Kootenay Lake TSA
Technical Summary of
Timber Supply Analysis

Forest Analysis and Inventory Branch
Ministry of Forests and Range
727 Fisgard Street
Victoria, B.C.
V8W 1R8

September 2009
# Kootenay Lake TSA Technical Summary

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Introduction

This document provides a technical summary of the timber supply analysis completed for the 2007-2009 timber supply review of the Kootenay Lake Timber Supply Area (TSA). The objective of the analysis is to provide an understanding of the timber supply for the Kootenay Lake TSA with respect to available inventory and management information about the forest and land base.

The analysis is based upon data and management information as described in the Kootenay Lake Timber Supply Area Timber Supply Review Data Package. This data package was originally published July 2008 and has been updated to correspond to the analysis completed in this analysis report.

The primary audience of this analysis report is the timber supply analysis staff of Forest Analysis and Inventory Branch (FAIB). The information in this report is used by the FAIB analysts to inform the chief forester for the determination of the allowable annual cut for a TSA under Section 8 of the Forest Act. Stakeholders such as forest licensees and First Nations are a secondary audience. For this audience, a primer is provided in the appendix to assist with understanding the various graphs in the report.

This document is a record that enables a timber supply analyst without previous knowledge about the analysis to understand how the analysis was completed and what are the dynamics identified. The document’s format facilitates additions to the analysis over time. The document is not meant to be a “polished” summary of the analysis but to be a working document (e.g., use of figures without providing a lot of descriptive wording around figures).

The format of the document follows the three stages of analysis:

1. Understanding the land base with respect to timber supply;
2. Developing a base model of current practices and reporting on the identified timber supply dynamics;
3. Understanding the uncertainties around components of the model and information through critical issue or sensitivity analyses.

The timber supply analysis should be viewed as a “work in progress”, not as a completed product. Prior to the chief forester’s AAC determination for the TSA, further analysis and updates to the technical summary are likely to be completed as a result of inputs received during the review process. Further, this technical summary may be updated with new analysis to explore issues other than the Section 8 allowable annual cut determination.

The Land Base

Timber supply area (TSA) boundaries encompass a variety of land ownerships and tenures. For the chief forester’s AAC determination we must identify a specific land base within the TSA against which timber harvested is billed under ‘Section 8’ AAC. Section 8 of the Forest Act is the legislation which requires the chief forester to make an AAC determination and specifies the land base for this decision.

For analysis purposes we classify the land base into three main components: (1) THLB – timber harvesting land base on which timber harvest is considered feasible and economical and included within a Section 8 AAC, (2) CFLB – Crown forested land base, and (3) Non-CFLB – lands that either are not crown owned, do not apply to the Section 8 decision or are considered non-forest. Under this schema THLB is a subset of CFLB and non-CFLB is complementary to CFLB. For timber supply analysis, only THLB and CFLB are used for modelling.
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Timber Harvesting Land Base Classification

The derivation of the timber harvesting land base is typically presented in a “netdown” table (Table 1). The netdown table shows the sequential steps of determining the THLB starting at the total area of the TSA, deriving the crown forested land base, and finishing off with deriving the THLB. The distribution of the CFLB and THLB is shown in Figure 1.

Specifics about the exclusions identified in the netdown table are described in the Kootenay Lake TSA data package as updated to August 17, 2009. A few changes to the initial July 2008 published data package have occurred including new orders for Mountain caribou management.

The netdown land classes have wide overlap with each other (Table 2). The overlap indicates robustness in the defining of the timber harvesting land base. As such, minor differences in definition or available information around any one netdown factor likely have minimal impact.

The timber harvesting land base is defined for modelling of timber supply. The netdowns for many of the classifications are the expectations of land base that is never available for harvesting. However, in actuality some of this land base could be available for harvesting in the future. For example, some areas identified as inoperable are actually harvested as the inventory label may have been misclassified or are found to be economical at the time of adjacent harvesting.

It should be emphasized that the timber harvesting land base is a product of modelling assumptions and will not always correspond to field location of harvestable areas.
## Kootenay Lake TSA Technical Summary

### Table 1. Netdown table deriving the timber harvesting land base for the 2009 Kootenay Lake TSA timber supply review analysis

<table>
<thead>
<tr>
<th>Land classification</th>
<th>Data package reference section</th>
<th>Area (ha)</th>
<th>Sequential netdown to determine THLB (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area</td>
<td></td>
<td>1,240,843</td>
<td>1,240,843</td>
</tr>
<tr>
<td>Non-forest / non-productive</td>
<td>3.1.5</td>
<td>535,311</td>
<td>-535,311</td>
</tr>
<tr>
<td>Not administered by the province of BC¹</td>
<td>3.1.1 &amp; 3.1.2</td>
<td>119,866</td>
<td>-77,611</td>
</tr>
<tr>
<td>Not administered by the MFR for timber supply²</td>
<td>3.1.3 &amp; 3.1.4 &amp; 3.1.9</td>
<td>86,891</td>
<td>-58,301</td>
</tr>
<tr>
<td>Crown forested land base</td>
<td>3.4.4</td>
<td>569,620</td>
<td>569,620</td>
</tr>
<tr>
<td>Park³</td>
<td>3.4.12</td>
<td>219,014</td>
<td>96,682</td>
</tr>
<tr>
<td>Old growth management areas</td>
<td>3.4.12</td>
<td>264,535</td>
<td>112,521</td>
</tr>
<tr>
<td>Inoperable areas</td>
<td>3.2.1</td>
<td>708,417</td>
<td>-126,418</td>
</tr>
<tr>
<td>Uneconomic areas</td>
<td>3.2.2</td>
<td>41,052</td>
<td>-1,715</td>
</tr>
<tr>
<td>Low timber productivity</td>
<td>3.2.3</td>
<td>88,520</td>
<td>-6,844</td>
</tr>
<tr>
<td>Problem forest types</td>
<td>3.2.3</td>
<td>76,795</td>
<td>-14,034</td>
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<td>Caribou</td>
<td>3.4.11</td>
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<td>Sensitive terrain areas</td>
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<td>Riparian areas</td>
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<td>-8,537</td>
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<td>Existing roads and trails</td>
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<td>Railways and transmission lines</td>
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<tr>
<td>Current timber harvesting land base</td>
<td></td>
<td>199,282</td>
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</tr>
</tbody>
</table>

¹ Includes areas under federal government jurisdiction (Indian Reserves, national parks), private land and private land within woodlots.

² Includes areas managed by other Crown agencies (controlled recreation areas, woodlots, community forest agreements).

³ Includes parks and goal 2 protected areas.

