

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)

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1 Introduction

For four years, we have been developing a 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 2006 Provincial Aerial Overview of Forest Health and revisions to “the model” (BCMPB.v4)⁵. This year’s results are only slightly different than last year’s results⁶. The information gathered continues 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.v4.ModelDocumentation.Update.pdf>

⁶ <http://www.for.gov.bc.ca/hre/bcmpb/BCMPB.v3.BeetleProjection.Update.pdf>

2 Summary of Results

2.1 Annual Mortality

Last year⁷, we estimated that the provincial peak in annual kill for this outbreak occurred during the summer of 2004 and was seen during the summer of 2005⁸, with an annual mortality of approximately 139 million m³ of merchantable (>12.5 cm dbh) pine on the Timber Harvesting Land Base (THLB)⁹. Observed mortality did, in fact, decline and we estimate that approximately 108 million m³ of merchantable pine on the THLB were observed killed during the summer of 2006 (killed during the summer of 2005) (Figure 1). We now project that the infestation will continue to kill more than 80 million m³ per year until 2009. At that time, we expect the infestation to begin to subside rapidly, and within 10 years it will likely be killing less than 5 million m³ annually. The rate at which the infestation will subside is still a matter of some uncertainty.

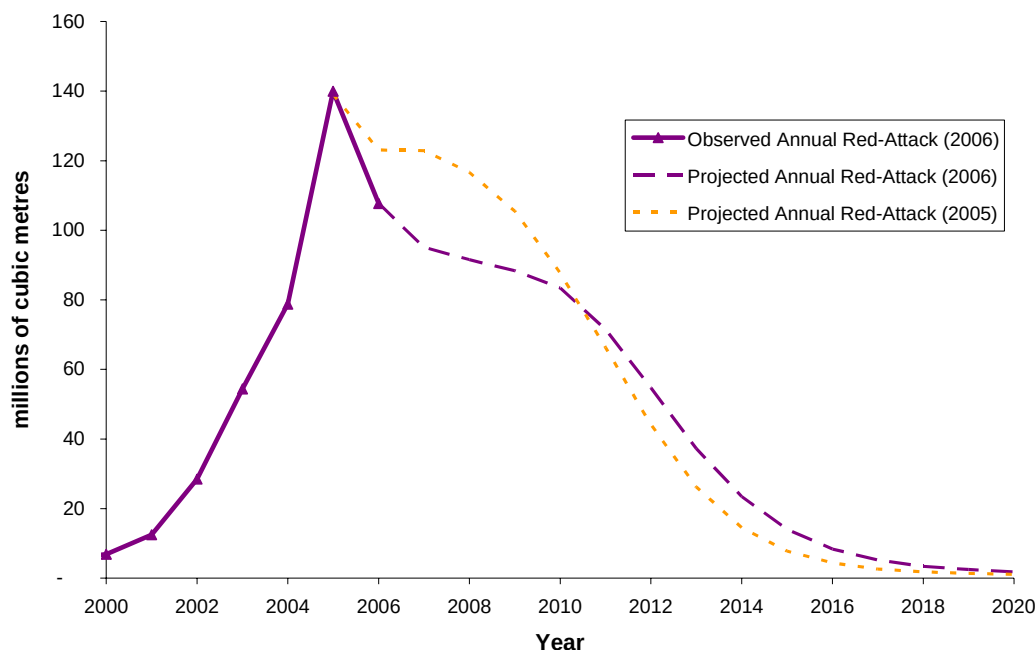


Figure 1. Comparison of observed and projected annual kill (red-attack) on the Timber Harvesting Land Base of the entire province, based on the 2005 and 2006 Provincial Aerial Overviews.

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 <http://www.for.gov.bc.ca/hre/bcmapb/BCMPB.v3.BeetleProjection.Update.pdf>

⁸ Note that the mortality caused by MPB (green-attack) occurs in the year prior to that 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.

⁹ All volume figures reported are for the Timber Harvesting Land Base only.

4 “pine units”¹⁰ 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. We believe the infestation peaked in Morice this past summer. The remaining pine units, near the periphery of the current outbreak, will not peak in kill until some time in the future.

