TYPE 4 SILVICULTURE STRATEGY IN THE OKANAGAN TSA

DATA PACKAGE

Prepared for:

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1.0 INTRODUCTION

1.1 Context

The Okanagan TSA has been selected as one of five similar Type 4 silviculture strategy projects being completed in the interior of British Columbia (BC), to provide tactical level direction for steering silviculture investment to help mitigate mid-term timber supply impacts created from the mountain pine beetle (MPB) epidemic. Ecora Natural Resource Group Ltd (Ecora) has been contracted by the MFLNRO to undertake the Type 4 silviculture strategy on the Okanagan TSA.

The Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), Resource Practices Branch (RPB) has recognized the value in strategically investing in the land base at this pivotal point in the outbreak cycle. The need to define clear timber objectives in the Okanagan TSA and ensure silviculture activities are consistent with objectives for all forest values has also been identified.

The project plan of action is to:

- Identify present and emerging issues;
- Identify objectives and create targets;
- Create vision for timber and habitat supply;
- Create and implement silviculture plan to translate the vision into operational reality;
- Allow for monitoring and iterative updates in the process.

This will be achieved by holding a series of meetings with a wide range of local and regional participants and utilizing expert's input to facilitate the inclusion of specific values into a forest estate modeling environment. Ecora has worked with the Ministry to facilitate these discussions and tie it all together in an optimization modelling environment that allows for the inclusion of the many complex and overlapping timber and non-timber resource values in the Okanagan TSA. The main outcome from this process is the **5-year silviculture investment plan** that links strategic level planning to management level actions. There are substantial additional benefits associated with the planning tool that can be utilized for decision support for a wide variety of other resource management decisions. The process has identified, modeled and provides a foundation to monitor the performance of important indicators on the land base.

This 'data package' document is the second of four documents to make up this type 4 Silviculture Strategy for the Okanagan TSA:

1. **Situational analysis:** describing the general situation for the TSA. PowerPoint slides that were presented at the initial meeting are included at the end of the document;
2. **Data Package:** describing the input data, information and assumptions;
3. **Analysis Report:** describing the modeling output and rationale; and
4. **Silviculture Strategy:** providing treatment options, targets and benefits.

2.0 MODELING APPROACH

2.1 Model selection

As the demands on natural resource management have increased, modeling processes and techniques have been evolving to more adequately capture the complexity of the situation. The Okanagan Type 4 has endeavored to explicitly model multiple land base objectives while spatially assessing and scheduling silvicultural and harvesting activities. This enables silviculture activities such as fertilization, spacing, and enhanced reforestation to be scheduled considering a wide variety of values such as forest health, range, hydrology, wildfire risk, and forest carbon in addition the many traditional values considered in TSR

A fully spatial metaheuristic optimization approach has been selected for this project. The specific model selected is *Patchworks*, which is developed and commercially available by Spatial Planning Systems Inc. of Deep River, Ontario.

2.2 *Patchworks* Model

Patchworks is well suited to the project primarily due to its ability to consider multiple resource values in optimizing a long-term treatment schedule. *Patchworks* was first introduced in 2001 and is still being actively developed. It is currently used by resource analysts across Canada. It is a spatially-explicit model that allows the user to explore trade-offs between a broad range of conflicting management goals.

Patchworks has the flexibility to integrate operational-level considerations into a strategic-level environment and includes an easy to use interface that allows users to access and understand information in real-time.

The *Patchworks* data structure is very flexible. Indicators and targets can be based on any age-based attribute. Users are free to define any age-base curve, and the dependent variables can be continuous (e.g. stand volume or height) or boolean (is or is not 'old seral').

The scheduling model itself, and the associated tools, are all available through a graphic user interface (GUI). This GUI also provides a view of the input spatial data and also configurable views of the spatial results while the model is running. Basic model output consists of graphical and tabular summaries, and an HTML framework for easily viewing them.

More information and documentation on the model can be found on the web at: http://www.spatial.ca/products/index.html.

3.0 DATA SOURCES

Table 3.1 shows the input spatial data sources for this analysis- much of the data was used in the most recent timber supply analysis on the Okanagan TSA- the OIFS Uplift Analysis (Ecora, 2012). The VRI age was projected to 2012 and recent harvest depletions from RESULTS data until 2012 were used to update stand age.

Table 3.1: Spatial Data Sources

Data Description	Date	Source
Land base Classification		
ESA	2002	MOF
Indian Reserves	Aug-12	LRDW
Land Ownership	2012	LRDW
Old Growth Mgmt Areas	Aug-11	LRDW
Operability	11-Aug	MSRM
Parks and Protected Areas	Feb-12	LRDW
Riparian Classifications	2002	LRDW/TNRG
Terrain Stability	2002	LRDW
TFL Boundary	Feb-11	LRDW
Timber Licenses	Aug-11	LRDW
TRIM Roads	TRIM II	LRDW
Buffered roads	Jan-02	MSRM
TSA Boundary	Aug-11	LRDW
Woodlots and Community Forests	Jun-12	MOF
Disturbance Updates		
Fire History	Aug-12	LRDW
RESULTS	Aug-12	RESULTS
Growth and Yield		
Biogeoclimatic Zones (BGC) Version 8	Jun-12	MOF
Forest Health Overview (FHO)	Feb-12	MOF
Mountain Pine Beetle (MPB) Projections	2012	MOF
Predictive Ecosystem Map (PEM)	2007	ECOCAT
Vegetation Resource Inventory (VRI)	2012	LRDW
Wet-belt / Dry-belt	From BEC	
Resource Management		
Biodiversity Emphasis Options (BEO)	2012	LRDW
Community Watersheds	2012	LRDW
Lakeshore Management Zone (LMZ)	2012	LRDW
Landscape Units (LU)	2012	LRDW
Range Units	2012	LRDW
Slope	2012	TRIM II
Third Order Watersheds	2012	LRDW
Ungulate Winter Ranges (UWR)	2012	LRDW
VLI Inventory	2012	LRDW
Wildlife Habitat Areas (WHA)	2012	LRDW

4.0 LAND BASE CLASSIFICATION

The land base classification is the stepwise process of defining the productive land base and timber harvestable land base (THLB) from the gross TSA area according to classification criteria detailed below.

From the gross TSA area, areas classified as non-TSA, non-forest, non-commercial brush and existing roads are removed to produce the productive forest area. The productive land base is the forested land that contributes towards meeting non-timber objectives.

Further from this, the productive land base is reduced by areas unlikely to be harvested or areas reserved from harvesting for another purpose to define the THLB. The THLB is the land base that timber harvesting is assumed to occur on.

The land base classification steps are summarized in Table 4.1. The land base classification was done considering the best available information as defined in TSR and the recent OIFS Uplift Analysis (Ecora, 2012). A detailed discussion around each classification step is provided in the following section.

Table 4.1: Netdown Table

Land Classification	TSR II (ha)	Uplift Analysis (ha)	Type 2 (ha)	Type 4 (ha)
Total Area	**2,246,713**	**2,219,037**	**2,251,552**	**2,251,590**
Non-crown land	405,579	349,714	446,466	430,595
Non-forest	399,203	400,799	393,662	294,401
Non-commercial brush	0	7,525	6,572	485
Existing roads, trails, landings	21,358	21,288	25,289	26,132
Productive Forest	**1,420,573**	**1,439,711**	**1,379,563**	**1,499,977**
Parks	46,793	117,777	119,756	142,123
Inoperable areas	115,342	103,410	96,009	172,453
Low productivity	17,433	15,461	14,063	42,875
Terrain Stability	n/a	n/a	n/a	17,031
Regeneration ESAs	47,403	38,617	32,759	38,905
Deciduous forest types	35,658	36,235	23,893	12,200
Problem forest type Hemlock	62,512	46,008	51,392	26,336
Riparian reserves	37,677	36,608	35,724	35,850
Enhanced riparian areas	n/a	9,224	8,853	8,907
CRAs	n/a	n/a	3,739	n/a
WHAs	n/a	n/a	2,223	3,163
OGMAs	n/a	n/a	52,589	58,571
No Harvest Caribou	n/a	n/a	12,051	14,979
Total reductions	**362,818**	**403,339**	**453,049**	**573,393**
Current Timber Harvesting Land base	**1,057,755**	**1,022,088**	**926,514**	**926,584**
Less future roads, trails landings	41,256	24,187		
Future Timber Harvesting Land base	1,031,101	1,018,254	926,514	926,584

4.1 Total Area

The Okanagan TSA is defined by all area that falls within the Okanagan forest district but not within a tree farm license (TFL). From a total gross area of 2,251,590 ha, all other areas are netted out.

4.2 Non-Crown Land

Items included under non-crown are: private land, Indian reserves, community forests (CF), woodlots and controlled recreation areas (CRA). Private land was identified using the ownership values of 40 (Private – Crown Grant) and 50 (Federal Reserve). 245,971ha were removed as private land. Indian reserve land was identified using the LRDW coverage "CLAD_INDIA" where reserve name was not blank. A total of 64,329ha of Indian reserves were removed from the land base. There are many new CFs in the Okanagan TSA since the last TSR and all were removed from the crown land base. A total of 79,464ha were removed from CF licenses K1P, K2U and K3T. Woodlots were identified as any license starting with "W" in LRDW's forest tenure coverage and a total of 48,536ha were removed from the crown land base as woodlots. Controlled recreation areas (CRA) that are removed from the productive area include park name "Big White Mountain Ecological Reserve". A total of 956ha were removed for this CRA.

4.3 Non-Forest and Non-Productive

The non-forest descriptor equal to 'NTA' (no typing available) in the vegetative resource inventory (VRI) is used to identify non-forested sites.

The 2010 TSR data package describes the non-forest and non-productive netdown as "including the British Columbia Land Cover Classification Scheme, site index, a history of harvesting and other VRI attributes". To mimic this, areas with either a crown closure < 10%, a non-productive descriptor or a non-forested descriptor and no harvest history were removed. A total of 294,401ha was removed as non-forest and non-productive.

4.4 Non-Commercial Brush

Consistent with the previous analyses, area with the non-forest descriptor "NC" or "NCBR" in the VRI were removed as non-commercial brush. 485ha was removed as non-commercial brush from a total 1,701ha identified. The area identified as non-commercial brush is significantly less in the new VRI.

4.5 Existing Roads Trails and Landings

In the source data, many the roads, trails and landings are specially identified and able to be removed from a timber supply analysis. For this analysis the linework for linear features such as roads have been removed in order to clean up/operationalize the blocking layer. This significantly reduces the number of smaller polygons and "sliver" polygons in the final database. Instead these linear netdowns are applied as aspatial reductions to the forest cover polygons that they intersect. To do this, the buffered road layer was overlaid with the VRI and the area of existing roads within each forest cover polygon was determined as a percentage of each stand. This percentage was then applied to the resultant at the forest cover polygon level, reducing the net productive area of each stand. The end result is a layer where blocks are not split by buffered roads. A total of 26,132ha were removed to account for existing roads, trails and landings of which 8,894ha were removed to account for additional in-block existing road trails and landings.

4.6 Productive Forest Area

The productive forest area represents the crown forested land base, which excludes non-crown, non-forest / non-productive, non-commercial brush and existing roads. The productive forest area in this analysis is 1,499,977ha.

4.7 Parks

Parks represent 142,123ha, which are protected areas and ecological reserves. These areas are part of the productive forest, but are excluded from the THLB.

4.8 Inoperable Areas

There are 172,453ha of area identified in the operability layer as not being operable (Operability = “I”). If an area is identified as inoperable, but has a harvest history then the area remains in the THLB.

4.9 Low Productivity/Non-Merchantable Areas

Previous analyses defined low productivity and non-merchantable categories using a combination of species, site index, height and crown closure. The intent of this netdown was to identify those stands not likely to be harvested due to merchantability issues. In order to improve the accuracy of this netdown and more closely reflect the intent of the land base removal, low productivity stands were identified as those not reaching $100m^3$/ha merchantable volume by 140 years and having no harvest history. 79,640ha were removed as part of this low productivity netdown.

4.10 Terrain Stability/Regeneration ESAs

The use of terrain stability to model unstable soils is a new netdown step that was recommended by the Chief Forester in the 2006 AAC rationale. Slope stability class 5 areas (very high instability) are removed as described in the 2010 TSR data package when there is no harvest history. 17,031ha are removed as part of the terrain stability netdown.

Environmentally sensitive areas (ESA) for regeneration were identified as ESA high or low code containing “P” (planting). 38,905ha were removed as regeneration ESAs.

4.11 Deciduous Forest Types

Consistent with previous analyses, all deciduous leading stands are removed that have no harvest history. Deciduous leading is defined as species 1 in the VRI is equal to: AC, AT, ACT, D, DG, DR, E, EP, M or MB. 12,200ha was removed as deciduous leading.

4.12 Hemlock Leading Types

Consistent with TSR, hemlock leading types are removed that have no harvest history and age greater than 140 years. Hemlock leading is defined as species 1 in the VRI equal to: H, HW, Hw, HM, or Hm. 26,336ha was removed as hemlock leading.

4.13 Riparian Reserves and Enhanced Riparian Reserves

Consistent with the roads, linework for linear futures such as riparian reserves have been removed in order to clean up/operationalize the blocking layer. This significantly reduces the number of smaller polygons and "sliver" polygons in the final database. Rather these linear netdowns were applied as aspatial reductions to the forest cover polygon that they intersected. To do this the buffered riparian layer was overlaid with the forest inventory and the area of riparian buffer within each forest cover polygon was determined. This percentage was then applied to the analysis database at the forest cover polygon level reducing the net productive area of each stand. The end result is a layer where blocks are not split by riparian areas. 8,907ha were removed to account for enhanced riparian reserves.

4.14 Wildlife Habitat Areas

Wildlife habitat areas (WHAs) that are identified as having “no harvesting” within them were removed from the THLB. No harvest WHAs were identified by WHA number as shown in Table 4.2 (Table 7 from the 2010 TSR data package). The species Grizzly Bear, Lewis’s Woodpecker, Tiger Salamander, Western Screech Owl, White-headed Woodpecker and Williamson’s Sapsucker all have WHA numbers listed as no harvesting. 3,163ha were removed for WHAs in this analysis.

Note that the Mountain Caribou no harvest WHA will be dealt with separately in a following section.

