

Provincial-Level Projection of the Current Mountain Pine Beetle Outbreak:

Update of the infestation projection based on the
2007 Provincial Aerial Overview of Forest Health
and revisions to the “Model” (BCMPB.v5)

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1 Introduction

For each of the past five years, we have released an updated version of the Provincial-Level Mountain Pine Beetle Model (BCMPB)¹. The model uses forest cover maps², the Provincial Aerial Overview of Forest Health³ and information from a stand level mountain pine beetle (MPB) population model⁴ to estimate the current extent of pine mortality, and to project a possible course of the infestation into the future.

We have now completed a revised estimate of current and potential future impact of the MPB infestation based on the 2007 Provincial Aerial Overview of Forest Health and revisions to “the model” (BCMPB.v5)⁵. This year’s results are only slightly different than last year’s results⁶ but continue to provide insight into how the infestation may progress in the future.

It is important to note that the results of the projection of the infestation described in this document do not include any effects of forest management. Here we discuss only the infestation itself.

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 <http://www.for.gov.bc.ca/hre/bcmpb/BCMPB.v5.ModelDocumentation.Update.pdf>

⁶ <http://www.for.gov.bc.ca/hre/bcmpb/BCMPB.v4.BeatleProjection.Update.pdf>

2 Summary of Results

2.1 Annual Mortality

We currently estimate that the provincial peak in annual kill for this outbreak occurred during the summer of 2004 and was seen during the summer of 2005⁷. At the peak, we observed an annual mortality of approximately 141 million m³ of merchantable (>12.5 cm dbh) pine on the Timber Harvesting Land Base (THLB)⁸. Mortality has declined since then, and we now estimate that approximately 99 million m³ of merchantable pine on the THLB were observed killed during the summer of 2007 (killed during the summer of 2006) (Figure 1). We now project that the infestation will continue to subside rapidly for one more year, after which time the rate of annual mortality will remain in the 68 to 78 million m³ range until 2011. At that time, the infestation will begin to subside rapidly again, and within 7 years it is projected that less than 5 million m³ will be killed annually.

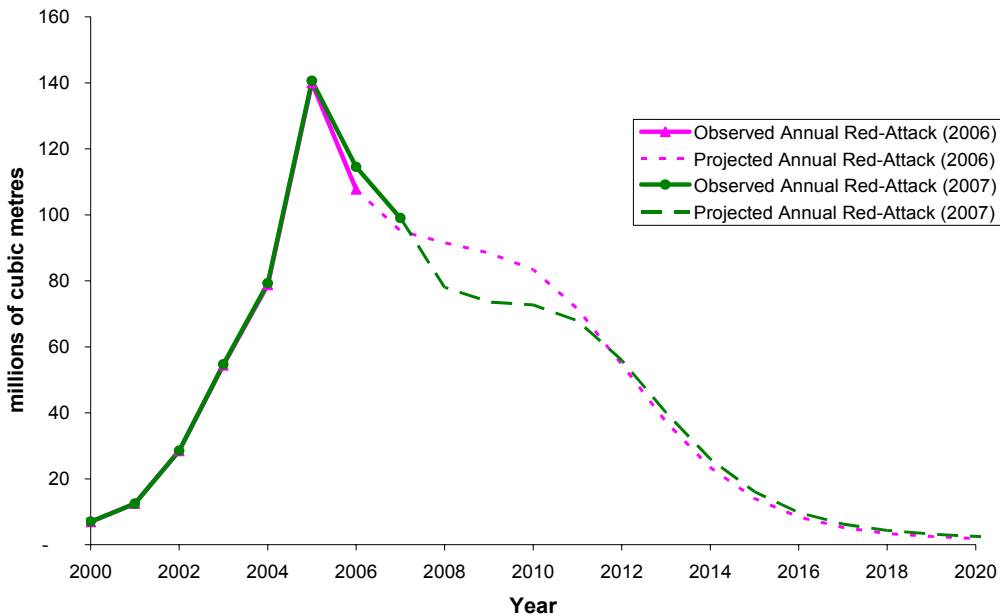


Figure 1. Comparison of observed and projected annual kill (red-attack) on the Timber Harvesting Land Base of the entire province, based on the 2006 and 2007 Provincial Aerial Overviews.

