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EFFECTS OF WESTERN BALSAM BARK BEETLE OUTBREAKS IN THE BIGHORN NATIONAL FOREST

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INTRODUCTION

Found throughout western North America, the western balsam bark beetle (WBBB) (*Dryocoetes confusus*) (Figure 1) is the most aggressive and destructive member of its genus (Smith and Hulcr 2015). Helped by the pathogenic fungi *Ceratocystis dryocoetidis* (Molnar 1964), WBBB primarily attack subalpine fir (*Abies lasiocarpa*), but has also been recorded in other *Abies* species (true firs), Engelmann spruce (*Picea engelmannii*), and lodgepole pine (*Pinus contorta*) (Furniss and Carolin 1977). The beetle is associated with spruce-fir stands containing a high density of large fir trees on the Bighorn National Forest. Storm-damaged fir trees (e.g., windthrow or blowdown) also may play an important role in triggering population increase of this beetle (McMillin et al 2003).

Figure 1. Western balsam bark beetle adult (left) and adult in its gallery (right). Photos by K. Schotzko.

Although the biology of the WBBB is not well known, the need to understand its life cycle and behavior has increased in relation to the increased commercial, aesthetic and recreation value of true firs (Hansen 1996). Information from Utah, Idaho, Montana, and British Columbia suggests that it has a two-year life cycle, but may vary between one – two years depending on latitude, weather conditions, and elevation

(Bright 1963, Hansen 1996). Beetles can fly throughout the summer beginning in early June in Utah, Montana, and British Columbia. Males typically initiate attacks on the boles of susceptible host trees. Upon initiating attack, males bore into the phloem, excavate a nuptial chamber, then attract and mate with several females. Two to seven egg galleries radiate from the central nuptial chamber (Figure 1). Larvae feed through late summer and fall in the phloem and extend their galleries until freezing weather. The first overwintering period is therefore typically spent as dormant larvae. Development is then resumed in the spring and summer. The second overwintering period is then usually spent as pupae or adults (Hansen 1996).

Mortality caused by WBBB is typically thought to result from multiple generations repeatedly colonizing a single tree (Wood 1982). In the Bighorn National Forest significant outbreaks of WBBB have also been documented and associated with extensive mortality within subalpine fir dominated stands (McMillin et al 2003). Subalpine fir plays an important role in providing wildlife habitat and watershed protection (Figure 2). Large scale losses will negatively affect these resources.

Figure 2. Subalpine fir stands in the Bighorn National Forest with western balsam bark beetle caused mortality. Photos by K. Schotzko.

METHODS

Stands were distributed haphazardly across the landscape (Figure 3), and were predominantly subalpine fir. In each stand, four 1/20th acre plots were installed, each two chains apart on a compass bearing that kept the cruise line within the selected stand. All trees above three inches DBH (diameter at breast height) were considered mature and potential host material for WBBB. The species, DBH, and condition (live, killed by WBBB, or killed by another mortality agent) were assessed for all trees with DBHs greater than three inches. Trees with DBH less than three inches were considered regeneration, and for these trees only species and condition were recorded. At each plot within the stand, five trees were thoroughly examined for the presence of root disease, particularly *Armillaria*. Dead trees were generally selected for root disease examination, although a limited number of live trees had to be examined when there were not enough dead trees. Additionally, in a subset of stands, trees were cored to determine age and 10 years growth. In those stands sampled by coring, three live and three recently killed trees of roughly equal diameter were cored.

