FOREST ANALYSIS AND INVENTORY BRANCH

TIMBER SUPPLY AND THE MOUNTAIN PINE BEETLE INFESTATION IN BRITISH COLUMBIA 2007 UPDATE

B.C. Ministry of Forests and Range

Cover photograph by Lorraine Maclauchlan.
Ministry of Forests and Range, Southern Interior Forest Region.
Aerial view of extensive attack by mountain pine beetle.

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Introduction and objectives

In October 2003, the Ministry of Forests published a report titled *Timber Supply and the Mountain Pine Beetle Infestation in British Columbia*. At that time, the mountain pine beetle (MPB) had affected about 4.2 million hectares (red-attack) to varying degrees and the report forecasted the **timber supply** impact of a continuation of this infestation, based on the information then available. The infestation has been re-assessed annually since then and it is estimated that the cumulative area of provincial Crown forest affected to some degree (**red-attack and grey-attack**) for 2007 is about 13 million hectares. Given the potential impact of the infestation on the environment, timber supply, and local economies that depend on the timber, the Ministry of Forests and Range decided that the 2003 publication should now be updated and expanded.

The 2003 report reflected the understanding at that time of how the infestation might progress, what impact control strategies might have, how long the beetle-killed wood might be useable for various products, how effective control operations might be, and how many management units might be affected. The report acknowledged that there was much uncertainty about the infestation and suggested it would be important to re-assess and re-analyze the infestation as new information became available to ensure the timber supply forecasts remained current.

The 2003 report looked at the impact of the infestation on the timber supply of 12 management units in the Interior (7 timber supply areas and 5 tree farm licences) as an aggregate. Given the size of the infestation today, this updated timber supply analysis explores the impact of the infestation on 20 timber supply areas (TSAs) shown in Figure 1. These 20 TSAs contain most of the mature pine available for harvest (87 percent of the 1.35 billion cubic metres of mature pine in the provincial timber harvesting land base). As shown in Figure 2, the mature pine volume within the **timber harvesting land base** of these 20 TSAs ranges from 12 percent of total mature volume in the Robson Valley TSA to more than 73 percent in the Vanderhoof portion of the Prince George TSA. In an effort to recover economic value from beetle-affected stands, the allowable annual cuts (AACs) of 10 of these 20 TSAs have been increased by a total of 17 million cubic metres per year to 54.6 million cubic metres per year (almost 81 percent of the AAC of the Interior). The actual harvest from the 20 TSAs was 45.9 million cubic metres in 2006, 8.7 million cubic metres less than the AAC.

The primary objective of this analysis was to provide information on short- and mid-term timber supply (i.e., the next 60 years) to inform current discussions on environmental, social and economic issues.

The analysis does not provide estimates of the long-term timber supply (i.e., more than 60 years from now). However, once the

Timber supply is the quantity of timber available for harvest over time. Timber supply is dynamic, not only because trees naturally grow and die, but also because conditions that affect tree growth, and the social and economic factors that affect the availability of trees for harvest, change through time.

Red-attack and grey-attack are stages of infestation. Trees turn red after the first year of attack. The red-attack trees are easily observed and mapped. In the following year, the trees generally turn grey.

Timber harvesting land base is land that is considered available for harvest taking into account economic, environmental, social and cultural considerations.

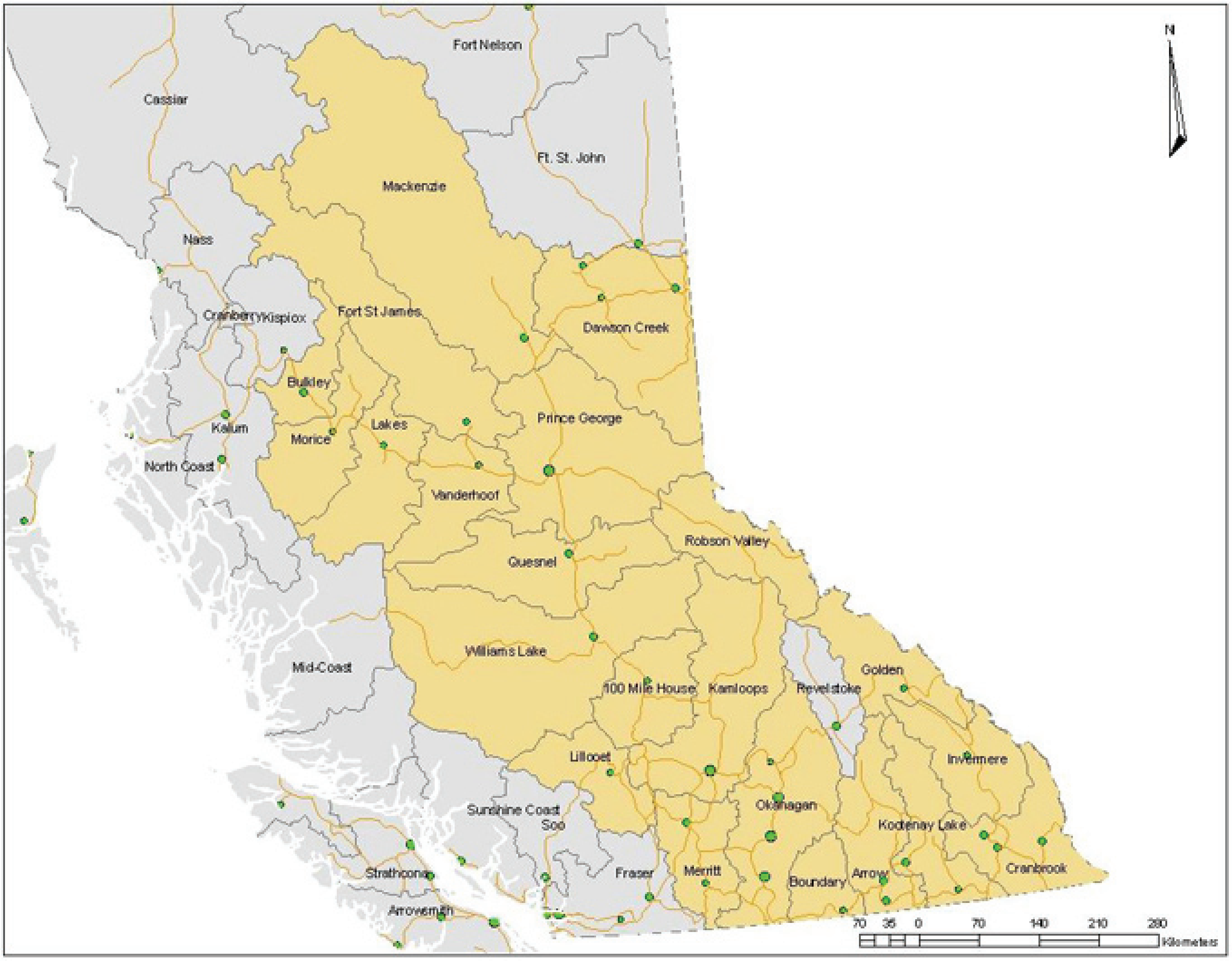


Figure 1. Map of the province showing the 20 TSAs (Vanderhoof, Prince George and Fort St. James are forest districts within the Prince George TSA) comprising the study area.

infestation is over, forest stands will recover. The pace and level of recovery will depend on efforts to reforest and rehabilitate areas after they are attacked.

The long-term timber supply could also be affected by climate change, but whether those impacts will be positive or negative is uncertain at this time. Work is ongoing under the Future Forest Ecosystems Initiative to develop ecological knowledge and adaptive management processes that will enable effective responses to a changing climate.

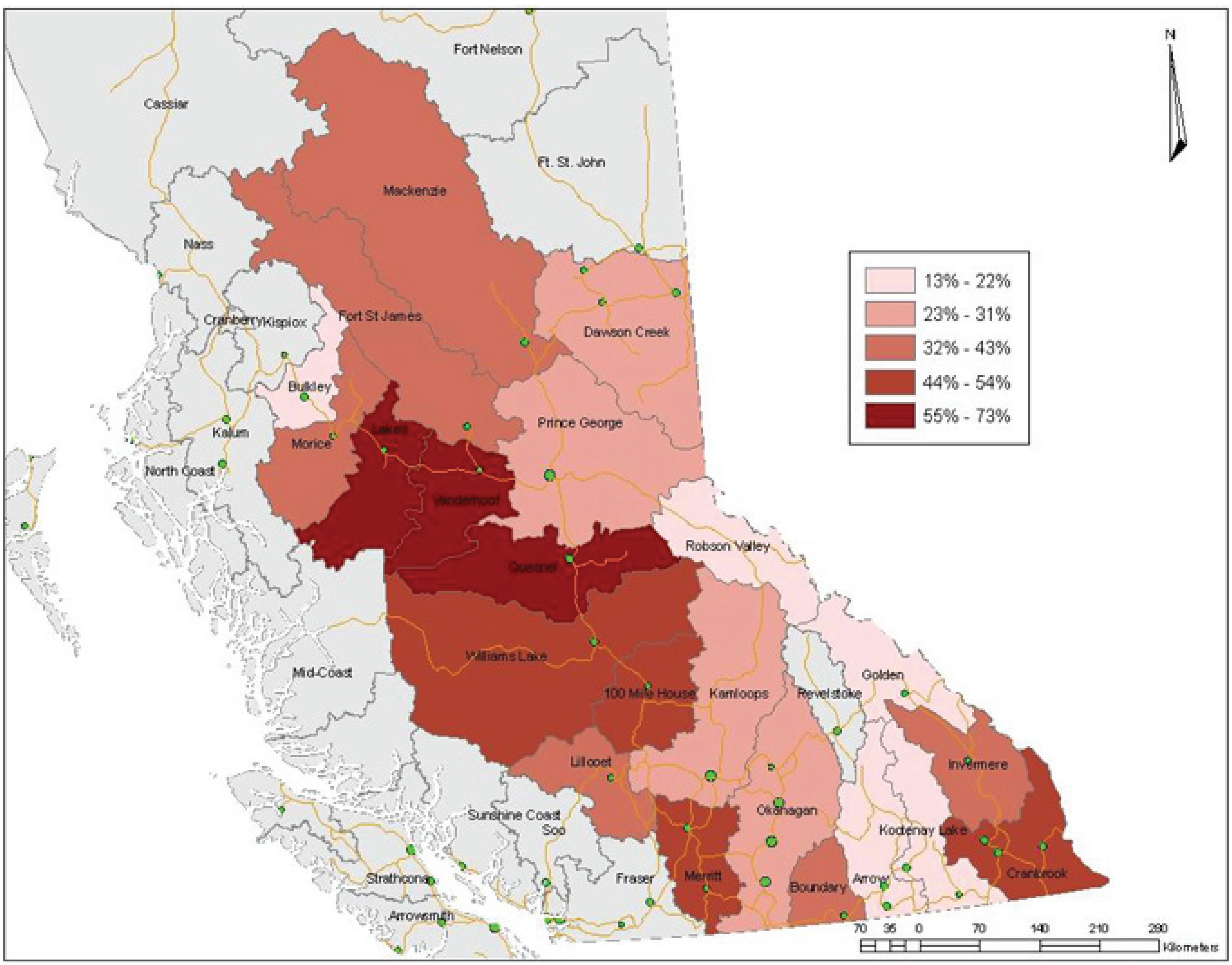
This analysis reflects the latest understanding on magnitude and intensity of the infestation, length of time the dead wood can be used as sawlogs, and the potential volume for products other than sawlogs.

