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FGrOW Quicknote #2

March 2017

Monitoring Tree Infection and Mortality after Mountain Pine Beetle Attack

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A network of 240 buffered permanent sample plots (PSP's) in Alberta was reserved from harvesting in 2007 to allow monitoring of stand development following mountain pine beetle (MPB) attack. Changes in tree health in 63 permanent sample plots occurring in stands attacked before 2010 have been monitored since 2008. The intent of the study is to assess the impact of MPB infestation on tree mortality, growth of residual trees, tree regeneration, and development of non-tree vegetation in attacked stands that have not been subject to salvage or other management interventions. Because baseline measurements were made before the initial outbreak of MPB, and monitoring of mortality commenced usually within a year initial infestation, the study has provided the earliest possible opportunity to assess these impacts in Alberta.

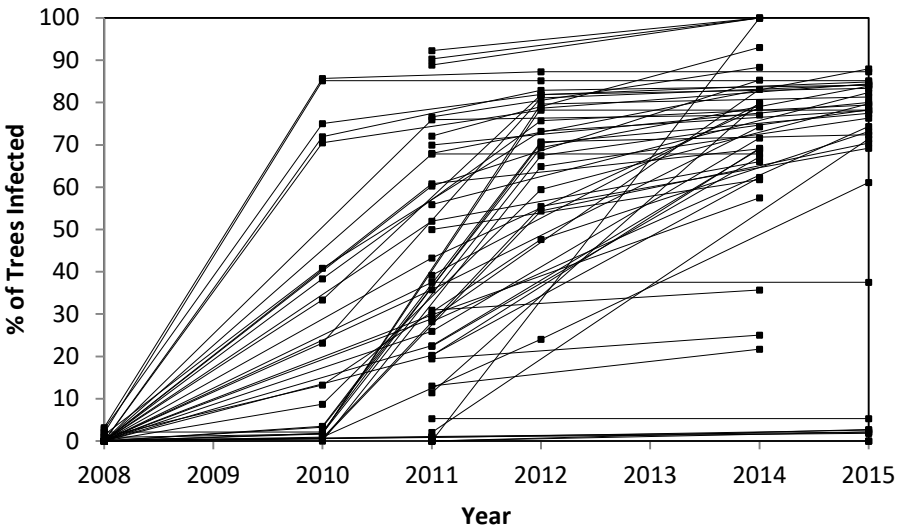

Figure 1. Rates of MPB infection in permanent sample plots.

Preliminary analyses to date and those reported here are restricted to rates of infection, mortality and fall-down. This involved tracking the condition of almost 5000 lodgepole pine trees on 63 PSP's. Most of the plots are in the Lower Foothills natural sub-region; an insufficient number of plots are located in the Central Mixedwood (3), Dry Mixedwood (2) and Upper Foothills (4) to illustrate regional differences. Trees were tagged, alive and measured before MPB attack, and assessed two to four times during the post-attack period 2008 to 2015 (additional measurements taken in 2016 are currently being compiled).

Figure 1 illustrates the trajectories over time for MPB infection on the 63 plots. The latest field assessments were made six to eight years after initial attack occurred in the vicinity of the plots, and five to seven years after attack was actually detected in the plots.

Table 1 summarizes levels of infection, mortality and lodgepole pine fall-down by 2015.

Table 1. Range of lodgepole pine tree conditions 6 to 8 years after MPB attack, expressed as percentages of the number of trees per plot that were alive prior to attack. Infected refers to trees observed with pitch tubes. Dead (total) and Dead Down refer to all dead trees, while Dead (MPB) includes only dead trees where MPB infection has been confirmed by pitch tubes.

Condition	% of Trees per Plot		
	Average	Maximum	Minimum
Infected	64	100	0
Dead (total)	68	100	9
Dead (MPB)	57	100	0
Dead (other)	11	29	0
Dead Down	5	25	0

The distribution of mortality among plots appears skewed or bi-modal (Figure 2). In approximately 50% of the plots more than 75% of trees are dead, with rates of mortality peaking at 70% to 80% of trees per plot. Some plots however show much lower levels of mortality, with 15% of plots having less than 25% mortality 6 to 8 years after initial attack. Note that these observations include mortality not directly attributable to MPB, and levels of actual kill by MPB are probably lower. The 5% average fall-down also includes trees whose deaths were not confirmed as attributable to MPB.

