# Mountain Pine Beetle
# Timber Supply Impact Assessment
# for the Cranbrook and Invermere TSAs

**DRAFT**

**Version 1.0**

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*Prepared For:*
B.C. Ministry of Forests and Range
Rocky Mountain Forest District
1902 Theatre Road
Cranbrook, B.C. V1C 7G1

*Submitted by:*
Forsite
Box 2079, 330-42nd Street SW
Salmon Arm, B.C V1E 4R1
(250)832-3366

# Executive Summary

Current harvesting in the Cranbrook and Invermere TSA's is largely focused on salvaging Mountain Pine Beetle (MPB) infested Lodgepole pine (Pl). There is concern that the scale of the infestation in both TSA's may increase significantly over the next few years and overwhelm the TSA's ability to salvage impacted stands. This report proactively explores the timber supply implications of what is assumed to be a worst case MPB impact and assesses practical alternatives to the current salvage strategy being implemented in the TSA's.

<u>Invermere TSA Results</u>

- The worst case MPB scenario shows harvest levels starting to drop in ~10 yrs and falling by 77,000 $m^3$/yr (13.5%) before beginning to recover in 50 years.
- Over the next decade, the current AAC appears adequate to harvest all of the available and merchantable MPB impacted volumes (59.5% of total mortality). The unsalvaged volume was either below minimum harvest ages (i.e. uneconomic) at the time of death (85%), or constrained by non timber issues such as ECA's (15%).
- Based on these assumptions, no uplift appears necessary in Invermere although verification of the economic viability of the unsalvaged volume would be important.
- An alternative salvage strategy was not pursued because there is no need for a 'better' prioritization process when it is possible to harvest all of the available stands (no economic/available stands get left behind).

<u>Cranbrook TSA Results</u>

- The worst case MPB scenario shows harvest levels falling by 171,200 $m^3$/yr (22%) once salvage opportunities are exhausted in ~10 yrs, and then recovering in 70 years.
- With 75% of the current AAC dedicated to salvage, only 46.2% (6.8 million $m^3$) of the anticipated mortality can be captured.
- Increasing the first period harvest to 1,016,000 $m^3$/yr, with the uplift concentrated on infested stands, allows the maximum salvage to occur (58.3% of the mortality or 7.9 million $m^3$) with no negative impacts on the mid or long term harvest flows. The remaining unsalvaged mortality (6.9 million $m^3$ or 41.7%) is either not economic to harvest (younger than minimum harvest age at time of death) or unavailable due to non timber issues such as watersheds exceeding maximum ECA's. Of the 6.9 million $m^3$ that goes unsalvaged, 82% is due to minimum harvest ages and 18% is unavailable because of non timber issues. The economic viability of unsalvaged volume should be examined carefully when making decisions around uplifts.
- An alternative salvage priority scenario using merchantability mapping was completed and showed no discernable difference in harvest flow, although there may be economic benefits to such a strategy.

Throughout the East Kootenay's, the fate of the MPB infestation is still uncertain relative to other TSA's in the southern interior of BC. Unique geographic circumstances combined with a long past history of managing MPB in these areas leaves questions about whether the "worst case scenario" investigated here will occur. The longer the rise in beetle populations can be postponed, the more flexibility the TSA's have to capture impacted and/or susceptible volume without extraordinary measures (i.e. uplifts) that cause negative impacts on future timber supply.

The BCMPB predictions of MPB mortality show that both TSA's are on the cusp of exponential growth in mortality, so the next few years of Forest Health Survey results will be important indicators of what the MPB epidemic is likely to do in the East Kootenay's.

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# 1. Introduction

Current harvesting in the Cranbrook and Invermere TSAs is largely focused on salvaging Mountain Pine Beetle (MPB) infested Lodgepole pine (Pl). There is concern that the scale of the infestation in both TSAs may increase significantly over the next few years and overwhelm the TSA's ability to salvage impacted stands. This report is meant to proactively explore the timber supply implications of this scenario and assess practical alternatives to the current salvage strategy being implemented in the TSAs.

# 2. Pine Distribution

## 2.1. Invermere

The Invermere TSA currently contains ~11.0 million m³ of Pl volume, of which 81.5% (8.96 million m³) exists in Pl-leading stands (Table 1). Within non-Pl leading stands, Douglas-fir stands contain the most Pl volume (9.1%), while spruce stands contain the next largest amount of Pl volume (5.2%).

Table 1. Distribution of Pl volume (m³) in the THLB by leading species and Pl percent

| | Percent Lodgepole Pine (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Leading Species** | **100-91** | **90-81** | **80-87** | **70-61** | **60-51** | **50-41** | **40-31** | **30-21** | **20-11** | **10-1** | **Total** |
| **Lodgepole Pine** | 2,342,319 | 2,033,606 | 1,553,994 | 1,300,565 | 1,033,076 | 520,674 | 176,403 | 4,620 | 57 | 0 | **8,965,314** |
| **Douglas-fir** | 0 | 0 | 0 | 0 | 0 | 17,667 | 201,280 | 272,636 | 320,768 | 188,166 | **1,000,517** |
| **Spruce** | 0 | 0 | 0 | 0 | 0 | 13,909 | 96,949 | 196,719 | 154,240 | 110,561 | **572,378** |
| **Larch** | 0 | 0 | 0 | 0 | 0 | 12,641 | 110,635 | 144,303 | 105,532 | 48,218 | **421,328** |
| **Balsam** | 0 | 0 | 0 | 0 | 0 | 0 | 2,574 | 6,187 | 8,713 | 8,094 | **25,568** |
| **Other** | 0 | 0 | 0 | 0 | 0 | 0 | 365 | 5,706 | 5,963 | 2,455 | **14,489** |
| **Decid.** | 0 | 0 | 0 | 0 | 0 | 0 | 412 | 758 | 1,083 | 1,048 | **3,301** |
| **Total** | **2,342,319** | **2,033,606** | **1,553,994** | **1,300,565** | **1,033,076** | **564,891** | **588,617** | **630,929** | **596,356** | **358,541** | **11,002,895** |

For context, Pl volume makes up 39.4 % of the current growing stock on the THLB (27.9 million m3). If the current conventional AAC in the Invermere TSA (598,570 m³/yr) could be dedicated to Pl salvage, it would take approximately 18 years to harvest all the pine volume in the TSA.

## 2.2. Cranbrook

The Cranbrook TSA currently contains ~24.3 million m³ of Pl volume, of which 88.4% (21.5 million m³) exists in Pl-leading stands (Table 2). Within non-Pl leading stands, Larch stands contain the most Pl volume (5.5%), while Douglas-fir stands contain the next largest amount of Pl volume (2.8%).

Table 2. Distribution of Pl volume (m³) in the THLB by leading species and Pl percent

| | Percent Lodgepole Pine | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Leading Species** | **100-91** | **90-81** | **80-87** | **70-61** | **60-51** | **50-41** | **40-31** | **30-21** | **20-11** | **10-1** | **Total** |
| **Lodgepole Pine** | 8,559,087 | 4,442,209 | 3,051,210 | 2,481,684 | 1,597,809 | 1,031,891 | 340,283 | 21,536 | 0 | 0 | **21,525,710** |
| **Larch** | 0 | 0 | 0 | 0 | 0 | 82,861 | 347,912 | 478,548 | 300,408 | 133,578 | **1,343,307** |
| **Douglas-fir** | 0 | 0 | 0 | 0 | 0 | 27,404 | 89,745 | 161,199 | 241,523 | 151,377 | **671,247** |
| **Spruce** | 0 | 0 | 0 | 0 | 0 | 8,914 | 105,726 | 201,219 | 151,320 | 126,037 | **593,216** |
| **Balsam** | 0 | 0 | 0 | 0 | 0 | 174 | 25,495 | 62,764 | 46,737 | 29,142 | **164,312** |
| **Other** | 0 | 0 | 0 | 0 | 0 | 0 | 4,006 | 15,138 | 15,030 | 12,999 | **47,174** |
| **Cedar** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 243 | 3,511 | 2,222 | **5,976** |
| **Decid.** | 0 | 0 | 0 | 0 | 0 | 0 | 229 | 79 | 4,918 | 836 | **6,063** |
| **Hemlock** | 0 | 0 | 0 | 0 | 0 | 0 | 245 | 2,081 | 203 | 3,689 | **6,218** |
| **Total** | **8,559,087** | **4,442,209** | **3,051,210** | **2,481,684** | **1,597,809** | **1,151,243** | **913,642** | **942,807** | **763,651** | **459,882** | **24,363,224** |

Again for context, Pl volume makes up 49.7% of the current growing stock on the THLB (49 million m3). If the current conventional AAC in the Cranbrook TSA (851,000 m³/yr) could be dedicated to Pl salvage, it would take approximately 29 years to harvest all the pine volume in the TSA. This coarse measure of a TSA's ability to address large scale Pl mortality shows that the Cranbrook TSA is more likely to face challenges than the Invermere TSA.

# 3. MPB Mortality

In order to explore the implications of large scale mortality from MPB, we must first define what that mortality might look like in each TSA.

## 3.1. Invermere

BCMPB modeling work[i] has predicted that 70% of all pine volume in the Invermere TSA will die by the end of the current outbreak and yearly volume killed by MPB will peak in 2010 at 1.42 million m³ killed/yr (Figure 1).

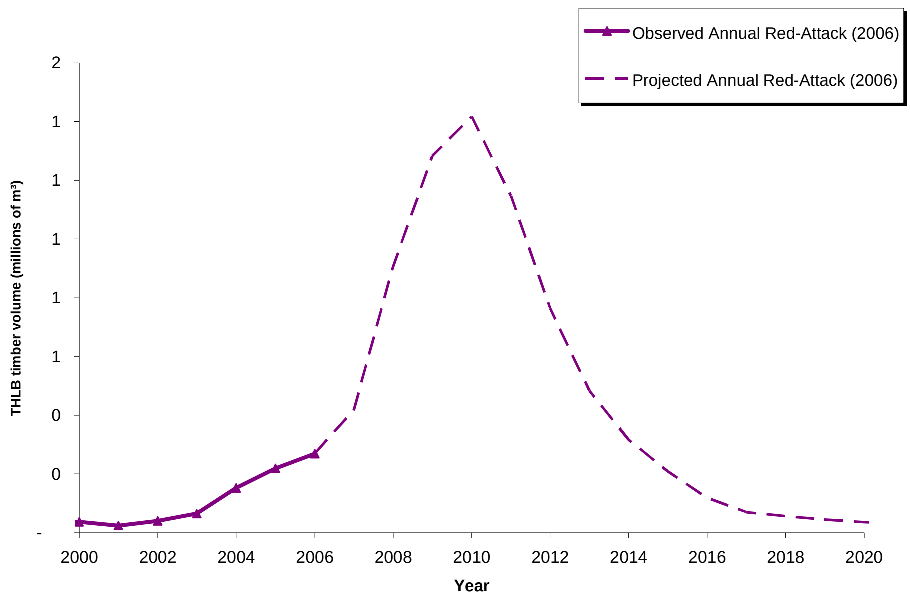



Figure 1. Yearly Pl volume killed by MPB in the Invermere TSA (BCMPB, 2006).

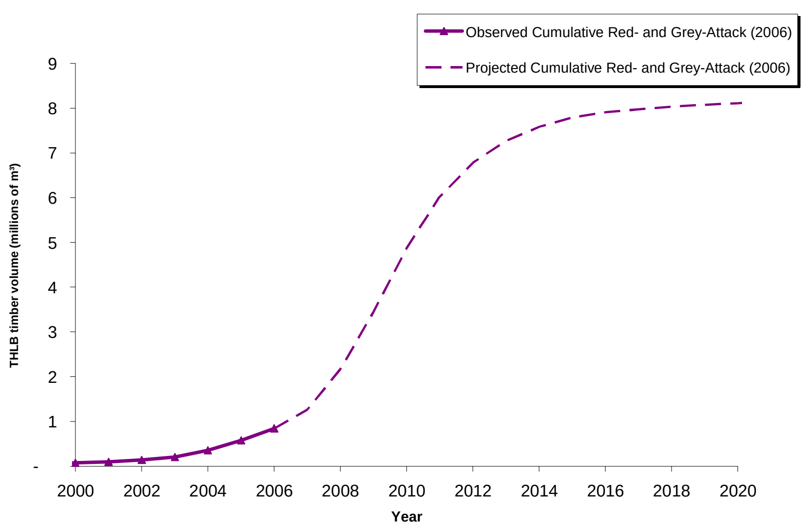



Figure 2. Cumulative Pl Volume killed by MPB in the Invermere TSA (BCMPB, 2006)

[i] Provincial-Level Projection of the Current Mountain Pine Beetle Outbreak: Update of the infestation projection based on the 2006 Provincial Aerial Overview of Forest Health and revisions to the "Model" (BCMPB.v4)., Walton. et al 2006

These projections suggest that the vast majority of pine volume that is expected to die (8.2 million $m^3$)[ii] will be dead by 2014 (Figure 2). However, the current years attack mapping (not in graph) indicates that the 2007 attack was significantly less than what the BCMPB model predicted. A decline in attack was observed relative to 2006, instead of an exponential increase. Some of the reasons that the BCMPB model is not performing well relative to central interior TSAs are as follows:

- Dispersion assumptions in the model do not fully recognize the impact of the topographic breaks provided by the Selkirk, Monashee, and Purcell Mountains.
- The pulse of beetle coming from the central interior is broken up by the topographic breaks and areas of less susceptible stand types (i.e. Kootenay Lake TSA).
- Stands in the East Kootenay tend to be more mixed species and less pure pine so this further serves to break down the pulse of beetle and slow dispersion.
- Historically, the beetle populations in the East Kootenay's are rarely controlled by cold weather and so the warming of the winters has not really changed the population dynamics.
- Beetle has been present in the East Kootenay's since at least the 1960's and has had numerous spikes in activity since that time (i.e. Flathead infestation). Thus, local foresters have been dealing with beetle for a long time (full careers) and are good at managing beetle populations.