Although the report focuses on timber supply, it also provides some information on the potential impacts of the beetle epidemic on other forest values. For more information on government's response to the epidemic see the "Sustaining Communities for the Future" backgrounder posted on the Ministry of Forests and Range mountain pine beetle website at www.gov.bc.ca/pinebeetle .

It should be noted that the Council of Forest Industries (COFI) also undertook a timber supply impact assessment in consultation with the Ministry of Forests and Range, regional beetle action coalitions and forest licensees. The resulting report, *Timber Supply Analysis: Mountain Beetle Impact on Interior Timber Supply Areas*, released in 2006, contributed to the understanding of the timber supply impacts of the beetle epidemic. This 2007 update analysis represents a further step from the COFI analysis in incorporating improved knowledge of the beetle epidemic.

This report provides information on the current state of the MPB infestation, a forecast of its potential further spread, a discussion of key analysis assumptions, and a projection of possible timber supply outcomes. The report then briefly discusses the implications of those outcomes with regard to the existing forest industry, the use of non-sawlog material, stream hydrology, wildlife and biodiversity.

Figure 2. Pine volume as a percentage of total volume within the timber harvesting land base.



Current state and projection of the infestation

The preferred host of the MPB is large diameter, mature lodgepole pine (60 years or older). Mountain pine beetles are currently in the outbreak phase of the infestation cycle over much of their range in British Columbia. Although the exact progression of the infestation cannot be predicted with certainty, it is possible to project a range of outcomes, using a variety of assumptions.

For four years, the Ministry of Forests and Range and the Canadian Forest Service have been developing the Provincial-Level Mountain Pine Beetle Model (BCMPB)[1]. The model uses forest cover maps[2], the Provincial Aerial Overview of Forest Health[3] and information from a stand-level MPB population model[4] to estimate the current extent of pine mortality, and to project a possible course of the infestation into the future[5].

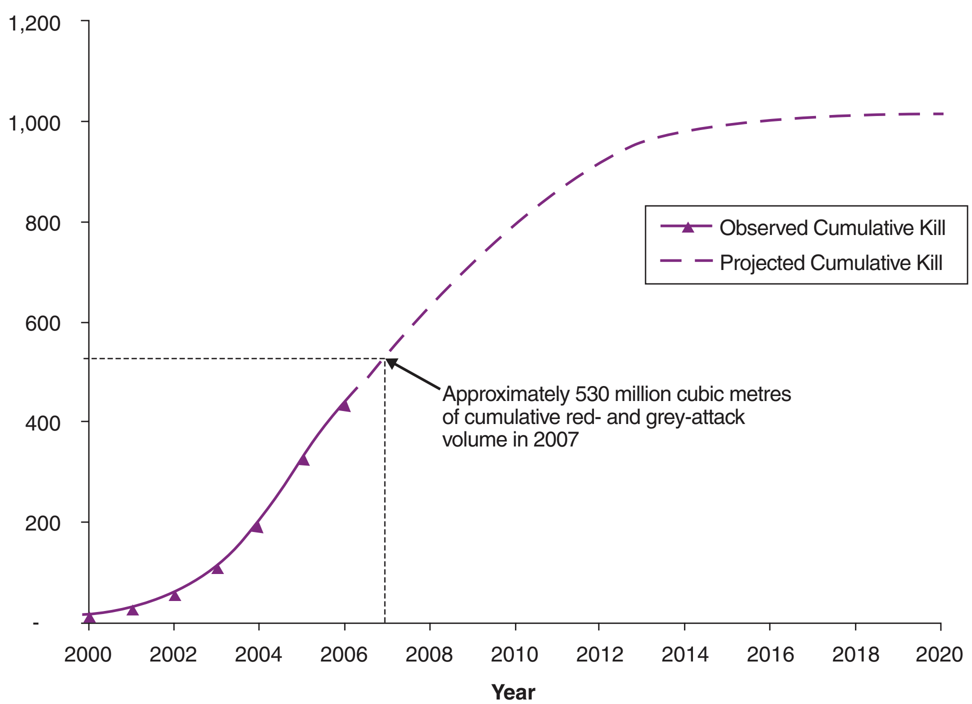


Figure 3. Observed and projected cumulative volume killed (red- and grey-attack) on the timber harvesting land base of the entire province, based on the 1999 to 2006 Provincial Aerial Overviews and the Provincial-Level Mountain Pine Beetle Model (version 4).

1 http://www.for.gov.bc.ca/hre/bcmpb

2 http://www.for.gov.bc.ca/hts/vri/

3 http://www.for.gov.bc.ca/hfp/health/overview/overview.htm

4 http://www.pfc.forestry.ca/entomology/mpb/tools/modeling/mpbsim_e.html

5 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/

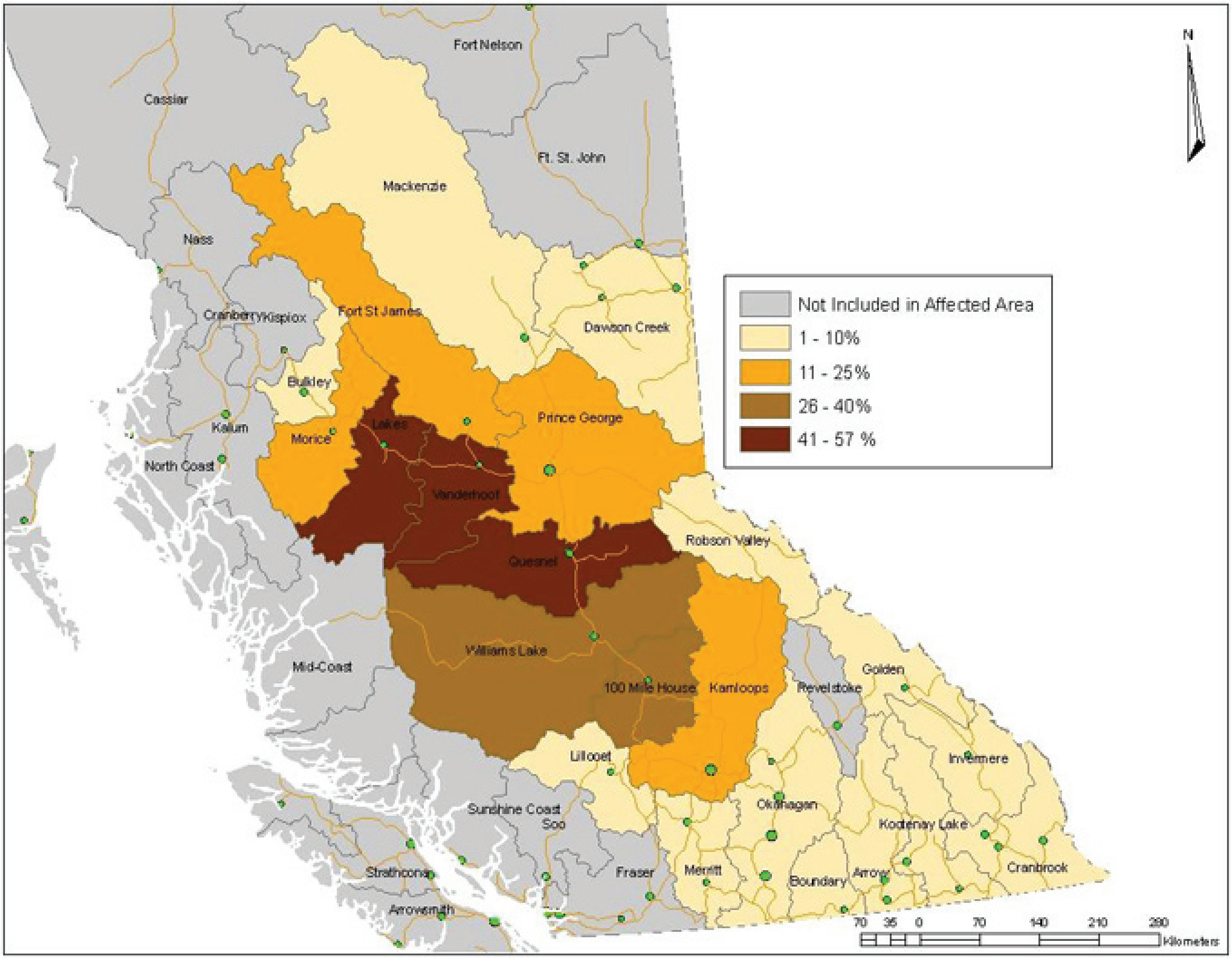


Figure 4. Percent of total management unit volume killed (red- and grey-attack) on the timber harvesting land base cumulative to 2007.

Cumulative impact

Based on the 1999 to 2006 aerial overview of forest health and version 4 of the BCMPB, it is estimated that the standing dead volume (red- and grey-attack) is approximately 530 million cubic metres in 2007 (Figure 3). This represents approximately 40 percent of the merchantable pine volume (1.35 billion cubic metres) and 12 percent of the total provincial merchantable volume on the timber harvesting land base (4.6 billion cubic metres). The majority of that mortality (495 million cubic metres) occurs within the study area analyzed in this report.

