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Diesel Fuel Oil for Increasing Mountain Pine Beetle Mortality in Felled Logs

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Abstract—Diesel fuel oil was applied to mountain pine beetle (*Dendroctonus ponderosae* Hopkins) infested bolts of ponderosa pine (*Pinus ponderosa* Lawson) in early June. Just prior to the fuel oil application and 6 weeks later, 0.5 ft^2 bark samples were removed from each bolt and the numbers of live beetles counted. Beetle survival was 8.3% in bolts arranged in a single layer and 4.8% in bolts arranged in 2 layers.

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Disclaimer

Diesel fuel oil used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions for the handling and use of fuel oil.

Keep out of the reach of childern and animals. Store safely, away from food, feed, and possible sources of ignition.

Apply diesel fuel oil so that it does not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply diesel fuel oil in ways that may contaminate water; do not clean equipment or dump excess diesel fuel oil near ponds, streams, or wells. Dispose of empty diesel fuel oil containers properly.

Avoid prolonged inhalation of diesel fuel oil; wear protective clothing and equipment as specified by the appropriate material data safety sheet.

If your hands become contaminated with diesel fuel oil, do not eat or drink until you have washed. In case diesel fuel oil is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If diesel fuel oil is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

For additional information, visit the website: http://www.arfarfarf.com/msds/diesel_no2.html

Introduction

Populations of the mountain pine beetle (*Dendroctonus ponderosae* Hopkins) infest and kill ponderosa pine (*Pinus ponderosa* Lawson) trees in the Front Range of Colorado. Groups of trees may be killed each year because the mountain pine beetle (MPB) has a 1-year life cycle and a new generation of beetles emerges annually to attack green trees. Tree mortality caused by the MPB becomes a concern for forest managers, especially private landowners who wish to prevent tree mortality on their property. Initial MPB infestations probably go undetected until the needles on the infested trees fade. Once detected, landowners seek ways to kill the beetles and prevent the infestation of additional trees.

Methods of killing MPBs vary with the circumstances of the infestation. Sanitation logging of infested trees (McMillin and Allen 1999), felling and burning infested trees (Evenden et al. 1943, McMillin and Allen 1999), felling infested trees and exposing them to solar radiation (Leatherman 2001, Negron et al. 2001), felling and peeling off the bark (Evenden et al. 1943), and felling and applying lethal chemicals (McCambridge 1972, McCambridge et al. 1975) are methods for increasing MPB mortality. Sanitation logging may be useful only where the number of infested trees is large enough to make logging profitable. Felling and exposing to solar radiation may be useful for landowners with a small number of infested trees and the equipment to handle the trees. Felling and applying lethal chemicals is a simple procedure but the chemicals may be unavailable without a special permit or landowners may refrain from using it because the chemical(s) may cause adverse effects on other animal species. Further, the availability of chemicals for this purpose has declined substantially in the past decade (Leatherman and Cranshaw 1998). For example, Lindane, a chemical highly effective against the MPB, has almost disappeared because its registration for this particular use has expired. As the availability of suitable chemicals has become limited, the search for substitutes has modestly increased. Many chemicals are restricted in their use and therefore unavailable to landowners. Diesel fuel oil, a commonly used fuel in vehicles, is readily available to landowners. Because diesel fuel oil reduced spruce beetles (*D. rufipennis* (Kirby)) an average of 90% when applied to spruce logs (Schmid 1972b), we tested its effectiveness for causing mortality in MPB populations.

Methods

This study was conducted in ponderosa pine stands on the Canyon Lakes District of the Arapaho-Roosevelt National Forest in northern Colorado. More specifically, the location was about 45 miles northwest of Fort Collins in Section 20, R.73 W, T. 9 N, which lies about 3 miles north of the resort area known as Rustic in the Poudre Canyon.

Four MPB-infested trees were felled on June 1 and 2, 2000. The infested portions of the trees were cut into 4-ft bolts; each tree yielded about 5 bolts. The lowermost and uppermost portions of the trees were not used because, although MPB attacks were present, they lacked MPB brood. Mid-bolt diameters ranged from 9.9 to 15.1 inches for the 4 trees.

