Using Aggregation and Antiaggregation Pheromones of the Douglas-Fir Beetle to Produce Snags for Wildlife Habitat

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ABSTRACT. *Pheromone baits for the Douglas-fir beetle were applied alone and in combination with the antiaggregation pheromone, 3-methylcyclohex-2-en-1-one (MCH), to test potential treatments for creating snags to improve wildlife habitat. All baited trees were attacked by beetles following both treatments. However, more unbaited trees were attacked on plots without MCH than on plots with MCH. One year after treatment, more of the attacked trees were dead on plots without MCH than on plots with MCH. Bark beetle pheromones can be used effectively to create snags for improving wildlife habitat, but to achieve specific objectives treatments must be prescribed based on knowledge of the expected beetle population densities. West. J. Appl. For. 12(2):00–00.*

On many forestlands, the number of snags in managed stands is insufficient to meet the minimum number specified in management guidelines (Morrison et al. 1986). Consequently, techniques have been developed and implemented to create snags from living trees (Bull and Partridge 1986, Bull et al. 1986). Methods that have been tested for creating snags include topping with chainsaws or dynamite, herbicide injections, burning, girdling, fungal inoculations, and application of bark beetle (*Dendroctonus* spp.) pheromones. Topping has been the most common method used (Bull and Partridge 1986, Bull et al. 1986), but it is expensive and hazardous. Furthermore, snags created by topping may not be exploited by the same succession of fungi and insects that commonly occur in snags resulting from natural processes, and this may limit the suitability of those snags for wildlife habitat.

Tree-baiting with bark beetle aggregation pheromones is potentially a more efficient and less hazardous method of creating snags than topping. If a sufficient number of bark beetles are attracted by the pheromone, they may successfully attack and kill the baited tree. Bull and Partridge (1986) found that western pine beetle (*Dendroctonus brevicomis* LeConte) pheromones were less effective than topping for producing ponderosa pine (*Pinus ponderosae* Dougl. ex Laws.) snags. However, they applied the pheromones for only 15 days and provide no indication of beetle population densities in the study area or timing of their pheromone application in relation to the beetle flight period. Also, some of their other treatments such as topping may have provided competing sources of attraction that reduced the beetle population that was available to attack the baited trees. Pheromones must be applied at the proper time and under appropriate conditions to be effective.

Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopkins) aggregation pheromones are highly effective for inducing mass attacks on baited trees. They are used in a beetle management tactic known as trap-tree harvest (Knopf and Pitman 1972, Pitman 1973, Ringold et al. 1975, Thier and Weatherby 1991). This technique involves baiting selected trees with aggregation pheromones and then harvesting those trees after they become infested to destroy the developing broods. A similar strategy could be used to create snags for wildlife habitat by leaving the baited trees after they become infested. A possible limitation of this approach is the lack of control over attacks on adjacent unbaited trees. The number of trees adjacent to baited trees that are attacked and killed depends on the density of the local beetle population and stand conditions (Pitman 1973,

Furniss et al. 1981, Thier and Weatherby 1991). Therefore, tree baiting alone may result in more dead trees than desired to meet management objectives. However, it may be possible to restrict attacks to baited trees by simultaneously applying the antiaggregation pheromone, 3-methylcyclohex-2-en-1-one (MCH) (Hedden and Pitman 1978).

Our objective was to determine if the number of beetle-attacked trees resulting from tree baiting could be regulated by the concurrent application of an antiaggregation pheromone.

Methods

The study was conducted on the Wallowa Valley Ranger District of the Wallowa-Whitman National Forest about 50 km northeast of Enterprise, OR, in an area with an ongoing Douglas-fir beetle outbreak (Ross and Daterman 1994, 1995). On May 4, 1994, six pairs of circular plots (diam = 80 m) were selected for the study. Paired plots were about 200 m apart and at least 1 km from all other plot pairs. Each plot included at least 10 healthy, mature Douglas-fir trees and was free of any currently infested trees. Within each pair, the plots were randomly assigned to receive one of two treatments: (1) tree-bait alone or (2) tree-bait plus MCH. Douglas-fir beetle tree-baits (Phero Tech Inc., Delta, BC, Canada) supplemented with 30 mg of frontalin and 15 mg of seudenol in 5% polyvinyl chloride plastic formulations (Daterman 1974) were attached to each of three Douglas-fir trees near each plot center. Baits were stapled to the trees at a height of about 2.5 m. Bubble capsules containing 400 mg of MCH (Phero Tech Inc., Delta, BC, Canada) were attached at a height of 2 m to trees and snags around the plot perimeter at about 4.5-m spacings [mean dose (± SE) = 54.8 ± 1.1 capsules/plot].

On September 18, 1994, plots were surveyed for Douglas-fir beetle infestations. The dbh of all baited and unbaited Douglas-fir trees (≥ 20 cm dbh) within 25 m of the plot center were measured. Each tree was classified as mass-attacked or unattacked based on the presence or absence of large amounts of frass on the lower bole (Knopf and Pitman 1972, Ringold et al. 1975, Ross and Daterman 1994). Stand basal area by tree species also was measured at the center of the group of baited trees. On August 25, 1995, plots were revisited to determine if trees classified as mass-attacked had died or survived based on foliage color.

