Williams Lake TSA – Type IV Silviculture Strategy

Working Data Package

Version 3.0

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Project 419-25

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1 Introduction

The British Columbia Ministry of Forests, Lands and Natural Resource Operations initiated a Type IV Silviculture Strategy for the Williams Lake Timber Supply Area (TSA). The data package describes the information that is material to the analysis including the model used, data inputs and assumptions.

This draft data package is not yet complete. Missing from this document are the assumptions specific to silviculture strategies that will be explored during this project. This preliminary version of the data package is primarily meant to present the data and assumptions planned for the base case. Once silviculture strategy assumptions are finalized, they will be included to this document.

1.1 Study Area

The Williams Lake TSA is located in the Fraser Basin and Interior Plateau between the Coast Mountains on the west and the Cariboo Mountains on the east. The TSA includes the communities of Williams Lake, Alexis Creek and Horsefly. The Williams Lake TSA is administered by the Cariboo-Chilcotin District.

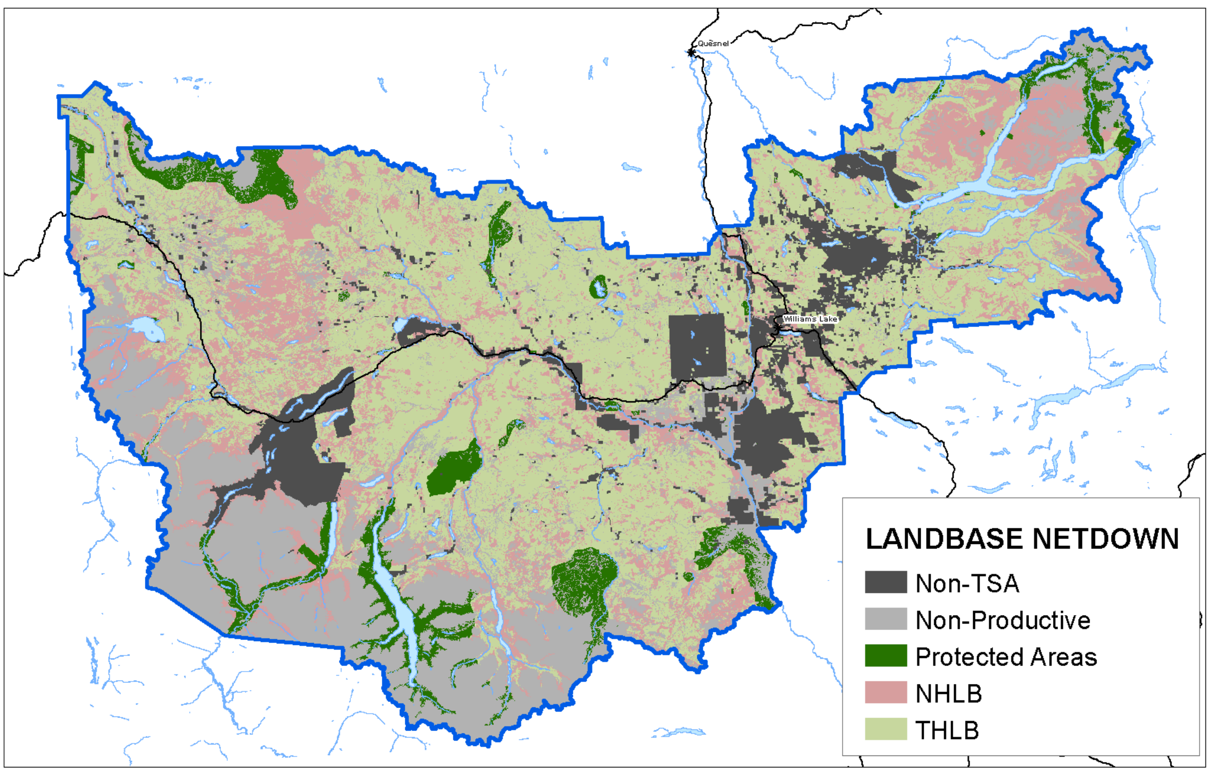

Figure 1 Williams Lake TSA

The Williams Lake TSA covers approximately 4.87 million hectares of land where about 3.2 million ha (65%) is considered productive Crown forest (excludes First Nations reserves, private lands, non-forest, woodlots, and community forests). This area contains 1.77 million ha of working forest (56%) with the balance of that area set aside for biodiversity, fish or wildlife or because the site is too poor to grow trees economically. Lodgepole pine comprises about 61 percent of the total mature volume on the Timber Harvesting Land Base (THLB).

The Cariboo-Chilcotin Land Use Plan (CCLUP) is a legal higher level plan covering 100 Mile House, Quesnel and Williams Lake timber supply areas. The CCLUP was established by cabinet as a legal higher level plan under the Forest Practices Code in January 1996. Extensive planning was then done at the sub-regional level to further refine and map many of the land uses in consultation with industry, interest groups and some First Nations. Legal objectives were established for 13 values under the Land Use Objectives Regulation (June 2010) and nine species under the Government Actions Regulation (various dates). Many of the land use designations overlap to reduce impacts on timber availability (e.g. an old growth management area may also be a visual management area).

Previous silviculture strategies for the TSA (2006, 2009) indicate that the general silviculture strategy for the Williams Lake TSA is to reforest MPB impacted stands, fertilize thrifty Douglas-fir/spruce, and thin/fertilize repressed lodgepole pine stands to improve mid-term timber supply, while mitigating habitat supply impacts associated with the MPB epidemic and restoring the structure and health of dry-belt Douglas-fir ecosystems. Now that the MPB has effectively run its course in the TSA, this Type 4 silviculture strategy aims to develop updated TSA objectives and strategic guidance for harvesting and basic / incremental silviculture - resulting in a tactical plan to support implementation. It will also be used to guide allocation of Land Base Investment Strategy resources.

1.2 CONTEXT

This document is the second of four documents that make up a type IV Silviculture Strategy:

- Situational Analysis – describes in general terms the situation for the unit – this could be in the form of a PowerPoint presentation with associated notes or a compendium document.
- Data Package - describes the information that is material to the analysis including the model used, data inputs and assumptions.
- Modeling and Analysis report –provides modeling outputs and rationale for choosing a preferred scenario.
- Silviculture Strategy –provides treatment options, associated targets, timeframes and benefits.

2 Modelling Approach

2.1 MODEL

The PATCHWORKS ™ modeling software was used for forecasting and analysis. This suite of tools is sold and maintained by Spatial Planning Systems Inc. of Deep River, Ontario (Tom Moore - www.spatial.ca).

PATCHWORKS is a fully spatial forest estate model that can incorporate real world operational considerations into a strategic planning framework. It utilizes a goal seeking approach and an optimization heuristic to schedule activities across time and space in order to find a solution that best balances the targets/goals defined by the user. Targets can be applied to any aspect of the problem formulation. For example, the solution can be influenced by issues such as mature/old forest retention levels, young seral disturbance levels, patch size distributions, conifer harvest volume, growing stock levels, snag densities, CWD levels, ECAs, specific mill volumes by species, road building/hauling costs, delivered wood costs, net present values, etc. The PATCHWORKS model continually generates alternative solutions until the user decides a stable solution has been found. Solutions with attributes that fall outside of specified ranges (targets) are penalized and the goal seeking algorithm works to minimize these penalties – resulting in a solution that reflects the user objectives and priorities. Patchworks' flexible interactive approach is unique in several respects:

- PATCHWORKS' interface allows for highly interactive analysis of trade-offs between competing sustainability goals.
- PATCHWORKS software integrates operational-scale decision-making within a strategic-analysis environment: realistic spatial harvest allocations can be optimized over long-term planning horizons. Patchworks can simultaneously evaluate forest operations and log transportation problems using a multiple-product to multiple-destination formulation. The model can identify in precise detail how wood flows to mills over a complex set of road construction and transportation alternatives.
- Allocation decisions can be made considering one or many objectives simultaneously and objectives can be weighted for importance relative to each other. (softer vs. harder constraints)
- Allocation decisions can include choices between stand treatment types (Clearcut vs. partial cut, fertilization, rehabilitation, etc.).
- Unlimited capacity to represent a problem – only solution times limit model size.
- Fully customizable reporting on economic, social, and environmental conditions over time.

Reports are built web-ready to share analysis results easily – even comparisons of multiple indicators across multiple scenarios.

2.2 DATA SOURCES

Table 1 lists the spatial data and sources used for this analysis.

Table 1 Spatial data sources

Spatial Data	Source	Feature Name	Effective
TSA Boundary	WHSE_ADMIN_BOUNDARIES	FADM_TSA	2010
Parks and Protected Areas	WHSE_TANTALIS	TA_PARK_ECORES_PA_SVW	2012
Candidate Goal 2 Protected Areas	WHSE_LAND_USE_PLANNING	RMP_PLAN_NON_LEGAL_POLY_SVW	2009
Indian Reserves	WHSE_ADMIN_BOUNDARIES	CLAB_INDIAN_RESERVES	2012
New Community Forest	RSI	WLCF_BOUNDARY	2012
Ownership	WHSE_FOREST_VEGETATION	F_OWN	2012
Biogeoclimatic Ecosystems (BEC)	WHSE_FOREST_VEGETATION	BEC_BIOGEOCLIMATIC_POLY	2012
Snowpack	FORSITE (BEC)	BEC_BIOGEOCLIMATIC_POLY	2012
Stand Structure Habitat Class	MOE	STND_STRC_HAB_CLS	2006
Landscape Units (LU)	WHSE_LAND_USE_PLANNING	RMP_LANDSCAPE_UNIT_SVW	2011
Old Growth Management Areas (OGMA)	WHSE_LAND_USE_PLANNING	RMP_OGMA_LEGAL_CURRENT_SVW	2011
Ungulate Winter Ranges (UWR)	WHSE_WILDLIFE_MANAGEMENT	WCP_UNGULATE_WINTER_RANGE_SP	2004
Wildlife Habitat Areas (WHA)	WHSE_WILDLIFE_MANAGEMENT	WCP_WILDLIFE_HABITAT_AREA_POLY	2011
Proposed Wildlife Habitat Areas	REG_LAND_AND_NATURAL_RESOURCE	WLD_WHA_PROPOSED_SP	2012
Watershed Reporting Units – Sub-basins	WHSE_BASEMAPPING	FWA_ASSESSMENT_WATERSHEDS_POLY	2011
Watershed Reporting Units – Basins	FORSITE (watershed sub-basins)	ALL_WATERSHEDS	2011
Community Watersheds	WHSE_WATER_MANAGEMENT	BC_COMMUNITY_WATERSHEDS	2012
Grassland Benchmark Area	WHSE_LAND_USE_PLANNING	RMP_PLAN_LEGAL_POLY_SVW	2012

Spatial Data	Source	Feature Name	Effective
Critical Fish Habitat	WHSE_LAND_USE_PLANNING	RMP_PLAN_LEGAL_POLY_SVW	2012
Scenic Areas	WHSE_LAND_USE_PLANNING	RMP_PLAN_LEGAL_POLY_SVW	2012
Buffered Trail Areas	WHSE_LAND_USE_PLANNING	RMP_PLAN_LEGAL_POLY_SVW	2012
Birch Areas for First Nations	WHSE_LAND_USE_PLANNING	RMP_PLAN_LEGAL_POLY_SVW	2012
Community Areas of Special Concern	WHSE_LAND_USE_PLANNING	RMP_PLAN_LEGAL_POLY_SVW	2012
Lakeshore Management Classes	WHSE_LAND_USE_PLANNING	RMP_PLAN_LEGAL_POLY_SVW	2012
Wetland Management Zones (Buffers)	REG_LAND_AND_NATURAL_RESOURCE	WETLAND_MGMT_CAR_POLY	2011
Stream Management Zones (Buffers)	REG_LAND_AND_NATURAL_RESOURCE	STREAM_MANAGEMENT_CAR_POLY	2011
Riparian Buffers	TECO – Type2 Silviculture Strategy	RIPARIAN	2008
Environmentally Sensitive Areas	TECO – Type2 Silviculture Strategy	ESA	2007
Terrain Stability	WHSE_TERRESTRIAL_ECOLOGY	STE_TER_ATTRIBUTE_POLYS_SVW	2010
Slope Class	Forsite	SLOPE_CLS	2012
Haul Cycle Times	FAIB – Mid-Term Analysis (fig 2)	CYCLETIMES	2011
Forest Inventory –VRI	WHSE_FOREST_VEGETATION	VEG_COMP_LYR_R1_POLY	2011
Forest Inventory – Depletions	FAIB	CONSOLIDATED_CUTBLOCKS_2012	2012
Forest Inventory – Cut Blocks	WHSE_FOREST_TENURE	FTEN_CUT_BLOCK_POLY_SVW	2012
Forest Inventory – Results Openings	WHSE_FOREST_VEGETATION	RSLT_OPENINGS_SVW	2012
Forest Inventory – Reserves	WHSE_FOREST_VEGETATION	RSLT_FOREST_COVER_RESERVE_SVW	2012
Forest Inventory – Results Forest Cover	WHSE_FOREST_VEGETATION	RSLT_FOREST_COVER_INV_SVW	2012
Forest Inventory – Results SU	WHSE_FOREST_VEGETATION	RSLT_STANDARDS_UNIT_SVW	2012
Forest Inventory – Managed Site Index	FAIB	SITE_PROD_WILLIAMS_LAKE	2011
Spaced/Fertilized	WHSE_FOREST_VEGETATION	RSLT_ACTIVITY_TREATMENT_UNIT_SVW	2012
Wildfires – Historic (1996-2012)	WHSE_LAND_AND_NATURAL_RESOURCE	PROT_HISTORICAL_FIRE_POLYS_SP	2011
Wildfires – Current (2012)	WHSE_LAND_AND_NATURAL_RESOURCE	PROT_CURRENT_FIRE_POLYS_SP	2012

2.3 Forest Inventory Updates

The current forest inventory of the Williams Lake TSA is comprised of a series of projects spanning the last fifty years. Most of the TSA east of the Fraser River has been updated to the current Vegetation Resources Inventory (VRI) standard. Conversely, west of the Fraser River, the vast majority of the TSA is based on older inventories rolled-over from the previous Forest Inventory Planning (FIP/FC1) standard – with the notable exception of a large area near Alexis Creek that was part of the Lignum VRI project.

The forest inventory was initially acquired from the provincial data distribution service which is updated for specific aspects and attributes and projected for growth to 2011. Further updates to these data were required to prepare the inventory for this analysis.

Disturbance

The forest inventory was updated for logging disturbance to July 2012 and detailed attributes from RESULTS were brought into the inventory for logged blocks. This process aimed to retain opening identifiers to link with RESULTS in the next step. Stand level reserves identified in RESULTS were not treated as disturbance data.

Various attributes were updated using the most current survey data from RESULTS. Where appropriate, area-weighted average values were calculated and used to replace existing inventory attributes for these openings (VRIMs uses dominant SU attributes and does not use density information out of RESULTS). Forest attributes were not updated where RESULTS data identified openings logged using partial harvest systems (e.g., selection, shelterwood, patch cut).

Managed stand site indices

Managed stand site indices were calculated for each forest polygon using its leading species and the provincial site productivity layer which provides SIBEC estimates for site series identified in the predictive ecosystem mapping for Williams Lake TSA. Values were assigned to forest cover polygons using area-weighted averages from the raster dataset.

Past incremental treatments

To assist in developing silviculture strategies, boundaries for past and proposed spacing and fertilization activities were extracted from RESULTS then incorporated and flagged into the forest inventory. There are many areas spaced in the past that were not included in the RESULTS data. These missing treatments, largely within the IDF BEC zone, were therefore unavailable for this analysis.

No adjustments were made to forest attributes but previously treated stands were grouped into Analysis Units that incorporated yield adjustments (see sections 3.5.12 and 3.5.13).

Mountain Pine Beetle

The 2011 update to the Provincial Forest Cover incorporates changes to account for current MPB losses:

- For inventories captured before MPB, stand density and volume estimates were adjusted / prorated based on the BCMPB Model (cumkill2010) and a Year-of-Death data layer. For inventories captured after the peak MPB attack period of 2006, volumes did not need to be adjusted because the MPB impact was already reflected in the typing.
- Growth and yield projections utilized the dead stand percentage available in the inventory and no additional future mortality from MPB was implemented. The dead stand percentage attributes reflect percentages for the entire stand – factored according to the pine component within the stand.

Spruce Beetle

The BC MFLNRO conducts annual forest health aerial flights that identify tree mortality from tree foliage colour. After a peak in 2003, levels of spruce beetle attack declined rapidly. Over the past decade, spruce beetle has impacted an average of 3,795 hectares each year (48% moderate, 38% severe and 14% very severe -see Table 2 and Figure 2). Unlike the mountain pine beetle, spruce beetle infestations can be managed through the application of various forest health measures that utilize trap trees and sanitation harvest.

Table 2 Disturbance classes for spruce beetle

Intensity Class	Disturbance Description
Trace	<1% of the trees in the polygon recently killed.
Light	1-10% of the trees in the polygon recently killed.
Moderate	11-29% of the trees in the polygon recently killed.
Severe	30-49% of the trees in the polygon recently killed.
Very Severe	50%+ of the trees in the polygon recently killed.

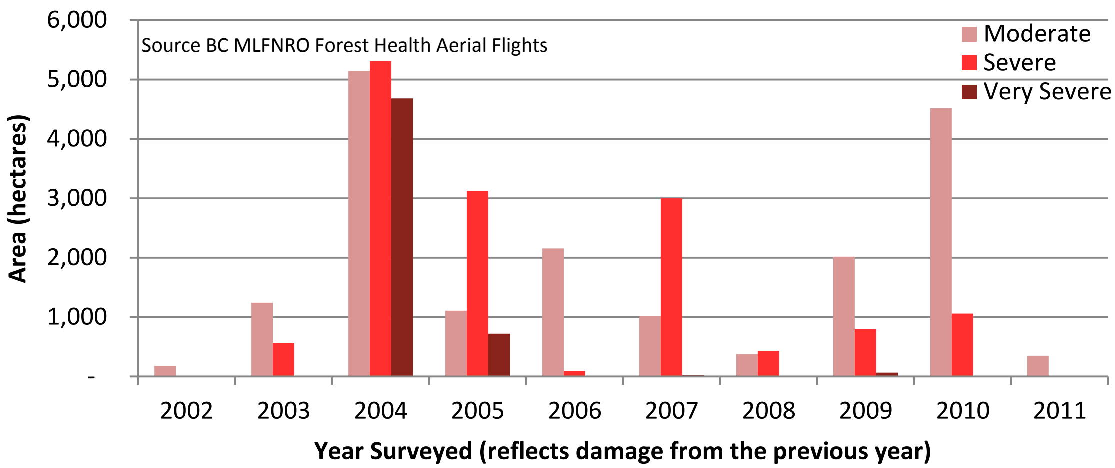

Figure 2 Area impacted by year from Spruce Beetle

These forest health aerial flights have recorded relatively small areas of tree mortality as a result of damage from spruce beetle. Accordingly, this analysis did not account for volume losses to the inventory beyond those already considered in the natural stand volume projections in VDYP7 (section 3.5.2).

Western Spruce Budworm

Western spruce budworm feeds primarily on Douglas-fir. Because of the budworm's preferential feeding on current year's buds and foliage, height growth is severely reduced or eliminated during years of defoliation. A single year of defoliation by spruce budworm generally has little impact on tree mortality but repeated budworm defoliation can cause tree mortality, a reduction in growth rates, and reduced lumber quality. Over the past decade, western spruce budworm has impacted an average of 46,291 hectares each year at intensity classes of 80% moderate, 20% severe, 0% grey (see Table 3 and Figure 3).

Table 3 Disturbance classes for western spruce budworm

Intensity Class	Disturbance Description
Light	Some branch tip and upper crown defoliation, barely visible from the air.
Moderate	Noticeably thin foliage, top third of many trees severely defoliated, some completely stripped.
Severe	Bare branch tips and completely defoliated tops, most trees sustaining more than 50% total defoliation.
Grey	Cumulative foliage damage resulting in mortality, recorded at end of damage agent cycle.

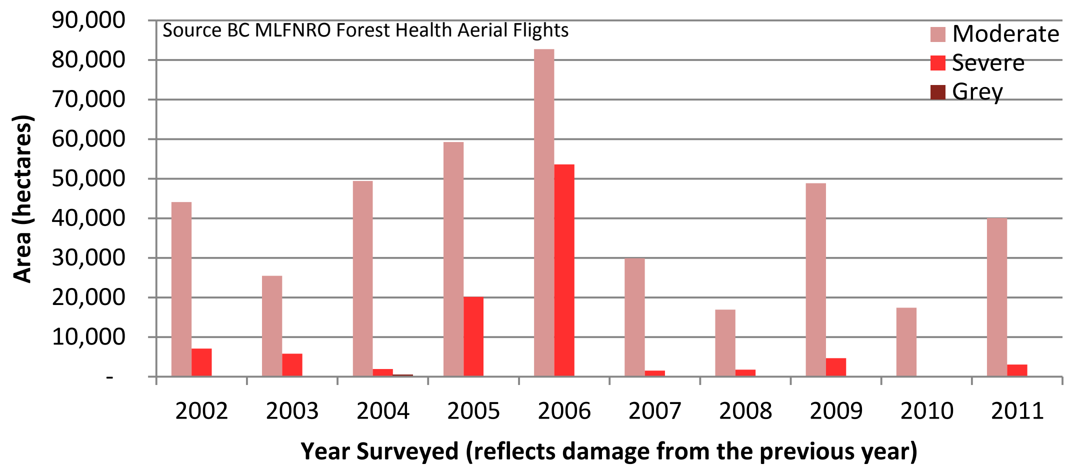

Figure 3 Area impacted by year from Western Spruce Budworm

These forest health aerial flights have recorded some damage but very little tree mortality (grey attack) as a result of damage from western spruce budworm. Accordingly, this analysis did not account for volume losses to the inventory beyond those already considered in the natural stand volume projections in VDYP7 (section 3.5.2).