⁴ The sequential netdown reflects the calculation to determine the CFLB and THLB. Each negative value is the amount of land that is not THLB in that category considering the removal of area from the categories above it. For example we see that inoperable areas have 232 284 hectares in CFLB but only 126 418 hectares removed from the THLB. This infers that the 105 866 hectares difference was already removed within the categories of park and old growth management areas.
Figure 1. The crown forested land base and timber harvesting land base of the 2008 Kootenay Lake TSA timber supply review base case scenario.
Table 2. **Overlap of land base categories excluded from the timber harvesting land base**

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<thead>
<tr>
<th>Category</th>
<th>Non-forest / Non-productive</th>
<th>Not administered by the province of BC</th>
<th>Not administered by the MFR for timber supply</th>
<th>Park</th>
<th>Old growth management areas</th>
<th>Inoperable areas</th>
<th>Uneconomic areas</th>
<th>Low timber productivity</th>
<th>Problem forest types</th>
<th>Caribou</th>
<th>Sensitive terrain areas</th>
<th>Riparian areas</th>
<th>Existing roads and trails</th>
<th>Railways and transmission lines</th>
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<tr>
<td>Non-forest / Non-productive</td>
<td>42,255</td>
<td>24,741</td>
<td>123,602</td>
<td>423,360</td>
<td>33,073</td>
<td>49,272</td>
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<td>Low timber productivity</td>
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¹ For linear features (riparian = streams) the overlap area is over-estimated because the linear features may only occupy a percentage of the grid cell and therefore may not overlap with other features. However, for the calculation they will register as a complete overlap for the area.
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Current Forest Conditions

This section describes the land base and forest conditions of the management unit. Details about individual inventory or management assumptions are found in the data package.

Biogeoclimatic Ecosystem Classification

The Kootenay Lake TSA falls within three zones ESSF, ICH, and IMA (Figure 2) with the timber harvesting land base falling predominating in the ICHdm, ICHw1, ICHw2, and ESSFdm subzones.

Figure 2. Biogeoclimatic subzones distribution of the timber harvesting and crown forested land base in the Kootenay Lake TSA.
Tree Species

The Kootenay Lake TSA is composed of a variety of stand types. Balsam-leading stands, while significant on the TSA as a whole, are seen as less important on the timber harvesting land base (Figure 3).

Figure 3. Leading species distribution of the timber harvesting and crown forested land base in the Kootenay Lake TSA.
The area weighted mean site indices by leading species for the Kootenay Lake TSA are shown in Figure 4.

Figure 4. Mean area weighted site index by leading species of the timber harvesting and crown forested land base in the Kootenay Lake TSA.
The age of forest stands within the timber harvesting land base of the Kootenay Lake TSA is generally less than 120 years (Figure 5).

Figure 5. Age class distribution of the timber harvesting and crown forested land base in the Kootenay Lake.
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Analysis Set Up

Introduction

A forest estate modelling approach was used to investigate the timber supply dynamics of the Kootenay Lake TSA. This approach incorporates both the spatial and temporal dynamics of timber supply as well as incorporating forest management objectives.

The Model Parameters and Objectives

The forest estate model

The Ministry of Forests and Range in conjunction with Gowlland Technologies Ltd. developed a timber supply model (STSM) with the Spatially Explicit Landscape Event Simulator (SELES v 3.3 June 21, 2006). The STSM model, modified for the current Kootenay Lake TSA timber supply review, has been used in several analyses within British Columbia. Details on the model origin and version are described in the data package.

STSM uses raster based inputs. The Kootenay Lake TSA analysis uses a one hectare (100 m by 100 m) raster grid. The use of a raster grid influences how certain features are modelled. For example, if a forest inventory polygon boundary cut through the raster, the raster was assigned the dominate forest inventory type group. To handle small linear features, such as buffered riparian areas that are removed from the timber harvesting land base, a timber harvesting land base percent attribute was assigned to each raster. For example if 10% of a raster was in riparian buffer, the THLB attribute would be reduced by 10 percentage points.

STSM operates as a simulation model

Harvest flow objectives

How much timber is harvested in a time period is a function of both the timber that is available and a decision when to harvest. For modelling purposes, there are many options on how much and when timber will be harvested. To enable consistent and relevant information about this harvest flow, general harvest flow objectives for modelling are established.

The underlying harvest flow objective for this analysis and typical for timber supply review in British Columbia is to (1) maintain the maximum flat long-term harvest level where the total growing stock remains constant, (2) maintain an initial harvest level at the current AAC level as long as possible, (3) do not allow mid-term harvest level to drop below natural stand long run sustain yield or preferably do not allow to drop below identified long-term harvest level, and (4) manage any stepdown between the short-term and mid-term harvest levels by no more than 10% decreases per decade.

Model parameters

The model was run with the following parameters unless otherwise stated:
- decadal time steps;
- 400 year planning horizon;
- relative oldest first harvest selection;
- contributing non-THLB was not allowed to age.

Management objectives

The forest land base provides numerous values and uses in addition to timber supply. To protect many resources such as the protection of old forest or caribou habitat forest management objectives and practices have been established. These management objectives may in some case restrict available timber supply and have been accommodated in the timber supply analysis by several techniques.

The simplest technique is the removal of the associated land base from the timber harvesting land base. Other techniques may temporally limit the amount of harvesting within specified resource management zones either by stating a desired objective for the relative amount of older forest or limiting the relative amount of younger forest.

Table 3 summarizes the modelling of the management objectives in the current timber supply analysis. Further details about individual management objectives are available in the data package.
### Table 3. Model considerations for forest management objectives in the Kootenay Lake TSA timber supply analysis

<table>
<thead>
<tr>
<th>Other management objectives</th>
<th>Data package section</th>
<th>Criteria</th>
<th>Cover requirement</th>
<th>Applied to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other timber tenure (e.g., woodlots, community forests)</td>
<td>3.1.3 3.1.4</td>
<td>100% netdown</td>
<td>Specified tenures</td>
<td></td>
</tr>
<tr>
<td>Provincial parks</td>
<td>3.4.4</td>
<td>100% netdown</td>
<td>Specified parka</td>
<td></td>
</tr>
<tr>
<td>Controlled recreation areas</td>
<td>3.1.9</td>
<td>100% netdown</td>
<td>Specified CRA</td>
<td></td>
</tr>
<tr>
<td>Riparian zones</td>
<td>3.4.3</td>
<td>Equivalent area netdown</td>
<td>All rasters</td>
<td></td>
</tr>
<tr>
<td>Archaeological sites</td>
<td>3.4.5 2.1.29</td>
<td>Not modelled assumed overlap with other objectives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community and domestic watersheds</td>
<td>3.4.2 2.1.4</td>
<td>Maximum disturbance</td>
<td>No more than 25% can be less than 6 m Community and domestic class 1, 2, 3 watershed boundaries</td>
<td></td>
</tr>
<tr>
<td>Visual resources</td>
<td>3.4.7 2.1.28</td>
<td>Maximum disturbance</td>
<td>No more than a specified percentage based on VQO can be less than a green-up height based on slope VQO by landscape unit</td>
<td></td>
</tr>
<tr>
<td>Landscape biodiversity</td>
<td>3.4.12</td>
<td>OGMA have 100% netdown</td>
<td>Specified OGMAs</td>
<td></td>
</tr>
<tr>
<td>Stand-level biodiversity (wildlife tree)</td>
<td>3.4.13</td>
<td>A volume table reduction of 5.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caribou</td>
<td>3.4.11 2.2.23</td>
<td>100% netdown of no harvest UWR units</td>
<td>Specified UWR units</td>
<td></td>
</tr>
<tr>
<td>Elk</td>
<td>3.4.8</td>
<td>Minimum retention</td>
<td>Individual UWR units</td>
<td></td>
</tr>
</tbody>
</table>

(continued)
### Table 4. Model considerations for forest management objectives in the Kootenay Lake TSA timber supply analysis (concluded)