There is substantial variation in the timing and magnitude of the peak in annual kill in different management units throughout the province. Table 1 shows that there are

⁷ Note that the mortality caused by MPB (green-attack) occurs in the year prior to that in which it is observed by the Provincial Aerial Overview of Forest Health (observed as red-attack). The model (BCMPB) reports on and projects the overview and we, therefore present the “observed mortality” in graphs and tables unless otherwise specifically noted.

⁸ All volume figures reported are for the Timber Harvesting Land Base only.

4 “pine units”⁹ where the peak in annual kill (green-attack) probably occurred in 2004: Vanderhoof Forest District, Quesnel, Lakes and Prince George Forest District. The peak in kill probably occurred in Williams Lake, 100 Mile House, and Kamloops in the summer of 2005, and Fort St. James probably experienced peak mortality in 2006. We believe the infestation peaked in Morice this past summer. The remaining pine units, near the periphery of the current outbreak, will peak sometime within the next four years.

Table 1. Observed (2004 – 2006) and projected (2007 – 2011) annual **green-attack** volume (millions m³) for the 22 “pine units” (peak year of kill is highlighted by an outlined box). Note that the mortality caused by MPB (green-attack) occurs in the year prior to that in which it is observed by the Provincial Aerial Overview of Forest Health (observed as red-attack).

Pine Unit	Year							
	2004	2005	2006	2007	2008	2009	2010	2011
Vanderhoof (District)	25.0	7.2	3.9	2.0	0.9	0.4	0.2	0.2
Quesnel	23.8	11.7	5.1	1.7	0.5	0.2	0.1	0.1
Lakes	15.0	9.9	6.2	3.4	1.4	0.7	0.3	0.2
Prince George (District)	12.5	8.3	7.7	3.3	1.8	1.0	0.6	0.4
Williams Lake	19.4	20.8	17.5	12.9	8.6	5.0	2.7	1.3
100 Mile House	8.6	18.0	7.1	2.7	1.3	0.7	0.4	0.3
Kamloops	6.0	9.1	6.8	5.1	3.9	2.7	1.8	1.2
Ft. St. James (District)	10.7	8.9	14.7	10.8	9.3	7.7	6.3	4.5
Morice	3.7	6.4	5.8	6.5	6.0	4.3	2.7	1.6
Lillooet	0.4	0.9	1.2	2.2	2.9	2.7	2.0	1.3
Merritt	1.3	2.5	3.9	6.1	7.8	8.3	6.7	4.6
Dawson Creek	0.0	0.1	2.7	3.4	4.3	4.6	3.6	2.3
Bulkley	0.1	0.1	0.2	0.6	1.5	2.2	2.1	1.5
Robson Valley	0.1	0.2	0.3	0.4	0.6	0.7	0.6	0.4
Arrow	0.5	0.6	0.2	0.3	0.6	0.8	0.8	0.6
Mackenzie	0.6	2.1	4.8	5.5	7.9	11.6	14.2	13.5
Okanagan	1.0	1.4	1.7	2.6	4.5	6.3	6.6	5.6
Invermere	0.2	0.3	0.2	0.3	0.7	1.1	1.3	1.1
Golden	0.2	0.3	0.1	0.1	0.2	0.4	0.5	0.5
Cranbrook	0.6	0.5	0.2	0.4	0.8	1.9	2.9	3.5
Boundary	0.1	0.2	0.1	0.2	0.6	1.3	2.0	2.1
Kootenay Lake	0.3	0.4	0.2	0.4	0.7	1.1	1.4	1.5
Grand Total	130.3	109.8	90.5	70.8	66.7	65.5	59.9	48.1

The rate at which the provincial annual kill will subside is a matter of substantial uncertainty that arises, in part, from the uncertainty around when and how intensely the infestation will peak in areas on the periphery of the current outbreak. In particular, there are three pine units on the periphery of the current outbreak with significant amounts of live pine (i.e. Mackenzie, Merritt, Okanagan). The timing and intensity of the outbreak in these areas will influence the provincial rate of infestation subsidence. Other pine units near the periphery of the current outbreak

⁹ Pine units are defined as those Timber Supply Areas (TSA) where more than 10% of the merchantable volume is pine. Note that the individual forest districts in the Prince George TSA are reported on separately.

have also not yet experienced their peak in annual kill, but these units contain less pine and, therefore, will have less impact on the provincial rate of infestation subsidence.

