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

Update of the infestation projection based on the 2005 Provincial Aerial Overview of Forest Health and revisions to "the model" (BCMPB.v3)

by:
Marvin Eng, Research Branch, BC Forest Service
Andrew Fall, Gowlland Technologies Ltd.
Josie Hughes, Research Consultant
Terry Shore, Pacific Forestry Centre, Canadian Forest Service
Bill Riel, Pacific Forestry Centre, Canadian Forest Service
Adrian Walton, Research Branch, BC Forest Service
Peter Hall, Forest Practices Branch, BC Forest Service

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1.0 Introduction

For three years we have been developing a 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 mountain pine beetle (MPB) population model[4] to estimate the current extent of pine mortality, and to project a possible course of the infestation into the future.

Our estimates of the current and potential future impact of the MPB infestation, published in May 2005[5], have been widely used in the media and a host of government and non-government publications. Additionally, detailed output from the model (digital maps and tabular results) has been used in a variety of natural resource analysis and management applications.

We have now completed a revised estimate of current and potential future impact of the MPB infestation based on the 2005 Provincial Aerial Overview of Forest Health and revisions to "the model" (BCMPB.v3)[6]. While the conclusion most widely reported[7] remains essentially unchanged there are other differences in this year's results that have significant implications for some interpretations. In this document we provide a summary of the differences. Based on this summary, users of the model output can decide whether differences are significant enough to warrant the additional effort of obtaining and incorporating new results.

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. The analysis of the forest management response is discussed in a separate document[8].

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[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_MainReport_2004.pdf
[6] http://www.for.gov.bc.ca/hre/bcmpb/BCMPB.v3.ModelDocumentation.Update.pdf
[7] "80% of the merchantable pine volume may be killed by 2013"
[8] http://www.for.gov.bc.ca/hre/bcmpb/BCMPB.v3.ReferenceScenario.Update.pdf

2.0 Summary of Results

2.1   Annual Mortality

We estimate that the peak in annual kill for this outbreak, seen during the summer of 2005, occurred during the summer of 2004[9]. Approximately 139 million m^3 of merchantable (>12.5 cm dbh) pine on the Timber Harvesting Landbase (THLB)[10] were killed that year (Figure 1). This is substantially higher and somewhat earlier than our estimate based on the 2004 overview data. We previously projected that the annual kill would peak in 2006 at approximately 90 million m^3. We now project that the infestation will continue to kill more than 100 million m^3 per year until 2008. At that time we expect the infestation to begin to subside much more rapidly than we projected in 2004 and within eight years it will likely be killing less than 5 million m^3 annually. The rate at which the infestation will subside is a matter of some significant uncertainty.
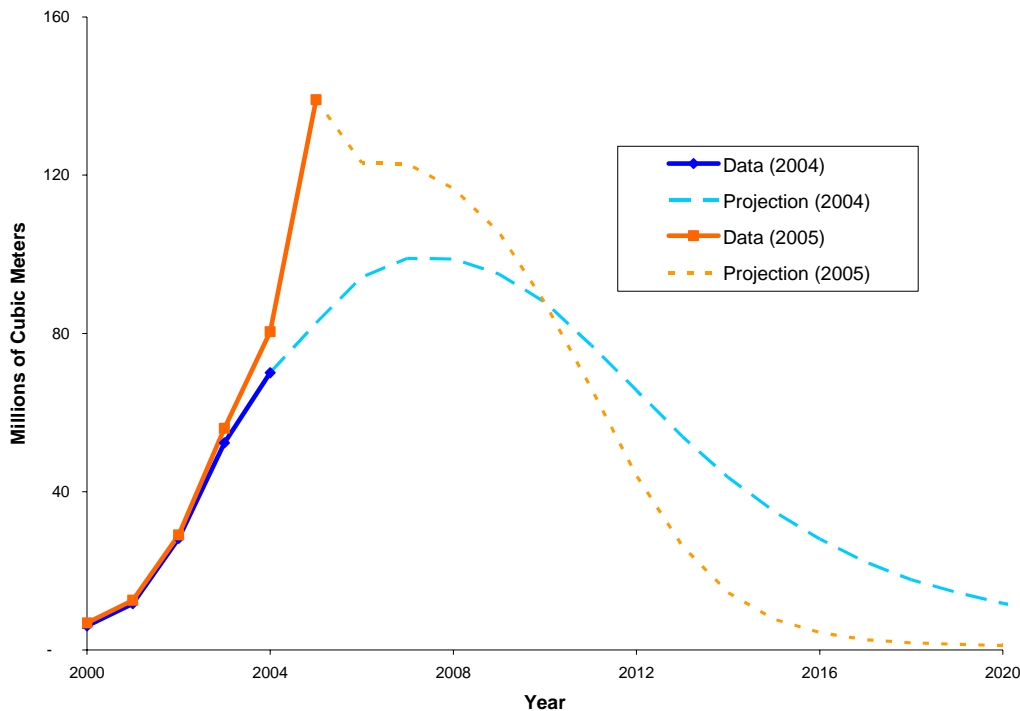