Wildfires

Prior to 1996, forest inventory update processes incorporated wildfires but no updates have been made since. To address this, fire disturbances mapped since 1996 were used to update the forest inventory according to the criteria shown in Table 4.

Table 4 Inventory updates for fire disturbance

Stand Types	Disturbance	Stands Selected	Adjustments
Douglas-fir Leading Stands	70% Live	Randomly select 70% of the mature stands by area	None
	30% Dead	Select all remaining Fd stands	o Stand ages set to zero; o Regeneration delay of 30 years to unsalvaged stands; o Regeneration delay of 7 years to salvaged stands; o Normal regeneration delays (section 0) to managed stands as plantations are assumed to have sec 108 funding and shorter delay.
Other	10% Live (2009 fires only)	Randomly select 10% of the mature stands by area	None
	20% Live (All other fires)	Randomly select 20% of the mature stands by area	None
	Remaining Dead	Select all remaining non-Fd stands	o Stand ages set to zero; o Regeneration delay of 30 years to unsalvaged stands; o Regeneration delay of 7 years to salvaged stands; o Normal regeneration delays (section 0) to managed stands < as plantations are assumed to have sec 108 funding and shorter delay.

Note: only applies to fire disturbances mapped since 1996

Fire disturbance levels for these stand types were estimated by the TSA group, and where required, stand ages were adjusted based on the fire disturbance date. The overall effect of this update approach is that all of the randomly-selected live stands remain unchanged while all of the dead stands selected are totally removed. Yield assumptions for stands impacted by past wildfires are discussed in section 3.5.14.

Volume Adjustments

No volume adjustments were applied to the forest inventory. Past VRI ground sampling and adjustment projects undertaken in the Williams Lake TSA were deemed inconclusive for this analysis because of the uncertainty around how they applied to the current inventory conditions.

- IFPA VRI – indicated a decrease in volume (-9.5%) (Boston Bar Protocol)
- Williams Lake VRI – Has no Phase 2 adjustment work completed.
- FIP rollover – indicated an increase in volume (+14-15%) (Fraser Protocol) for the entire TSA less the IFPA area in 2003. The new Williams Lake VRI has now replaced a portion of this assessed inventory resulting confusion around how the removal of that area would impact the adjustments statistics.

3 Base Case Scenario

This section describes the assumptions used to model the base case scenario (status quo management). This scenario will provide the base from which to compare various silviculture treatment scenarios.

3.1 Land Base Assumptions

Land base assumptions are used to define the forest management land base (FMLB) and timber harvesting land base (THLB) in the TSA. The THLB is designated to support timber harvesting while the FMLB is identified as the broader productive forest that can contribute toward meeting non-timber objectives (e.g. biodiversity).

Table 5 provides a summary of the land base area by netdown category. The Williams Lake TSA covers a total area of approximately 4.94 million hectares. From this total area, approximately 64.7% is considered the FMLB while 36.6% is considered the THLB.

Table 5 Williams Lake TSA land base area summary

	Gross Areas (Ha)	Effective Areas (Ha)	Percent of Total Area (%)	Percent of FMLB (%)
Total Area	**4,941,569**	**4,941,569**	**100.0%**	
less:				
Non TSA (Woodlots, Non-Crown)	481,919	481,919	9.8%	
Non-Forest / Non-Productive	1,410,422	1,260,518	25.5%	
Forest Management Land Base		**3,199,132**	**64.7%**	**100.0%**
less:				
Parks and Protected Areas	593,375	250,724	5.1%	7.8%
Candidate Goal2 Protected Areas	14,503	9,313	0.2%	0.3%
Environmentally Sensitive Areas	212,598	88,923	1.8%	2.8%
Low Productivity Stands	1,982,556	415,567	8.4%	13.0%
Physically/Economic Inoperable	511,396	66,450	1.3%	2.1%
Northern Caribou No-Harvest	41,206	25,064	0.5%	0.8%
Mountain Caribou No-Harvest	172,443	74,178	1.5%	2.3%
WHA Grizzly No-Harvest	1,996	846	0.0%	0.0%
WHA Data Sensitive No-Harvest	91	26	0.0%	0.0%
OGMA (Permanent and Rotation)	296,690	179,187	3.6%	5.6%
Scenic Area – Preservation	14,056	1,480	0.0%	0.1%
Lakeshore Management Class A	19,169	7,742	0.2%	0.2%
Critical Habitat for Fish	51,643	12,657	0.3%	0.4%
Buffered Trail Areas	46,013	14,476	0.3%	0.4%
Community Areas of Special Concern	436,140	28,341	0.6%	0.9%
Riparian Management	433,898	69,161	1.4%	2.2%
Roads, Trails, and Landings (Aspatial @ 4.1%, 6.2%)		** 69,304*	1.4%	2.2%
Wildlife Tree Retention (Aspatial @ DCC 3.6%, DCH 5.0%)		** 79,148*	1.6%	2.5%
Timber Harvesting Land Base		**1,806,546**	**36.6%**	**56.5%**

** Aspatial netdowns are applied in the model but are not reflected in the GIS dataset areas.*

More detailed descriptions of these land base assumptions are provided within the following subsections. After applying these assumptions, the landbase was summarized below according to BEC zones and age classes.

The distribution of the major BEC zones for both the THLB and Non-THLB (together equalling the FMLB) are shown in Figure 4.

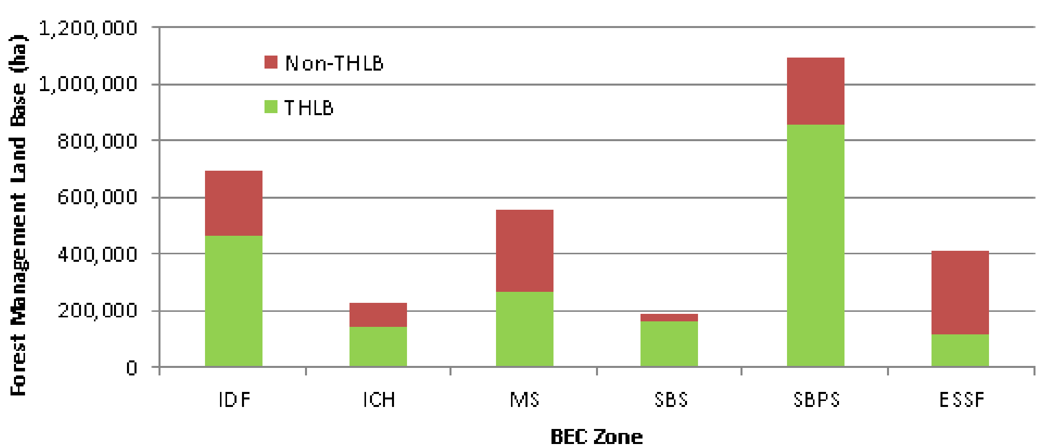

Figure 4 BEC zone distribution across the forest management land base

Considering the magnitude of area affected by the MPB and fire across the spectrum of age classes, we can expect a large shift of future stands into a narrow age class range. Once mature, these stands will become available for harvest again in a common period. It will be necessary to find ways to break up this age class cohort and minimize the risk of future MPB outbreaks.

After applying assumptions to reflect changes in stand age from disturbances (i.e., fire, insects and harvesting) the current age class distribution on both the THLB and Non-THLB are shown in Figure 5.

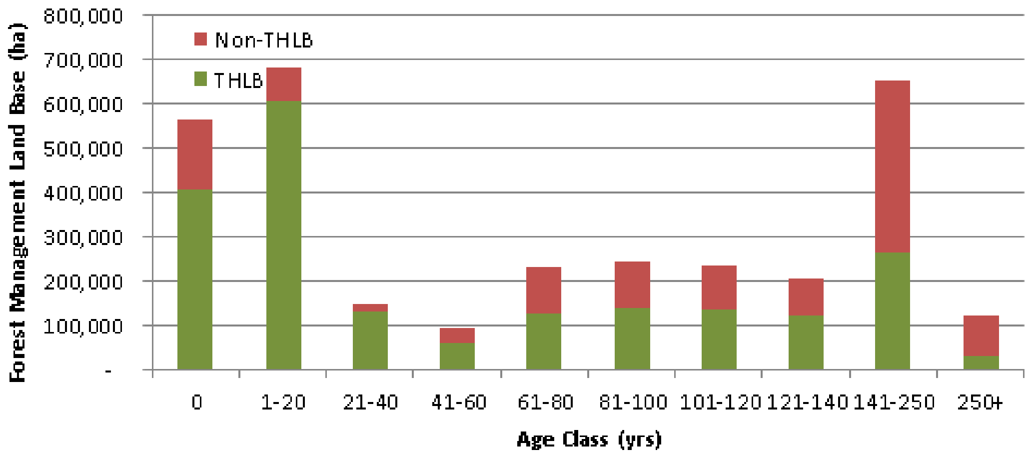

Figure 5 Age class distribution across the forest management land base

3.1.1 Non-TSA Ownership

Ownership considered outside of the TSA was identified using various data sources. For this analysis, the FMLB was spatially reduced for all areas identified as private land (40N), federal reserve (50N), indian reserve (52N), military reserve (53N), woodlots (77A, 77B), community forests (79B), and miscellaneous leases (99N).

Areas retained within the FMLB included: ecological reserves (60N), public reserves (61C, 61N), TSA lands (62C), provincial parks (63N), crown reserves (67N), and miscellaneous reserves (69C, 69N).

While not legally established, 22,938 hectares were also removed from the FMLB for the proposed Williams Lake Community Forest because District staff no longer issue cutting permits within this area.

3.1.2 Non-Forest and Non-Productive

Non-forest and non-productive areas were identified using the FMLB attribute (Y/N) provided in the forest inventory. This attribute is assigned as N in areas that have not been logged and the BCLCS indicates non forest types or forest types with an SI <5m).

3.1.3 Parks and Protected Areas

While the productive forest within parks and protected areas contribute to the FMLB, 593,375 hectares were removed from the THLB in this analysis. These areas included ecological reserve (60N), public reserves (61C), provincial parks (63N), crown reserves (67N), and miscellaneous reserves (69N).

After parks and protected areas are removed, areas remaining within the THLB included: TSA lands (62C) and miscellaneous reserves (69C).

While they are not legally established, 14,503 hectares for candidate Goal 2 protected areas were also excluded from the THLB. This reflects current management practice that excludes harvesting within these areas (i.e., No Cutting Permits Issued).

3.1.4 Environmentally Sensitive Areas

Areas designated in the previous FC1/FIP forest inventory with high environmental sensitivity are not normally available for sustained timber production. In this analysis, 212,517 hectares designated as highly sensitive areas for snow avalanche, forest regeneration and fragile or unstable soils, were removed from the THLB, unless they had a previous harvest history.

3.1.5 Low Productivity Stands

Low productivity stands cannot grow enough merchantable volume to make a harvest entry within a reasonable timeframe. In this case, these are stands whose merchantable volumes never reach the minimum harvest volume thresholds discussed in section 3.3.3.

The following criteria were used to identify and remove a total of 1,982,118 hectares of low productivity stands:

- Past harvesting has not occurred,
- Volume less than 100 m^3/ha for deciduous, 110 m^3/ha for pine and 150 m^3/ha for non-pine at any age, and
- Site indices less than those shown in Table 6 for each BEC Zone and leading species.

Table 6 Site index criteria for identifying non-merchantable stands

BEC Zone	Pine	Spruce	Douglas-fir	Other Conifer	Deciduous
BG	SI < 9.0	SI < 11.0*	SI < 11.4	SI < 11.0*	SI < 9.3
IDF	SI < 7.7	SI < 8.7	SI < 10.7	SI < 7.0*	SI < 10.6
ICH	SI < 8.7	SI < 9.6	SI < 10.7	SI < 8.8	SI < 9.8
SBS	SI < 9.2	SI < 10.0	SI < 10.8	SI < 7.0*	SI < 9.9
SBPS	SI < 7.5	SI < 8.9	SI < 10.5	SI < 7.0*	SI < 10.2
ESSF	SI < 9.1	SI < 11.1	SI < 11.0	SI < 7.0*	SI < 9.5
MS	SI < 9.3	SI < 11.2	SI < 10.6	SI < 7.2	SI < 9.9
CWH	SI < 7.5	SI < 11.0*	SI <9.3	SI < 7.2	SI < 8.6
MH	SI < 7.5	SI < 11.0*	SI < 9.1	SI < 7.0*	SI < 8.7

*Note: Using VDYP 7, these site indices reflect the yield thresholds where the required volume could no longer be attained (110 m^3/ha for pine, 150 m^3/ha for non-pine and 100 m^3/ha for deciduous). * denote estimates.*

3.1.6 Physically/Economically Inoperable

Terrain classification, steep slopes and site productivity criteria were used to identify areas deemed to be inoperable and unsuitable for conventional timber harvesting. Using Level C and D terrain mapping where it was available in the TSA, any unstable (U or 5), potentially unstable (P or 4) terrain was 100 % removed. Areas within potential initiation zones for slow and fast mass-movement were also removed.

Steep slopes that are unlikely to be harvested were also 100% removed from the THLB:

- West of the Fraser River where slopes exceed 40%; and
- East of the Fraser River where slopes exceed 70%.

Where cable harvest systems will be required for stands on slopes between 40-70% east of the Fraser River, larger trees/volumes are required to make harvesting economically viable. Accordingly, the following criteria were used to remove low volume stands in this area:

- Within LUs corresponding to the old Horsefly district on slopes east between 40% and 70%,
- Past harvesting has not occurred,
- Age ≥160 yrs and volume less than 200 m^3/ha; or
- Age <160 yrs and site indices less than those shown in Table 7.

Table 7 Site index criteria for identifying appropriate stands for cable harvest systems

BEC Zone	Pine	Spruce	Douglas-fir	Other Conifer	Deciduous
IDF	SI < 11.4	SI < 10.7	SI < 12.5	SI < 10.0*	SI < 16.8
ICH	SI < 12.9	SI < 12.3	SI < 12.4	SI < 7.0*	SI < 14.6
SBS	SI < 13.9	SI < 14.2	SI < 12.7	SI < 10.0*	SI < 14.6
SBPS	SI < 10.9	SI < 11.3	SI < 12.2	SI < 10.0*	SI < 16.0
ESSF	SI < 13.9	SI < 14.1	SI < 13.1	SI < 9.0*	SI < 14.1

*Note: Using VDYP 7, these site indices reflect the yield threshold where the required volume could no longer be attained (200 m^3/ha within 160 years). * denote estimates.*

A total of 660,494 hectares were removed from the THLB as physically or economically inoperable.

3.1.7 Wildlife Habitat

Various legal orders exist for wildlife habitat areas (WHA) and wildlife management areas (WMA) where harvesting is not permitted on 216,340 hectares – typically within wildlife habitat core areas. Table 8 lists the WHAs that were removed from the THLB in this analysis, including two proposed WHAs for grizzly bear.

Table 8 Spatial reductions for wildlife habitat areas

Species	WHA/WMA Identifiers	Total Hectares
Northern Caribou	5-118	41,206
Mountain Caribou	5-096, 5-102, 5-103, 5-104, 5-105, 5-106, 5-107, 5-109, 5-110, 5-112, 5-113, 5-114, 5-115, 5-117	172,443
Grizzly Bear	5-037, 5-038, 5-039, 5-040, 5-041, 5-042, 5-043 (5-068, 5-070)	1,996
Data Sensitive	5-003, 5-004, 5-005, 5-006, 5-072, 5-752	91
Marsh	Chilanko Marsh	604

Note: Identifiers in brackets indicate a proposed WHA or WMA

Unless specified in section 3.2.4, this analysis restricted harvesting in WHAs management area buffer zones.

3.1.8 Old Growth Management Areas

The CCLUP identified a total of 403,212 hectares of permanent, rotational and transitional Old Growth Management Area (OGMA). This analysis removed permanent and rotational OGMAs for the duration of the planning horizon. Transitional OGMAs were retained within the THLB (net area of 61,019 hectares) but made unavailable for harvest until 2030 and forest cover requirements to retain mature-plus-old stands were applied (see section 3.2.1).

3.1.9 Scenic Areas – Preservation VQO

The CCLUP designated various scenic areas to be managed to visual quality objectives (VQO). A total of 14,056 hectares designated as Preservation VQO were removed from the THLB because harvesting is very unlikely to occur in these areas due to the extremely restrictive limits on disturbance levels. Other types of VQOs were managed using forest cover disturbance constraints (section 3.2.3).

3.1.10 Lakeshore Management Class A

The CCLUP identified 19,169 hectares as Lakeshore Management Class A zones. Because of the no harvest objective within these areas, they were removed from the THLB. Other lakeshore management classes were applied as forest cover constraints (section 3.2.7).

3.1.11 Critical Habitat for Fish

The CCLUP identified a total of 51,643 hectares as critical habitat for fish where no harvest may occur – thus they were removed from the THLB.

3.1.12 Buffered Trail Areas

The CCLUP identified 50 meter management zones on either side of specified trails, totalling 46,013 hectares where at least 85% of the treed area must be retained. In this analysis, the buffered trail areas were spatially reduced by 100% for these areas.

3.1.13 Community Areas of Special Concern

The CCLUP identified 436,140 hectares as community areas of special concern where no harvest may occur. This analysis spatially reduced the THLB by 100% for these areas.

3.1.14 Riparian Zones

Riparian management areas were amalgamated from riparian buffers previously prepared for lakes, wetlands and streams within the Cariboo region. The widths shown in Table 9 for riparian reserve and riparian management zones along with the corresponding retention levels used for this analysis identified a total of 433,898 hectares of riparian management area.

Table 9 Riparian zone buffer widths and retention levels

Feature	Class	Reserve Zone		Management Zone	
		Buffer Widths	Retention Levels	Buffer Widths	Retention Levels
Lake	L1 - A	10	100%	30	25%
	L1 - B	10		30	
	L2 - C	10		30	
	L3 - D	10		30	
	L4 - E	10		30	
	U	10		30	
Wetland	W1	10	100%	40	25%
	W2	10	100%	20	
	W3	0		30	
	W4	0		30	
	W5	10	100%	40	
Stream	S1B	50	100%	20	50%
	S2	30	100%	20	50%
	S3	20	100%	20	50%
	S4	0		30	25%
	S5	0		30	25%
	S6	0		20	5%

For this analysis, riparian zones and retention levels were first assigned spatially within intersecting polygons and total riparian retention percent levels were calculated for each polygon. These percent levels were then joined back to the resultant dataset and managed as an aspatial netdown to each polygon. This approach significantly reduced the number of small polygons / slivers in the resultant dataset. The model set aside the designated percentage of each polygon's area as a reserve and tracked its age independently so that it can contribute toward non-timber objectives.

3.1.15 Roads, Trails, and Landings

A complete classified road network was not available for a spatial reduction to the THLB. Instead, the THLB area was reduced aspatially using the approach used described for the upcoming TSR (BC Ministry of Forests 2013). A total of 34,600 hectares were estimated to reflect the loss of productive forest land due to existing roads, trails and landings (RTL). When applied to the stands less than 70 years in age, the area removed for RTLs represented an aspatial reduction of 4.3%.

Reductions for future RTLs were estimated from the average on-block permanent access structures over the past 5 years. Aspatial reductions for both existing and future RTLs were applied as yield reductions in the model. These are shown in Table 10, along with corresponding area reductions for reference.

Table 10 Roads, trails and landings

RTL Type	Stand Description	THLB (1) (ha)	Aspatial Reduction	Area Reduction (2) (ha)
Existing	Age <70 years (roaded)	812,283	4.3%	34,928
Future	DCC - Age ≥70 years	695,057	3.4%	23,632
Future	DCH - Age ≥70 years	447,658	2.4%	10,744

(1) Area prior to aspatial netdowns for RTL and WTR

(2) Represents an aspatial netdown of approximately 69,304 ha - applied as yield reductions.

3.1.16 Wildlife Tree Retention

The CCLUP sets limits for wildlife tree retention by landscape unit (LU), BEC variant and species group resulting in 614 individual targets in the TSA. While some existing retention areas are available in RESULTS, they do not account for overlapping retentions to provide estimates of net WTR and thus were not used for tracking wildlife tree retention targets.