Based on these facts, the recent populations trends, and the expert opinion of regional and local foresters, it is expected that the BCMPB model represents an extreme worst case scenario and the likely extent of mortality will be less. Thus, for the purpose of this project, the cumulative kill will be reduced by 10% to 60% - and this is still felt to be a pessimistic view of the extent of Pl mortality. **Based on a 60% mortality rate, MPB was assumed to kill 6.6 million $m^3$ of Pl in the next decade during modeling of the Invermere TSA.**

## 3.2. Cranbrook

For the Cranbrook TSA, BCMPB modeling work has predicted that 73% of all pine volume will die by the end of the current outbreak and yearly volume killed by MPB will peak in 2010 at 3.5 million $m^3$ killed/yr (Figure 3). These projections suggest that the vast majority of pine volume that is expected to die (17.9 million $m^3$)[iii] will be dead by 2016 (Figure 4). However, the current years attack mapping (not in graph) indicates that attacked area has dropped again and is significantly less than what the BCMPB model predicted. Based on this and the points discussed under Invermere TSA above, the anticipated cumulative kill was reduced by 10% to 63%. **Based on a 63% mortality rate, MPB was assumed to kill 15.3 million $m^3$ of Pl in the next decade during modeling of the Cranbrook TSA.**

[ii] BCMPB report shows a total of 11.74 million $m^3$ Pl volume in the Invermere TSA. Updated Invermere TSR3 resultant shows 11.0 million $m^3$ of Pl volume. Mortality values were prorated to account for this discrepancy.

[iii] BCMPB report shows a total of 30.8 million $m^3$ Pl volume in the Cranbrook TSA (2000). Updated Cranbrook TSR3 resultant shows 24.4 million $m^3$ of Pl volume. Mortality values were prorated to account for this discrepancy.

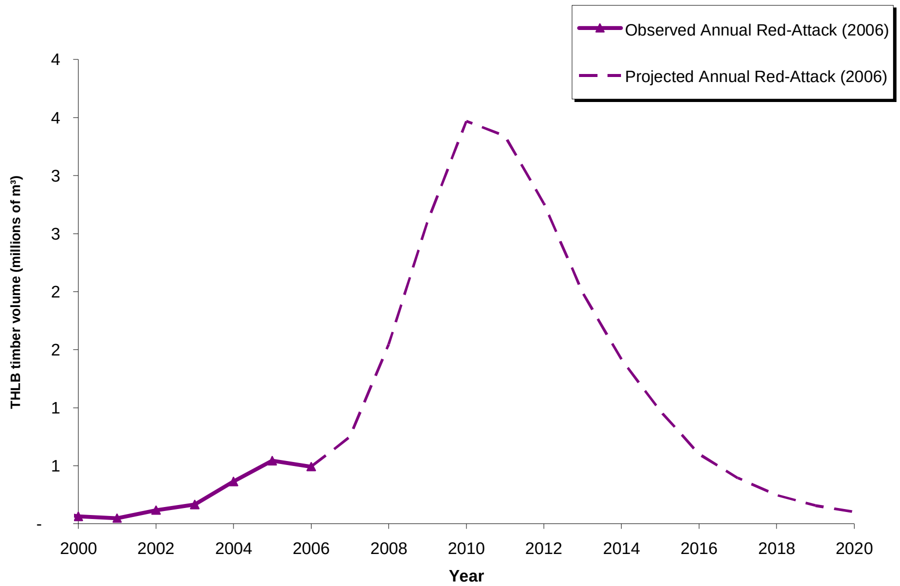



Figure 3. Yearly Pl volume killed by MPB in the Cranbrook TSA (BCMPB, 2006).

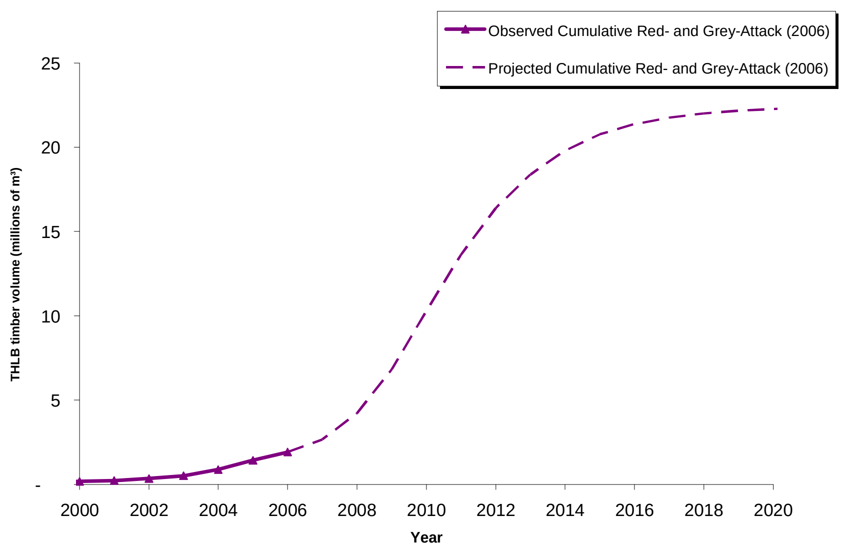
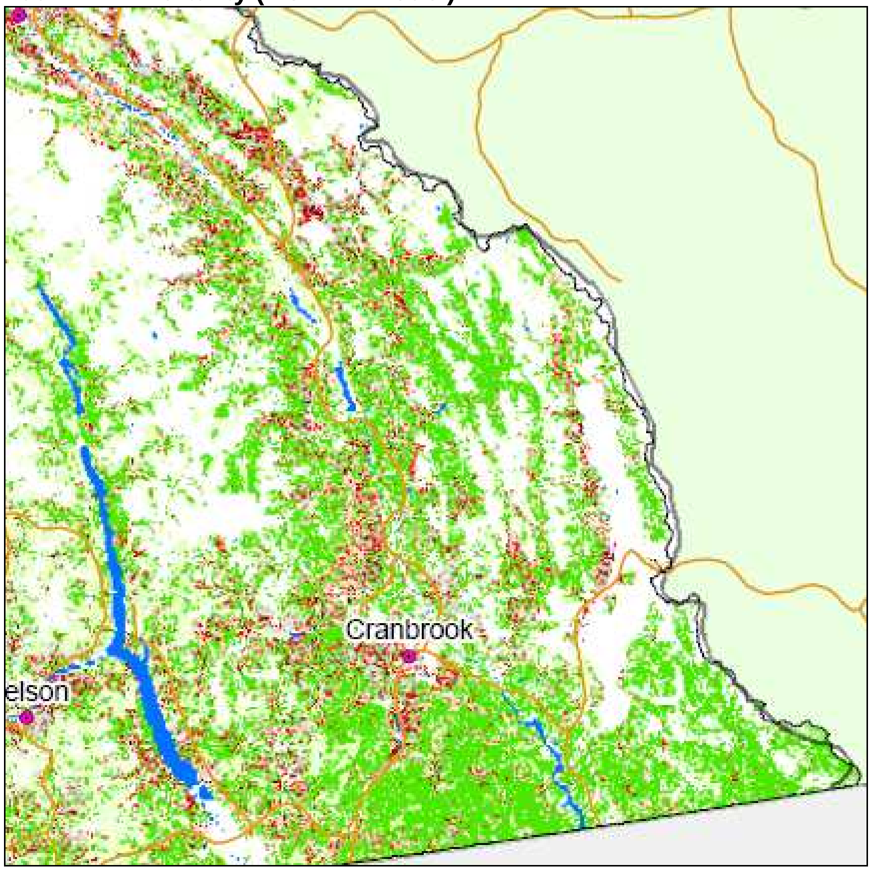
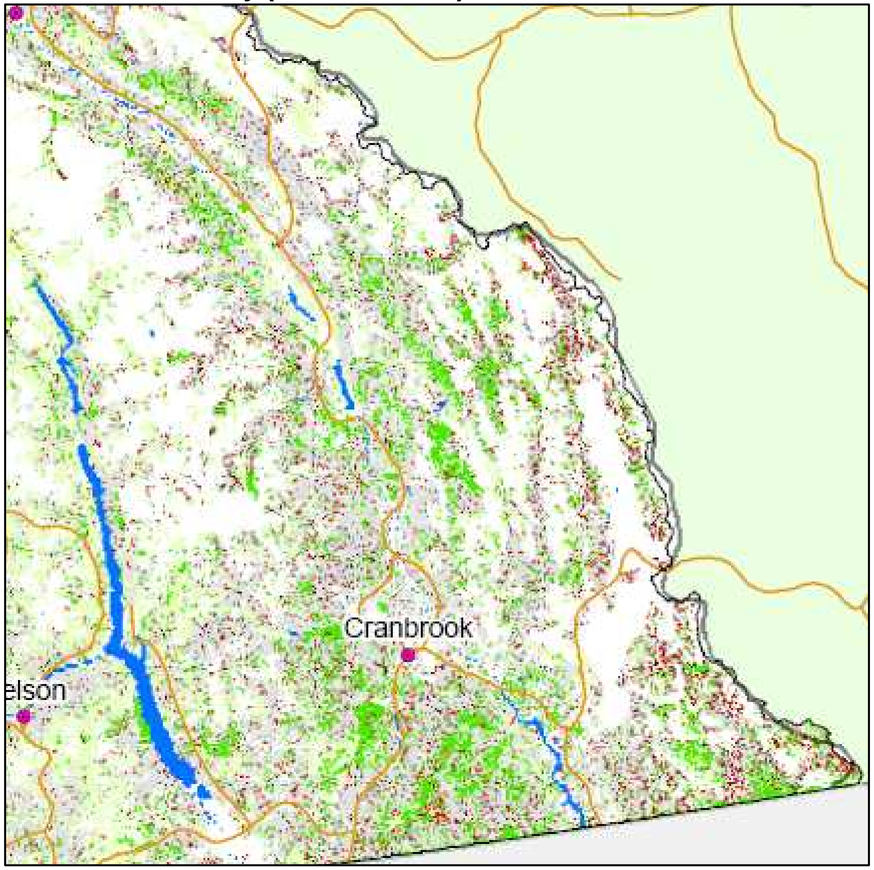



Figure 4. Cumulative Pl Volume killed by MPB in the Cranbrook TSA (BCMPB, 2006)

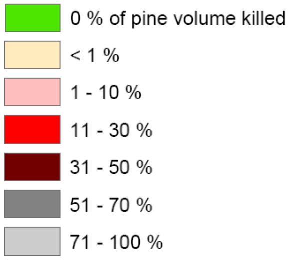
**2007 MPB Mortality (BCMPB Model)**




**2015 MPB Mortality (BCMPB Model)**




Ministry of Forests and Range, Research Branch
April 2007
Projection of the infestation alone assuming no forest harvesting - See: www.for.gov.bc.ca/hre/bcmpb for details



# 4. Scenario Overview

In total, four different scenarios were modeled and analysed for each TSA and are briefly described below. Further details can be found in Section 5.

Current Practice – No MPB

The TSR3 base case was updated to reflect current practice by including the new UWR management guidelines, draft SaRCO caribou reserves, and explicit modeling of ECA's in community and domestic watersheds. The inventory was also updated to reflect updated ages/volumes (2006) and the depletions from fires and logging to Nov 2007. No mortality from MPB was implemented.

Worst Case MPB – Current Practice

This scenario adds MPB mortality and salvage to the previous scenario. The volume of Pl killed and its spatial location were provided by the BCMPB model (total mortality reduced as discussed in section 3 above). Salvage was implemented as per current practices in the TSA and limited to 75% of the annual harvest. VQO polygons with Pl stands were modeled with less restrictive constraints for the first 20 years while all remaining Integrated Resource Management (IRM) assumptions remained the same as the "Current Practice – No MPB" scenario.

Worst Case MPB + Uplift

This scenario was designed to implement an increase in the first period harvest aimed at capturing a larger portion of the pine mortality. The target was to capture 75% of the expected mortality for each TSA. Capturing 100% was not the target because of concerns with harvesting green volume in mixed stands with lower proportions of pine.

Worst Case MPB – Alternative Practice

The use of merchantability mapping was used to prioritize salvage efforts in this scenario. All other assumptions remained the same as the "Worst Case MPB – Current Practice" scenario. The intent was to ensure the best economic sites were being salvaged and returned into productivity quickly.

