United States
Department of
Agriculture

Forest Service

Southern Forest
Experiment Station

Research Note

SO-342
November 1997

Southern Pine Beetles Attack Felled Green Timber

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SUMMARY

Southern pine beetles attacked green, uninfested downed trees and logs, as well as nearby standing trees. Beetles infesting horizontal trees and decked logs reproduced sufficiently to indicate that in some circumstances freshly cut, green trees may provide a utilizable resource for beetle populations.

Keywords: *Dendroctonus frontalis,* dispersal, *Ips calligraphus,* southern pine beetle.

INTRODUCTION

Although Hopkins (1909) briefly mentioned that the southern pine beetle (SPB) *(Dendroctonus frontalis* Zimmermann) will breed in felled pines (*Pinus* spp.), this behavior has been thought to be uncommon (Gara and others 1965). MacAndrews (unpublished MS thesis 1926)[1] first reported SPB completing a generation in felled logs of shortleaf pine (*Pinus echinata* Miller) in an "epidemic" situation. In summer and fall he noticed that the logs were attacked simultaneously by SPB and *Ips calligraphus* (Germar) within 2 days after felling and that the bottoms of logs were colonized more heavily by SPB than the tops. Highest emergence:attack ratio (E/A) (10.4) was in the butt logs where bark was thickest. The average number of beetles was 21 .4/cm^2 (198/ft^2). In standing timber, the E/A was lower (about 8.0), but numbers of emerging SPB were higher (32.41 cm^2 or 300/ft^2).

Craighead and others (1927) (cited by Dixon and Osgood 1961) also noted that SPB attacked downed material, but discounted its importance. St. Georgeand Beal (1929), however, noted that "blow downs" during the summer, and large quantities of timber normally cut at that time, created conditions that were a menace to the surrounding healthy trees because the freshly cut or damaged timber was frequently attractive to the beetles. Beal and Massey (1945) viewed the phenomenon as occurring during non-outbreak conditions, but included a photo revealing *Ips* galleries in the upper portion of a downed log with SPB colonizing the side and bottom. Gara and others (1965) reported that the SPB prefers to land on vertical rather than horizontal objects under any condition. Subsequent SPB literature did not dispute this statement, and in one recent article it is stated that, "SPB won't touch trees that are on the ground" (Anon. 1987).

We report here observations of SPB attacking logs cut from green uninfested trees and stacked horizontally in a log deck, as well as freshly cut green trees adjacent to a spot in which infested trees were felled and not removed. Results indicated that beetles may land on, attack, and reproduce in felled green trees much more commonly than generally thought.

MATERIALS AND METHODS

Horizontal Trees

This study was conducted on the Kisatchie National Forest, Catahoula Ranger District, about 5 km (3 mi) north of Williana, Louisiana. The test area was in a

[1] MacAndrews, A.H. 1926. The biology of the southern pine beetle. Unpublished M.S.thesis. N.Y. State College of Forestry. 103 p.

35-year-old mixed stand of loblolly pine (*Pinus taeda* L.) and shortleaf pine, with a mesic understory of mixed hardwoods.

The SPB infestation was located by District personnel on November 12, 1985, when it contained 20 infested trees. By the first week of December, trees containing SPB brood in various stages of development and 89 non-infested trees were felled but not removed (fig. 1). The uninfested trees were felled to ensure that no infested trees were overlooked, and to provide a buffer strip at the advancing front of the infestation. East of and adjacent to this area, about 40 infested trees, cut but not removed, remained from a previous control operation. One hundred meters (328 ft) to the northeast was an active infestation with 50 trees containing SPB brood, and within a 0.4-km (0.25mi) radius of the infestation were hundreds of additional infested trees.

Starting January 10, 1986, we examined the downed trees at weekly intervals to determine which were attacked by SPB or *Ips* spp. and for evidence of parent adult emergence.

On March 24, each of the downed trees infested with SPB was destructively examined to determine the stage of the most advanced brood. Five of the most heavily infested trees were sampled intensively. Trees selected for sampling had SPB brood in the pupa-callow adult stage and were 20 to 25 cm (8 to 10 in) or greater in stump diameter (fig. 2). Using a hole-saw, 100-cm^2 (15.5-in^2) samples were taken at 1.5-m (5-ft) intervals from the tree butt to the base of the live crown. Four samples were taken at each sample interval-one from each side and one from the top and bottom of the tree. To obtain bottom samples, trees were cut into bolts and rolled over. Samples were examined as they were removed to record any larvae and pupae not in the outer bark.