Two of the trees were used in one replication of the treatments while the other two trees were used in a second replication of the treatments on an adjacent site. Bolts from each pair of trees were sorted into 2 piles but were intermixed during sorting so each treatment would have bolts from both trees and bolts of various diameters.

The two treatments consisted of: 1) 5 bolts arranged in a single layer that were oriented north-south after fuel oil application, and 2) 5 bolts arranged in 2 layers also oriented north-south after application (figure 1). The physical arrangement of the bolts was similar to the design used in the solar treatment study by Negron et al. (2001) so that comparisons could be made between the results of the 2 studies.

Diesel fuel oil was applied to all surfaces of each bolt with a sprinkling can on June 1 and 2, 2000 (figure 2). Initially, the oil was liberally applied on the upper surface so that it was thoroughly soaked and the oil began to run down on the lateral surfaces. If the oil began to drip off the bark on the lateral surface, application ceased and the bolt was rotated slightly so that the oil would not drip on the ground. After the oil had soaked into the bark on the upper surfaces (figure 3), each bolt was rotated 180 degrees and the diesel fuel oil was applied to the opposite side in the same manner. Bolts in the 2-layer treatment were treated individually and then stacked; the diesel fuel oil was not applied to the bolts in the stacked position.

Prior to the cutting of the trees into bolts, the north sides of the trees were marked with paint. After application of the fuel oil, the north sides of the bolts were placed so that they faced the ground. This orientation was performed because: 1) previous observations indicated that densities of MPB brood are usually greater on the north sides (Schmid 1972a), and 2) work in 1999 by Negron et al. (2001) indicated that

Figure 1. After application of diesel fuel oil, the bolts were arranged in single and double layers.

Figure 2. Application of the diesel fuel oil to the bolt with a sprinkling can.

Figure 3. End view of a bolt showing the extent of the runoff of the diesel fuel oil on the end.

MPB densities in bolt surfaces directly exposed to the sun would suffer substantial mortality. While increasing mortality through solar radiation is desirable, the effectiveness of the fuel oil treatment might have been confounded by solar-caused mortality. Therefore, the side of the bolt with the greatest potential for brood (north side) was positioned downward so mortality would not be influenced by solar radiation.

Before the diesel fuel oil was applied, one 0.5 ft^2 bark sample was removed from the north surface of each bolt. By confining bark sampling to the north surfaces, the effect of solar radiation on brood survival is minimized. MPB brood (larvae, pupae, and callow adults) and the number of attacks were counted and recorded. On July 10-12, 2000, 0.5 ft^2 bark samples were removed from the north surfaces of all bolts. MPB brood were counted and recorded. Brood in several post-treatment samples were alive but appeared discolored and sluggish. Although we suspect that the inactive and discolored brood probably would not have survived, they were still counted as live brood. Mean brood densities and their standard errors were computed for each treatment for each sampling period. MPB brood densities were used in analysis of variance testing for significant differences between treatments and time of sampling, alpha = 0.05.

Mean number of attacks per 0.5 ft^2 of bark were also computed for each treatment. The mean number of MPB brood and attacks per 0.5 ft^2 of bark were used to determine a population trend ratio (PTR) for the MPB brood (see Lessard and Schmid 1990). The PTR is the number of beetles expected to emerge (the live brood) divided by the number of attacking beetles. The number of attacking beetles is derived by doubling the attack density because it is assumed that 2 beetles (a female and a male) are needed in each attack to create the gallery and produce the brood. A PTR greater than 1 indicates the MPB population in the bolts would be increasing, while a PTR of less than 1 indicates a decreasing population.

Results and Discussion

Mean densities of MPB brood were significantly different between sampling periods but were not different between treatments (table 1). Thus, the two-layer treatment was just as effective as the one-layer treatment with respect to mortality on the bottom surfaces. Because Negron et al. (2001) have shown that survival can be substantial on the upper surfaces of bolts in the lower layer in the two-layer solar treatment, the one-layer fuel oil treatment is probably preferable in order to gain the benefit of solar radiation on the upper surface and thus maximize mortality from the fuel oil and solar radiation on the entire circumference.