Table 4.2: Wildlife Habitat Areas by Species

Table 7. Wildlife habitat areas by species

Species	Total hectares	WHA number	Modelling constraints
Antelope-Brush/Needle-And-Thread Grass	198	8-338, 8-339, 8-343, 8-344, 8-345, 8-347, 8-348, and 8-349	no measures to model
Bighorn Sheep	385	8-006, 8-007, 8-008, 8-009, and 8-010	no measures to model
Brewer's Sparrow	48	8-002	no measures to model
Grizzly Bear	4722	8-131, 8-132, 8-133, 8-134, 8-135, 8-136, 8-137, 8-138, 8-144, 8-145 and 8-146	no harvesting
Grizzly Bear	unknown	8-232	see ORDER constraints below
Lewis's Woodpecker	469	8-221, 8-122, 8-123, 8-245, 8-246, 8-247, 8-248, 8-249, 8-250, 8-251, 8-253, 8-266, 8-274, 8-275, 8-276, 8-277, 8-278, 8-280, 8-293 and 8-294	no harvesting
Mountain Caribou	5600		no harvesting
Tiger Salamander	151	8-090, 8-091, 8-092, 8-093 and 8-094	no harvest constraints
Tiger Salamander	70	8-236, 8-237 and 8-238	no harvest
Western Screech Owl	148	8-124, 8-261 and 8-262	no harvest
White-headed Woodpecker	199	8-014, 8-015, 8-016 and 8-017	no harvest
Williamson's Sapsucker	471	8-101, 8-102, 8-103, 8-106, 8-107, 8-108, 8-110, 8-113, 8-190, 8-191, 8-192, 8-194, 8-197, 8-199, 8-201 and 8-211	do not harvest or salvage
Yellow-breasted Chat	38	8-018, 8-067, 8-068, 8-069, 8-070, 8-071, 8-072, 8-073, 8-074, 8-075, 8-076, 8-127, 8-128, 8-129, 8-130, 8-234 and 8-235	no forest constraints

4.15 Old Growth Management Areas

Old growth management areas (OGMAs) are identified using the most current OGMA data layer from the LRDW. 58,571ha were removed from the THLB as OGMAs.

4.16 'No Harvest' Caribou

Mountain Caribou no harvest areas are part of the approved ungulate winter range (UWR) dataset. Each UWR is associated with a Government Actions Regulation (GAR) order that outlines the objectives associated with the UWR. As described in the 2010 TSR data package, areas associated with 2 UWRs are treated as no harvest zones:

- UWR #U-3-005: Revelstoke-Shuswap (effective 2009);
- UWR #U-8-004: Revelstoke-Shuswap and South Monashee (effective 2006); and
- BEC in: ESSFvcp, ESSFwcp, ESSFxcp or ESSFdcp.

14,979ha was removed in this netdown from a total identified area of 36,948ha.

5.0 GROWTH AND YIELD

Forest estate modelling requires projecting how a stand will change over time, such as the growth in terms of height and volume. These projections are inputs to the forest estate model that are developed using growth and yield models. For efficiency the productive forest is assigned to analysis units (AU), which are aggregates of areas with similar characteristics. Natural stands AUs are assigned to forested areas that haven't been harvested and managed stand AUs are assigned to the entire productive land base. Those stands harvested since 1975 or are less than 35years are classified as managed, and stands that are older than 35years are classified as natural.

For each AU a series of growth and yield curves are developed. Existing natural stands growth and yield is modelled using VDYP, whereas managed stands are modelling using TIPSY. The assumptions, inputs and applicable outputs used in this analysis are documented in this section.

5.1 Analysis Unit Aggregation

AUs are aggregations of stands with similar species composition, site productivity and treatment regime. The following sections describe how natural and managed stand AUs are defined. These AUs are defined to accommodate a wide variety of modeling functionality including volume projections, value projections, wild fire risk assessments, MPB modeling, forest carbon and range.

5.1.1 Natural Analysis Units

Natural stand AUs are defined according to species, productivity and MPB characteristics as follows:

- Harvest method (clear-cut or partial cut);
- MPB characteristics: the mortality percentage and year affected;
- Leading species;
- Age of stand (rounded to the nearest 20 years);
- Inventory site index (rounded to the nearest 3m);
- BGC zone; and
- Crown closure class (dense/open/sparse).

Grouping stands in the TSA by the above factors result in a very large number of AUs (~40,000), and because of this all AUs cannot be listed in this document. Instead, examples of some natural stand AU definitions are shown in Table 5.1.

Table 5.1: Example Natural Stand AU Definitions

Harvest method	BGC Zone	Leading Species	Site Index	Age	Crown closure class	MPB Characteristics	
						Mortality %	Year Affected
Clear-cut	IDFdk2	Spruce	21	150	dense	0	n/a
Clear-cut	IDFdk2	Spruce	21	150	open	40	2008
Clear-cut	IDFdk2	Pine	12	80	sparse	0	n/a
Clear-cut	IDFdk2	Pine	12	80	dense	40	2008
Clear-cut	IDFdk2	Pine	12	80	dense	60	2008
Clear-cut	IDFdk2	Pine	15	130	open	80	2012
Clear-cut	IDFdk2	Pine	15	130	open	70	2012
Partial-cut	IDFdk2	Douglas-fir	15	90	sparse	0	n/a
Clear-cut	IDFdk2	Douglas-fir	15	180	sparse	50	2012
Clear-cut	IDFdk2	Douglas-fir	15	90	open	0	n/a

5.1.2 Partial Harvesting

Partial harvesting is expected to occur in areas of the IDF, PP and BG BGC zones due to temperature extremes and their value as mule deer winter range (MDWR). All assumptions regarding the identification and modelling of partially harvested stands are from TSR 4. Partially harvested stands are identified as those stands meeting the following criteria:

- Dry-belt;
- BEC: PPxh1/PPxh2/IDFxh1/IDFxh2/IDFdk1/IDFdk2/IDFdm1/MSxk/BGxh1; and
- Douglas-fir leading.

Partially harvested stands are assumed to regenerate on the same yield curve, have 33% of their volume removed when harvesting occurs, and a minimum return interval of 30 years.

5.1.3 Managed Analysis Units

Managed stands are grouped into AUs (Table 5.2) based on criteria consistent with the most recent analyses (OIFS Uplift Analysis, (Ecora, 2012), TSR 4 (MFLNRO, 2011) and the Type II Silviculture Analysis (Timberline, 2008). Table 5.2 the criteria for assigning the managed stand AUs. These are assigned to stands that are currently managed and also to natural stands for modeling their growth after harvesting.

Table 5.2: Managed Stand AU Definitions

AU #	Leading species	Dry / Wet	Age	SI
103	Fir (Fd)	Wet	<= 140	>= 14.5
104			<= 140	< 14.5
105			> 140	>= 14.5
106			> 140	< 14.5
107	Cedar (Cw)	Wet	<= 140	>= 16
108			<= 140	< 16
109			> 140	>= 16
110			> 140	< 16
111	Hemlock (Hw)	Wet	<= 140	>= 15
112			<= 140	< 15
113			> 140	>= 15
114			> 140	< 15
115	Balsam (B)	Wet	<= 140	>= 13
116			<= 140	< 13
117			> 140	>= 13
118			> 140	< 13
119	Spruce (S)	Wet	<= 140	>= 12.5
120			<= 140	< 12.5
121			> 140	>= 12.5
122			> 140	< 12.5
123	Lodgepole Pine (Pl)	Wet	<= 140	>= 13.5
124			<= 140	< 13.5
125			> 140	>= 13.5
126			> 140	< 13.5
153	Fir (Fd)	Dry	<= 140	>= 14.5
154			<= 140	< 14.5
155			> 140	>= 14.5
156			> 140	< 14.5
157	Cedar (Cw)	Dry	<= 140	>= 16
158			<= 140	< 16
159			> 140	>= 16
160			> 140	< 16
161	Hemlock (Hw)	Dry	<= 140	>= 15
162			<= 140	< 15
163			> 140	>= 15
164			> 140	< 15
165	Balsam (B)	Dry	<= 140	>= 13
166			<= 140	< 13
167			> 140	>= 13
168			> 140	< 13
169	Spruce (S)	Dry	<= 140	>= 12.5
170			<= 140	< 12.5
171			> 140	>= 12.5
172			> 140	< 12.5
173	Lodgepole Pine (Pl)	Dry	<= 140	>= 13.5
174			<= 140	< 13.5
175			> 140	>= 13.5
176			> 140	< 13.5

5.2 Managed Stand Yields

Table Interpolation Program for Stand Yields Version 4.2 (TIPSY4.2) is used to model the growth and yield for managed stand AUs. The inputs for TIPSY are assigned based on a combination of management practices and site productivity.

Productivity estimates for managed stand yields are sourced from the MFLNRO's provincial site productivity layer. This layer is a province-wide 100m by 100m grid that combines and utilizes PEM/TEM and SIBEC information where available and fills in the gaps with an in-house a bio-physical model. For more information on this layer, see the MFLNRO website at: http://www.for.gov.bc.ca/hts/siteprod/provlayer.html.

The site productivity layer has a site index (height at age 50) estimate for each species. To calculate an average managed site index for each AU, an area-weighted average site index for the leading planted species was used. In cases where the site index was not populated for the leading planted species, the site index was defaulted to the inventory site index.

5.2.1 TIPSY Input Assumptions

Management practices such as species and planting densities are assigned using a combination of past practice and a review of current practice. Table 5.3 shows the managed stand assumptions by AU. Other assumptions that are constant include for all analysis units are:

- Planting at 1,312 stems/ha;
- Regeneration delay of 2 years (years between harvest and establishment of new trees);
- Operational adjustment factors (OAFs) consistent with TSR 4 were used: OAF1 of 15% and OAF2 of 5% except in Douglas-fir leading stands where an OAF2 of 10% was applied to account for the uncertainty around root rot in these stands;
- Utilization levels consistent with TSR 4 of 12.5 cm for pine leading stands and 17.5 cm for all others; and
- Genetic gains estimates shown in Table 5.4.

Table 5.3: Managed Stand Input Assumptions

AU #	Sp1	Sp1 %	Sp2	Sp2 %	Sp3	Sp3 %	Sp4	Sp4 %	SI Est.
103	FD	50	PL	30	SW	10	CW	10	22.9
104	FD	50	PL	30	SW	10	CW	10	22.3
105	FD	50	PL	30	SW	10	CW	10	22.2
106	FD	50	PL	30	SW	10	CW	10	21.8
107	FD	50	SW	30	PL	20			24.5
108	FD	50	SW	30	PL	20			23.9
109	FD	50	SW	30	PL	20			23.6
110	FD	50	SW	30	PL	20			23.7
111	FD	50	SW	30	PL	20			25
112	FD	50	SW	30	PL	20			24
113	FD	50	SW	30	PL	20			24.7

AU #	Sp1	Sp1 %	Sp2	Sp2 %	Sp3	Sp3 %	Sp4	Sp4 %	SI Est.
114	FD	50	SW	30	PL	20			23.7
115	SW	90	PL	10					17.5
116	SW	90	PL	10					13.1
117	SW	90	PL	10					16.4
118	SW	90	PL	10					11.4
119	SW	90	PL	10					18.9
120	SW	90	PL	10					14.3
121	SW	90	PL	10					18.1
122	SW	90	PL	10					13.6
123	PL	90	FD	10					20.7
124	PL	90	FD	10					19.9
125	PL	90	FD	10					20.2
126	PL	90	FD	10					19.3
153	FD	50	PL	30	SW	10	CW	10	18.8
154	FD	50	PL	30	SW	10	CW	10	18.5
155	FD	50	PL	30	SW	10	CW	10	18.7
156	FD	50	PL	30	SW	10	CW	10	18.2
157	FD	50	SW	30	PL	20			21.8
158	FD	50	SW	30	PL	20			19.6
159	FD	50	SW	30	PL	20			21.1
160	FD	50	SW	30	PL	20			21.7
161	FD	50	SW	30	PL	20			20.6
162	FD	50	SW	30	PL	20			15.7
163	FD	50	SW	30	PL	20			20
164	FD	50	SW	30	PL	20			15.7
165	SW	90	PL	10					17.3
166	SW	90	PL	10					12.7
167	SW	90	PL	10					16.5
168	SW	90	PL	10					11
169	SW	90	PL	10					17.5
170	SW	90	PL	10					12
171	SW	90	PL	10					16.5
172	SW	90	PL	10					12.6
173	PL	90	FD	10					18.2
174	PL	90	FD	10					17.9
175	PL	90	FD	10					17.6
176	PL	90	FD	10					17

TSR 4 estimates of genetic gains will be used for managed stand yields in TIPSY in this analysis. Table 19 from TSR 4 data package shows these estimates (shown as Table 5.4 here) – the column titled “5 year average – net GW by spp” is used.

Table 5.4: Table 19 from TSR 4 Data Package

Table 19. Genetic gain and select seed use

Species	5 year average – genetic gain	5 year average – % select seed used	5 year average – net GW by spp
Fdi	16.4	4.7	0.8
Pli	6.6	31.1	2.1
Sx	9.4	84.7	8.0

5.3 Natural Stand Yields

Stands without harvest history are classified as natural stands with yield projections produced the Variable Density Yield Prediction model version 7 (VDYP7). Productivity estimates for natural stands are sourced directly from the VRI via VDYP using age, height and species. A yield curve is generated for each stand and then these yield curves are area-weighted to produce one yield curve for each AU.

A phase II adjustment is a statistical adjustment on the Phase I VRI using Phase II ground sample data. This sample data is statistically compared to the Phase I VRI interpreted attributes to calculate adjustment ratios according to the 2011 adjustment protocol provided by the ministry (MFLNRO, 2011b). The OIFS completed a Phase II VRI adjustment on the new VRI in 2011 (Ecora, 2011). Adjustment ratios from this report are applied to the volume as shown in Table 5.5. Pine leading stands were not adjusted.

Table 5.5: Phase II Adjustment Ratios

Strata	Adjustment Ratio		
	Age	Height	Volume
Balsam - Mature	1.0034	1.1143	1.2902
Douglas-fir - Mature	0.9382	0.9055	1.2943
Other - Mature	0.6772	0.8618	1.0826
Spruce - Mature	0.9445	0.9072	1.1330
Immature	1.4142	1.2199	1.3469
Pine (no adjustment)	n/a	n/a	n/a

5.4 Other Timber Management Parameters

5.4.1 Utilization Levels

Utilization levels are consistent with TSR 4 of 12.5 cm for pine leading stands and 17.5 cm for all others

5.4.2 Minimum Harvest Age

Minimum harvest age (MHA) is an estimation of the lowest age at which a stand can be harvested economically. MHA is calculated for each AU as the age that a stand achieves 90% of the culmination maximum mean annual increment (CMAI) with a minimum harvestable volume of 150m^3/ha. The exact MHA for each AU is different depending on AU-specific characteristics such as species and productivity. On the Okanagan TSA, MHA varies between 40 years (for a few extremely high productivity stands) and 140 years, with the average at 100 years.