An additional source of uncertainty is that we don't really know how much infestations on the periphery are driven by beetle dispersal from management units at the heart of the current outbreak (Vanderhoof, Quesnel, Lakes and Prince George). It may be that outbreaks in peripheral landscapes subside faster than expected once the central outbreak subsides¹⁰. BCMPB projections include a "dispersal pressure" component to capture some effect of beetle movement between regions, but the true extent and importance of dispersal remains unknown, and BCMPB does not completely account for observed spatial structure in the infestation data.

2.1.1 Comparing Annual Mortality from Last Year's Results to This Year's Results

The annual mortality observed (red-attack) during the summer of 2007 was nearly the same as that projected last year by BCMPB.v4. Last year, we projected that approximately 95 million m³ of merchantable pine on the THLB would be observed killed during the summer of 2007. We now estimate that approximately 99 million m³ of merchantable pine on the THLB were observed killed during the summer of 2007 (about 4% higher than projected). The higher than anticipated annual kill, however, was not consistent across the provincial THLB.

Dawson Creek Timber Supply Area and Fort St. James Forest District both experienced higher than anticipated amounts of observed red-attack in the summer of 2007, but for separate reasons. In the summer of 2006, Dawson Creek experienced an unexpected mass immigration of beetles originating from the outbreak in the central interior. This caused the mortality to increase dramatically from 0.1 million m³ in 2005 to 2.7 million m³ in 2007 (Figure 2).

The higher than anticipated infestation in the Fort St. James Forest District was due to dramatic year-to-year variations in the aerial overview mapping in Fort St. James. Last year, BCMPB.v4 showed a sharp decline in the observed volume of pine killed between 2005 and 2006. This decline may have resulted in BCMPB.v4 generating a more conservative estimate of the rate of infestation growth in this area. BCMPB.v5 with the addition of the 2006 aerial overview of forest health, however, now shows another dramatic increase in the observed annual red-attack (Figure 3). This may explain the lower than anticipated infestation in Fort St. James in 2006.

An interesting feature to note about Fort St James Forest District is the significant difference between the 2006 estimate of observed annual red-attack derived from BCMPB.v4 and BCMPB.v5. BCMPB.v4, which used the 1999 through 2006 aerial overviews of forest health, showed a significant drop in the annual red-attack between 2005 and 2006. BCMPB.v5, which additionally includes the 2007 aerial overview of forest health, shows a subsequent rise in the annual red-attack following this drop. What is interesting is that BCMPB.v5 increases the estimate of annual

¹⁰ Recent detailed MPB population studies in Dawson Creek TSA and west-central Alberta show that external immigration is a key driver of population dynamics in these regions.