In the laboratory, samples were examined to determine 1) the number of emergence holes and 2) the number of SPB attack sites (Linit and Stephen 1978). The samples were then placed in rearing containers to collect emerging brood. Total emergence included the number of emergence holes, plus the number of brood adults that emerged, plus any larvae and pupae exposed on the inner bark surface when collected. The E/A ratio was calculated as total emergence divided by 2 times the number of attack sites (Thatcher and Pickard 1964).

Analysis of variance tests for the downed trees were designed to compare ($P \le 0.05$) attack density and total

Figure 1.—*Aerial photo of study area showing majority of green trees in* a *buffer strip adjacent* to standing *frees. The arrow* (also *see figure 2) points to the first infested standing* tree *in the plot.*

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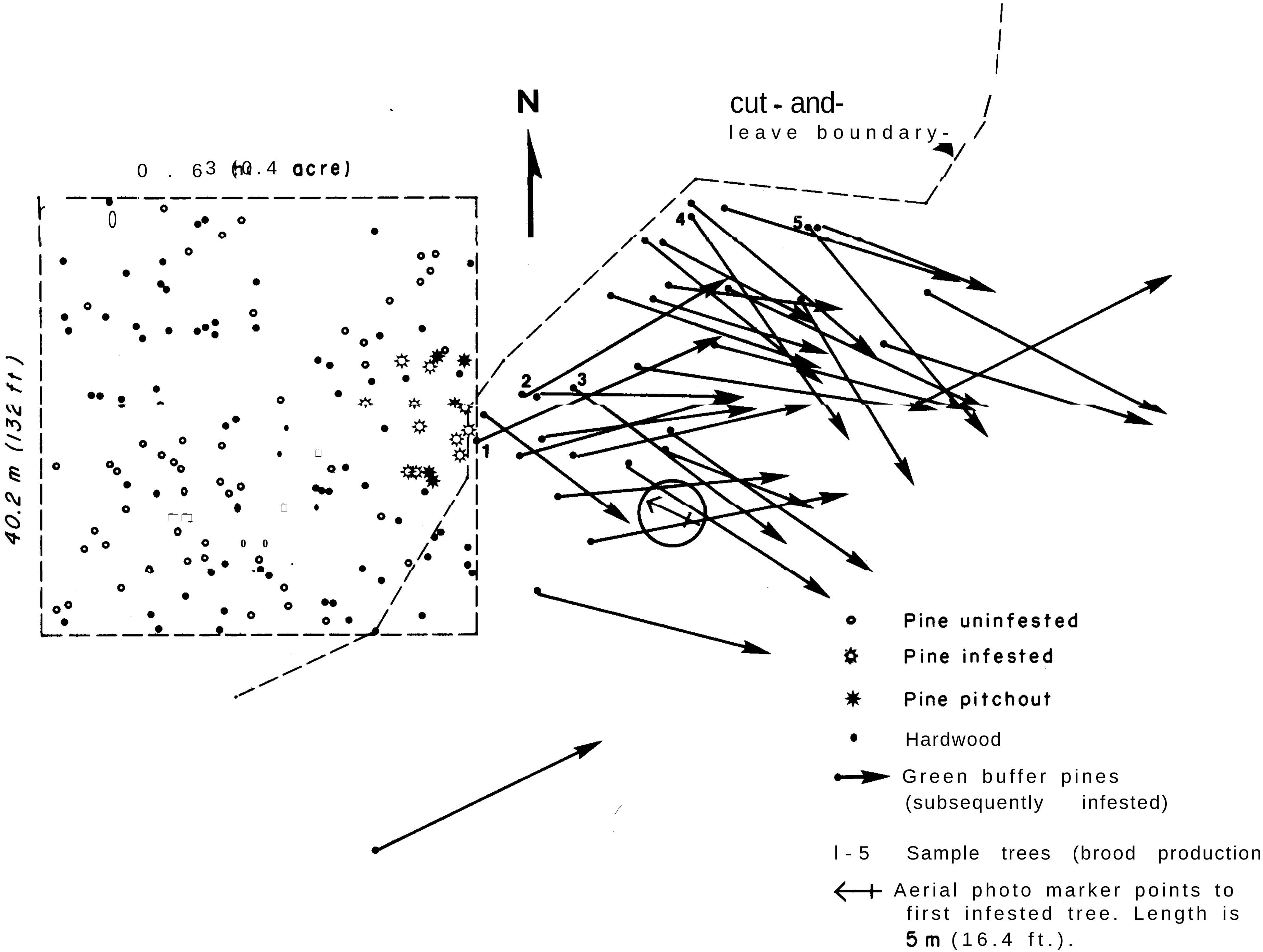