Figure 4 shows the current estimate of mortality caused by MPB in each management unit (TSA or forest district) analyzed in this report. If the infestation continues to behave as it has over the past eight years, it is projected that 78 percent of the pine volume, or 23 percent of the total volume on the provincial timber harvesting land base, will be killed by 2015 (Figure 5). By that time, the infestation will have largely subsided and only

Total provincial timber supply

	THLB total volume*	THLB pine volume*
Province	4.60	1.35
Interior	3.68	1.34
Coast	0.92	0.01

* billions of cubic metres

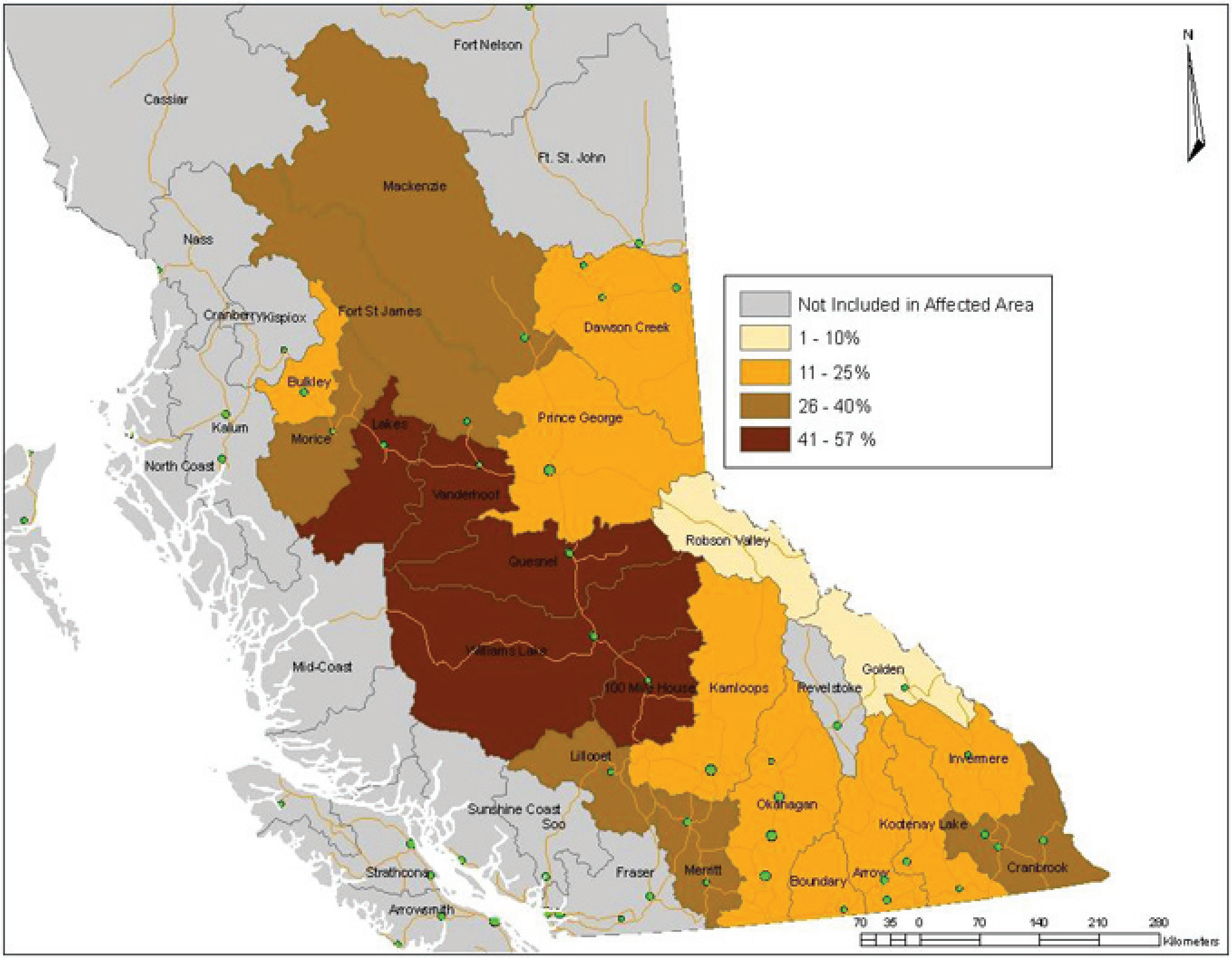


Figure 5. Projected percent of total management unit volume killed (red- and grey-attack) on the timber harvesting land base cumulative to 2015.

an additional one percent may be killed by 2019. This estimate of the progression of the infestation is essentially the same as for the 2003 analysis.

Annual mortality

It is estimated that the provincial peak in observed annual kill (red-attack) for this outbreak occurred during the summer of 2005, with an annual mortality of approximately 139 million cubic metres of merchantable pine on the timber harvesting land base (Figure 6). It is projected that there will be approximately 95 million cubic metres of merchantable pine on the timber harvesting land base that is red-attack in the summer of 2007, and that the beetles will continue to kill more than 80 million cubic

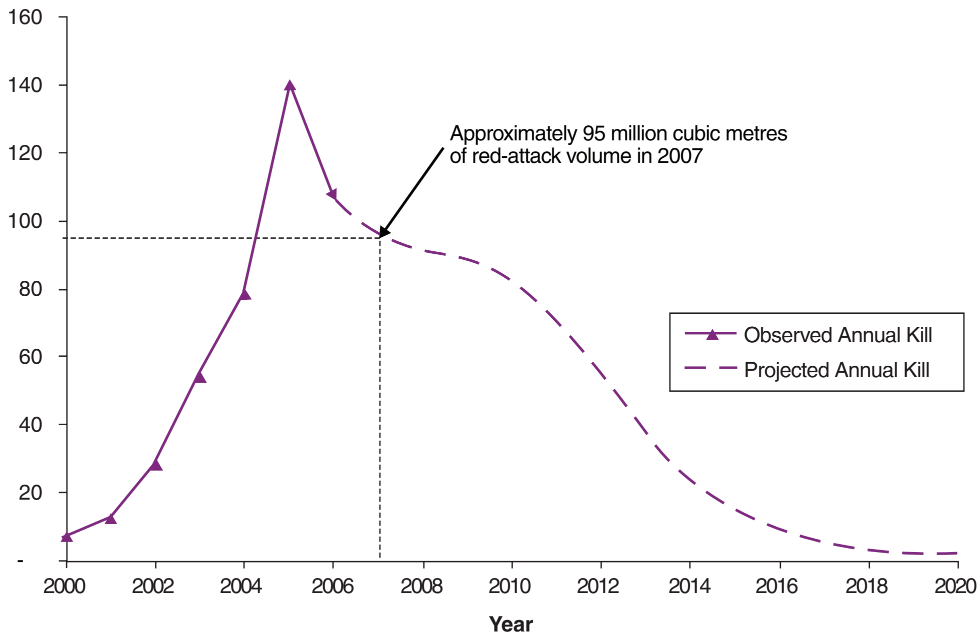


Figure 6. Observed and projected annual volume killed (red-attack) on the timber harvesting land base of the entire province, based on the 2006 Provincial Aerial Overviews and the BCMPB (version 4).

metres per year until 2009. After that, the infestation is expected to subside rapidly, and within 10 years it will likely be killing less than 5 million cubic metres annually.

There is substantial variation in the timing and magnitude of the peak in annual kill in different management units throughout the province. In four management units the peak probably occurred in 2005: Vanderhoof Forest District, Quesnel TSA, Lakes TSA and Prince George Forest District. The peak in annual kill in Williams Lake, 100 Mile House, and Kamloops TSAs probably occurred in 2006. It is anticipated that the peak in red-attack in the Morice TSA will occur in 2007. In the remaining pine units, which are near the periphery of the current outbreak, annual kill will not peak until some time in the future.

Stands at risk to mountain pine beetle — now and in the future

Stands more than 60 years old

It is estimated that in 1999, which is commonly regarded as the beginning of the current outbreak, mature pine (over 60 years old) contributed about 29 percent, or 1.35 billion cubic metres of the total volume in the provincial timber harvesting land base. Of this total mature pine volume which is all considered at risk to the MPB, approximately 1.18 billion cubic metres (87 percent) is in the timber harvesting land base of the 20-TSA study area.

Younger stands

Normally, lodgepole pine less than 40 years old is not considered at risk to MPB because of small diameter, good health and other attributes. Despite this, some young stands are currently being affected by the MPB and this will have downward pressure on the mid-term timber supply projections presented in this report.

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During 2005 and 2006, the Ministry of Forests and Range conducted aerial surveys across seven forest districts and ground surveys across 10 forest districts (Maclauchlan 2006 unpublished) to determine the extent and severity of mortality in young pine stands. Ground-surveyed districts include Prince George, Quesnel, Vanderhoof, Nadina, Central Cariboo, 100 Mile House, Kamloops, Chilcotin, Cascades and Okanagan Shuswap. Stands aged 20 to 55 years old were sampled. In addition, the Vanderhoof and Prince George Forest District commissioned more intensive surveys of immature pine plantations. In the case of Vanderhoof, the plantations had been spaced between 1980 and 2000. The Prince George study targeted plantations between 20 and 40 years old.

The Maclauchlan study reported some level of attack in 70 percent of the young stands surveyed (see Figure 7). The majority of affected stands showed red-attack levels of less than 10 percent. Only five percent of all stands surveyed showed red-attack levels in excess of 50 percent.

The Maclauchlan report concluded that young pine stands will continue to be at risk until the intensity of the outbreak in nearby mature pine subsides. In 2006, many areas in the Vanderhoof and Quesnel Districts saw reduced attack of young stands, probably because they are surrounded by dead grey-attack stands. However, in the central and southern portions of the province, some increase in mortality in young stands can be expected as the outbreak intensifies.