Table 1. Observed (2004 – 2005) and projected (2006 – 2011) annual **green-attack** volume (millions m³) for the 22 “pine units” (peak year of kill is highlighted in bold font). Note that the mortality caused by MPB (green-attack) occurs in the year prior to that 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)	24.5	6.6	4.5	2.6	1.3	0.6	0.3	0.2
Quesnel	23.7	11.3	5.4	2.0	0.6	0.2	0.1	0.1
Lakes	15.1	9.5	6.9	3.5	1.8	0.9	0.5	0.2
Prince George (District)	12.5	7.7	7.6	5.0	2.8	1.5	0.8	0.4
Williams Lake	19.2	19.5	15.9	12.9	9.3	5.8	3.3	1.8
100 Mile House	8.6	17.5	6.5	3.7	2.0	1.1	0.5	0.3
Kamloops	5.9	8.6	7.1	6.2	4.7	3.2	2.0	1.2
Morice	3.8	6.1	8.4	7.8	6.0	4.1	2.5	1.4
Ft. St. James (District)	10.7	7.2	11.4	12.1	10.9	9.4	7.4	4.9
Merritt	1.3	2.3	4.6	7.6	9.1	8.4	6.1	3.9
Lillooet	0.4	0.9	1.6	2.6	2.9	2.6	1.8	1.1
Arrow	0.5	0.6	0.7	0.9	1.0	0.8	0.5	0.3
Golden	0.2	0.3	0.3	0.5	0.6	0.5	0.4	0.3
Okanagan	1.0	1.3	2.2	4.2	6.6	7.5	6.5	4.7
Cranbrook	0.5	0.5	0.7	1.5	2.6	3.5	3.3	2.8
Bulkley	0.1	0.0	0.3	0.9	1.9	2.5	2.0	1.3
Boundary	0.1	0.2	0.3	0.8	1.6	2.1	2.0	1.5
Kootenay Lake	0.3	0.4	0.6	1.0	1.4	1.7	1.5	1.1
Invermere	0.2	0.3	0.4	0.9	1.3	1.4	1.1	0.8
Robson Valley	0.1	0.2	0.3	0.6	0.7	0.8	0.6	0.4
Mackenzie	0.7	2.1	4.7	8.6	10.5	12.1	13.5	12.1
Dawson Creek	0.0	0.1	0.3	0.7	1.6	3.2	4.7	4.9
Grand Total	129.5	103.1	90.9	86.4	81.2	74.0	61.6	45.6

The uncertainty in the subsidence rate of the provincial annual kill stems, in part, from the uncertainty around when, and how fast, the infestation will peak in areas near the periphery of the current outbreak. At a provincial scale, the amount of annual kill has begun to subside. There are, however, four pine units on the periphery of the current outbreak with significant pine volumes (i.e. Ft. St. James, Mackenzie, Merritt, Okanagan). The timing of their peak in annual kill will influence the provincial rate of infestation subsidence. If their peak in annual kill occurs at a later time than we project, then the rate of provincial infestation subsidence may be slowed. Although other pine units near the periphery of the

¹⁰ 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.

current outbreak have not yet experienced their peak in annual kill either, these units have lower volumes of pine and will have less impact on the provincial rate of infestation subsidence. Additionally, there is some uncertainty regarding the degree to which beetle dispersal from management units at the heart of the current outbreak (Vanderhoof, Quesnel, Lakes and Prince George) drives the rate of infestation within management units near the periphery of the current outbreak.

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 2006 was lower than predicted last year by BCMPB.v3 using the 2005 aerial overview survey. Last year, we predicted that approximately 123 million m³ of merchantable pine on the THLB would be observed killed during the summer of 2006. We now estimate that approximately 108 million m³ of merchantable pine on the THLB were observed killed during the summer of 2006 (about 12% lower than last year's estimate). The lower than anticipated annual kill, however, was not consistent across the provincial THLB.

