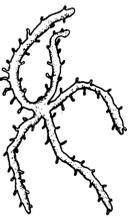




# Impacts of western balsam bark beetle on forest conditions of the Bighorn National Forest



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## Introduction

Western balsam bark beetle (*Dryocoetes confusus* Swaine) reproduces in subalpine fir (*Abies lasiocarpa*) throughout western North America (Furniss and Caroling 1980). Little is known about the stand conditions associated with outbreaks of this species and its potential impacts to both the forest overstory and understory. Questions addressed in this study included: 1. What was the impact of western balsam bark beetle on stand conditions and subalpine fir (SAF) in the overstory? 2. What were the forest conditions present in areas that have experienced high levels of mortality over the past 10 years? 3. What changes occurred in the understory of infested stands of SAF? 4. What role does tree blowdown play in the population increase of western balsam bark beetle? Answers to these critical issues are not only of value to managers on the Bighorn National Forest, but also should be applicable to other areas of the central and northern Rockies where there are extensive stands of predominantly subalpine fir, blowdown events have occurred and western bark beetle is present.

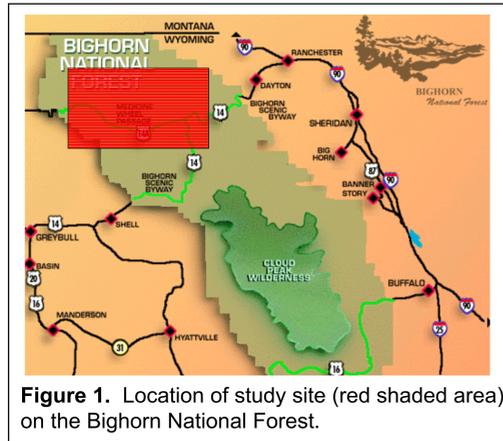


Figure 1. Location of study site (red shaded area) on the Bighorn National Forest.

## Methods and Materials

The studies were conducted on the Bighorn National Forest, Wyoming (Figure 1). The area was characterized by mixed stands of SAF, Engelmann spruce and lodgepole pine, and by blowdown events that occurred in the mid-1990's (Figure 2). Elevation in the study area ranged from 8,500 to 9,500 ft. Forest conditions and western balsam beetle impact were measured during the summer of 2000 using systematic sampling through stands that were predominantly spruce-fir and that had experienced older mortality. Fixed radius plots (1/50<sup>th</sup> ac) were installed every 20 chains (1340 ft.) in 11 transects to measure forest conditions and beetle impacts. Within each plot, Forest Health Monitoring-type mensuration measurements were taken on all trees greater than 4 inches in diameter at breast height. Tallies of beetle-killed trees were recorded along transects.

In addition, similar measurements were recorded using pairs of infested and uninfested fixed radius plots (1/20<sup>th</sup> ac). These plots were installed to develop prediction models for western balsam bark beetle-caused mortality. Understory growth, abundance, and height also were measured by counting the number of total inches that grass, forb and shrub species cover along 10 foot lines running North - South and East - West of plot center. The species, number, and regeneration class also were measured in 0.01 ac plots.

To examine the relationship between tree blowdown and western balsam bark beetle, transects also were conducted through areas of blowdown that occurred in the mid-1990's. The absence or presence of egg galleries on all downed SAF logs was recorded within fixed radius plots (1/50<sup>th</sup>).

## Results

Western balsam bark beetle had significant impacts of the forest overstory (Tables 1 and 2). Western balsam bark beetle killed on average 71 trees per acre (Figure 3) and caused considerable reductions in stand all stand measurements except live diameter at breast height (DBH).

The percentage of SAF in the stand, SAF stand density index, and SAF basal area were important in determining the level of western balsam bark beetle impact. For example, the amount of basal area killed increased linearly with SAF basal area (Figure 4).

Western balsam bark beetle also had an impact on the understory (Table 2 and Figure 5). Although the ranking of forbs, shrubs, and grass did not change relative to each other, there was a > 2.5-fold increase in their total abundance in the infested plots compared with the uninfested plots (Figure 5). In addition, there was a 25 % increase in regeneration in the infested plots compared with the uninfested plots; however, the relative proportion of subalpine fir seedlings was the same in both plots (data not shown).