In this analysis, the THLB was aspatially reduced by 79,148 hectares by applying the CCLUP targets for WTR less all areas represented by riparian reserves within the THLB. Area-weighted average net WTR estimates were summarized for each forest district (DCC 3.6%, DCH 5.0%) and applied as aspatial reductions. These were incremental to all other netdowns and managed in the model the same as riparian retention (i.e., % of each polygon retained and tracked separately).

The model was not configured to retain additional stand level retention and structure in large-scale salvage operations because, although licensees retain additional area in these circumstances, they are expected to be available for harvest again within 20 to 30 years. Only wildlife tree retention areas are held for a full rotation.

3.2 NON-TIMBER MANAGEMENT ASSUMPTIONS

This section describes the criteria and considerations used to model non-timber resources.

3.2.1 Landscape-Level Biodiversity

To address landscape-level biodiversity the CCLUP established spatially-defined OGMAs. Accordingly, permanent and rotational OGMAs were removed from the THLB through the land base netdown process.

Transition OGMAs are a temporary designation meant to exist until the other contributing no-harvest areas in a LU develop into old forest. The model was configured to prevent harvesting within transitional OGMAs prior to 2030.

As well, minimum retention targets for mature plus old seral stages within the FMLB were applied according to the criteria provided in Table 11 and Figure 6. Consistent with the CCLUP, stands with >70% PL were modelled with this requirement only after the first 30 years of the planning horizon.

Table 11 Mature plus old seral requirements

			Minimum	Biodiversity emphasis (% Retention)		
BEC zone	**BEC variant**	**NDT**	**Mature Age**	**Low**	**Intermediate**	**High**
BG – Fd (1)	xh3, xw2,	4	100	22	43	65
BG – Other	xh3, xw2,	4	100	11	23	34
IDF– Fd (1)	dk3, dk4, dw, ww, xm, xw	4	100	22	43	65
IDF – Other	dk3, dk4, dw, ww, xm, xw	4	100	11	23	34
ICH	wk1, wk2, wk4	1	100	17	34	51
ICH	mk3	2	100	15	31	46
ICH	dkw, dw, mk1, mk2	3	100	14	23	34
ICH	Xw	4	100	17	34	51
MS	dc2, dv, xk3, xv	3	100	14	26	39
SBS	wk1	2	100	15	31	46
SBS	dw1, dw2, mc1, mc3, mh, mw	3	100	11	23	34
SBPS	dc, mc, mk, xc	3	100	8	17	25
ESSF	wc3, wcw, wk1	1	120	19	36	54
ESSF	mm1, mw, xv1, xv2, xvw	2	120	14	28	42
ESSF	dvw, xc3, xcw	3	120	14	23	34
CWH	Un	1	80	18	36	54
CWH	ds1, ms1	2	80	17	34	51
MH	mm2	1	120	19	36	54

(1) Fd identified using species group designation

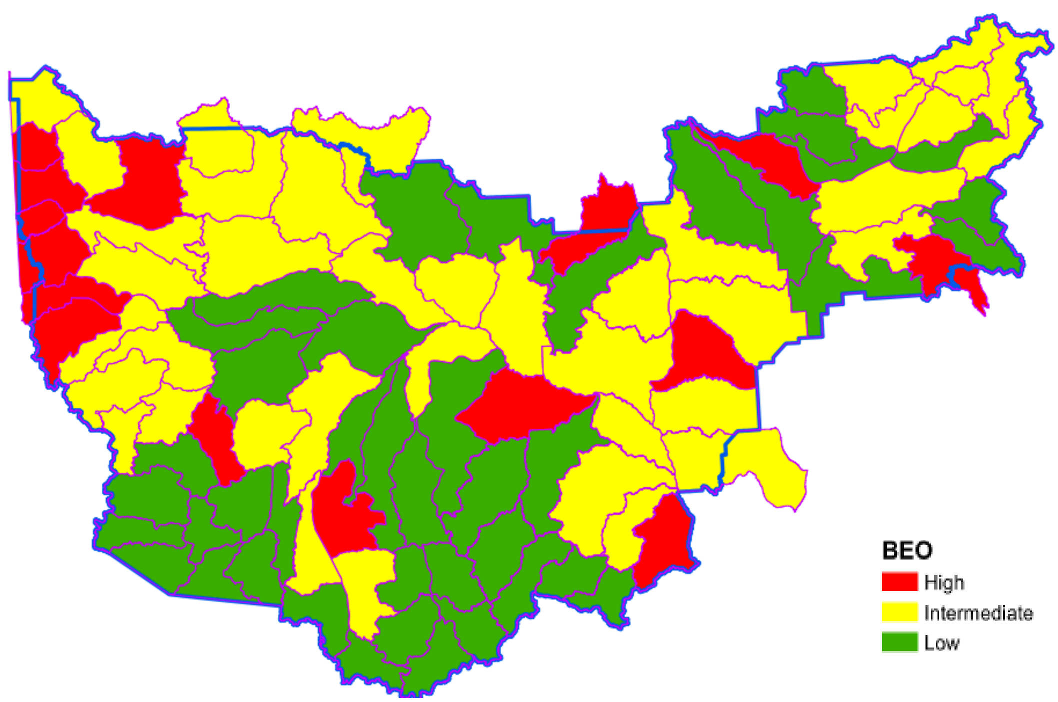

Figure 6 Landscape Units and Biodiversity Emphasis Option

3.2.2 Stand-Level Biodiversity

To address stand-level biodiversity, the CCLUP established wildlife tree retention targets by LU, biogeoclimatic ecosystem variant and species group. This results in 714 units with 421 individual targets within the Williams Lake TSA. These targets were not modeled in this analysis in favour of the landbase netdown described earlier in section 3.1.16.

3.2.3 Scenic Areas

The CCLUP identified over1,400 scenic areas or VQO polygons within the Williams Lake TSA THLB that require maintenance of visual quality objectives (VQO). During harvest design, maximum denudation limits are considered for each individual VQO polygon. To simplify this constraint for modelling, mid-point disturbance limits were applied to VQO classes within each LU (see Table 12).

Table 12 Maximum percent denudation by visual quality objective

Visual Quality Objectives	Number of Visual Polygons in THLB	Maximum Denudation calculated by VQO class in a LU	VEG Height
Retention	332	1.1% to 5% (mid 3.0%)	6.0 metres
Partial Retention	817	5.1% to 15% (mid 10.5%)	5.5 metres
Modification	299	15.1% to 25% (mid 20.5%)	5.0 metres

Note: these limits are applied to VQO classes by LU.

Visual recovery from the denudation occurred when stands achieved the visually effective green-up (VEG) height. For each analysis unit, Site Tools (Version 3.3) was used derive ages for the VEG heights.

3.2.4 Wildlife Habitat Areas and Ungulate Winter Ranges

A variety of Wildlife Habitat Areas (WHAs) and Ungulate Winter Ranges (UWR) were established within the study area. General wildlife measures and appropriate modelling assumptions for these spatially-defined areas are summarized in Table 13. To achieve the required forest cover conditions timber harvesting was implemented as partial harvesting treatment regimens thus no forest cover constraints were necessary. Silvicultural systems are discussed further in section 3.5.18 and Appendix 2.

Table 13 Modelling assumptions to address modified harvest within wildlife habitat areas

Habitat ID	Specific Sites	Treatment	Modelling Approach
Northern Caribou			
5-086	Terrestrial lichen sites	Irregular group selection (80% of the modified harvest area)	50% minimum retention of stands greater than 70 years or 140 year rotation with 2 entries
5-086	Arboreal lichen sites	Partial harvest (20% of the modified harvest area)	33% minimum retention of stands greater than 80 years or 240 year rotation with 3 entries
Mountain Caribou			
5-093, 5-111		Group selection harvest	33% maximum harvest on an 80 year cutting cycle or 240 year rotation with 3 entries
Mule Deer (Note that some ungulate winter range units occur in both snowpack zones)			
u-5-002	**Shallow/Moderate SZ** (1)		
	○ Low SSHC (2)	Uniform selection harvest	33% maximum harvest on a 30 year cutting cycle or 90 year turnover with 3 entries
	○ Moderate SSHC (2)	Uniform selection harvest	25% maximum harvest on a 30 year cutting cycle or 120 year turnover with 4 entries
	○ High SSHC (2)	Uniform selection harvest	20% maximum harvest on a 30 year cutting cycle or 150 year turnover with 5 entries
u-5-002	**Transition/Deep SZ** (1)		
	○ Low SSHC (2)	Group selection harvest Regenerating to Douglas-fir	33% maximum harvest on a 40 year cutting cycle or 120 year turnover with 3 entries
	○ Moderate SSHC (2)	Group selection harvest	25% maximum harvest on a 40 year cutting

Habitat ID	Specific Sites	Treatment	Modelling Approach
		Regenerating to Douglas-fir	cycle or 160 year turnover with 4 entries
	○ High SSHC (2)	Group selection harvest Regenerating to Douglas-fir	20% maximum harvest on a 40 year cutting cycle or 200 year turnover with 5 entries
American White Pelican			
5-007, 5-008, 5-011, 5-014, 5-015, 5-020, 5-021, 5-022, 5-023, 5-024, 5-029, 5-031, 5-034		Access restrictions and harvest timing restrictions only	Not applicable
Data Sensitive 5-003, 5-004, 5-005, 5-006, 5-072, 5-752		Timing restrictions within management area buffers	Not applicable

Note: the simplified modelling approaches attempt to mimic rather than replace prescribed treatment measures
(1) SZ = Snowpack Zone
(2) SSHC = Stand Structure Habitat Class

3.2.5 Grizzly Bear

The CCLUP identified grizzly bear habitat apart from WHAs that require retention of security cover adjacent to critical foraging habitats. As current practice addresses this objective through placement of wildlife tree retention areas, this analysis did not incorporate any further constraints associated with the grizzly bear units.

3.2.6 High Value Wetlands for Moose

The CCLUP identified high value wetlands for moose that require sufficient retention for security and thermal cover. As most wetland buffers are removed from the THLB and current practices address this objective through placement of wildlife tree retention areas, this analysis did not incorporate any further constraints associated with the high value wetlands for moose.

3.2.7 Lakeshore Management Classes

The CCLUP identified areas around key lakes that must be managed according to specific visual quality objectives. Accordingly, the model was configured to apply clearcut treatments with maximum disturbance limits shown in Table 14. To simplify this constraint, these limits were applied for lakeshore management class and LU combination rather than each individual lakeshore management zone. The visually effective green-up height was set to 5.0 metres. Lakeshore management class A zones were removed from the landbase during the netdown process (see section 3.1.10).

Table 14 Maximum percent denudation by lakeshore management class

Lakeshore Management Class	Visual Quality Objectives	Partial Cutting Maximum Denudation calculated by LU	Clear Cutting Maximum Denudation calculated by LU	Visually Effective Green-up Height
A	Preservation	0%	0%	
B	Retention	20%	10%	
C	Partial Retention	40%	20%	5.5 metres
D	Modification	60%	30%	
E	Modification	100%	50%	

3.2.8 Birch Areas for First Nations

First Nations cultural use of birch trees was accommodated in the CCLUP by designating areas where at least 40 percent of the existing mature birch must be maintained. To simplify this constraint in the model, all birch-leading and birch-secondary stands within the designated areas were excluded from the analysis. These stands total 2,958 hectares and over 42% of the FMLB within the designated birch areas.

3.2.9 Hydrology

The level of disturbance in a watershed can impact stream flows, sediment delivery, channel stability, riparian function and aquatic habitat. Assessing equivalent clearcut areas (ECA) is a coarse-level indicator of forest disturbance and recovery in a watershed. For this analysis, ECAs were assessed in each watershed reporting unit using a single ECA height recovery curve for logged areas as shown in Table 15.

Table 15 Criteria for estimating hydrological recovery

Time since harvest (yrs)	Stand Height Minimum (m)	Stand Height Maximum (m)	Hydrologic Recovery (%)	Equivalent Clearcut Area (%)
0-12	0.0	3.0	0	100
13-17	3.0	5.0	25	75
18-21	5.0	7.0	50	50
22-25	7.0	9.0	75	25
26-32	9.0	12.0	90	10
>33	**>12**	**n/a**	**100**	**0**

Significant uncertainty exists regarding the hydrologic impact of dead pine trees and residual forest canopy, but it is clear that snow interception and shading can be considerably reduced for stands attacked by MPB. As well, incomplete information on existing advanced regeneration makes it difficult to estimate the rate of hydrologic recovery of these stands.

In this analysis, the <u>pine proportion</u> of any unsalvaged stand impacted by MPB (>40% Pl) was assigned an ECA value shown in Table 16. Immediately after attack these stands contribute little towards ECAs. After 15 years, however, they contribute much like a clearcut, before they recover through natural regeneration; approximated here based on professional judgement.

Table 16 Criteria for estimating hydrological impact on MPB-attacked stands

Time since attack (yrs)	Equivalent Clearcut Area (%)	Time since attack (yrs)	Equivalent Clearcut Area (%)
0-2	10	20-25	90
3-4	30	26-35	75
5-8	50	36-45	50
9-10	70	46-55	25
11-15	85	55+	0
16-19	90		

Note: For pine stands greater than 80 years of age.

Watershed reporting units were assigned at two levels: watersheds and basins. Watersheds cover the entire TSA while basins are overlapping subunits of watersheds. Only a portion of the TSA is covered by the basins selected for modeling (areas of concern). Basins are typically used for assessing ECAs for operational planning purposes. The watershed reporting units and maximum ECA limits applied in the model are shown in Table 17. ECAs do not directly pose constraints on harvesting but can act as red flags to identify when professional hydrologists should be consulted for management recommendations. Disturbance limits used in operational circumstances typically vary by watershed and basin relative to professional hydrologic recommendations. The maximum ECA values shown here represent levels above 'red flag' levels and are expected to approximate typical conditions where harvesting would be curtailed in most watersheds/basins.

Table 17 ECAs for watershed reporting units

	Maximum ECA	Watershed Reporting Units
Watersheds	50%	Atnarko River, Beaver Creek, Big Bar Creek, Big Creek, Caribou River, Chilanko River, Clisbako River, Dog Creek, Hawks Creek, Homathco River, Horsefly River, Klinaklini River, Lower Chilcotin River, Lower Dean River, Mackin Creek, Middle Fraser, Mitchell River, Narcosli Creek, Niagara Creek, Quesnel River, San Jose River, Taseko River, Twan Creek, Upper Chilcotin River, Upper Chilko River, Upper Dean River, Upper Eutsuk Lake, Upper Nazko River
Basins	40%	Alexis Creek, Alkali Creek, Anahim Creek, Aneko Creek, Beece Creek, Beedy Creek, Bidwell Creek, Big Lake Creek, Brittany Creek, Chimney Creek, Choate Creek, Clinchintamoan Creek, Clusko River, Downton Creek, Elkin Creek, Grain Creek, Gravel Creek, Haines Creek, Hazeltine Creek, Keithly Creek, Little Horsefly River, Little River, Lord River, MacKay River, McKinley Creek, McKusky Creek, McLeese Creek, Meldrum Creek, Mid Chilko Lake, Minton Creek, Moffat Creek, Moore Creek, Morehead Creek, Nemaia Creek, North Chilcotin, Nuntsi Creek, Palmer Creek, Penfold Creek, Punkutlaenkut Creek, Puntzi Creek, Rainbow Creek, Ramsey Creek, Riske Creek, Roaring River, Spanish Creek, Spusks Creek, Sword Creek, Taate Angela Creek, Tatla Lake Creek, Tautri Creek, Tchaikazan River, Tingley Creek, Twan Creek, Upper Chilanko River, Upper Chilko River, Upper Clisbako Creek, Upper Hawks Creek, Upper Horsefly River, Upper Mackin Creek, Upper Narcosli Creek, Upper Taseko River, Zenzaco Creek
Community Watershed	30%	Nemaia, Rim Rock, Weetman, Harold

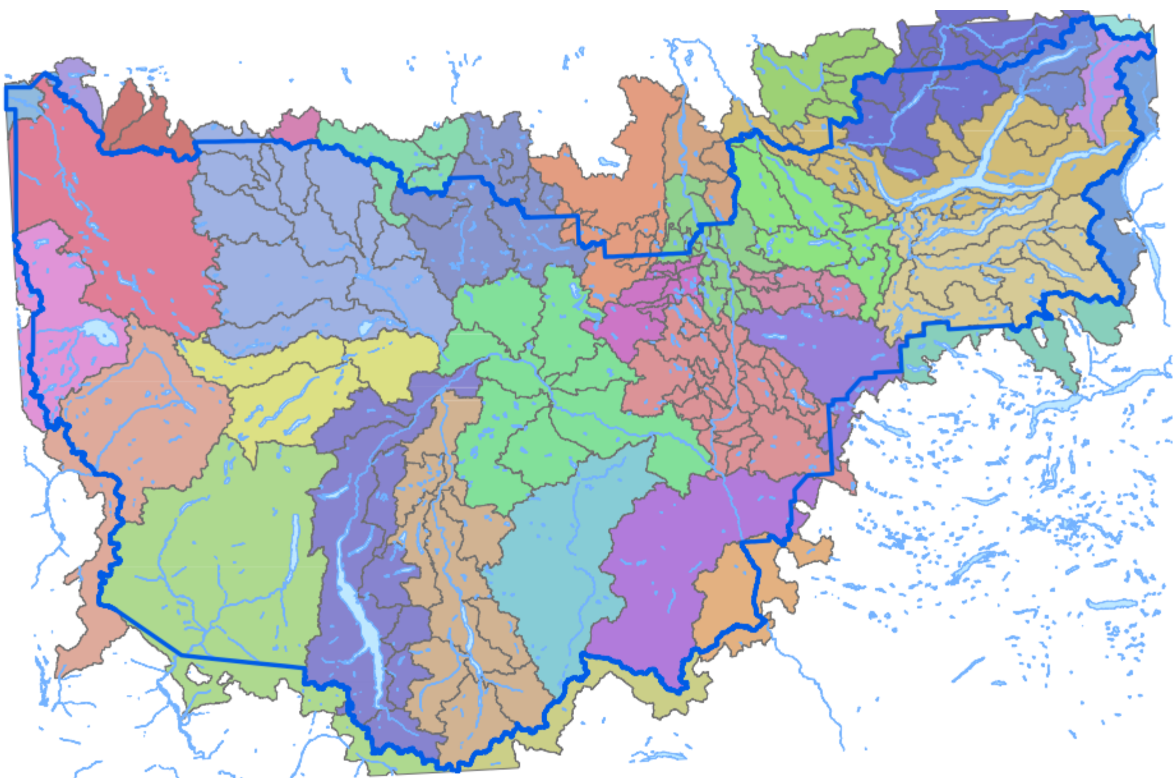

Figure 7 Watershed units (colour theme) and basins (internal lines) for ECA assessments

3.2.10 Other Resource Features

Various resource features for cultural and archaeological sites, and research installations (e.g., permanent sample plots) that exist throughout the TSA are considered and typically protected within reserve areas during operational planning. Accordingly, no further modelling assumptions were applied for other resource features in this analysis.

3.3 Harvesting Assumptions

This section describes the criteria and considerations used to model timber harvesting activities.

3.3.1 Utilization Levels

The minimum merchantable timber specifications for all species and analysis units (natural and managed) are shown in Table 18.

Table 18 Utilization Levels

Leading Species	Minimum Diameter at Breast Height	Maximum Stump Height	Minimum Top Diameter Inside Bark
All Species	12.5 cm	30.0 cm	10.0 cm

3.3.2 Volume Exclusions

No species-specific volume exclusions were applied in this analysis.

Volume from deciduous species in predominately coniferous stands is typically not harvested today but this may present future harvest opportunities. Accordingly, merchantable volumes for both deciduous and coniferous stand types were tracked and reported in the analysis. Harvest levels were set to target coniferous volumes while deciduous volumes harvested were considered incidental.

3.3.3 Minimum Harvest Criteria

Minimum harvestable criteria are used to determine the age when stands become available for harvesting. In preparation for the upcoming TSR3, a study of harvested volumes between 1997 and 2009 suggested minimum merchantable harvest volumes of 80 m^3/ha (sawlog + pulp) for pine leading and 120 m^3/ha for other leading species. Only a small percentage (~10%) of historic harvest was coming from stands with these low volumes.

For this analysis, additional criteria were introduced for post-salvage stands: a) consider minimum sawlog volumes rather than total merchantable volumes, and b) increase minimum volumes where cable harvest systems are needed (Table 19 and section 3.1.6).

Pulpwood volumes make up an increasingly larger % of merchantable volume as stand age/volume decrease. For example, a 40 year old Pl plantation containing 80 m^3/ha of merchantable volume contains many small diameter, short stems. Only a proportion of these stems contain 16 foot sawlogs, leaving a significant volume in short logs and pulp. Minimum harvest volumes were adjusted so that 80 m^3/ha of sawlog is achieved for pine stands (110 m^3/ha merchantable volume), and 120 m^3/ha of sawlog is achieved for non-pine stands (150 m^3/ha merchantable volume).

The model will only harvest stands whose merchantable volumes meet these minimum thresholds now or sometime in the future.