The pine units that experienced peak annual green-attack volume in 2004 all encountered lower than anticipated amounts of observed red-attack in the summer of 2006. Most notable, were Prince George and Vanderhoof, where the observed red-attack volume was approximately 2.5 million m³ lower than anticipated in both management units. The pine units that experienced peak annual green-attack volume in 2005 all encountered higher than anticipated amounts of red-attack in the summer of 2006. For example, the observed red-attack in 100 Mile House was more than 5 million m³ higher than anticipated. The pine units at the periphery of the current infestation, which we anticipate will encounter peak amounts of green-attack volume between 2006 and 2009, all experienced slightly lower than anticipated amounts of annual kill (on average, 250,000 m³ lower than anticipated). Mackenzie and Dawson Creek, which the model projects will peak in green-attack volume after 2009, both experienced marginally (less than 50,000 m³) higher than anticipated amounts of annual kill.

We now expect that the peak in annual kill will be lower and occur later for all pine units still expecting to experience peak annual kill. With the exception of Morice, which we still believe experienced peak green-attack in the summer of 2006, the peak in annual kill will occur one year later than we projected using the 2005 aerial overview survey. The amount of peak annual kill will also be approximately 15% lower than we projected from the 2005 aerial overview. However, this does not imply a 15% reduction in the cumulative volume of pine killed. Instead, we expect that it will take one year longer for the annual kill amounts to subside significantly.

We have learned three things from the comparison of last year's annual kill results to this year's annual kill results. 1) The infestation is subsiding faster than expected in the areas where the infestation has already peaked (Figure 2). 2) We underestimated the annual volume killed in units where the peak in the infestation has already occurred (Figure 3). 3) We are overestimating how fast the infestation is growing in the units at the periphery of the current outbreak (Figure 4).

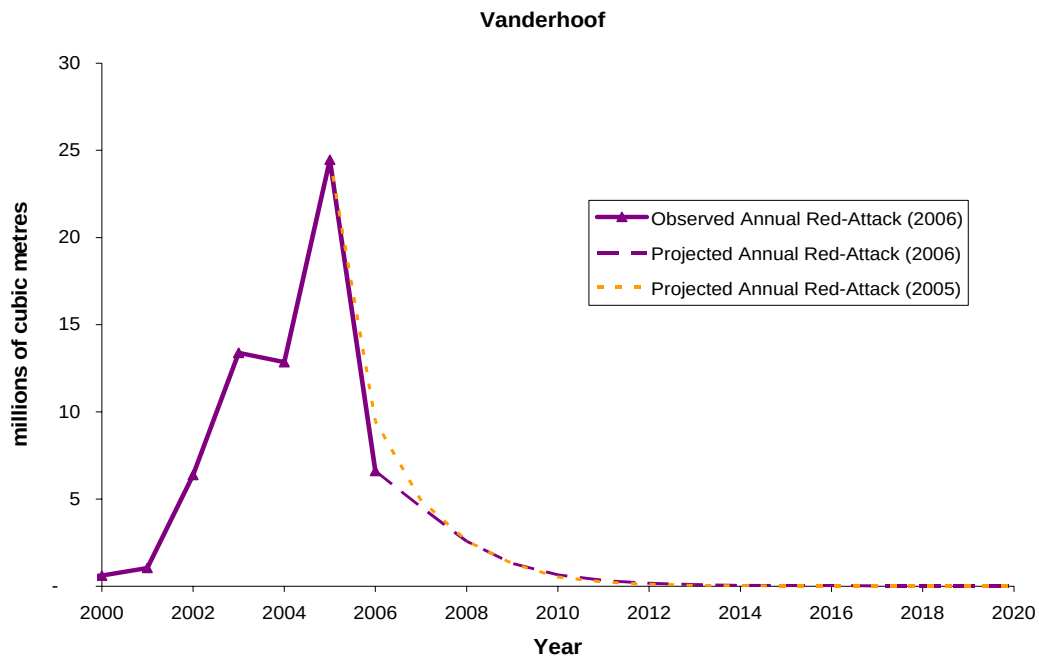


Figure 2. Comparison of the observed and projected annual red-attack for the Vanderhoof Forest District, based on the 2005 and 2006 Provincial Aerial Overviews of Forest Health. Vanderhoof Forest District is an example of a management unit that experienced a greater than anticipated reduction in annual red-attack in 2006, after peaking in 2005. In fact, annual red-attack volume in Vanderhoof dropped an additional 9% more than anticipated.