# 5. Modeling Approach / Methodology

The modeling approach used for the scenarios mentioned in Section 4 are detailed in this section. Unless otherwise stated, all assumptions for the "Worst Case MBP – Current Practice" and the "Worst Case MBP – Alternative Practice" scenarios remained the same as the "Current Practice – No MPB" Scenario.

## 5.1. Current Practice – No MPB

Baseline modelling assumptions for this project used the base case assumptions documented in the Invermere and Cranbrook TSR3 Analysis Reports (Forsite 2004).

### 5.1.1 Input Resultant File

The source datasets used for this project are the TSR3 resultant input files that were updated in 2006 to include new OGMAs and HLP variance 4 caribou. Forest cover attributes were also projected to 2006. Additional updates to this dataset have been made for this project, including:

- recent harvest depletions[iv],
- updates for major fires on the TSAs,

[iv] Harvest data obtained from the Kootenay Spatial Data Partnership: http://www.kootenayspatial.ca in January 2008.

- inclusion of Draft SARCO Caribou Linework (Feb. 2008),
- inclusion of the 2007 BCMBP modeling output data[v] for cumulative stand mortality to 2020, and
- inclusion of stand level merchantability mapping.

### 5.1.2 Caribou

Draft SaRCO Caribou linework (Feb. 27, 2008) was used in place of the HLP caribou guidelines modelled in TSR3 for both Cranbrook and Invermere. Table 3 and Table 4 summarize the areas impacted by the SaRCO reserves.

Table 3. Draft SaRCO Caribou (Feb. 08) area details for the Invermere TSA.

| Habitat Type | OGMA | THLB Area (ha) | CFLB not THLB Area (ha) | Total CFLB Area (ha) |
|---|---|---|---|---|
| Core Habitat | Yes | 541 | 2,291 | 2,833 |
| | No | 556 | 10,326 | 10,883 |
| Core Linkage | Yes | 7 | 615 | 622 |
| | No | 16 | 3,333 | 3,349 |
| **Total** | | **1,120** | **16,566** | **17,686** |

Table 4. Draft SaRCO Caribou (Feb. 08) area details for the Cranbrook TSA.

| Habitat Type | OGMA | THLB Area (ha) | CFLB not THLB Area (ha) | Total CFLB Area (ha) |
|---|---|---|---|---|
| Core Habitat | Yes | 3,267 | 9,488 | 12,756 |
| | No | 9,531 | 23,804 | 33,335 |
| Core Linkage | Yes | 9 | 965 | 974 |
| | No | 44 | 5,120 | 5,164 |
| **Total** | | **12,852** | **39,377** | **52,229** |

Figure 5 and Figure 6 show a comparison between the draft SaRCO reserves and the area affected by HLP Variance 4 caribou. In both TSAs, the draft SaRCO reserves impact more forested land base than with the HLP Variance 4, and will also have a larger net impact on the THLB even though mapped areas can be smaller. Because SaRCO is implemented as full reserves and the HLP caribou is typically managed using percent constraints, only a portion of the HLP caribou area effectively limits harvest. The areas shown in the graphs below represent the full extent of the management areas, but do not include the HLP areas that do not require management (i.e. Pl, Fd, Lw leading stands in Zone 2 and 3).

Overall, SaRCO caribou will put a very slight downward pressure on the timber supply in the TSA. The impact is not greater because of the very small proportion of the TSAs that are managed for caribou.

[v] Walton A., J. Hughes; M. Eng; A. Fall; T. Shore; B. Riel; and P. Hall. 2007. Provincial-Level Projection of the Current Mountain Pine Beetle Outbreak: Update of the infestation projection based on the 2006 Provincial Aerial Overview of forest Health and revisions to "the model" (BCMPB.v4). http://www.for.gov.bc.ca/hre/bcmpb/

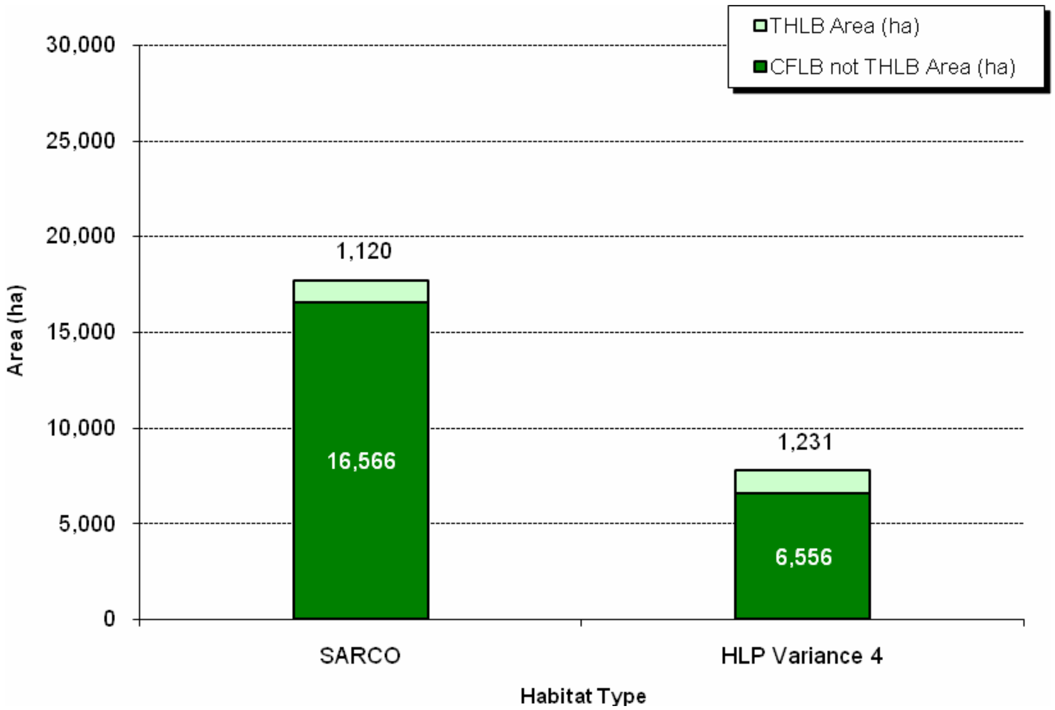



Figure 5. Draft SaRCO caribou reserves vs HLP variance 4 caribou habitat (Invermere)

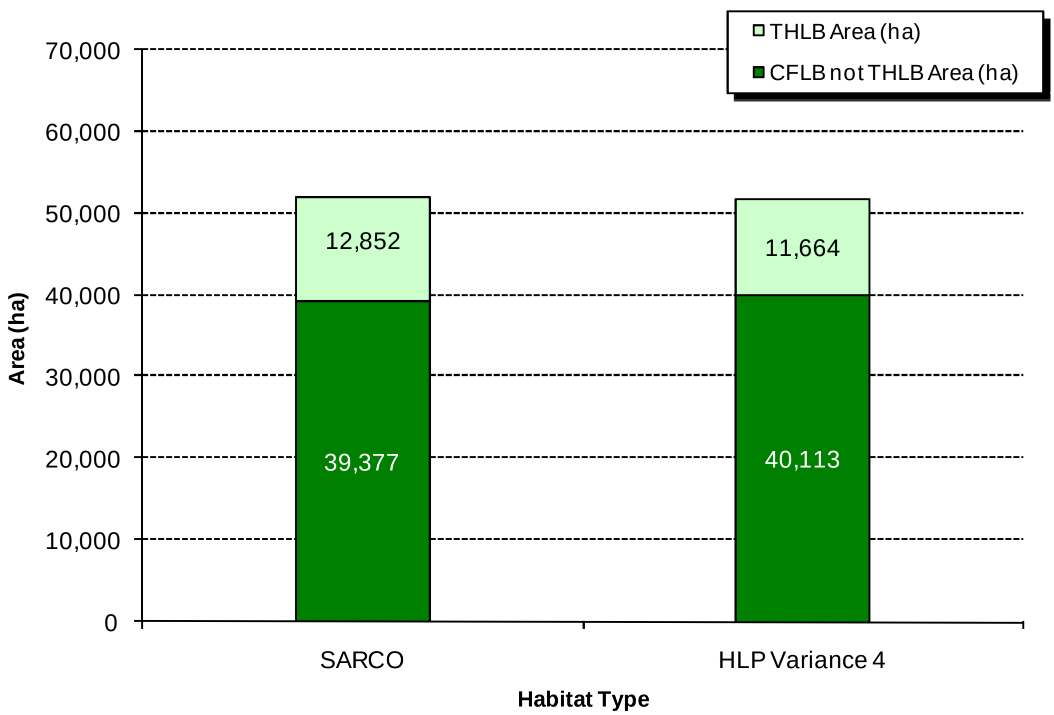



Figure 6. Draft SaRCO caribou reserves vs HLP variance 4 caribou habitat (Cranbrook)

### 5.1.3 Ungulate Winter Range

In February 2005, new ungulate winter range orders were introduced for the Invermere and Cranbrook TSAs (U-4-008 and U-4-006 respectively). The required management of ungulate winter range under this order are similar but not the same as the PEM UWR range modelled in TSR3 as a sensitivity. Since these cover requirements reflect current management of UWR in these TSAs, they were applied on the CFLB portion of each LU as cover constraints in the model.

Table 5. Summary of UWR cover constraints for the Invermere and Cranbrook TSAs.

| Habitat Type | Mature Forest Cover Requirements | Maximum Young Seral Requirements |
|---|---|---|
| Managed Forest - Dry | Min. 10% > 100 years | Maximum 33% <21 year |
| Managed Forest - Transitional | Min. 10% > 60 years and Min. 10% > 100 years | |
| Managed Forest - Mesic | Min. 10% > 60 years and Min. 20% > 100 years | |
| Managed Forest - Moist | Min. 20% > 60 years | |
| Managed Forest - Wet | Min. 30% > 60 years | |

### 5.1.4 Community/Domestic Watersheds

Even without salvage harvesting, Equivalent Clearcut Area (ECA) values are expected to increase substantially in pine dominated watersheds due to the pine mortality. In TSR3, a cover constraint (max 30% < 6m or 22 years) was modelled as a surrogate for ECA in community and domestic watersheds, however due to the impacts of MPB mortality and salvage, it was decided that more detailed ECA constraints would be applied. This was done by assigning ECA curves to each AU and placing a maximum 30% ECA constraint on each Community/domestic watershed. ECA heights were determined by first determining the area weighted average site index of each analysis unit within community and domestic watershed and then using Site Tools (v.3.3) to determine recovery heights. Full recovery was assumed at 12m in height.

Pine stands that died and were not salvaged only contributed 50% to ECA calculations. In order, to recognize the prolonged effects of dead and unsalvaged stands and the expected regeneration delays associated with them, ECA recovery was prolonged by 10 years.

### 5.1.5 Regeneration Delay for Managed stands

In both the Invermere and Cranbrook TSR3 analyses, regeneration delays for future managed stands were accounted for in the model (FSSIM) however the model used for this project does not have the ability to explicitly model regeneration delays – they must be built into yield curves. Therefore, in order to recognize impacts from delayed regeneration for this project, yields for future managed stands were reduced by 2% (volume development delayed).

## 5.2. Worst Case MPB – Current Practice

### 5.2.1 Mortality in Mature Stands (>60 years)

For mortality in mature stands, 6.6 million m³ in Invermere and 15.3 million m³ in Cranbrook were selected and unless salvaged, were depleted in the first decade. The spatial location of mortality was based on the BCMPB model output. The stands chosen to make up the kill volume were selected using the highest % stand mortality until an area representing the kill volume (all species) was identified, and then set to age zero. Because of the way this was implemented, there was some non-Pl volume depleted from the inventory but it is cancelled out by the fact that an equivalent amount of Pl volume remained on landbase. In reality the mortality that occurs on the landbase would be more spatially dispersed in mixed stands.

Dead unsalvaged stands were given a regen delay of 10 yrs and were regenerated according to their original VDYP curves.

### 5.2.2 Mortality in Young Stands (<60 years)

In order to reflect MPB mortality in young pine stands, additional area was killed in pine leading stands <60 yrs old. The percent of pine killed in younger age classes was estimated based Lorraine Maclauchlan's recent work[vi] (% of population with attack) and professional judgment about the ultimate extent of the attack in these stands. These assumptions should be considered a best guess based on limited research. An area of 3,333 ha for Invermere and 7,198 ha for Cranbrook of young Pl stands were killed in the first decade. These stands had their ages set to 0 and were given a 20 year regen delay (longer delay than mature stands because of less opportunity for natural regen).