The Vanderhoof Forest District study indicated attack levels in older spaced stands (35 years and older) of approximately 70 percent declining to approximately 20 percent in younger spaced stands (20 to 35 years old). The Prince George Forest District study indicated attack levels of approximately 46 percent

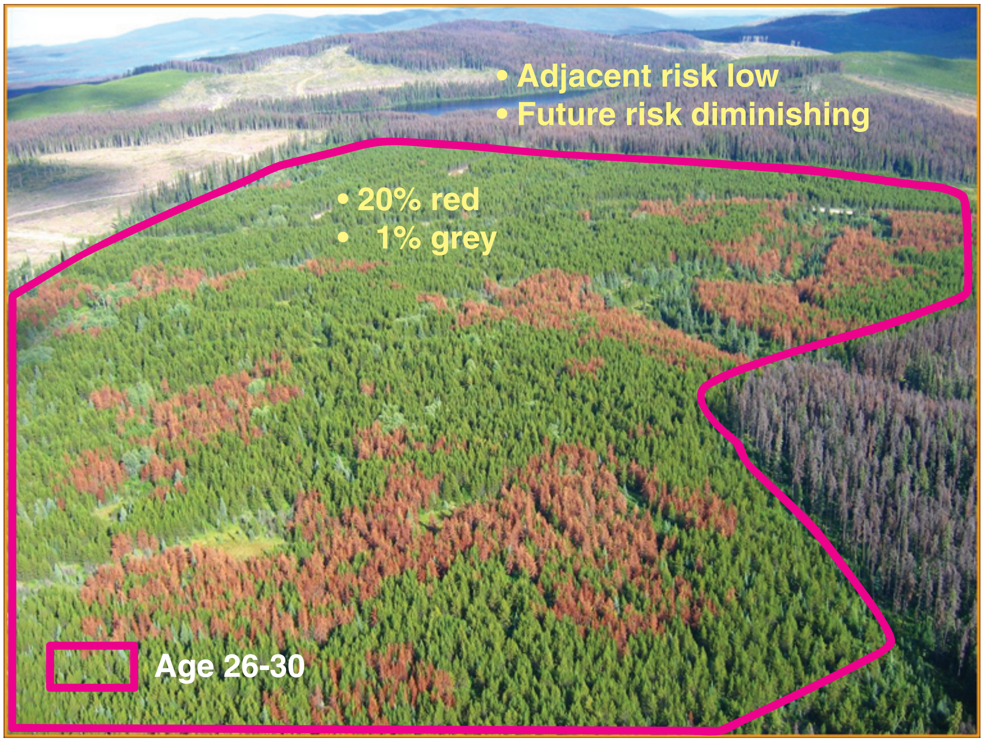


Figure 7. A 26- to 30-year-old lodgepole pine stand assessed during the aerial survey.

in 20- to 40-year-old lodgepole pine stands. These figures are significantly higher than those found by Maclauchlan and are probably due to the fact that the Prince George and Vanderhoof surveys involved more intensive surveys, and targeted plantations (spaced plantations in Vanderhoof). In summary, young pine is generally a host of last resort, and the probability that beetles will produce a successful brood in these trees is low. However, spaced trees, due to their larger size, can be a more desirable host for beetles.

The timber supply effect of mortality in younger stands is discussed later under "Young stand mortality impacts". In future timber supply updates the ramifications of pine mortality in young stands on timber supply will be more fully explored. However, as indicated earlier, young stand mortality was not explicitly accounted for in this analysis.

Attack of other tree species

There have been recent reports of the mountain pine beetle attacking spruce trees. Researchers indicate that this behaviour can be expected when the beetle population is very large and more desirable food sources (i.e., mature pine) become scarce in a local area. However, the current research suggests that pine beetles are not able to reproduce well in spruce trees, and therefore are unlikely to kill them. Available knowledge indicates that attack of spruce by the mountain pine beetle is not likely to cause significant timber volume losses, and therefore, that kind of attack was not included in the analysis.

Timber supply analysis: Key assumptions and uncertainties

"…about one billion cubic metres of mature pine within the timber harvesting land base will be affected by 2015."

In order to explore the implications of the MPB epidemic on timber supply, a number of key assumptions were required to reflect the evolving understanding of both the progression of, and the forest management response to the infestation. For the 20-TSA analysis presented in this publication the following key assumptions shaped the analysis.

Short-term forecast

Timber supply analyses commonly include a projection of a long-term sustainable timber supply level. However this analysis focuses on the available supply of timber in the short-term (next 5 to 10 years) and the expected mid-term levels (until about 60 years from now) which will occur after the infestation and salvage are concluded. This focus was believed to be relevant for planning of salvage harvesting in the next several years while beetle-attacked pine is still useable, and for community planning for the mid term once the infestation is over and adjustments to lower timber supply levels will be required in many areas.

With respect to long-term timber supply, it is expected that once the infestation is over forest stands will recover and produce long-term timber supply at levels close to those projected in previous timber supply review analyses. In future timber supply reviews, updated information on regeneration and rehabilitation strategies and forest productivity will be incorporated into the analyses to provide projections of long-term timber supplies.

Progression of the infestation

For the analysis, the infestation was assumed to progress as projected by BCMPB version 3 (version 4, which supplied the projection described earlier, was not available at the time data were being prepared for this analysis). This model uses forest cover maps, the Provincial Aerial Overview of Forest Health and a stand-level MPB population model to estimate the current extent of pine mortality, and to project the infestation into the future. As discussed under "Current state and projection of the infestation", this model predicts that about one billion cubic metres of mature pine within the timber harvesting land base will be affected by 2015. As of 2007 it is estimated that about half of this volume (530 million cubic metres) is already dead, but researchers are unsure as to how quickly the infestation will progress and what level of mortality will occur before the infestation ends.

Shelf-life

A major assumption affecting the results of this analysis is the shelf-life of the dead lodgepole pine, that is, the length of time it will remain commercially viable for a given product. For this analysis the product of concern was sawlogs, since the Interior forest sector primarily produces lumber. Once the shelf-life has passed for sawlogs, the volume not harvested may still be useable for chips or other non-sawlog products. Shelf-life depends on the moisture content of the log, which affects decay rates and checking, technology at the mill, and market prices. Given these variables, no single number can be determined that will apply in all locations for all mills.

The assumption of shelf-life for the analysis was derived based on the BCMPB model projection of the progression of beetle infestation through stands, as well as on harvest assessments and discussions with licensees and Ministry of Forests and Range district staff.

Based on that information, it was assumed that 100 percent of dead trees were useful as sawlogs for the first 2 years after being killed, 50 percent could be used as sawlogs in the third year after death, and 0 percent thereafter. The BCMPB model projects that progression of the infestation over the landscape. Combining the BCMPB landscape-level projection with the tree-level shelf-life estimate, the result is that pine-dominated stands are estimated to become uneconomical to harvest about four to eight years after initial attack as the sawlog volume remaining in the stand decreases below an economic threshold.

Some harvesting has occurred in stands that have been dead for longer than the four to eight year period. However, harvest assessments and discussions with licensees and district staff indicate that there has been limited harvest activity in stands with significant amounts of killed timber more than a few years after initial attack. As discussed later in this report, a **sensitivity analysis** was conducted to examine the timber supply impact of a longer shelf-life.

Sensitivity analysis is a timber supply analysis process used to examine how uncertainties about data and management practices could affect timber supply. Inputs to the analysis are changed, and the results are then compared to a baseline or base case.

Salvage harvest focus

In two recent MPB-related AAC decisions—for the 100 Mile House and Williams Lake TSAs—the chief forester stressed the importance of focusing the harvest on stands with at least 70 percent pine. The chief forester reasoned that those stands contain insufficient volume of other species to be economically viable in the mid-term if the pine is killed and goes beyond the shelf-life. The exception to this direction was stands with at least 70 percent pine that have a well-developed understorey which may grow through the dead canopy to produce a mid-term harvest opportunity. Similarly, pine-leading stands with less than 70 percent pine may have enough non-pine volume to provide a mid-term harvest opportunity in times of scarcity, despite their reduced volumes. It is recognized that beetle-induced mortality will reduce the economic value in pine-dominated stands. However, failure to salvage attacked stands with a large pine composition could result not only in loss of the pine volume, it could also delay the establishment of new stands. In addi-

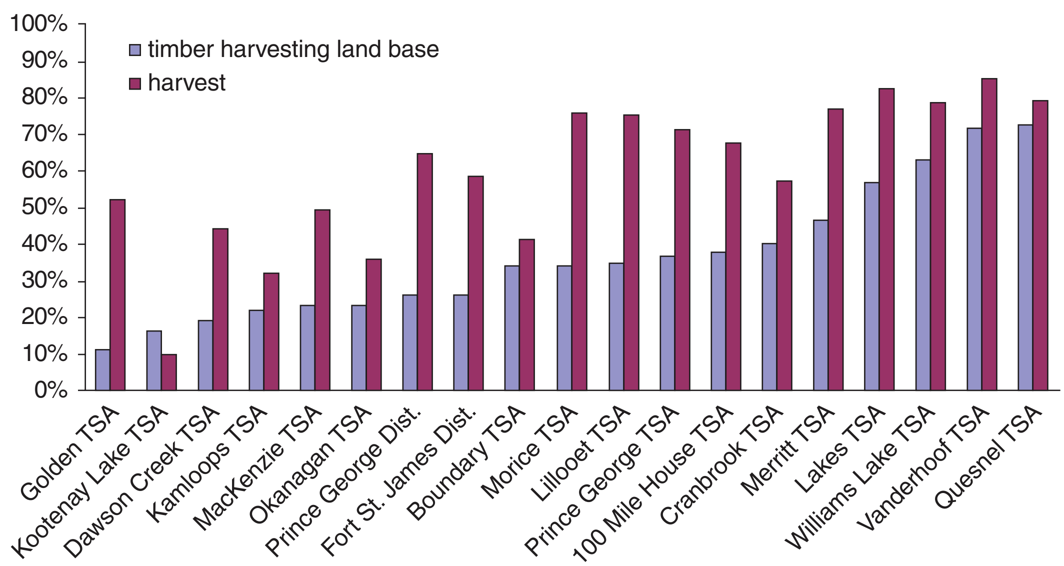
"In two recent MPB-related AAC decisions… the chief forester stressed the importance of focusing the harvest on stands with at least 70 percent pine."

tion, if harvests target stands with substantial amounts of either non-pine volume or understory trees, mid-term timber supply could be negatively affected.