<table>
<thead>
<tr>
<th>Other management objectives</th>
<th>Data package section</th>
<th>Criteria</th>
<th>Cover requirement</th>
<th>Applied to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moose</td>
<td>3.4.8</td>
<td>Minimum retention</td>
<td>At least 20% must be greater than or equal to 61 years</td>
<td>Identified UWR management units</td>
</tr>
<tr>
<td>UWR Forage Area</td>
<td>3.4.8</td>
<td>Minimum retention</td>
<td>At least 10% must be greater than or equal to 81 years</td>
<td>Identified UWR management units</td>
</tr>
<tr>
<td>Mule deer</td>
<td>3.4.8</td>
<td>Minimum retention</td>
<td>At specified percent must be greater than or equal to a specified age based on subzone</td>
<td>Identified UWR management units</td>
</tr>
<tr>
<td>UWR General</td>
<td>3.4.8</td>
<td>Maximum disturbance</td>
<td>No more than 40% below 21 years</td>
<td>All UWR U-4-001 management units</td>
</tr>
<tr>
<td>IRM General</td>
<td>3.4.6</td>
<td>Maximum disturbance</td>
<td>No more than 33% can be less than 2 m height</td>
<td>Landscape Units</td>
</tr>
<tr>
<td>Wildlife Management Areas</td>
<td>3.4.10</td>
<td>Modelled in base scenario as 100% constrained</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

KBHLPO – Kootenay Boundary Higher Level Plan Order  
CFLB – Crown Forested Land Base  
THLB – Timber Harvesting Land Base  
VQO – Visual Quality Objective  
OGMA – Old Growth Management Area  
NDT – Natural Disturbance Type  
IRM – Integrated Resource Management
Growth and yield
The projection of merchantable timber volumes and other forest stand attributes (e.g., height) is a key component of forest estate modelling.

The forest estate model STSM uses tables of merchantable volume and stand height reported at decadal intervals. Each raster in STSM is associated with a specific volume and height table that may transfer over time. For example, a raster may initially be associated with an existing natural stand volume table and following harvest it is transferred to a future managed volume table.

In the current analysis, volume tables are created for natural and managed stands. The volume tables of these two classes are generated with two different growth and yield models.

For natural stands, the inventory projection model VDYP is used. VDYP is an empirically derived model based on growth and yield sample plots collected across the province over the past 50 years. Current inventory information is used as the input to VDYP. Natural stands are those stands that have not yet been harvested or were harvested pre-1987.

For managed stands, the model TIPSY is used to generated volume tables. TIPSY is an interpolation program of yield tables generated from another model (TASS) that simulates the growth of individual trees in a stand based on internal growth processes, crown competition, environmental factors, and silviculture practices. A managed stand is considered a stand harvested after 1987 when current basic silviculture requirements became law.

Typically to increase the efficiency of the modelling process or due to the detail of input information, volume tables are generated for an aggregate of stands called an analysis unit.

In the current analysis, volume tables for existing natural stands were generated for each single forest polygon. These volume tables had been generated by MFR Forest Analysis and Inventory Branch staff for all forest cover polygons in BC using the model VDYP6. Each raster in the current analysis was assigned one of these volume tables based on its dominant forest polygon type. The individual volume tables were not aggregated into analysis units.

It was not possible to assign a unique yield table to managed stands as the regeneration input information cannot be sufficiently distinct. As such, analysis units were created to group growth and yield projections into broader land base and composition strata (e.g., by species, site index class, biogeoclimatic zone) to which regeneration information could be assigned. Analysis units were created for stands with an existing harvest record post-1987 to the present and for those stands not yet harvested.
Base Case Scenario

The base case scenario is presented in this section. The base case represents the projected harvest flows that result from modelling current forest management practice using the best available information at the time of the analysis. The data package provides greater description about the assumptions underlying the base case.

Base harvest flow

The base case provides a benchmark but uncertainties in information used exist. Modelling enables testing how these uncertainties impact the base case. Further, modelling of the sensitivities of information can assist the chief forester understanding the impact of new information that may become available after the completion of the analysis.
Kootenay Lake TSA Technical Summary

Diagnostic outputs

growing stock (millions cubic metres)

- Base case total growing stock
- Base case merchantable growing stock

total area harvested (hectares/year)
Kootenay Lake TSA Technical Summary

mean volume harvested (m$^3$/hectares)

mean harvested age (years)
Interpretation

The base case scenario identifies that the current AAC level cannot be obtained. The reduced short-term harvest can be primarily attributable to the establishment of community forests since the last AAC determination. Community forests are not considered part of the land base modelled in the timber supply review, therefore the removal of this 77 000 hectares of land base results in a reduced timber supply. Secondarily, changes in other forest management objectives such as Mountain caribou also likely negatively impacted the timber supply.

The current identified timber harvesting land base of 199 282 hectares is 23% less than the THLB reported in the March 2001 analysis. However, the timber supply percent reduction is much less than the 9% less timber supply difference in the long-term harvest level identified. This lower impact is due to changes in the management of objectives and how they are modelled. For example, landscape-biodiversity objectives for old forest in the previous timber supply review were managed and modelled by the minimum retention requirements (i.e., no spatial delineation of old-growth management areas was available). Currently, old-growth management areas have been spatially delineated and for the current timber supply analysis these areas were removed from the timber harvesting land base. Thus, the old-growth management areas are the on-ground reflection of the same minimum retention requirements modelled and should result in little change in timber supply dynamics.

Modelling the base case and the various sensitivities involves hundreds of runs of the model from which the analyst learns about the dynamics of the timber supply. From the base case runs it was seen that harvest flow is largely sensitive at two locations over the 400 year planning horizon that was modelled. The first common pinch point is seen at about 60-90 years from present and appears to be related directly to the transition between existing stands and the first harvest of managed stands (i.e., problems where you harvest too much before the new forests have had a chance to become merchantable). The second sensitivity is seen typically around 260 years from present. This appears to be a point in time where there is simply a low number of stands meeting minimum harvestable age requirements and is not related to any specific forest management objective.
Critical Issue and Sensitivity Analyses

The base case scenario tells the timber supply story under very specific conditions. We know that there is uncertainty and known differences around those conditions. To better understand the timber supply dynamics, it is necessary to explore assumptions around the inputs to the base scenario and to the model parameters (i.e., sensitivity analysis). In some cases, it is necessary to explore a scenario with very different inputs (i.e., critical issues analysis).

The remainder of the technical summary of the timber supply analysis provides a description of all the individual sensitivity or issue analyses. A primer on the interpretation of graphs presented in the section is provided in Appendix A.

Below is a summary of a selection of the sensitivity and critical issue analyses completed.