Figure 1 Comparison of observed and projected annual kill on the Timber Harvesting Landbase of the entire province, based on the 2004 and 2005 Provincial Aerial Overviews.

There is substantial variation in the timing and magnitude of the peak in different management units throughout the province. Table 1 shows that there are 5 "pine

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[9] Note that the mortality caused by MPB occurs in the year prior to that which it is observed by the Provincial Aerial Overview of Forest Health. The model (BCMPB) reports on and projects the overview and we, therefore present the "observed mortality" in graphs and tables unless otherwise specifically noted.
[10] All volume figures reported are for the Timber Harvesting Landbase only.

units"[11] where the peak in annual kill probably occurred in 2004. The peak in kill probably occurred in 100 Mile House last summer. There are 4 units where we expect the peak of the infestation to occur this summer. The remaining units, near the periphery of the current outbreak, will not peak in kill until some time in the future. Along with the higher peak in annual kill at a provincial scale (Figure 1) we are projecting higher peaks in annual kill, than we were last year, for all management units. (For example Figure 2).

Table 1 Observed (2004) and projected (2005 – 2011) annual green attack volume (millions m^3) for the 22 "pine units" (Peak year of kill is highlighted in bold font).

|	2004	2005	2006	2007	2008	2009	2010	2011
Vanderhoof (District)	**24.5**	9.5	4.9	2.6	1.3	0.5	0.2	0.1
Quesnel	**23.3**	12.4	4.8	1.8	0.6	0.2	0.1	0.0
Williams Lake	**19.1**	18.6	15.8	12.6	9.8	6.9	4.3	2.3
Lakes	**15.0**	10.2	7.0	3.9	2.0	1.0	0.5	0.2
Prince George (District)	**12.3**	10.2	8.5	5.3	2.9	1.5	0.7	0.4
100 Mile House	8.5	**12.2**	9.9	5.7	2.9	1.3	0.6	0.2
Ft.St.James (District)	11.0	16.2	**16.8**	14.7	11.4	7.6	4.5	2.4
Morice	3.8	7.4	**10.9**	9.3	6.0	3.3	1.6	0.7
Kamloops	5.8	7.4	**8.7**	7.5	5.5	3.3	1.8	0.9
Arrow	0.5	1.0	**1.4**	1.2	0.9	0.5	0.3	0.2
Invermere	0.2	0.4	1.1	**1.8**	1.6	1.3	0.9	0.5
Golden	0.2	0.4	0.7	**0.8**	0.7	0.5	0.3	0.2
Merritt	1.3	3.4	7.3	9.8	**9.9**	7.6	5.0	2.7
Okanagan	1.0	2.0	4.2	6.8	**8.2**	7.6	5.7	3.6
Cranbrook	0.5	1.0	2.3	3.6	**4.1**	3.7	2.8	1.8
Lillooet	0.4	0.9	1.9	2.6	**2.9**	2.5	1.8	1.1
Bulkley	0.1	0.3	1.2	2.4	**2.7**	1.9	1.1	0.5
Boundary	0.1	0.3	1.0	1.9	**2.5**	2.2	1.6	1.0
Kootenay Lake	0.3	0.6	1.3	1.9	**2.0**	1.6	1.1	0.7
Robson Valley	0.1	0.3	0.5	0.9	**1.0**	0.8	0.5	0.3
Mackenzie	0.7	2.0	5.6	10.3	13.7	**15.4**	14.9	11.9
Dawson Creek	0.0	0.1	0.3	1.1	2.9	5.4	**5.8**	4.2
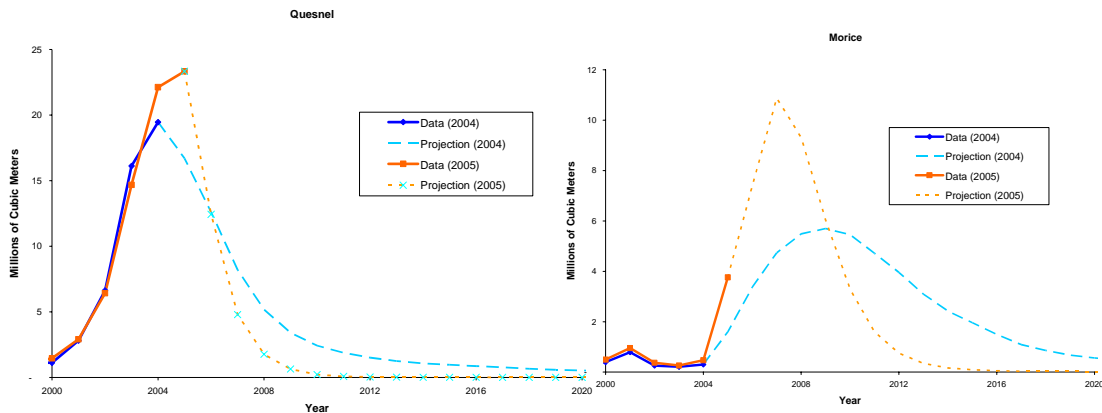
Figure 2 Comparison of observed and projected annual kill based on the 2004 and 2005 data for example the Quesnel and Morice TSAs.