Table 19 Minimum harvest thresholds

	Clearcut [1]		Partial Cut [1]	
Stand Types	<= 40% Slope (ground)	> 40% Slope (cable)	<= 40% Slope (ground)	> 40% Slope (cable)
Pine-Leading (Salvage) [2]	80 m^3/ha	200 m^3/ha		
Pine-Leading	110 m^3/ha	200 m^3/ha	150 m^3/ha	450 m^3/ha
Non-Pine Leading	150 m^3/ha	200 m^3/ha	(50 m^3/ha removal)	(200 m^3/ha removal)
Deciduous Leading	100 m^3/ha	200 m^3/ha		

(1) Minimum merchantable volumes as standing stock. Volumes removed equal the total volume divided by number of passes.
(2) Lower thresholds were applied throughout the salvage period to reflect the larger trees present within decaying pine stands.

A sensitivity analysis will also be undertaken to include an additional minimum harvest criteria that requires stands to attain at least 90% of the cumulative mean annual increment (CMAI - see section 4.1).

3.3.4 Harvest Profiles

Harvest profiles were configured in the model to track or limit harvest profiles were being achieved for each time period.

3.3.4.1 Small Pine Profile

A small pine-leading product profile was applied in the model to track the harvest from pine-leading stands less than 125 m^3/ha. This harvest profile is intended to complement the minimum harvest criteria (section 3.3.3) to ensure that the annual harvest does not comprise an unreasonable amount of small pine products.

When a stand is harvested, its volume is compared to the small pine profile, and then tallied into the profile if it meets the criteria. This small pine volume is then compared to the total harvest volume to evaluate the harvest flow for the small pine product profile.

If the model harvests a significant amount of small pine in any period, then a maximum harvest percentage (between 20% and 50%) may be applied to limit the harvest from this profile. A sensitivity analysis will also be undertaken that adjusts the harvest thresholds relative to distances from processing facilities – principally at Williams Lake (see section 4.3).

3.3.4.2 Haul Distance Profile

This harvest profile is intended to monitor the harvest pattern is across the landbase. A haul distance profile was applied in the model to report, rather than limit, the harvest contribution from five cycle time zones: <3 hours; ≥3 and <5 hours; ≥5 and <7 hours; ≥9 and <9 hours; ≥9 hours (see Figure 8). These cycle time zones were originally established from a single point of appraisal for the TSA – in this case at Williams Lake – so new or proposed facilities in the western portion of the TSA are not specifically considered in this harvest profile. Instead, the model was configured to harvest a minimum annual rate of 250,000 m^3/yr from the ≥9 hour cycle time zone to supply mills at Anahim Lake and to a lesser extent, Hanceville.

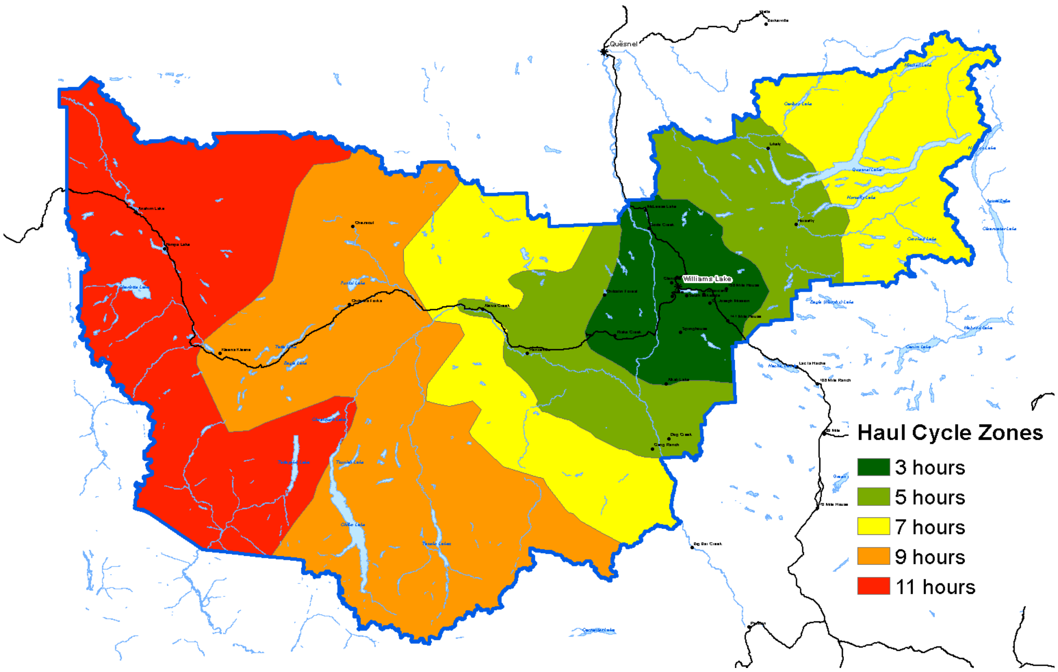

Figure 8 Haul cycle time zones

3.3.4.3 Product Profile

Modelling products distributions delivered to the mill is a complex and often criticized exercise. The considerations required for this are not trivial: stand-level variations for predicting products on the stump, harvesting practices, preferred log specifications specific to each manufacturing facility. This is further complicated by the damage from insects – particularly shelf-life, and other disturbances (e.g., piece size, decay, checking, and blue-stain).

Rather than categorizing harvested products as a model input, this analysis tracked and reported leading species harvested by age class. Through a post-processing exercise, product distributions were then combined with the harvest summaries (as a model output). Table 20 shows the preliminary product distributions applied. With this approach, one can easily adjust the product distribution with specific assumptions to generate new product profiles.

Table 20 Preliminary product distributions by age class and species group

Age Class	Peeler/ Premium	Sawlog	Pulp/ Biomass	Peeler/ Premium	Sawlog	Pulp/ Biomass
		Dead Pl			**Live Pl**	
≥40 to <60			100%		85%	15%
≥60 to <80			100%		92%	8%
≥80 to <120			100%		95%	5%
≥120 to <200			100%	1%	96%	3%
≥200			100%	2%	96%	2%
		Spruce/Balsam			**Douglas-fir**	
≥40 to <60		40%	60%		65%	35%
≥60 to <80		60%	40%		85%	15%
≥80 to <120	4%	71%	25%	5%	90%	5%
≥120 to <200	8%	76%	16%	10%	85%	5%
≥200	10%	80%	10%	25%	70%	5%

Age Class	Peeler/ Premium	Sawlog	Pulp/ Biomass	Peeler/ Premium	Sawlog	Pulp/ Biomass
		Cedar			Hemlock	
≥40 to <60		93%	7%		83%	17%
≥60 to <80	7%	89%	4%		90%	10%
≥80 to <120	35%	63%	2%	5%	88%	7%
≥120 to <200	62%	37%	1%	25%	70%	5%
≥200	69%	30%	1%	35%	61%	4%

Note: these figures are preliminary estimates that can easily be modified and incorporated into a post-modelling process

As this approach applies product distributions through a post-modelling process, the model was not configured regulate the harvest flow for any specific product, or combination of species and age class.

3.3.5 Silvicultural Systems

The most common silvicultural system implemented within the TSA is clearcut with reserves. However, shelterwood systems were modelled in dry-belt Douglas-fir units outside of MDWR to improve regeneration performance and selection systems were modelled to address general wildlife measures within:

- MDWR fir-leading stands (within dry-belt fir), according to snowpack zone and stand structure habitat class, and
- WHAs requiring modified harvesting practices (i.e., Northern Caribou according to terrestrial/arboreal lichen sites and Mountain Caribou).

The modelled silvicultural systems simplified prescribed harvest treatments with unique responses. Yield curves for each silvicultural system treatment were developed for future managed stands. The approach applied to model these treatments is shown Appendix 2. Table 13 shows the criteria used within wildlife habitat areas while growth and yield assumptions are discussed in section 3.5.18.

3.3.6 Patch Size Distribution

The model was configured to create, where possible, patches that are consistent with very young seral (<20yr) patch size distributions as defined in the Biodiversity Guidebook. This is meant to control the spatial distribution of harvest on the landbase while avoiding strict 40 hectare green-up rules and or unrealistically sized harvest openings. This objective was not active during the first 20 years of the planning period.

Patches were defined as contiguous areas less than 20 years of age. Stands within 50 metres of each other were considered to be contiguous so patches could be made up of a single cutblock or an aggregation of cutblocks close together.

Patch size targets were applied by forest district (DCH/DCC) according to NDTs shown in Table 21.

Table 21 Patch size targets by forest district

		Patch Sizes (ha)			Target Forested Area (%)		
NDT	BEC Unit	Small	Medium	Large	Small	Medium	Large
1	ESSFwc/wk, ICHwk, MHmm, CWHun	<40	40-80	80-250	30-40	30-40	20-40
2	ESSFxv/mw, ICHmk, SBSwk, CWHds/ms	<40	40-80	80-250	30-40	30-40	20-40
3a	MS, SPBS, SBSdw/mc/mh/mw	<40	40-80	80-250	20-30	25-40	30-50
3b	MS, SPBS, SBSdw/mc/mh/mw	<40	40-250	250-1000	10-20	10-20	60-80
4	BG, IDF	<40	40-80	80-250	30-40	30-40	20-30

Note: Only early seral stands (Age <20 years) were modelled; target sizes/% adopted from the biodiversity guidebook.

3.4 Incorporating Related Strategies

This section describes the criteria and considerations used to incorporate elements from other related strategies into the model.

3.4.1 Wildfire Management Strategy

Wildfire management strategies aim to encourage healthier ecosystems, reduce the risk of loss to communities, address climate change and enable more cost-effective fire response. The five goals for these strategies are to:

- Reduce the hazards and risks associated with wildland fire in and around communities and other high-value areas.
- Plan and implement careful use of controlled burning in appropriate ecosystems under suitable conditions to reduce hazards and risks and achieve healthy forests and grasslands.
- Monitor wildfires occurring in areas where there is minimal risk to identified values and intervene when appropriate to reduce hazards and risks and ensure optimum use of fire suppression budgets and personnel.
- Ensure that plans adequately consider the management of wildland fire at all appropriate scales in order to reduce hazards and risks, achieve healthy forests and grasslands and ensure resource-efficient fire suppression.
- Develop a high level of public awareness and understanding about wildland fire and its management in order to garner support for proactive and resource-efficient wildland fire and fuels management (including policies, planning and on-the-ground actions).

In some cases, the wildfire management strategies will seek to continue or reinstitute the use of fire to remove logging slash and support achievement of silviculture objectives. In this analysis, however, no specific land base or modeling assumptions were incorporated to account for wildfire management strategies.

3.4.1 Fuel Management Strategy

Fuel management strategies aim to minimize the impacts of fire in the urban-rural interface surrounding communities. While an Interface Fire Plan was prepared for areas in the vicinity of Williams Lake, specific actions were deemed too detailed to include in this forest-level analysis. Typically, fuel management strategies are considered in more detail when silviculture treatment prescriptions are prepared. Accordingly, no land base or modeling assumptions were incorporated to account for fuel management strategies in this analysis.

3.4.2 Forest Health Strategy

Forest health strategies aim to recommend actions to address forest health issues. The list of significant forest health agents and current strategies is shown in Table 22.

Table 22 Forest health agents and strategies

Category	Agents	Strategy
Bark Beetles	Mountain pine beetle	Salvage
	Douglas-fir beetle	Suppression
	Spruce beetle	Suppression
Defoliators	Western spruce budworm	Treat moderate and severely defoliated high-value stands with Btk.
	Gypsy moth	Monitor
	Aspen serpentine leaf miner	Monitor

Category	Agents	Strategy
	Two year cycle budworm	Monitor
	Western hemlock looper	Monitor
	Weevils	Monitor individual stands affected
Diseases	Lophodermella needle cast	Monitor
	Elytroderma needle cast	Monitor and document damage
Root Diseases	Armillaria	Monitor and treat detected infestation areas
	Tomentosus	
	Laminated root rot	
Rusts	Comandra blister rust	Monitor young stands
	Stalactiform blister rust	
	Western gall rust	
Dwarf Mistletoe	Lodgepole pine dwarf mistletoe	Monitor young pine stands and conduct post-harvest sanitation thinning to limit the spread of disease
Abiotic Injuries	Windthrow	Harvest Douglas-fir and spruce within one year
	Drought and flood damage	Monitor
	Wildfire	Monitor and treat affected areas as appropriate

Suppression is the most aggressive forest health strategy while salvage is intended to minimize value loss. One of the key forest health strategies that can protect stands contributing to the mid-term timber supply is to treat Douglas-fir stands attacked by western spruce budworm.

For this analysis then, growth and yield assumptions were developed for mountain pine beetle, Douglas-fir beetle and Spruce bark beetle. These are discussed in more detail under various headings in sections 3.5.15, 3.5.17 and 3.6.2.

3.4.3 Protecting Secondary Structure

Section 43.1 of the Forest and Range Practices Act Forest Planning and Practices Regulation requires forest licensees to protect secondary structure (i.e., understory advanced regeneration and non-pine canopies) in MPB affected areas. These areas are typically considered during operational planning and protected as harvest reserves.

Since areas temporarily protected for secondary structure will ultimately be harvested, they are assumed to remain within the THLB. Furthermore, no constraints or treatments were incorporated in this analysis as secondary structure attributes are not readily available at a forest level and a process for identifying, protecting and tracking potential or actual stands retained as secondary structure does not currently exist.

3.4.4 Enhanced Retention Strategy

In the latest AAC rationale, the Chief Forester encouraged district staff and licensees to monitor green up and the level of retention across the landscape. He also encouraged development of a landscape-level retention strategy based on guidance on retaining forest structure in large-scale salvage operations.

A landscape level retention strategy is not currently available in the Williams Lake TSA but as these enhanced retention areas are only temporary they are still considered within the THLB. For this analysis, no areas were excluded for enhanced retention beyond those already considered in section 3.1.16.

3.4.5 Wildlife Habitat Mapping

Based on predictive ecosystem mapping, the BC Ministry of Environment is creating habitat models for moose, mountain caribou, northern caribou, mule deer, elk, white-tailed deer, grizzly bear, marten, lynx, three-toed woodpecker, and northern goshawk. The draft habitat maps from these models were not available in time for inclusion with this analysis but our results may be incorporated back into the habitat model later to identify areas where silviculture treatments might improve or exacerbate the situation. At this time, specific silviculture-related strategies to address wildlife habitat were not available.

3.4.6 Climate Change

Rapid change in climate is an overarching pressure on the forests affecting both timber and environmental values. Collaborative work with UBC and the ability to use previous climate change work (Kamloops Future Forest Strategy, 2012 and San Jose Watershed RAC project, 2012) can help identify pending vulnerabilities and potential management strategies.

Developing strategies for adapting to climate change is difficult due to the complexities of forest ecosystems and uncertainties of the potential impacts. For the Williams Lake TSA, a formal strategy is not yet in place to address changes in tree species occurrence, impacts of forest pests and forest productivity over mid- and long-term planning horizons. While this is an important topic to consider for identifying future regeneration opportunities, these changes were not explored in this analysis.

3.5 Growth and Yield Assumptions

Growth and yield assumptions describe how net volumes for natural and managed stands are developed and incorporated in the model. They also describe changes in other tree and stand attributes over time (e.g., height, tree diameters, presence of dead trees, etc.).

3.5.1 Analysis Unit Characteristics

Stands were grouped into analysis units (AU) to reduce the complexity and volume of information in the model and for assigning potential treatments and transitions to yield curves following harvest. The analysis units are complex because of the desire to reflect MPB impacts, secondary structure, past silvicultural investments, and potential future silviculture investments. For example, only stands in specific BEC zones and post-harvest regenerated (PHR) site index classes were eligible for fertilization. The criteria used to group stands are provided in Table 23.

Table 23 Criteria used to group stands into analysis units

Existing Stand Type	Future Stand Type (Transition)
Existing Natural Stands (1,000,000 series) o BEC (BG/IDF, MS, SBPS, SBS, ICH/CWH, ESSF/MH/BAFA/IMA) o Leading species groups (Pl, Fd, Sx/Bl/Ba, Cw/Hw, Decid) o Site productivity (PHR SI for Pine @ SI <19, ≥19&<25, ≥25; PHR SI for Non-pine @ SI <15, ≥15&<24, ≥24) o % Stand Dead (<20, ≥20&<40, ≥40&<60, ≥60&<80, ≥80) o Year of Death (VRI Disturbance date) o Age class for MPB attacked stands (5 yr increments) o Secondary Structure Class (None, L, M, H) o Clearcut or Partial Cut (Dry-Belt Fd, MDWR, Caribou) o Ground vs. Cable harvest systems (different Min Harvest Ages) o Wildfire Impact (Regeneration delay if not salvaged) o Dry-belt Fd stand types (subdivisions of IDF, Fd Leading in MDWR)	Future Managed Stands (3,000,000 series) Clearcuts o BEC (BG/IDF, MS, SBPS, SBS, ICH/CWH, ESSF/MH/BAFA/IMA) o Leading species (Pl, Fd, Sx, Cw/Hw) o Site productivity (PHR SI for Pine @ SI <19, ≥19&<25, ≥25; PHR SI for Non-pine @ SI <15, ≥15&<24, ≥24) o Planted vs. Natural Regeneration Partial Cuts (IDF, MDWR, Caribou) o Use curves for existing natural stands adjusted for harvest entries
Existing Managed Stands (2,000,000 series) o BEC (BG/IDF, MS, SBPS, SBS, ICH/CWH, ESSF/MH/BAFA/IMA) o Leading species (Pl, Fd, Sx/Bl/Ba, Cw/Hw, Decid)	Future Managed Stands (4,000,000 series) Same criteria as existing managed stands (i.e., transition onto the same yields)

Existing Stand Type	Future Stand Type (Transition)
○ Site productivity (PHR SI for Pine @ SI <19, ≥19&<25, ≥25; PHR SI for Non-pine @ SI <15, ≥15&<24, ≥24) ○ Density class (SPH <700, ≥700&<1000, ≥1000&<2500, ≥2500&<10000, ≥25000) ○ Age class for MPB attacked stands (5 yr increments) ○ Planted vs. Natural Regeneration ○ Wildfire Impacted ○ MPB Impacted ○ Past Incremental Treatments (Spaced, Fertilized)	

A detailed list of the analysis units and TIPSY inputs is provided in Appendix 1.

For existing natural stands, a VDYP yield was first generated for each forest polygon then area-weighted averages of these curves were calculated according to the assigned AUs. For MPB-impacted stands, yield curves were also adjusted to reflect the future trajectories for both live and dead portions of the stand using the average dead/live ratio from the forest inventory for the stands in the AU (max 20% span in any AU).

3.5.2 Stand Projection Models

Yield curves developed for the forest estate model were prepared using the following stand projection models:

- Existing natural stands: Variable Density Yield Prediction (VDYP) 7
- Existing and future managed stands: Table Interpolation Program for Stand Yields (TIPSY) 4.2
- IDF, Douglas-fir leading outside MDWR (Shelterwood silvicultural system): TISPY 4.2
- IDF, Douglas-fir leading inside MDWR: VDYP net volumes (benchmarked using PrognosisBC v 4.2)

3.5.3 Decay, Waste, and Breakage

For natural stands, default reductions to stand volume for decay, waste and breakage were applied to the VDYP7 model for Forest Inventory Zones D, G and H. Reductions for decay, waste and breakage are also incorporated in the TIPSY model for managed stands as operational adjustment factors (section 3.5.5) that affect both the magnitude and the shape of the yield curve.

3.5.4 Managed Stand Definition

To project stand growth and yield, stands are classified as natural or managed stands based on their silviculture regime. Natural stands were established naturally under various scenarios that affect the timing and stocking of stands while managed stands are post-harvest regenerated based on specific silviculture treatments. In this analysis, post-harvest regenerated (PHR) stands established after 1965 (≤46 yrs old) and within the THLB were assumed to be managed while those established prior to 1965 were handled as natural stands. For some analysis units, however, this was adjusted for recent natural disturbance events.

3.5.5 Operational Adjustment Factors Applied to Managed Stand Yields

The TIPSY projection model reports the potential yield of a specific site, species and management regime. Operational adjustment factors (OAFs) were applied to reflect the operational environment accordingly:

- OAF1 of 15% to address a constant reduction for unmapped stocking gaps (e.g., non-productive areas, management effects, and losses due to forest health and random risk factors).
- OAF2 of 5% to address dynamic reductions over the life of the stand such as decay, waste and breakage and some forest health concerns.

3.5.6 Site Index Assignments

Managed stand site index reflects the potential productive capacity of a stand. The inventory site index was used as the site productivity input to develop yield curves for existing natural stands while the managed site index was used for existing managed and future managed stands.

For this analysis, site index for managed stands was calculated as area-weighted averages from provincial site productivity estimates. These estimates were based on SIBEC estimates and site series identified in the predictive ecosystem mapping for Williams Lake TSA (section 2.3). The distribution of natural and managed stand site indices across the THLB is shown in Figure 9. The area-weighted average site index of the THLB for natural stands is 12.1 m. After the THLB is converted into managed stands the average site index increases to 16.0 m.