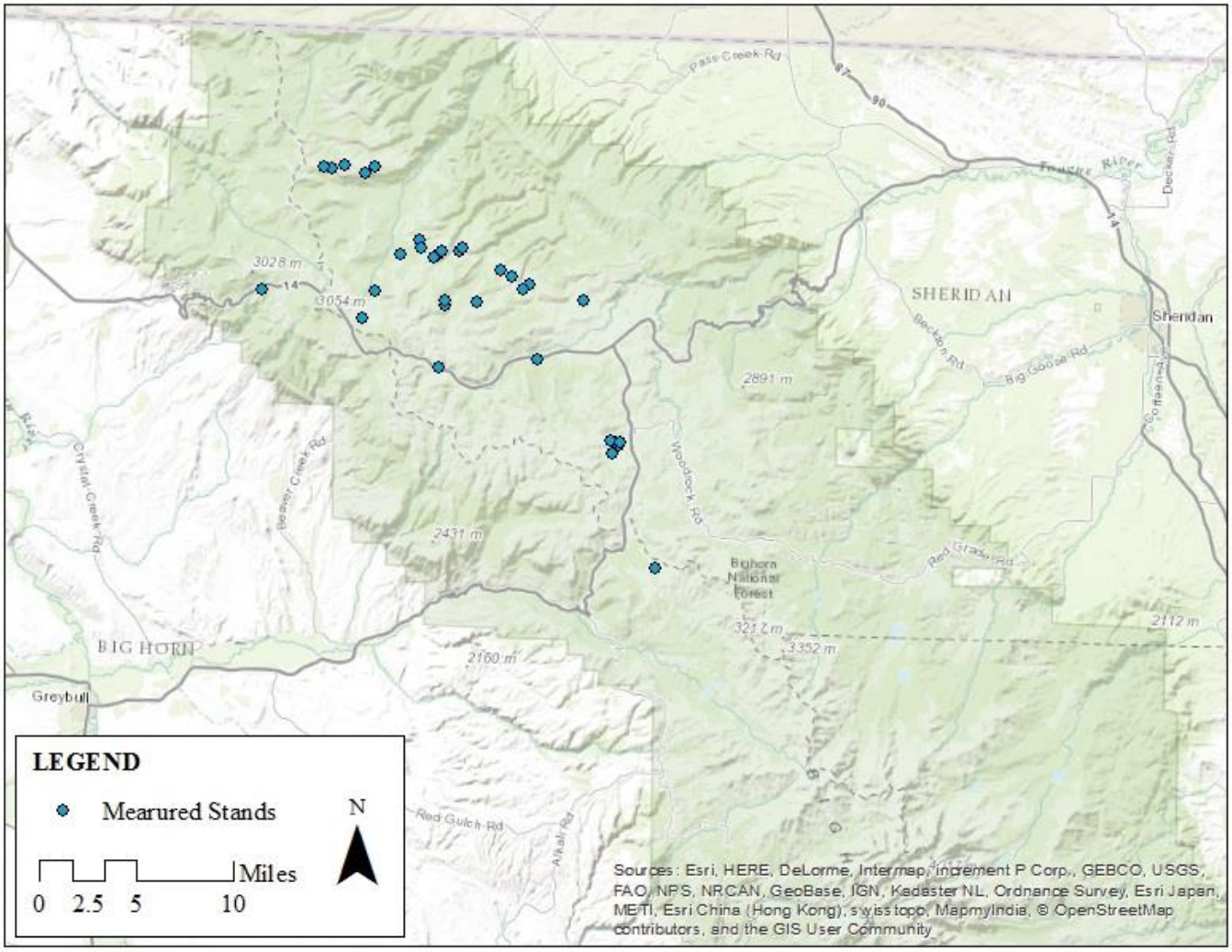

Figure 3. Map of stand locations in the northern Bighorn National Forest, 2016.

RESULTS

Over 4,000 mature trees were measured, of which 3,510 were subalpine fir (81% of total trees). Five hundred and ninety-five Engelmann spruce (14% of total trees) were also present within the plots. Minor species included lodgepole pine (195 trees, 5%), limber pine (11 trees), quaking aspen (4 trees) and Douglas-fir (2 trees). The roots of over 680 trees were examined for the presence of *Armillaria*. There was no *Armillaria* found in any of the stands. On average, 53% of the subalpine fir within measured stands was killed by WBBB during the most recent epidemic. The range of this mortality, however, was wide. The least impacted stand experienced about 9% mortality of the subalpine fir component, and the most severely impacted stand lost roughly 79% of its subalpine fir.

There was a trend towards larger diameter subalpine fir being preferentially attacked (Figure 4). However, all size classes above three inches DBH suffered considerable mortality. Overall, the average size of live fir trees was 7 inches DBH, while the average size of a killed fir tree was 8 inches. Of note is that the majority of the trees (67%) occurred in the three to nine inch DBH categories, while 33% of the total trees were 9 inch DBH and greater, so there were substantially more small diameter than large

diameter trees available for attack. The average diameter of both the live and dead core trees was eight inches. The average age of the dead trees was 83, and of live trees 81. The average 10 year growth rates of both live and dead trees were the same at 0.41 inches.