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

The projection of a higher peak in annual kill at an earlier date is primarily a result of the new data obtained from the overview survey in 2005. We under projected based on the 2004 data. The fact that the infestation was more intense (although not larger in area) than we expected has immediate effects on the projection for those units where we now believe that the infestation has peaked. However, it also has "downstream" effects on other units in that we now expect them to peak at higher levels and earlier than we previously projected (See Morice in Figure 2). A minor component of the difference is a result in our explicit inclusion of the "very severe" category in the overview data in this year's BCMPB model.

We now believe that the infestation will subside more rapidly than we thought it would last year primarily because the mortality in 2004 was so much more severe than we expected. Higher mortality now leaves less volume available for attack in subsequent years. Additionally, because the peak in kill has passed in some units we have some more information about the subsidence of the infestation.

2.1   Cumulative Impact

We estimate that the cumulative pine mortality from 1998 to 2004 (observed in 2005) was approximately 330 millions m^3. Based on the model projection we estimate that an additional 120 million m^3 was killed during the summer of 2005 bringing the total standing dead volume to approximately 450 million m^3. This represents one third of the total provincial pine volume (1.35 billion m^3). The majority of that mortality (420 million m^3) has occurred in the "pine units" and represents 36 per cent of the pine volume in those units (Table 2).

If the infestation continues to behave as it has over the past seven years we project that 80 per cent of the pine volume in the "pine units" will be killed by 2013 (Table 2). The infestation will have largely subsided by that time and only an additional 1 per cent may be killed by 2017. Not surprisingly, there is substantial variability in the cumulative percentage of the pine killed at 2005 ranging from 76 per cent in Quesnel to <1 per cent in Dawson Creek. However, there will be much less variability by the time the infestation subsides (75 per cent to 89 per cent in 2017). 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.

Last year we projected that the infestation would continue past 2013 but that the rate of mortality would slow substantially after that (Figure 3). This slowing of the rate of mortality indicated to us that there was little evidence to support a claim that more than 80 per cent of the pine volume would be killed. This year the model projects that the infestation will essentially completely subside after 80 per cent of the pine has been killed (Figure 3). The difference is that we now have a significant amount of data from areas where the infestation is beginning to subside or has subsided. This allows us to more correctly parameterise our model with respect to the subsidence of the infestation. Additionally, we have made some conceptual changes to the model, mainly about the amount that beetle populations can affect the epidemic over long distances. These changes have contributed to the more abrupt subsidence projected by the model.

