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# Drift Resulting from Ground-based Sprays of Carbaryl to Protect Individual Trees from Bark Beetle Attack in the Western United States

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Figure 1. Many forest health specialists consider carbaryl to be the most effective, economically viable, and ecologically-compatible insecticide available for protecting individual trees from bark beetle attack in the western U.S. Several liquid formulations are available (A) and are typically applied with hydraulic sprayers (B) until the tree bole is saturated (C), Lassen County, California.

Bark beetles are commonly recognized as important tree mortality agents in western coniferous forests, but relatively few species (<25) are capable of killing apparently-healthy trees. However, during the last decade extensive levels of tree mortality were attributed to bark beetle outbreaks in spruce forests of south-central Alaska and the Rocky Mountains, lodgepole pine forests of western Canada and the Rocky Mountains, pinyon-juniper woodlands of the southwestern U.S., and ponderosa pine forests throughout much of their range. Large scale outbreaks occur when favorable climatic (e.g., droughts) and stand (e.g., dense stands of suitable hosts) conditions coincide.

Losses of trees in residential or recreational (e.g., campgrounds) sites generally result in reduced shade, screening and aesthetics, reductions in homeowner property values and costs associated with hazardous tree inspections and removal. Tactics for managing bark beetle infestations are generally limited to tree removals (thinning) that reduce stand density and presumably host susceptibility; applications of semiochemicals (i.e., chemicals produced by one organism that elicit a response, usually behavioral, in another organism) to protect individual trees or small-scale stands (e.g., <20 acres); or applications of insecticides to protect individual high-value trees [e.g., several (but not all) trees may be treated within a campground].

A common method of protecting trees from bark beetle attack in the western U.S. is to saturate the tree bole with carbaryl (1-naphthyl methylcarbamate) using a hydraulic sprayer at high pressure (≥325 psi for trees <20 inches and ≥400 psi for trees ≥20 inches diameter at breast height) (Figs. 1A-C). Hastings et al. (2001) provide an excellent review of the use of carbaryl in coniferous forests of North America. Several formulations are available and effective (Haverty et al. 1998, Hastings et al. 2001, DeGomez 2006, Fettig et al. 2006) if properly applied in accordance with the label. Generally, a single application of carbaryl will provide two field seasons of protection for most western bark beetle species (e.g., mountain pine beetle, spruce beetle and western pine beetle). Failures are typically associated with inadequate coverage (e.g., the root collar, one or more bole faces and/or the upper bole not adequately treated), improper (e.g., using an alkaline water source with pH >8) or inaccurate mixing resulting in solutions of reduced concentration, improper storage, and/or improper timing (e.g., applying treatments to trees already successfully attacked).

The purpose of this report is to provide forest managers with information about the amount of drift that occurs during applications of carbaryl to protect individual trees from bark beetle attack. Technical assistance concerning the use and application of carbaryl as a single tree protection treatment can be obtained from the companion University of Arizona bulletin by DeGomez (2011) on protecting conifers from bark beetle attack with insecticides, Forest Health Protection (USDA Forest Service) entomologists (www.fs.fed.us/foresthealth/), state forest entomologists and/or county extension agents (www.csrees.usda.gov/Extension/). We encourage forest managers and others to use these resources. Interestingly, carbaryl is ineffective for protecting loblolly pine from southern pine beetle attack in the southeastern U.S. (Berisford et al. 1981), and thus may also be ineffective for protecting ponderosa, Chihuahua and Apache pines from southern pine beetle in Arizona and New Mexico.