Table 6. Mortality applied to stands <60 years - Invermere

| Age Class | Pl Leading Area (ha) | % of Stands With Attack | Extent of Mortality | % Pine Mortality | Total Area Impacted |
|---|---|---|---|---|---|
| <20 | 15,206 | 0 | 0 | **0%** | - |
| 20-29 | 11,062 | 30% | 50% | **15%** | 1,659 |
| 30-39 | 2,951 | 62% | 50% | **31%** | 915 |
| 40-49 | 974 | 83% | 50% | **41%** | 399 |
| 50-59 | 765 | 93% | 50% | **47%** | 360 |
| **Total** | **30,958** | | | | **3,333** |

Table 7. Mortality applied to stands <60 years - Cranbrook

| Age Class | Pl Leading Area (ha) | % of Stands With Attack | Extent of Mortality | % Pine Mortality | Total Area Impacted |
|---|---|---|---|---|---|
| <20 | 16,692 | 0 | 0 | **0%** | - |
| 20-29 | 10,958 | 30% | 50% | **15%** | 1,644 |
| 30-39 | 6,272 | 62% | 50% | **31%** | 1,944 |
| 40-49 | 2,760 | 83% | 50% | **41%** | 1,132 |
| 50-59 | 5,275 | 93% | 50% | **47%** | 2,479 |
| **Total** | **41,956** | | | | **7,198** |

### 5.2.3 Salvage

In both TSAs, a maximum of 75% of annual harvest was dedicated to salvage efforts in the first period (436,180 $m^3$/yr for Invermere and 628,500$m^3$/yr for Cranbrook).

Table 8 shows the factors and the assigned weightings used to prioritize stands for MPB salvage opportunities. This priority scheme is meant to reflect current practice in the TSA's. Each stand had a salvage score assigned and then this score was used to prioritize stands for salvage harvest (highest scores first). In general, stands in the priority LU's with high % Pl, high volumes, high mortality rates, and on conventional ground were salvaged first.

Table 9 provides the consolidated list of priority Landscape Units provided by both licensees and government and their associated priority scores.

[vi] MacLauchlan, L., 2006. Determining susceptibility of young pine plantations to the mountain pine beetle *Dendroctonus ponerosae*, and manipulating future stands to mitigate losses. Forest Investment Account (FIA project Y0610003) – Forest Science Program. Ministry of Forests and Range.

Table 8. Stand prioritization matrix for MPB Salvage – Current Practice.

| Factor | Categories | Score | Rationale |
|---|---|---|---|
| Landscape Unit | Priority LUs Provided by Licensees (see Table 9) | 5-10 Depending on relative priority | Licensees are targeting areas where they know salvage efforts are required and accessible. |
| Percent Pine | >=70% | 10 | Targeting higher percent Pl stands means less "by catch" and captures more mortality in the long run. |
| | >50% and <70% | 5 | |
| Volume | >=350 m³/ha | 7 | Prefer to harvest better stands. Moderate (11-30%) |
| | >=200 and <350 m³ | 5 | |
| | <200 m³ | 3 | |
| Percent of total Stand volume that is dead (by 2020) | >=70% | 10 | Going after higher % attack areas captures more mortality |
| | >=50% and <70% | 8 | |
| | >=30% and <50% | 6 | |
| Slope | Conventional (<40%) | 10 | Prefer to harvest less expensive stands. |
| | Cable (>=40%) | 5 | |

Table 9. Priority salvage LU's in the Invermere and Cranbrook TSAs.

| Invermere | | | | Cranbrook | | | |
|---|---|---|---|---|---|---|---|
| Priority | LU | LU Name | Score | Priority | LU | LU Name | Score |
| 1 | I23 | Cross | 10 | 1 | C31 | Lost Dog - Mather | 10 |
| 2 | I26 | Horsethief | 10 | 2 | C08 | Kimberley Watershed | 10 |
| 3 | I24 | Pedley | 10 | 3 | C02 | Perry - Moyie | 10 |
| 4 | I20 | Palliser | 9 | 4 | C01 | Moyie Lake | 9 |
| 5 | I15 | Toby | 9 | 5 | C09 | Yahk River | 9 |
| 6 | I14 | Brewer/Dutch | 9 | 6 | C12 | Cranbrook Watershed | 9 |
| 7 | I32 | Dunbar/Templeton | 8 | 7 | C18 | East Flathead | 8 |
| 8 | I29 | Steamboat | 8 | 8 | C20 | Alexander - Line | 8 |
| 9 | I03 | Skookumchuck/Torrent | 8 | 9 | C22 | Upper Elk | 8 |
| 10 | I07 | East-Middle White | 7 | 10 | C23 | West Elk | 7 |
| 11 | I08 | North White | 7 | 11 | C27 | Upper Bull | 7 |
| 12 | I09 | Grave | 7 | 12 | | All others | 0 |
| 13 | I12 | Doctor/Fir | 6 | | | | |
| 14 | I14 | Brewer/Dutch | 6 | | | | |
| 15 | I22 | Albert | 5 | | | | |
| 12 | | All Others | 0 | | | | |

### 5.2.4 Minimum Harvest Ages

Licensees have indicated that salvage harvesting is commonly being directed into productive age class 4 stands (61-80 years). In order to reflect this practice, the minimum harvest ages (MHAs) for Pl stand groups used in TSR3 were reduced for the pine stand groups. Table 10 shows the stand groups and MHAs that were reduced for the MPB scenarios.

Table 10. Minimum harvest ages used for MPB scenarios.

| TSA | Stand Group | Description | TSR3 MHA (age) | MHA for MPB Scenarios (age) |
|---|---|---|---|---|
| Invermere | 110 | Pl leading - poor SI - ground based | 105 | 90 |
| | 111 | Pl leading - mod. SI - ground based | 80 | 70 |
| | 112 | Pl leading - High SI - ground based | 70 | **60** |
| | 114 | Pl leading - poor SI - cable ground | 100 | 110 |
| | 115 | Pl leading - mod. SI - cable ground | 130 | 110 |
| | 116 | Pl leading - High SI - cable ground | 110 | 90 |

| TSA | Stand Group | Description | TSR3 MHA (age) | MHA for MPB Scenarios (age) |
|---|---|---|---|---|
| Cranbrook | 110 | Pl leading - poor SI - ground based | 100 | 90 |
| | 111 | Pl leading - mod. SI - ground based | 80 | 70 |
| | 112 | Pl leading - High SI - ground based | 70 | **60** |
| | 113 | Pl leading - Extended Rotation | 120 | 110 |
| | 114 | Pl leading - poor SI - cable ground | 170 | 130 |
| | 115 | Pl leading - mod. SI - cable ground | 130 | 110 |
| | 116 | Pl leading - High SI - cable ground | 110 | 90 |

### 5.2.5 Relaxation of Visual Constraints

VQO's with at least 25% Pl leading stands within them were modeled using the next less restrictive VQO rating for the first 20 years.

## 5.3. Worst Case MPB – Alternative Practice

### 5.3.1 Salvage

The alternative salvage strategy used a similar approach to the current practice but the primary variables used were stand level merchantability ratings and the amount of stand mortality (Table 11). Merchantability modeling considers both harvest costs and potential revenues. By combining stand level economics with the percentage of total stand volume killed by MPB, the resulting salvage harvest schedule should maximize pine salvage within economically viable stands.

Table 11. Stand prioritization matrix for MPB Salvage – Alternative Salvage Scenario

| Factor | Categories | Score | Rationale |
|---|---|---|---|
| Percent of total Stand volume that is dead (by 2020) | >=70% | 10 | Targeting stands with higher percent mortality means less "by catch" and captures more mortality in the long run. |
| | >=50% and <70% | 7 | |
| | >=30% and <50% | 5 | |
| Merchantability | High Return Stands | 10 | Merch model should represent which stands are best to get to first (from an economic perspective) because it will allow for higher return stands to be targeted first. |
| | Moderate Return Stands | 8 | |
| | Economic Stands | 6 | |
| | Marginal Stands | 4 | |

## 5.4. Worst Case MPB + Uplift

The possibility of an uplift was explored with the goal of capturing 75% of the mortality. The 75% target was selected because it seemed to be a reasonable balance between maximizing salvage (capturing dead volume and ensuring prompt regeneration) and avoiding harvest of mixed stands where Pl mortality would only be a minor component of the stand. Leaving as much green wood standing (not captured as salvage bicatch) is the best method for minimizing midterm timber supply impacts.

# 6. Invermere Results

## 6.1. Current Practice – No MPB

### Harvest Flow

The Invermere TSR3 sensitivity that most closely resembles the current practice (without regards to MPB) is the PEM UWR sensitivity. This scenario was therefore used as a rough benchmark for comparison. Figure 7 compares the harvest flow result of implementing the assumptions described in Section 5.1 to the TSR3 PEM UWR sensitivity. The initial harvest volume (581,570m³/yr) can only be maintained for the first decade before dropping slightly (-1.8%) to 570,700 m³/yr. The mid-term was improved significantly and increased by 10% 40 years from now to a level of 630,200 m³/yr, eventually rising to 676,400 m³/yr in the long-term. The differences in flow regimes are primarily related to the difference in harvest priorities between the two runs (TSR3 had a young Pl priority before going to oldest first).

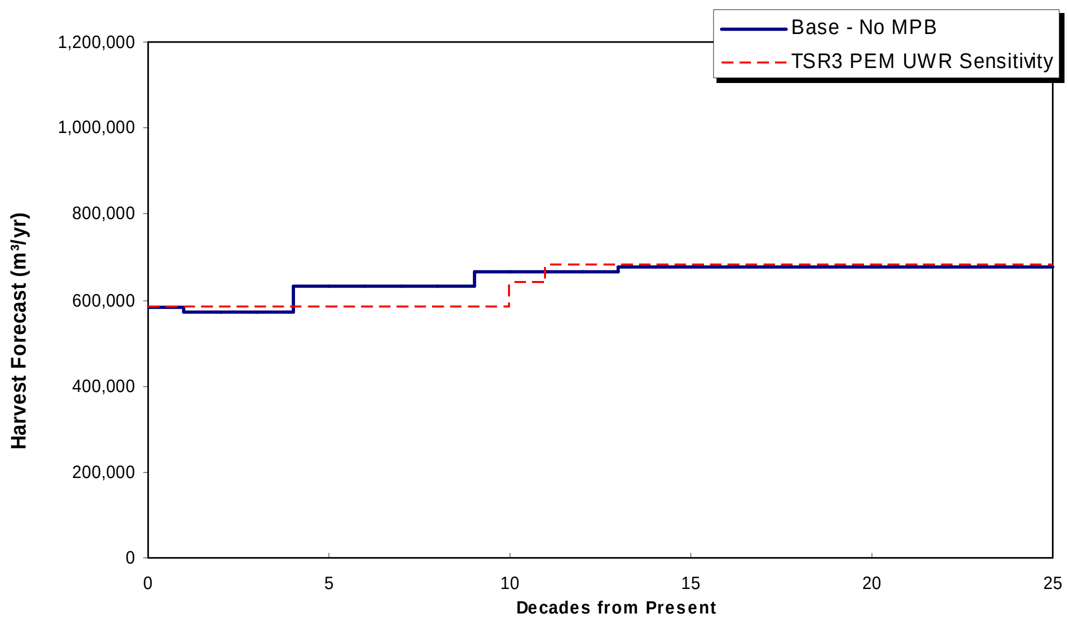



Figure 7. Invermere Current Practice - No MPB Harvest Flow vs. TSR3 PEM UWR Sensitivity

### Growing Stock

The total and merchantable growing stock (m³) over time resulting from the current practice scenario is shown in Figure 8. The initial growing stock is approximately 5 million m³ less than the TSR3 growing stock because of the harvesting and fires that have occurred on the TSA since TSR3.

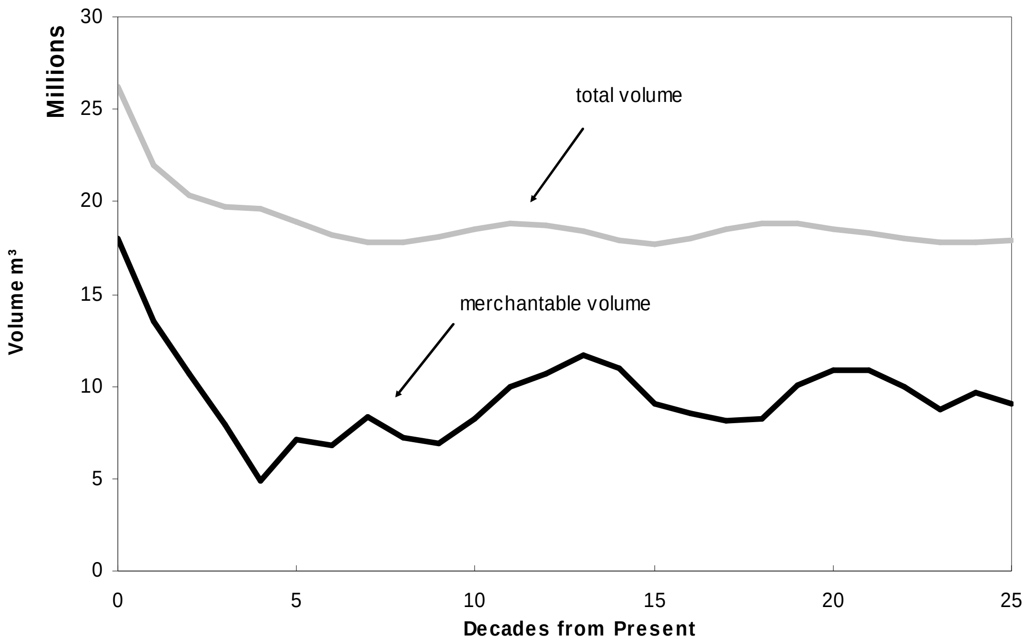



Figure 8. Total and merchantable growing stock on the THLB: Invermere Current Practice – No MPB

### Harvest Attributes

The contribution of species groups to the harvest profile is shown in Figure 9. Spruce leading stands contribute the most in the first period because of their relatively older ages compared to other species on the landbase (harvest priority was oldest first).

