Spruce Beetle Population Suppression in Northern Utah


ABSTRACT: The spruce beetle is a widely dispersed, native bark beetle that attacks and kills North American spruces. We describe a project that was initiated to suppress an endemic spruce beetle population in an isolated 1000 ac area of spruce in northeastern Utah. Techniques used included baited pheromone traps, selective harvesting and burning of infested trees, and trap trees. Over the 3 yr period of monitoring, the number of standing, currently infested spruce trees was reduced 91%. Field surveys and data trends, in comparison with a nearby spruce beetle population that continued to increase, indicate that the treatments played a major role in decreasing the trend of spruce beetle-infested trees during the study period. This combination of suppression techniques was successful due to the isolated nature of the spruce stands, early detection of the beetle population, accessibility of the stands, and coordinated efforts of local, state, and federal agencies. West. J. Appl. For. 15(3):122-128.

The spruce beetle (Dendroctonus rufipennis), a native bark beetle associated with North American spruces (Picea spp.), is widely distributed throughout North America. The beetle’s range follows that of its host from Alaska southward along the Rocky Mountain range into eastern Arizona and western New Mexico and across the Canadian provinces into northeastern United States (Wood 1982). In general, spruce trees tend to be shallow-rooted with little windfirmness and consequently are prone to blowdown (Alexander 1986). The spruce beetle takes advantage of this particular aspect of its host behavior, preferentially attacking downed trees to live standing ones. As population levels increase, however, live standing spruce may also be attacked in large numbers, resulting in widespread tree mortality over expansive acreages (Schmid and Frye 1977).

NOTE: B.J. Bentz is the corresponding author and can be reached at (435) 755-3560; Fax: (435) 755-3563; E-mail: bbentz@fs.fed.us. Chuck Frank (silviculturist), Dwayne Bell (forestry technician), Evelyn Sibberson (forester), and Kent O’Dell (timber management coordinator) with the Wasatch Cache National Forest, and Jim Long with Utah State University were instrumental in the success of this project. Discussions with Pat Shea provided insight into funnel trap placement. The authors thank field crews from Forest Health Protection, Ogden, UT; Department of Forest Resources—Utah State University; and the Rocky Mountain Research Station, Logan, UT, for help with the extensive surveys. Tom Bradley was responsible for GPS measurements and GIS analysis. Jim Long, Ed Holsten, and an anonymous reviewer provided valuable input to the manuscript.

This article reports the result of research only. Mention of a proprietary product does not constitute an endorsement or a recommendation by the USDA Forest Service for its use. Pheromones used in this study are not currently registered for use by the general public. Caution should be used when pheromones are deployed in a forest setting to avoid undesirable tree mortality. A qualified state or federal entomologist should be contacted for advice on the use of bark beetle pheromones.

In northern Utah, spruce beetles emerge from brood trees and disperse to attack new hosts between May and late July when temperatures reach approximately 16°C (Dyer 1973). Throughout its host range, populations typically require 2 yr to complete a generation, although generation time depends greatly on temperature (Safranyik and Linton 1999, Werner and Holsten 1985, Bentz and Hansen unpublished data) and may require as little as 1 yr or as long as 3 yr. In 2 yr populations, brood emerge the second summer after a tree has been attacked.