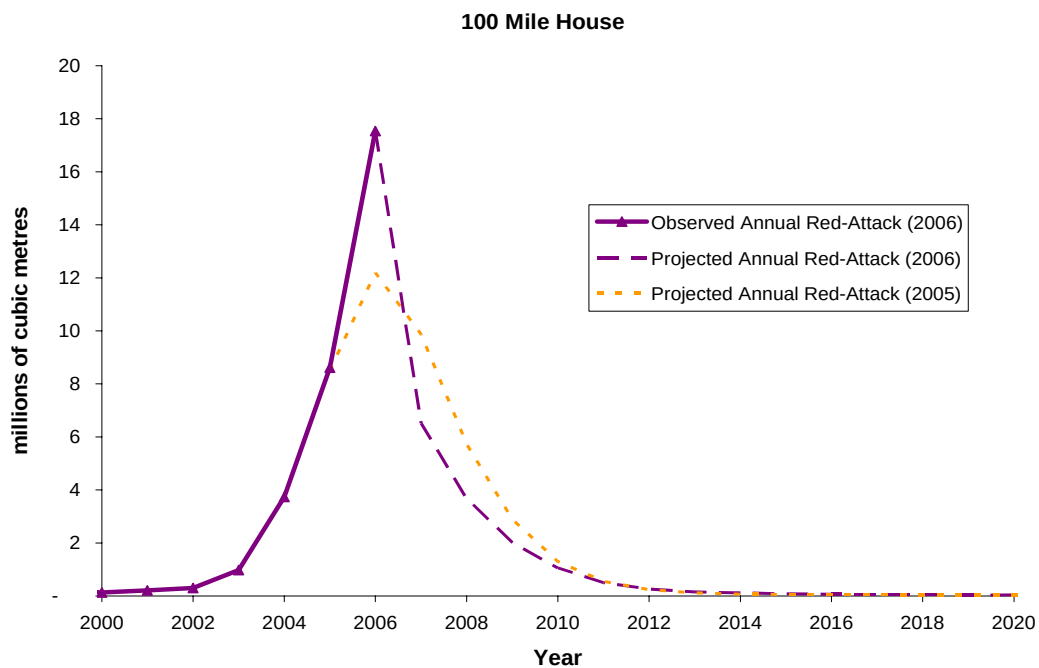


Figure 3. Comparison of the observed and projected annual red-attack for the 100 Mile House Timber Supply Area, based on the 2005 and 2006 Provincial Aerial Overviews of Forest Health. 100 Mile House is an example of a management unit that experienced a greater than anticipated peak in annual red-attack in 2006.