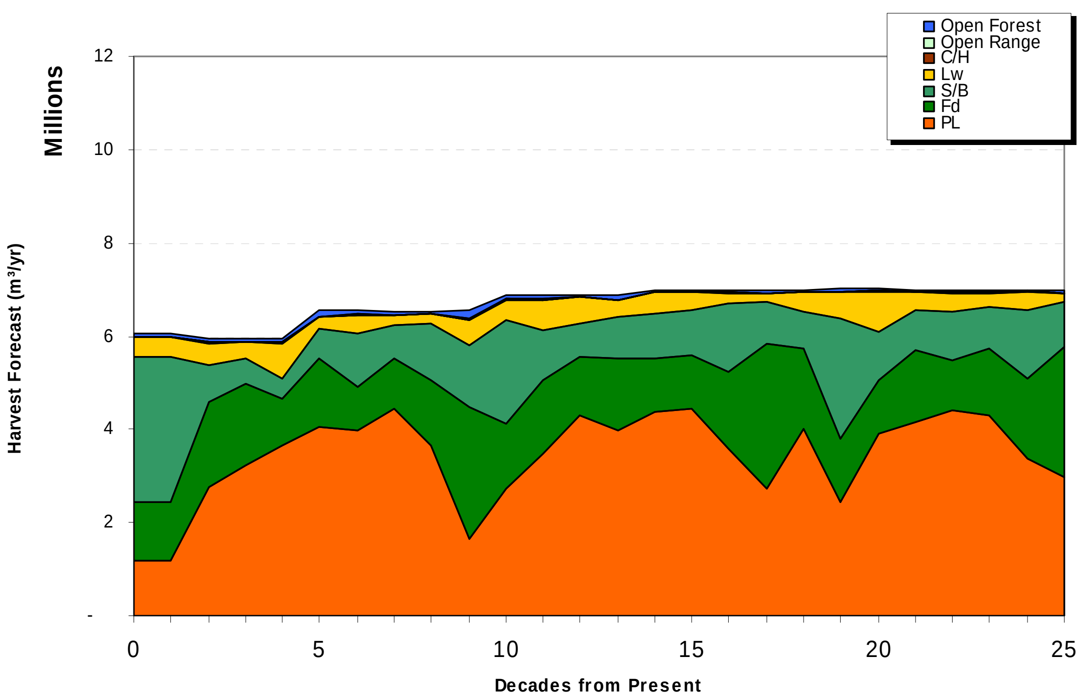



Figure 9. Contribution of species groups to the Invermere Current Practice scenario (no MPB)

### Age Class Distribution

A time-series showing the age-class distribution of the Invermere TSA's forest is shown in Figure 10. Initially, area is distributed unevenly over the age classes. Over time, the contributing THLB becomes more or less evenly distributed in the 0-90 age classes, and the area in the non-contributing landbase is dispersed more or less evenly over all age classes due to modelled disturbances. The exception is a build up of NCLB area in stands >250 years.

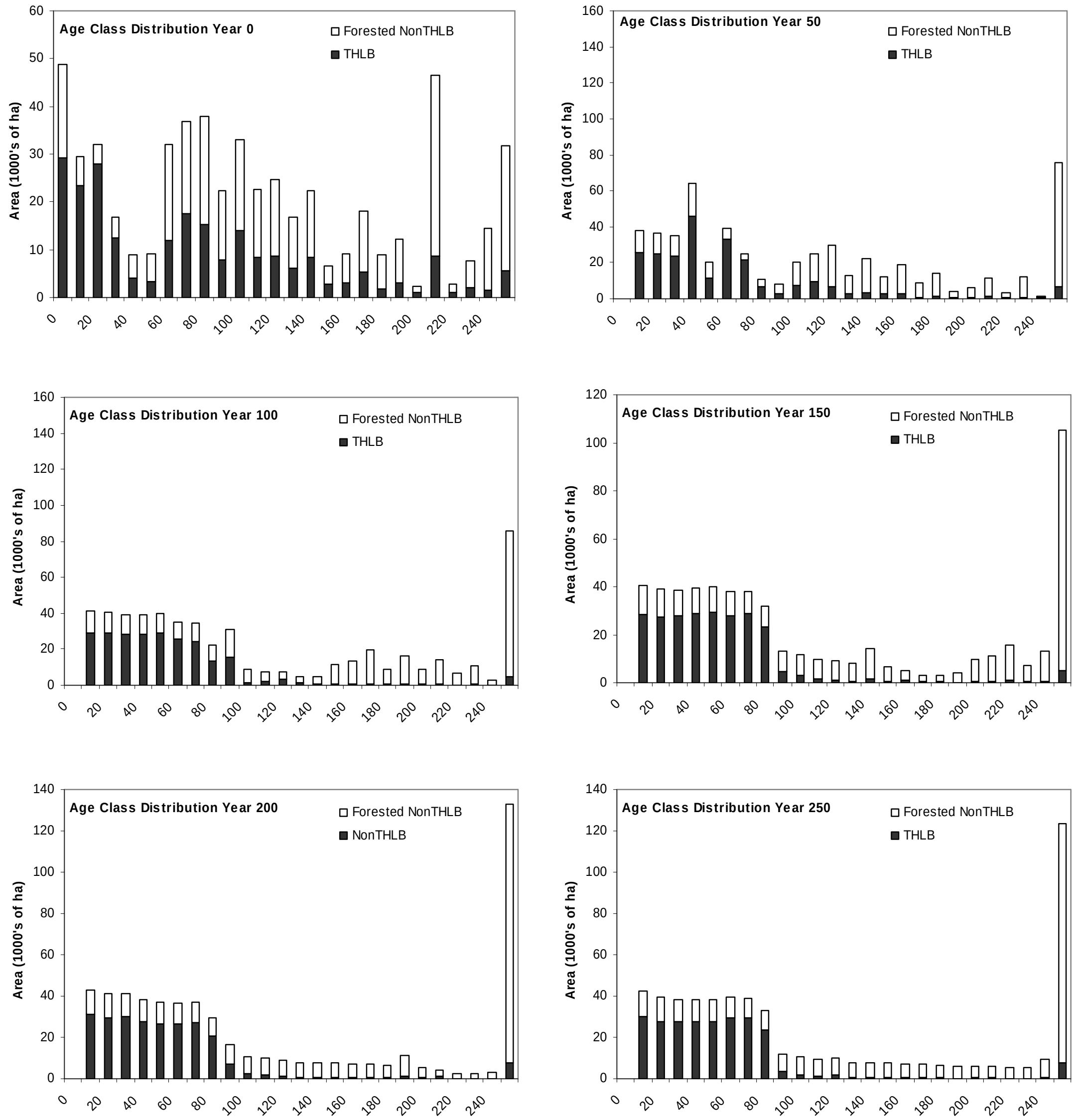



Figure 10. Age class snapshots at 0, 50, 100, 150, 200, 250 yrs: Invermere Current Practice – No MPB

## 6.2. Worst Case MPB – Current Practice

When MPB mortality and salvage assumptions are included, the harvest level falls into an early midterm trough in the second period, reaching a low of 493,700 m³/yr or 13.5% lower than the Current Practice-No MPB scenario (Figure 11). The harvest remains at this level for two decades before rising to a later mid-term harvest level of 622,600 m³/yr. The initial trough occurs because of the loss of mature growing stock, while the reductions in the later midterm occur because of the delayed regeneration of MPB killed stands and extended minimum harvest ages for these unsalvaged stands. The long-term is slightly lower than the current practice scenario (-1.7%) because of the harvest priority placed on pine stands. With such a priority, the harvest schedule is further limited from harvesting stands at their maximum Mean Annual Increment (MAI) and thus, long-term harvest levels (LTHL) suffer.

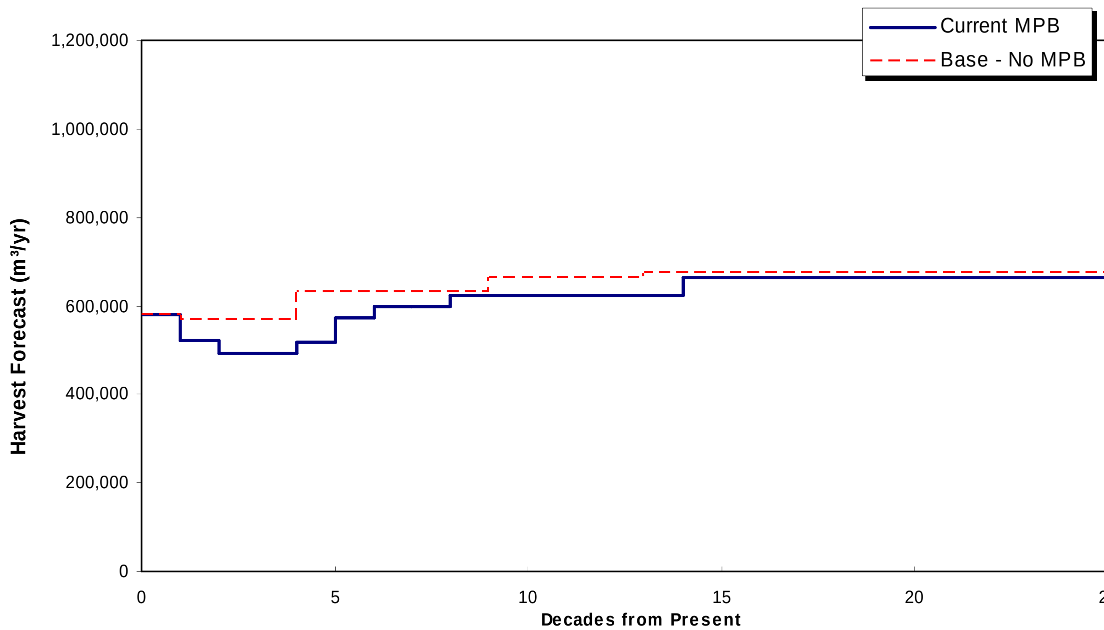



Figure 11. Invermere Harvest flow comparison – Worst Case MPB vs. Current Practice Scenario (no MPB)

The salvage program implemented in this scenario (described in section 5.2.3) managed to capture 59.5% or 3,958,000 m³ of the total MPB mortality. Additional analysis found that this represented the maximum amount of salvage possible because the remainder of the impacted volume was considered uneconomic (younger than minimum harvest ages) or constrained by non timber objectives such as ECA (see Table 12 and Figure 12). Of the 19,600 ha that was not salvaged, 85% were younger than the already reduced minimum harvest ages (see Table 10 on page 11) and 15% were not salvaged due to forest cover constraints (i.e. ECAs for community watersheds, UWR, visuals, and Greenup). The vast majority of the areas that had not yet reached minimum harvest age (not yet economic) were either low productivity stands and/or cable ground.

