

Using Verbenone to Protect Host Trees from Mountain Pine Beetle Attack

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Introduction

Verbenone (trimethyl-bicyclo-heptenone) is a pheromone important in the chemical communication system of several economically important bark beetles. It plays a role in colonization of host trees, specifically in mediating mass attacks so that optimum attack densities are achieved. Verbenone has been categorized as an *anti-aggregant* because in the process of mass attack it causes attacking beetles to spread out, taking advantage of the host's entire surface. Later in the attack sequence, release of larger amounts of verbenone results in newly arriving beetles being repelled and forced to attack other trees. Thus, in these latter stages of host colonization, verbenone serves to send a message the host is fully occupied and no longer suitable for further occupation.

Recognition of verbenone's function as an anti-aggregant has been the basis of much work to deter bark beetles from attacking host trees. In many cases, field trials have been successful in preventing attack of susceptible trees. However, in some situations verbenone failed to protect host trees. In some instances, successes and failures occurred in the same locations, in the same time frame, and under comparable conditions. In a few studies, a slight alteration of conditions has resulted in great differences in results. In other situations the source of variable results has been unknown. **This lack of consistency in some verbenone trials has been a source of great frustration to the bark beetle research community.** (Above adapted from: Eager, Tom. 2006. "History and Prospects for Using Verbenone to Manage Bark Beetles")

History of Verbenone Testing in the West

Early tests of 0.5-gram bubble capsules (up to 68 per acre), in 1988 and 1989 in both lodgepole (LPP) and ponderosa (PP) pine stands, showed promising, but mixed, results in protecting trees from mountain pine beetle (*Dendroctonus ponderosae* Hopkins) (MPB) attack. For the next several years, up to and including 1993, USDA Forest Service-Forest Health Protection (FHP) and Forest Service research conducted one kind of verbenone test or another: we tested it in both PP and LPP stands, we used hand applications of bubble capsules at several rates, and even tested aerial applications of verbenone-impregnated beads. By about 1994, we had pretty much decided results were variable enough we couldn't justify its continued use. During the mid-1990s, MPB populations were relatively low—and there wasn't much interest in verbenone and MPB (at least in the Northern Region). In the meantime, Ron Billings (Texas Forest Service) and others were finding some success using much higher doses of verbenone against southern pine beetle (*D. frontalis* Zimmerman).

In 2000, Rob Progar (FHP, Boise Field Office) instituted a test against building MPB populations in central ID, using the relatively new 5-gram verbenone pouch that Pherotech was then manufacturing. Noting some success in Rob's project, we (Northern Region, FHP) initiated an "area" test in LPP in building MPB populations in western MT and whitebark (WBP) stands in northern ID. Since then, FHP and FS Research in the West, have had a yearly verbenone test of one-kind or another in LPP, PP, and/or WBP stands in our Region—and others have been conducted throughout western US and Canada. We've looked at a couple of different verbenone pouches, singly and coupled with varying combinations of green-leaf volatiles (GLVs—most commonly used is a 50:50 blend of hexenol and hexanol). Suffice it to say, after 7-8 years of fairly rigorous testing—and not a minor amount of operational use; if someone were to ask any of us if verbenone protects host trees from MPB attack, we would have to honestly reply, "Sometimes!" A "silver bullet" verbenone is not!

Over the past few years, questions have arisen pertaining to verbenone's use. This is not an exhaustive list, but a few of the more prevalent are:

1. Does verbenone work well enough, consistently enough, that we should be recommending its use to protect MPB hosts from attack?
2. If so, when and how much? Individual-tree protection: 2 or more pouches per tree? Area protection: 20, 30, 40 pouches per acre? Does it depend on beetle population? Do we need to replace pouches at mid-season?
3. Are there certain population levels—infestation thresholds—where we shouldn't be recommending the use of verbenone, and can we significantly increase the effectiveness of verbenone by removing currently infested trees in conjunction with its use? And as a part of that, if we can't remove infested trees, are we wasting our time (and money) using verbenone?
4. Can we enhance verbenone's effectiveness by using GLVs in conjunction with it? What GLVs are most effective? Do they work well enough that we should make that part of a standard recommendation? If so, what are NEPA requirements for using GLVs? Do we know?
5. What about "push-pull" strategies? Does verbenone work better at "pushing" beetles if we are "pulling" them somewhere with tree baits or traps?