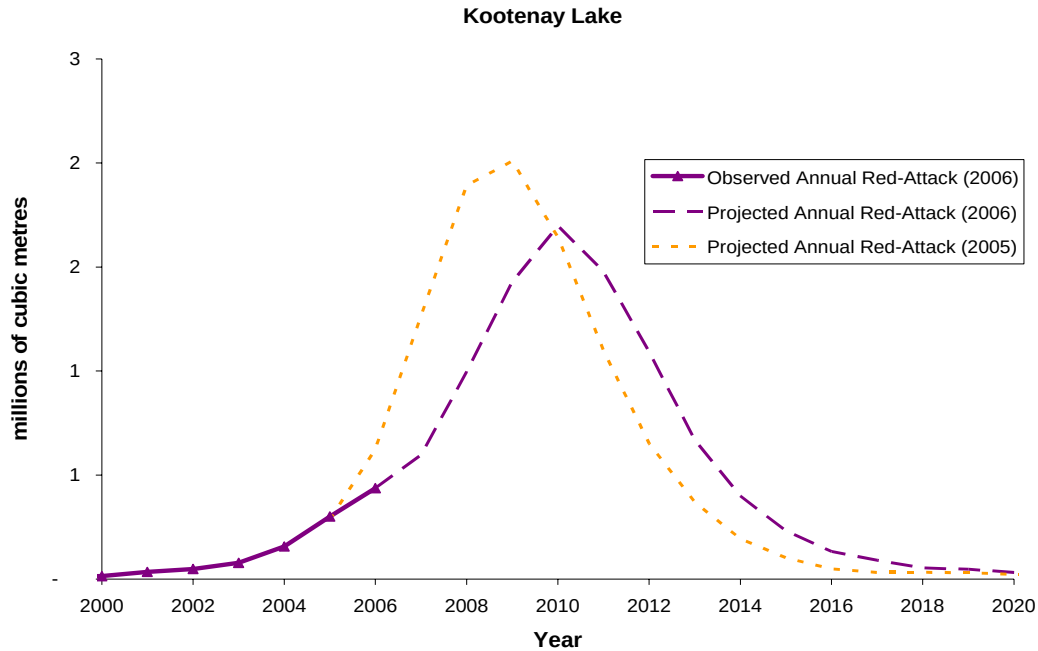


Figure 4. Comparison of the observed and projected annual red-attack for the Kootenay Lake Timber Supply Area, based on the 2005 and 2006 Provincial Aerial Overviews of Forest Health. Kootenay Lake is an example of a management unit at the periphery of the current outbreak that is yet to peak in annual red-attack volume, and has experienced a lower than anticipated increase in annual red-attack in 2006. Using the 2006 Provincial Aerial Overview of Forest Health, we expect that the peak in annual kill will be less intense and occur one year later than we did using the 2005 Provincial Aerial Overview of Forest Health.

In the past, we had little information about how infestations might subside. We now have a significant amount of data from areas where the infestation is beginning to subside, which allows more confident estimates of infestation-subsidence parameters in the model. However, we still have no data about the peak in the infestation at the periphery of the outbreak.

2.2 Cumulative Impact

We estimate that the cumulative pine mortality from 1998 to 2005 (red- and grey-attack in 2006) was approximately 435 millions m^3 . Based on the model projection, we estimate that an additional 95 million m^3 was killed (green-attack) during the summer of 2006, bringing the total standing dead volume (green-, red-, and grey-attack) to approximately 530 million m^3 . This represents approximately 40% of the total merchantable pine volume on the THLB (1.35 billion m^3). The majority of that mortality (495 million m^3) has occurred in the “pine units” and represents 42 per cent of the pine volume in those units (Table 2).

We project that 77% of the pine volume in the “pine units” will be killed by 2014 (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 2018. There is substantial variability in the cumulative percentage of pine killed in 2006, ranging from 80% in Quesnel to 1% in Dawson Creek. However, there will be much less variability by the time the infestation subsides

(84% to 69% in 2018). 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			
	2006	2010	2014	2018
Quesnel	80%	82%	82%	82%
Vanderhoof	72%	77%	77%	77%
Lakes	72%	81%	82%	82%
100 Mile House	67%	79%	80%	81%
Prince George	58%	71%	72%	72%
Williams Lake	53%	75%	78%	78%
Kamloops	44%	72%	76%	77%
Morice	37%	73%	77%	78%
Ft. St. James	36%	73%	83%	84%
Arrow	31%	72%	81%	83%
Golden	21%	61%	73%	76%
Lillooet	16%	67%	80%	81%
Merritt	16%	63%	75%	76%
Robson Valley	15%	59%	74%	77%
Kootenay Lake	13%	56%	75%	77%
Invermere	11%	51%	66%	69%
Okanagan	10%	54%	72%	74%
Cranbrook	9%	44%	67%	72%
Mackenzie	7%	45%	71%	74%
Bulkley	5%	61%	81%	82%
Boundary	5%	48%	71%	74%
Dawson Creek	1%	35%	75%	81%
Grand Total	42%	68%	77%	78%

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 80% of the provincial pine volume by 2013, and that mortality would then slow substantially and the infestation would essentially be over by 2017 with 81% of the pine volume killed (Figure 5). We now project that: 1) the infestation may take an additional year to essentially be over (year 2018 instead of 2017), and 2) the cumulative pine volume killed may be three percent less at that time (78% instead of 81%) (Figure 5).