Figure 2.-Diagrammatic sketch of the felled buffer-strip trees, subsequently infested by SPB, and adjacent inventory plot.

emergence among top, bottom, and side samples. Significantly different means were identified by Duncan's new multiple range test. To stabilize the variance, attack data were transformed using $\log(X+0.5)$.

Starting January 10, we checked the adjacent stand for infested trees to a depth of 1 chain (66 ft) along the infestation perimeter (fig. 1). A 0.16-ha (0.4-ac) plot was installed encompassing 15 infested trees adjacent to this perimeter. This was a loo-percent inventory tally of all pines and hardwoods equal to or greater than 9.2 cm (3.6 in) in diameter (fig. 2). The basal area of the plot was compared with the basal area of SPB spots within a radius of 0.8 km (0.5 mi).

Infestations treated by using the cut-and-leave method (Swain and Remion 1981) werechecked during May through October for evidence of SPB attack and brood development in buffer-strip trees. Spotsexamined were treated in May (five spots; Grant Parish, LA), June (six spots; Grant Parish, LA), and October (nine spots; Lafayette County, MS). Five or more buffer-strip trees were examined in each infestation. Bark samples having SPB galleries were returned to the laboratory where the number of larval mines and frass-filled larval feeding cells were tallied.

Log Deck

This study was conducted in the Kisatchie National Forest, Catahoula Ranger District, about 6.5 km (4 mi) northeast of Ball, LA. The test area was in a 35-year-old stand of loblolly pine with a dogwood-waxmyrtle (*Cornus florida* L. - *Myrica cerifera* L.) understory. The infestation was located by District personnel in early December, and about 800 trees were cut for salvage December 17 through 27. One group of 32 logs trimmed to lengths of 5.5 and 8 m (18 and 27 ft) was piled in a log deck adjacent to the cut area and not removed immediately (fig. 4).

On December 31, 1985, we observed SPB attacking three fresh logs in the deck. Beetles were observed entering and exiting from pitch tubes in attempts to establish egg galleries. Apparently, eight logs in the deck had been attacked by SPB before cutting because they contained extensive gallery systems. However, the three logs attacked after being felled had little or no gallery systems. Each log was numbered and the length and diameters of the upper and lower ends measured.

Thereafter, the logs were examined weekly to document new attacks and parent adult emergence and to determine stage of brood development. Starting on March 24, each log was destructively examined to determine when sampling for brood production should begin. *Ips* spp. attacks were also monitored.

Five logs ranging from25 to38 cm (10 to25 in) d.o.b. (small end) with SPB in the pupa-callow adult stage were sampled intensively to determine numbers of emerging brood adults. Using a hole saw, 100-cm^2 (15.5-in^2) samples were taken at 1.5-m (5-ft) intervals from the log base to the top (fig. 4). Ideally, three samples were taken at each sample interval-one from each side and another from the top. Because the logs could not be turned, only the exposed areas were sampled. The samples were examined and the beetles reared as for the horizontal trees.

The trees surrounding the log deck were examined weekly to determine if SPB attack had occurred.

Analysis of data for the log deck was the same as for horizontal trees. Likewise, comparison of means for horizontal trees with those for the log deck were limited to top and side samples.

RESULTS AND DISCUSSION

Horizontal Trees

Of the89 unattacked trees felled in December 1985 in the controlled infestation (fig. 2), 32 were attacked by one or more pairs of SPB. Of these, five were colonized by January 10, another 21 by January 28, and six more by February 18, which was the last date that new attacks were seen. All 32 attacked trees were in the middle third of the area (fig. 2). The trees most heavily attacked were those over 25 cm (10 in) in stump diameter and those elevated above the ground, but none less than 18 cm (7 in) in stump diameter were infested.