Percent survival averaged 8.3% in the single layer treatment and 4.8% in the double layer treatment (table 1). Most of the samples had no surviving beetles. Because some "live" brood appeared discolored and sluggish, we suspected that some of the "live" brood would eventually die and thus result in a lower survival percentage. We also suspect that live brood in some samples may have occurred because portions of the bark on these bolts were not soaked as throughly as the bark in bolts with no survival.

Table 1. Mean (± std. error) numbers of mountain pine beetle brood per 0.5 ft^2 of bark surface. Means represent combined data for the two sets of treatments.

Treatment	Pretreatment	Posttreatment	Percent survival
Single Layer	34.8 ± 5.9	2.9 ± 1.4	8.3%
Double Layer	41.3 ± 5.9	2.0 ± 1.4	4.8%

Mean attack densities for bolts in the single and double layer treatments were 4.1 and 3.5 per 0.5 ft^2 (table 2). Based on these numbers and assuming the mean densities of MPB at the last sampling period would emerge to attack live trees later in the summer, the PTR was 0.35 for the single layer treatment and 0.29 for the 2 layer treatment. Thus, both treatments resulted in a decreasing MPB population.

In a solar treatment study conducted simultaneously in the same area, survival averaged 47.2% in the bottom surfaces of bolts in a single layer (Negron et al. 2001). Survival in the bottom surfaces of bolts in a 2 layer treatment averaged 53.9% for bolts in the upper layer and 56% for bolts in the lower layer (Negron et al. 2001). Thus, the diesel fuel oil treatments were much more effective than solar radiation treatments in reducing beetle survival on the bottom surfaces of the bolts.

Table 2. Population trend ratios (PTR) for the single layer and double layer diesel fuel oil treatments based on attack and brood densities per ft^2.

Treatment	Attack densities	Attacking MPB	Emerging MPB	PTR
Single Layer	4.1	8.2	2.9	.35
Double Layer	3.5	7.0	2.0	.29

Because the number of sample trees (4) sprayed with diesel oil is low, the reader might question whether the diesel oil would be effective under different brood densities. Our pretreatment brood densities were comparable to the 1999 and 2000 pretreatment brood densities of Negron et al. (2001) wherein about 50 trees were felled and sampled. Although our sample is small, it appears to be representative of existing conditions at the time so that the fuel oil would be effective against the brood densities we observed as well as those observed by Negron et al. (2001).

Application Procedure

Fuel oil can be easily applied with a sprinkling can. Liberally apply the fuel oil to the upper surface of a bolt so that it flows onto the lateral surfaces without dripping onto the ground or splashing on adjacent vegetation. Allow the fuel oil to soak in before rotating the bolt and applying more fuel oil. Repeat the sequence until the bark surface area has been well soaked. After all bolts have been treated, thoroughly clean the sprinkling can before it is to be used for other purposes like watering flowers or garden vegetables.

Application Costs

Approximately 5 gallons of diesel fuel oil were used to treat the 10 bolts for each replication of the 2 treatments. Diesel fuel oil at a local gas station at the time of this study cost about $1.20 per gallon. Based on this price, treatment of the MPB-infested portion would cost about $3 per tree. Additional costs would be incurred for felling and cutting the tree into treatable-length bolts.

Environmental Concerns

If forest managers use diesel fuel oil when treating MPB-infested bolts, they should observe all precautions because the treatment can be injurious to humans, animals, and plants. However, judicious application of the diesel fuel oil can essentially eliminate the detrimental effects of the treatment to everything outside the MPB-infested bolt.

Fuel oil is a flammable substance that burns readily. While fuel oil-soaked bolts will burn more readily than dry bolts, we do not believe that they will spontaneously combust and start a fire.

Benefits for the Private Forest Managers

Private landowners should consider using diesel fuel oil for treatment of MPB-infested trees because:

1. Diesel fuel oil will effectively lower MPB brood survival.
2. Diesel fuel oil is effective on all surfaces of the bolts and the bolts do not have to be rotated or handled after application.
3. Diesel fuel oil is relatively cheap and may be more cost effective than solar radiation because the bolts have to be handled only once.
4. Diesel fuel oil can be just as effective as some insecticides but does not require the special applicator's licenses or permits needed for purchase and application of some insecticides.

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