In June 2007, the Ministry of Forests and Range released the report *Monitoring Harvest Activity across 16 Mountain Pine Beetle Impacted Timber Supply Areas*. This study compared the proportion of the harvest coming from stands with at least 70 percent pine to the proportion of the timber harvesting land base containing such stands. The time period assessed varied by TSA depending on the data available. However, in all cases the assessment covered a period prior to summer 2006. This study encompassed only 16 of the 20 TSAs presented in this report due to data limitations. The plan is to repeat the harvest monitoring study annually and to include all 20 TSAs in subsequent years. Figure 8 below summarizes some of the results of the study.

As seen in Figure 8, across the 16 TSAs, harvesting was largely focused on pine-dominated stands. However, results varied reflecting the unique circumstances in each TSA. For example, the Kootenay Lake TSA harvest is still focused on slowing the infestation by targeting any attacked pine stand, while other units, such as the Prince George District where the infestation is more advanced, are salvaging stands expected to become non-merchantable in the near future. For further details please refer to the original report [6].

Figure 8. Comparison of the percentage of the total harvest that came from stands with greater than 70 percent pine to the occurrence of these stands within the timber harvesting land base.



[6] Monitoring harvest activity across 16 mountain pine beetle impacted timber supply areas, June 2007 http://www.for.gov.bc.ca/hts/MPB_Harvest_2007.pdf

These results reflect the practices and market conditions of the time (prior to summer 2006). Given uncertainty about the future focus of salvage, the analysis explores the impact on mid-term timber supply of two harvesting scenarios that reflect the upper and lower bounds of the focus of salvage operations on stands with high pine content. Those scenarios are described under "Analysis scenarios and results".

Harvest flow

The 20 TSAs were modelled with the initial harvest targets matching the current AAC, including any **uplifts**. The harvest level was maintained until targeted stands were either harvested or became uneconomical to harvest due to trees going past their shelf-life and reducing the stand volume below the merchantability threshold of 65 cubic metres per hectare.

The mid-term harvest level was determined by finding the highest harvest a TSA could sustain that allowed the forest growing stock on the timber harvesting land base to recover to the level expected had this infestation not occurred. That growing stock level was defined based on the most recent pre-infestation Timber Supply Review analysis.

Young stand mortality impacts

There is much uncertainty about the impact of beetles on young stands. For this analysis, young stands (between 20 and 60 years old) were assumed not to experience beetle mortality. To gain some insight about the risks to mid-term timber supply of pine mortality in young stands, an examination of the species composition of these stands was undertaken. On average, 44 percent of stands in the study area between 20 and 60 years old were pine-leading.

As discussed earlier under "Stands at risk to mountain pine beetle – now and in the future", researchers have observed mortality in these young stands ranging from five to 20 percent. If mid-term timber supply is directly proportional to the mortality in stands currently between 20 and 60 years old – a reasonable assumption since these currently young stands will be one main source of the mid-term supply – the impact of mortality in young stands may be as little as four to five percent. However, if the mortality in young stands observed in the Prince George and Vanderhoof Forest Districts is more typical, then the impact to mid-term timber supply may be in the order of about 20 percent. This level of uncertainty indicates the need for additional work to provide a more refined estimate for subsequent updates of this report.

A more complete list of data sources and analysis assumptions can be found in Appendix A.

uplifts – B.C.'s chief forester has increased some allowable annual cuts temporarily to respond to the current infestation. Temporary uplifts involve the same detailed technical analysis and public review normally required for harvest level determinations, and all logging and forest practices reflect current requirements.

Analysis scenarios and results

The 20-TSA analysis done for this report and discussed below was not as detailed as those done to support AAC determinations. The purpose of this analysis is to provide an indication of what the future timber supply could be for the 20 beetle-affected TSAs that provide 81 percent of the current Interior AAC. The analysis reflects the current state of knowledge and is intended to point out some of the challenges the epidemic poses and encourage discussion amongst stakeholders about mid-term forest values.

Shelf-life is a key factor in determining the impact of the infestation. Once pine trees have been killed, they can remain standing for a number of years. However, their commercial value deteriorates steadily over time.

Of the key analysis assumptions outlined above, those that can most easily be influenced in the short term are the level of harvest and the degree to which that harvest is focused on stands subject to beetle attack. In order to demonstrate the impact of harvest strategy on mid-term timber supply in beetle-impacted TSAs, two harvest scenarios were run.

Scenario one

Scenario one focuses all short-term harvest in pine-dominated stands that are experiencing mortality (i.e., the stands expected to be unharvestable in the mid-term due to the beetle infestation). In this scenario, the first priority for harvest was stands with greater than 70 percent pine that have any mortality. The second priority for harvest was stands with greater than 70 percent pine that do not have mortality. The third priority was stands that are pine-leading but have less than 70 percent pine.

Non-pine leading stands were given the lowest priority for harvesting.

Within each priority group, stands with higher merchantable volumes were harvested before those with lower volumes. The initial harvest level (the current AAC) was maintained until the available stands of the first priority (stands with more than 70 percent pine and any mortality) were either harvested or became uneconomical to harvest due to trees exceeding their assumed **shelf-life**. As the modelled harvest level declined, harvesting shifted to available stands in the second, third and fourth priority groups sequentially.

The harvest forecast shaded in green in Figure 9 represents the harvest resulting from the first scenario, in which harvest focused on pine stands with mortality. This forecast is a summary of 22 separate forecasts for the 20 TSAs (Prince George TSA was analyzed as three separate forest districts).

The harvest forecast starts at the current AAC of 54.6 million cubic metres per year, which can be maintained for four years before declining to a harvest level near the pre-uplift AAC (37.2 million cubic metres per year) in the fifth year. The harvest forecast then declines more gradually to about 25.1 million cubic metres per year by year 11. As discussed under "Harvest flow", this harvest level

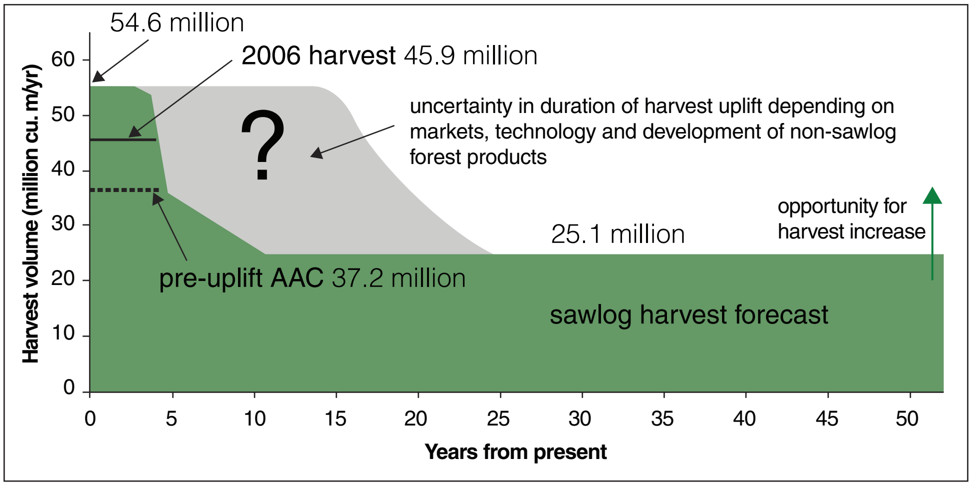


Figure 9. Timber supply forecast reflecting the harvest priorities of scenario one.

allows the growing stock to recover and affords the opportunity to gradually increase timber supply in some of the 20 TSAs starting about 50 years from now, as indicated by the green upward arrow.

As noted in "Introduction and objectives", the actual harvest in the 20 TSAs was 45.9 million cubic metres in 2006. The mid-term harvest level in the first scenario of 25.1 million cubic metres per year is about 29.5 million cubic metres below the current AAC, 20.8 million cubic metres below the 2006 harvest level, and 12.1 million cubic metres or 33 percent below the pre-uplift AAC of 37.2 million cubic metres.

As discussed under "Shelf-life", there is wide variation about the length of time dead wood is useable either as sawlogs or for non-sawlog forest products. If dead pine can be used for longer than assumed in this analysis or new products and markets are developed for dead wood, the uplifts could possibly be maintained for longer than was modelled in the sawlog forecast, as shown by the grey shaded area in Figure 9. This additional timber supply could come from the volumes of dead wood that are forecast to be unharvested in the sawlog forecast because stands become uneconomical to harvest as trees go beyond their assumed shelf-life.

Sensitivity analysis indicated that the ability to maintain the uplift levels is related directly to shelf-life. That is, if shelf-life were two years longer than assumed for this analysis, the uplift could be maintained for an additional two years.

In scenario one, over the next 20 years, 184 million cubic metres of dead wood past the shelf-life are forecast to be left unused after harvest of stands with at least 70 percent pine content, while 261 million cubic metres are forecast to be left unused in unharvested pine-dominated stands. In addition, new

"The mid-term harvest level in the first scenario of 25.1 million cubic metres per year is about…33 percent below the pre-uplift AAC of 37.2 million cubic metres."

uplifts may be possible in TSAs that have not yet experienced the peak in MPB mortality (e.g., Mackenzie TSA) which could provide additional sawlog volumes to extend the current AAC.

The maps in Figure 10 show projected declines from the pre-uplift AACs to mid-term timber supply levels for the 20 TSAs for both harvest priority scenarios.

The declines within the Prince George TSA are represented by district. Results for the first scenario, in which pine stands with mortality were targeted, showed six units in the least impacted category (Arrow, Bulkley, Fort St. James, Kootenay Lake, Okanagan, and Robson Valley) and three units in the highest impacted category (Lakes, Vanderhoof and Quesnel).

The magnitude of the decline to the mid-term timber supply for a TSA is a function of the degree to which pine was previously expected to contribute to mid-term supply, the amount of pine projected to be killed and on management requirements for non-timber values such as visual quality and biodiversity that restrict harvest in the mid-term.