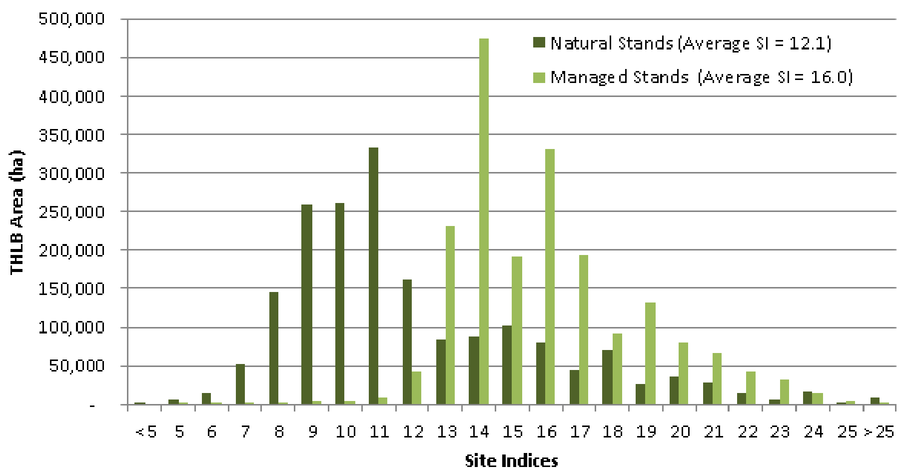

Figure 9 Distribution of natural and managed stand site indices over the THLB

3.5.7 Not Satisfactorily Restocked

Not satisfactorily restocked (NSR) is defined as a forested area that does not have a sufficient number of well-spaced trees of desirable species. This definition does specify why the area is NSR (harvesting or natural disturbances) but does suggest that NSR areas require some remedy or consideration (i.e., it is not satisfactory).

Current NSR typically refers to stands recently disturbed (i.e., since 1987) that are not yet declared as being stocked while *backlog* NSR refers to stands disturbed prior to 1987 that are not declared as satisfactorily restocked. District personnel are taking action to ameliorate approximately 2,450 hectares of backlog NSR that may exist in the Williams Lake TSA. With the lack of information, backlog NSR was thus not addressed in this analysis.

Current NSR is addressed in the analysis as part of the regular regeneration assumptions (average regeneration delay). NSR was also considered in yields for stands affected by natural disturbance (i.e., extended regeneration delays in fire areas).

3.5.8 Select Seed Use / Genetic Gain

Genetic gains were applied to both existing and future managed stands.

Genetic gain assumptions for existing managed stands were based on historical select seed use and genetic gain history records. RESULTS data were used to calculate, by species, the proportion of trees planted from Class A (orchard) seed for each year between 1965 and 2010. These proportions were then factored by the genetic worth identified on Seed Planning and Registry (SPAR) application for each seedlot to yield a weighted average genetic worth for each species and year. The weighted average of these estimates was used for modelling (see Table 24).

Table 24 Genetic gains for existing managed stands

Description	Fdi	Pli	Sx
Percent of tree species planted from class A seed (1965-2010)	7.9%	1.5%	39.7%
Genetic worth estimated by seedlot (1965-2010)	3.4%	3.6%	13.1%
Genetic gains modelled	1.7%	0.1%	5.7%

Genetic gain assumptions for future managed stands were derived from a review of both current (recent seed use and genetic gain practices estimated over the past 5 years) and future (near to short term) estimates of seed use and genetic gain projected over the next 10 years. Forecasted seed production and genetic gain estimates were identified for all seed planning units falling within the TSA (source: Forest Genetics Council of BC 2012/13 species plans). The production forecast of class A seed projected over the next 10 years was used to weight the estimated gains achievable (based on orchard capacity and current seed use behaviour) for each SPU years relative to demand (based on total SPU seed use –all seed users). To provide average species gains for the TSA, the production-weighted gains were area-weighted by the proportion of the SPU within the THLB where each species is planted. The seedling need assigned for each SPU is assumed to account for the needs in the Williams Lake TSA. Table 25 summarizes the information used to calculate the anticipated genetic gains for future managed stands.

Table 25 Genetic gain for future managed stands

Seed Planning Unit	Seedling Need (million)	Production Forecast (million)	Estimated Gain 2012	Production (1) Weighted Gain	Area (2) Weighting	Applied Genetic Gain
19 FDCSMLOW	0.8	0.8	19%	16%	0%	
37 FDIQLLOW	1.0	1.0	26%	24%	27%	Fdi 9.7%
43 FDICTLOW	1.0	1.4	14%	14%	24%	
12 PLIPGLOW	29.6	17.2	14%	8%	24%	
17 PLIBVLOW	21.4	12.9	13%	8%	1%	Pli 3.0%
Class B+	20.9	20.9	3%	1%	75%	
14 SXPGLOW	28.0	12.7	26%	12%	1%	
28 SXTOHIGH	4.6	5.1	15%	14%	9%	
30 SXTOLOW	2.7	2.6	19%	17%	49%	
35 SXBVLOW	9.3	11.6	24%	24%	1%	
42 SXPGHIGH	2.4	3.5	15%	14%	0%	Sx 12.8%
44 SXNELOW	0.8	2.4	24%	24%	12%	
4 SXNEMID	6.4	9.4	15%	15%	1%	
5 SXNEHIGH	1.0	6.9	15%	15%	0%	

(1) Estimated gain weighted by the proportion of the annual seedling need to the annual production forecast over 10 years
(2) Proportion of the SPU within the THLB where each species is planted

Gains for some seed planning units were dropped because they were located outside of the THLB (e.g., FDC SM LOW, SX PG LOW). The eastern portion of the TSA is classified as a zone of overlap (i.e. PGN). Zones of overlap or 'transition areas' allow for seed selection choices from either of the 'mother' seed zones (e.g. PG or NE orchards). At the time of seed selection, seed users have the option to select seed produced from either orchard, where available. For example, in SX PGN LOW, seed can be selected from either the SX PG LOW or SX NE LOW orchards.

Over the past 5 years, 40% of the pine planted used Class B+ (natural stand superior provenance) stock. Despite the high demand and fluctuating inventories for this material, the deficit in Class A seed production was assumed to be filled through production of Class B+ pine using the Oie Lake and Udy Creek superior provenance for use in areas associated with the natural stand seed planning zones of Big Bar, Chilcotin, Cariboo Transition and Quesnel Lakes. While estimated gains for this material may be higher on certain sites, the current Genetic Worth is 3%, based on the provenance testing and analysis to date for zonal sites across the 'tested' seed planning zones. As the production weighted gain was assumed to be 40% of the total gain (a net down based on a 5 year average 40% B+ seed use), the B+ class seed contributed an additional 0.9% to the applied genetic gain for pine.

3.5.9 Regeneration

Regeneration assumptions for existing managed stands were based on summaries of the current inventory (updated directly with RESULTS data) while assumptions for future managed stand were based on general regeneration strategies employed across the TSA. These were expressed in recent data summarized from RESULTS according to biogeoclimatic zones. Regeneration assumptions for existing and future managed stands are provided in Appendix 1.

3.5.10 Deciduous

Deciduous volumes are included in this analysis for both leading species and mixed stands. In the base scenario, however, deciduous volumes harvested are tracked as a separate product while harvest targets are based on coniferous volumes. Moreover, only coniferous volumes contribute in determining minimum harvest age.

A sensitivity analysis will also be undertaken that include both coniferous and deciduous volumes in determining minimum harvest age (see section 4.2).

3.5.11 Repressed Pine

District staff and licensees estimated that over 10,000 hectares of potentially height repressed lodgepole pine stands that exist in the Williams Lake TSA, predominantly on the Chilcotin Plateau. Spacing opportunities have been considered but most areas were deemed unsuitable due to forest health concerns. It was also estimated that approximately 1,500 hectares of these repressed stands have been spaced but specific details were unavailable or this analysis.

In the updated forest inventory, over 22,000 hectares were identified as greater than 70% live, less than 10 metres in height and greater than 30 years in age. Currently, there is little or no future timber value in these areas. As these areas represent only 1% of the THLB, no assumptions were incorporated in this analysis to account for the growth and yield or available treatment of repressed pine.

3.5.12 Spacing

RESULTS data identifies over 117,000 hectares spaced since 1975, however, most of these data did not coincide with disturbance and forest cover attributes so only fertilized stands meeting the following criteria were identified: within the THLB, current age ≥13 and <55 years and not pine-leading (i.e., significant attack by MPB) or deciduous-leading. These criteria reduced the area identified for past spaced to 9,237 hectares. The identified stands were addressed as separate AUs and adjusted accordingly to reflect the following treatment outcomes:

- Density reduced to 1500 sph for spruce-leading and 1200 sph for Douglas-fir-leading.
- Change species composition to Pine-leading.
- Drop the minimum harvest age on these stands by 5 years (earlier operability due to larger trees relative to an untreated stand).
- Decrease the volume by 10% to reflect loss of growing stock due to forest health issues over time.

3.5.13 Fertilization

RESULTS data identifies over 13,000 hectares fertilized since 1987. Again, most of these data did not coincide with disturbance and forest cover attributes so only fertilized stands meeting the following criteria were identified: within the THLB, current age ≥25 and <50 years and not pine-leading (i.e., significant attack by MPB). These criteria reduced the area identified for past fertilization to 2,745 hectares. The identified stands were addressed as separate AUs and adjusted accordingly to reflect the following treatment outcomes:

- Stand volumes were increased by 12 m^3/ha for Pl and 15 m^3/ha for Fd and Sx.

3.5.14 Stands Impacted by Wildfires

The approach taken to update the forest inventory impacted by past wildfires was discussed in section 2.3. The following approach was used to adjust yield curves were assigned accordingly:

- <u>Live stands</u>: existing natural yield curve (VDYP)
- <u>Unlogged, dead stands</u>: existing natural yield curve (VDYP) with 30 year regeneration delay from the year of disturbance
- <u>Logged, dead stands (plantations)</u>: existing managed curve (TIPSY) with 7 year regeneration delay from the year of disturbance.

3.5.15 Mountain Pine Beetle Impacts on Stands ≥60 yrs Old

Using current forest inventory attributes, VDYP was used to generate full volume yield curves for each natural stand. These curves were then adjusted to develop volume curves that reflect MPB impacts on pine mortality, shelf-life and understory regeneration.

3.5.15.1 MPB Mortality

It is estimated that 60% of the pine volume in the Williams Lake TSA has been killed by MPB (Walton 2012). For this analysis, estimates of stand mortality and year of death, derived from the provincial MPB model and the 2010 aerial overview surveys, were taken from the forest inventory. District staff considered these pine mortality estimates, ranging between 45% and 67% by BEC unit, appropriate for this analysis.

3.5.15.2 Stands with dead percentage ≥ 60%

Natural (unsalvaged) stands with greater than 60% MPB attack were assigned three yield curves; combined to reflect growth and yield over time. The three stand components (live volume + dead, merchantable volume + naturally regenerating understory volume) are described in Table 26 and illustrated in Figure 10.

Table 26 Approach to reflect post-attack MPB impacts to yields for natural stands

Stand Component	Timing [1]	Yield Adjustments [2]
Dead overstory trees	○ Model age adjusted to 0 from year of death	○ VDYP used to project yield s for each polygon ○ Yield and density reduced according to attack severity ○ (Dead% x Yield) ○ Yield static for 5 years, then drops incrementally to 0 m³/ha over 38 years (see shelf life assumptions below).
Live overstory trees	○ Model age adjusted to 0 from year of death	○ VDYP used to project yield s for each polygon ○ Yield and density reduced according to attack severity ((100%-Dead%) x Yield) ○ Yield calculated as the incremental growth from the original unattacked projection: LV = UV x (1-AS), where LV is live volume, UV is unattacked volume and AS is percent attack severity.

Regenerating understory trees [3]	○ Assigned advanced regeneration period (model age minus 10 yrs)	○ TASS used to project average yields for BEC Zone and density class (see Table 27), applying the following assumptions:
		  ○ Fix species composition including a high clumpiness factor
		  ○ Reduce potential site index by 2 metres
		  ○ Adjust OAF1 to 25% and OAF2 to 15%
		  ○ 10 year advanced regeneration (i.e., +-10 from year of death)
		○ Density classes are randomly assigned to stands with >60% attack according to the proportions for BEC zones (see Table 27).

1. Year of death was determined as the year when MPB attack exceeds 50%.
2. Stand dead % applies to the stand – the pine component within each stand is factored into this estimate.
3. Yields for regenerating understory trees were prepared by Jim Thrower and Ken Polsson.

The example in Figure 10 below (110 yr old stand, 80% dead), shows the stand's dead merchantable volume declines over the 38 years following attack (red dashed line), while the remaining live portion of the stand continues to grow (green dashed line), and the understory regeneration (green solid line - 10 yrs old at time of attack) begins to contribute volume in 2027. The sum of the three curves provides the total merchantable volume at any time. In this example, the stand never recovers to post attack volumes because of the reduced growth associated with the naturally regenerating portion of the stand. This is only an example for discussion.

These stands are considered ineligible for harvesting when the total merchantable volume for the stand (dead + live + regeneration) falls below the minimum volume threshold (110 m^3/ha).

For modelling purposes, the age of stands with ≥ 60% dead, was initially reduced to 5 years old, depending on whether the year of death was classified as 2006, as the initial year for modelling was 2011. The live and dead merchantable volumes, however, remained available for harvest but were adjusted as described above. This approach assumes that stands in both the THLB and NHLB, with less than 60% live volume, do not contribute towards meeting some non-timber management assumptions for old seral stages (see section 3.2). To reduce the number of analysis units, stands with less than 60% live volume were adjusted to their respective age class mid-points. Finally, managed stands and any unattacked stands maintained their original age as of 2011.

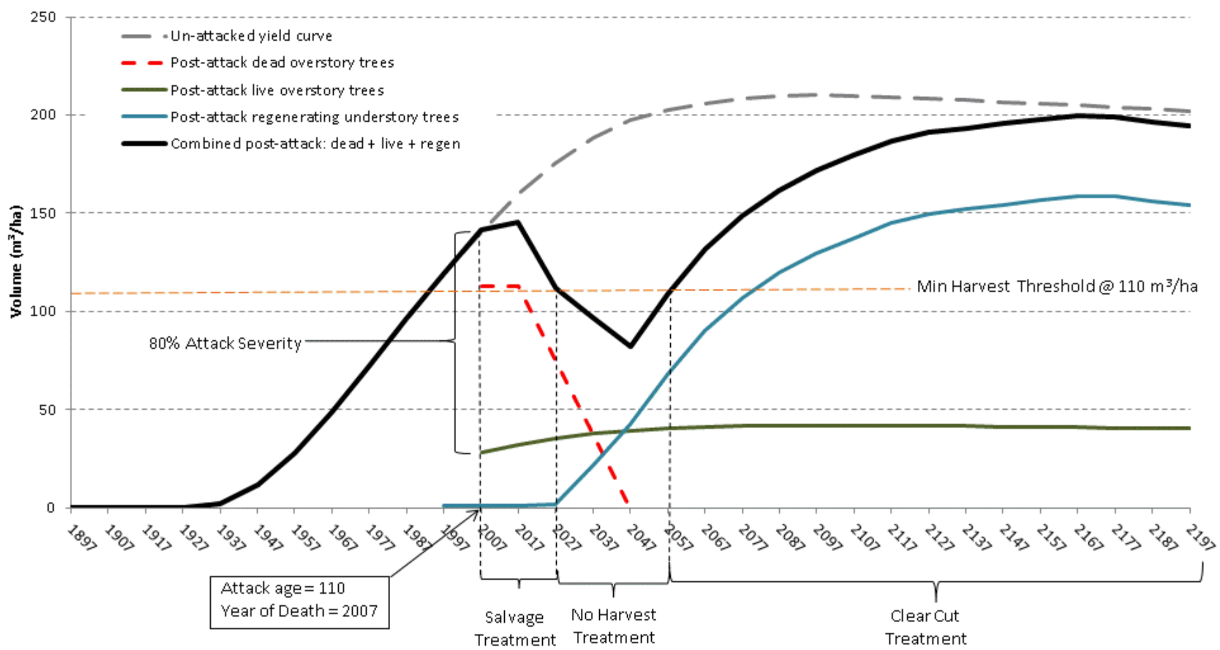

Figure 10 Example of how natural yields are impacted by MPB

3.5.15.3 Shelf Life Assumptions

Shelf life is the time a tree/stand will remain economically viable to harvest. Typically, this begins the year that a stand dead percentage from MPB exceeds 50%. This analysis adopted the shelf life assumptions developed for the Enhanced Type 2 Silviculture Analysis (Timberline Natural Resource Group Ltd. 2008), that projected a declining yield of sawlog and pulpwood material that would be unavailable after 16 and 38 years respectively, as shown in Figure 11.

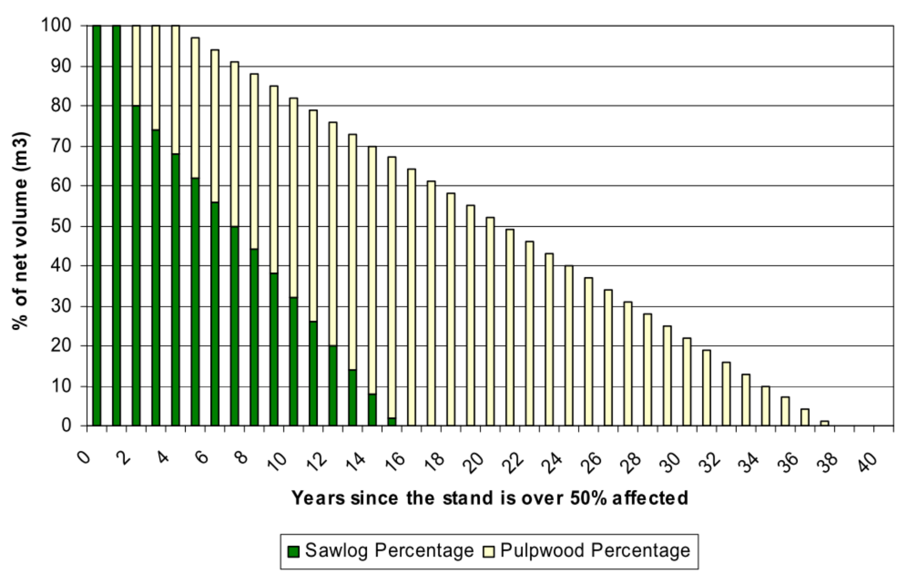

Figure 11 Shelf life of MPB-attacked, dead overstory trees

3.5.15.4 Understory regeneration

Yield tables were developed to represent the growth and yield of the understory component, or secondary structure, of unsalvaged, MPB-attacked stands (Thrower 2012). Some of the inputs for these yields used data assembled to estimate the amount of secondary structure in MPB-impacted stands (Coates and Sachs 2012).

The yields incorporated specific assumptions regarding species composition, site index, stand density class, spatial and age distribution of trees, operational adjustment factors, and regeneration delay (see Table 26). Since this understory regeneration cannot be identified in the current forest inventory, density classes were randomly assigned to stands with ≥50% remaining live volume and according to the proportions for BEC zones given in Table 27.

Table 27 Density class and species compositions modelled for regenerating understory component

BEC Zone	Species Composition	SI (m)	Low Density (200/ha)	Med Density (800/ha)	High Density (1600/ha)
ESSF	Sx 100	12	15%	10%	75%
MS	Pl 100	14	40%	20%	40%
SBPS	Pl 100	13	30%	25%	45%
IDF	Fd 75 Pl 25	15	30%	20%	50%
SBS	Sx 100	18	30%	25%	45%
ICH	Hw 100	16	25%	15%	60%

From Thrower (2012)

3.5.15.5 Stands with dead percentage < 60%

For natural stands (unsalvaged) with up to 60% MPB attack, only the two overstory curves were applied (live volume + dead merchantable volume). Naturally-regenerating understory volumes were not included because any secondary structure will not likely perform as well with a denser overstory.

3.5.16 Mountain Pine Beetle Impacts on Stands <60 yrs Old

Young regenerating stands form a key component of the future harvest – particularly during the late mid-term period. Mortality from MPB in young pine stands was estimated across the BC interior (Maclauchlan 2009) and within the Central Cariboo, most stands were impacted to some degree between the ages of 25 and 60 years (approximately 8% of the THLB). Overall damage to young stands is also exacerbated by attack from secondary bark beetles and diseases.

Table 28 Mortality of pine in young stand in the Central Cariboo

	Percent stands with MPB Attack		Average % attack in attacked stands	
Age	**2007**	**2008**	**2007**	**2008**
20-25	80.0%	87.9%	20.5%	24.7%
26-30	91.1%	95.7%	32.2%	38.2%
31-40	95.7%	100.0%	38.4%	40.0%
41-50	100.0%	100.0%	34.9%	42.1%
51-55	100.0%	100.0%	47.0%	38.0%

From MacLauchlan (2009)

The pattern of this damage was most often patchy, creating numerous holes in the regenerating canopy, particularly on larger diameter trees. Trees with higher productivity situated at lower elevations were most likely to be attacked. Similarly, stands that had been juvenile spaced exhibited higher levels of attack.