Field observations that fewer SPB galleries were on the top half of felled trees than on the sides or bottoms (fig. 3) were supported by survey data. Of the five trees sampled, mean numbers of SPB attacks per 100 cm^2 (15.5 in^2) were greater ($P \leq 0.5$) on the bottom (5.23) and sides (4.67) than on the top (2.60). Mean square error (MSE) for transformed attack data was 0.249. Similarly, brood adult emergence per 100 cm^2(15.5 in^2) was significantly higher ($P \leq 0.05$) on the bottoms (15.74) and sides (12.12) than on tops (7.55) (MSE=93.85). This suggests that attacking adults selectively oviposit most often on the sides and bottoms of downed trees (fig. 3). Emergence:attack ratios (E/A)* were not significantly different ($P > 0.05$) among tops (1.66), sides (1.47), and bottoms (2.21) (MSE=3.49).

Attack densities in this study were higher than the average of 19/ft^2(=2.04/100 cm^2) given by MacAndrews (1926). Conversely, our maximum emergence figure of 15.74/100 cm^2(=146/ft^2) was less than his average number of 198/ft^2. Thus, his average E/A of 10.42 was far higher than our maximum of 2.21.

Although no standing trees in the area were examined, in 223 trees sampled during the summers of 1983 and 1984, emergence averaged 21.8/100 cm^2 (range 2.9-52.5) (Bridges, unpublished). In standing trees

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Figure 3.-*Section of horizontal tree about0.3 m (1 ft) above ground, stripped of bark and showing gallery distribution of beet/es shortly after attack. Most SPB galleries are on the sides and bottom of tree, whereas* Ips calligraphus *(arrows) is starting to occupy the top. Gallery pattern on this tree is typical of those in other buffer-strip trees. The free was cut about 76 km (10 mi) from the area discussed in this article. The tree was felled May 1, 1986 and photographed May 13. Ambient temperature was about 34" C (93" F) at time photo was taken, indicating indentical patterns of attack in both cool and hot weather. A similar photograph appears in Beal and Massey (1945).*

MacAndrews found a much higher average emergence of 32.3/100 cm^2(=300 ft^2). The highest E/A found by Bridges (unpublished) was 3.9, much lower than the average of 7.9 found by MacAndrews.

SPB attack termination was apparently due to competition by *Ips calligraphus,* and to a lesser extent by *I. grandicollis* Eichoff and *I. avulsus* Eichhoff. A few *Ips* spp. were seen in the first observations in early January (fig. 3), but colonization became intense by February 6 when all but 6 of the 89 trees were attacked by 1 or more *Ips* sp. By February 18, all of the larger diameter trees were infested so heavily that little, if any, bark surface was available for incoming SPB.

Re-emergence holes of parent adult SPB were seen February 18 in 7 trees, and a total of 14 trees were tallied by March 24. Examination of the outer bark on March 24 revealed mature brood adults ready to fly from six of the downed trees.

Fifteen standing trees were attacked by SPB between January 13 and February 5, but the attacks were unsuccessful in five trees (fig. 2). The infestation failed to continue to enlarge, perhaps for several reasons. Although the attacked trees were closely grouped on the edge of the treated area, other pines in the immediate area were more widely spaced and were interspersed with hardwoods (see 0.16-ha (0.4-ac) plot in fig. 2). These conditions could constitute a barrier to continued spot growth. The basal area at the center of this plot was 1.8 m^2(20 ft^2) of pine and 2.8 m^2(30 ft^2) of hardwood, while the average basal area of nine active spots within 0.8 km(0.5 mi) was 10.1 m^2(110 ft^2) of pine and 2.8 m^2(30 ft^2) of hardwood, with extremes of 5.5 to 12.9 m^2(60 to 140 ft^2) of pine and 1.8 to 4.6 m^2(20 to 50 ft^2) of hardwood.

Another factor could have been a limited population of beetles in the immediate vicinity, some of which attacked the downed, green trees in the buffer strip. However, a significant portion of the emerging population may have dispersed to other areas because the literature suggests that beetles have a tendency to do so at this time of the year (Billings 1979).

Examination of buffer-strip trees in spots controlled by the cut-and-leave procedure showed that trees in some of the infestations were attacked by SPB. Trees in four of five spots cut in May, one of six spots cut in June, and three of nine spots cut in October became infested with SPB and *Ips* spp. In these spots, SPB colonized 20 to 35 percent of the green horizontal trees examined. Again, *Ips* spp. were observed on the upper surface of the downed trees and SPB on the sides and lower surface. Examination of bark samples revealed that SPB development was poorer in June-compared to May-treated spots. Poor brood development was apparently associated with poor food substrate because the

Figure *4.-The log deck. Technician is removing circular disks of bark for determination of attack and emergence data. The three flagged standing trees were attacked (unsuccessfully) by a few SPB.*

larval mines were abnormally long and narrow. This suggests that in hot weather, downed trees may act as a sink for SPB.