Of the units analyzed, the Lakes TSA, Quesnel TSA and Vanderhoof District contain the most pine (Figure 2), experience the highest losses to the beetle, and therefore show the largest percent declines to the mid-term level. It should be noted that the timber supply forecast generated for the Bulkley TSA for this analysis projected a decline to the mid-term level that would technically place the TSA in the highest impact category. However, a significant decline in mid-term timber supply was expected in the Bulkley TSA prior to the beetle outbreak. Pine-leading stands contribute only about 18 percent to the Bulkley TSA timber harvesting land base, and the impact of the beetle infestation would be at most proportionate to the amount of pine on the land base. Therefore, the Bulkley TSA was placed in the lowest impact category. Units where large areas of the forest are managed for visual quality, such as the Kamloops TSA, were forecast to experience a larger mid-term decline than would be expected from the amount for pine projected to be killed. The larger impact occurred because the visual management requirements add to the beetle impacts by restricting harvest access to the already reduced supply.

Scenario two

The second scenario examined the impact on mid-term timber supply of avoiding harvesting in pine-dominated stands with mortality. For this scenario two groups of stands were created. Group one comprised stands with more than 70 percent pine and beetle-induced mortality. Group two comprised all other stands within the timber harvesting land base. The first priority for harvesting was the stands in group two.

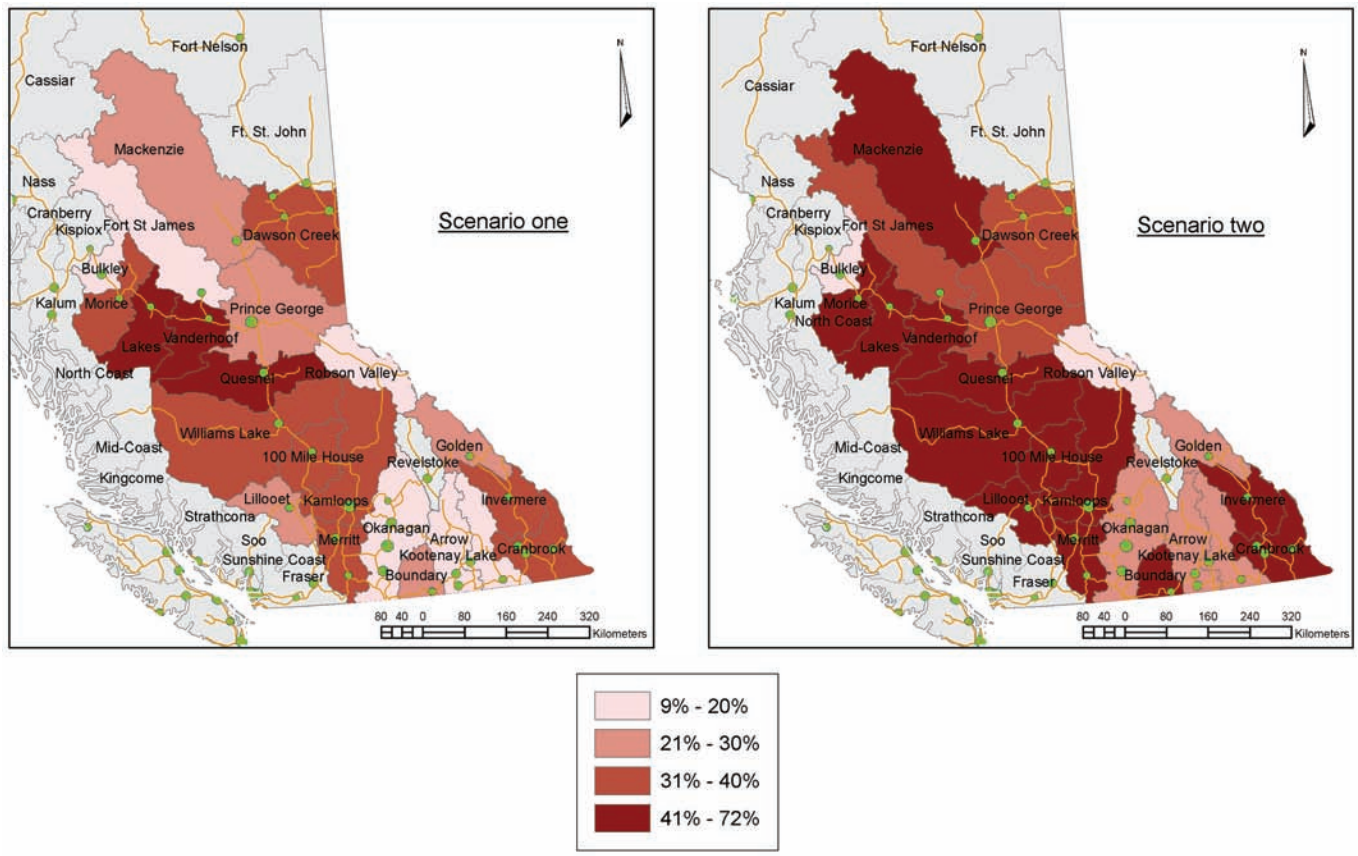


Figure 10. Percent decline in mid-term timber supply under alternative harvest strategies.

As in scenario one, stands with higher merchantable volumes were harvested before those with lower volumes. The initial harvest level in scenario two was maintained for the same length of time as in scenario one to facilitate comparison of the effect of harvesting strategies on mid-term timber supply.

The second scenario explored the impact of setting the harvest priority to avoid pine-dominated stands (greater than 70 percent pine) with mortality. This harvest priority resulted in a reduction in the mid-term harvest level to 20.5 million cubic metres or 18 percent lower than the mid-term of the first scenario (25.1 million cubic metres) or 45 percent below the pre-uplift AAC (37.2 million cubic metres).

From the evaluation of harvest activity discussed under "Salvage harvest focus", it is believed that current salvage harvesting activity is probably better represented by the first scenario than by the second, but harvest focus continues to be a concern given the potential mid-term timber supply impact.

The map in Figure 10 for the second scenario in which harvest priority was set to largely avoid dead pine, shows only two TSAs in the least impacted category

"Given the amount of regeneration that will be needed, the risk of future beetle outbreaks and a warming climate being a possibility, short-term silvicultural practices will have a large influence on forest conditions in the mid- and long-term."

(Bulkley and Robson Valley) and 13 units (TSAs or districts) in the highest impacted category (100 Mile House, Boundary, Cranbrook, Invermere, Kamloops, Lakes, Merritt, Mackenzie, Morice, Quesnel, Lillooet, Vanderhoof and Williams Lake).

Discussion of analysis results

The change in mid-term impact between the two scenarios demonstrates the sensitivity of mid-term timber supply to the short-term harvest strategy. Focusing harvesting now in pine-dominated stands with beetle kill, which are not expected to be available in the mid term, minimizes the reduction in mid-term timber supply resulting from the beetle infestation.

The analysis results also highlight the need to ensure forest management practices and priorities balance timber and non-timber values in future forests that will be significantly younger, lower volume and of different species composition than originally expected. Figure 11 shows the current and projected age class distributions of the timber harvesting land base within the 20 TSAs resulting from the first scenario. The amount of forest less than 50 years of age is predicted to climb from 21 percent today to over 45 percent within 30 years. The larger the beetle losses in a TSA the more significant the shift to young forests will be.

Given the amount of regeneration that will be needed, the risk of future beetle outbreaks and a warming climate being a possibility, short-term silvicultural practices will have a large influence on forest conditions in the mid- and long-term.

The contribution of dead pine stands to forest cover requirements for non-timber values also needs

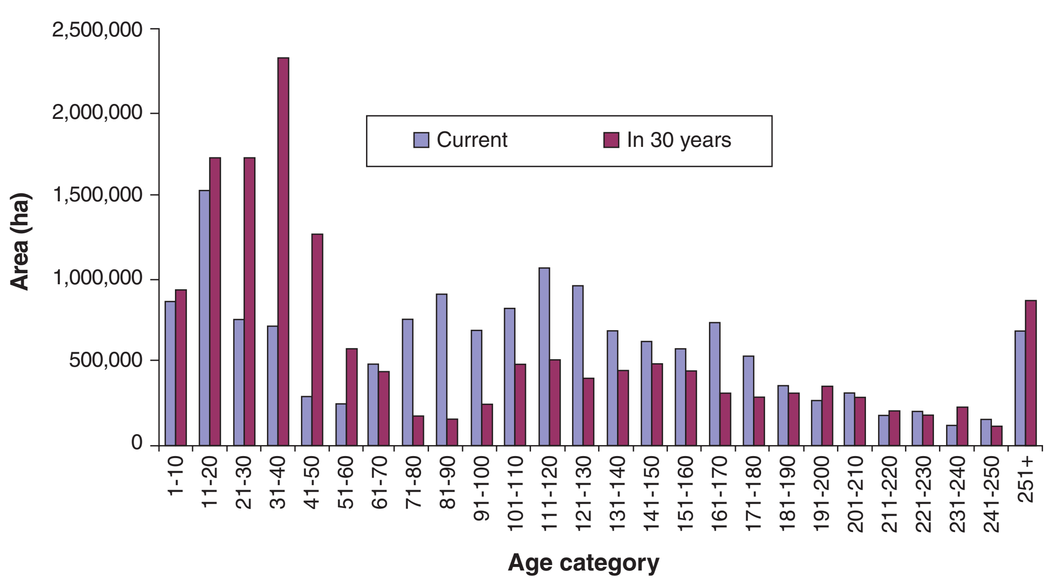


Figure 11. Current age class distribution on the timber harvesting land base compared to that expected 30 years from now for all 20 TSAs under scenario one.

to be considered. For the analysis, it was assumed that unharvested pine-leading stands with beetle-kill would contribute as mature forest to forest cover requirements for 30 years after attack. After the 30-year period, these unharvested stands were then treated as if they had been harvested (i.e., assigned an age of zero). Analysis results showed that forest cover requirements applied to achieve visual quality objectives restricted the mid-term timber supply in visually sensitive areas. Therefore, depending on how beetle-killed stands are treated with respect to forest cover requirements, visual quality and other objectives could have large impacts on timber availability. Attention will need to be given to whether stands regenerating naturally after beetle attack should be treated the same as a regenerating harvested stand or if they likely have characteristics that will contribute to achievement of forest cover requirements for non-timber values.