Discussion

Perception remains that verbenone is not consistently reliable. In some places, at some times, and under proper circumstances, it works relatively well. At other times results are disappointing. The following is from a discussion on verbenone use—What do we and don't we know?—held at a WFIWC workshop in Boulder, CO in April 2008:

Does verbenone protect MPB hosts from infestation? Most agree where there are no alternatives (carbaryl treatments, silvicultural manipulations), using verbenone is better than doing nothing. Most of the time, individual-tree protection is good—typically 80% or greater. “Area” protection seems to be less so.

“Area” protection was evaluated in the Northern Region, in 2001, using 5-gram pouches. Based on Ian Wilson’s work in Canada, we used 40 pouches per acre (about a 33-foot grid). Results were quite satisfactory, so in 2002 we compared 20 (about a 47-foot grid) to 40 pouches per acre. Results were equally good, so we began suggesting 20 pouches per acre were probably adequate for most area treatments. In other parts of western US, recommendations have been for higher application rates. John Borden (Pherotech Inc.) suggested 20-40, 5-gram pouches per acre should work well, most of the time. And they did until subjected to unusually warm summers. In those conditions, 5-gram pouches were depleted before beetle flight was over. The newer 7.0- and 7.5-gram pouches have performed much better. Warmer summers and milder winters may also be producing variability in MPB life cycle—early emergence, late flights, etc. Even with larger pouches, we may need more than one application per season on occasion, depending on seasonal weather.

More than how many pouches per acre to use, we question the source of verbenone’s inconsistency. That may be a function of both beetle behavior and verbenone activity under varying conditions. No doubt, both require additional research.

Perhaps verbenone should be considered a “tool” on a continuum of short-term protection using carbaryl on one end, and long-term, stand-altering silvicultural treatments on the other. Verbenone would fall somewhere between those two extremes—and may be more effectively used as a mid-term method to reduce beetle-caused mortality while more long-term strategies are implemented. Inherent variabilities encountered using verbenone under varying conditions may result in using it in a judicious application of both “art” and “science.”

We should not only make sure verbenone is used properly, we should also evaluate where and when it is used, to make sure its use has met management objectives.

Economic considerations are also important in using verbenone. It is an expensive material, and we need to make sure we are getting appropriate returns on investments. Verbenone demand is high now and that may be contributing to expense; but it will always be fairly expensive to produce and use—mostly because of high quantities required. A combination of economics and variable results suggest verbenone’s indefinite use in a particular area may be inappropriate.

We should recognize there are situations where verbenone should not be used at all. Using verbenone year after year in the same area—where beetle populations are high—may result in disappointments. Studies conducted for several years in the same area showed favorable results initially, poorer results in succeeding years. That may have been a function of stand conditions, beetle populations, weather or all three.

But, if verbenone is not going to protect trees through an outbreak, we must accept its effectiveness may be finite. Essentially, we should consider verbenone a stop-gap measure, not a long-term fix, and perhaps should not be supporting verbenone projects unless managers are committed to long-term stand management. There could be places where we should not be recommending use of verbenone.

Questions have arisen about verbenone attracting MPB at low levels. Recent research suggests that is not the case. Low-concentration attraction is not enough of a concern to require removal of pouches towards the end of beetle flight, for example.