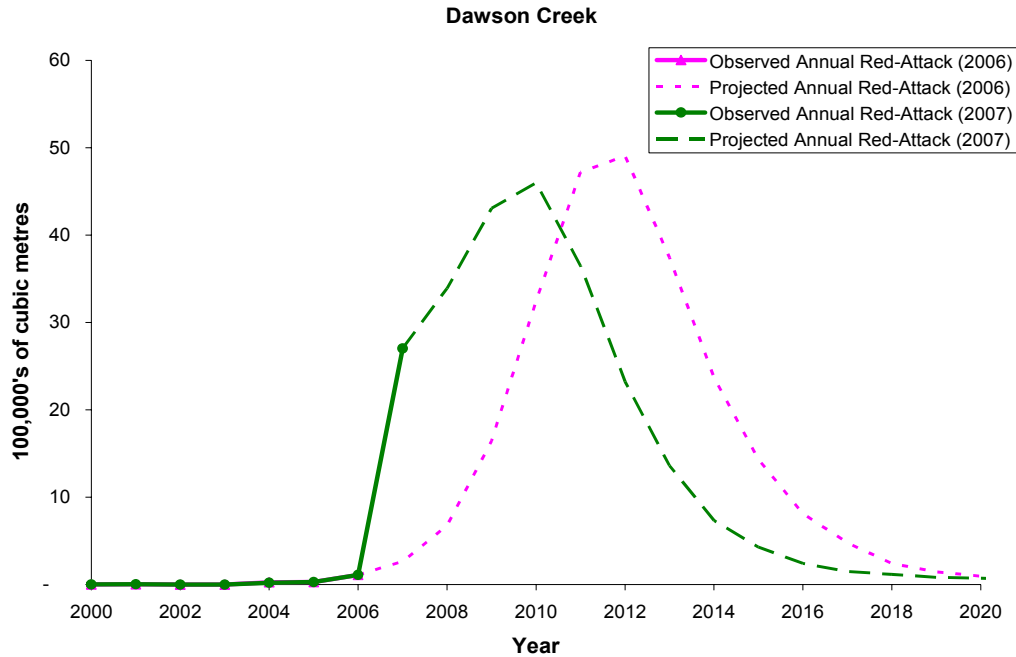


Figure 2. Observed and projected annual red-attack for the Dawson Creek Timber Supply Area, based on the 2006 and 2007 Provincial Aerial Overviews of Forest Health. Dawson Creek Timber Supply Area experienced a dramatic increase in annual pine mortality between 2006 and 2007 due to an unexpected mass immigration of mountain pine beetles from the outbreak in the province’s central interior.

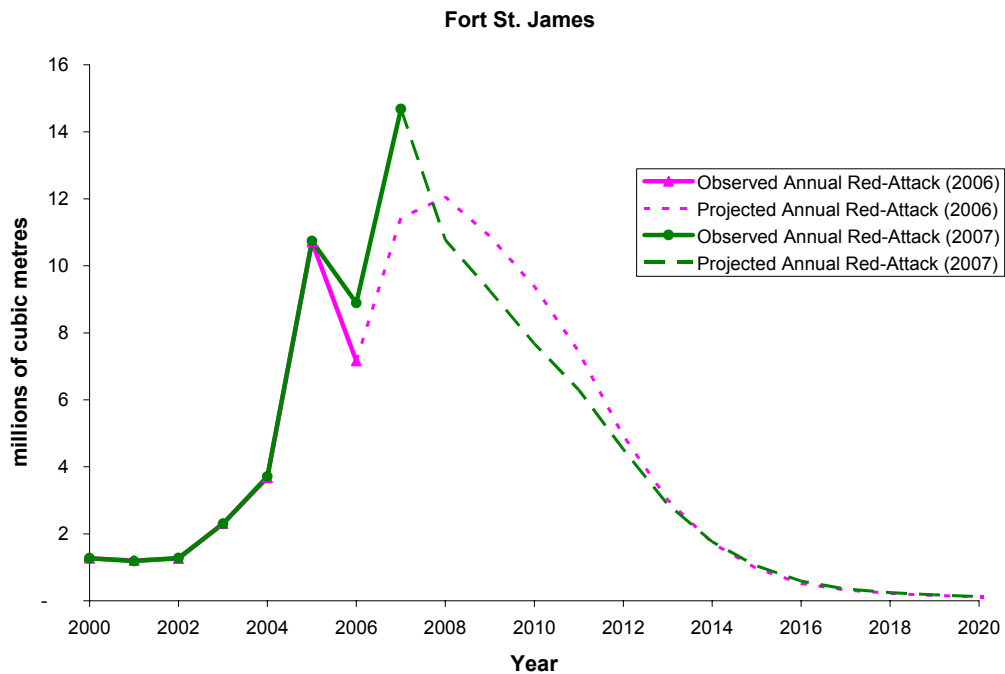


Figure 3. Comparison of the observed and projected annual red-attack for the Fort St. James Forest District, based on the 2006 and 2007 Provincial Aerial Overviews of Forest Health. Fort St. James experienced a dramatic fluctuation in the observed annual red-attack between 2005 and 2007.

red-attack for 2006, which reflects the model’s assumption that a significant decrease in infestation severity at a given location followed by a significant increase in infestation severity is “unrealistic”. Consequently, the model increases the infestation severity at such locations in the intervening year to reduce the impact of this assumed inconsistency.

In comparison to the 2007 projected annual mortality from BCMPB.v4, the pine units at the periphery of the current infestation, which the model projects will encounter peak amounts of green-attack volume between 2007 and 2010, all experienced lower than anticipated amounts of annual kill (on average, 300,000 m³ lower than anticipated) (see Figure 4 for an example).