5.4.3 Non-Recoverable Losses

Non-Recoverable Loss (NRL) estimates are taken from Table 24 from the TSR 4 data package and are shown in Table 5.6.

Table 5.6: NRL Estimate From TSR 4

Table 24. Non-recovered losses

Cause of loss	Annual NRLs (m³/year)
Fire	178 800
Douglas-fir beetle	29 800
Spruce bark beetle	3 200
Windthrow	16 500
Mountain pine beetle	Currently an epidemic and modelled separately from these non-recovered losses
Total	228 300

5.4.4 Harvest Systems

A harvest system characterizes the type of harvesting expected to occur on a stand and in the Okanagan TSA, clear-cut harvesting is the norm with partial harvesting utilized in the MDWR and dry-belt Douglas-fir areas as described in the section above.

5.4.5 Planning Horizon

A 250-year planning horizon is used in this analysis to ensure the long term sustainability of the harvest level.

5.4.6 Reductions

Deciduous Component: The deciduous component of conifer leading stands has been modeled as a reduction in area.

Wildlife Tree Patches (WTP): Wildlife tree patches (WTPs) are groups of wildlife trees (standing dead and live green trees) that are intended to maintain important stand-level structural elements during forest harvesting and silviculture.

Consistent with TSR4, WTPs will be modeled as a 6.45% reduction in area at time of harvesting. This WTP area is assumed to age continually from the pre-harvest age and can contribute to land base level resource management requirements. These reductions interact with the reductions for the deciduous component, in that if the deciduous component was >6.45%, it is assumed that WTPs would be placed in deciduous component and the reduction was not implemented as it would be double accounting.

Future Road Reduction: Consistent with TSR4 assumptions, to account for the area removed from productive state by the construction of roads for future harvesting, a 4.9% area reduction will be applied after harvesting for the first time on all natural stands.

5.5 Disturbing the Non-THLB

In the timber supply model, the productive area that is not part of the THLB (non-THLB) will continuously age throughout the planning horizon because harvesting is traditionally the only form of disturbance modeled. This causes concern because eventually, in the model, all the non-THLB becomes old whereas in reality, there will be some level of natural disturbance within the non-THLB. Because the entire productive land base is available to fulfill various retention requirements, this can lead to the non-THLB fulfilling an unrealistic portion of forest cover requirements in the long term. This is addressed by modeling disturbances in the non-THLB.

This section describes the process of disturbing the non-THLB used for this analysis. The intentions are to achieve the early, mature and old seral percentages for each BGC zone in accordance with the natural range of variation defined in the Biodiversity Guidebook (MOF, 1995). The method used for this analysis is for each BGC zone to:

1. Impose an annual disturbance to the non-THLB of each BGC zone. The size of the disturbance will be determined from the disturbance frequency in the Biodiversity Guidebook; and
2. A retention requirement on the non-THLB of each BGC variant is applied, which will force the non-THLB to achieve a seral zone distribution similar to the natural rate of variation (NROV) from the Biodiversity Guidebook.

5.5.1 Annual Disturbance

The area in each BGC zone is summarized and the NDT and disturbance return interval are found from the Biodiversity Guidebook (MOF 1995). This information allows the annual disturbance to be calculated by BGC. The annual disturbance is 1% the disturbance interval and the annual disturbance area is this percentage * non-THLB area (as shown in Table 5.7).

Table 5.7: Non-THLB Annual Disturbance

BGC Label	NDT	Disturbance	% Disturbed	Total Non-	Annual
BGxh1	4	250	0.40%	479	2
ESSFdc1	3	150	0.67%	12,939	86
ESSFdc2	3	150	0.67%	2,293	15
ESSFdc3	3	150	0.67%	5,442	36
ESSFdcw	3	150	0.67%	5,347	36
ESSFvc	1	350	0.29%	19,129	55
ESSFvcw	1	350	0.29%	9,550	27
ESSFwc1	1	350	0.29%	1,266	4
ESSFwc2	1	350	0.29%	24,536	70
ESSFwc4	1	350	0.29%	33,831	97
ESSFwcw	1	350	0.29%	50,589	145
ESSFxc1	3	150	0.67%	33,660	224
ESSFxc2	3	150	0.67%	10,469	70
ESSFxcw	3	150	0.67%	5,340	36
ICHmk1	3	150	0.67%	12,022	80
ICHmk2	3	150	0.67%	3,732	25
ICHmw2	2	200	0.50%	32,062	160
ICHmw3	2	200	0.50%	26,797	134
ICHvk1	1	250	0.40%	24,375	98
ICHwk1	1	250	0.40%	41,376	166
IDFdk1	4	250	0.40%	13,272	53
IDFdk1a	4	250	0.40%	867	3
IDFdk2	4	250	0.40%	9,397	38
IDFdk2b	4	250	0.40%	297	1
IDFdm1	4	250	0.40%	10,883	44
IDFmw1	4	250	0.40%	15,397	62
IDFmw2	4	250	0.40%	5,022	20
IDFxh1	4	250	0.40%	42,142	169
IDFxh1a	4	250	0.40%	2,059	8
IDFxh2	4	250	0.40%	3,133	13
MSdm1	3	150	0.67%	16,619	111
MSdm2	3	150	0.67%	9,763	65
MSdm3	3	150	0.67%	2,003	13
MSxk1	3	150	0.67%	16,928	113
PPxh1	4	250	0.40%	16,413	66
PPxh1a	4	250	0.40%	1,542	6

5.5.2 Retention Requirement

The seral stage distribution is estimated using the negative exponential equation from Appendix 4 of the Biodiversity Guidebook (MOF 1995). The negative exponential equation uses the disturbance return interval and gives the percent older than the input age from the equation:

Percent older then specified age = exp (-[age/return interval])

Table 5.8shows the retention requirements placed on each BGC zone in order to achieve the desired NROV.

Table 5.8: Retention Requirements for the non-THLB

BGC Label	NDT	Mature Requirements		Old Requirements	
		Minimum Age (years)	Minimum %	Minimum Age (years)	Minimum %
BGxh1	4	100	67%	250	37%
ESSFdc1	3	120	45%	140	39%
ESSFdc2	3	120	45%	140	39%
ESSFdc3	3	120	45%	140	39%
ESSFdcw	3	120	45%	140	39%
ESSFvc	1	120	71%	250	49%
ESSFvcw	1	120	71%	250	49%
ESSFwc1	1	120	71%	250	49%
ESSFwc2	1	120	71%	250	49%
ESSFwc4	1	120	71%	250	49%
ESSFwcw	1	120	71%	250	49%
ESSFxc1	3	120	45%	140	39%
ESSFxc2	3	120	45%	140	39%
ESSFxcw	3	120	45%	140	39%
ICHmk1	3	100	51%	140	39%
ICHmk2	3	100	51%	140	39%
ICHmw2	2	100	61%	250	29%
ICHmw3	2	100	61%	250	29%
ICHvk1	1	100	67%	250	37%
ICHwk1	1	100	67%	250	37%
IDFdk1	4	100	67%	250	37%
IDFdk1a	4	100	67%	250	37%
IDFdk2	4	100	67%	250	37%
IDFdk2b	4	100	67%	250	37%
IDFdm1	4	100	67%	250	37%
IDFmw1	4	100	67%	250	37%
IDFmw2	4	100	67%	250	37%
IDFxh1	4	100	67%	250	37%
IDFxh1a	4	100	67%	250	37%
IDFxh2	4	100	67%	250	37%
MSdm1	3	100	51%	140	39%
MSdm2	3	100	51%	140	39%
MSdm3	3	100	51%	140	39%
MSxk1	3	100	51%	140	39%
PPxh1	4	100	67%	250	37%
PPxh1a	4	100	67%	250	37%

6.0 TSR Resource Management Zones

Direction on resource management zones (RMZ) comes from a variety of sources including:

- The 2002 Okanagan-Shuswap Land and Resource Management Plan (OSLRMP);
- Under the Forest and Range Practices Act, objectives that are grand-parented from the Forest Practices Code – such as community watershed objectives;
- Ministry of Environment's approved ungulate winter ranges (UWR) and associated orders (http://www.env.gov.bc.ca/wld/frpa/uwr/index.html);
- Wildlife habitat areas (WHA) and associated general wildlife measures (GWM) through the ministry's identified wildlife management strategy (IWMS) (http://www.env.gov.bc.ca/wld/frpa/iwms/index.html).

The sources of information and modelling assumptions for each RMZ are documented in the sections below.

6.1 Bighorn Sheep

The bighorn sheep habitat RMZ originates from the OSLRMP and will be modeled consistent with the Okanagan Type II Silviculture Analysis (Timberline, 2008): a minimum of 33% must be greater than 16m height (applied by BGC-LU).

6.2 Caribou

Mountain Caribou requirements in this analysis come from the WHA #8-233 "Mountain Caribou Specified Area", available on the MOE website listed above. Consistent with the GWM, a requirement of a minimum of 30% greater than 14m will be applied on each WHA area within this zone.

6.3 Community Watersheds

Each community watershed (CWS) in the Okanagan TSA has a disturbance requirement of a maximum of 30% less than 6m height.

6.4 Elk

The elk habitat RMZ originates from the OSLRMP and will be modeled consistent with the Okanagan Type II Silviculture Analysis (Timberline, 2008): a minimum of 30% must be greater than 16m height (applied by BGC-LU).

6.5 Goat

The mountain goat habitat RMZ originates from the OSLRMP and will be modeled consistent with the Okanagan Type II Silviculture Analysis (Timberline, 2008) for each goat habitat zone:

- In pine leading areas: a maximum of 33% may be less than 33years; and
- In non-pine leading areas: a maximum of 33% may be less than 50 years.

6.6 Grizzly Bear

As per the Grizzly Bear Specified Area #8-232, the retention requirements of a minimum 10% greater than 19.5m height must be maintained in each LU/BGC combination within WHA #8-232.

6.7 Integrated Resource Management

THLB area is grouped into the integrated resource management (IRM) zone by LU-BGC combination. A maximum of 30% may be less than 3m height in each IRM zone.

6.8 Lakeshore Management Zones

Lakes > 5ha have been classified as (A/B/C/D or E) according to the "Lake Classification and Lakeshore Management Guidebook: Kamloops Forest Region, September 1996". Consistent with recommendations here and in the OSLRMP, the lakeshore management zone (LMZ) for Class A and B lakes should be managed according to retention VQO guidelines. The LMZ for Class C lakes should be managed according to partial retention VQO guidelines.

6.9 Landscape Level Biodiversity

Landscape level biodiversity requirements are addressed through explicit old growth management area (OGMA) removal from the THLB.

6.10 Marten Habitat

Consideration of pine marten habitat originates from the OSLRMP. In these areas, consistent with past analyses, a retention requirement of a minimum of 33% greater than 19m height will be modeled by LU-BGC).

6.11 Mule Deer Winter Range

Mule Deer Winter Range (MDWR) requirements in this analysis come from the "Approved Ungulate Winter Ranges" (UWR) on the Ministry of Environment's (MOE's) website athttp://www.env.gov.bc.ca/wld/frpa/uwr/approved_uwr.html. The applicable order with regard to mule deer on the Okanagan TSA is: "Ungulate Winter Range #U-8-001-Okanagan TSA".

Many of the objectives in this order are operational (e.g. which trees to leave in WTPs) and are therefore not implemented in this strategic level analysis. The requirements are implemented by planning cell and depend upon snowpack zone (defined by BGC).

Table 6.1 (Table 1 from UWR #U-8-001) shows the definition of snow interception cover (SIC) attributes by snowpack zone.

Table 6.1: MDWR SIC Definition by Snowpack Zone

Snowpack Zone	Biogeoclimatic Units	Dominant Tree Species	Minimum Stand Age (years)	Canopy Closure
Shallow	BG PP IDFxh	Douglas-fir	Not less than 140	None specified Small patches, clumps or 'vets' acceptable
Moderate	IDFdk IDFdm IDFmw MS ICHdw	Douglas-fir	IDFmw – not less than 140 All other units – not less than 175; or not less than 40 cm dbh	At least 36%
Deep	ICH (except ICHdw)	Douglas-fir	Not less than 100, or not less than 40 cm dbh	At least 46%

The following section summarizes the requirements applied to each MDWR planning cell by snowpack zone:

- **Shallow Snowpack**: SIC retention as set out in the feature notes of the GIS file "tuwra_bc";
- **Moderate Snowpack**:
  - SIC retention as set out in the feature notes of the GIS file "tuwra_bc"; and
  - On all BECs excluding IDFmw, up to 50% of the retention requirement can be met on the non-THLB. This was dealt with by applying half of the retention objective on the THLB only (MOD1); and
  - On IDFmw, there is no restriction on the amount of SIC located in the non-THLB so the total retention requirement was applied across the productive area of each planning cell; and
  - A disturbance requirement that a maximum of 30% can be less than 20 years is implemented on each planning cell.
- **Deep Snowpack**: SIC retention as set out in the feature notes of the GIS file "tuwra_bc".

6.12 Moose Winter Range

Moose Winter Range (MWR) requirements come from the "Approved Ungulate Winter Ranges" on the MOE website: www.env.gov.bc.ca/wld/frpa/uwr/approved_uwr.html. The applicable order with regard to moose on the Okanagan TSA is: "Ungulate Winter Range #U-8-006-Okanagan TSA". This order establishes MWR boundaries and the regulations that apply within these areas. Schedule 1 – GWMs requires in each MWR that:

- A minimum of 33% be maintained >= 16m height; and
- A minimum of 15% is < 25 years (in the ICH/IDF) or < 35 years (MS/ESSF).

6.13 Visual Management

The visual landscape inventory (VLI) delineates areas of visual sensitivity near communities or adjacent to travel corridors. Restrictions on the acceptable limits of visual change are applied by visual polygon and are characterized by combination of visual quality objective (VQO) and visual absorption capability (VAC).

A VQO describes the extent of alteration allowable from cut blocks and roads for a given area and the VQO classes are defined as follows (from FPPR):

- **Modification (M):** an altered forest landscape in which the alteration is very easy to see and is either large in scale or natural in its appearance or small to medium in scale but with some angular characteristics;
- **Partial Retention (PR):** an altered forest landscape in which the alteration is easy to see, small to medium in scale and natural and not geometric in shape;
- **Preservation (P):** an altered forest landscape in which the alteration is very small in scale and not easily distinguishable from the pre-harvest landscape; and
- **Retention (R):** an altered forest landscape in which the alteration is very small in scale and not easily distinguishable from the pre-harvest landscape.