One strategy for managing spruce beetle populations is the use of trap trees. This method takes advantage of the tendency for spruce beetles to attack downed trees. Larger diameter, green spruce are felled into the shade and left unbuckled and unlimbed (Hodgkinson 1985, Nagel et al. 1957). Trap trees typically have greater mean attack densities than standing spruce (Schmid and Frye 1977) and can absorb as many as 10 times the number of beetles (Wygant 1960, unpublished). In areas with lower infestation levels, one trap tree is cut down for each four to five infested standing trees, with no more than 1/4 mi between an infested group of trees and the trap trees. When feasible, legal, and accessible, trap trees may be injected with a translocating silvicide to eliminate the need for trap tree removal or brood destruction through debarking or burning (Gray et al. 1990, Lister et al. 1976). Otherwise, infested trap trees must be removed from the stand, burned, or buried before the next beetle flight to avoid a localized increase in the beetle population. In areas that are accessible by road, sanitation-salvage logging of infested trees before beetle flight is a recommended treat-
The T.W. Daniel Experimental Forest lies within the Logan Ranger District of the Wasatch-Cache National Forest, which contains approximately 17,000 ac of spruce-fir vegetation type. The Experimental Forest makes up approximately 2,560 ac of the Logan Ranger District, with approximately 1000 ac of spruce-fir type. Mensurational information was gathered for three stands within the T.W. Daniel Experimental Forest (hereafter referred to as the study area) in 1996 when the beetle population was first observed (Table 1). The unmanaged area lies within Stand 9 (Table 1), which is located on the western edge of the study area in steeper terrain. Although the proportion of basal area (BA) comprised of Engelmann spruce varies throughout the study area, the unmanaged area had the highest proportion of spruce BA (62%) and the highest total stand BA (224).

In Fall 1996, a survey was conducted within the area to identify infested hosts. A tree was considered fully attacked if attacks on the tree bole exceeded 75% of the circumference and strip-attacked if the attacks were confined to less than one-third of the tree bole. In the roaded or managed area, all infested hosts were removed, and 85 green spruce trees were cut to serve as trap trees. The majority of trap trees were placed near infested tree clusters. Generally, two to five trap trees were planted near infested trees, and a single detectable bait trap was placed in each group of trees to monitor beetle populations.

Table 1. Site characteristics for three stands on the T.W. Daniel Experimental Forest, measured 1996.

<table>
<thead>
<tr>
<th>Stand #</th>
<th>Acres</th>
<th>Basal area (ft²)</th>
<th>Live</th>
<th>ES</th>
<th>QMD (in.)</th>
<th>ES</th>
<th>SAF</th>
<th>ASP</th>
<th>LP</th>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>75.0</td>
<td>165</td>
<td>18.0</td>
<td>49</td>
<td>36</td>
<td>5</td>
<td>11</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>45.9</td>
<td>155</td>
<td>19.9</td>
<td>32</td>
<td>46</td>
<td>4</td>
<td>14</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>259.7</td>
<td>224</td>
<td>21.6</td>
<td>62</td>
<td>33</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE: ES = Engelmann spruce, SAF = Subalpine fir, ASP = aspen, DF = Douglas fir, QMD = quadratic mean diameter.
Table 2. Site characteristics for 13 stands measured in 1997 on the Ogden Ranger District.

<table>
<thead>
<tr>
<th>Stand #</th>
<th>Acres</th>
<th>Basal area (ft²)</th>
<th>Live ES</th>
<th>QMD (in.)</th>
<th>SAF</th>
<th>ASP</th>
<th>DF, LP</th>
</tr>
</thead>
<tbody>
<tr>
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<td>247</td>
<td>147</td>
<td>11.9</td>
<td>42</td>
<td>27</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>68-2</td>
<td>51</td>
<td>60</td>
<td>6.0</td>
<td>11</td>
<td>0</td>
<td>78</td>
<td>11</td>
</tr>
<tr>
<td>59-15</td>
<td>25</td>
<td>170</td>
<td>10.8</td>
<td>71</td>
<td>29</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>59-32</td>
<td>29</td>
<td>130</td>
<td>10.0</td>
<td>8</td>
<td>23</td>
<td>0</td>
<td>69</td>
</tr>
<tr>
<td>30-14</td>
<td>35</td>
<td>127</td>
<td>19.1</td>
<td>53</td>
<td>47</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>30-9</td>
<td>21</td>
<td>216</td>
<td>19.9</td>
<td>72</td>
<td>26</td>
<td>2</td>
<td>0</td>
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<tr>
<td>27-5</td>
<td>59</td>
<td>146</td>
<td>16.3</td>
<td>78</td>
<td>12</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>27-2</td>
<td>90</td>
<td>133</td>
<td>12.2</td>
<td>82</td>
<td>8</td>
<td>0</td>
<td>10</td>
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<tr>
<td>27-1</td>
<td>33</td>
<td>175</td>
<td>9.7</td>
<td>77</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>27-6</td>
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<td>175</td>
<td>20.1</td>
<td>87</td>
<td>13</td>
<td>0</td>
<td>0</td>
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<tr>
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<td>15.5</td>
<td>38</td>
<td>28</td>
<td>27</td>
<td>7</td>
</tr>
<tr>
<td>25-8</td>
<td>8</td>
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<td>17.0</td>
<td>92</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>66-2</td>
<td>171</td>
<td>209</td>
<td>15.2</td>
<td>65</td>
<td>9</td>
<td>26</td>
<td>0</td>
</tr>
</tbody>
</table>