<table>
<thead>
<tr>
<th>Sensitivity analysis</th>
<th>Change</th>
<th>Short</th>
<th>Mid</th>
<th>Long</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managed yields</td>
<td>+10%</td>
<td>0</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>-10%</td>
<td>0</td>
<td>-4</td>
<td>-11</td>
</tr>
<tr>
<td>Existing yields</td>
<td>+5%</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>-5%</td>
<td>-5</td>
<td>-5</td>
<td>0</td>
</tr>
<tr>
<td>Minimum harvestable age</td>
<td>+10 yrs</td>
<td>-16</td>
<td>-3</td>
<td>-3</td>
</tr>
<tr>
<td></td>
<td>-10 yrs</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>THLB</td>
<td>-10%</td>
<td>-10</td>
<td>-11</td>
<td>-11</td>
</tr>
<tr>
<td></td>
<td>+5%</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Stand productivity</td>
<td>+3 m Site index</td>
<td>0</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>-3 m Site index</td>
<td>0</td>
<td>-18</td>
<td>-29</td>
</tr>
<tr>
<td>OGSI type increase</td>
<td>4</td>
<td>24</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Management objectives/issues</td>
<td>No mgmt constraints except 2m adjacency</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>No caribou requirements</td>
<td>3</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Use KBHLPO caribou</td>
<td>3</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Mountain pine beetle – remove all pine from existing yield tables</td>
<td>-48</td>
<td>-20</td>
<td>-15</td>
</tr>
<tr>
<td></td>
<td>Use high incident for root rot to model managed yield tables</td>
<td>0</td>
<td>0</td>
<td>-9</td>
</tr>
<tr>
<td>Modelling issues</td>
<td>Highest initial</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Maximum even</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Parallel TSR 2 harvest flow</td>
<td>-6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Ageing of non-THLB</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Random harvest priority rather than relative oldest</td>
<td>-10</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Mountain Caribou – no requirements

General description

In February 2009 new GAR orders established ungulate winter ranges for Mountain Caribou. These ungulate winter ranges are primarily no harvest and replace the previous KBHLPO caribou zones that were based on specified measures that limited but did not prevent harvesting. In this issue analysis we looked at the harvest flow as if there were no Mountain caribou resource management requirements. The sensitivity in the next section looks at the harvest flow using the former KBHLPO caribou zones.

Modelling change

The base case considers Mountain Caribou management by (1) removing zones that are not to be harvested from the THLB and (2) forcing for a few small zones an expected amount harvest in the zone that is enabled under the GAR for a set time period before reverting to a no harvest. In this issue analysis, the scenario returns all of the caribou management zones to timber harvesting land base upon which there are no restrictions associated with Mountain caribou management.

It should be noted that this sensitivity analysis is based simply on turning off modelling constraints as presented. This does not recognize that other management objectives may have been set to assist or compensate for another management objective. For example, a number of old-growth management areas were identified specifically to meet KBHLPO requirements as well as landscape-biodiversity requirements. These areas, which are retained under the old-growth management areas, might not have been excluded from the THLB, if no Mountain Caribou management objectives were present. This demonstrates that one needs to be cautious about interpretation of impacts

Harvest flow

The following figure and table shows the resulting “flowed” harvest for the issues analysis as compared to base case.

![Graph showing harvest flow](image-url)
Kootenay Lake TSA Technical Summary

Diagnostics
The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.

growing stock (’000000s cubic metres)

harvest (hectares/year)
Kootenay Lake TSA Technical Summary

Mean harvest volume ($m^3$/hectare)

- **Base Case**
- **No Caribou**

Mean harvest stand age (years)

- **Base Case**
- **No Caribou**
**Interpretation**

Modelling a sensitivity analysis may involve multiple runs of the model from which the analyst learns about the dynamics of the timber supply. Below are interpretations or insights that the analyst obtained while developing this sensitivity analysis and as seen through the diagnostic outputs.

The difference in initial total growing stock between the base case and the no caribou requirements reflects the growing stock of the no harvest zones for the mountain caribou objectives that is returned to the timber harvesting land base.

The sensitivity analysis was done in two steps. First the caribou zones were brought back into the THLB maintaining the priority harvest in the smaller caribou zones (i.e., forced model to harvest in some caribou areas to reflect licensees ability to harvest in these areas for a short time period). This first step actually had a higher possible long-term harvest level (610 000 cubic metres) than where there was no priority. When the priority was removed, the harvest was not met at only one point (260 years). Normally, one would expect both to be similar. The reason for the different harvest levels is not clear — maybe just a scheduling issue.

District staff expected a greater impact might be present. However, it was recognized that the spatial old-growth management areas had in some cases been indentified specifically to overlap Mountain caribou management zones under the previous order.

**KBHLPO Caribou**

**General description**

In February 2009 new GAR orders established ungulate winter ranges for Mountain Caribou. These UWR are primarily no harvest and replace the previous KBHLPO caribou zones that were primarily based on specified measures that limited but did not prevent harvesting.

**Modelling change**

The base case considers Mountain Caribou management by (1) removing no harvest and likely no harvest zones from the THLB and (2) for a few small zones forces through priorities (and cover constraints) to harvest an expected amount of the zone that is enabled under the GAR for a set time period before reverting to a no harvest.

In this issue analysis, the scenario the GAR UWR caribou zones are replaced with the KBHLPO zones and applied management constraints.

**Harvest flow**

The following figure and table shows the resulting harvest flows. As the KBHLPO is less constraining than the 2009 GAR orders we are able to exceed the base case harvest flow.
Kootenay Lake TSA Technical Summary

Diagnostics
The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.

Growing stock ('000000s cubic metres)

Decades from present

Growing stock ('000000s cubic metres)
Kootenay Lake TSA Technical Summary

harvest (hectares/year)

mean harvest volume (m$^3$/hectare)
Interpretation

Modelling a sensitivity scenario may involve multiple runs of the model from which the analyst learns about the dynamics of the timber supply. Below are interpretations or insights that the analyst obtained while developing the sensitivity analyses and as seen through the diagnostic outputs.

The difference in initial total growing stock between the base case and the application of the KBHLPO requirements reflects the growing stock of the no harvest zones for the mountain caribou objectives that is returned to the timber harvesting land base.

There is little difference in the short-term harvest flow between the modelled current GAR orders and the previous KBHLPO. However, in the long-term harvest an 8% difference is observed. The difference seen here is about 3% but comparison to other alternative harvest flows (i.e., see Maximum Initial) suggest less than 3%.

Site index minus 3 metres

General description

Inventory site indices that are typically based on photo interpreted age and height have been found to be deficient in identifying potential site indices used in managed stand modelling. This sensitivity analysis decreases all inventory site indices by three metres.

Other sensitivity analyses look at increasing site indices by three metres and also the application of provincial old-growth site index studies.

Modelling change

The base case used site indices of the forest inventory. These site indices are either derived from a height-age relationship or were placed in the data base from silviculture records. These site indices have not been adjusted based on a Phase 2 Vegetation Resource Inventory.

This sensitivity analysis decreases the site indices of all stands by three metres. This change was then used to develop new managed stand volume and height tables (i.e., TIPSY model based) and new minimum harvestable ages that were applied in STSM.

Harvest flow

The following figure and table shows the resulting “flowed” harvest for the sensitivity or critical issues analysis.
Kootenay Lake TSA Technical Summary

Diagnostics
The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.

![Graph of growing stock ('000000s cubic metres)](#)

![Graph of harvest (hectares/year)](#)
Kootenay Lake TSA Technical Summary

**Graph 1:**
- Title: Mean harvest volume (m$^3$/hectare)
- X-axis: Decades from present
- Y-axis: Mean harvest volume (m$^3$/hectare)
- Lines:
  - Base Case (dashed line)
  - SI minus 3 m (solid line)

**Graph 2:**
- Title: Mean harvest stand age (years)
- X-axis: Decades from present
- Y-axis: Mean harvest stand age (years)
- Lines:
  - Base Case (dashed line)
  - SI minus 3 m (solid line)
Site indices plus three metres

General description

Inventory site indices that are typically based on photo interpreted age and height have been found to be deficient in identifying potential site indices used in managed stand modelling. This sensitivity analysis provides a look at increasing all inventory site indices by three metres.