Most data on the deposition, toxicity, and environmental fate of carbaryl in forest ecosystems is derived from aerial applications to control tree defoliators. In a recent study, Fettig et al. (2008) reported carbaryl drift resulting from single tree protection treatments poses little threat to adjacent aquatic environments, a primary concern when treating trees in campgrounds in the western U.S. Their publication serves as the basis of information presented in this bulletin. The authors evaluated the amount of drift (ground deposition) occurring at 25, 50, 75 and 125 feet from the tree bole (Table 1). Values ranged from 162 mg carbaryl/acre at 125 feet to 53,823 mg carbaryl/acre at 25 feet. Approximately 97% of total spray deposition occurred within 50 feet of the tree bole (Fig. 2). Application efficiency (i.e., the percentage of insecticide applied that is retained on trees) ranged from 80.9% to 87.2%, which agreed with a previous study conducted by Haverty et al. (1983). Less drift is expected in dense forest stands due to reduced wind speeds and interception by foliage.

To evaluate the potential threat of single tree protection treatments to aquatic environments, mean deposition was

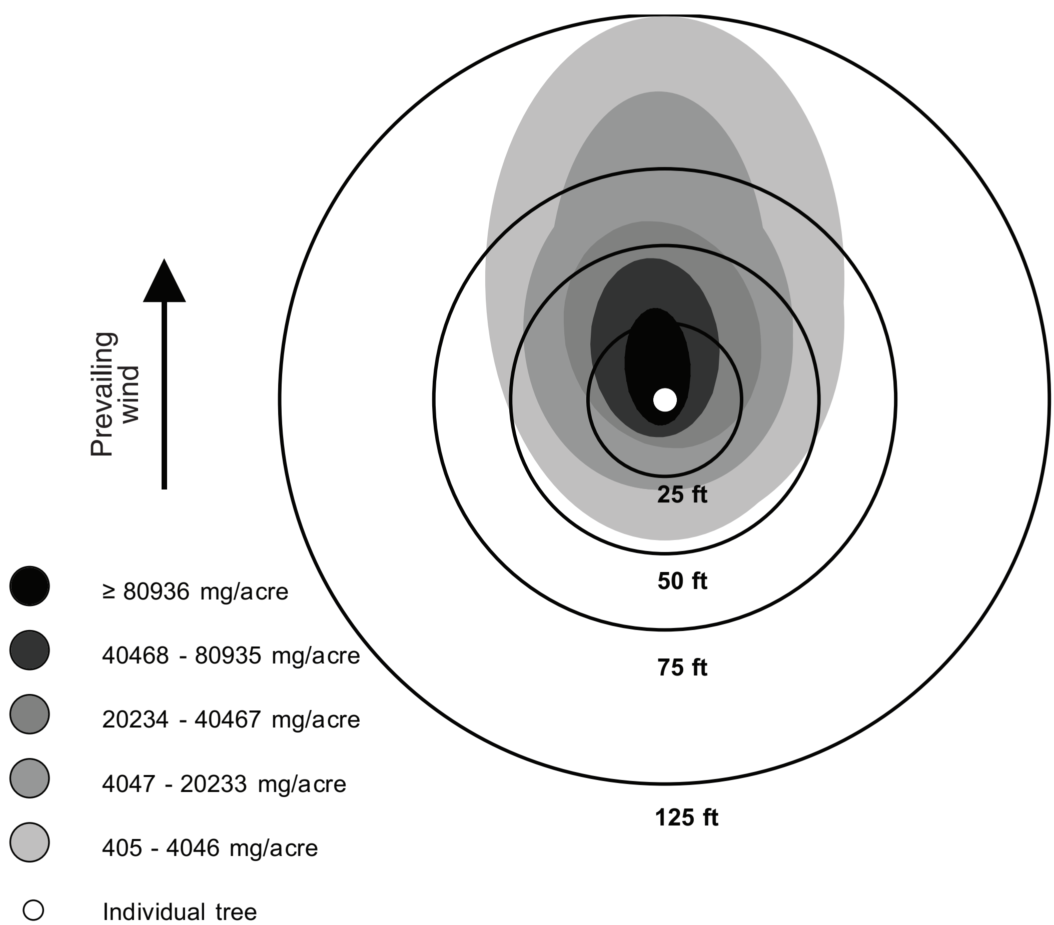


Figure 2. Average drift following the application of carbaryl to individual trees, Wasatch-Cache National Forest, Utah. Data obtained from Fettig et al. (2008).