Egg galleries were found in more than 30 % of the downed SAF based on the transects through the three blowdown areas surveyed (Figure 6). Moreover, the percent of attacked logs increased with the percentage SAF logs within the blowdown.



Figure 2. Subalpine fir mortality caused by western balsam bark beetle adjacent to area of blowdown on the Bighorn National Forest.

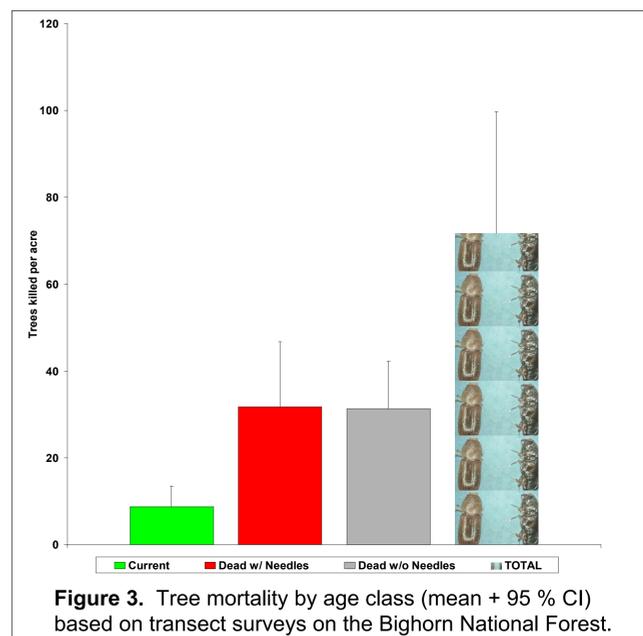


Figure 3. Tree mortality by age class (mean + 95 % CI) based on transect surveys on the Bighorn National Forest.

Table 1. Summary (mean +/- 95% CI) of stand conditions based on transect surveys in the Bighorn National Forest.

Variable	Mean	95% CI
Basal area (ft <sup>2</sup> /ac)	250.8	22.6
Live basal area	156.1	42.6
SAF basal area	137.6	40.6
Basal area killed	94.7	44.0
DBH (inches)	9.26	0.87
Live DBH	9.12	0.43
SAF DBH	8.45	1.03
Percent SAF	65.2	15.5
Live percent SAF	42.9	13.8
Stand density index (SDI)	487.9	45.2
Live SDI	301.3	85.0
SAF SDI	273.3	78.5
Trees per acre (TPA)	561.0	87.8
Live TPA	352.1	103.8
SAF TPA	357.3	103.1

Table 2. Summary (mean +/- 95% CI) of western balsam bark beetle impacts on stand conditions based on paired uninfested and infested plots on the Bighorn National Forest.

Variable	Uninfested	Infested	Difference (%)	p > t*
Basal area (ft <sup>2</sup> /ac)	234.0 (25.9)	257.4 (26.2)	+ 9.1	0.071
Live basal area	209.0 (26.9)	76.8 (17.8)	- 63.3	<0.001
SAF basal area	131.3 (23.5)	202.2 (27.7)	+ 35.0	<0.001
Basal area killed	25.0 (26.9)	180.5 (8.7)	+ 86.1	<0.001
DBH (inches)	9.20 (0.40)	9.31 (0.47)	+ 1.2	0.340
Live DBH	9.30 (0.47)	8.79 (0.91)	- 5.5	0.174
SAF DBH	8.15 (0.39)	8.93 (0.43)	+ 8.7	0.002
Percent SAF				
pre-infestation	69.9 (10.2)	84.2 (5.4)	+ 17.0	0.008
post-infestation	68.2 (10.5)	65.2 (12.4)	- 4.4	0.396
Trees per acre (TPA)	511.8 (49.7)	559.3 (62.0)	+ 8.5	0.082
Live TPA	450.7 (52.2)	172.1 (37.4)	- 61.8	<0.001
SAF TPA	353.9 (58.6)	477.9 (69.5)	+ 25.9	0.004
Stand density index (SDI)	470.0 (47.0)	498.3 (54.5)	+ 5.7	0.192
Live SDI	417.7 (49.5)	153.4 (34.5)	- 63.3	<0.001
SAF SDI	269.0 (47.6)	404.9 (54.5)	+ 33.6	<0.001
Understory height (inches)	1.23 (0.66)	2.76 (0.91)	+ 55.4	0.006
Seedlings per acre	255 (101.4)	345 (111.0)	+ 26.0	0.093

\* Probability associated with Student's t-test.