Other sensitivity analyses look at decreasing site indices by three metres and the application of provincial old-growth site index studies.

Modelling change

The base case used site indices as presented with the forest inventory. These site indices have not been adjusted.

This sensitivity analysis increased the site indices of all stands by three metres. This change then was used to develop new managed stand volume and height tables (i.e., TIPSY model based) and new minimum harvestable ages that were applied in STSM.

Harvest flow

The following figure and table shows the resulting “flowed” harvest for the sensitivity analysis.
The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.

**Diagnostics**

The following graphs show characteristics of the growing stock ('000000s cubic metres):
Kootenay Lake TSA Technical Summary

mean harvest stand age (years)

- Base Case
- SI plus 3 m

harvest ('000s/year)

- Managed Stands
- Existing Stands

decades from present
**Kootenay Lake TSA Technical Summary**

**Existing yields less five percent**

**General description**
Sensitivity to see the impact of removing 5% from the existing stand yield tables.

**Modelling change**
In the base case a yield table has been created for each existing stand. For this sensitivity the yields were multiplied by 0.95 and rounded to nearest cubic metre.

**Harvest flow**
The following figure shows the resulting “flowed” harvest for the sensitivity analysis. This figure also shows what happened when we attempted to maintain base harvest flow (i.e., where it breaks). See Appendix A for a description on interpretation of the figure.

The smoothed harvest flow as expected shows about a five percent decrease over the eight decade period of liquidation of existing stands.

---

**Graph Description**

- **Base Case**
- **Existing Yield less 5 Break**
- **Existing Yield less 5 Smoothed**

**Harvest ('000 s m³/year)**

- 645 000 m³/year
- 516 800 m³/year
- 544 000 m³/year

**Decades from Present**

- 0
- 5
- 10
- 15
- 20
- 25
- 30
- 35
- 40

**Harvest ('000 s m³/year)**

- 0
- 100
- 200
- 300
- 400
- 500
- 600
- 700
The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.

**growing stock (’000000s cubic metres)**

- Base Case Total Growing Stock
- Base Case Merchantable Growing Stock
- Existing Yield less 5 Total Growing Stock
- Existing Yield less 5 Merchantable Growing Stock

**harvest (hectares/year)**

- Base Case
- Existing Yield less 5
Existing yields plus five percent

**General description**

Sensitivity to see impact of adding 5% to the existing stand yield tables.

**Modelling change**

In the base case a yield table has been created for each existing stand. For this sensitivity the yields were multiplied by 1.05 and rounded to nearest cubic metre.

**Harvest flow**

The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis. This figure also shows what happened (i.e., where it breaks) when we attempted to maintain base case scenario harvest flow levels. On this graph, the base case is primarily covered by the “break” flow. See Appendix A for a description on interpretation of the graph.
Diagnostics
The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.
Kootenay Lake TSA Technical Summary

harvest (hectares/year)

mean harvest volume (m³/hectare)
Managed yield tables less 10 percent

General description
The managed stand yield tables that were generated with the growth and yield model TIPSY were reduced by 10 percent.

Modelling change
In the base case a yield table has been created for each analysis unit associated with a managed stand. These yield tables were generated using the growth and yield model TIPSY. For this sensitivity the yields were multiplied by 0.90 and rounded to nearest cubic metre.

Harvest flow
The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis. This figure also shows what happened (i.e., where it breaks) when we attempted to maintain base case scenario harvest flow levels. See Appendix A for an explanation about the break harvest flow.
The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.
Kootenay Lake TSA Technical Summary

mean harvest volume (m$^3$/hectares)

- Base Case
- Managed Yield less 10

mean harvest stand age (years)

- Base Case
- Managed Yield less 10
Managed yield tables plus 10 percent

General description
The managed stand yield tables that were generated with the growth and yield model TIPSY were increased by 10 percent.

Modelling change
In the base case a yield table has been created for each analysis unit associated with a managed stand. These yield tables were generated using the growth and yield model TIPSY. For this sensitivity the yields were multiplied by 1.10 and rounded to nearest cubic metre.

Harvest flow
The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis. This figure also shows what happened (i.e., where it breaks) when we attempted to maintain base case scenario harvest flow levels. On this graph, the base case is covered by the “break” flow.
Diagnostics
The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.

harvest ('000s m³/year)

Base Case
Manage Yield Plus 10 Break
Managed Yield Plus 10 Smoothed

0 5 10 15 20 25 30 35 40 decades from present

544 000 m³/year
645 000 m³/year
605 000 m³/year

growing stock ('000000s cubic metres)

Base Case Total Growing Stock
Base Case Merchantable Growing Stock
Managed Yield Plus 10 Total Growing Stock
Managed Yield Plus 10 Merchantable Growing Stock

0 5 10 15 20 25 30 35 40 decades from present
Kootenay Lake TSA Technical Summary

harvest (hectares/year)

mean harvest (volume m³/hectares)
Kootenay Lake TSA Technical Summary

mean harvest stand age (years)

Managed Stands
Existing Stands
Managed Yield plus10

harvest ('000s/year)

Managed Yield plus10
Managed Stands
Existing Stands
Higher levels of root rot

General description
The future managed yield tables in the ICH were modelled.

Modelling change
In base case the future managed yield tables were generated with the growth and yield program TIPSY with the option of low incidence for root rot.

For this sensitivity new future managed yield tables were generated with the option of high incidence for root rot.

Harvest flow
The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis. This figure also shows what happened (i.e., where it breaks) when we attempted to maintain base case scenario harvest flow levels. On this graph, the base case is partially covered by the “break” flow. See Appendix A for an explanation of the break harvest flow.
Kootenay Lake TSA Technical Summary

Diagnostics

The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.

1. **Growing Stock** ('000000s cubic metres)
   - Base Case Total Growing Stock
   - Base Case Merchantable Growing Stock
   - High Root Rot Total Growing Stock
   - High Root Rot Merchantable Growing Stock

2. **Harvest** (hectares/year)
   - Base Case
   - High Root Rot

These graphs illustrate changes in growing stock and harvest over time from the present, with different scenarios compared to the base case.
Kootenay Lake TSA Technical Summary

mean harvest volume (m$^3$/hectare)

- Base Case
- High Root Rot

decades from present

mean harvest stand age (years)

- Base Case
- High Root Rot

decades from present
Minimum harvestable age increased 10 years

General description

Minimum harvestable ages or volumes are required for a timber supply analysis to prevent the model from selecting unrealistic stands to be harvested, especially during low availability points in the planning horizon.

In the timber supply analysis, the average age at which stands are harvested is always higher than the minimum harvestable age because other forest management objectives delay the harvest of stands (e.g., UWR requirement maintaining older stands).

Minimum harvestable ages were determined for the base case scenario as the approximate age at which 95% of the maximum mean annual increment is first reached.