Table 1. Mean deposition at four distances from the bole of individual lodgepole pine and Engelmann spruce treated with 2.0% (active ingredient) carbaryl for protection against bark beetle attack, Wasatch-Cache National Forest, Utah, 2006. Data obtained from Fettig et al. (2008).

| Orifice size | 25 feet | 50 feet | 75 feet | 125 feet |
|---|---|---|---|---|
| | Mean deposition† | Mean deposition† | Mean deposition† | Mean deposition† |
| 8 | 29906.0 | 4694.3 | 647.5 | 161.9 |
| 10 | 39820.7 | 5746.5 | 1335.5 | 161.9 |
| 12 | 53822.7 | 4330.1 | 1173.6 | 161.9 |

† Based on collections of eight filters (3.5-inches diameter) per tree at each distance for each of 20 trees per orifice size. Expressed as mg carbaryl/acre.

Table 2. Predicted concentration in water at four distances from the bole of individual lodgepole pine and Engelmann spruce treated with 2.0% (active ingredient) carbaryl, Wasatch-Cache National Forest, Utah. Data obtained from Fettig et al. (2008).

| Orifice size | 25 feet† | 50 feet† | 75 feet† | 125 feet† |
|---|---|---|---|---|
| 8 | 0.0916 | 0.01438 | 0.00189 | 0.00038 |
| 10 | 0.12226 | 0.01779 | 0.00416 | 0.00038 |
| 12 | 0.16503 | 0.01325 | 0.00379 | 0.00038 |

† Mean concentration based on assumption of mean deposition into a static body of water 1 foot deep. Expressed as mg carbaryl/gallon.

converted to mean concentration assuming a water depth of 1 foot (Table 2). This depth was arbitrarily selected by the authors to represent the average size of lotic systems, primarily small mountain streams, adjacent to many recreational sites where single tree protection treatments are commonly implemented (Fettig et al. 2008). No adjustments were made for the degradation of carbaryl by hydrolysis, which is rapid in streams, or for dilution by natural flow. Comparisons were made with published toxicology data available for select aquatic organisms.

No-spray buffers of 25 feet would be sufficient to protect freshwater fish, amphibians, crustaceans, bivalves and most aquatic insects. For example, rainbow trout is reported to be one of the most sensitive fish species tested and a no or low effect concentration of 3.56 mg carbaryl/gallon is reported for that species (Dwyer et al. 2005). This value is about 22 times greater than the highest concentration calculated by Fettig et al. (2008) (Table 2). In laboratory studies, carbaryl was found to be highly toxic to stoneflies (Plecoptera) and mayflies (Ephemeroptera), which are widely distributed and important food sources for freshwater fishes, but negative impacts in field populations are short-lived (Beyers et al. 1995). No-spray buffers > 75 feet appear sufficient to protect the most sensitive aquatic insects such as stoneflies.

We encourage applicators to be cognizant of wind direction as in some cases they can further limit deposition to sensitive attributes, such as streams and neighboring properties, by accounting for this variable. For example, while Fettig et al. (2008) detected carbaryl drift at 125 feet on the leeward side of treated trees [maximum wind speed averaged 2.2 miles per hour)], drift was undetectable less than half that distance on the windward side (Fig. 2). Spray treatments should not be applied if maximum wind speeds exceed 10 miles per hour.

Carbaryl is an important tool for protecting high-value trees from bark beetle attack in the western U.S. We hope that forest health professionals and other resource managers use these data and other published reports to make informed, judicious decisions concerning the application of carbaryl. To that end, using reasonable no-spray buffers will ensure that adjacent aquatic and terrestrial environments are protected from any negative impacts.

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