

**New Pheromone Release Systems:
Aerial and Ground Applications
for Bark Beetle Control**

N. Gillette, S. Mori, and G. Fiddler (USDA FS, PSW Research Station, Berkeley, CA)

D. R. Owen (State of California, CDF, Redding, CA)

J. D. Stein (USDA FS, FHTET, Morgantown, WV)

N. Erbilgin and D. L. Wood, (University of California, Berkeley, CA)

J. N. Webster (Total Forestry, Anderson, CA)

C. Mehmel (USDA FS, FHP, Wenatchee, WA)

Introduction. Verbenone is an anti-aggregation pheromone for many beetle species, including most *Dendroctonus* spp., which are the most devastating bark beetle pests in most western forests. Use of verbenone to protect forest stands, however, has been limited by a lack of effective release systems to disperse the pheromone in forest stands. To date, the most widely available formulations have been bubble caps, pouches, and beads. The first two release systems require laborious hand application using a long-handled hammer, and thus have limited utility for area-wide control. The last formulation, the bead, consists of 5 mm plastic beads with verbenone adsorbed onto the outside of the beads. This formulation has shown inconsistent efficacy when applied for control of other *Dendroctonus* spp., perhaps because the release rate from the beads was not optimal.

In recent years, a few new products have become available for testing in forest ecosystems. Among these are various sprayable, microencapsulated systems, slow-releasing polymers, and slow-releasing laminated flakes. Of these, the slow-releasing polymers and flakes appear to have the most promising characteristics for use in controlling bark beetles in the genus *Dendroctonus*. Most bark beetles have a flight and attack period spanning 60 days or more, so the pheromone release systems must provide behaviorally significant release during that entire period.

Material and Methods. We tested a new formulation of verbenone, the Verbenone "Disrupt" Flake¹ (Hercon Environmental, Emigsville, PA), for protection of both individual trees (ground applications) and forest stands (aerial applications) from bark beetle attack. This flake consists of a 3 X 3 mm plastic laminate "sandwich," where the outer layers are impermeable and the inner layer contains the active ingredient verbenone. The pheromone thus is released only at the perimeter of the flake, possibly resulting in more favorable release characteristics (longer duration and more consistent release over time). A similar flake formulation has been used successfully for many years in mating disruption in the Gypsy Moth "Slow-the-Spread" program, but this is the first such formulation of a bark beetle pheromone. The verbenone flake was tested as an aerial application for control of *Dendroctonus brevicomis*, the western pine beetle, in a ponderosa pine stand in the Big Valley Mountains, Lassen County, California and for individual tree protection against the mountain pine beetle, *Dendroctonus ponderosae*, attacking lodgepole pine at Whaleback Ridge in Siskiyou County, CA.

Area wide application. Aerial application was made using fixed-wing aircraft fitted with a hopper and metered dispensing system to disperse the flakes evenly over five 50-acre plots, with

¹ Mention of a commercial product does not constitute endorsement of its use by USDA

five 50-acre untreated plots serving as controls. The verbenone was applied at the rate of 150 grams of active ingredient/acre, or one kilogram of flakes/acre. In order to challenge the anti-aggregation effect of the flakes, we baited 4 trees per plots and placed eight Intercept traps/plot, also baited with western pine beetle aggregation pheromone lures. Efficacy of the flake was assessed using several variables, including numbers of beetles trapped/plot, number of *D. brevicomis* attacks/tree/plot, and tree mortality. We also took the opportunity to assess efficacy for protection of trees from attack by *Dendroctonus valens*, a secondary pest that has also been shown to use verbenone as a behavioral chemical.

Individual tree application. Ground applications were made at the rate of 15 g/AI/tree, with a suspension of the flakes in water with sticker, using a trailer-mounted hydroseeder. The formulation was applied in a single band on only one side of the tree to a height of seven meters. All trees were baited with *D. ponderosae* aggregation pheromone immediately after treatment. Forty trees were selected for the study, and twenty were chosen at random for treatment with the remainder serving as controls. The basal area, DBH, and live crown ratios of control trees and treated trees were not significantly different. Efficacy of the individual tree protection strategy was measured by number of *D. ponderosae* attacks/tree, number of *D. valens* attacks/tree, numbers of pitch tubes producing dry frass, and tree mortality one year following treatment.

Results.

Aerial application. Aerial application of verbenone flakes resulted in significant reduction in numbers of *D. brevicomis* trapped on treated plots for up to sixteen weeks following application. Baited trees on treated plots showed significantly lower rates of fading at twelve weeks following application, with 75% of control trees fading compared to only 20% of trees in treated stands.

Ground (individual tree) applications. Treated trees showed significantly fewer attack rates by both *D. ponderosae* and *D. valens*. At eight weeks following treatment, the numbers of *D. ponderosae* pitch tubes with dry frass was significantly lower in treated trees than in control trees. Nearly one year following treatment, tree mortality in treated trees was significantly lower than in control trees. Two parallel studies testing this strategy for protection of ponderosa pines from attack by *D. brevicomis*, however, failed to provide protection, despite the success of the aerial application strategy targeting *D. brevicomis*.

Conclusions.

- Verbenone flakes show promise for aerial applications targeting *D. brevicomis* (western pine beetle), *D. valens* (red turpentine beetle), and possibly *D. ponderosae* (mountain pine beetle).
- Verbenone flakes are also promising for individual tree protection from *D. valens* and *D. ponderosae*, but not *D. brevicomis*