As stated earlier, there are many uncertainties in this analysis that could lead to a mid-term timber supply that is higher or lower than forecast in this analysis. For example, if the infestation does not ultimately kill almost 80 percent of the merchantable pine, or kills it more slowly than predicted, the mid-term could be higher than forecast. As discussed under "Timber supply analysis: Key assumptions and uncertainties", young-stand mortality not reflected in this analysis could reduce mid-term harvest levels from those presented in this analysis. Shelf-life, market prices, technology development, and other uses for the dead fibre all impact the amount of beetle-killed timber that could be used by the forest sector. As a result, the forecasts provided here do not describe a certain view of the future, and need to be updated as our knowledge of the infestation, the effects of forest management responses and other factors improves.

"…if the infestation does not ultimately kill almost 80 percent of the merchantable pine, or kills it more slowly than predicted, the mid-term could be higher than forecast."

Opportunities beyond sawlogs

As noted previously, the forecasts provided in this report reflect a specific set of assumptions including a sawlog economy. Those forecasts may not reflect the total utilization of beetle-killed timber across the Interior. While sawlogs will remain the highest value component of harvested stands, beetle-killed timber can be used for other purposes such as bioenergy and alternative wood products.

Increasing attention is being brought to the potential use of beetle-killed trees in bioenergy generation. Bioenergy includes wood-fired electricity generation, production of wood pellets, wood gasification, and liquid biofuel production. The provincial government has set a goal for electrical energy self-sufficiency in B.C. by 2016. As part of the *BC Energy Plan*, the province is developing a bioenergy strategy to promote new sources of sustainable and renewable energy to take advantage of MPB-infested timber and other biomass resources. The goals of the strategy are for bioenergy to help meet electricity needs, supplement conventional natural gas and petroleum supplies, maximize job and economic opportunities, promote diversity and competitiveness in the province's forestry and agriculture sectors, and protect health and the environment.

Substantial amounts of electricity are already produced using wood. Energy co-generation using sawmilling waste and wood chips is a big part of the wood processing industry in B.C. The production of wood pellets is a mature industry in British Columbia, with exports going primarily to the European thermal power industry. Through the *BC Energy Plan*, B.C. Hydro is expected to issue a call for proposals for further electricity generation from wood residue and MPB-infested timber.

Existing markets for bioenergy are growing, including the world wood-pellet market, domestic and international electricity markets, and emerging bio-fuel and biochemical markets. B.C. is committed to taking advantage of its position as a developer of technology and as a producer of value-added bio-products. Bioenergy can help to achieve social demands to reduce greenhouse gas production and reliance on fossil fuels.

When determining the amount of wood to allocate to electricity generation in the short term, potential competing demands will need to be considered. For example, emerging opportunities such as bio-refining will likely develop within 5 to 10 years, as will markets for carbon sequestration. Further, some beetle-killed stands will need to be reserved from harvest to protect the younger trees that are growing underneath them, since that advanced regeneration will form part of the future timber supply. Finally, other trees will need to be reserved to protect forest values such as water quality and quantity, biodiversity, wildlife habitat, and cultural and social values.

In addition to bioenergy, there is the potential for use of beetle-killed trees in engineered wood products. New sawmilling technologies under development may allow greater value to be attained from low-grade, dead trees. When markets improve, mills that invest in new equipment will be positioned to create high-value products from stands which are not attractive under today's market conditions.

Economic implications

This section provides further discussion on some of the industry and market issues associated with bioenergy and alternative wood production.

The structure of the B.C. Interior forest sector has been changing for the past 15 years. To compete in the global market place, the Interior forest sector has made significant investments in plants and equipment to increase the efficiency of its operations. These investments have resulted in fewer but more highly skilled workers in the sector. The MPB infestation has accelerated and concentrated many of these changes.

The economic implications of the MPB epidemic will depend on many factors including but not limited to:

- The ability of industry to utilize beetle-killed timber;
- The dependency of a community on the forest sector for its employment and economic base;
- The relative share of the harvest associated with pine; and
- The relative strength of the B.C. economy and job market.

The capability of the forest sector to utilize timber killed by the MPB is strongly linked to both the time period over which the timber will be used and the existing plant and equipment in the area. In the next two to three years, firms are limited to using existing manufacturing capacity and technologies, while over the next four to seven years, new technologies could be used within existing manufacturing plants. Because of the limitations on introducing new technology and building new facilities to use the dead timber, the uplift volumes will need to be processed primarily using existing plants and equipment, with the potential for integration of some new technologies into that existing capacity.

Based on data from the 2005 *Major Primary Timber Processing Facilities in British Columbia Survey*, it is clear the forest sector is focused on production of commodity grade lumber. Approximately 84 percent of the sector's capacity is structured to manufacture lumber used in building houses.

Given the current significance of lumber production, the capability of industry to use the uplift volume over the next several years is a function of factors that affect the demand, price, and profitability of commodity grade lumber, along with the sawlog shelf-life of the dead timber. The level of U.S. housing starts, access rules to the U.S. market as set out under the Softwood Lumber Agreement, and the Canadian dollar exchange rate are three such factors.

"It is therefore important that a clearer understanding of the shelf-life characteristics of beetle-damaged timber for sawlogs and other products be developed."

Beyond several years from now, there is the possibility of replacing existing plants and equipment with new technologies and facilities that could improve utilization of damaged timber. These kinds of technologies could range from the development of new bioenergy processes to production of strand lumber or other uses not currently identified.

The most significant driver for longer-term utilization of beetle-killed timber may well be wood characteristics of trees in the years after beetle attack, which determines shelf-life for various products. The longer damaged timber remains sound, the greater the time available to recover investments in new technologies. Firms will be unlikely to invest in new technologies if the new facilities will experience shortages of appropriate timber before they can pay off the costs of development.

It is therefore important that a clearer understanding of the shelf-life characteristics of beetle-damaged timber for sawlogs and other products be developed. This will allow industry to better evaluate the relative risks and rewards of developing a new use for damaged timber.

Once beetle-killed timber can no longer be utilized, the economic impact on communities will depend on the degree to which the forest sector underpins a particular community's economic base — the more diversified the economy the smaller the overall impact. In addition, the relative share of the harvest associated with pine will affect the economic impact on communities. Areas where non-pine species make up a greater proportion of the harvest will likely experience smaller socioeconomic impacts.

Finally, the scope of the possible economic impacts is also related to the overall level of the provincial economy. In many areas it may be possible for impacted forestry workers to readily find alternative employment in other sectors that are expanding and recruiting workers. The forest sector is currently finding it difficult to keep and recruit workers. The skill-sets of many workers in the forest sector are easily transferable to other expanding industries like construction and oil and gas.

Considerations in determining cut levels in the short- and mid-term

When determining cut levels in management units impacted by the beetle epidemic, the chief forester must weigh the potential benefits of salvage harvesting in the short term—recovering economic value from dead pine before it decays, rapid return of stands to timber production, reduction of fire hazard—against the need to maintain non-timber values, and the desire to ensure mid-term timber supply is as high as possible. Even if it were possible to harvest every stand containing dead pine, it would not be a desirable course of action. Since pine does not always grow in pure stands, it is inevitable that there will be pine losses in mixed stands.

In addition to accepting volume losses in mixed stands, a number of other considerations need to be weighed against the desire to minimize loss of pine volume. Some additional considerations that can temper estimates of short-term timber availability are briefly outlined below.

Hydrology

Trees affect stream flows mainly through evapo-transpiration, shading and interception of rain and snow. Beetle-killed trees do not transpire moisture into the air, and are less effective than live trees in providing shade and interception; therefore, the infestation could affect hydrology.

Recently the Forest Practices Board released *The Effect of Mountain Pine Beetle Attack and Salvage Harvesting on Streamflows*. The report describes computer modelling efforts to examine the combined effects of beetle infestation and salvage operations on stream flows in the 1,570-square-kilometre Baker Creek watershed near Quesnel.

Varying beetle attack and salvage harvesting levels were modelled to help determine the scale of hydrological changes to Baker Creek. The Baker Creek model indicates the mountain pine beetle epidemic could increase stream flow in spring since impacted stands allow more sun to penetrate, and snow melt occurs faster. In addition, the model suggests that spring flows could be increased further by clearcut salvage logging of beetle-infested trees, since shading is further reduced when trees are removed. This more rapid snow melt could result in flood events occurring more frequently than in the past.

The Ministry of Forests and Range has recently published a report that discusses the hydrological consequences of the infestation and associated salvage operations, and maps that identify watersheds that have high hydrological sensitivity to beetle attack due to their high proportion of mature pine.[7] The report and maps provide guidance for the planning of salvage

"Even if it were possible to harvest every stand containing dead pine, it would not be a desirable course of action."

[7] www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/hydrology/

operations, including deciding if such operations should occur in areas of hydrological concern.

In March 2007, the chief forester released a letter outlining current research and sources of guidance on managing interactions between logging MPB-infested stands and hydrology.[8]

Research will continue to increase the understanding of hydrological impacts of the beetle infestation and salvage operations with a view to improving guidance for forest management.

Secondary structure is trees that are either younger or a different species compared to the dominate trees in the upper forest canopy.

Secondary stand structure

In 2006, Coates et al[9] released a report on the *Abundance of Secondary Structure in Lodgepole Pine Stands Affected by the Mountain Pine Beetle*. This report highlights that some pine-dominated stands have a considerable number of non-pine stems in the canopy, sub-canopy and **understorey** that could potentially produce a mid-term harvest opportunity faster than if the stands were harvested and regenerated. In response, the Ministry of Forests and Range is examining alternatives to ensure that forest professionals identify stands with a minimum number of healthy secondary structure trees and either retain these areas until the mid term, or harvest in a manner that protects the secondary structure.

Understorey is the lower level of vegetation in a forest. In this report, it specifically refers to the smaller regenerating trees.

Short of ground-sampling all stands, the identification of stands that have sufficient secondary structure is difficult at the landscape level since the inventory does not contain sufficient information to identify these stands. Despite the difficulty in identifying stands with substantial secondary structure at the landscape level, some consideration of the potential role of these stands in providing mid-term timber supply will be warranted when determining harvest levels.

Biodiversity conservation

In December 2005, the chief forester released guidance on structural retention in large-scale MPB salvage operations[10]. One reason for retaining structure at the stand and landscape levels is to conserve biodiversity.