Data on stand characteristics, Douglas-fir beetle infestation, and condition of mass-attacked trees were subjected to analysis of variance (ANOVA) for a randomized complete block design to test for treatment differences.

Prior to ANOVA, each variable was tested for homogeneity of treatment variances by Levene's method (Milliken and Johnson 1984). If the variances were found to be nonhomogeneous, variables were transformed to $\ln(Y)$, $\ln(Y + 1)$, or arcsin $\sqrt{Y}$ as appropriate prior to ANOVA. Nontransformed means are reported here. Statistical analyses were performed with SAS computer programs (SAS Institute 1988).

Results

The basal area, percent of total basal area, tree density, and dbh of potential host Douglas-fir trees were not significantly different between plots with and without MCH (Table 1). All of the baited trees within each treatment were mass-attacked in 1994. Although the percentage of Douglas-fir trees ≥ 20 cm dbh that were mass-attacked on plots without MCH was nearly twice that on the plots with MCH (Table 1), the difference was not statistically significant at the $\alpha = 0.05$ probability level ($P = 0.0568$). The number of unbaited trees that were mass-attacked on the plots without MCH was significantly greater than on the plots with MCH (Table 1).

One year after treatment, a significantly greater number of baited trees were dead on the plots without MCH compared to the plots with MCH (Table 2). After 1 yr, there were no significant differences in the condition of unbaited, mass-attacked trees between the treatments (Table 2). However, the only unbaited, mass-attacked trees that had died were found on the plots without MCH. An average of 2.4 trees were killed within 1 yr of treatment on the plots without MCH compared to only 0.3 trees on the plots with MCH (Table 2).

Discussion

The application of MCH was successful in limiting the number of unbaited trees that were mass-attacked while allowing infestation of the baited trees (Table 1). However, after 1 yr, fewer of the baited trees had died on the plots treated with MCH than on the plots without MCH (Table 2). We did not measure attack densities, but it is possible that the MCH reduced attack densities below the threshold necessary to kill the trees (Hedden and Pitman 1978). This could have resulted from an inhibition of attacking females or higher levels of predation by checkered beetles (Cleridae) on the plots with MCH (Ross and Daterman 1994). Many of the trees attacked in 1994 that remained alive had fresh beetle attacks in 1995 and may succumb to beetles or other mortality agents in the next several years. A lower dose of MCH than the one we tested may result in higher rates of mortality to baited trees while still protecting unbaited trees.

Table 1. Mean stand and tree characteristics (± SE) for Douglas-fir ≥ 20 cm dbh on pheromone treated plots in northeastern Oregon, 1994.

Treatment	Basal area (m²/ha)	% of total basal area	Tree density (stems/ha)	Dbh (cm)	% mass-attacked	No. of unbaited, mass-attacked trees
Tree-bait	21.9 ± 1.8a	88.8 ± 4.2a	103.6 ± 9.2a	42.7 ± 1.9a	36.6 ± 6.7a	3.5 ± 1.1a
Tree-bait + MCH	18.4 ± 2.5a	79.6 ± 8.3a	106.1 ± 17.6a	40.6 ± 2.0a	18.8 ± 2.9a	0.5 ± 0.3b

[1] Within a column, means followed by the same letter are not significantly different ($P = 0.05$).

Table 2 Mean percent and number of trees (± SE) classified as mass-attacked by the Douglas-fir beetle that were dead 1 yr after infestation on pheromone treated plots in northeastern Oregon, 1994.

Treatment	% dead	No. dead per plot
Baited trees		
Tree-bait	38.9 ± 5.6a	1.2 ± 0.2a
Tree-bait + MCH	11.1 ± 7.0b	0.3 ± 0.2b
Unbaited trees		
Tree-bait	19.3 ± 10.3a	1.2 ± 0.8a
Tree-bait + MCH	0a	0a

[1] Within a column and category of trees, means followed by the same letter are not significantly different ($P = 0.05$).

Our results were influenced by the density of the local Douglas-fir beetle population. Beetle populations were at outbreak densities from 1991 through 1993, but declined significantly in 1994 in the study area (unpublished data, D.W.R.). The number of trees killed would probably have been higher if the treatments were applied during the preceding years when beetles were more abundant, or lower if the treatments were applied during a year with endemic populations. Using pheromones effectively to create snags will require modifying treatments based on expected beetle population densities. For example, at very low beetle densities, it may be necessary to adjust the composition or strength of tree-baits to ensure attack densities that will result in tree mortality. Conversely, at very high beetle densities, tree-baits alone may result in large groups of dead trees. Under these conditions, the simultaneous application of antiaggregation pheromones will provide some level of control on the size of the mortality patches. In deciding whether or not to use pheromones and how to apply them to create snags, managers should rely on available estimates of beetle activity such as recent aerial surveys and consultations with pest management specialists.