Using MacLauchlan's data, district staff estimated the yield impacts that consider the spatial distribution attack levels expected in each age class. Accordingly, yield reductions were applied to existing managed stand yields of Pl-leading AUs according to the criteria in Table 29. These were applied as OAF1 reductions in TIPSY regardless of the pine component or attack levels described in the forest inventory. Yields from non-pine-leading AUs were not adjusted.

Table 29 MPB impact applied to yields for immature stands < 60 years old

		Yield Impact	
Stand Age	**DCC & Pl≥80%**	**DCH & Pl≥80%**	**All & Pl<80%**
<20	0%	0%	0%
20-25	20%	0%	0%
26-30	35%	15%	0%
31-40	40%	20%	20%
41-50	40%	20%	20%
51-60	40%	20%	20%

3.5.17 Stands Impacted by Spruce Beetle and Western Spruce Budworm

Past damage from spruce beetle and western spruce budworm (section 2.3) suggests that at least some damage is likely to occur on existing and future stands. However, no specific adjustments were made to existing and future yields or annual target harvest levels beyond those considered for endemic insect losses incorporated into OAF2 (see 3.5.5) and non-recoverable losses for insects (section 3.6.2).

3.5.18 Silvicultural systems

The silvicultural systems used to model various management regimes are discussed below while the modelling approach for these treatments is shown Appendix 2.

<u>Clearcut System</u>

Clearcut with reserves (WTPs) was assumed to be the silvicultural system used for all stand types other than Fd leading stands in the IDF (Dry-belt Fd).

<u>Shelterwood System</u>

Although it is used little currently, licensees and district staff indicate that a shelterwood silvicultural system is the most likely to occur as licensees begin to harvest in Dry-belt Fd stand types that occur outside of MDWR. This two phase system provides enough volume at initial harvest to realize cost efficiencies while also promoting regeneration. Operationally, not all stands will be suited to this approach but it has been assumed for all non-MDWR Dry-belt Fd stands in this analysis. It will be modeled using VDYP for existing stands yields and TIPSY for regenerated stand yields.

Shelterwood modeling assumptions were adapted from Table 13 as follows:

- Initial entry will remove 50% of the volume in the stand.
- After a period of 10 years, the remaining volume is extracted without impacting the regeneration that has been established. The 1-2-3 Shelterwood approach to harvesting provides a good method for achieving the desired outcomes (Meek and Cormier 2004).
- Regeneration is assumed to occur naturally during the 10 year regeneration phase. Fill planting would occur after the final harvest if necessary to achieve stocking standards. TIPSY curves to use natural regeneration assumptions, 2000 sph, and standard OAF's. Using natural regeneration in TISPY will implement a delayed and gradual establishment of stems over a 3-8 year period.

Selection System

Selection silvicultural systems were modeled within Dry-belt Fd MDWR stands and in certain Caribou areas. Growth assumptions for dry-belt Fd selection is being explored with VDYP and Prognosis yields while Caribou areas will use VDYP for both existing and future stand volumes.

Selection modeling assumptions were adapted from Table 13 and Appendix 2 as follows:

- MDWR Shallow/Moderate Snowpack
  - Low Habitat Class: 33% of volume harvested every 30 years (9 yr rotation)
  - Mod Habitat Class: 25% of volume harvested every 30 years (120 yr rotation)
  - High Habitat Class: 20% of volume harvested every 30 years (150 yr rotation)
- MDWR Transition/Deep Snowpack
  - Low Habitat Class: 33% of volume harvested every 40 years (120 yr rotation)
  - Mod Habitat Class: 25% of volume harvested every 40 years (160 yr rotation)
  - High Habitat Class: 20% of volume harvested every 40 years (200 yr rotation)
- Northern Caribou
  - Terrestrial lichen sites: 50% of volume harvested every 70 years (140 yr rotation)
  - Arboreal lichen sites: 33% of volume harvested every 80 years (240 yr rotation)
- Mountain Caribou
  - 50% of volume harvested every 70 years (140 yr rotation)

3.6 Natural Disturbance Assumptions

Natural disturbance assumptions define the extent and frequency of natural disturbances across the land base. Assumptions used to model disturbance within and without the THLB are explained below.

3.6.1 Natural Disturbance within Non-THLB

For this analysis, a constant area was disturbed annually within each LU and natural disturbance type (NDT). The area of disturbance varied based on the biogeoclimatic variants present, their associated natural disturbance intervals and old seral definitions, as outlined in the Biodiversity Guidebook (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1995). Table 30 shows the process used to determine the annual disturbance limits applied to the forested non-THLB.

Table 30 Annual natural disturbance limits in the forested non-THLB by BGC Zone/NDT

BGC ZONE	NDT	Disturbance Interval (yrs)	"OLD" Defn (yrs)	% Area > OLD*	Effective Rotation Age (yrs)*	Contributing Non-THLB Area (ha)	Annual Area Disturbed (ha) (area/rot age)
CWH	2	200	250	29%	350	15,148	43
ESSF	1	350	250	49%	490	156,715	320
ESSF	2	200	250	29%	350	133,108	380
ICH	1	250	250	37%	395	68,981	174
ICH	2	200	250	29%	350	9,063	26
IDF/BG	4	250	250	37%	395	237,274	600
MH	1	350	250	93%	363	4,756	13
MS	3	150	140	39%	231	285,421	1,237
SBPS	3	100	140	25%	186	237,516	1,278
SBS	2	200	250	29%	350	1,485	4
SBS	3	125	140	33%	208	25,505	123
Total						1,174,972	4,199

** % area old = exp (-[old age / disturbance interval]), Effective rotation age = old age / (1 – % area old)*

To reduce the number of modeled zones required, modeling disturbance was simplified BGC/NDT combinations for applying annual disturbances. Stands were randomly selected to account for these natural disturbance areas. Ages were then adjusted in each period according to the effective rotation age so that all stands within each unit were turned over once throughout the effective rotation. This process continued throughout the planning horizon and avoided seral requirements because disturbance was selected randomly; independent of modeled harvest priority.

Across the NCLB, approximately 4,199 ha (0.36%) is disturbed each year, resulting in an average disturbance turn-over of the non-THLB approximately every 277 years (range is 186 to 490 years).

3.6.2 Natural Disturbance within the THLB

Throughout the planning horizon, natural disturbance within the THLB are addressed as non-recoverable losses (NRL). These are estimates of annual volume losses resulting from catastrophic events such as insect epidemics, fires, wind damage or other agents.

Table 31 shows the NRL figures adopted from the upcoming TSR (BC Ministry of Forests 2013). In these summaries, forest cover information was used to derive impacted merchantable volume within areas mapped in annual overview flights. NRLs for damaging agents were estimated as follows:

- The NRL for fire was determined using a 15 year fire history calculating Douglas fir and spruce volumes only (pine loss has already been accounted for), excluding OGMA and Caribou no-harvest areas. The NRL is estimated at 25% of the total impacted volume of merchantable timber within mapped fire perimeters.
- The NRL for insects (Douglas-fir beetle, Spruce beetle and Western Spruce Budworm) was calculated using a volume loss percentage based on the attack level of insects mapped in the aerial overview survey. Five year averages were used to calculate the impacted volumes. Harvested area and volumes were removed from the area calculation. Impacted stands in OGMAs, Caribou no-harvest areas and area based tenures were not included in the calculations. However, adjustments were not made for other constrained areas such as riparian or MDWR.

Table 31 Non-recoverable losses

Analysis Unit	Damaging Agent	Annual NRL (m^3/yr)
All	Fire	35,480
All	Insects	77,489
All	Wind	8,684
	Total	**121,653**

Modelling natural disturbance within the THLB involved removing the total NRL (121,653 m^3/yr) from the annual target harvest level.

3.7 MODELING ASSUMPTIONS

General assumptions were incorporated into the model to improve its efficiency or to produce results that are more realistic spatially. Table 32 summarizes the modelling assumptions employed in this analysis.

Table 32 Modelling assumptions

Criteria	Assumption
Minimum Polygon Size	Resultant polygons less than 0.25 ha in size were merged into neighbouring polygons through a geoprocessing exercise to eliminate small polygons.
Blocking	To improve modelling performance, resultant polygons were blocked (or grouped) where possible by maintaining the same AUs and 10-year age classes and the model was configured for a target harvest opening size of 25 ha and a maximum opening size of 50 ha.
Planning Horizon	A 300 year planning horizon was applied reported in 5-year increments (i.e., 60 periods).
Harvest Flow Objectives	o Short-term: Concentrate harvest on salvageable MPB-impacted pine stands as much as possible but less than 80% of harvest profile for the first decade of the planning horizon. o Mid-term: Minimized the depth and duration of the mid-term timber supply short-fall resulting from the MPB-pine mortality. o Long-term: Adjusted the long-term harvest flow until the harvest level reflected managed stand yields while producing growing stock that neither declined nor increased.

4 Sensitivity Analyses

4.1 Revised Minimum Harvest Criteria – Biological

To explore the impact minimum harvest criteria have on harvest flows, a sensitivity analysis will be undertaken to include an additional criterion that requires stands to attain at least 90% of their mean annual increment at culmination (CMAI).

This additional criterion is often used to ensure long term productivity is not being compromised to meet short- or mid-term harvest goals. It will provide a comparison point to the base case which is designed foremost to minimize the midterm trough by entering stands as soon as they are merchantable (discussed in section 3.3.3). This revised approach should increase the minimum harvest age for some analysis units.

4.2 Incorporate Deciduous Stands / Volumes

To explore the impact of merchandizing hardwood logs a sensitivity analysis will be undertaken that includes deciduous leading stands in the THLB and recognizes the deciduous volumes present in coniferous stands. This will add volume to existing stands and potentially lower minimum harvest ages if the minimum volumes are reached at a younger age when deciduous volume is added.

The harvest of deciduous would be limited to a maximum of 100,000 m^3/yr to ensure unrealistic volumes are not logged in any given year.

4.3 Limit the Harvest of Small Pine

To explore the harvest forecast impacts of limiting the harvest of small pine stands, a sensitivity analysis will be undertaken that adjusts the harvest thresholds relative to distances from processing facilities – principally at Williams Lake, but also Anahim Lake.

The base scenario approach discussed in section 3.3.4.1 tracks the volume in any period harvested from small pine stands (< 125m^3/ha) across the TSA, including a target rate fixed for the ≥9hr cycle time zone to supply Anahim Lake. This revised approach applies targets according to the figures provided in

Table 33, reflecting the notion that harvesting small pine becomes more economic for stands with shorter haul distances.

Table 33 Revised small pine harvest targets

Cycle Time Zone (hours)	Maximum proportion of harvest volume in any period
< 3	30%
≥3 and <5	20%
≥5and <7	15%
≥7 and <9	10%
≥9	25%

4.4 HARVEST SEQUENCING

An uplift policy that targets harvesting of dead pine eventually leads to incidental harvesting of green trees from mixed stands of both live and dead trees. Accordingly, the longer this uplift is in place the more harvesting occurs of green trees that could otherwise be harvested within the mid-term. An appropriate transition from the current uplift to the mid-term is an important consideration for this TSA.

This sensitivity analysis explored the impact to harvest forecast from adjusting the pattern and duration of the short-term uplift in order to maximize the mid-term harvest level.

The harvest sequencing strategy adjusted the short-term uplift levels and duration to strike a balance between salvaging dead Pl and avoiding the harvest of green trees required to support higher mid-term harvest levels. The approach involved an immediate drop to a maximum mid-term harvest level and continues without declining throughout the planning period.

5 Silviculture Strategies

This section describes several silviculture strategies considered for the analysis. Given budget constraints, it is unlikely that all strategies will be pursued so details pertaining to the strategy will be refined or developed once they have been reviewed by the project steering group.

Several silviculture treatments and one optimization scenario were examined in this analysis. Each was constrained to an annual budget of $3 million. The silviculture strategies proposed for investigation included:

1. Single Fertilization;
2. Multiple Fertilization;
3. Pre-commercial Thinning and Fertilization
4. Spacing Dry-Belt Douglas-fir;
5. Rehabilitating MPB Impacted Stands;
6. Partial Cutting Constrained Areas;
7. Enhanced Basic Reforestation; and
8. Composite Mix of Treatments.

5.1 SINGLE FERTILIZATION

This silviculture strategy will examine the impact to harvest flows from applying a single fertilization treatment. To avoid duplication, stand eligibility criteria, treatment windows, responses and application costs are discussed in the next section 5.2.

5.2 MULTIPLE FERTILIZATION

This silviculture strategy examines the impact to harvest flows from applying an intensive fertilization program to Sx (every 5 years) and successive fertilisations to Pl and Fd stands (every 10 yrs). Windows for these multiple fertilization treatments are between age 25 and 60 years. Fertilization beyond these ages is most likely to fall into the single fertilization.

This strategy also assumes that harvesting of treated stands will not occur for 10 year following application (5 yrs for Sx). This treatment will be limited to stands already in the ground today (existing natural and existing managed stands).

As illustrated in Figure 12, minimum harvest ages will be adjusted as necessary to reflect earlier achievement of minimum harvest volumes. Accordingly, this strategy should provide additional volume in the mid-term by increasing stand volumes or allowing harvest to occur sooner.

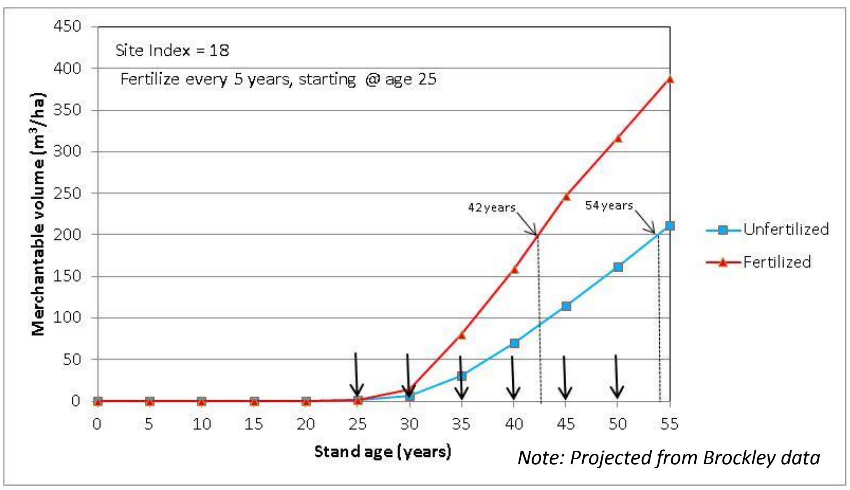

Figure 12 Intensive Sx fertilization response starting treatment at 25 yrs old

Eligible stands for this strategy are identified using the criteria provided in Table 34. Approximately 205,000 ha of existing stand types are eligible for fertilization.

Table 34 Criteria for the multiple fertilization strategy

BEC Zones	Species Groups	SI Range	Existing Density Range (sph)
ICH, SBS, SBPS	Pl leading	≥19 & <25	≥1,000 & <10,000
ICH, SBS, SBPS	Sx leading	≥15 & <24	≥1,000 & <10,000
ICH, SBS	Fd leading	≥15 & <24	≥1,000 & <10,000

Note: Stands within the IDF were not included as responses are less certain with the drier sites.

Cumulative responses to multiple fertilization treatments are shown in Table 35 and Table 36. The response from multi-fertilization of Pl and Fd are based on simple multiples of a single treatment response applied every 10 years.

Table 35 Cumulative incremental responses from multiple fertilization treatments (Pl & Fd)

Number of Applications	Stand Age Window (yrs)	Pine Response (m^3/ha; 10 yrs after treat)	Fd Response (m^3/ha; 10 yrs after treat)	Efficiency
1	30 – 80	12	15	100%
2	30 – 70	24	30	100%
3	30 – 60	36	45	100%
4	30 – 50	48	60	100%

Pl and Fd response are simple multiples of the single treatment response.

The response from multi-fertilization of Sx is based on initial research findings and ongoing monitoring of repeat applications would be needed to ensure the full response is being achieved (per com. Rob Brockley). These responses were based on a stand with SI 18 (SI 20 and 22 had even higher gains) where N, S and B are applied every 6 years.

Table 36 Cumulative incremental responses from multiple fertilization treatments (Sx)

Number of Applications	Stand Age Window (yrs)	Spruce Response (m^3/ha; 10 yrs after treat)	Efficiency
1	30 – 80	15	100%
2	25 – 55	49	100%
3	25 – 50	89	100%
4	25 – 45	132	100%
5	25 – 40	155	100%
6	25 – 35	176	100%

Note: Sx response was derived from information provided by the MFLNRO in the document "Intensive fertilization graphs.xlsx" (Rob Brockley email June 14,, 2012, Mel Scott/Ralph Winter email June15, July 28, 2012).

Ten years following the corresponding fertilization treatments, stand yields are increased using these responses (5 yrs for Sx). Due to the methodology for developing analysis units (section 3.5.1), some ineligible stands will be treated (i.e., Sx leading AU's includes the leading species: B, Ba, Bl, S, Sb, Se, Ss, Sw, and Sx).

The following modelling assumptions will also be incorporated for the multiple fertilization strategy:

- Stands are assumed to be fully stocked and healthy.
- Responses are assumed to follow the same progression regardless of the stand age when the first fertilization was applied;
- Minimum harvest ages for applicable analysis units are reduced by 2 years for each application;
- Harvest eligibility is delayed for 10 years following the final fertilizer application; and
- Application cost for single fertilization treatments of Sx, Pl and Fd is $450/ha.
- Application cost for multiple Sx treatment is increased to $600 per hectare as different fertilizer blends are required to ensure an appropriate mix of micro-nutrients. The cost for each application of Pl and Fd remains at $450/ha.

5.3 PRE-COMMERCIAL THINNING AND FERTILIZATION

This silvicultural strategy examined the impact of pre-commercial thinning (PCT) dense Pl stands between the ages of 10-20 years old (typically 6,000-20,000 sph), to a target density of ~2,500 sph, then fertilize these stands according to the regimes discussed in section 5.2. The purpose of the treatment is to improve stand quality/health/resilience through leave tree selection, increase stand volumes through fertilization and advance operability in these stands.

Eligible stands for this strategy are identified using the criteria provided in Table 37. It is estimated that approximately 6,800 ha are eligible for this treatment.

Table 37 Criteria for the spacing strategy

BEC Zones	Species Groups	SI Range	Existing Density Range (sph)
IDF, ICH, SBS, SBPS	Pl leading	≥19	>6000

The following assumptions will be used in modeling this strategy:

- Minimum harvest ages for applicable analysis units are reduced by 3 years after treatment. Merchantable volumes are seen to only improve slightly as a result of the PCT but the average diameter of the prime 250 trees will increase and is expected to allow more economic harvesting and higher lumber recovery /ha (albeit with potential for lower quality lumber due to increased knot size/density). This is assumed to provide an incremental product value of $30/m³.
- Spacing costs are applied at $1100 per hectare (FFT Cost Benchmarks 2012).

Subsequent thinnings down to 1000 sph at 30 years and 600sph at 50 yrs were considered as a strategy to allow access to early volume while holding the stand through its peak MAI years to harvest at age 70. It was expected that the model will be offered either an early clearcut option or this more intensive thinning option so some stands may follow different regimes.

5.4 SPACING DRY-BELT DOUGLAS-FIR

This strategy examines the impact of spacing stagnant thickets in the second and third layers of dry-belt Douglas-fir stands. Research on these stands suggests this strategy can rehabilitate stands partially harvested with diameter-limit cutting, which promotes excessive stocking in the lower layers that behave as if they are repressed.

The anticipated benefits of this strategy include improving both timber and non-timber resources, such as mule deer habitat and urban interface fuels reduction. Expected gains in merchantable volume post thinning should increase available volumes in the mid- to long-term. It is anticipated that treated stands are less likely to experience defoliation from spruce budworm because foliage is less palatable and tree response to damage is more vigorous (resilient). Consequently, continued spraying of Btk is likely not necessary.

For this strategy, eligible stands are described in Table 38, where these stands have not been thinned previously. This selection of stands is expected to over-represent the extent of the opportunity so refinement will need to happen at the operational level. The current inventory poorly reflects multi-storied stands but local knowledge suggests that there are stands that could benefit from this treatment and produce an acceptable return on investment (ROI). Dense thickets are often associated with areas were partial harvest systems were employed between 1960 and 1980 (per. com. Ken Day/Jeff McWilliams). Stands within MDWR would also benefit from this treatment but the ROI is expected to be too low to warrant treatment based on timber values alone. Consideration should be given to treating these stands for other values.

Table 38 Criteria for the spacing dry-belt Douglas-fir strategy.

BEC Zones	Species Groups	SI Range (Managed SI)	Existing Density Range (sph)	Harvested	Management

IDF	Fd leading	≥15	≥1,000	1960-1980	Non-MDWR

Treated stand curves will be developed by adjusting the base VDYP curves to reflect responses seen in exploratory Prognosis modeling (detail yet to be finalized). Ideally, targeted stands exceed a maximum density of 3,500 stems per hectare in layers 2, 3, and 4. Stands outside of MDWR will provide higher return on investment but stand improvements in MDWR are still valuable and should be considered.