Modelling change

In the base case scenario the minimum harvestable age was based on the approximate age at which 95% of the maximum mean annual increment is first reached.

For this sensitivity the minimum harvestable ages were increased by 10 years.

Harvest flow

The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis. This figure also shows what happened (i.e., where it breaks) when we attempted to maintain base case scenario harvest flow levels. See Appendix A for an explanation of the break harvest flow.
Kootenay Lake TSA Technical Summary

Diagnostics
The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.

harvest (’000s m³/year)

![Graph showing harvest flow](image)

530,000 m³/year

![Graph showing growing stock](image)

growing stock (’000000s cubic metres)
Kootenay Lake TSA Technical Summary

![Graph showing harvest (hectares/year) and mean harvest volume (m³/hectare) over decades from present for Base Case and MHA plus 10 yrs.]
Minimum harvestable age decreased 10 years

General description
Minimum harvestable ages or volumes are required for a timber supply analysis to prevent the model from selecting unrealistic stands to be harvested, especially during low availability points in the planning horizon.

In the timber supply analysis, the average age at which stands are harvested is always higher than the minimum harvestable age because other forest management objectives delay the harvest of stands (e.g., UWR requirement maintaining older stands).

Minimum harvestable ages were determined as the approximate age at which 95% of the maximum mean annual increment is first reached.

Modelling change
In base case scenario the minimum harvestable age was based on the approximate age at which 95% of the maximum mean annual increment is first reached.

For this sensitivity the minimum harvestable ages were decreased by 10 years.

Harvest flow
The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis. This figure also shows what happened (i.e., where it breaks) when we attempted to maintain base case scenario harvest flow levels. See Appendix A for an explanation of the break harvest flow.

harvest (’000s m³/year)

```
645 000 m³/year
600 000 m³/year
544 000 m³/year
495 000 m³/year
```

Base Case MHA less 10 Break MHA less 10 Smoothed

decades from present

0 5 10 15 20 25 30 35 40
Diagnostics

The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.
Aging of non-THLB

General description
Timber supply modelling simplifies forest growth and management. In the current analysis, the only disturbance of the forest that is modelled is harvesting within the timber harvesting land base. Forest stands outside of the timber harvesting land base however do contribute to management objectives such as mature forest. As such, the disturbance history (i.e., age class distribution) of this non-THLB can influence management objectives and it is important that consideration be given to this.

Modelling change
In base case scenario forests stands outside of the timber harvesting land base were assigned their current age rather than allowing a stand to age indefinitely.

For this sensitivity forest stands outside of the timber harvesting land base were allowed to age.

Harvest flow
The following figure shows the resulting “flowed” harvest for this sensitivity issue analysis. This figure also shows what happened (i.e., where it breaks) when we attempted to maintain base case scenario harvest flow levels. On this graph, as there is no difference among the scenarios all are shown by a single line.
Diagnostics
The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.
No management minimum retention or maximum disturbance constraints

General description
The base scenario contains management constraints for visuals, landscape biodiversity, community and domestic watersheds, ungulate winter range, and general green-up adjacency. These management constraints are modelled by minimum retention (i.e., must have x% of a specified land base above a certain age) and maximum disturbance (i.e., must have no more than x% of a specified land base below a certain age or height). In the base scenario, some of these constraints are seen to affect timber supply particularly in the first decades.

Further sensitivity analysis work may look at the implications of other management objectives that were modelled by other methods (e.g., old-growth management areas by spatial netdowns of timber harvesting land base).

Modelling change
For this sensitivity all minimum retention and maximum disturbance constraints were removed except the general adjacency constraint of no more than 33% under two metres. This sensitivity maintains all other management objectives that were modelled by different methods such as THLB netdowns (e.g., old-growth management areas, riparian areas) and volume table reductions (e.g., wildlife tree patches).

This sensitivity provides a boundary of the potential increased availability of timber supply if there were reduced management constraints. If there is a significant increase available (e.g., >10%) then other sensitivity analyses for the individual management objectives (e.g., visuals) will be investigated.

Harvest flow
The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis. This figure also shows what happened (i.e., where it breaks) when we attempted to maintain base case scenario harvest flow levels. On this graph, the base case is covered by the “break” flow. See Appendix A for an explanation of the break scenario.
Kootenay Lake TSA Technical Summary

Diagnostics

The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.

Growing stock (‘000000s cubic metres)

- Base Case Total Growing Stock
- Base Case Merchantable Growing Stock
- No Constraint Total Growing Stock
- No Constraint Merchantable Growing Stock

Harvest (hectares/year)

- Base Case
- No Constraints
Kootenay Lake TSA Technical Summary

**Mean Harvest Volume (m³/hectare)**

![Graph showing mean harvest volume over decades from present for Base Case (dashed line) and No Constraints (solid line).](image)

**Mean Harvest Stand Age (years)**

![Graph showing mean harvest stand age over decades from present for Base Case (dashed line) and No Constraints (solid line).](image)
Old growth site indices

General description
Site indices determined from inventory height and age estimates have been recognized to underestimate the potential site productivity of older and younger stands.

The Ministry of Forests and Range conducted two studies that investigated the differences in inventory as compared to potential site indices. These studies have been used in past timber supply reviews to investigate potential implications of the uncertainty around site indices.

Modelling change
In base case inventory site indices were used as input to project future managed stand yields.

For this sensitivity new managed stand yield tables and minimum harvestable ages were generated using provincial estimates of potential site productivity in the studies of Nussbaum (1998) and Nigh (1998).

The site indices of all stands were adjusted based on these studies. This is an incorrect application. Only stands greater than 140 years and recently harvested stands (i.e., assumed to have been greater than 140 years when harvested and site index assigned) should have been adjusted. This incorrect application will result in higher yields in the yield tables and thus a higher timber supply impact.

Harvest flow
The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis. This figure also shows what happened (i.e., where it breaks) when we attempted to maintain base case scenario harvest flow levels.
Diagnostics
The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.
Kootenay Lake TSA Technical Summary

harvest (hectares/year)

mean harvest volume (m³/hectare)
Maximum initial harvest level

General description

The initial harvest level of the base case was initially selected based on an earlier analysis and was reflective of harvest flow lost due to the removal of the community forests.

This analysis investigated whether additional harvest flow was available in the initial decades.
Modelling change

No changes except for harvest flow were made in this sensitivity analysis. The objective was to obtain the highest harvest level in the first two decades while maintaining similar mid- and long-term objectives.

Harvest flow

The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis.

![Harvest Flow Graph](image-url)

- **655,000 m³/year**
- **600,000 m³/year**
- **544,000 m³/year**
Kootenay Lake TSA Technical Summary

Diagnostics

The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.
Kootenay Lake TSA Technical Summary

**Graph 1:**
- **Y-axis:** Mean harvest volume (m³/hectare)
- **X-axis:** Decades from present
- **Legend:**
  - **Base Case** (dashed line)
  - **Maximum Initial** (solid line)

**Graph 2:**
- **Y-axis:** Mean harvest stand age (years)
- **X-axis:** Decades from present
- **Legend:**
  - **Base Case** (dashed line)
  - **Maximum Initial** (solid line)
Even flow harvest level

General description
Interest is often expressed in the harvest level that could be maintained throughout the planning horizon. In a management unit where the harvest flow is seen to stepdown from a higher harvest level of the accumulated volume to a maximum long term non-increasing level, the maximum feasible evenflow level (with the characteristic of a flat long-term total growing stock) is inherently the long-term harvest level. However, a slightly higher evenflow level is generally possible that distributes the initial inventory over the planning horizon.