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placed within the infested host clusters (Figure 3). Some were missed and remained in the woods. For Fall 1998, and no additional trap trees were utilized. An additional 116 infested trees dropped in 1996 were all infested and subsequently removed or burned in Fall 1997. An additional 116 infested trees were found in Fall 1997. Spillover into the study area was made to remove a portion of the attacked trees, resulting in an unmanaged area of approximately 140 ac.

During the flight, the maximum daily temperature in northern Utah was recorded using a datalogger, which measured a low of 9.7øC and a high of 20.4øC. Maximum daily temperatures remained below 25øC throughout the flight. Beetles were first caught in traps on July 2, 1997, with a peak spruce beetle flight the week of July 14. Maximum daily temperatures were light. All identified infested trees were removed in the month of October. Of these, 199 infested trees were removed in October. Sixty-five full-attacked trees, 33 strip-attacked trees, and 9 windthrow-attacked trees were found in Fall 1997. The 42 trap trees dropped in Fall 1997 were all infested and subsequently caught in the 42 trap clusters (126 total traps). Seventy-two beetles were determined to be predators of the spruce beetle, and none of the traps were removed.

The majority of 1997 full-attacked trees were in the 24 and 30 in. diameter classes, with a distribution ranging from 12 to 48 in. Although there were far fewer trees attacked in 1998, the attack density in 1998 was less than in 1997. Full attacks of trees, which occurred in 1996, were attacked again in 1997 and left in the woods. From 31 trees strip-attacked in 1996, 27 of the 31 trees were still in the woods. Of the 14 trees strip-attacked in 1996, 2 of the 14 trees strip-attacked in 1996 were found to be still in the woods. These trees provided a result of blowdown. A small proportion of the blowdown in the northwestern edge of the study area (Figure 4), in the same general location as the traps which caught the majority of spruce beetles in 1997 (Figure 3).

The impact of the spruce beetle in an area of isolated Engelmann spruce was evident in the Logan and Ogden Ranger Districts. The number of trees infested in the Logan Ranger District, estimated to be infested in 1995, and the number increased to 1,635 infested trees in 1997 (16% increase). During the same time period, the number of trees infested in the study area trend on the Ogden Ranger District continued to increase to 1,635 infested trees in 1997 (16% increase). The population of trees infested on the Ogden Ranger District in 1995, 1996, and 1997 was similar (16,000 and 17,000 ac respectively), and all mortality on the Logan Ranger District, except for two groups of trees in 1996, were confined to the northwestern edge of the study area. However, treatments only occurred within the study area. Despite an effort to remove or burn all infested trees each year, some were missed and remained in the woods. For Fall 1998, and no additional trap trees were utilized. An additional 116 infested trees were found in Fall 1997. Spillover into the study area was made to remove a portion of the attacked trees, resulting in an unmanaged area of approximately 140 ac.

The effects of this logging are not reflected in our data, due to the year time lag involved in detecting infested trees. Despite an effort to remove or burn all infested trees each year, some were missed and remained in the woods. For Fall 1998, and no additional trap trees were utilized. An additional 116 infested trees were found in Fall 1997. Spillover into the study area was made to remove a portion of the attacked trees, resulting in an unmanaged area of approximately 140 ac.

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Figure 3. Spatial location of 1997 spruce beetle-infested trees, by attack type, and pheromone-baited funnel traps displayed on a topographic map. Elevation contours are displayed every 20 m. Of beetles caught in 1997, 72% were caught in trap numbers 20, 21, and 28 (see text).