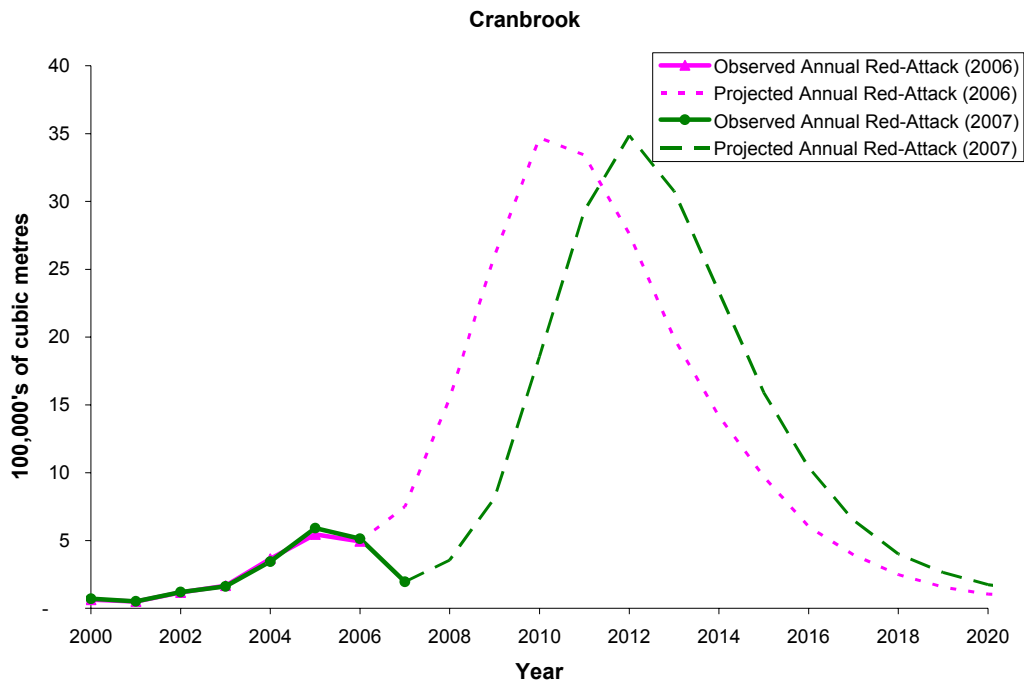


Figure 4. Comparison of the observed and projected annual red-attack for the Cranbrook Timber Supply Area, based on the 2006 and 2007 Provincial Aerial Overviews of Forest Health. Cranbrook is an example of management unit that experienced a drop in the observed annual red-attack between 2006 and 2007. Cranbrook also shows the reduced and delayed peak annual red-attack that is typical of management units still waiting to experience peak infestation.

The unpredicted drop in infestation in the south east of the province (Arrow, Boundary, Kootenay Lake, Cranbrook, Invermere and Golden TSAs) may not have occurred. Information gathered by Ministry of Forests and Range Entomologist Art Stock indicates that the aerial overview survey overestimated the amount of red-attack in the south east of the province during the 2005 and part of the 2006 survey years. So, although there appears to be a significant drop in infestation severity between 2005 and 2007 (see Figure 4 for an example), the 2007 estimates of red-attack are closer to the actual infestation levels than those reported for years 2005 and 2006. It should be noted, however, that the volume of pine in the south east of the province is fairly small compared to the interior TSAs, and the inter-year fluctuations caused by surveyor technique represents only a small variation in the

total pine volume affected in the province. The slight overestimate in the south east of the province during the 2005 and 2006 overview surveys highlights the difficulty of conducting consistent aerial overview surveys in this area.

Consequently, the drop in infestation in the periphery units has also impacted the projected timing of peak annual mortality in these units. With the exception of Dawson Creek, which is projected to peak two years earlier due to the unanticipated beetle migration in 2006, the peak in annual kill in those pine units still expecting to experience peak infestation will occur on average one year later than we projected using the 2006 aerial overview survey. The amount of peak annual kill will also be 7% lower on average than we projected from the 2006 aerial overview. However, this does not imply a 7% reduction in the cumulative volume of pine killed. Instead, we project that it will take one year longer for the annual kill amounts to subside significantly.

In the past, we had little information about how infestations might subside. We now have a significant amount of data from central areas where the infestation is beginning to subside, which allows better estimates of infestation-subsidence parameters in the model. However, projections at the outbreak periphery remain relatively uncertain due to uncertainty about the role of dispersal from central regions, effects of weather, topography, and the mix of tree species within forest stands.

2.2 Cumulative Impact

We estimate that the cumulative pine mortality from 1998 to 2006 (red- and grey-attack in 2007) was approximately 542 million m³. Based on the model projection, we estimate that an additional 78 million m³ was killed (green-attack) during the summer of 2007, bringing the total standing dead volume (green-, red-, and grey-attack) to approximately 620 million m³. This represents approximately 46% of the total merchantable pine volume on the THLB (1.35 billion m³). The majority of that mortality (575 million m³) has occurred in the “pine units” and represents 49% of the pine volume in those units (Table 2).