Modelling change
No changes except for harvest flow were made in this sensitivity analysis. The objective was to obtain the highest evenflow harvest in the 400 year planning horizon without the total growing stock going lower than that of the total growing stock found in the base case scenario.

Harvest flow
The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis.
Kootenay Lake TSA Technical Summary

Diagnostics
The following graphs show characteristics of the harvest flow of the sensitivity analysis against the base case.

harvest ('000s m³/year)

Base Case: 546 000 m³/year

Even Flow:

growing stock ('000000s cubic metres)

Base Case Total Growing Stock
Base Case Merchantable Growing Stock
Even Flow Total Growing Stock
Even Flow Merchantable Growing Stock
Kootenay Lake TSA Technical Summary

![Graphs showing mean harvest stand age and harvest ('000s/year) over time.]

- **Mean Harvest Stand Age (Years):**
  - Base Case (dashed line)
  - Even Flow (solid line)
  - X-axis: decades from present
  - Y-axis: mean harvest stand age (years)

- **Harvest ('000s/year):**
  - Managed Stands
  - Existing Stands
  - X-axis: decades from present
  - Y-axis: harvest ('000s/year)
Random harvest priority

General description
Which stands a model selects for harvest can influence the timber supply dynamics and if it differs from actual practice can result in misleading harvest flows. Common harvest priority rules include selection of the oldest stands or the relative oldest stand.

Modelling change
In the base case the harvest priority rule is to select the oldest stand relative to its minimum harvestable age.

In this sensitivity, the harvest rule is set to be a random selection for all available stands (i.e., above minimum harvestable age and volume and which will not result in the model exceeding any management constraint).

Harvest flow
The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis.
Kootenay Lake TSA Technical Summary

Diagnostics
The following graphs show characteristics of the harvest flow of the sensitivity analysis against the base case.

Growing stock ('000000s cubic metres)

- Base Case Total Growing Stock
- Base Case Merchantable Growing Stock
- Random Total Growing Stock
- Random Merchantable Growing Stock

Harvest (hectares/year)

- Base Case
- Random
TSR 2 harvest flow pattern

General description
Harvest in the short term can usually be flowed in a variety of patterns. To describe change between the present timber supply review and the past timber supply review, a comparison using a similar shaped harvest flow, if possible, is informative.

Modelling change
No changes except for harvest flow were made in this sensitivity analysis. The objective was to obtain a harvest flow that mimics the base case of the 2001 analysis report. This 2001 base case had an initial harvest level for five decades before stepping down to the long term with one 10% step down in decade six.

Harvest flow
The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis.
Kootenay Lake TSA Technical Summary

Diagnostics

The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.

The growing stock graph identifies the transition of the accumulated existing stand volume to a lower “flat” level that is reflective of harvesting closer to the maximum productivity and the management constraints present.
Kootenay Lake TSA Technical Summary

Decades from present

Mean harvest stand age (years)

- Base Case
- TSR2 Harvest Flow Pattern

Harvest ('000s/year)

- Managed Stands
- Existing Stands

TSR2 Harvest Flow Pattern
Timber harvesting land base
10 percent smaller

General description
Timber supply is dependent on the composition of the forest, the growth of the forest, and the management of the forest. A key component of both the composition and the management is the amount of land base, particularly the timber harvesting land base.

In determining the allowable annual cut of a management unit, the chief forester is often faced with new information or uncertainty around the actual size of the timber harvesting land base. A sensitivity analysis that removes or adds THLB provides information about whether assumptions about whether known changes in THLB would be proportionately reflected in the timber supply.

Modelling change
All rasters with THLB present were assigned a THLB area that was 10% lower.

Harvest flow
The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis. This figure also shows what happened (i.e., where it breaks) when we attempted to maintain base case scenario harvest flow levels. On this graph, the base case is covered by the “break” flow.

![Graph showing harvest flow](image-url)
The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.
Timber harvesting land base
five percent larger

General description

Timber supply is dependent on the composition of the forest, the growth of the forest, and the management of the forest. A key component of both the composition and the management is the amount of land base, particularly the timber harvesting land base.

In determining the allowable annual cut of a management unit, the chief forester is often faced with new information or uncertainty around the actual size of the timber harvesting land base. A sensitivity analysis that removes or adds THLB provides information whether assumptions about changes in THLB would be proportionately reflected in the timber supply.

Modelling change

All rasters with THLB present were assigned 100% THLB area. This is equivalent to about a 5.5% increase in timber harvesting land base.
Harvest flow

The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis. This figure also shows what happened (i.e., where it breaks) when we attempted to maintain base case scenario harvest flow levels.
Diagnostics
The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.

growing stock ('000000s cubic metres)

harvest (hectares/year)
No pine volumes

**General description**

The Mountain pine beetle could significantly affect timber supply in the Kootenay Lake TSA. A sensitivity that provides the worst possible case (i.e., all pine is killed and unsalvageable and no rehabilitation of low volume stands) demonstrates the lower boundary of timber supply under a Mountain pine beetle infestation. This worst case scenario would not occur as not all pine volume is lost, salvage will occur, and rehabilitation of low volume stands will occur either through management or naturally.

It is likely that the issue of the Mountain pine beetle infestation will require additional analysis to closer reflect current infestation levels and management expectations.

**Modelling change**

In base case volume tables were created based on the species composition of the current inventory. This inventory was developed prior to the current Mountain pine infestation that has spread throughout British Columbia. For this issues analysis, the projected yield of all existing stand volume tables were reduced by the initial inventory percent of pine.
Harvest flow

The following figure shows the resulting “flowed” harvest for the sensitivity issue analysis. This figure also shows what happened (i.e., where it breaks) when we attempted to maintain base case scenario harvest flow levels. On this graph, the base case is covered by the “break” flow.

harvest ('000s m³/year)

645 00 m³/year

decades from present
Kootenay Lake TSA Technical Summary

Diagnostics

The following graphs show characteristics of the smoothed harvest flow of the sensitivity analysis against the base case.

- **harvest (hectares/year)**
  - X-axis: decades from present
  - Y-axis: number of hectares/year
  - Graphs show the comparison between Base Case and No Pine scenarios.

- **mean harvest volume (m³/hectares)**
  - X-axis: decades from present
  - Y-axis: mean harvest volume in m³/hectares
  - Graphs illustrate the mean harvest volume comparison between Base Case and No Pine scenarios.
The graphs illustrate the mean harvest stand age and harvest for two different scenarios:

1. **Base Case** represented by the dashed line. The mean harvest stand age decreases over time, indicating a gradual reduction in the average age of harvested stands.
2. **No Pine** represented by the solid line. The mean harvest stand age remains relatively constant, suggesting minimal impact on the stand age distribution.

### Harvest (000s/year)

- **Managed Stands**: Represented by a dotted pattern. There is an initial peak in harvest followed by a steady decline and eventual stabilization.
- **Existing Stands**: Represented by a solid square pattern. The pattern covers a wide range of decades, indicating a consistent but lower harvest rate.

