base case. Requirements must be met in part from stands within the THLB. By the 6th decade the requirement can again be met without change from the base case. (P&T, 1998b:34)	See "Age Class" above, "Biodiversity contribution from areas outside the THLB" below.		Silviculture action only needed if policy demands meeting this requirement in full at once. Use CT to create old-seral stand structures at earlier ages? Could be effective by 3rd decade.
	Biodiversity contribution from areas outside the THLB The age class distribution of the non-harvestable land base is aged but not regenerated. By the end of period 25, almost all of these stands are 250+ years of age, creating an abundance of stands to satisfy old seral requirements. However, the current age class structure indicates these stands have historically been subject to stand replacing events. To the extent this continues, allowing for modern fire suppression activities substantially altering historic patterns, the non-harvestable land base may not adequately meet future requirements. This would have consequences to the harvest forecast. <u>Note:</u> In the Golden TSA, when the current age class distribution of forests outside the THLB is held constant the IHL must drop 5% below the base case and LTHL is about **10% lower**, due to the increased need to use stands within the THLB to meet seral stage requirements. The base case assumption that there will be no creation of young stands in forests outside the THLB does not likely represent the future distribution of the land base and **will likely overestimate the long term timber supply**. (BC MoF, 1998c:46–47)	Not regenerating stands in the operational landbase (OLB) possibly overestimates the timber supply. Further modelling is required to define the point at which the harvest forecast begins to show sensitivity. Once this frontier is established, decisions can be made as to whether silviculture actions to early recruit old seral forests are needed.		Use CT to create old-seral stand structures at earlier ages. (MT, LT) As forested areas outside of the THLB are damaged they may revert to NSR for long time periods. For those areas outside of parks, would it be of long term benefit to consider stocking establishment? (LT)