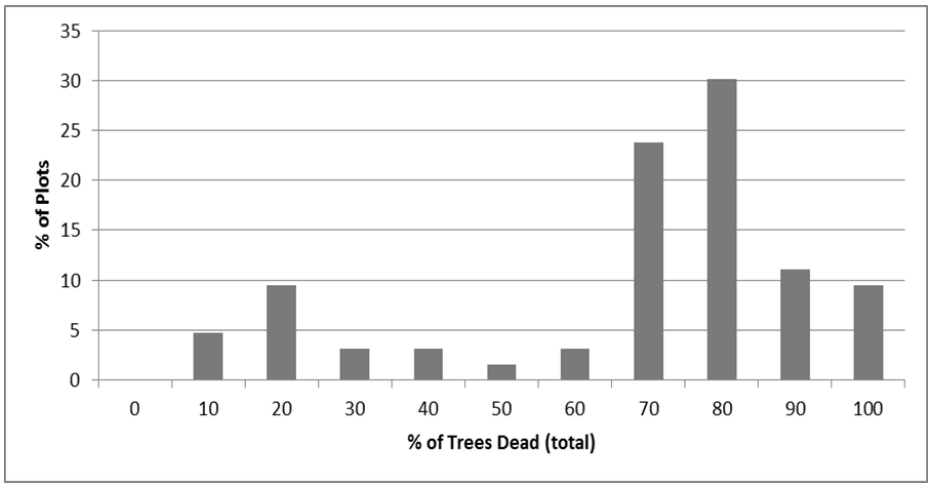

Figure 2. Distribution of mortality in sample plots 6 to 8 years after initial attack

Stands attacked since 2010 in the Grande Prairie and Whitecourt forest areas, and others attacked earlier in southern Alberta, have not been re-measured recently and were not included in the analysis. Selection of the measured 63 plots was therefore probably biased towards stands with more aggressive MPB activity, which implies that Figure 2 may underestimate the proportion of attacked stands having low mortality levels.

The wide range of infection and mortality observed, and the variability of stand conditions (structure and health) that are likely to result, have potential significance for salvage and rehabilitation planning. Understanding the factors influencing the range of mortality is therefore important. Preliminary nominal logistic regression analyses were

conducted, exploring the relationship of probability of tree infection at the plot cluster level to after-winter MPB success (mapped R-value classes)[1], variables used elsewhere to calculate stand susceptibility (SSI)[2], and other site factors.

Only weak trends were found between tree infection and stand and site variables, including those conventionally used in assessing stand susceptibility. A possible explanation is that beetle pressure from the original in-flight and subsequent high levels of overwintering success have had an overriding effect on probabilities and rates of tree infection since initial attack. A significant longitudinal effect was observed and may reflect the west to east spread direction. Stand density, tree diameter and percentage pine basal area show statistically significant but weak relationships with probabilities of tree infection. Stand age does not show any trend with infection probability, even though the plot clusters are distributed over a fairly wide range (60 to 135 years). The strongest trend was seen for soil nutrient regime, with infection increasing from poor to rich sites; more work is required to determine whether this is a real causal effect or artefact arising from the geographic distribution of the intense in-flight and subsequent spread of the infestation.

A more detailed analysis will therefore be undertaken with assistance from Alberta Agriculture and Forestry who is providing detailed aerial and ground survey data on the year-by-year progress of the infestation which we can relate to each of the monitored PSP locations and measurements. This will allow a more comprehensive assessment of the relationships of R-value (the Alberta government's measure of MPB overwintering success) and beetle pressure with probabilities and rates of tree infection than was possible in the preliminary analysis. Additional measurements and compilations made this year, which will extend the range of site conditions and infection rates studied, will also support a more comprehensive and detailed analysis. Regeneration, growth and recruitment, and changes in non-tree vegetation will also be assessed.

The study so far indicates that MPB attack does not always result in levels of mortality likely to lead to stand replacement (versus stand modification). Causes of the variation in infection and mortality are currently unclear, and it is hoped that the extended analysis proposed above will shed more light on the causal factors and implications of the preliminary results.

[1] Government of Alberta. 2010. The relative after winter success of mountain pine beetle across Alberta, Spring 2010. (Note that this was the only basis used for assessing the R-value effect in Table 2.)

[2] T.L. Shore & L. Safranyik. 1992. Susceptibility and risk rating systems for the mountain pine beetle in lodgepole pine stands. CFS Pacific Forestry Centre, Information Report BC-X-336.