Table 12. MPB mortality vs. Salvage for the Worst Case MPB Scenario - Invermere

| Total Area scheduled for MPB mortality (ha) | Total Area Salvage harvested (ha) | Total Mortality not Captured by salvage (ha) | Total Area not salvaged that is younger than MHAs (ha) | Total Area not salvaged due to Cover Contraints (ha) |
|---|---|---|---|---|
| 36,960 | 17,350 | 19,600 | 16,690 | 2,910 |
| Percent Salvaged | 47% | | | |
| Percent not salvaged | | 53% | | |
| | Percent of area not salvaged | | 85% | 15% |

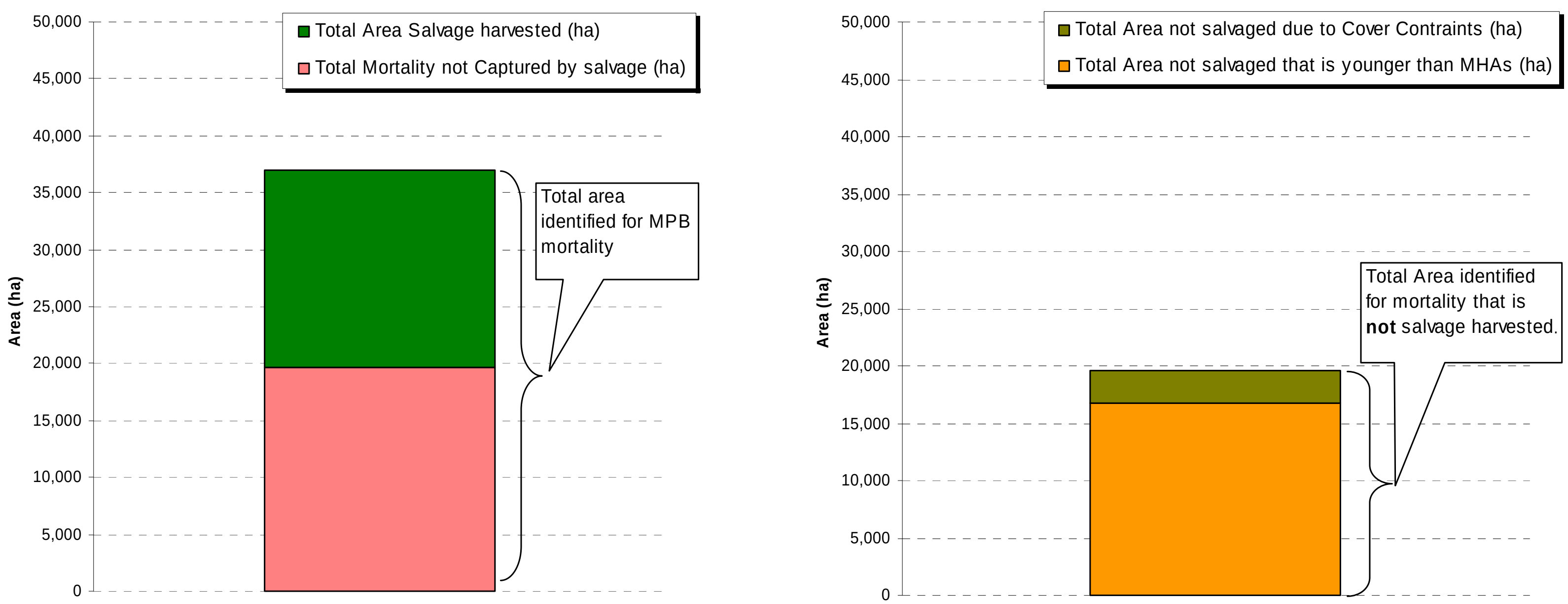



Figure 12. MPB mortality vs. Salvage for the Worst Case MPB Scenario - Invermere

The resulting change in total growing stock on the THLB over time with MPB mortality assumptions is shown in Figure 13. Growing stock drops sharply in the second period as a result of the MPB mortality. In total, 6.6 million m³ are killed in the first period (3.9 million m³ is salvaged and 2.7 million m³ is lost). Combined with the growth and harvest that occurred during this decade, the net change in growing stock is ~6.9 Million m³. By the 5th decade, the growing stock recovers to the similar levels as the current practice scenario due to reduced harvest rates in earlier periods.

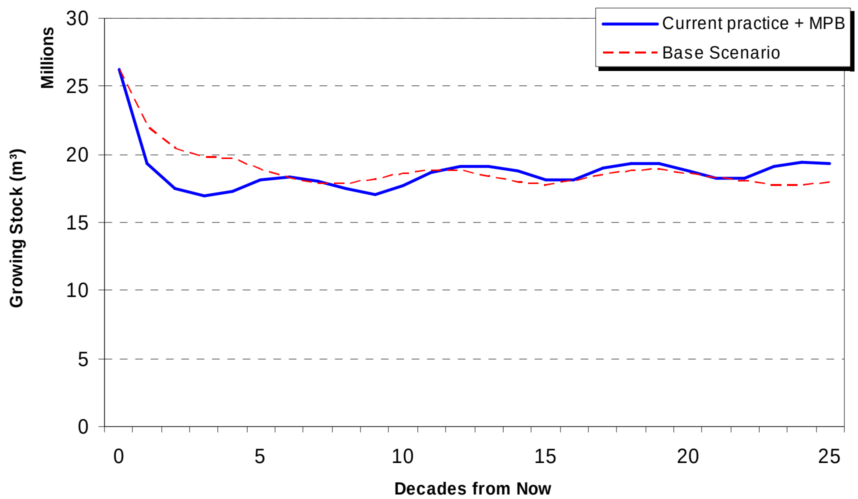



Figure 13. Total Growing Stock (m³) on the THLB – Worst Case MPB vs. Current Practice Scenario - Invermere

Figure 14 shows that the first period harvest is now largely dominated by the harvest of Pl leading stands (75%). The total harvest in Pl leading stands was capped at 75% of the current AAC, however as mentioned previously, only 3.95 million m³ of Pl mortality was captured. Thus, an additional ~0.6 million m³ of 'green' Pl-leading stands were also harvested in the first decade. This indicates that there is enough 'AAC horsepower' in the Invermere TSA to salvage the merchantable and available MPB mortality as predicted by the documented assumptions. An uplift does not appear necessary unless merchantability criteria can be lowered or mortality levels spike and the AAC is insufficient to access the mortality before shelf life expires.

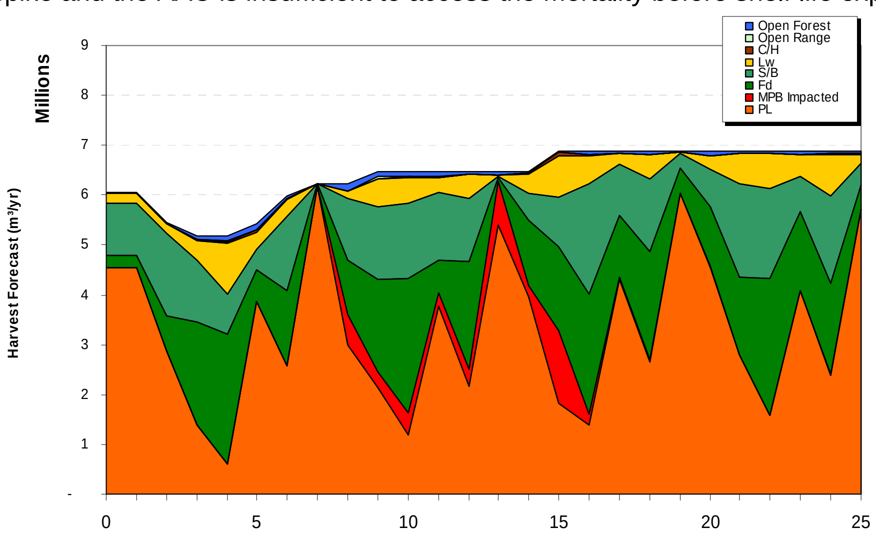



Figure 14. Contribution of species groups to Invermere Worst Case MPB - Current Practice

# 7. Cranbrook Results

## 7.1. Current Practice – No MPB

### Harvest Flow

As with Invermere, the Cranbrook TSR3 sensitivity that most closely resembled current practice (without regards to MPB) was the PEM UWR sensitivity. This scenario was therefore used as the benchmark. Figure 15 compares the harvest flow result of implementing the current practice assumptions (section 5.1) to the TSR3 PEM UWR sensitivity. The initial harvest volume (838,000 m³/yr) is maintained for two decades before dropping slightly by 3.8% (down to 803,000 m³/yr). The drop in mid-term harvest levels can be attributed to changes in harvest priorities, the use of explicit ECA constraints, and the use of the Draft SARCO Caribou reserves. The LTHL of 871,000 is achieved 100 years from now when harvest occurs entirely in managed stands.

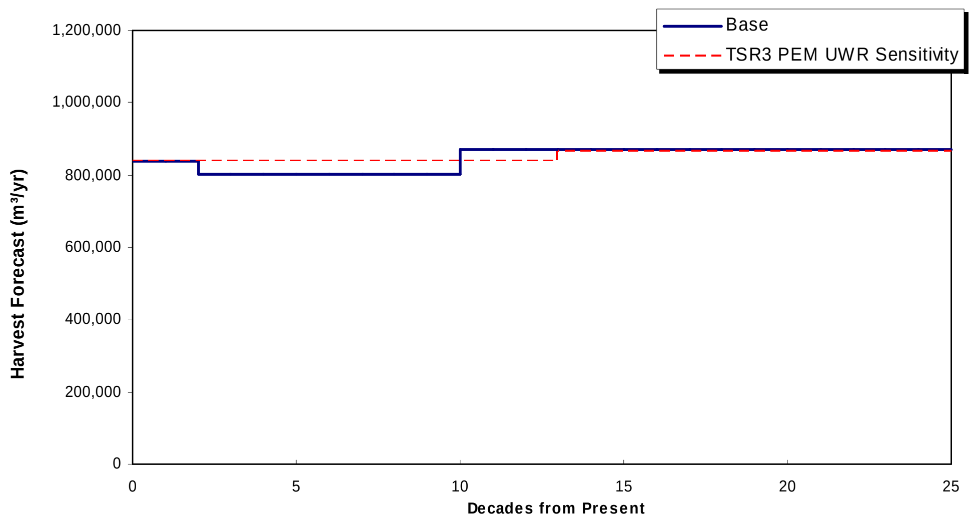



Figure 15. Cranbrook Current Practice - No MPB vs. TSR3 PEM UWR Sensitivity Harvest Flow

### Growing Stock

The total and merchantable growing stock (m³) projection for the Cranbrook Current Practice-No MPB scenario is shown in Figure 16. The initial growing stock is approximately 3.5 million m³ less than the TSR3 growing stock because of harvesting and fires that occurred on the TSA since TSR3. The 2003 fires were salvaged in the first period in the TSR3 model.

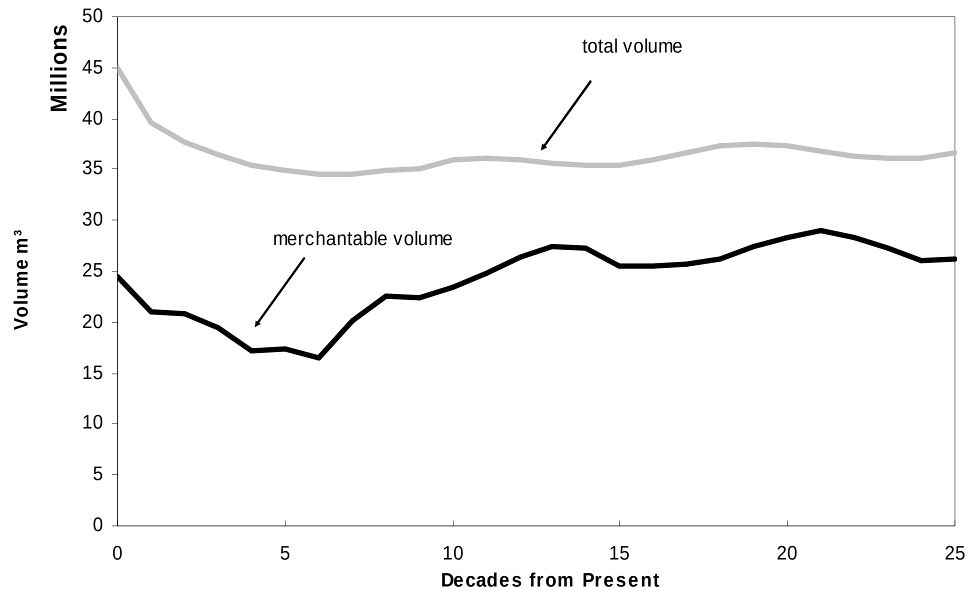



Figure 16. Total and Merchantable growing stock on the THLB: Cranbrook Current Practice-No MPB

### Harvest Attributes

The contribution of species groups to the harvest profile is shown in Figure 17. Pine leading stands contribute the most to the harvest profile because of their relative abundance on the TSA as well as their age class distribution relative to other species groups on the landbase.

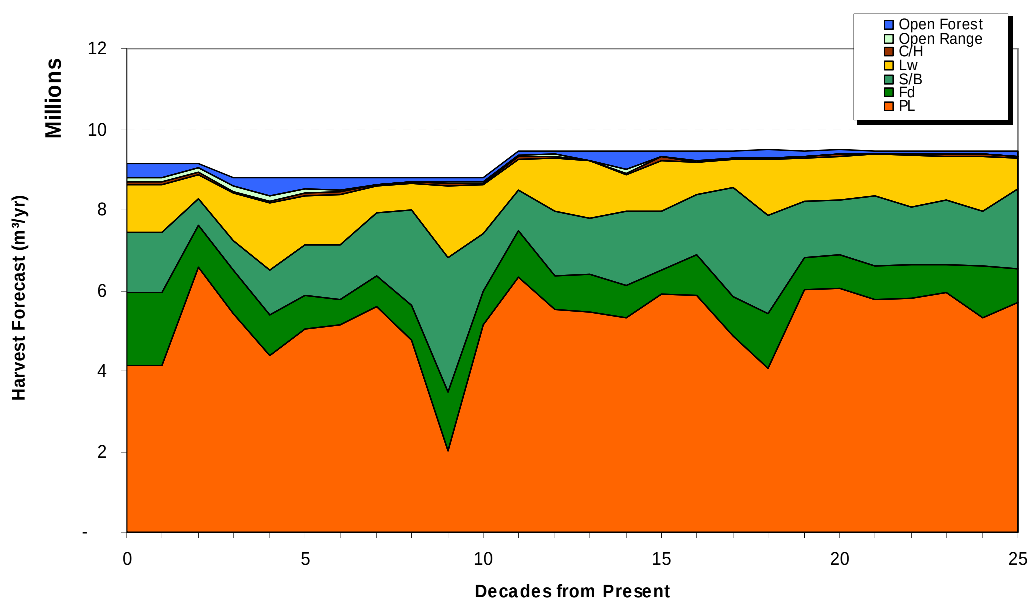



Figure 17. Contribution of species groups to the Cranbrook Current Practice scenario (No MPB)

### Age Class Distribution

A time-series showing the age-class distribution of the Cranbrook TSA's forest is shown in Figure 18. Initially, area is concentrated largely in 60-100 year old stands with a significant area in stands <20 years old, due largely in part to harvesting. Over time, the contributing THLB becomes more or less evenly distributed in 0-100 age classes. In addition, area in the non-contributing landbase is dispersed more or less evenly over age classes due to modelled disturbances. The exception is a build up of NCLB area in stands >250 years.