The graphs together depict the contrasting effects of managing or not managing pine trees on the mean harvest stand age and overall harvest rates.
Interpretation

Modelling a sensitivity scenario may involve multiple runs of the model from which the analyst learns about the dynamics of the timber supply. Below are interpretations or insights that the analyst obtained while developing the sensitivity analyses and as seen through the diagnostic outputs.

Significant impacts were seen by this scenario. These impacts are the likely result of the model including a minimum harvestable volume of 100 cubic metres per hectare. If removing the pine component brings a stand below 100 cubic metres then the remaining volume is also not available in the short term for harvest. Further if these stands are not harvested, they do not contribute to the long-term harvest level.

This scenario, while a boundary on the impact, is unrealistic. A further analysis is needed to provide a more realistic look at the impact of the Mountain pine beetle infestation.
Appendix A: Interpretation of Harvest Flow and Diagnostic Graphs

This technical summary was written for an audience that has an understanding of timber supply analysis. The prime purpose of the technical summary was to provide a simple reporting structure for the analysis outputs but which would provide sufficient detail such that an analyst who is unfamiliar with the analysis can understand the underlying dynamics.

In this appendix, we provide a brief primer for the non-analyst on how to view the harvest flow and diagnostic graphs in this analysis report.

**Harvest flow graph**

Harvest flow (a.k.a. timber supply) is the amount of timber volume that is projected to be harvested in a given time period. A harvest flow is dependent on both the amount of timber available (i.e., what the model allows you to harvest considering available merchantable inventory and management constraints) and a decision on how to distribute the harvest that is available over time (i.e., your harvesting flow objectives).

It is important to understand that initial harvest flows are largely choices made by the analyst on how to distribute the currently available inventory. For example in the first decade it might be possible to harvest double the volume if we chose not to harvest any volume in the second decade. However, for the harvest flows in this analysis we chose to follow a specified (see description in technical summary or data package) harvest flow objective typically used by the MFR.

The figure below is the harvest flow graph of the sensitivity analysis where the site indices were decreased by three metres. This figure shows three separate harvest flows.

The underlying harvest flow is for the base case scenario. This harvest flow is indicted by the dashed line. Note that the thin solid line and the thick solid line are both on top of this dashed line for the first six decades. The base case scenario is the harvest flow against which we wish to compare the sensitivity harvest scenarios.

The thin solid line shows the resulting harvest flow where we applied the sensitivity analysis change. In this case where we used managed stand yield tables that reflected a decrease in site index of three metres. This thin line is the resulting available harvest flow where we told the model to try and harvest at the base case scenario harvest levels (i.e., the dashed line). As seen in the figure, the model cannot meet these harvest objectives starting in decade 7. This point is referred to as a “break”.

The thick solid line shows the harvest flow where we applied the sensitivity analysis change but smoothed the harvest flow according to the same harvest flow objectives (i.e., start at initial harvest level, no more than 10% step downs, long-term level where flat total growing stock. This specific graph shows that the harvest flow of this sensitivity can follow the base case harvest flow for four decades before stepping below the base case scenario level down to a long-term level that is 29% lower.

Note for this graph that the horizontal axis is decades from the present. In the case of the Kootenay Lake 2009 analysis the present is January 2008. Further note that since our modelling was based on annual harvest flow within a decade, the shape of the graph was purposely made “bar” like. On the vertical axis is the projected harvest in 1000 cubic metre per year units. Thus, the initial harvest in decade one is 645 000 cubic metres per year.
Growing stock

The primary diagnostic graph that assisted with the analysis is the graph of total and merchantable growing stock. Total growing stock is actually the volume projected by the growth and yield models. This value is therefore the volume above the specified diameter limits (e.g., 12.5 cm dbh for pine and 17.5 cm dbh for other species). The merchantable growing stock is the total growing stock volume that is above the minimum harvestable criteria (e.g., specified age and volume per hectare).
Kootenay Lake TSA Technical Summary

The graph shows the growing stock for the base case and the smoothed harvest flow for the site index sensitivity.

In this graph, we again have decades from present on the horizontal axis and on the y-axis instead of harvest flow we have the total amount of growing stock available (in million cubic metres). Thus for the starting total growing stock (for both base case and for sensitivity) we have a little over 35 million cubic metres. For the merchantable growing stock this is about 30 million cubic metres. These graphs demonstrate that currently there is a high level of growing stock which harvesting activities reduce to a lower level. This lower growing stock level, does not mean that harvesting is not at a sustainable level. It reflects that the forests has accumulated wood volumes for a long period of time. The lower long-term growing stock levels actually reflect a closer balance between harvest and the maximum forest growth rates (considering other forest management objectives).

In this graph, the key point is that the harvest flows selected (see harvest flow graph above) result in flat non-decreasing growing stock. Both of these graphs are ideal for the total growing stock. Often you may see some cyclic patterns over time, but in the long term it does not decrease.

It can be seen that the merchantable growing stock is more cyclic and that there is about 10 million cubic metres present at any time in the long term. For the merchantable growing stock, we are interested in seeing if there are any particularly unusually time periods.

**Area harvested**

The graph labelled with the vertical axis harvest (hectare/year) shows the amount of area harvested each year in the model for the base case and for the sensitivity analysis. In this graph we are looking to see how the change for the sensitivity impacts the amount of area. Changes in the amount of area occur particularly where the volume per hectare and/or the harvest flow levels have changed.

In the below example where the site index (and hence managed volume) was changed we might have expected more area to be harvested under the sensitivity than the base case (i.e., base case has a higher volume per hectare). However, as the lower harvest flow level overrides this change resulting in a lower area per year being harvested. As expected given similar initial harvest levels and natural stand volumes, the area harvested in the first four decades is similar.
Volume per hectare harvested

In the below graph with a vertical axis labelled “Mean Harvest Volume (m³/hectare) we view the projected mean volume per hectare of the harvested stands. We again are looking at the difference between the base case scenario and the sensitivity analysis, in this case a lower site index. Differences in this graphs should be related to changes in volume tables or significant changes in the harvesting pattern (e.g., if we force harvest to an area of lower productivity). Specific to the below graph we see the expected lower volume per hectare in the scenario where the site index (and hence volume) was decreased. We also note little change in the first decades where the unchanged existing natural volume tables are used.
Mean stand age harvested

The mean stand age of harvested stands can provide information about how the model is selecting stands for harvest relative to the minimum harvestable age. Comparing the age between the base case scenario and the sensitivity provides feedback.

In the below graph it can be seen that the base case and the sensitivity analysis have similar mean stand ages at harvest over the first decades. This would be expected since reducing site indices three metres has no impact on existing natural stand volumes. In the long term it can be seen that mean stand age at harvested increases under lower site indices. This would be expected as the age at which maximum mean annual increment is reached would be higher. Thus, the maximum harvest flow would reflect a mean stand age at harvest that is nearer to the maximum mean annual increment.
Existing versus managed stands harvested

The transition between existing natural stands and managed stands is critical to harvest flow. The below graph showing the transition demonstrates that future managed stands are expected to dominate the harvest in 70-90 years from the present. Further the graph can identify if the transition modelled is sharp or if due to other management constraints (e.g., an old forest requirement) that some existing stands are kept for an extended time period.