These descriptions are translated into disturbance requirements for the purpose of strategic level timber supply modeling. Requirements are applied across the productive land base to each visual polygon and are not applied in areas that are partially harvested because this type of harvesting is assumed to address visual objectives. VQOs are applied consistent to the Okanagan Type II Silviculture Analysis (Timberline, 2008) and TSR 4. Table 6.2 shows Table 16 from the TSR 4 data package and summarizes the disturbance requirements for VQO and VAC.

Table 6.2: Visual Quality Objectives

Table 16. Forest cover requirements for visually sensitive areas

Visual quality objective	Visual absorption capability	LRMP % visible alteration	LRMP VEG height (m)
P	L	5.0	5.0
P	M	7.5	4.0
P	H	10.0	3.0
R	L	10.0	5.0
R	M	15.0	4.0
R	H	20.0	3.0
PR	L	15.0	5.0
PR	M	25.0	4.0
PR	H	25.0	3.0
M	L	25.0	5.0
M	M	30.0	4.0
M	H	35.0	3.0

6.14 Summary of Area by RMZ

Table 6.3 is a summary of the area modeled in each RMZ listed above.

Table 6.3: RMZ Area Summary (ha)

RMZ	Area (ha)		
	THLB	Non-THLB Productive	Total Productive
Caribou WHA	8,981	5,420	14,401
CWS	176,675	83,566	260,241
Elk	18,739	14,319	33,059
Goat	1,479	26,793	28,271
IRM	149,162	19,807	168,969
LMZ	11,464	13,129	24,593
MDWR	82,561	100,471	183,032
Moose	89,322	45,844	135,165
Marten	19,726	9,016	28,742
Sheep	31,134	94,812	125,946
Visuals	233,708	185,090	418,798
WHAs	374,741	345,523	720,264

7.0 Mountain Pine Beetle Modelling

This section provides a synopsis of the mountain pine beetle (MPB) modeling assumptions in this analysis. The MPB modeling has been done consistent with previous analysis and uses direction from:

1. The Okanagan Shuswap Forest District (OSFD) forest health strategy, which directs forest health management to minimize timber losses and hazard risk from forest health factors (Hodge, 2008);
2. Forest Health Overview (FHO): The BC MFLNRO (formerly MOF / MOFR) has carried out an annual aerial survey on the majority of the forested land to locate and report disturbances from forest health factors. This FHO survey uses experts to perform sketch mapping of disturbances which is then summarized to annual reports and digital maps.
3. BCMPB Projections: Since 1999, the BC Ministry has been projecting the spread of MPB throughout the province and recalibrating the projections each year with the FHO.

7.1 MPB Projections

The MPB projections are a spatial rasterized database developed using stochastic modelling in SELES. Ecora post processes the projections to show the cumulative impact of MPB (instead of the annual outputs provided), which are useful for capturing the total MPB impacts to date and the projected impacts.

The most recent version of these projections, the 2012 BCMPB model (year 9), has been used in this analysis and is based up on FHO conducted from 1999 and 2011 (Walton, 2012). Severity classes from the FHO are used as shown in Table 7.1.

Table 7.1: FHO Severity Class Definitions

Classification	Classification abbreviation	% of stand attacked by MPB
Trace	T	0 – 1 %
Light	L	1 – 10 %
Moderate	M	10 -30 %
Severe	S	30 – 50 %
Very Severe	V	> 50 %

The 2012 BCMPB projections are shown spatially in Figure 7.1. Because the projections are rasterized (at 400m X 400m or 16 ha), they are used in conjunction with the stand-specific pine percentage from the VRI to calculate MPB mortality at the stand level. The MPB mortality of a stand calculated as the minimum of both values.

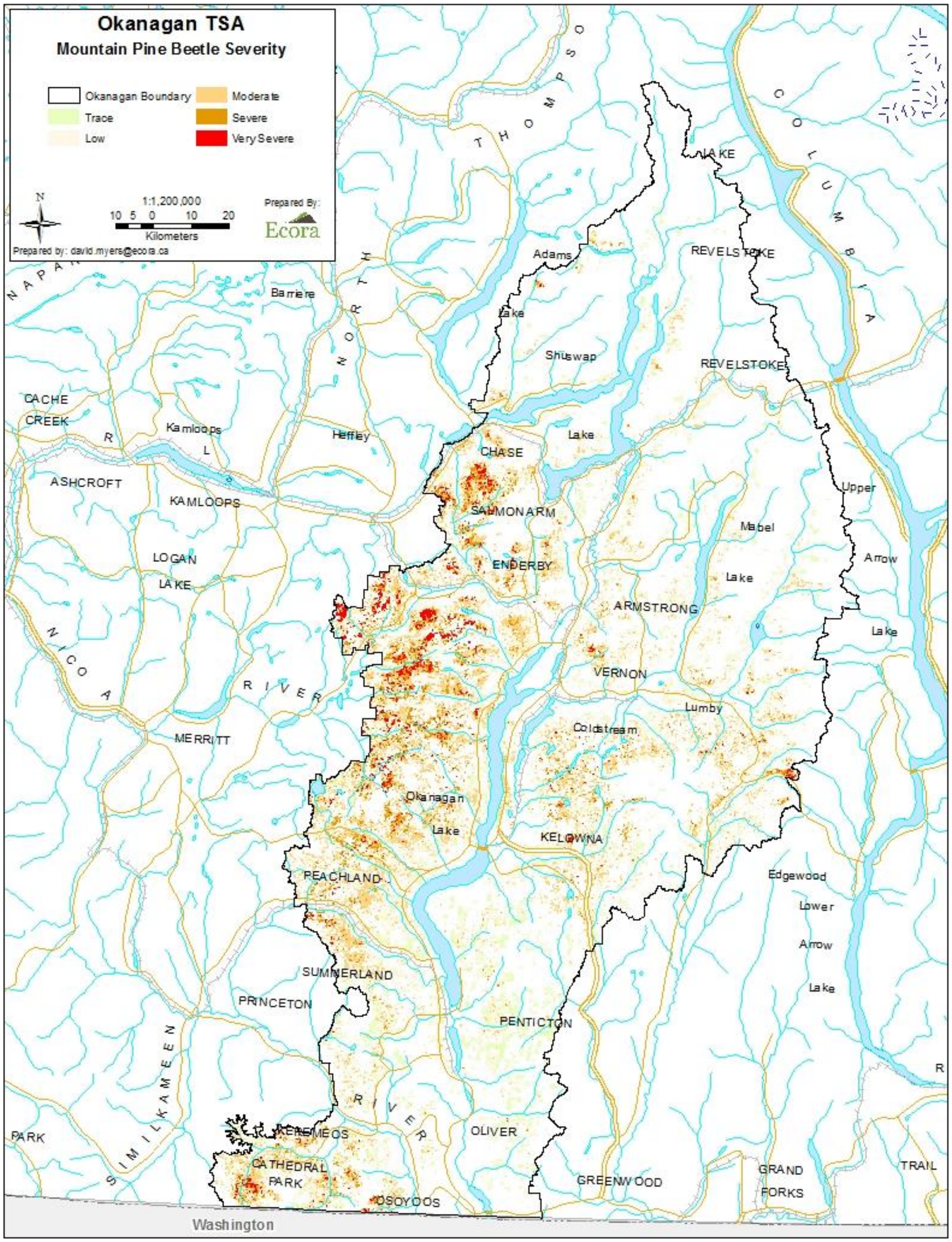


Figure 7.1: 2012 BCMPB V and S Projections - Okanagan TSA

7.2 Shelf Life

Shelf life is defined as the time a stand will remain economically viable to harvest. This time is taken from the year that a stand first becomes affected by MPB to its maximum classification level. Figure 7.5 shows the percentage of merchantable volume that is considered viable as sawlogs as a function of years since attack. This curve is applied to the pine portion of each stand and is consistent with modelling from the OIFS Uplift Analysis (Ecora, 2012) and Okanagan Type II Silviculture Analysis (Timberline, 2008).

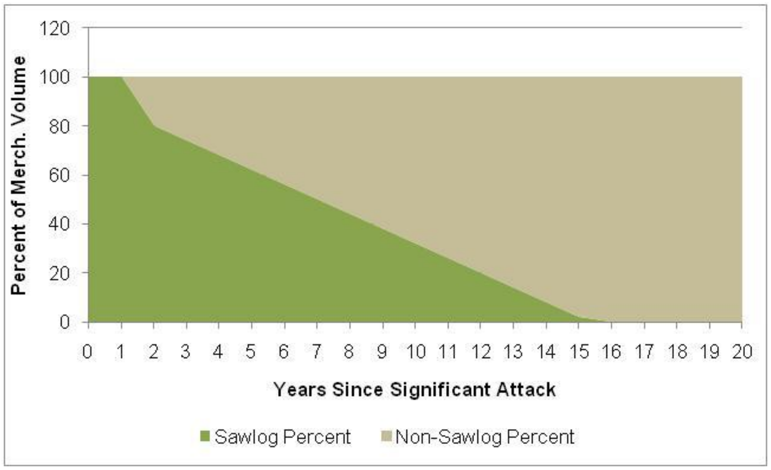


Figure 7.2: Shelf Life Decay Curve

Figure 7.3 shows the effect on stand sawlog volume as the MPB affected pine volume is degraded and a new stand is assumed to naturally regenerate.

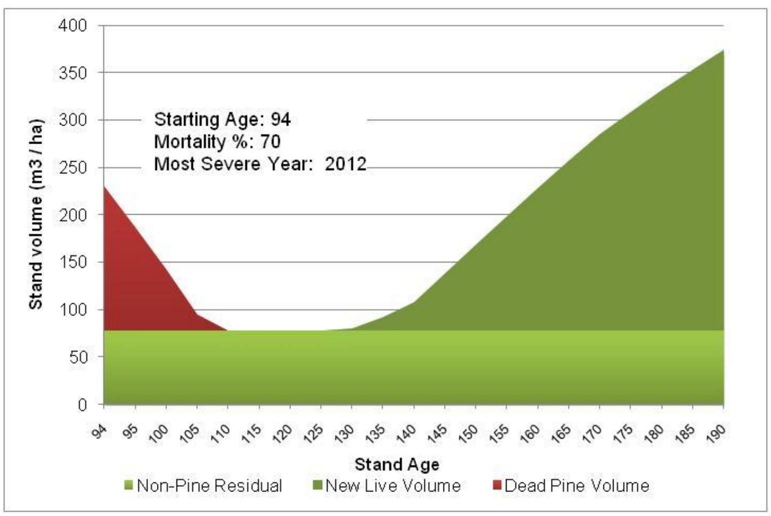


Figure 7.3: Application of Decay Curve to Stand Volume

7.3 Pine Percent Target

For the first 5 years of the modeled planning horizon, the MPB salvage and pine percentage target is an important factor in the amount of mortality vs salvage modeled. Consistent with TSR, a target of 54% pine for the first 15 years would reflect operational reality.

7.4 MPB Mortality Modelling

MPB affected stands that were harvested regenerate on a managed stand yield curve.

Stands that are affected in the 2012 BCMPB projection model by 2012 and not harvested, loose the affected volume according to the shelf-life rules detailed above. Depending on stand classification (i.e. THLB or non-THLB) and mortality percentage (greater or less than 50%) stands are subsequently modeled as either (Figure 7.4):

- Being killed and stand age reset; or
- Having a volume reduction applied and stand age not affected.

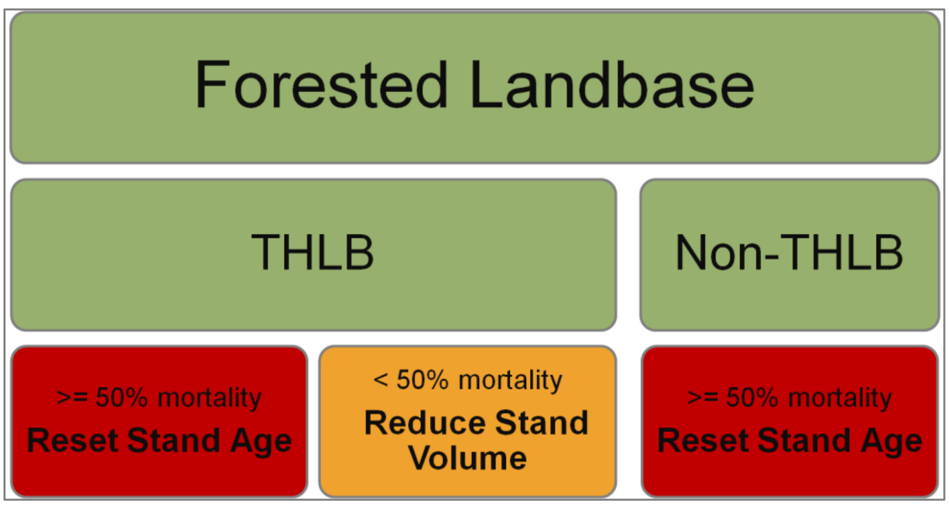


Figure 7.4: Un-harvested MPB Modelling Paths

8.0 Activities Modeled in the Analysis

Activities are defined as agents of change that affect the land base in some way. Generally, these are human activities such as harvesting or fertilization, but disturbance from wildfire is also modeled in the non-THLB. An important outcome from the kick-off meeting was to identify and discuss the range of major activities that are likely to occur on the land base and that affect values of interest. Activities to be modeled in this analysis include:

- Clear-cut harvesting (MPB salvage/non-MPB);
- Partial-cut harvesting;
- Clear-cut of partial-cut stands to deal with problem forest types;
- Fertilization;
- Rehabilitation of MPB-affected stands;
- Spacing of overstocked stands;
- Harvesting with altered practices to allow for range values (cut-block types: 1_2, 3 and 4);
- Ecosystem restoration (ER); and
- Wildfire (non-THLB natural disturbance);

For each of these activities, two main pieces of information are presented in this section:

- The candidate criteria (i.e. the criteria that decides whether a stand is a eligible to be considered for the given activity); and
- Possible treatment pathways for a candidate stand.

The interaction of the activity with affected indicators will be discussed in detail in the section for each indicator.

8.1 Clear-cut Harvesting

Clear-cut harvesting is the predominant disturbance on the Okanagan TSA land base. In order to be considered a candidate for clear-cut harvest, a stand must satisfy the following criteria:

- THLB - only the timber harvest land base is viable for harvest;
- >= MHA - the stand must be old enough to have enough predicted volume to be viable for harvest (as described in section 5.4.2 Minimum Harvest Age) and in the case of an MPB-affected stand, it must also have enough non-degraded wood to be viable; and
- A clear-cut stand (i.e. not covered under partial-cut criteria).