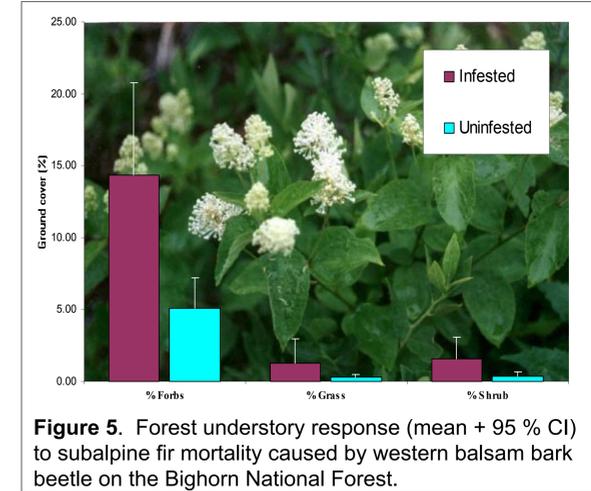
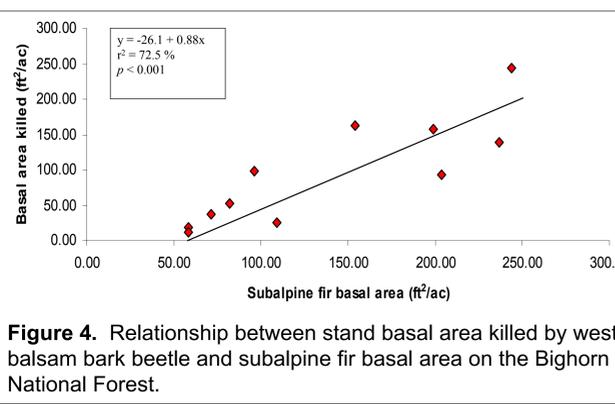


Figure 5. Forest understory response (mean + 95 % CI) to subalpine fir mortality caused by western balsam bark beetle on the Bighorn National Forest.

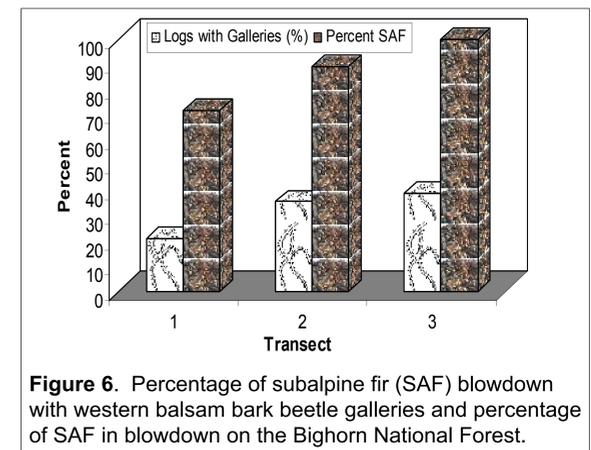


Figure 6. Percentage of subalpine fir (SAF) blowdown with western balsam bark beetle galleries and percentage of SAF in blowdown on the Bighorn National Forest.

## Conclusions

- Western balsam bark beetle is significantly impacting the overstory and understory of spruce-fir forests on the Bighorn National Forest.
- There are significant relationships between subalpine fir basal area, subalpine fir stand density index, and percent fir in the stand and the amount of western balsam bark beetle-caused tree mortality.
- The response of the forest understory to overstory mortality is slower in spruce-fir forests than other forest types such as Douglas-fir and pine forests (McMillin and Allen 2000).
- Tree blowdown likely plays a role in initiating western balsam bark beetle population increase.
- Blowdown events in the mid-1990's in combination with a high percentage of fir component has provided ideal conditions for continued beetle expansion in the northern Bighorn National Forest.

## Literature Cited

Furniss, R.L. and V.M. Caroling. 1980. Western Forest Insects. USDA Forest Service Misc. Publication 1339.

McMillin, J.D. and K.K. Allen. 2000. Impacts of Douglas-fir beetle on overstory and understory conditions of Douglas-fir stands, Shoshone National Forest, Wyoming. USDA Forest Service Technical Report R2-64.