Figure 4. Spatial location of 1998 spruce beetle-infested trees, by attack type, and pheromone-baited funnel traps displayed on a topographic map. Elevation contours are displayed every 20 m. Of beetles caught in 1998, 93% were in trap number 27 (see text).
Figure 5. Diameter distribution of spruce beetle-infested trees in the study area (T.W. Daniel Experimental Forest), by attack type, in (a) 1997 and (b) 1998.

Sections of downed trees that were exposed to the sunlight were colonized by Ips pilifrons, while spruce beetles were generally found on the underside of downed boles.

Several biotic and abiotic factors could be responsible for a decline in spruce beetle populations including: (1) lack of adequate food source, (2) unfavorable environmental factors such as temperature, and (3) excessive beetle mortality due to predators such as woodpeckers.

Our surveys indicated an abundant source of susceptible host trees remaining in the area which could support a beetle population, and therefore this is not the reason the population has declined. Air temperatures during the spring and summer of 1998 in the study area and the area used for comparison, where the beetle population trend had increased in the previous 3 yr, reveal similar temperature patterns. This suggests that environmental effects on beetle population rate of development and survival were similar between the two areas. Although we did not conduct a formal woodpecker study, there were no signs to indicate that woodpecker populations, the most important predator of the spruce beetle, were overly abundant in the area.

Most infested trees exhibited little evidence (bark flaking) attributed to woodpecker feeding. Field surveys and data trends indicate that the sanitation-salvage treatment, in conjunction with pheromone-baited traps and trap trees, played a major role in the decreasing trend of spruce beetle-infested trees on the T.W. Daniel Experimental Forest from 1995 to 1998. This combination of techniques was successful in part due to the isolated nature of the study area, the early detection of the beetle population, and road access to the study area. The ability of federal and state agencies to act in a rapid and coordinated manner was also instrumental in the success of the project.

Placing pheromone-baited traps within the host type, even though they were within clusters of dead trees, resulted in focusing beetles into surrounding green trees. This practice should not be conducted in future suppression efforts of this type, unless the dead-tree groups are much larger than 10 to 15 dead trees. Traps should only be placed in nonhost type. Wind direction may have had an effect on beetle dispersal and subsequent trap catches. The majority of beetles for both years were caught in traps situated in the same relative location on the northwestern edge of the study area at the top of a drainage. Although we did not have wind measurements, personal observations indicated an easterly wind pattern in that area. Since our results indicate that wind direction may significantly affect spruce beetle-trap catches, a trapping array should be based on prevailing wind patterns to maximize spruce beetle catch and reduce clerid beetle catch.
Because the spruce beetle has a 2 yr life cycle in this area, beetles that initially infested trees in 1996 dispersed to attack new host trees in 1998. Assuming all infested trees were identified in our surveys, the 5 full-attacked trees and 13 strip-attacked trees remaining from 1996, in addition to the residual spruce beetle populations in the 1999 stumps of trees removed, were responsible for production of beetles that attacked trees and were caught in traps in 1998. Because infested trees in 1996 were harvested in late October and November, which is after hibernation emergence, a large proportion of the adults could have moved to the lower bole of the tree. Thus, the stumps of the harvested trees may have contained a large number of adult beetles. If possible, selective harvest of infested trees should be conducted in early August following beetle flight, yet before hibernation emergence from trees infested the previous year.

Use of the techniques described here does not dramatically alter conditions of the treated stands, leaving the residual spruce component susceptible to further spruce beetle infestation. Although sanitation-salvage efforts in an isolated stand may help to reduce the beetle population to endemic levels, an increase in windthrow and/or favorable climatic conditions could result in another population expansion. Other silvicultural strategies, such as thinning, to reduce stand susceptibility to the spruce beetle have not yet been tested. To maintain minimal beetle-related impacts in susceptible, isolated spruce stands, population levels should be monitored and the direct suppression efforts identified previously employed if the population surpasses endemic levels of beetle activity.

Literature Cited


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