Previous work suggests if we can't remove infested trees in conjunction with verbenone use, chances of success are greatly diminished. If more than 15% of the stand to be protected is currently infested, and most to all infested trees cannot be removed before beetle flight, treatment results may be disappointing. (In 2009, a multi-Region test will be initiated in the US to measure the effect of removing infested trees in conjunction with verbenone use. Data collected should provide support for proposals regarding the benefit of removing infested trees as a means of increasing verbenone's effectiveness.)

Can we enhance verb by using GLVs? Results to date have not been conclusive, but promising. Tests conducted in 2007 and 2008 in MT showed good success using a combination of verbenone and GLVs. GLVs are much less expensive than verbenone, and because of their benign properties, there shouldn't be many roadblocks to getting them registered. Legal requirements should not be a deterrent to continued testing of GLVs.

What of a "push-pull" strategy? This seems to be a very attractive alternative—pulling beetles (with attractant pheromones in traps or as tree baits) out of an area we are trying to protect (with verbenone). Such projects can be fairly difficult to design; but in theory, they should work relatively well; probably more so if beetle populations are not extreme. Some operational uses have shown promise, but additional studies are needed.

Conclusions

- Verbenone is not, and likely never will be a "silver bullet," but we can recommend its use with appropriate reservations and cautions.
- There are places where we can reasonably use verbenone, and others where it may not be appropriate.
- We should use our expertise to provide more oversight to verbenone's use.
- There seems to be the possibility of enhancing verbenone's effectiveness thru the use of GLVs.
- Economics should be more of an issue in verbenone's use than they appear to be.
- Is verbenone effective against other bark beetles? Recent research indicates verbenone may affect behavior of western pine beetle (*D. brevicomis* LeConte) and some engraver beetle (*Ips*) species; but much more testing needs to be done.

- A “User’s Guide” for verbenone is not currently available. A “cookbook” approach to using verbenone may never be feasible. We may learn that individual uses of verbenone will be unique enough to preclude a “one-size-fits-all” solution.

Current Recommendations for Using Verbenone
(Including above-noted caveats!)

1. Area and/or stand to be treated should be assessed for both hazard (susceptibility) and risk (likelihood of infestation) to MPB. If more than 15% of the stand (trees per acre or basal area—whichever stocking measurement is more conveniently obtained) is occupied by currently infested trees, and those trees cannot be removed prior to beetle flight; do not use verbenone—results may not be worth the cost of treatment.
2. For individual-tree protection, use two 7- or 7.5-gram pouches per tree. Staple (through the strip provided) on northeast and northwest side of tree, as reasonably high as one can reach. In recreation or high-use areas, we suggest attaching them about 10 feet from the ground—easily accomplished with something like a roofing hammer. For larger trees (>24” d.b.h.) use 3-4 pouches per tree, stapled equidistantly around tree’s circumference.
3. For area protection, recommendations vary with nearby beetle populations. We have achieved reasonably good protection (70-80% protection when compared with untreated controls) using as few as 20 pouches per acre and as many as 40 pouches per acre. In areas where beetle populations are lower (less than 15% infestation rate in surrounding stands), 20 pouches per acre will likely give good protection. If higher than about 30%, 40 pouches per acre will give better protection. (For 20 pouches per acre, place on approximate 47-foot grid; for 30, about a 38-foot grid; for 40, 33-foot grid.)
4. Keep in mind, area protection may decline as beetle populations increase in a particular area. Area protection should be considered a “time-buying” measure intended to be effective for only 2-3 years.
5. Verbenone pouches should be in place in lower-elevation stands by July 1. MPB flight in most years, in most host stands, occurs from about mid-July to late-August (occasionally early September). In high-elevation WBP stands, we often encounter MPB life cycles of varying lengths, and sometimes beetle flight as early as late-May. For treating WBP, we recommend treatments be in place by the latter part of May.
6. Verbenone is a fairly innocuous chemical—but it is still a chemical, and some care should be exercised in its use. Manufacturers recommend using chemical-resistant gloves when applying and any other safety equipment typically used in the field. Care should be taken to follow all precautions found on registration label.

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