The following modelling assumptions will incorporated for this strategy:

- Initial entry harvest volume (shelterwood and selection) is increased by 10% for stands treated at least 30 years prior to harvest.

Spacing treatment costs are applied at $750 per hectare; less than typical because much less cutting will be required.

5.5 Rehabilitating MPB Impacted Stands

This silviculture strategy examines the impact to harvest flows from rehabilitating MPB impacted stands with little or no salvage opportunity. By ensuring unsalvaged stands are ameliorated and managed, this strategy is expected to increase late mid-term harvest levels.

Recovery of any merchantable (green) volume from these stands will support mid-term harvest levels while long-term harvest levels are improved because of the regeneration volumes are significantly improved. Rehabilitating damaged stands should also help to ensure issues such as watershed recovery were minimized – potentially improving mid-term harvest levels.

Following the salvage period of MPB-killed stands, conditions exist where stands will not recover to pre-attack conditions or minimum merchantability criteria (110 m^3/ha) within the planning horizon. Effectively, these stands cease to contribute to the working forest. Within this profile, a continuum of stands exists ranging from marginally economic to uneconomic:

- Marginally economic stands: some green volume and larger piece sizes to produce lumber, pulp chips and potentially bio-fuel feed stocks (similar for stands treated under the ITSL program).
- Uneconomic stands: younger, small-diameter trees, higher percent dead and long haul distances.

The challenge with this strategy involves identifying stands that would not otherwise regenerate to become operable on their own; thus maximizing the ROI. Moreover, the analysis data does not include some spatially-explicit, stand-level criteria required to distinguish the viability of some treatments. With no direct stand-level data to draw from, assumptions for this strategy were designed from opinions of local forest professionals.

For this analysis, eligible stands included all unlogged MPB-impacted stands (identified from the Base Case scenario) with at least 40% dead and greater than 40 yrs old at time of attack. It was assumed that younger stands offer little opportunity for rehabilitation treatments.

Treatments and costs associated with the rehabilitation strategy can vary considerably according to specific site characteristics. Again, with no quantitative information available for this strategy, local forest professionals provided opinions on a set of basic treatments off-set according to potential economic recovery from these stands. Treatments and costs were applied according to the amount of recoverable sawlog volume in the stand and distance cost criteria were added based on haul cycle times (see Table 38).

Table 38 Treatments and costs for rehabilitating damaged stands

Treatment	Marginal Economic (≥50 m^3/ha)	Uneconomic (<50m^3/ha)
Knockdown and site prep	$500	$1000/ha
Planting	$1000/ha	$1000/ha
Total Cost (1)	$1500/ha	$2000/ha

(1) Add distance costs: <5 hrs @ $0/ha, ≥5 & <7 hrs @ $50/ha, ≥7 hrs @ $250/ha

Responses for these treatments were modelled by transitioning stands onto future managed stands from the treatment date. Accordingly, these responses take advantage of improved OAFs, lower regeneration delay and select seed to produce higher yields that achieve minimum harvest volumes much sooner. These stand regeneration improvements will contribute to the long-term and potentially the final mid-term periods of the harvest flow. Conversely, operational plans employing this strategy should carefully consider potential issues related to animal damage (e.g., hare, horse, cattle, etc.).

In the field, opportunities to rehabilitate most stands will be limited by access. This is considered somewhat by including distance-related costs, but it is likely that the costs to build new roads into the stands are prohibitive. Accordingly, one should consider results from this scenario as optimistic.

5.6 Partial Cutting Constrained Areas

This silviculture strategy examines the impact to harvest flows from a single removal of 1/3 of the volume within stands currently constrained for visuals, lakeshore management, mature-plus-old seral and watershed ECA requirements.

This strategy is expected to increase the mid-term harvest level as operating within these otherwise constrained areas should effectively increase the harvestable landbase and volume available during this heavily constrained timeframe. As well, low removal level is assumed to maintain sufficient stand conditions to satisfy the non-timber values present.

Eligible stands for this strategy include THLB areas with forest cover constraints applied to maintain specific conditions (limit disturbance, maintain older age classes): mature-plus-old seral constraints, visuals, lakeshore management classes and watershed ECAs. While it is conceivable that this strategy can be applied within Parks, WHAs and OGMAs, fostering public support to alter these constraints was considered highly unlikely and these areas were disregarded.

Stands severely impacted by MPB (≥60% killed) were not eligible for this treatment as they are unlikely to maintain non-timber values after the partial harvest treatment.

This strategy was implemented by providing a treatment option for identified stands to remove 1/3 of the existing volume but retain the existing age. This allows volume to be removed without impacting the non-timber objective. For example, a visual requirement might limit stands less than 25 yrs of age to less than 15% of the forested area. If the selection harvest option is selected by the model, volume can be removed without having any impact on the visually disturbed area. The incremental cost of implementing the partial harvest treatment over clear cutting is estimated at $7.50/m^3$ for slopes <40% and $12.50/m^3$ for slopes ≥40%. These costs will be considered as part of the TSA budget for silviculture strategies for purposes of exploring cost effective treatments, but in reality this cost would be borne by licensees (or government through stumpage allowances).

5.7 ENHANCED BASIC REFORESTATION

Free growing guidelines set minimum standards for establishing stands with appropriate species selection, stocking, and specified requirements. This silviculture strategy examines the impact to harvest flows from enhancing basic reforestation practices where current performance is not optimal (achieving minimum well-spaced trees/ha versus target well-spaced trees/ha). The objective of this approach is to increase timber volume and quality when these stands are harvested rather than focusing on meeting minimum standards at free growing.

This strategy is unlikely to increase the mid-term harvest level as it will only influence stands regenerated in the future that will not be harvested for at least 45-50yrs from now. There may be some benefit to the back end of the midterm trough but this strategy is expected to increase long-term harvest levels by improving well-spaced densities, reducing stocking gaps (OAF1) and achieving the benefits of Class A seed. This is expected to reduce minimum harvest ages, improve product quality, and help to address climate change concerns through species selection.

This strategy will increase initial well-spaced stand densities and reduce stocking gaps through a combination of site preparation, planting to higher densities, and/or fill planting as soon as ingress is complete. Planting would utilize Class A seed with volume gains associated with it. It will be implemented by increasing the planting density in TIPSY for planted stands, plus lowering OAF 1 to 10%, and incorporating planting to 800 sph plus ingress on naturally regenerating stands (Class A seed gains and shorter regeneration delay).

Eligible stands for this aggressive regeneration strategy are limited to the better sites within the TSA as described in Table 39.

Table 39 Criteria for enhanced basic reforestation

Objective	Location	BEC Zones	Species	SI Range
intensive management	Fraser East	IDF, ICH, SBS,SBPS	Pine leading	≥19
intermediate investment	Fraser East	IDF, ICH, SBS,SBPS	Spruce/Fir leading	≥15 & <24
Fibre	Fraser West	All	All	≥15 & <24

Improving regeneration regimes for harvest volumes and values involved revisions to future yield assumptions. The most significant changes involved increasing initial establishment densities. Specific assumptions applied for this strategy were as follows:

- Increase planting method to 100%
- Plant to 1800 sph with select seed
- Decrease regeneration delay for portions regenerated naturally from 3 to 2 years
- Lower OAF1 from 15% to 10%

Treatment costs were applied as $450/ha for incremental planting of trees sown from select seed or $1000/ha where natural regeneration was originally applied.

5.8 COMPOSITE MIX OF TREATMENTS

For this scenario, the model will be configured to include assumptions from all strategies so that the timing and range of treatments that produce the best outcome subject to the same annual budget constraint of $3 million, as was used in the previous silviculture strategy scenarios. In addition, a scenario will be run using a more optimistic, or preferred budget of $5 million/year.

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Appendix 1 Analysis Unit Details

Analysis Units for Existing Natural Stands

ANALYSIS UNIT DESCRIPTION (Existing Natural Stands)								TIPSY INPUTS FOR FUTURE STANDS					
AU EN	THLB (ha)	EN (Pct)	BEC Group	Species Group	Site Index Class	Special Resource Zone	Silvicultural system	Regen Method	Pct	Delay (yrs)	Density (sph)	SI	Species Composition
1001	1,305	0.1%	Any	OS	<15	Grassland	CON	N/A					
1002	1,111	0.1%	Any	OS	≥15to<19	Grassland	CON	N/A					
1003	1,098	0.1%	Any	OS	≥15to<24	Grassland	CON	N/A					
1004	111	0.0%	Any	OS	≥19	Grassland	CON	N/A					
1005	69	0.0%	Any	DE	<15	Grassland	CON	N/A					
1006	752	0.1%	Any	DE	≥15to<24	Grassland	CON	N/A					
1051	2,958	0.2%	Any	Any	Any	Birch Areas	RES	Same pre-harvest curve (VDYP)					
1101	3,928	0.3%	IDF	FD	<15	MDWR (Shallow/Mod)	STS	Same pre-harvest curve (VDYP)					
1102	78,722	5.5%	IDF	FD	≥15to<24	MDWR (Shallow/Mod)	STS	Same pre-harvest curve (VDYP)					
1103	2	0.0%	MS	FD	<15	MDWR (Shallow/Mod)	STS	Same pre-harvest curve (VDYP)					
1104	34	0.0%	MS	FD	≥15to<24	MDWR (Shallow/Mod)	STS	Same pre-harvest curve (VDYP)					
1105	204	0.0%	SBPS	FD	<15	MDWR (Shallow/Mod)	STS	Same pre-harvest curve (VDYP)					
1106	282	0.0%	SBPS	FD	≥15to<24	MDWR (Shallow/Mod)	STS	Same pre-harvest curve (VDYP)					
1107	657	0.0%	SBS	FD	≥15to<24	MDWR (Shallow/Mod)	STS	Same pre-harvest curve (VDYP)					
1201	2,588	0.2%	ICH	FD	≥15to<24	MDWR (Trans/Deep)	GRP	Same pre-harvest curve (VDYP)					
1202	224	0.0%	ICH	FD	≥24	MDWR (Trans/Deep)	GRP	Same pre-harvest curve (VDYP)					
1203	359	0.0%	MS	FD	≥15to<24	MDWR (Trans/Deep)	GRP	Same pre-harvest curve (VDYP)					
1204	50	0.0%	SBPS	FD	≥15to<24	MDWR (Trans/Deep)	GRP	Same pre-harvest curve (VDYP)					
1205	10,566	0.7%	SBS	FD	≥15to<24	MDWR (Trans/Deep)	GRP	Same pre-harvest curve (VDYP)					
1206	1	0.0%	SBS	FD	≥24	MDWR (Trans/Deep)	GRP	Same pre-harvest curve (VDYP)					
2001	1,695	0.1%	IDF	FD	<15	IDF Fd stands	SHE	Nat	100	3	1500	14	FD80PL20
2002	66,161	4.6%	IDF	FD	≥15to<24	IDF Fd stands	SHE	Nat	100	3	1500	17	FD80PL20
3001	399	0.0%	ESSF	CH	<15	None	CCR	Plt	100	2	1000	14	PL70SX20BL10
3002	1,038	0.1%	ESSF	CH	≥15to<24	None	CCR	Plt	100	2	1000	17	PL70SX20BL10
3003	8	0.0%	ESSF	FD	<15	None	CCR	Plt	100	2	1000	14	PL70SX20BL10
3004	2,130	0.1%	ESSF	FD	≥15to<24	None	CCR	Plt	100	2	1000	20	PL70SX20BL10
3005	1	0.0%	ESSF	FD	≥24	None	CCR	Plt	100	2	1000	25	PL70SX20BL10
3006	30,187	2.1%	ESSF	PL	<15	None	CCR	Nat/Plt	30/70	3/2	2000/1000	14	PL70SX20BL10
3007	6,462	0.4%	ESSF	PL	≥15to<19	None	CCR	Nat/Plt	30/70	3/2	2000/1000	16	PL70SX20BL10
3008	1,935	0.1%	ESSF	PL	≥19	None	CCR	Nat/Plt	30/70	3/2	2000/1000	20	PL70SX20BL10
3009	24,118	1.7%	ESSF	SB	<15	None	CCR	Nat/Plt	30/70	3/2	2000/1000	13	SX70BL20PL10
3010	13,705	1.0%	ESSF	SB	≥15to<24	None	CCR	Nat/Plt	30/70	3/2	2000/1000	17	SX70BL20PL10
3011	294	0.0%	ESSF	SB	≥24	None	CCR	Nat/Plt	30/70	3/2	2000/1000	26	SX70BL20PL10
3012	90	0.0%	ESSF	DE	<15	None	RES	Same pre-harvest curve (VDYP)					
3013	103	0.0%	ESSF	DE	≥15to<24	None	RES	Same pre-harvest curve (VDYP)					

ANALYSIS UNIT DESCRIPTION (Existing Natural Stands)								TIPSY INPUTS FOR FUTURE STANDS					
AU EN	THLB (ha)	EN (Pct)	BEC Group	Species Group	Site Index Class	Special Resource Zone	Silvicultural system	Regen Method	Pct	Delay (yrs)	Density (sph)	SI	Species Composition
3014	0	0.0%	ESSF	DE	≥24	None	RES	Same pre-harvest curve (VDYP)					
3015	24,833	1.7%	ICH	CH	≥15to<24	None	CCR	Plt	100	2	1000	18	CW50FD30HW20
3016	2	0.0%	ICH	CH	≥24	None	CCR	Plt	100	2	1000	24	CW50FD30HW20
3017	26,288	1.8%	ICH	FD	≥15to<24	None	CCR	Plt	100	2	1000	23	FD60CW30HW10
3018	5,279	0.4%	ICH	FD	≥24	None	CCR	Plt	100	2	1000	24	FD60CW30HW10
3019	3	0.0%	ICH	PL	<15	None	CCR	Plt	100	2	1000	15	PL70FD20CW10
3020	13	0.0%	ICH	PL	≥15to<19	None	CCR	Plt	100	2	1000	18	PL70FD20CW10
3021	7,538	0.5%	ICH	PL	≥19	None	CCR	Plt	100	2	1000	23	PL70FD20CW10
3022	818	0.1%	ICH	SB	<15	None	CCR	Plt	100	2	1000	14	SX100
3023	21,268	1.5%	ICH	SB	≥15to<24	None	CCR	Plt	100	2	1000	22	SX70PL30
3024	3,222	0.2%	ICH	SB	≥24	None	CCR	Plt	100	2	1000	26	SX60PL30FD10
3025	6	0.0%	ICH	DE	<15	None	RES	Same pre-harvest curve (VDYP)					
3026	6,697	0.5%	ICH	DE	≥15to<24	None	RES	Same pre-harvest curve (VDYP)					
3027	761	0.1%	ICH	DE	≥24	None	RES	Same pre-harvest curve (VDYP)					
3028	16,572	1.1%	IDF	PL	<15	None	CCR	Nat/Plt	80/20	3/2	2000/1000	12	PL100
3029	124,063	8.6%	IDF	PL	≥15to<19	None	CCR	Nat/Plt	80/20	3/2	2000/1000	17	PL70FD30
3030	19,832	1.4%	IDF	PL	≥19	None	CCR	Nat/Plt	80/20	3/2	2000/1000	19	PL60FD40
3031	16	0.0%	IDF	SB	<15	None	CCR	Nat/Plt	80/20	3/2	2000/1000	13	SX100
3032	6,475	0.4%	IDF	SB	≥15to<24	None	CCR	Nat/Plt	80/20	3/2	2000/1000	17	SX90PL10
3033	1,003	0.1%	IDF	DE	<15	None	RES	Same pre-harvest curve (VDYP)					
3034	11,700	0.8%	IDF	DE	≥15to<24	None	RES	Same pre-harvest curve (VDYP)					
3035	5	0.0%	MS	FD	<15	None	CCR	Plt	100	2	1100	12	FD60PL20SX20
3036	196	0.0%	MS	FD	≥15to<24	None	CCR	Plt	100	2	1100	17	FD60PL20SX20
3037	14,669	1.0%	MS	PL	<15	None	CCR	Nat/Plt	60/40	3/2	2000/1100	14	PL80SX15BL5
3038	144,268	10.0%	MS	PL	≥15to<19	None	CCR	Nat/Plt	60/40	3/2	2000/1100	16	PL80SX15BL5
3039	3	0.0%	MS	PL	≥19	None	CCR	Nat/Plt	60/40	3/2	2000/1100	19	PL80SX20
3040	1,555	0.1%	MS	SB	<15	None	CCR	Nat/Plt	60/40	3/2	2000/1100	13	SX100
3041	7,930	0.5%	MS	SB	≥15to<24	None	CCR	Nat/Plt	60/40	3/2	2000/1100	17	SX90PL10
3042	71	0.0%	MS	DE	<15	None	RES	Same pre-harvest curve (VDYP)					
3043	567	0.0%	MS	DE	≥15to<24	None	RES	Same pre-harvest curve (VDYP)					
3044	1,902	0.1%	SBPS	FD	<15	None	CCR	Plt	100	2	1000	14	FD60PL20SX20
3045	1,983	0.1%	SBPS	FD	≥15to<24	None	CCR	Plt	100	2	1000	17	FD60PL20SX20
3046	448,165	31.1%	SBPS	PL	<15	None	CCR	Nat/Plt	80/20	3/2	2000/1000	14	PL100
3047	66,097	4.6%	SBPS	PL	≥15to<19	None	CCR	Nat/Plt	80/20	3/2	2000/1000	17	PL90SX10
3048	37,872	2.6%	SBPS	PL	≥19	None	CCR	Nat/Plt	80/20	3/2	2000/1000	20	PL80SX20
3049	729	0.1%	SBPS	SB	<15	None	CCR	Plt	100	2	1000	14	SX100
3050	19,457	1.3%	SBPS	SB	≥15to<24	None	CCR	Plt	100	2	1000	17	SX90PL10
3051	456	0.0%	SBPS	DE	<15	None	RES	Same pre-harvest curve (VDYP)					
3052	10,156	0.7%	SBPS	DE	≥15to<24	None	RES	Same pre-harvest curve (VDYP)					

	ANALYSIS UNIT DESCRIPTION (Existing Natural Stands)							TIPSY INPUTS FOR FUTURE STANDS					
AU EN	THLB (ha)	EN (Pct)	BEC Group	Species Group	Site Index Class	Special Resource Zone	Silvicultural system	Regen Method	Pct	Delay (yrs)	Density (sph)	SI	Species Composition
3053	46	0.0%	SBS	CH	≥15to<24	None	CCR	Plt	100	2	1100	19	CW60HW20SX20
3054	22,682	1.6%	SBS	FD	≥15to<24	None	CCR	Plt	100	2	1100	20	FD60PL20SX20
3055	272	0.0%	SBS	FD	≥24	None	CCR	Plt	100	2	1100	25	FD60PL20SX20
3056	28	0.0%	SBS	PL	<15	None	CCR	Nat/Plt	30/70	3/2	2000/1100	13	PL80SX20
3057	5,064	0.4%	SBS	PL	≥15to<19	None	CCR	Nat/Plt	30/70	3/2	2000/1100	18	PL60SX40
3058	20,254	1.4%	SBS	PL	≥19	None	CCR	Nat/Plt	30/70	3/2	2000/1100	21	PL50SX40FD10
3059	160	0.0%	SBS	SB	<15	None	CCR	Plt	100	2	1100	14	SX100
3060	19,647	1.4%	SBS	SB	≥15to<24	None	CCR	Plt	100	2	1100	20	SX90PL10
3061	3	0.0%	SBS	DE	<15	None	RES	Same pre-harvest curve (VDYP)					
3062	16,631	1.2%	SBS	DE	≥15to<24	None	RES	Same pre-harvest curve (VDYP)					
7001	7	0.0%	ESSF	CH	≥15to<24	Caribou WHA	GRP	Plt	100	2	1000	16	SX90BL10
7002	170	0.0%	ESSF	PL	<15	Caribou WHA	GRP	Plt	100	2	1000	13	SX70BL20PL10
7003	217	0.0%	ESSF	PL	≥15to<19	Caribou WHA	GRP	Plt	100	2	1000	15	SX70BL20PL10
7004	516	0.0%	ESSF	SB	<15	Caribou WHA	GRP	Plt	100	2	1000	14	SX70BL20PL10
7005	1,418	0.1%	ESSF	SB	≥15to<24	Caribou WHA	GRP	Plt	100	2	1000	17	SX70BL20PL10
7006	1	0.0%	ICH	CH	≥15to<24	Caribou WHA	GRP	Plt	100	2	1000	23	CW50FD30HW20
7007	0	0.0%	IDF	PL	<15	Caribou WHA	GRP	Plt	100	2	1000	13	FD70CW30
7008	2,451	0.2%	MS	PL	<15	Caribou WHA	GRP	Plt	100	2	1100	13	SX100
7009	32,710	2.3%	MS	PL	≥15to<19	Caribou WHA	GRP	Plt	100	2	1100	15	SX100
7010	125	0.0%	MS	SB	<15	Caribou WHA	GRP	Plt	100	2	1100	14	SX100
7011	866	0.1%	MS	SB	≥15to<24	Caribou WHA	GRP	Plt	100	2	1100	17	SX90BL10
7012	3	0.0%	MS	DE	≥15to<24	Caribou WHA	RES	Same pre-harvest curve (VDYP)					
7013	28,582	2.0%	SBPS	PL	<15	Caribou WHA	GRP	Plt	100	2	1000	13	SX100
7014	2,669	0.2%	SBPS	PL	≥15to<19	Caribou WHA	GRP	Plt	100	2	1000	15	SX100
7015	4	0.0%	SBPS	PL	≥19	Caribou WHA	GRP	Plt	100	2	1000	19	SX100
7016	5	0.0%	SBPS	SB	<15	Caribou WHA	GRP	Plt	100	2	1000	14	SX100
7017	1,390	0.1%	SBPS	SB	≥15to<24	Caribou WHA	GRP	Plt	100	2	1000	16	SX90BL10
7018	0	0.0%	SBPS	DE	<15	Caribou WHA	RES	Same pre-harvest curve (VDYP)					
7019	71	0.0%	SBPS	DE	≥15to<24	Caribou WHA	RES	Same pre-harvest curve (VDYP)					