We project that 76% of the pine volume in the “pine units” will be killed by 2015 (Table 2) if the infestation continues to behave as it has over the past eight years. The infestation will have largely subsided by that time and only an additional 1% may be killed by 2019. There is substantial variability in the cumulative percentage of pine killed in 2007, ranging from 81% in Quesnel to 5% in Boundary. However, we project there will be much less variability by the time the infestation subsides (83% to 65% in 2019). The variation in the projected percentage of pine that may be killed appears to be due mainly to differences in the spatial arrangement of the initial pine volume.

Table 2. Cumulative percentage of the pine projected to be killed (green-, red- and grey-attack) in each “pine unit” during selected years.

Pine Unit	Year			
	2007	2011	2015	2019
Quesnel	81%	82%	82%	82%
Lakes	76%	80%	81%	81%
Vanderhoof	75%	76%	77%	77%
100 Mile House	73%	78%	79%	79%
Williams Lake	65%	77%	78%	78%
Prince George	63%	68%	69%	70%
Kamloops	54%	70%	73%	74%
Ft St James	51%	76%	82%	83%
Morice	44%	70%	73%	74%
Arrow	29%	65%	77%	79%
Lillooet	25%	71%	78%	80%
Merritt	24%	65%	73%	74%
Robson Valley	22%	60%	71%	73%
Dawson Creek	20%	68%	77%	79%
Golden	19%	49%	66%	71%
Okanagan	14%	54%	69%	71%
Kootenay Lake	13%	49%	70%	73%
Mackenzie	12%	52%	71%	73%
Invermere	11%	47%	62%	65%
Bulkley	10%	65%	78%	80%
Cranbrook	8%	38%	64%	69%
Boundary	5%	45%	69%	71%
Grand Total	49%	69%	76%	77%

2.2.1 Comparing Cumulative Mortality from Last Year’s Results to This Year’s Results

Last year, we projected that the infestation would kill 77% of the provincial pine volume by 2014, and that mortality would then slow substantially and the infestation would essentially be over by 2018 with 78% of the pine volume killed (Figure 5). We now project that: 1) the infestation may take an additional year to essentially be over (year 2019 instead of 2018), and 2) the cumulative pine volume killed may be one percent less at that time (76% instead of 77%).

The 1-year delay in the provincial progression of the infestation is from lower than anticipated annual kill (green-attack) in 2006 within management units on the periphery of the current outbreak. It also appears that after the infestation begins to subside, a slightly larger proportion of the pine volume is being left alive than was projected last year. This has resulted in a one percent drop in cumulative pine mortality. Similarly, the cumulative pine mortality projections for the pine units and the provincial summary are reduced by incorporating this observation into our model of the infestation’s behaviour.