Figure 8.1 shows the possible treatment pathways for a clear-cut stand in a MPB context. There are 3 possible paths that a MPB-affected stand can take in this analysis:

1. No treatment;
2. Clear-cut (salvage logged and subsequently replanted to fulfill silviculture obligations); and
3. Rehab planting.

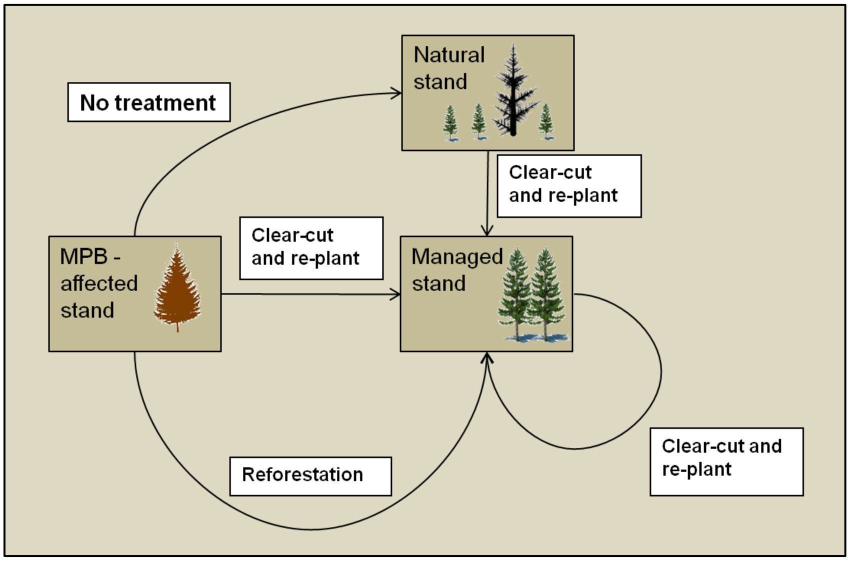


Figure 8.1: Clear-cut Treatment Modelling Paths

8.2 Partial-cut Harvesting

Partial harvesting occurs in areas of the IDF, PP and BG BGC zones due to temperature extremes and their value as MDWR. In order to be considered a candidate for partial-cut harvest, a stand must satisfy the following criteria:

- THLB;
- Dry-belt;
- BEC: PPxh1/PPxh2/IDFxh1/IDFxh2/IDFdk1/IDFdk2/IDFdm1/MSxk/BGxh1;
- Douglas-fir leading; and
- Have no harvest history for the previous 30 years.

Figure 8.2 shows the possible treatment pathways for a candidate partial-cut stand.

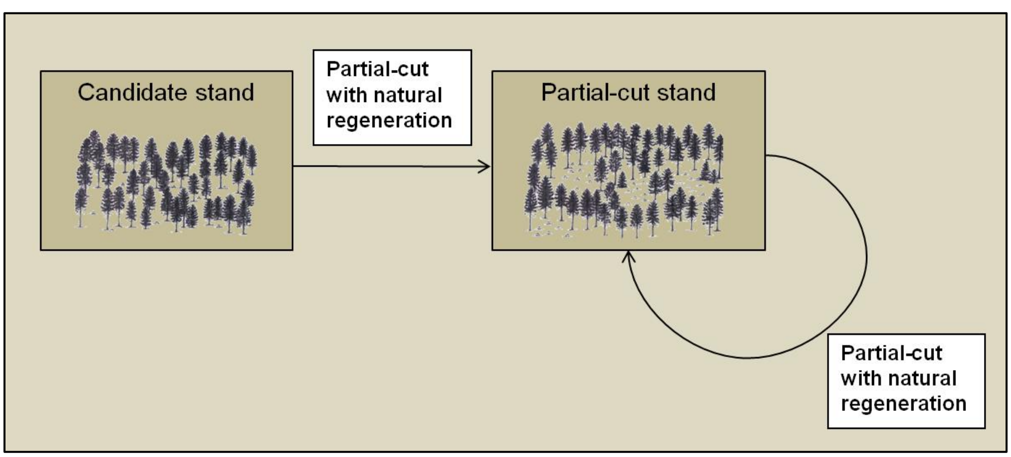


Figure 8.2: Partial-cut Treatment Modelling Paths

These types of ecosystems are generally located in dry or very-dry IDF ecosystems. These areas are highly constrained and generally overlap with: MDWR, visuals, SARA, high wildfire hazard and forage opportunities. In addition there are past high-grading removals that are not identified in the inventory and significant forest health issues such as root-rot, mistletoe and insects. With the current inventory, we are unable to identify problem forest types- i.e. those that have mistletoe, root-rot, previous high-grading harvest entries. A one-off clear-cut treatment option is considered in these problem stand types to get them back into production.

8.3 Fertilization

A fertilization program is one method to increase volume on existing mature stands that will be available for harvest in the near future. In order to be considered a candidate for fertilization, a stand must satisfy the following criteria (from the LBIS MFLNRO 2013/14 to 2017/18 LBIS Silviculture Funding Criteria for Forests for Tomorrow (FFT)):

- THLB;
- Leading species: Douglas-fir , spruce and Lodgepole pine;
- Age either:40 – 80 years (first priority) or 15-40 years;
- Site index:15 – 25 (inventory site index);
- Forest health: minimal forest health hazard- MPB mortality projected at <20%;
- Exclusions: exclude stands in the Interior Douglas Fir (IDF); and
- Must be in large enough contiguous areas to be operationally viable for fertilization (to be controlled by input block size and the patching functionality in *Patchworks*).

Figure 8.3 shows the possible treatment pathways for a candidate fertilization stand.

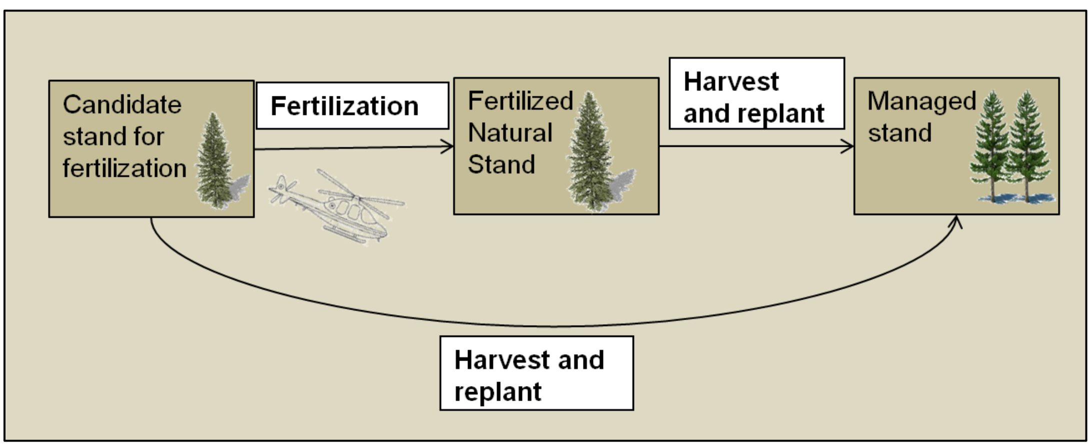


Figure 8.3: Fertilization Treatment Modelling Paths

The growth response from fertilization is assumed to be:

- Douglas-fir and spruce: 15 m^3/ha; and
- Pine: 12 m^3/ha.

A stand cannot be harvested for at least 10 years after treatment in order to allow for the growth response to be realized.

8.4 Rehab (planting) post MPB

A rehab (planting) program is a major focus to get MPB-affected stands back to productivity earlier in order to address the mid-term timber supply crunch. In order to be considered a candidate for rehab, a stand must satisfy the following criteria (from the LBIS MFLNRO 2013/14 to 2017/18 LBIS Silviculture Funding Criteria for FFT):

- THLB;
- Heavily affected by the MPB- modeled as >= 50% MPB mortality;
- Site index: > 20 (first priority) and 15-20 (second priority); and
- Not salvage harvested.

Figure 8.1, in the clear-cut section above shows the possible treatment pathways for a MPB-affected stand. If a stand is rehabilitated, it is assumed to regenerate on a managed stand yield curve.

8.5 Spacing

In the kick-off meeting, the spacing of high density fire-origin stands was suggested as a good LBIS treatment option. Candidate stands are identified according to the spacing criteria from the 2013/14 to 2017/18 MFLNRO Silviculture Funding Criteria document (MFLNRO, 2012) for central interior spacing:

- Height: between 2 and 8m;
- Site index: >=16;
- Stand density>=8,000 (Fd and Spruce) and >= 10,000 stems/ha (Pine); and
- Minimal forest health hazard.

Figure 8.4 shows possible treatment pathways for a candidate spacing stand.

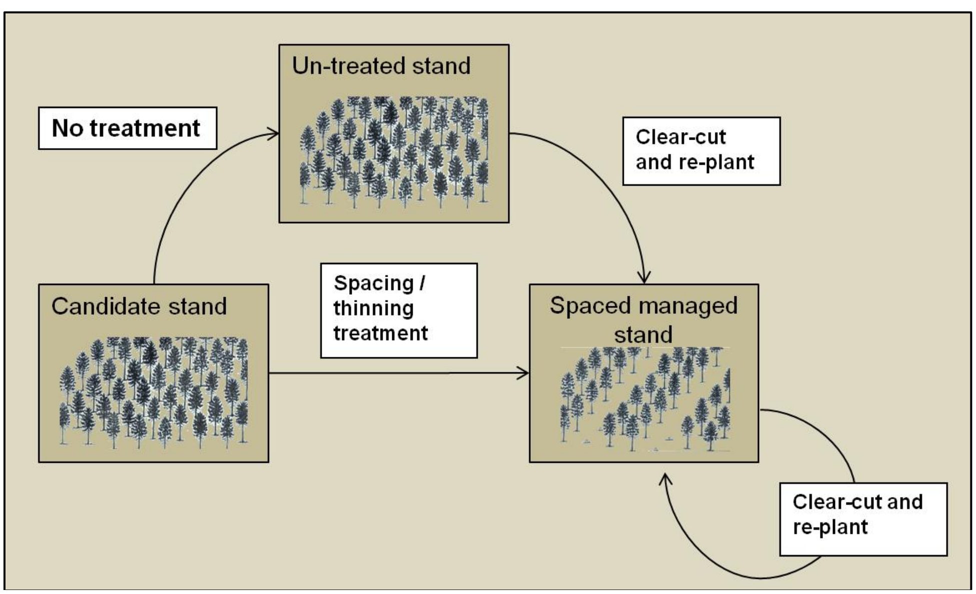


Figure 8.4: Spacing Treatment Modelling Paths

8.6 Ecosystem Restoration

Stands considered for ER treatment must be:

- NDT4 ecosystems[1];
- THLB or non-THLB;
- Mature stand (> 120 years);
- In community wildfire interface areas only; and
- In high wildfire hazard areas only.

Treatment is assumed to consist of removing ladder fuels and combustible surface material and spacing to lower densities. For modelling purposes it is assumed that half the stand volume is removed. It is also assumed that there is no timber value gained from removing the trees- even though in reality there may be some instances when there is some merchantable wood removed.

[1] BGC: BGxh1/2, IDFdk1/1a, IDFmw2/2b, IDFxh1/1a/2/2a, PPxh1/1a/2/2a

9.0 Indicator Modeling

Indicators are key attributes that are represented in the analysis to characterize important land base values. This section lists the indicators that are being modeled in this analysis and describes how they are being represented. The assumptions, sources and how various activities affect the given indicator are described. The following indicators are being modeled:

- Hydrology:
  - EDA- above and below the H40 line;
- Timber and economic factors:
  - volume;
  - value and harvesting cost;
- TSR resource management zones: CWS, IRM, UWR, Visuals and WHAs as described in section “6.0 TSR Resource Management Zones”;
- Range:
  - Forage supply by pasture;
- Harvesting the profile:
  - Terrain - cable vs conventional logging;
  - Harvesting type - clear-cut vs partial-cut;
  - Visually constrained areas;
- Forest health:
  - MPB hazard;
  - Spruce beetle hazard;
  - Douglas-fir beetle hazard;
- Wildfire hazard;
- Carbon (biomass and dead organic matter (DOM));
- Species trends:
  - species composition on land base;
  - species composition harvested;
  - diversity index (Berger-Parker Index); and
- Road density.

9.1 Hydrology

Operationally, hydrological impacts are tracked at the basin or sub-basin level using Equivalent Clearcut Area (ECA) and the H40 line. These concepts will form the basis for hydrological modelling in this analysis. The modelling approach will follow procedures developed in a prior project that developed the modelling of hydrology into a multiple-value framework (Ecora, 2012) and using direction from Adam Wei Ph.D (associate professor at UBCO).

EDA is an extension of the ECA concept in that it includes contribution from not only clear-cut disturbance but other disturbances as well e.g. MPB mortality and fire. EDA uses established relationships between vegetation growth post disturbance and hydrological recovery rates.

Three types of equivalent disturbance area (EDA) targets will be implemented in the analysis:

1. 25% EDA target above the H40 line by watershed;
2. 25% EDA target below the H40 line by watershed; and
3. Equal ratio between EDA above and below the H40 line.

Stand-level values will be summarized up to the reporting unit in the analysis - from 2 sources:

- Basins from the June 2012 Merritt / Southwestern Okanagan TSA Watershed Risk Analysis (based off the BC digital freshwater atlas assessment units); and
- BC digital freshwater atlas assessment units everywhere else[2].

The watershed basin boundaries that are used in this analysis are shown in Figure 9.1.