Table 2 Cumulative percentage of the pine projected to be killed in each "pine unit" during selected years.

| Management Unit	Year			
	2005	2009	2013	2017
Quesnel	76%	83%	83%	83%
Vanderhoof (district)	71%	81%	81%	81%
Lakes	64%	83%	84%	85%
Prince George (district)	52%	75%	77%	77%
100 Mile House	46%	80%	82%	82%
Williams Lake	42%	73%	79%	79%
Ft. St. James (district)	35%	81%	89%	89%
Kamloops	30%	72%	78%	79%
Arrow	28%	78%	87%	88%
Morice	25%	76%	81%	82%
Golden	17%	68%	80%	82%
Robson Valley	11%	63%	79%	81%
Merritt	10%	62%	77%	79%
Kootenay Lake	10%	62%	80%	82%
Invermere	9%	58%	73%	75%
Lillooet	8%	59%	79%	81%
Cranbrook	8%	52%	73%	75%
Okanagan	8%	54%	76%	77%
Bulkley	6%	67%	83%	84%
Boundary	4%	54%	78%	79%
Mackenzie	3%	41%	74%	77%
Dawson Creek	<1%	32%	78%	83%
Grand Total	**36%**	**69%**	**80%**	**81%**
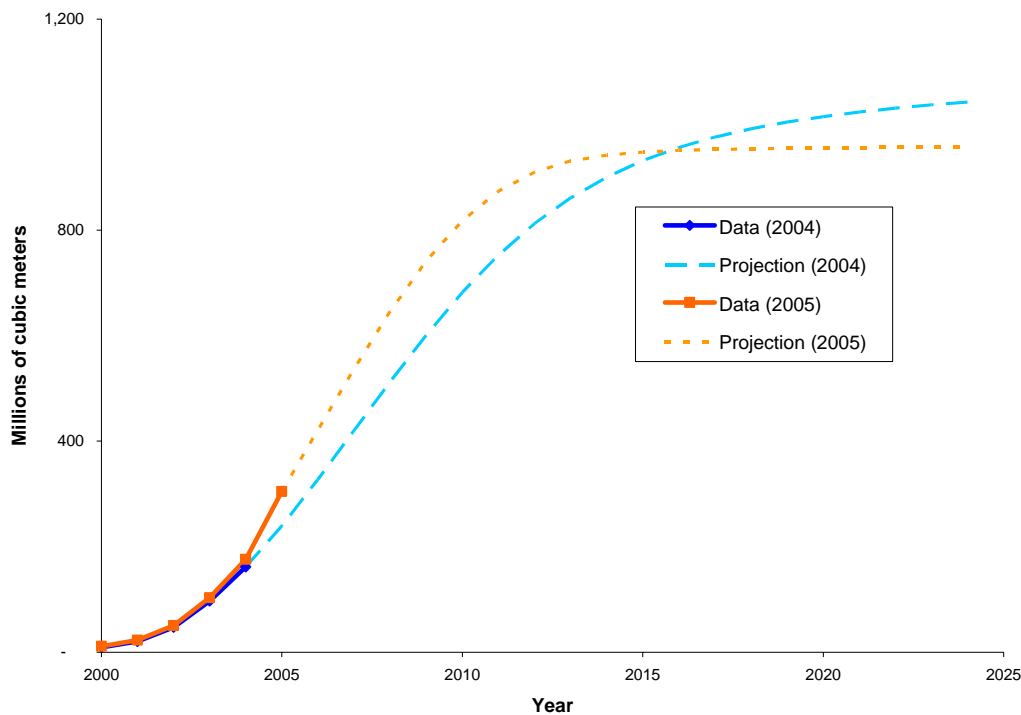
Figure 3 Comparison of observed and projected cumulative kill in the "pine units", based on the 2004 and 2005 Provincial Aerial Overviews.

3.0 Caveats and Conclusions

The principal conclusions about the infestation are:

- Over one third of the merchantable pine volume in the province has likely already been killed.
- It appears that the worst year of the infestation, at a provincial scale, was 2004.
- The infestation is projected to continue to cause significant damage for at least three more years, killing over 100 million m^3 per year until 2008. At that point it may begin to rapidly subside and will be essentially over by 2014 or 2015.
- 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 extremely serious 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 seven 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 end.
- The model is provincial in scope. There will be local scale variation in the progression of the infestation that is not accommodated in the results. Notably, we cannot predict local weather events that may affect the beetle populations.