Bark beetle pheromones will never be as predictable as tree topping for creating snags. However, pheromone applications may be less expensive, and they produce snags in a more natural way than topping. Trees that are killed by bark beetles will be structurally intact and they are immediately inoculated with a variety of microorganisms that are carried by the beetles (Rumbold 1936, Harrington et al. 1981, Lewinsohn et al. 1994). In addition, the bark beetle pheromones are attractive to associated insects that increase the rate of deterioration (Edmonds and Eglitis 1989) and provide a source of food for many other animals. Properly designed bark beetle pheromone applications can be an effective method for creating snags to improve wildlife habitat.

Literature Cited

BULL, E.L., AND A.D. PARTRIDGE. 1986. Methods of killing trees for use by cavity nesters. Wildl. Soc. Bull. 14:142–146.

BULL, E.L., J.W. THOMAS, AND K. HORN. 1986. Snag management on National Forests in the Pacific Northhwest —1984. West. J. Appl. For. 1:41–43

DATERMAN, G.E. 1974. Synthetic sex pheromone for detection survey of European pine shoot moth. USDA For. Serv. Res. Pap. PNW-180.

DAVIS, J.W., G.A. GOODWIN, AND R.A. OCKENFELS (technical coordinators) 1983. Snag habitat management: Proc. of the symp. USDA For. Serv Gen. Tech. Rep. RM-99.

EDMONDS, R.L., AND A. EGLITIS. 1989. The role of the Douglas-fir beetle and wood borers in the decomposition of and nutrient release from Douglas-fir logs. Can. J. For. Res. 19:853–859.

FURNISS, M.M., R.L. LIVINGSTON, AND M.D. MCGREGOR. 1981. Development of a stand susceptibility classification for Douglas-fir beetle. P. 115–128 in Proc., Hazard-rating systems in forest insect pest management, Hedden, R.L., S.J. Barras, and J.E. Coster (tech. coords.). USDA For. Serv. Gen Tech. Rep. WO-27.

HARRINGTON, T.C., M.M. FURNISS, AND C.G. SHAW. 1981. Dissemination of Hymenomycetes by Dendroctonus pseudotsugae (Coleoptera: Scolytidae) Phytopathology 71:551–554.

HEDDEN, R.L., AND G.B. PITMAN. 1978. Attack density regulation: A new approach to the use of pheromones in Douglas-fir beetle population management. J. Econ. Entomol. 71:633–637.

KNOPF, J.A.E., AND G.B. PITMAN. 1972. Aggregation pheromone for manipulation of the Douglas-fir beetle. J. Econ. Entomol. 65:723–726.

LEWINSOHN, D., E. LEWINSOHN, C.L. BERTAGNOLLI, AND A.D. PARTRIDGE. 1994 Blue-stain fungi and their transport structures on the Douglas-fir beetle Can. J. For. Res. 24:2275–2283.

MILLIKEN, L.H., AND D.E. JOHNSON. 1984. Analysis of messy data. Volume 1 Designed experiments. Van Nostrand Reinhold Co., New York.

MORRISON, M.L., M.F. DEDON, M.G. RAPHAEL, AND M.P. YODER-WILLIAMS 1986. Snag requirements of cavity-nesting birds: Are USDA Forest Service guidelines being met? West. J. Appl. For. 1:38–40.

PITMAN, G.B. 1973. Further observations on douglure in a Dendroctonus pseudotsugae management system. Environ. Entomol. 2:109–112.

RINGOLD, G.B., P.J. GRAVELLE, D. MILLER, M.M. FURNISS, AND M.D. MCGREGOR 1975. Characteristics of Douglas-fir beetle infestation in northern Idaho resulting from treatment with douglure. USDA For. Serv. Res. Note INT-189.

ROSS, D.W., AND G.E. DATERMAN. 1994. Reduction of Douglas-fir beetle infestation of high-risk stands by antiaggregation and aggregation pheromones. Can. J. For. Res. 24:2184–2190.

ROSS, D.W., AND G.E. DATERMAN. 1995. Efficacy of an antiaggregation pheromone for reducing Douglas-fir beetle, Dendroctonus pseudotsugae Hopkins (Coleoptera: Scolytidae), infestation in high risk stands. Can Entomol. 127:805–811.

RUMBOLD, C.T. 1936. Three blue-staining fungi, including two new species, associated with bark beetles. J. Agric. Res. 52:419–437.

SAS INSTITUTE INC. 1988. SAS/STAT user's guide, release 6.03 edition. SAS Institute Inc., Cary, NC. 1028 p.

THIER, R.W., AND J.C. WEATHERBY. 1991. Mortality of Douglas-fir after two semiochemical baiting treatments for Douglas-fir beetle (Coleoptera Scolytidae). J. Econ. Entomol. 84:962–964.

THOMAS, J.W., R.G. ANDERSON, C. MASER, AND E.L. BULL. 1979. Snags. P. 60–77 in Wildlife habitats in managed forests, the Blue Mountains of Oregon and Washington, Thomas, J.W. (tech. ed.). USDA For. Serv. Agric Handb. No. 553.