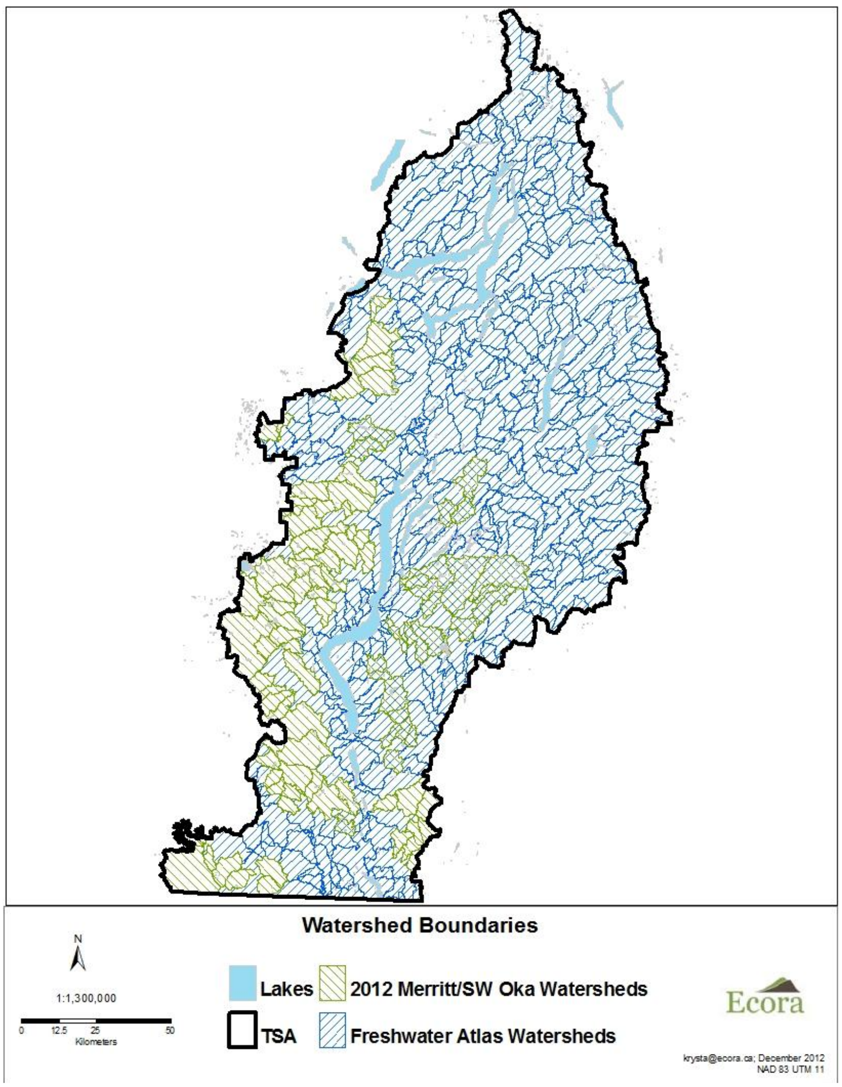


Figure 9.1: Freshwater Atlas Assessment Units

[2] Effort was made to gather watershed management linework from each individual license, however due to the piece-meal nature of the data, this layer remains incomplete.

Harvesting: EDA recovery curves have been developed for each treatment and disturbance type that is modeled in the analysis based off recovery curves from the IWAP (Figure 9.2). Figure 9.3 below shows the curves used for harvesting, post MPB reforestation and fire in the analysis. The EDA coefficient represents the contribution per hectare towards the EDA target.

Average height of the main canopy (m)	% Recovery
0–<3	0
3–<5	25
5–<7	50
7–<9	75
9+	90

Figure 9.2: Shows Table 8-1 from FPC- IWAP Guidebook

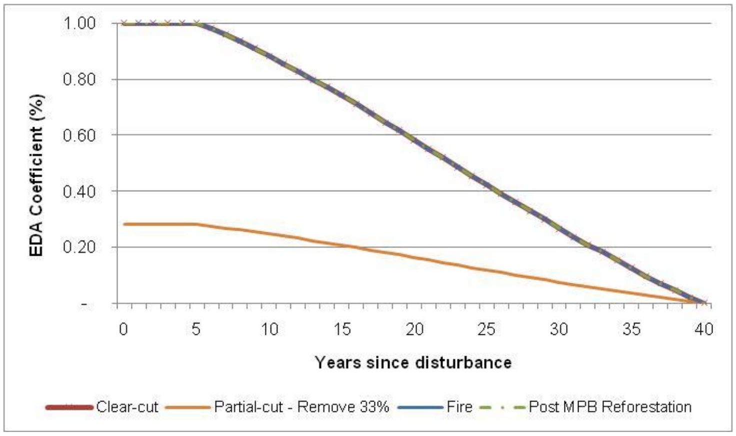


Figure 9.3: EDA Coefficient Curves (%)

MPB Mortality: The concept of ECA from a post MPB harvested stand versus un-salvaged stand is shown in Figure 9.4 from Huggard and Lewis, 2007. In this analysis, we have constructed multiple EDA curves post MPB mortality that vary with two factors:

- Mortality severity (i.e. the proportion killed). MPB mortality severity ranges from 0 - 100% in 10% increments; and
- Understory regeneration potential. Stands were characterized as either having good, moderate or poor understory regeneration potential by BGC zone as shown in the table below. In areas with good understory regeneration potential the un-salvaged EDA contribution is mitigated by 10% to account for the hydrological affect of understory regeneration. In moderate understory regeneration potential areas it is assumed to be mitigated by 5% and in BGC zones with poor understory regeneration there is no assumed EDA contribution mitigation.

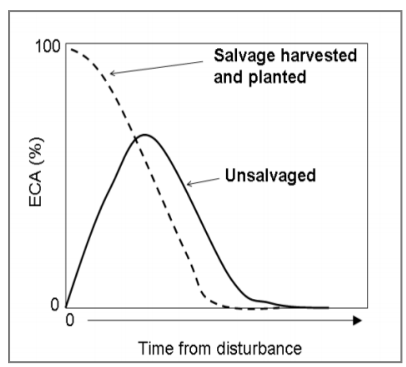


Figure 9.4: ECA harvested and un-harvested from Huggard and Lewis, 2007

Table 9.1 shows a BGC zone list by good, moderate or poor understory regeneration potential.

Table 9.1: Understory Regeneration Potential by BGC Zone

Understory Regeneration Potential	BGC Zone
Good	ESSFdc1, ESSFdc2, ESSFdc3, ESSFxc1, ESSFxc2, ICHmk1, ICHmk2, ICHmw2, ICHmw3, ICHwk1, ICHwk1c.
Moderate	ESSFdcw, ESSFwc1, ESSFwc2, ESSFxcw, IDFdm1, IDFmw1, IDFmw2, MSdm1, MSdm2, MSdm3, MSxk1.
Poor / not applicable	BGxh1, ESSFdcp, ESSFvc, ESSFvcp, ESSFvcw, ESSFwc4, ESSFwcp, ESSFwcw, ESSFxcp, ICHvk1, IDFdk1, IDFdk1a, IDFdk1b, IDFdk2, IDFdk2b, IDFxh1, IDFxh1a, IDFxh2, IDFxh2a, IMAun, PPxh1, PPxh1a, PPxh2.

Figure 9.5 shows this concept for many mortality and understory potential combinations.

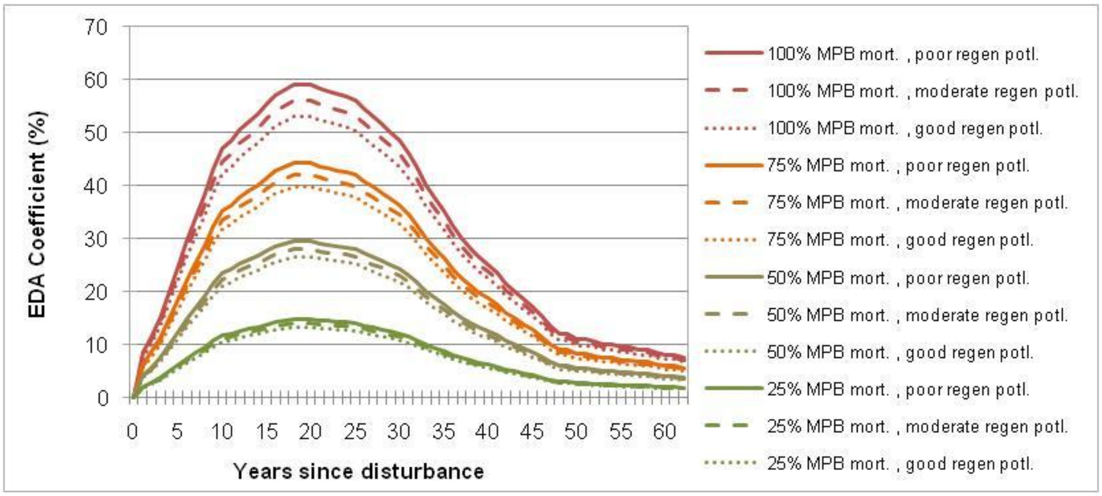


Figure 9.5: Post MPB EDA % at Varying Mortality and Understory Regen. Potential

H40 Line: In snow-hydrology dominated watersheds, hydrological responses to disturbance vary at different elevations. The term "H40" refers to the elevation line that 40% of the watershed is above. Harvesting in this zone can have a greater influence on peak flow due to the change in snow accumulation and snowmelt when the forest canopy is removed.

The H40 elevation will be calculated for each watershed in the analysis and the stand level EDA values will be calculated cumulatively by watershed on those areas above the H40 line. Within a watershed, the EDA ratio between above and below the H40 line will be calculated and kept to around 50%.

9.2 Timber and Economic Factors

In order to capture the economic component in this analysis, every activity will have a cost and/or value associated with it, including:

- Silviculture activities:

    - Cost of rehabilitation;
    - Cost of spacing;
    - Cost of fertilization;
- Harvesting:
    - Cost broken into overhead, harvesting, silviculture and road-related;
    - Value of harvested wood;
- Ecosystem restoration cost;
- Range cut-blocks: increase in cost associated with types 1/2, 3 and 4.

Silviculture Activities

Cost estimates for silviculture activities are based off LBIS guidelines for 2012/13 for: rehab, fertilization, spacing.

Rehab costs include:

- Recce surveys: $18/ha;
- Contract prep: $2/ha;
- Layout: $60/ha;
- Site-prep (buncher/knockdown pile and burn): $1,000/ha;
- Planting- seedlings: $0.68/seedling at approx 1,300 stems/ha = $884/ha;
- Planting- labor: $717/ha;
- Total: $2,681/ha.

Spacing costs includes:

- Spacing- interior max density/repressed stands: $1,500/ha;
- Total: $1,500/ha.

Fertilization costs include:

- Planning and prescriptions: $20/ha;
- Fertilizer application - Interior: $133/ha;
- Cost of fertilizer product: $297/ha;
- Total: $450/ha.

Ecosystem restoration costs include:

- Mechanical removal ~ $2,000/ha;
- Fire is ~ $500/ha;
- Assume that mechanical removal is used in 75% of cases;
- Total average cost of $1,625/ha.

Range cut-block type:

- Type 0 - current management- no altered treatment or cost;
- Type 1 and 2 - increase forage opportunities with standard tree stocking. Increased site-prep cost estimated at 15% - 20% additional;
- Type 3 - Silvo-pasture cut-blocks: High forage production with 50% to 100% of timber volume at next rotation. Increased site-prep cost estimated at 30% - 40% additional;
- Type 4 - Forage Pasture cut-blocks: Conversion to permanent forage production. Assumed total cost of $4,500/ha except in very dry forest/grasslands where $2,000/ha.

Harvesting Cost

Harvesting cost is broken into the following categories:

- Overhead;
- Harvesting;
- Silviculture; and
- Road-related costs including: construction, hauling and maintenance.

Overhead cost is assumed to be 7.06 $/m^3 (Thomae, 2006).

Harvesting cost is assumed to vary by harvest method (skid/cable/heli) and harvest type (clear-cut/partial-cut) as shown in Table 9.2.

Table 9.2: Harvesting Cost by Harvest Type

Slope Classes	Method	Cost ($/m^3) by harvest type	
		Clear-cut	Partial-cut*
0 - 35 %	Ground skid	21	23
35 - 70 %	Cable	38	42
70+	Heli	61	67

* a 10% increase in harvest cost for partial harvesting is estimated from draft TIPSY report

Basic silviculture cost estimates from the appraisal manual vary by biogeoclimatic (BGC) zone and include the cost of all activities that are required to achieve free-growing obligations (except root-disease control). Table 9.3 shows the BGC zones that are present in the Okanagan TSA.

Table 9.3: Silviculture Cost by BGC Zone

BGC	Silviculture cost estimate ($/ha)	BGC	Silviculture cost estimate ($/ha)	BGC	Silviculture cost estimate ($/ha)
BGxh1	n/a	ESSFxc2	988	IDFdm1	1,126
ESSFdc1	1,369	ESSFxcp	1,232	IDFmw1	1,569
ESSFdc2	1,156	ESSFxcw	1,232*	IDFmw2	1,438
ESSFdc3	1,156*	ICHmk1	1,318	IDFxh1	2,050
ESSFdcp	1,232	ICHmk2	1,328	IDFxh1a	2,050
ESSFdcw	1,232*	ICHmw2	1,683	IDFxh2	2,050
ESSFvc	3,343	ICHmw3	1,741	IDFxh2a	2,050
ESSFvcp	1,232	ICHvk1	2,963	IMAun	n/a
ESSFvcw	1,232*	ICHwk1	2,345	MSdm1	929
ESSFwc1	1,472	ICHwk1c	2,345	MSdm2	1,013
ESSFwc2	1,789	IDFdk1	908	MSdm3	1,013
ESSFwc4	1,568	IDFdk1a	908	MSxk1	832
ESSFwcp	1,232	IDFdk1b	908	PPxh1	25*
ESSFwcw	1,232*	IDFdk2	992	PPxh1a	25*
ESSFxc1	988	IDFdk2b	992	PPxh2	25

* no value exists in appraisal manual table so assumed equal to closest BGC zone

$$\text{Basic Silviculture (\$/m}^3\text{)} = \frac{[\text{NMA} * \text{Cost} * (\text{CAPCUT\%}/100) * 1.25] + [(\text{GSA} - \text{NMA}) * \text{Cost}]}{(\text{TNCV or NMV})^1}$$

For the silviculture cost estimates for partially cut stands, a factor similar to that applied in appraisal manual (formula above) will be applied using the % of area partial cut (30%) and multiplication factor of 1.25.

Road-related costs to be implemented in *Patchworks* include construction, maintenance and hauling cost. Values derived from the Okanagan TSA Timber Merchantability Analysis (Thomae, 2006) have been used to estimate these costs:

- Construction cost is primarily a function of side slope, however since this is beyond the resolution of data at the TSA-level, road construction is estimated at an average of $17,000/km of road in the dry-belt and $35,000/km in the wet-belt;
- Maintenance cost is estimated at 1.1 cents per m^3 per km; and
- Hauling cost is estimated at 3.3 cents per m^3 per km.

Wood Value

The value of timber is species based as shown in Table 9.4 (source: MFLNRO harvest billing system).