Objectives for biodiversity conservation were incorporated into the analysis described in this report in different ways depending on the status of biodiversity planning in each TSA. In the 100 Mile, Arrow, Boundary, Bulkley, Cranbrook,

8 http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/Chief_Forester_Hydrology_200703.pdf

9 Coates, K. David, Craig DeLong, Philip J. Burton, and Donald L.Sachs. 2006. Abundance of Secondary Structure in Lodgepole Pine Stands Affected by the Mountain Pine Beetle. Report for the Chief Forester. http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/report.pdf

10 http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/stewardship/cf_retention_guidance_dec2005.pdf

Golden, Invermere, Kamloops, Kootenay Lake, Merritt, Okanagan, Quesnel, Robson Valley and Williams Lake TSAs, where proposed or approved Old Growth Management Areas (OGMA) have been geographically located, specific areas were excluded from the land base available for harvesting. In the other six TSAs where OGMAs are not geographically defined, forest cover requirements were applied to attempt to ensure that a minimum amount of area was retained in an old-growth condition within the crown productive forest and the timber harvesting land base.

Projected timber supply in TSAs modelled with non-spatial biodiversity constraints was more affected by shortages of old forest in the mid-term than those with geographically defined OGMAs. The difference in potential impacts occurred because where aspatial requirements apply and old forest that was reserved to meet the requirements was killed, the model searched for replacement areas. Conversely, OGMAs that were affected by the beetle were not replaced with other old forest areas.

This difference raises the question of how biodiversity conservation and mid-term timber supply will be balanced. Retention of additional areas for biodiversity where existing OGMAs are affected by the infestation will reduce timber supply in the mid-term. Conversely, maximizing mid-term timber supply would likely mean that old forest areas affected by the beetle, which may not have ideal old forest conditions, would nevertheless need to be relied on for biodiversity conservation in the mid-term. These are choices that will need to be considered in harvest level determinations and in planning of salvage operations.

Wildlife

In timber supply analysis, wildlife habitat objectives are typically accounted for either by excluding habitat areas from the timber harvesting land base or applying forest cover requirements that require a minimum amount of the habitat area to be maintained in conditions needed by the wildlife species (normally mature or old forest). While this analysis incorporated reductions in the timber harvesting land base to account for wildlife habitat, forest cover requirements for habitat were not modelled. Therefore, the results likely overestimate timber supply, particularly in the mid-term.

Mortality associated with the MPB infestation will reduce the availability of mature stands for

"There is uncertainty about how the infestation will proceed, how much mortality will be experienced in younger stands, how much of the harvest will be directed to stands with significant beetle kill, and the length of time dead pine can be used for sawlogs or other products."

timber and for wildlife habitat in both the timber harvesting land base and forested areas unavailable for harvesting (e.g., parks, reserves, inoperable areas). While this will create competing demands for timber and habitat supply, the impact of the MPB will more profoundly affect the availability of harvestable timber than wildlife habitat because a disproportionate amount of susceptible stands occur within the timber harvesting land base.

Nevertheless, in many areas of the Interior, forests with high wildlife habitat value are dominated by old non-pine stands. Hence, a similar issue exists for wildlife as for biodiversity conservation. There will be competing demands on forests in the mid-term for wildlife habitat and timber supply, and a balance will need to be achieved between the values.

Over the coming years, to balance the needs of habitat and timber supply, it would be beneficial for research and adaptive management activities to focus on ways of integrating timber harvesting and wildlife habitat management, and more quickly developing and enhancing important habitat conditions in younger stands.

Summary and conclusions

This report has described an analysis focused on assessing the impact of the MPB on mid-term timber supply. It is estimated that the MPB epidemic will have killed 530 million cubic metres of pine by 2007, and this is projected to increase to over one billion cubic metres by 2015. The 20 TSAs analyzed in this report account for 87 percent of the mature pine in the Interior of the province. These 20 TSAs have a combined AAC of 54.6 million cubic metres per year or 81 percent of the Interior AAC. The actual harvest in 2006 from these 20 TSAs was 45.9 million cubic metres.

There is uncertainty about how the infestation will proceed, how much mortality will be experienced in younger stands, how much of the harvest will be directed to stands with significant beetle kill, and the length of time dead pine can be used for sawlogs or other products. With these uncertainties in mind, the analysis suggests that mid-term timber supply could be between 20.5 and 25.1 million cubic metres per year for the 20 TSAs depending on the degree of focus of salvage operations on stands with high pine content and significant mortality.

Based on the assumed sawlog shelf-life, the analysis indicates that timber supply could start declining in some TSAs within 4 to 5 years. The length of time the short-term timber supply could be maintained is highly dependent on shelf-life, which is subject to uncertainty. Shelf-life is a function of many variables including climate, markets, technology and the ability to develop new products in which dead pine can be utilized. There is enough dead volume in highly-affected stands to maintain uplifts longer if dead volumes can be utilized for longer than assumed in the analysis. Sensitivity analysis indicated that the ability to maintain the uplift levels is related directly to shelf-life. That is, if shelf-life were two years longer than assumed for this analysis, the uplift could be maintained for an additional two years. Additional AAC uplifts may be determined in TSAs where the infestation has not yet peaked, further extending the short-term timber supply increase in the Interior.

When setting short-term harvest levels, several other considerations should be weighed against the objective of maximizing utilization of killed pine. These considerations include: watershed hydrology; the potential for stands—including those with non-pine volume or substantial amounts of secondary structure—to contribute to mid-term timber supply; and non-timber values such as biodiversity and wildlife habitat. In the mid-term, decisions will need to be made about the balance between desires to harvest in stands after the infestation is over, and to preserve those same stands to protect non-timber values. Management plans and practices will likely also need to be reviewed in light of the rapid changes occurring in forests in beetle-affected TSAs.

As with the 2003 report, this report will need to be updated in the future. Further work will focus on refining the assumptions that influenced the mid-term timber supply forecasts presented in this report, more fully assessing the impact of juvenile stand mortality on timber supply and further investigating management options to balance timber and non-timber values in the mid-term.

Appendix A
Data sources and analysis assumptions

The total area of the 20 TSAs is 46 million hectares. The timber harvesting land bases for the 20 TSAs were defined using the most recent information available at the time the analysis was initiated, which was derived from the most recent timber supply review or land use plan decision for each management unit. The resulting timber harvesting land base for the 20 TSAs was about 15.6 million hectares.

- Inventory depletions — depletions were updated to 2006 to reflect recent harvesting activity.
- Projection of the MPB infestation — the infestation was assumed to progress as projected by the Ministry of Forests and Range and the Canadian Forest Service Provincial-Level Mountain Pine Beetle Model (BCMPB Version 3). This model uses forest cover maps, the Provincial Aerial Overview of Forest Health and information from a stand-level MPB population model to estimate the current extent of pine mortality, and to project the infestation into the future.
- Young-stand mortality — mortality in young stands (less than 60 years old) was not modelled directly in this analysis.
- Shelf-life — for scenarios one and two, assumed shelf-life was based on suitability for sawlogs. It was assumed that 100 percent of dead trees were useful as sawlogs for the first 2 years after being killed, 50 percent could be used as sawlogs in the third year after death, and 0 percent thereafter. This shelf-life assumption was based on harvest assessments and discussions with licensees and Ministry of Forests and Range district staff. The BCMPB projection assumes that mortality in a stand occurs over a number of years. Pine-dominated stands are estimated to become uneconomical to harvest about four to eight years after initial attack when the sawlog volume remaining in the stand decreases below an economic threshold. While some harvesting has occurred in stands that have been dead for longer than the four- to eight-year period, harvest assessments and discussions with licensees and district staff indicate that there has been limited harvest activity in stands with significant amounts of killed timber more than a few years after initial attack. Given uncertainty about shelf-life, a sensitivity analysis was conducted to examine the timber supply impact of extending the shelf-life by two years. Ongoing research and increased experience with killed timber are increasing the understanding of shelf-life.

- Merchantability threshold — a stand was considered merchantable until the green and dead pine volume not yet past the sawlog shelf-life dropped below 65 cubic metres per hectare.
- Site productivity and regeneration of harvested sites — in developing volume estimates for harvested and salvaged stands species mixes for planting were based on RESULTS records. Managed stand yield tables were generated using site indexes from the SIBEC system. The site index for the zonal site series was applied based on the BEC variant of the harvested site.
- Regeneration of killed stands — if a stand containing more than 70 percent pine became non-merchantable due to beetle attack and was not harvested, it was assumed to regenerate to natural stand yield curves with a 30-year regeneration delay. The killed stand was assumed to contribute to meeting requirements for non-timber values for 30 years after death. Salvaged stands were assumed to regenerate to managed stand yield curves.
- Harvest priority — two harvest scenarios were analyzed to explore the impact of harvesting activity on mid-term timber supply.
    1. The first scenario prioritized harvest based on highest stand volume within 70 percent plus pine stands with some mortality, then 70 percent plus pine stand without mortality, then pine-leading stands with less than 70 percent pine, and then the remainder of the stands in the timber harvesting land base;
    2. In the second scenario, highest harvest priority was given to stands with the highest stand volume, while attacked stands containing over 70 percent pine were given lowest priority.
- Initial harvest level — the 20 TSAs were modelled individually with the initial harvest target matching the current AAC, including any uplifts, and lasting until merchantable 70 percent plus pine stands with beetle attack were no longer available.
- Mid-term harvest level — the mid-term harvest level was selected as the harvest level that would allow the merchantable growing stock on the timber harvesting land base to return to the level projected in the last timber supply review within 100 years. Changes in the timber harvesting land base since the most recent analysis were considered when determining the target growing stock.

- Biodiversity — where information on updated spatial old growth management areas (OGMA) was available it was used to exclude the OGMAs from the timber harvesting land base. Where OGMAs have not been spatially defined (Lakes, Morice, Lillooet, Prince George, Dawson Creek and McKenzie TSAs), non-spatial biodiversity forest cover requirements were applied.
- Visually sensitive areas — visually sensitive areas were identified for the analysis and forest cover constraints applied to reflect the visual objectives for the area.
- Adjacency — except for visual quality requirements, adjacency constraints were not applied.
- Wildlife — areas reserved for exclusive wildlife use were excluded from the timber harvesting land base but to simplify the analysis, forest cover requirements for wildlife were not applied.

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