The 1-year delay in the provincial progression of the infestation is from lower than anticipated annual kill (green-attack) in 2005 within management units on the periphery of the current outbreak. It now 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 three percent drop in cumulative pine mortality. Similarly, the cumulative pine mortality projections for the other two types of management units and the provincial summary are reduced by incorporating this observation into our model of the infestation’s behaviour.

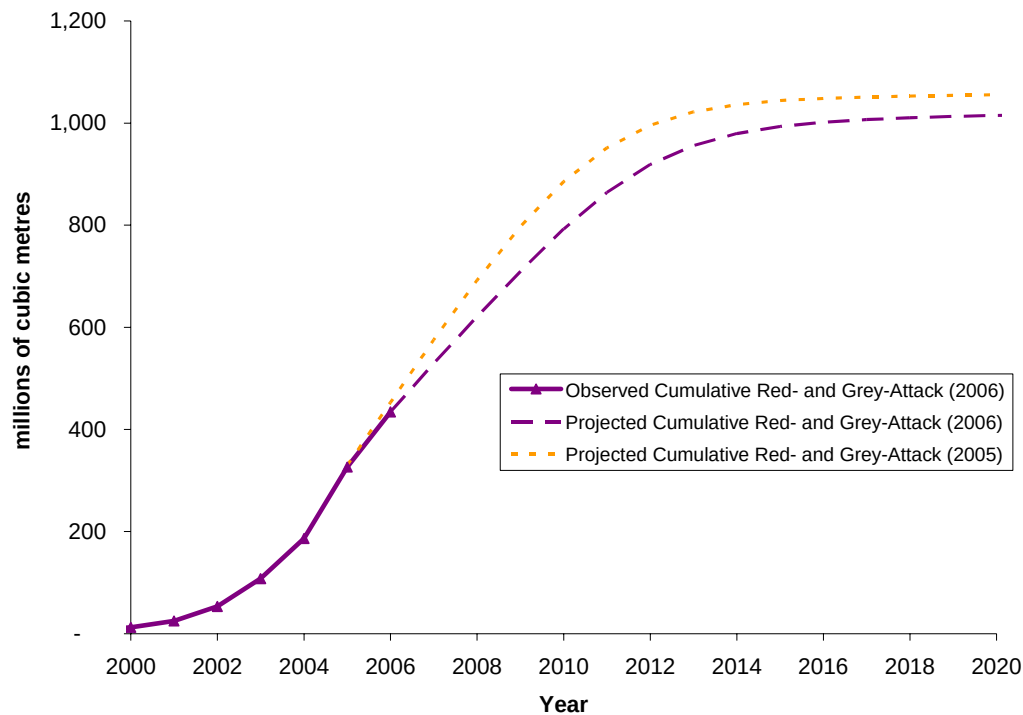


Figure 5. Comparison of observed and projected cumulative kill (red- and grey-attack) in the “pine units”, based on the 2005 and 2006 Provincial Aerial Overviews.

3 Conclusions and Caveats

The principal conclusions about the infestation are:

- Approximately 40% 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 2005.
- The infestation is projected to continue to cause significant damage for at least three more years, killing over 80 million m³ per year until 2009. At that point, it may begin to rapidly subside and will be essentially over by 2018.
- 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.
- 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.

- We underestimated the rate at which the infestation would increase during its growth phase and we now have one year of experience in which we have underestimated the rate at which the infestation is declining. It is possible that the infestation will subside more rapidly than we are now projecting, particularly in those areas near the centre of the outbreak. The accelerated subsidence of the infestation in the centre of the outbreak may also influence the infestation rate on the periphery of the current outbreak. After the centre of the outbreak collapses, the beetle's long-distance dispersal pressure may subside. This may result in lower than anticipated outbreak growth within management units on the periphery of the current outbreak, especially in the north. Although the BCMPB projections may include some of this effect (i.e. lower long-distance pressure leading to lower outbreak growth), they may not fully capture it.
- We suspect that 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. For this reason, BCMPB projections are less clumped than observed infestations, causing the model to under-predict intensely infested areas, and over-predict 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.