Table 9.4: Value By Species ($/m3)

Species	$/m^3
Balsam	47
Cedar - young	107
Cedar - old**	30
Deciduous	29
Douglas-fir - wet belt	67
Douglas-fir - dry belt*	33
Larch	50
Hemlock - young	47
Hemlock - old**	30
Pine	49
Ponderosa	38
Spruce	49

* assumed at half of Douglas-fir wet-belt
** assumes that old cedar and hemlock fetch pulp prices

9.3 Range / Forage

The BC range program allocates and supports grazing and hay-cutting agreements on crown land through licenses, permits and leases. Range agreements are broken down into pastures (areas for use during a particular season) that have a target forage requirement. Forage requirements are measured in animal unit months (AUMs) which is the amount of forage necessary for the sustenance of one cow or its equivalent for 1 month (450kg/AUM).

The range modelling in this analysis will use the concept of forage supply in a way that is similar to the traditional concept of timber supply. AUM targets by pasture are supplied by the MFLNRO Range Agrologist based on “Range Unit” and “Pasture”. There are 79 ranges modeled in the analysis, containing a total of 709 pastures. The total forage target is 88,114 AUMs per year.

Forage Growth
Assumed forage growth is dependent on how a cut-block is harvested (characterized by type of cut-block 0 - 4[3]) and site ecology (characterized by BGC zone).

Cut-block types:

- Type 0 Cut-blocks: No forage enhancement & standard tree stocking;
- Type 1 Forage Cut-blocks: Moderately increase forage opportunities with standard tree stocking;
- Type 2 Forage Cut-blocks: Enhanced forage opportunities with standard tree stocking;
- Type 3 Silvo-pasture Cut-blocks: High forage production with 50% to 100% (assumed to be at an average of 75%) of timber volume at next rotation; and
- Type 4 Forage Pasture Cut-blocks: Cut-blocks converted to permanent forage production.

To minimize the decisions in the analysis, type 1 and 2 cut-blocks will be grouped together. The intent is to model resource integration between timber and forage objectives on cut-blocks with Type 0 (none to high integration), Type 1-2 (maximum integration), Type 3 (moderate integration) and Type 4 (no integration).

BGC zones and elevation are used to spatialize estimations of forage growth potential by being grouped into the following types of forest:

- **High elevation ESSF**: all ESSF above 1700m or low shrub;
- **Moderate elevation ESSF**: all ESSF and MSdm3 between 1500-1700m
- **Wet forest**: all ICH and all ESSF and MSdm3 below 1500m or high shrub;
- **Moist forest**: IDFmw, IDFdm, IDFdk and MSdm1/2;
- **Dry forest**: IDFxh (merchantable stands with pinegrass); and
- **Very dry forest or grasslands**: IDFxh, PPxh and BG (non-merchantable stands or bunchgrass).

Assumed forage growth by forest type and cut-block type was provided by the MFLNRO Range Agrologist expert in tabular form and collated in Figure 9.6.

[3] Cut-block types 0 - 4 are defined in the Forage Strategy Okanagan Shuswap District, Approved March 2012, Ministry of Forests, Lands and Natural Resource Operations. Under strategic goal #3: Identify options in consideration of costs, benefits and impacts to resource values and uses.

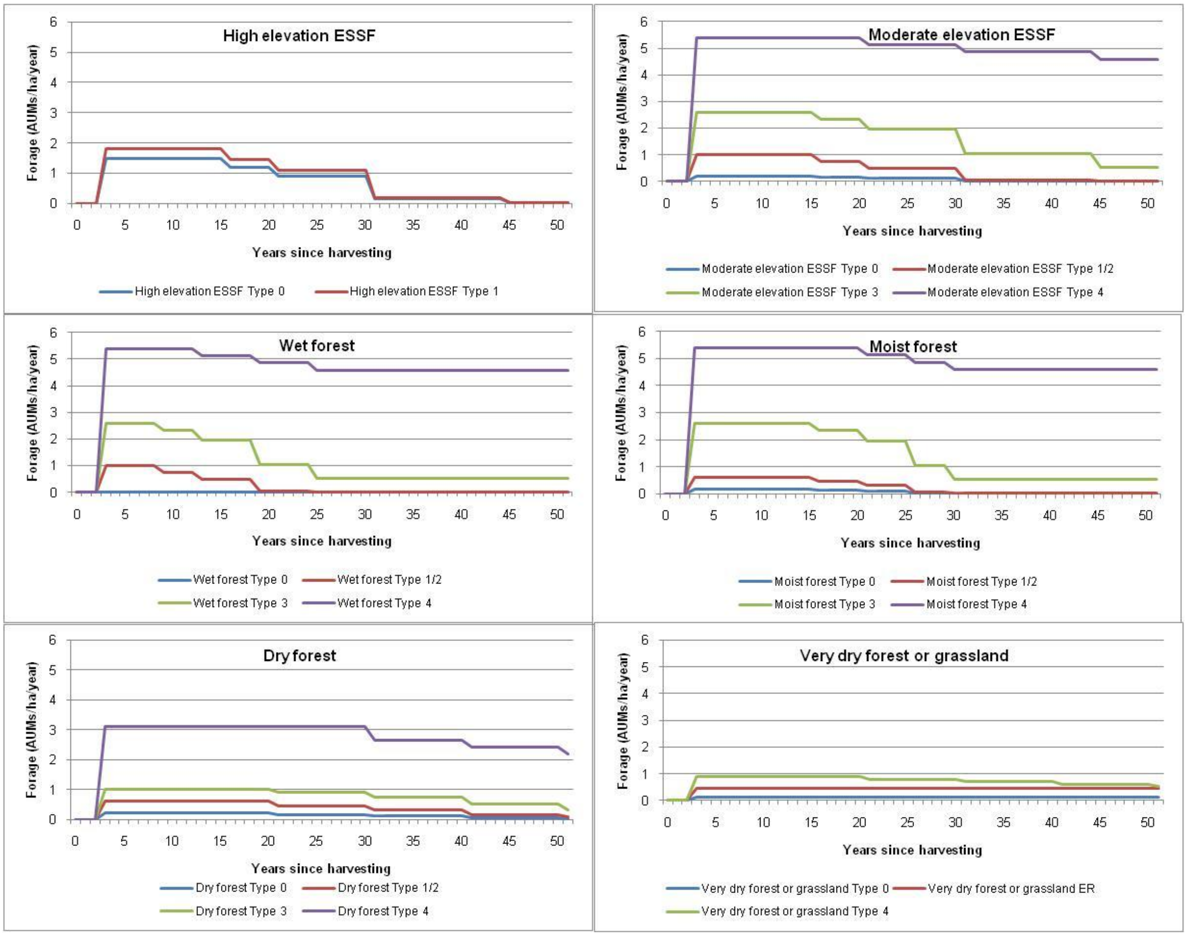


Figure 9.6: Forage Growth by Forest Type and Cut-block Type Since Harvesting

A strategy to minimize decisions in the analysis and only to include realistic cut-block type options is to limit when a particular cut-block type can be implemented as shown in Table 9.5.

Table 9.5: Candidate Stands by Cut-block Type

Type	Description of where implementation is allowed in the analysis.
0	Everywhere - assumed to be current practice
1 / 2	BGCs with minimal to moderate usability of native forage: ICH, ESSFdc, ESSFwc, IDFmw, IDFdm, MSdm
3	BGCs with low forage opportunities: ICH, ESSF (high shrub), MSdm3 &IDFmw BGC with higher native forage: PPxh, IDFxh/dk& ESSFwc4 where there is a win/win with other non-forage objectives.
4	BGCs with low forage opportunities & higher site productivity: ICH, ESSF, MSdm3 &IDFmw, and BGCs with moderate to high usability of native forage: PPxh, IDFxh/dk, IDFdm, MSdm& ESSFwc4, where there is a win/win with other non-forage objectives.

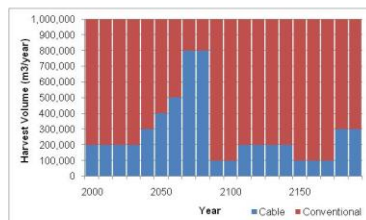
9.4 Harvesting the Profile

AAC levels are set assuming that all THLB is viable for harvest at some point in the future. Concern has been raised that if past and current harvesting patterns are not distributed proportionately across stand types, then at some point in the future harvesting will be forced heavily into the under-utilized type. The term "cable cliff" describes the anecdotal evidence that there has been a lack of harvesting in cable terrain in the recent past. Stand types that have been identified as of concern in the Okanagan TSA are:

- Terrain - cable vs conventional logging;
- Harvesting type - clear-cut vs partial-cut; and
- Visually constrained areas.

Modeling
Each stand in the analysis will be classified by terrain, harvest type and if visually constrained. For terrain, average stand slope will be used to classify each stand as either conventional (0 - 35% slope) or cable (35+ % slope). For harvesting type, stands are classified as either clear-cut or partial cut depending on the criteria outlined in section "5.1.2 Partial Harvesting". Areas identified in the VLI as described in section "6.13 Visual Management" will be classified as being 'in' visuals and all other areas will be classified as 'out'.

Reporting Unit
In the analysis, harvest at the stand level will be summarized up to the TSA level by classification. In this way, summary graphs will clearly show what proportion of the harvest is coming from each factor as shown in the figure to the right.



Targets
For each of the factors, depending on the analysis scenario and the performance of the indicator, these factors may need to be controlled or just monitored.

9.5 Forest Health

The impact and timing of forest health factors (FHFs) is complex and challenging to predict spatially, especially over a long term planning horizon. The main instrument for including forest health factors into this analysis is 'hazard ratings'. Hazard ratings in the analysis can be used in two main ways:

- Summarize the hazard across the land base that results from a given series of activities; or
- Use hazard ratings to drive land base activities and decisions to minimize hazard.

The Ministry has a well developed hazard rating systems for selected FHF that are generally based on factors such as vegetation, location and site productivity. Hazard ratings will be based upon these systems. The following FHF hazard ratings will be modeled in this analysis:

- Mountain Pine Beetle (MPB);
- Douglas-fir Beetle (DFB); and
- Spruce Bark Beetle (SBB).

There are many other FHF such as western balsam bark beetle, western spruce budworm as well as diseases such as *Armillaria* or mistletoe that are significant in Okanagan TSA and may be modeled in the future.

Mountain Pine Beetle Hazard Rating

MPB hazard rating is based upon the Pine Beetle Hazard Rating Documentation Version 1.2 (ILMB, 2006) which can be viewed for detailed documentation. In general, MPB hazard is calculated using the following formula as described in ILMB, 2006.

MPB hazard = P * A * D * L

Where:
P = proportion of pine
A = age factor
D = density factor
L = location factor

Douglas-fir Beetle Hazard Rating

DFB hazard rating is based upon the Douglas-fir Beetle Hazard Rating Documentation Version 1.2 (ILMB, 2007) which can be viewed for detailed documentation. In general, DFB hazard is calculated using the following formula as described in ILMB, 2007.

DFB hazard = A * D * G * P

Where:
A = age factor
D = diameter factor
G = growth factor
P = proportion of Douglas-fir

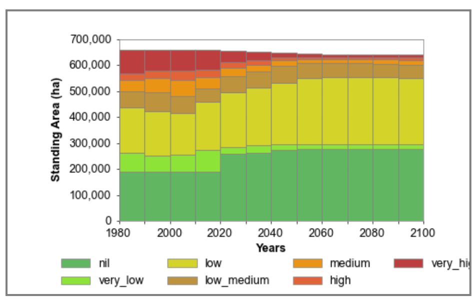
Spruce Beetle Hazard Rating

SBB hazard rating is based upon the Spruce Beetle Hazard Rating Documentation Version 1.1 (ILMB, 2007b) which can be viewed for detailed documentation. In general, SBB hazard is calculated using the following formula as described in ILMB, 2007b.

SBB hazard = 10 * (Q * A * P * L * S2) ^ 0.5

Where:
Q = site quality factor
A = age factor
P = proportion of Spruce
L = location factor
S2 = stand density and growth rate

Stand-level hazard ratings will be summarized up to the TSA level for reporting purposes in the analysis. An example of an output TSA-level hazard summary is shown in the figure to the right.



9.6 Wildfire Hazard

The Okanagan TSA Silviculture Strategy Type 4 has identified wildfire as an important landscape-level factor to be considered in resource management decisions in the

Okanagan TSA. The Okanagan Type 4 has made an effort to include wildfire hazard in the forest estate modelling and able to be used for decision support.

Elements of wildfire that have been identified to be included are:

- Wildfire hazard across the landbase;
- Wildfire hazard in community wildfire interfaces; and
- Incorporate wildfire hazard and ER considerations into LBIS investment decisions (spacing, planting, fertilization etc.).

Wildfire Hazard

Wildfire hazard (or the probability that a wildfire will occur at a given location) is complex to quantify and predict as it depends on many factors such as fuels, topography, ignition location, ignition probability and weather. In this analysis framework, wildfire hazard is one of many landscape-level values to be taken into consideration when deciding how to manage the landbase. In the Type 4 Silviculture Analysis, wildfire hazard will be captured at two levels, and has potential for a third:

1. Analysis results such as proposed silviculture activity can be compared with detailed existing wildfire risk rating maps to be cognoscente of fire risk prior to recommending silviculture investment;
2. A simplified wildfire hazard methodology will be implemented in the forest estate model to enable wildfire values to be considered in the activity scheduling; and
3. Potentially the schedule of activities could feed back into a more detailed wildfire model, such as burn P3 to provide a more detailed burn probability map.

Wildfire Hazard Modelling

This section describes how the simplified wildfire hazard modeling will be implemented in the forest estate model. This involves simplifying the concepts, with the intent to enable the model to consider fire hazard as well as the many other resource values. The Fire Behavior Prediction (FBP) system fuel types have been selected as the main input to classify fuels and calculate wildfire hazard. These fuel types are well understood and are consistent with the Burn P3 fire probability mapping.

Table 2. FBP System fuel types.

Group / Identifier	Descriptive name
Coniferous	
C-1	Spruce–lichen woodland
C-2	Boreal spruce
C-3	Mature jack or lodgepole pine
C-4	Immature jack or lodgepole pine
C-5	Red and white pine
C-6	Conifer plantation
C-7	Ponderosa pine–Douglas-fir
Deciduous	
D-1	Leafless aspen
Mixedwood	
M-1	Boreal mixedwood–leafless
M-2	Boreal mixedwood–green
M-3	Dead balsam fir mixedwood–leafless
M-4	Dead balsam fir mixedwood–green
Slash	
S-1	Jack or lodgepole pine slash
S-2	White spruce–balsam slash
S-3	Coastal cedar–hemlock–Douglas-fir slash
Open	
O-1	Grass

An outline of the FBP fuel types are shown in the figure to the right.