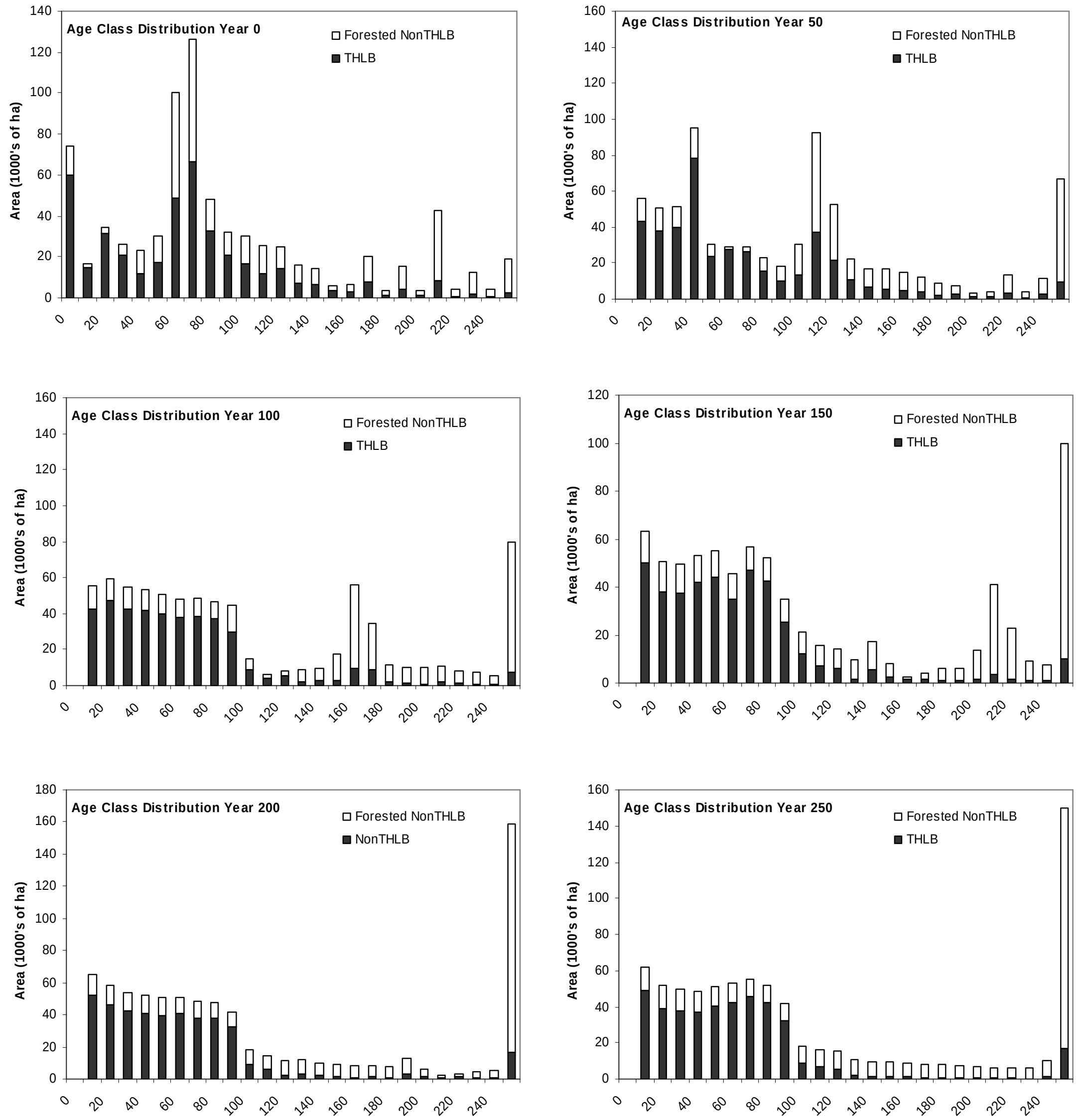



Figure 18. Age class snapshots at 0/50/100/150/200/250yrs – Cranbrook Current Practice-No MPB

## 7.2. Worst Case MPB – Current Practice

As a result of implementing the MPB mortality assumptions described in section 5.2, the harvest level drops sharply in the second decade to 656,800 m³/yr, a 22% decrease (Figure 19). The harvest remains at this level for five decades before stepping up to the LTHL of 812,800 m³/yr in 10% increments beginning 60 years from now. The long-term is lower than the current practice scenario (-6.7%) because of the harvest priority placed on pine stands. With such a priority, the harvest schedule is limited from harvesting stands at their maximum Mean Annual Increment (MAI) and thus long-term harvest levels (LTHL) suffer.

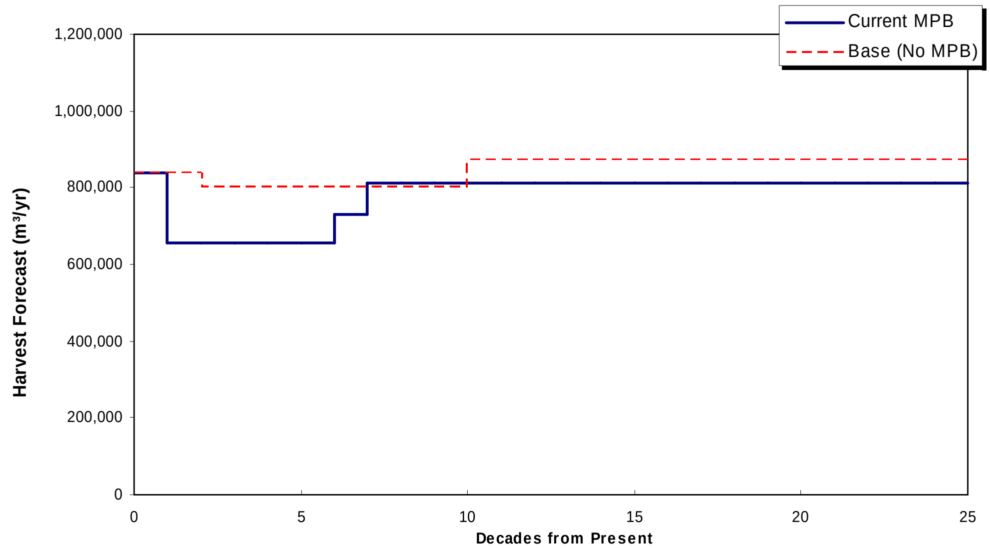



Figure 19. Cranbrook harvest flow comparison – Worst Case MPB vs. Current Practice (no MPB)

Because of the salvage priority utilized for this scenario (described in section 5.2.3) and the maximum 75% of AAC harvest allocation to MPB salvage in the first decade, only 46.2%[vii] or 6,857,000 m³ of the total MPB mortality was captured in the first decade. Thus, all pine harvest was directed towards stands killed by MPB.

Figure 20 shows that the first period harvest is now largely dominated (75%) by the harvest of Pl leading stands. The unsalvaged MPB mortality has a regeneration delay and then begins to contribute to the harvest profile 80 years from now (shown in red).

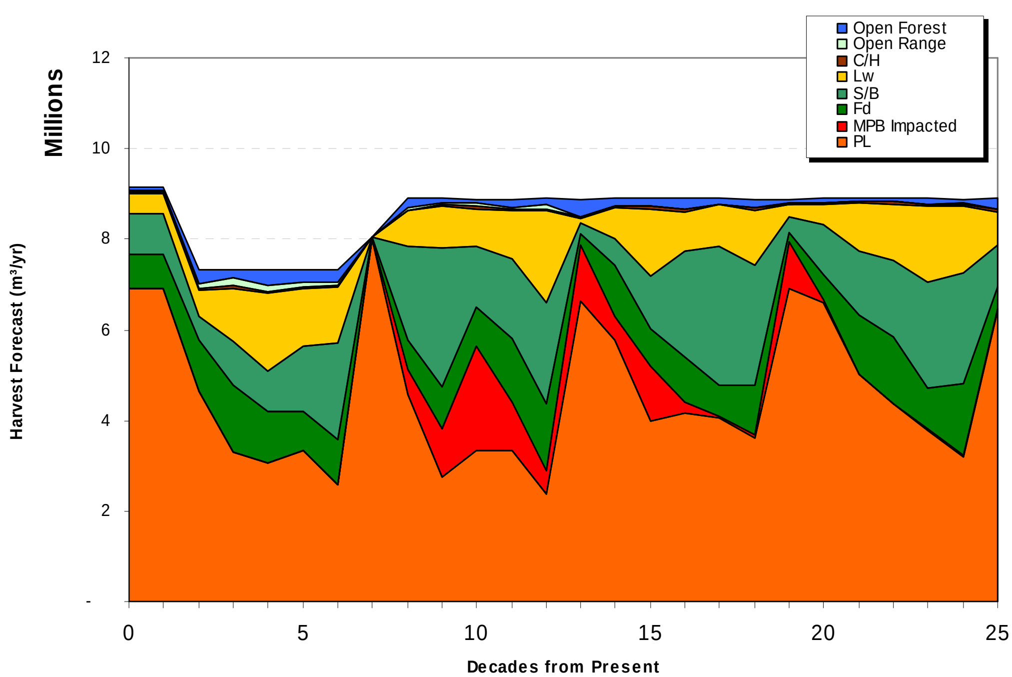



Figure 20. Contribution of species groups for the Worst Case MPB scenario – Cranbrook

vii Actual total mortality occurring in the model was 14.8 million $m^3$ (instead of the planned 15.3) because of differences between yield curve volumes and inventory volumes.

The resulting change in total growing stock on the THLB over time with MPB mortality assumptions is shown in Figure 21. Growing stock drops sharply in the second period as a result of the MPB mortality. In total, 14.8 million m³ are killed in the first period (6.85 million m³ is salvaged and 7.97 million m³ is lost). When this is combined with the harvest and growth that occurred during this decade, the net change in growing stock is ~12.8 Million m³.

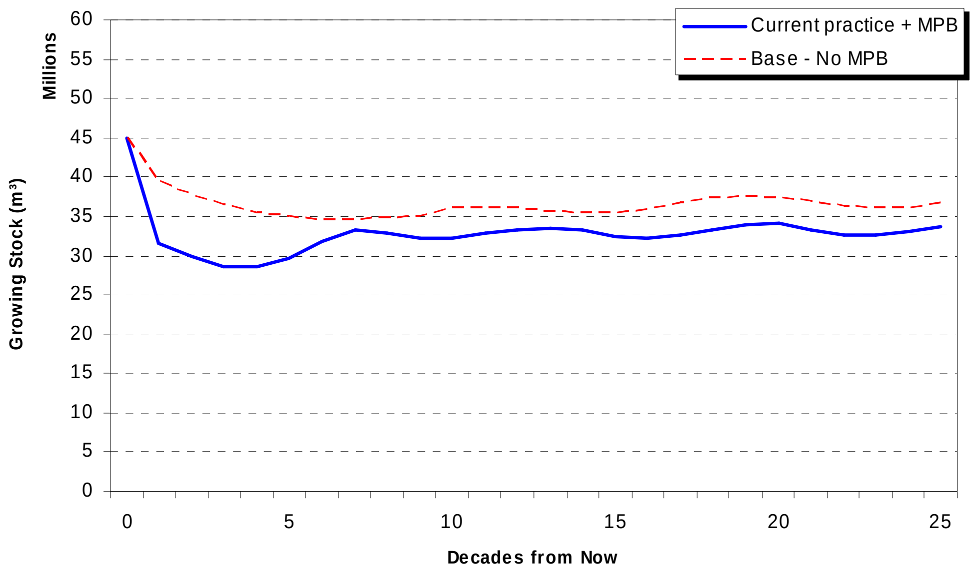



Figure 21. Growing Stock (m³) on the THLB – Worst Case MPB vs. Current Practice-No MPB - Cranbrook

### 7.2.1 Worst Case MPB – Current Practice + Uplift

Since the Worst Case MPB scenario was not able to capture all the available and merchantable MPB mortality, a scenario was designed to illustrate the result of increasing the AAC to salvage a higher proportion of the mortality. It was found that first period harvest could be increased by 178,000 m³/yr over the current AAC, a 19.5% increase without affecting the mid- and long-term harvest levels (Figure 22).