Log Deck

When we first discovered the log deck on December 31 (1 week after logs were cut and stacked), the eight trees attacked before felling were still under active attack; hence, they probably were still attractive at this time. Also, at this time three fresh logs were under attack. Many attacks resulted in large pitch tubes, with many beetles being pitched out. Temperatures on December 31 ranged as high as 24°C (75°F), and the adult SPB and their clerid predators [*Thanasimus dubius* (F).] were actively flying in the area, occasionally hitting us. They were also actively running about on the logs. Although the beetles were attacking the logs, they did not immediately attack the numerous standing trees adjacent to the log deck.

By January 10, seven logs had been attacked; by January 21, 12 more; and by February 6 all but one log had been attacked at least once. The latter log was on the bottom of the deck and mostly covered by other logs. As might be anticipated, those logs on the top of the deck and nearest the previously attacked logs were attacked by SPB first and received the most attacks.

Although most attacks ceased after February 6, weekly observations after this date revealed occasional attacks. The last fresh pitch tube was seen March 24.

Parent adults began re-emerging from one of the pre-attacked logs on January 21, and by March 3, parents had re-emerged from all eight logs. In the fresh material, parent adults began re-emerging March 3 from the first log, and by March 24 had re-emerged from six more.

Samples taken on March 24 revealed that six pre-attacked logs and at least one of the fresh logs contained callow adults. Brood development in most of the other logs had still not progressed past the mid-larval stage.

In contrast to the downed green trees, *Ips* spp. (mostly *I. calligraphus)* may not have been a major factor in SPB attack termination within the log deck. *Ips* attacked later than SPB and then in relatively few numbers. The first *Ips* attacks were not seen until March 3, but by March 21 a total of 21 of the35 trees had been attacked at least once. In a similar study of the spruce beetle, *D. rufipennis* (Kirby), Nagel and others (1957) also noted that few *Ips* spp. attacked downed spruce. *Ips* spp. preferred the tops of the logs, whereas *D. rufipennis* preferred the sides and bottoms. Five standing trees surrounding the log deck were attacked by SPB between January 21 and March 11. All beetles were pitched-out, and the trees survived the attacks.

Of the five logs sampled, mean numbers of SPB attacks per 100 cm^2 (15.5 in^2) were significantly greater ($P \leq 0.05$) on the sides (3.22) than on the tops (1.47) ($MSE=0.613$). Mean emergence was 9.30/100 cm^2 for the sides and 5.24/100 cm^2 for the tops ($MSE=107.97$); mean E/A was 1.69 for the sides and 1.42 for the tops ($MSE=3.56$). These differences were not significant.

The attack and emergence means for the horizontal trees and those for the log deck were not significantly different ($P > 0.05$).

The data confirm previous observations by Craighead and others (1927), St. George and Beal (1929), and Beal and Massey (1945) that downed timber can be attractive to SPB. This is common behavior for many species of *Dendroctonus,* such as *D. rufipennis* and the Douglas-fir beetle, *D. pseudotsugae* Hopkins, and occasionally occurs for others, such as the mountain pine beetle, *D. ponderosae* Hopkins (Wood 1982). In fact, Amman (1983) suggested a strategy for trap log cutting and removal to reduce mountain pine beetle populations in ponderosa pine forests because of the beetle's strong attraction to felled ponderosa pine (*Pinus ponderosa* Douglas).

CONCLUSIONS

This study shows that attacks of downed material by SPB are much more common than previously thought (Billings 1980, Gara and others 1965, Swain and Remion 1981, Thatcher and others 1982). Bufferstrip trees felled during a cut-and-leave operation were attacked, either by beetles emerging from infested trees in the controlled infestation or from trees in the surrounding area known to have emerging brood, or both. When a SPB spot is controlled during midwinter, some downed material may be attacked. Beetles in this infested material are able to reproduce and possibly provide a source for future SPB infestation. The study also shows that the SPB may also attack felled trees in spring, summer, and fall. However, SPB survival may be poor in hot weather. Research on SPB behavior and dispersal throughout the year is needed to determine the likely effects of a variety of control tactics and strategies.

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