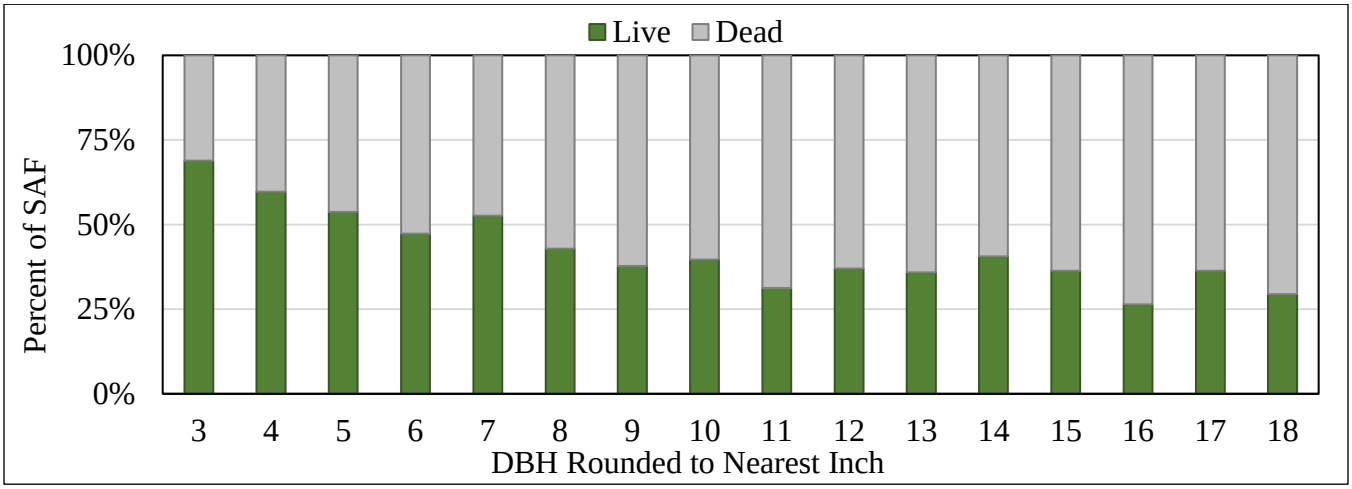

Figure 4. Percent of live and dead fir in one inch diameter classes. Dead fir were killed by western balsam bark beetle.