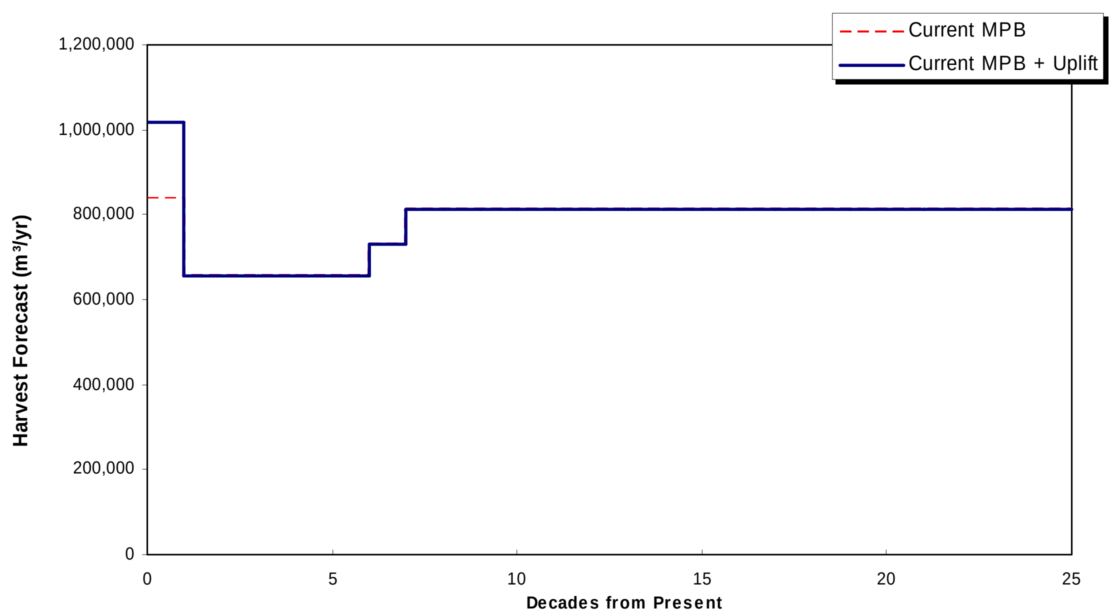



Figure 22. Harvest flow comparison – Worst Case MPB + Uplift vs. Current MPB Scenario - Cranbrook

Additional analysis found that this harvest level captured all of the available and merchantable MPB mortality on the TSA landbase. Of the 84,170 ha of MPB mortality, approximately 41,610 ha or 49% was salvaged under this scenario (Table 13 and Figure 23). Within the 42,550 ha that was not salvage harvested, 82% was not salvaged because it was below minimum harvest ages; even with reduced MHAs (see Table 10 on page 11). The other 18% of the MPB mortality was not salvaged due to forest cover constraints (i.e. UWR, ECAs for Domestic and Community watersheds, visuals, and green-up). The majority of the area limited by MHAs was found to be in lower productivity stand groups and/or on cable ground.

The lack of negative impact in the midterm from increased salvage harvest occurs because the model is not considering the loss of green volume when mixed stands are salvaged. It is assumed that the uplift is directed entirely towards Red and Gray attacked timber. In reality, the removal of green volume occurring in mixed stands would hinder midterm harvest levels. Thus, there is a need to balance the size of the salvage effort against the loss of green timber in mixed stands. However, it is unlikely that any sizeable midterm impacts would occur with this uplift scenario because only -49% of the impacted area (58.3% of the impacted volume) is ever salvaged and this is focused into high % Pl stands. Table 2 shows that 66% (16 million $m^3$) of the pine volume occurs in stands that are at least 70% Pl, and this scenario is based on the salvage of only 7.9 million $m^3$ of Pl mortality. The optimal Pl salvage strategy would involve focusing on high volume, high %Pl stands, while using the 25% of the AAC that is dedicated to non Pl volume to help access impacted Pl in mixed stands.

Table 13. MPB mortality vs. Salvage for the Worst Case MPB +Uplift Scenario - Cranbrook

| Total Area scheduled for MPB mortality (ha) | Total Area Salvage harvested (ha) | Total Mortality not Captured by salvage (ha) | Total Area not salvaged that is younger than MHAs (ha) | Total Area not salvaged due to Cover Contraints (ha) |
|---|---|---|---|---|
| 84170 | 41610 | 42550 | 34760 | 7790 |
| Percent Salvaged | 49% | | | |
| Percent not salvaged | | 51% | | |
| | Percent of area not salvaged | | 82% | 18% |

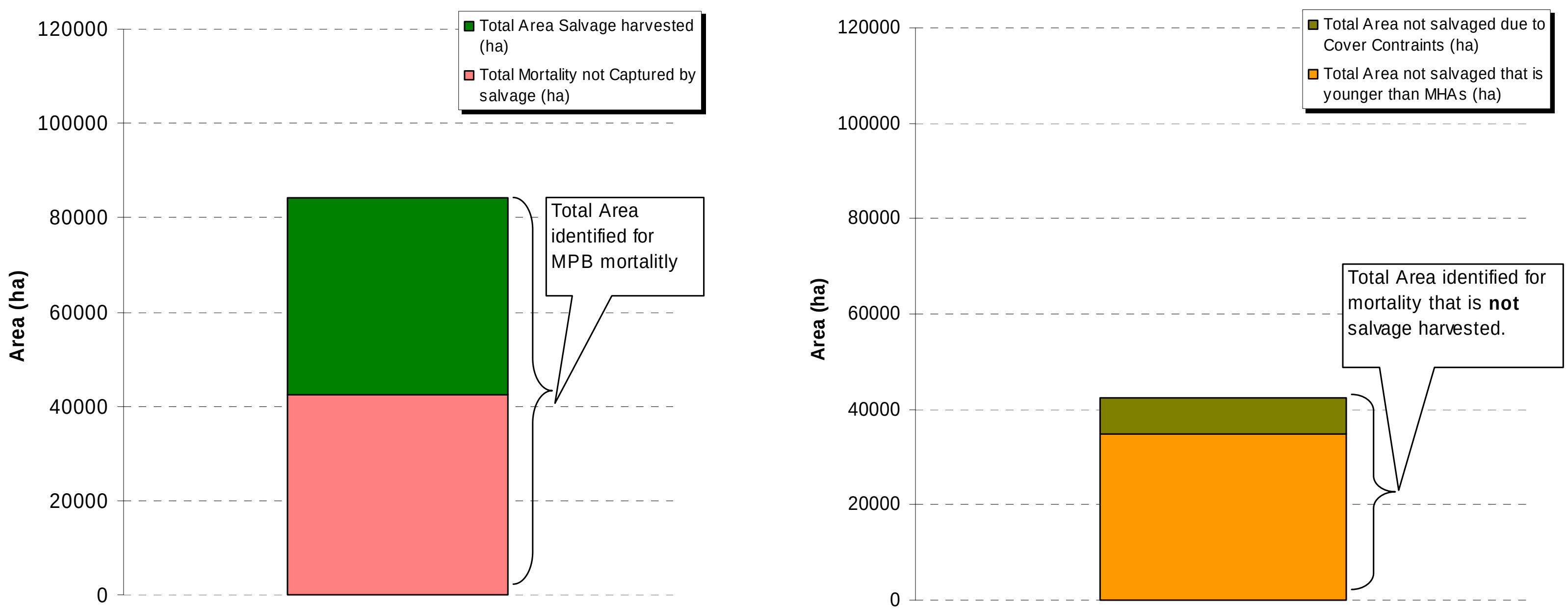



Figure 23. MPB mortality vs. Salvage for the Worst Case+Uplift Scenario - Cranbrook

Figure 24 shows that the first period harvest is dominated by Pl leading stands (80%). The harvest volume of non-Pl leading stands remains consistent with the pre uplift scenario. Constraints served to limit the model from harvesting nothing but Pl stands for the first decade. However, the constraints were not applied for the remainder of the projection and harvest in the 7th decade is entirely composed of Pine.

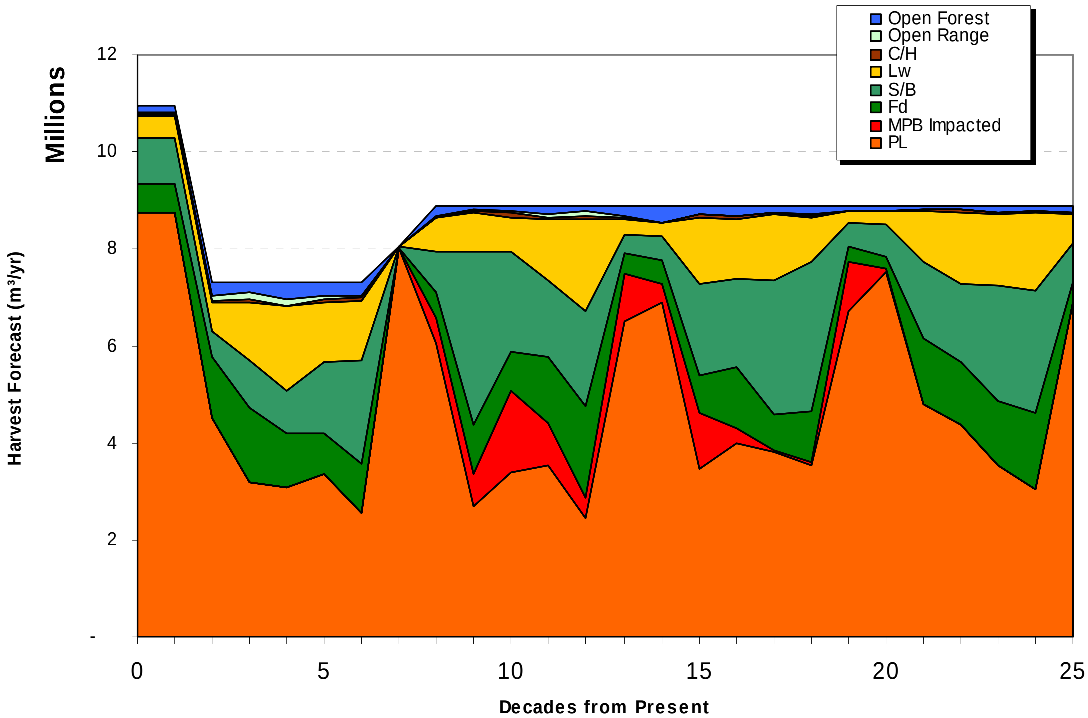



Figure 24. Contribution of species groups for the Worst Case MPB + Uplift Scenario – Cranbrook

### 7.2.2 Worst Case MPB – Alternative practice

A scenario was run where salvage priority was driven by stand level merchantability and mortality (see Section 5.3 on page 12), but no recognizable differences in volume flow were realized. There may be economic gains associated with this approach but it was not investigated here.

# 8. Summary / Discussion

Invermere

- The worst case MPB scenario shows harvest levels starting to drop in ~10 yrs and falling by 77,000 m³/yr (13.5%) before beginning to recover in 50 years.
- Over the next decade, the current AAC appears adequate to harvest all of the available and merchantable MPB impacted volumes (59.5% of total mortality). The unsalvaged volume was either below minimum harvest ages (i.e. uneconomic) at the time of death (85%), or constrained by non timber issues such as ECA's (15%).
- Based on these assumptions, no uplift appears necessary in Invermere although verification of the economic viability of the unsalvaged volume would be important.
- An alternative salvage strategy was not pursued because there is no need for a 'better' prioritization process when it is possible to harvest all of the available stands (no economic/available stands get left behind).

<u>Cranbrook</u>

- The worst case MPB scenario shows harvest levels falling by 171,200 $m^3$/yr (22%) once salvage opportunities are exhausted in ~10 yrs, and then recovering in 70 years.
- With 75% of the current AAC dedicated to salvage, only 46.2% (6.8 million $m^3$) of the anticipated mortality can be captured.
- Increasing the first period harvest to 1,016,000 $m^3$/yr, with an uplift (178,000 $m^3$/yr) concentrated on infested stands, allows the maximum salvage to occur (58.3% of the mortality or 7.9 million $m^3$) with minimal negative impacts on the mid or long term harvest flows. The remaining unsalvaged mortality (6.9 million $m^3$ or 41.7%) is either not economic to harvest (younger than minimum harvest age at time of death) or unavailable due to non timber issues such as watersheds exceeding maximum ECA's. Of the 6.9 million $m^3$ that goes unsalvaged, 82% is due to minimum harvest ages and 18% is unavailable because of non timber issues. The economic viability of unsalvaged volume should be examined carefully when making decisions around uplifts.
- An alternative salvage priority scenario using merchantability mapping was completed and showed no discernable difference in harvest flow, although there may be economic benefits to such a strategy.

Throughout the East Kootenay's, the fate of the MPB infestation is still uncertain relative to other TSA's in the southern interior of BC. Unique geographic circumstances combined with a long past history of managing MPB in these areas leaves questions about whether the worst case scenario investigated here will occur. The longer the rise in beetle populations can be postponed, the more flexibility the TSA's have to capture impacted and/or susceptible volume without extraordinary measures (i.e. uplifts) that cause negative impacts on future timber supply.

The BCMPB predictions of MPB mortality show that both TSA's are on the cusp of exponential growth in mortality, so the next few years of Forest Health Survey results will be important indicators of what the MPB epidemic is likely to do in the East Kootenay's.

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