FBP fuel types were assigned based on a decision tree that was provided by Ministry wildfire experts to assign FBP fuel types using VRI attributes. Non-time dependent attributes (e.g. species composition) were integrated into analysis units and age dependent factors (e.g. height, crown closure) were used to assign FBP fuel types for various age ranges. Factors that were used include:

- Leading species;
- Conifer / deciduous percentage;

- Crown closure classes (dense/open/sparse based on BCLCS_LVL_5[4] class definitions);
- BGC zone; and
- Stand height.

Table 9.6 shows an example of how the decision tree was applied.

Table 9.6: FPB Fuel Type Assignment

Leading species	Conifer class	CC class	BGC	Height	FBP Fuel Type
Pine	single species	sparse	ICH	n/a	D-1/2
Pine	single species	open	ESSF	10	C-3
Ponderosa	single species	dense	PP	22	C-7
Douglas-fir	mix (65-80%)	open	IDF	n/a	C-7
Douglas-fir	mix (65-80%)	dense	IDF	n/a	M-1/2
Aspen	single species	n/a	n/a	n/a	D-1/2

Wildfire hazard ratings are applied by FBP fuel type and wet/dry-belt in the Okanagan TSA as shown in Table 9.7.

Table 9.7: Wildfire Hazard Rating Assignment by FBP Fuel Type

FBP Fuel Type	Fuel Type Description	Wildfire Hazard Rating	
		Wet belt	Dry belt
C-2	Coniferous - Boreal spruce		
C-3	Mature jack or Lodgepole pine		
C-4	Immature jack or Lodgepole pine		
C-5	Red and white pine		
C-7	Ponderosa pine and Douglas-fir		
D-1/2	Aspen - leafless/green		
M-1/2	Mixedwood - Boreal mixedwood - leafless/green		
O-1a/b	Grass		
S1	Jack or Lodgepole pine slash		
S3	Coastal cedar-hemlock-Douglas-fir slash		

In the *Patchworks* analysis, a score that ranges from 0-4 is applied to the stand as show in Table 9.8. Using this methodology, the stand-level wildfire hazard can be summarized to various landscape level reporting units.

Table 9.8: Wildfire Hazard Ratings

Wildfire Hazard	
Null	0
Low	1
Moderate	2
High	3
Extreme	4

[4] British Columbia Land Cover Classification Scheme Level 5

A key concept that is captured in the modelling is how treatment decisions impact the wildfire hazard. Treatment decisions include where, when and how to harvest as well as where and when to implement silviculture activity fertilization, thinning, ecosystem restoration *etc*. In this analysis, treatments that are modeled to affect wildfire hazard are listed in Table 9.9.

Table 9.9: Description of How Treatments Affect Wildfire Hazard

Treatment	Affect wildfire hazard	Description
Fertilization	No	Assumed not to affect hazard rating even through increased growth in shrub layer may increase it. Minimize risk by not fertilizing in high risk wildfire hazard areas.
Planting post MPB	Yes	Same as clear-cut.
Spacing	Yes	After spacing, wildfire hazard is dropped one class for 20 years.
ER	Yes	After treatment, wildfire hazard is ‘low’ for 30 years before again increasing to the level dictated by FBP fuel type.
MPB mortality	No	Assumed not to affect hazard rating
Harvesting- clear-cut	Yes	As a stand is clear-cut and volume removed, the FBP fuel type changes and subsequently so does the hazard.
Harvesting - partial-cut	Yes	Not defined.
Harvesting- range cut-block type 1/2	Yes	Same as clear-cut.
Harvesting- range cut-block type 3	Yes	After treatment, wildfire hazard is dropped one class.
Harvesting- range cut-block type 4	Yes	Conversion to grassland- very low hazard

9.7 Carbon - Biomass and DOM

At a global level, climate change has been increasingly recognized as a significant concern. BC’s management of its vast forested land base influences enormous carbon pools, which has makes forest carbon a significant value of interest in making forest management decisions.

The carbon sources and sinks accounted for in this framework are the carbon:

- Stored as forest ecosystem carbon (biomass and dead organic matter [DOM]);
- Stored in forest wood products; and
- Emitted during activity (e.g. harvesting, fertilization).

Forest ecosystem carbon is the quantity of carbon held at a specific time in either biomass (the living mass from trees in a given area including above and below ground tree components) or DOM (dead standing and downed trees, coarse and fine woody debris, litter and soil carbon).

Carbon Budget Model of the Canadian Forest Service (CBM-CFS3) will be used to create ‘carbon curves’ that represent the quantity of carbon over time in each pool in the analysis. These curves will be created at the analysis unit level and will be tracked at the landscape level. For more information on the CBM-CFS3, see the Natural Resources Canada Carbon Accounting website at: http://carbon.cfs.nrcan.gc.ca/CBM-CFS3_e.html.

Carbon that is emitted while harvesting due to activities using machinery is tracked using assumptions from the report: "Fuel consumption for ground-based harvesting systems in western Canada" (FERIC 2002). Table 3 from this report shows an average 20,463 g/m^3 of total CO2e for ground-based harvesting. This is the equivalent of 0.20463 tones of C/ m^3 harvested.

Carbon storage in wood products is accounting for the long term storage of carbon in forest products (lumber, paper, chips etc) whereas stands naturally disturbed via wildfire or MPB infestation are emitted to the atmosphere.

An interim tool created by MFLNRO carbon experts (Li, Q and Dymond, C) was used to estimate the amount of carbon stored in wood products by making assumptions of the flow of volume from the forest to different primary uses, secondary uses, landfill and emissions.

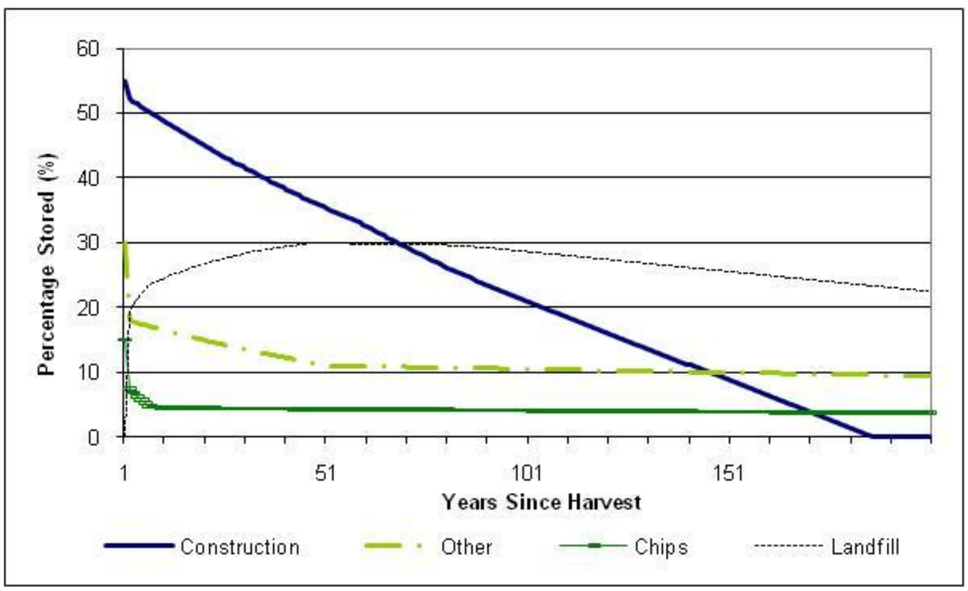


Figure 9.7: Carbon Storage Proportions

9.8 Species Trends

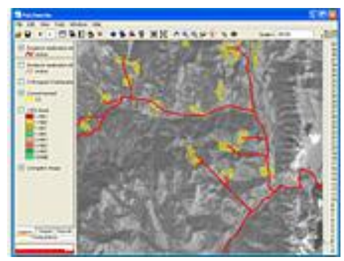
Species trends are important to track as indicators of diversity on the land base and also to provide insight to the species being harvested. Species diversity on the land base is important to promote resilient forests in response to uncertainly associated with many factors including natural disturbances, climate change, wildfire and forest health. For forest products species diversity is important to provide flexibility to respond to market conditions and to meet future demands. The Ministry provided a framework to track species trends for strategic level analysis, which has been implemented track the commercial tree species composition at the TSA level and monitor and predict the changes in these species over time. (MFLNRO. 2012b).

In the analysis, individual stands are combined into groups with similar characteristics called analysis units (AUs) to reduce the modeling complexity of the analysis. Natural stand AUs are nearly stand-level with 20,000 plus on the Okanagan TSA. Managed AUs are at a higher level of amalgamation, reflecting the relatively fewer regeneration options practices and modeled.

The stand-level species composition (dictated by AU) will be summarized up to the BGC zone and TSA level for reporting purposes in the analysis for the following factors:

- Standing species composition (volume / area);
- Harvested species composition (volume / area);
- Planted species composition (area);
- Average standing species diversity index -Berger-Parker Index[5] (BPI); and
- Average planting species diversity index - BPI.

9.9 Road Density



Roads used for forestry development have a major impact on the land base in many different ways: they affect hydrology and watershed values, terrestrial and aquatic wildlife, plant communities and visual values (Daigle, 2010). Road construction and maintenance is a large portion of harvesting cost. There is an estimated 450,000 kilometers of resource roads in BC and road densities have increased dramatically in the last few decades.

BC is moving towards consolidating the existing legislative framework for resource roads into a single act- the Natural Resource Road Act (NRRA). More information can be found at http://www.for.gov.bc.ca/mof/nrra/. At the landscape level, it is important to taking a strategic approach to road access and management.

Modeling

Roads are modeled dynamically in the *Patchworks* model through a linear road network. The existing road network is an input into the model and for areas that are not-roaded. *Patchworks* connects each forest stand to the road network and tracks the flow of forest products to mill or other destinations. It can consider road construction, maintenance and hauling costs and road densities during optimization.

Because of the strategic nature of this analysis, road density will be the main environmental indicator associated with roads that is modeled. Road density is the ratio of the length of road to land area (km/km2).

Reporting Unit

[5] The Berger-Parker Index (BPI) is calculated at the stand-level as the proportion of the most abundant species and summed using area-weight averaging to the TSA-level total.

Because of the importance of roads to many different land base values, road densities will be summarized to a variety of different reporting units:

- Grizzly Bear Specified Area #8-232;
- Watershed; and
- TSA-level.

Targets

Targets for active road density vary by reporting unit:

- Grizzly Bear Specified Area #8-232:
    - 0 - 0.4 km/km2 = low risk;
    - 0.4 - 0.6 km/km2 = moderate risk; and
    - > 0.6 km/km2 = high risk.
- Community watershed:
    - 0 - 2 km/km2 = low risk;
    - 2 - 4 km/km2 = moderate risk; and
    - > 4 km/km2 = high risk
- TSA-level (no target).

9.10 Timber Quality- Premium Logs

Log quality has been identified provincially as an important factor for consideration. In the stakeholder meetings there was general consensus among the stakeholders that there is a large amount of uncertainty around future demand for premium products, which made it difficult to define a premium log or set targets.

Furthermore it was identified that the data available for the analysis does not have the resolution to support managing for premium logs. For these reasons, there is no hard target for premium logs, but instead a premium log report has been created using definitions from previous silviculture strategies, which are still considered (Timberline, 2008). Table 9.10 shows the premium log definitions used in for reporting- e.g. volume coming from a stand that has a DBH >32.5 cm and height > 28m will be characterized as 'peeler' in the summary report.

Table 9.10: Premium Log Definition

Quality Class	Products	Species	Min av. Stand DBH	Av. Height Corresponding to min DBH (m)
Peeler	Peelers, poles, house-logs and high grade sawlogs	All except deciduous	32.5+	28
Standard profile sawlog	Sawlogs		27.5+	24
Merchantable			12.5/15+	11/12

9.11 Climate Change

The global changing climate affects BC's forests and other natural resources. Climate change introduces risk that forest managers should consider in making forest management decisions. Through the process of completing the Okanagan Type 4 Silviculture Strategy there was two presentations to the stakeholders that provided background information about climate change and discussed data needs to consider climate change in the analysis, such as drought and frost mapping. There are opportunities to adapt if we base the forest management decisions made today on information of our future climate- viewing forest management through the 'climate change lense'. In the Okanagan TSA, climate change can affect water supply and dry to very dry ecosystems that are common in the lower valleys is a major concern. One way identified to reduce the risk associated with an uncertain future climate is to increase diversity at the stand, ecosystem and TSA level. Species diversity is reported on using five indicators (see Section 9.8) including the Berger Parker Index, which is included as a measure of diversity.

9.12 Measuring Success- Risk Classes

One of the key elements of considering multiple values is to be able to define when any specific value is successfully achieved. To capture this concept; low, moderate and high risk classes have been established for each value (or indictor).

When results are shown they are generally presented with a risk-based backdrop in order to show how well the value is being achieved throughout the planning horizon. The risk classes have been defined using a variety of approaches and evaluated by subject matter experts wherever possible.

Interestingly, this approach of defining success proves to be difficult because often a team of resource managers cannot clearly quantify a suitable goal. For this reason the process of defining risk classes is very important. Table 9.11 shows a summary of how risk classes were defined for each type of indicator modeled in the analysis.

Table 9.11: Risk Class Definitions by Indicator

Indicator	Risk Class Definition
Net-revenue	High risk: below 80% of initial net-revenue Moderate risk: between 80% and100% of initial Low risk: above initial Calculated at a 2% discount rate through time.
EDA	High risk: 10% above target Moderate risk: +/- 10% around target Low risk: 10% below target Target set at 25% above/below H40 line by watershed
EDA H40 ratio	10% classes on either side of 50% ratio
Forage	High risk: 10% below target Moderate risk: +/- 10% around target Low risk: 10% above target Target set at AUM forage target by pasture

Indicator	Risk Class Definition
BPI	High risk: above 90% Moderate risk: between 75% and 90% Low risk: below 75%
Wildlife- minimum retention	High risk: 10% below target Moderate risk: +/- 10% around target Low risk: 10% above target Target set at retention level (GAR/OSLRMP)
Wildlife- maximum disturbance	High risk: 10% above target Moderate risk: +/- 10% around target Low risk: 10% below target Target set at maximum disturbance level (GAR/OSLRMP)
Visuals / IRM	High risk: 10% above target Moderate risk: +/- 10% around target Low risk: 10% below target Target set at maximum disturbance level
Road density- Grizzly WHA	High risk: above 0.6 km active road/km2 Moderate risk: between 0.4 and 0.6 km active road/km2 Low risk: below 0.4 km active road/km2
Road density- TSA	High risk: above 4 km active road/km2 Moderate risk: between 2 and 4 km active road/km2 Low risk: below 2 km active road/km2