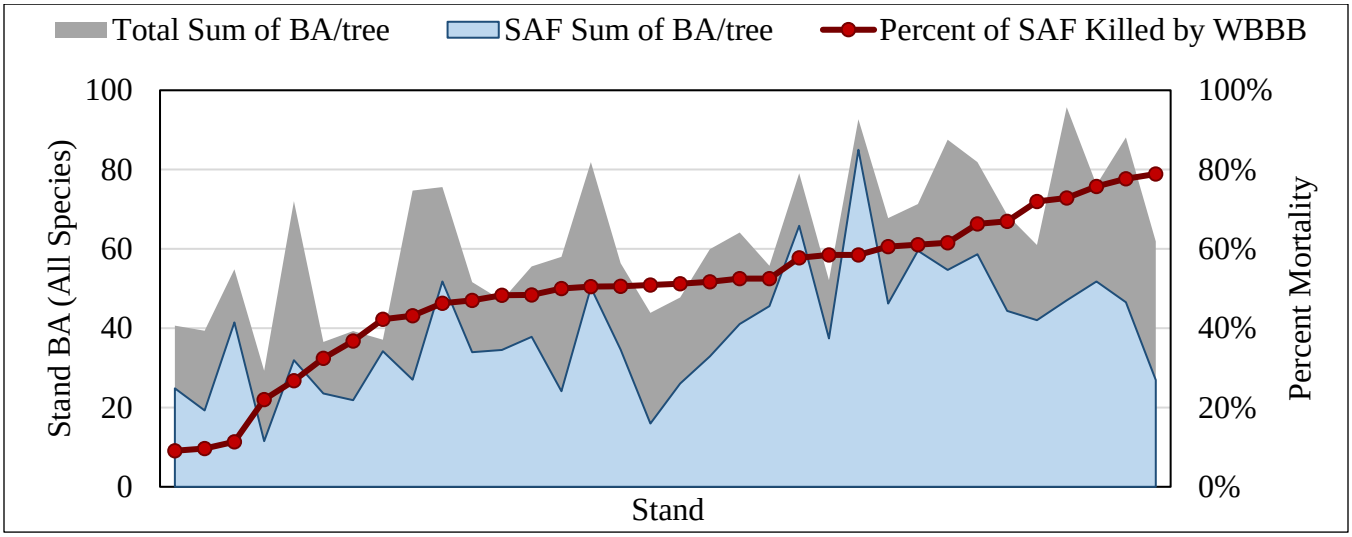

Figure 5. Total stand basal area and stand subalpine fir basal area with percent trees killed by western balsam bark beetle.

There also appears to be a positive association between total stand basal area, as well as subalpine fir basal area, in stands with high levels of subalpine fir mortality (Figure 5). Stands with higher overall basal area and those with higher levels of subalpine fir basal area typically had higher levels of WBBB caused mortality.

For the regeneration, over 4,500 trees were recorded. Even with high levels of mortality of overstory subalpine fir, the understory was dominated by subalpine fir. Fir seedlings and saplings accounted for 93% of the understory, which is an increase from the 81% of trees that were fir in the overstory. There

were a small number of saplings (less than three inches) that had been killed by WBBB. There was an average of 400 fir seedlings and saplings per acre across all stands. Spruce was the second most common understory species found, but accounted for only 6% of the seedlings and saplings. This is a reduction from the 14% of the overstory that is spruce in these areas. Lodgepole pine comprised 1% of the understory and was only found in two of the stands.

CONCLUSIONS

Over the past 20 years there has been an epidemic of WBBB that has killed a significant portion of the subalpine fir on the Bighorn National Forest. Over 50% of overstory trees have been killed during this time, with some stands approaching 80% tree mortality. Mortality at this level can change the function of the stand as it relates to habitat for wildlife and watersheds. Elevated mortality began in the early to mid- 1990's, shortly after some large areas of blowdown occurred in fir dominated areas of the Bighorn National Forest. While it is not conclusive, it is certainly suspicious that landscape level WBBB caused mortality of fir followed such an event.

Whatever the cause of epidemic initiation, once the epidemic began it appears that there was a positive association between tree size and stand density and the amount of subalpine fir mortality. This is consistent with what is seen with many other bark beetles, which often prefer larger trees and denser stands, including previous studies on WBBB (Bleiker et al 2002). While trees size appears to play some role in host selection, WBBB nevertheless attacked and killed many smaller diameter sized trees, which is uncommon for the major bark beetle species. A large proportion of three and four inch trees were killed by WBBB, and so at least on some level, trees of this size are suitable hosts for this beetle. Additionally, it appears that stand density plays a role in the amount of mortality caused by WBBB. Denser stands typically had higher levels of mortality. This is similar to results and behaviors found in other bark beetles, including WBBB (McMillin et al 2003).

Overall, the stands are regenerating with a high percentage of the understory coming back as subalpine fir. These stands will, in time, be dominated by subalpine fir with perhaps even less spruce than was originally in the overstory. In this particular case there was no connection between tree age or recent radial growth and whether or not a tree was killed, unlike what was found in Bleiker et al (2005). This lack of association could be due to the extremely high populations of WBBB that had been present in these stands leading to less selectivity of host trees.

There is no clear reason for the lack of root disease in subalpine fir on the Bighorn National Forest. *Armillaria* is frequently found in dead fir, but we found none. Frequently, death of subalpine fir is classified as a decline with multiple causal agents, such as beetles and root disease, ultimately responsible for tree death. In the Bighorn National Forest, however, subalpine fir mortality appears to be solely the work of WBBB.

Based on our results it appears that mortality caused by WBBB could be reduced in future stands through the following management actions:

1. Prompt cleanup of larger areas of blowdown
2. Removal of larger DBH subalpine fir
3. Reduction in overall stand density

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