Notes:

- *The analysis units described here do not include criteria that divide units further (e.g., Age class for MPB attacked stands, MPB impact classes, Wildfire impacts; past incremental silviculture treatments)*
- *BEC Groups: ESSFmc (ESSFmw,wc3,wcp,wcw,wk1,xv1,xv2,xvp);ICH (ICHmk3,wk2,wk4, CWHds1);IDF (IDFdk3,dk4,dw,ww,xm, BGxh3,xw2); MS (MSdc2,dv,xk3,xv); SBPS (SBPSdc,mc,mk,xc); SBS (SBSdw1,dw2,mc1,mc3,mh,mw,wk1)*
- *Species Groups: PL=Pine leading, SB=Spruce leading; CH=Cedar-Hemlock leading; FD=Douglas-fir leading; DE=Deciduous leading; OS=Other leading species*
- *Silvicultural systems: CON=conversion to grasslands; RES=reserved from harvesting; CCR=clearcut with reserves; GRP=group selection; STS=single tree selection; SHE=shelterwood*
- *With Shelterwood System (SHE - AUs 2001 and 2002), besides reduced densities, OAF1 was increased to 25% to account for areas occupied by overstory trees.*

Analysis Units and TIPSY Inputs for Existing Managed Stands

ANALYSIS UNIT DESCRIPTION (Existing Managed Stands)							TIPSY INPUTS					
AU_EM	THLB (ha)	EM (Pct)	Species Group	BEC	Density (sph)	SI Class	Regen Method	Pct	Delay (yrs)	Establishment Density (sph)	SI	Species Composition
1	31,955	5.5%	DE	Any	Any	Any	Nat	100	6	6000	19	PL40SX40BL20
2	4,728	0.8%	CH	Any	Any	Any	Plt	100	3	1200	17	CW64HW21SX15
3	2,162	0.4%	SB	Any	0-1,000	Any	Nat/Plt	30/70	6/3	1200/700	19	SX72BL22PL6
4	14,664	2.5%	SB	Any	>1,000	≥15	Nat/Plt	30/70	6/3	2000/1000	14	SX72BL14PL14
5	40,691	7.0%	SB	Any	>1,000	≥15	Nat/Plt	30/70	6/3	2000/1000	20	SX70PL16BL14
6	2,431	0.4%	FD	IDF	0-1,000	Any	Nat/Plt	80/20	6/3	1200/700	17	FD83PL13AT4
7	40	0.0%	FD	IDF	1,000-2,500	<15	Nat/Plt	80/20	6/3	2000/1000	13	FD87PL10AT3
8	243	0.0%	FD	IDF	2,500-25,000	<15	Nat/Plt	80/20	6/3	6000/1100	14	FD85PL13AT2
20	11,106	1.9%	FD	IDF	1,000-2,500	≥15to<24	Nat/Plt	80/20	6/3	2000/1000	17	FD77PL18AT5
21	14,782	2.5%	FD	IDF	2,500-25,000	≥15to<24	Nat/Plt	80/20	6/3	6000/1100	17	FD76PL22AT2
30	488	0.1%	FD	OTHR	0-1,000	Any	Nat/Plt	80/20	6/3	1200/700	21	FD73SX16PL11
31	15,671	2.7%	FD	OTHR	>1,000	Any	Nat/Plt	80/20	6/3	2000/1000	22	FD66PL21SX13
11101	31	0.0%	PL>80%	ESSF	0-1,000	<19	Nat/Plt	30/70	6/3	1200/700	18	PL75SX20AT5
11102	1,118	0.2%	PL>80%	ESSF	1,000-2,500	<19	Nat/Plt	30/70	6/3	2000/1000	16	PL90SX7BL3
11103	2,233	0.4%	PL>80%	ESSF	2,500-25,000	<19	Nat/Plt	30/70	6/3	6000/1100	15	PL90BL9SX1
11201	102	0.0%	PL>80%	ESSF	0-1,000	≥19to<25	Nat/Plt	30/70	6/3	1200/700	19	PL88SX12
11202	1,139	0.2%	PL>80%	ESSF	1,000-2,500	≥19to<25	Nat/Plt	30/70	6/3	2000/1000	20	PL89SX10BL1
11203	1,079	0.2%	PL>80%	ESSF	2,500-25,000	≥19to<25	Nat/Plt	30/70	6/3	6000/1100	20	PL94SX4BL2
12101	16	0.0%	PL>80%	SBS	0-1,000	<19	Nat/Plt	30/70	6/3	2000/1100	18	PL94SX3AT3
12102	96	0.0%	PL>80%	SBS	1,000-2,500	<19	Nat/Plt	30/70	6/3	2000/1100	18	PL94SX3AT3
12103	141	0.0%	PL>80%	SBS	2,500-25,000	<19	Nat/Plt	30/70	6/3	6000/1100	18	PL89AT6SX5
12201	1,060	0.2%	PL>80%	SBS	0-1,000	≥19to<25	Nat/Plt	30/70	6/3	1200/700	20	PL88AT6FD6
12202	2,166	0.4%	PL>80%	SBS	1,000-2,500	≥19to<25	Nat/Plt	30/70	6/3	2000/1100	21	PL92SX5AT3
12203	3,557	0.6%	PL>80%	SBS	2,500-25,000	≥19to<25	Nat/Plt	30/70	6/3	6000/1100	20	PL92SX4AT4
13101	1,612	0.3%	PL>80%	MS	0-1,000	<19	Nat/Plt	60/40	6/3	1200/700	16	PL100
13102	8,904	1.5%	PL>80%	MS	1,000-2,500	<19	Nat/Plt	60/40	6/3	2000/1100	16	PL94SX6
13103	39,512	6.8%	PL>80%	MS	2,500-25,000	<19	Nat/Plt	60/40	6/3	6000/1100	16	PL95SX4BL1
13104	119	0.0%	PL>80%	MS	>25,000	<19	Nat/Plt	60/40	6/3	10000/1600	16	PL100
14101	4,941	0.8%	PL>80%	SBPS	0-1,000	<19	Nat/Plt	80/20	6/3	1200/700	15	PL97AT2SX1
14102	34,182	5.9%	PL>80%	SBPS	1,000-2,500	<19	Nat/Plt	80/20	6/3	2000/1000	14	PL95AT3SX2
14103	132,660	22.8%	PL>80%	SBPS	2,500-25,000	<19	Nat/Plt	80/20	6/3	6000/1100	15	PL97AT2SX1
14104	564	0.1%	PL>80%	SBPS	>25,000	<19	Nat/Plt	80/20	6/3	10000/1600	14	PL98AT2
14201	838	0.1%	PL>80%	SBPS	0-1,000	≥19to<25	Nat/Plt	80/20	6/3	1200/700	20	PL89AT7SX4
14202	5,568	1.0%	PL>80%	SBPS	1,000-2,500	≥19to<25	Nat/Plt	80/20	6/3	2000/1000	20	PL93SX4AT3
14203	15,876	2.7%	PL>80%	SBPS	2,500-25,000	≥19to<25	Nat/Plt	80/20	6/3	6000/1100	20	PL92AT4SX4
15101	2,411	0.4%	PL>80%	IDF	0-1,000	<19	Nat/Plt	80/20	6/3	1200/700	16	PL94AT4FD2
15102	14,129	2.4%	PL>80%	IDF	1,000-2,500	<19	Nat/Plt	80/20	6/3	2000/1000	17	PL93AT5FD2

ANALYSIS UNIT DESCRIPTION (Existing Managed Stands)							TIPSY INPUTS					
AU_EM	THLB (ha)	EM (Pct)	Species Group	BEC	Density (sph)	SI Class	Regen Method	Pct	Delay (yrs)	Establishment Density (sph)	SI	Species Composition
15103	27,606	4.7%	PL>80%	IDF	2,500-25,000	<19	Nat/Plt	80/20	6/3	6000/1100	16	PL93AT6FD1
15201	1,081	0.2%	PL>80%	IDF	0-1,000	≥19to<25	Nat/Plt	80/20	6/3	1200/700	19	PL91FD5AT4
15202	4,206	0.7%	PL>80%	IDF	1,000-2,500	≥19to<25	Nat/Plt	80/20	6/3	2000/1000	19	PL93FD4AT3
15203	4,079	0.7%	PL>80%	IDF	2,500-25,000	≥19to<25	Nat/Plt	80/20	6/3	6000/1100	19	PL93AT4FD3
16102	5	0.0%	PL>80%	ICH	1,000-2,500	<19	Plt	100	3	1000	18	PL54SX40BL6
16201	161	0.0%	PL>80%	ICH	0-1,000	≥19to<25	Plt	100	3	700	23	PL93SX5HW2
16202	1,108	0.2%	PL>80%	ICH	1,000-2,500	≥19to<25	Plt	100	3	1000	23	PL91SX6FD3
16203	447	0.1%	PL>80%	ICH	2,500-25,000	≥19to<25	Plt	100	3	1200	23	PL88SX10CW2
21101	85	0.0%	PL	ESSF	0-1,000	<19	Nat/Plt	30/70	6/3	1200/700	18	PL75SX20AT5
21102	2,215	0.4%	PL	ESSF	1,000-2,500	<19	Nat/Plt	30/70	6/3	2000/1000	18	PL59SX35BL6
21103	1,673	0.3%	PL	ESSF	2,500-25,000	<19	Nat/Plt	30/70	6/3	6000/1100	17	PL65SX21BL14
21201	148	0.0%	PL	ESSF	0-1,000	≥19to<25	Nat/Plt	30/70	6/3	1200/700	20	PL61SX34AT5
21202	3,666	0.6%	PL	ESSF	1,000-2,500	≥19to<25	Nat/Plt	30/70	6/3	2000/1000	20	PL61SX34BL5
21203	2,695	0.5%	PL	ESSF	2,500-25,000	≥19to<25	Nat/Plt	30/70	6/3	6000/1100	20	PL64SX24BL12
22101	114	0.0%	PL	SBS	0-1,000	<19	Nat/Plt	30/70	6/3	1200/700	19	PL70SX21BL9
22102	1,069	0.2%	PL	SBS	1,000-2,500	<19	Nat/Plt	30/70	6/3	2000/1100	18	PL60SX32BL8
22103	1,422	0.2%	PL	SBS	2,500-25,000	<19	Nat/Plt	30/70	6/3	6000/1100	18	PL70SX20BL10
22201	1,653	0.3%	PL	SBS	0-1,000	≥19to<25	Nat/Plt	30/70	6/3	1200/700	20	PL68AT18FD14
22202	10,937	1.9%	PL	SBS	1,000-2,500	≥19to<25	Nat/Plt	30/70	6/3	2000/1100	21	PL67SX23FD10
22203	18,490	3.2%	PL	SBS	2,500-25,000	≥19to<25	Nat/Plt	30/70	6/3	6000/1100	21	PL69AT16SX15
23101	17	0.0%	PL	MS	0-1,000	<19	Nat/Plt	60/40	6/3	1200/700	16	PL100
23102	4,130	0.7%	PL	MS	1,000-2,500	<19	Nat/Plt	60/40	6/3	2000/1100	16	PL66SX27BL7
23103	4,746	0.8%	PL	MS	2,500-25,000	<19	Nat/Plt	60/40	6/3	6000/1100	16	PL68SX21BL11
24101	452	0.1%	PL	SBPS	0-1,000	<19	Nat/Plt	80/20	6/3	1200/700	14	PL68AT24FD8
24102	5,017	0.9%	PL	SBPS	1,000-2,500	<19	Nat/Plt	80/20	6/3	2000/1000	15	PL67AT18SX15
24103	14,019	2.4%	PL	SBPS	2,500-25,000	<19	Nat/Plt	80/20	6/3	6000/1100	15	PL68AT24SX8
24104	33	0.0%	PL	SBPS	>25,000	<19	Nat/Plt	80/20	6/3	10000/1600	14	PL98AT2
24201	183	0.0%	PL	SBPS	0-1,000	≥19to<25	Nat/Plt	80/20	6/3	1200/700	20	PL68AT19SX13
24202	2,664	0.5%	PL	SBPS	1,000-2,500	≥19to<25	Nat/Plt	80/20	6/3	2000/1000	20	PL65SX25AT10
24203	8,895	1.5%	PL	SBPS	2,500-25,000	≥19to<25	Nat/Plt	80/20	6/3	6000/1100	20	PL65AT26SX9
25101	808	0.1%	PL	IDF	0-1,000	<19	Nat/Plt	80/20	6/3	1200/700	17	PL59FD24AT17
25102	7,462	1.3%	PL	IDF	1,000-2,500	<19	Nat/Plt	80/20	6/3	2000/1000	17	PL67AT19FD14
25103	17,067	2.9%	PL	IDF	2,500-25,000	<19	Nat/Plt	80/20	6/3	6000/1100	17	PL68AT17FD15
25201	1,878	0.3%	PL	IDF	0-1,000	≥19to<25	Nat/Plt	80/20	6/3	1200/700	19	PL57FD25AT18
25202	2,815	0.5%	PL	IDF	1,000-2,500	≥19to<25	Nat/Plt	80/20	6/3	2000/1000	19	PL68FD19AT13
25203	6,648	1.1%	PL	IDF	2,500-25,000	≥19to<25	Nat/Plt	80/20	6/3	6000/1100	19	PL67AT23FD10
26102	35	0.0%	PL	ICH	1,000-2,500	<19	Plt	100	3	1000	18	PL54SX40BL6
26103	0	0.0%	PL	ICH	2,500-25,000	<19	Plt	100	3	1000	18	PL54SX40BL6
26201	359	0.1%	PL	ICH	0-1,000	≥19to<25	Plt	100	3	700	23	PL73SX14FD13

ANALYSIS UNIT DESCRIPTION (Existing Managed Stands)							TIPSY INPUTS					
AU_EM	THLB (ha)	EM (Pct)	Species Group	BEC	Density (sph)	SI Class	Regen Method	Pct	Delay (yrs)	Establishment Density (sph)	SI	Species Composition
26202	3,916	0.7%	PL	ICH	1,000-2,500	≥19to<25	Plt	100	3	1000	23	PL62SX27FD11
26203	5,332	0.9%	PL	ICH	2,500-25,000	≥19to<25	Plt	100	3	1200	23	PL66SX24FD10

Notes:

- *BEC Groups: ESSFmc (ESSFmw,wc3,wcp,wcw,wk1,xv1,xv2,xvp);ICH (ICHmk3,wk2,wk4, CWHds1);IDF (IDFdk3,dk4,dw,ww,xm, BGxh3,xw2); MS (MSdc2,dv,xk3,xv); SBPS (SBPSdc,mc,mk,xc); SBS (SBSdw1,dw2,mc1,mc3,mh,mw,wk1)*
- *Species Groups: PL>80%=Pure pine (≥80%); PL=Pine leading, SB=Spruce leading; CH=Cedar-Hemlock leading; FD=Douglas-fir leading; DE=Deciduous leading*
- *Curves built for these analysis units transition into the same future managed curves following harvest*

Appendix 2 Silvicultural systems

Approach for modelling silvicultural systems of stand / management regimes within THLB

Order	Stand Type	Management Type	BEC Zone	Species Group	Snowpack Zone	Habitat Type	Silviculture System	Modelled Treatment	Regeneration	Model	SI Source
1	EN	Grassland	NA	Deciduous	NA	NA	CCR	Clearcut; no regeneration	None (grassland)	VDYP	VRI then none
2	EN	Grassland	NA	Other	NA	NA	CCR	Clearcut; no regeneration	None (grassland)	VDYP	VRI then none
3	EM	Non-MDWR; Non-Caribou; Non-IDF_Fd	Any	By SPP GRP	NA	NA	CCR	Clearcut	Natural and planted	VDYP	VRI
4	EN/EM	MDWR	Any	Fd≥40%	Shallow /Moderate	Low Structure	STS (GRP)	Uniform Selection @ 3 entries on 30yr cycle	Natural; same as pre-harvest	Prognosis & VDYP	VRI
5	EN/EM	MDWR	Any	Fd≥40%	Shallow /Moderate	Mod Structure	STS (GRP)	Uniform Selection @ 4 entries on 30yr cycle	Natural; same as pre-harvest	Prognosis & VDYP	VRI
6	EN/EM	MDWR	Any	Fd≥40%	Shallow /Moderate	High Structure	STS (GRP)	Uniform Selection @ 5 entries on 30 yr cycle	Natural; same as pre-harvest	Prognosis & VDYP	VRI
7	EN/EM	MDWR	Any	Fd≥40%	Transition /Deep	Low Structure	GRP	Group Selection @ 3-pass on 40yr cycle	Same curve; Increase Fd composition	VDYP	VRI
8	EN/EM	MDWR	Any	Fd≥40%	Transition /Deep	Mod Structure	GRP	Group Selection @ 4-pass on 40yr cycle	Same curve; Increase Fd composition	VDYP	VRI
9	EN/EM	MDWR	Any	Fd≥40%	Transition /Deep	High Structure	GRP	Group Selection @5-pass on 40yr cycle	Same curve; Increase Fd composition	VDYP	VRI
10	EN/EM	MDWR	Any	Pl leading	Any	Any	CCR	Clearcut	Plant Pl Fd	TIPSY	SIBEC
11	EN/EM	MDWR	Any	Deciduous	Any	Any	CCR	Clearcut	Plant Pl Fd	TIPSY	SIBEC
12	EN/EM	MDWR	Any	Other	Any	Any	CCR	Clearcut	Plant Pl Fd	TIPSY	SIBEC
13	EN/EM	Caribou	Any	Fd Leading	Any	Terrestrial; Arboreal	GRP	Clearcut	Plant Pl Sx Fd	TIPSY	SIBEC
14	EN/EM	Caribou	Any	Pl leading	Any	Terrestrial; Arboreal	GRP	Clearcut	Plant Pl Sx Fd	TIPSY	SIBEC
15	EN/EM	Caribou	Any	Other	Any	Terrestrial;	GRP	Clearcut	Plant Pl Sx Fd	TIPSY	SIBEC

Order	Stand Type	Management Type	BEC Zone	Species Group	Snowpack Zone	Habitat Type	Silviculture System	Modelled Treatment	Regeneration	Model	SI Source
						Arboreal					
16	EN/EM	Caribou	Any	Deciduous	Any	Terrestrial; Arboreal	GRP	Clearcut	Plant Pl Sx Fd	TIPSY	SIBEC
17	EN/EM	Non-MDWR	IDF	Fd Leading	NA	NA	SHE	Shelterwood @ 2 pass: (50% then 50% after 15 yrs)	Natural Fd80 Pl10 At10 (3500 sph)	TIPSY with 25% OAF1	SIBEC
18	EN/EM	Non-MDWR	IDF	Pl leading	NA	NA	CCR	Clearcut	Plant Pl	TIPSY	SIBEC
19	EN/EM	Non-MDWR	IDF	By SPP GRP	NA	NA	CCR	Clearcut	Plant Pl	TIPSY	SIBEC
20	EN/EM	Non-MDWR	IDF	Deciduous	NA	NA	CCR	Clearcut	Plant Pl	TIPSY	SIBEC
21	EN/EM	Non-MDWR	Non-IDF	Fd Leading	NA	NA	CCR	Clearcut	Plant Pl Sx Fd	TIPSY	SIBEC
22	EN/EM	Non-MDWR	Non-IDF	Pl leading	NA	NA	CCR	Clearcut	Plant Pl Sx Fd	TIPSY	SIBEC
23	EN	Non-MDWR	Non-IDF	Leading Species	NA	NA	CCR	Clearcut	Plant Pl Sx Fd	TIPSY	SIBEC
24	EN/EM	Non-MDWR	Non-IDF	Deciduous	NA	NA	CCR	Clearcut	Plant Pl Sx Fd	TIPSY	SIBEC

Notes:

- *Stand Types (EN = existing natural; EM = existing managed);*
- *Silvicultural systems (CCR = clearcut with reserves; GRP = group selection; SHE = shelterwood; STS = single tree selection)*
- *Regeneration assumptions for these regimes are described in Appendix 1 – Analysis Units for Existing Natural Stands*