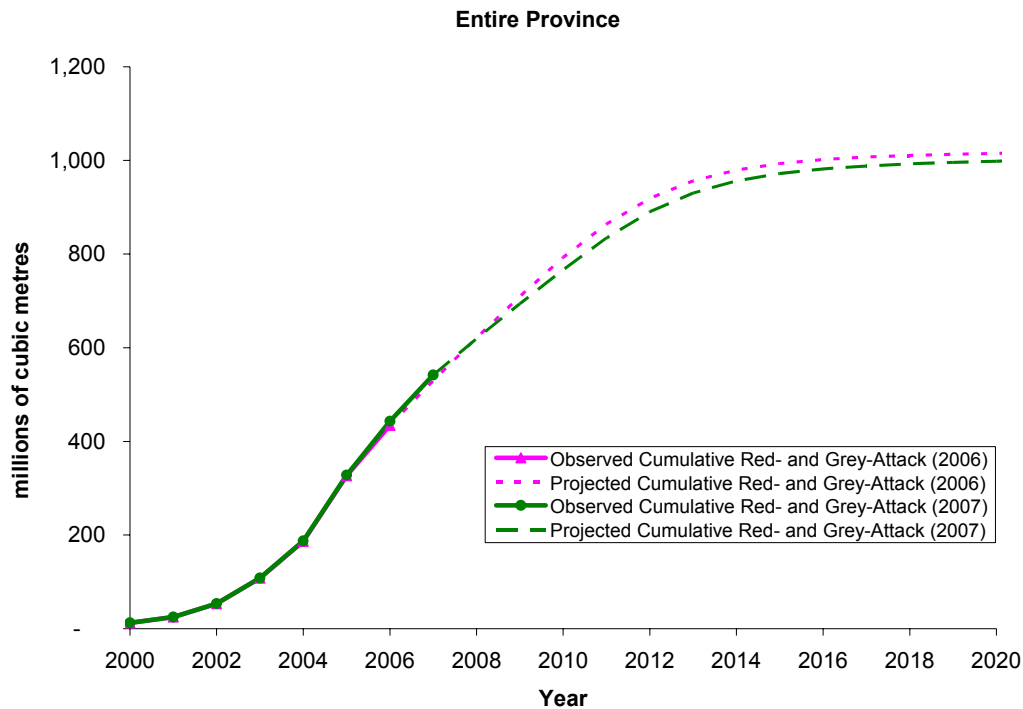


Figure 5. Comparison of observed and projected cumulative kill (red- and grey-attack) in the province, based on the 2006 and 2007 Provincial Aerial Overviews of Forest Health.

3 Conclusions and Caveats

The principal conclusions about the infestation are:

- Approximately 46% of the merchantable pine volume in the province has likely already been killed.
- The worst year of the infestation, at a provincial scale, was 2004.
- The volume of pine killed by the infestation declined rapidly, at a provincial scale, between 2004 and 2007.
- The infestation is projected to subside rapidly for one more year, after which time the rate of annual mortality will remain in the 68 to 78 million m³ range until 2011. At that point, it may begin to rapidly subside and will be essentially over by 2019.
- Approximately 76% of the pine volume in the “pine units” will be killed by 2015. The infestation will have largely subsided by that time and only an additional 1% may be killed by 2019.
- There is substantial variability in the timing of the peak in the infestation in different areas of the province.

The main caveats about these conclusions are:

- Current mortality estimates are based entirely on an analysis of the Provincial Aerial Overview of Forest Health. These estimates are essentially unverified. While there is no dispute that the infestation is causing extensive pine mortality provincially the precise magnitude of the impact is not known. We undoubtedly both overestimate and underestimate mortality in some areas.

We also acknowledge that our estimates of pine mortality differ from the Magnitude Survey, which is published jointly by the Council of Forest Industries and the Ministry of Forests and Range. We have consistently estimated pine mortality at levels below those estimated by the Magnitude Survey. Understanding the reason for the differences is difficult, as the two approaches are completely different. However, the fundamental message that comes out of both methodologies is consistent. The infestation has peaked in severity, it has killed off approximately half the mature pine in the interior, it has killed most of the lodgepole on the plateau, and it is now moving into the peripheral management units.

- The results presented assume that the future will resemble the past. The model produces a projection of what will occur if the infestation continues to progress as it has over the last eight years. It is important to realize that this is not a prediction of what will occur. There is substantial uncertainty about when and how the infestation will subside and eventually end.
- BCMPB does not include past weather effects or try to simulate future weather effects. As a result, the observed annual kill for a given year may vary considerably from the predicted annual kill. This was apparent in the red-attack observed during the summer of 2007 in the Dawson Creek area. In summer 2006, the Dawson Creek pine-unit experienced an unpredicted immigration of mountain pine beetles from the infestation in the central interior. This led to an unpredicted increase in the 2007 observed red-attack. As the outbreak subsides, we may expect an increased effect of specific weather events on variability in projected outcomes.
- We now have a significant amount of data from central areas where the infestation is beginning to subside, but we do not have information about subsidence in the peripheral areas. The BCMPB model allows some difference between outbreak dynamics and peripheral areas by considering the effect of “long-distance dispersal pressure”, which can reach higher levels in areas with abundant, extensive pine. However, the “dispersal pressure” component may not adequately capture all the differences between central and peripheral areas. In general, we suspect that many of the differences between projections and observed behaviour arise because the dispersal component of BCMPB does not adequately account for observed spatial structure in the infestation data. BCMPB projections are generally less clumped than observed infestations, causing the model to under-project intensely infested areas, and over-project light infestations. Adequately understanding and accounting for spatial structuring in infestation data is a challenging and rapidly developing area of research. Future modeling effort could likely benefit from insights and analysis techniques currently being developed, but incorporating this research is beyond the scope of the current BCMPB project.