USDA
United States Department of Agriculture

A TEST OF LETHAL TRAP TREES FOR CONTROL OF SPRUCE BEETLES

José F. Negrón, Robert Cain, Andy Cadenhead, and Brian Waugh

Abstract—The spruce beetle, *Dendroctonus rufipennis*, can cause extensive mortality of Engelmann spruce, *Picea engelmannii*, during outbreaks. Endemic populations breed in the underside of downed spruces. Outbreaks often develop after blowdowns that create abundant downed trees where beetle populations can increase. Occasionally, managers practice suppression to protect high-value resources. Although not common, lethal trap trees have been used to suppress populations by attracting beetles to insecticide-treated felled trees with the aim of killing the beetles yet little data is available on their effectiveness. In October 2003, a lethal trap tree treatment was implemented in the Routt National Forest in Colorado in an area adjacent to the Steamboat Ski Resort, to minimize population movement into this high-value area. Along with the project, a study was conducted to evaluate treatment effectiveness. Felled trees were divided into two sections; one was sprayed with carbaryl, a common insecticide, while the other one was left unsprayed. In August, 2004, bark samples were extracted from the study trees and from additional completely sprayed trees. We observed no differences in the number of beetle attacks, egg galleries, or life stages between treated and untreated sections of the experimental trees and the completely sprayed trees. Insect populations appeared to be low. We conclude that this technique should not be used until additional data is collected regarding its efficacy.

Keywords: *Dendroctonus rufipennis*, *Picea engelmannii*, bark beetles, Engelmann spruce, bark beetle suppression

Negrón, José F.; Cain, Robert; Cadenhead, Andy; Waugh, Brian. 2019. **A test of lethal trap trees for control of spruce beetles.** Res. Note RMRS-RN-83. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 9 p.

AUTHORS

Jose F. Negrón is a Research Entomologist with the U.S. Forest Service Rocky Mountain Research Station at the Forestry Sciences Laboratory in Fort Collins, Colorado.

Robert Cain is the Regional Entomologist with the U.S. Forest Service Rocky Mountain Region in Lakewood, Colorado.

Andy Cadenhead is the Physical Resource Staff Officer for the U.S. Forest Service Pike-San Isabel National Forests and Cimarron and Comanche National Grasslands in Pueblo, Colorado.

Brian Waugh is the Recreation Program Director for the U.S. Forest Service Medicine Bow Routt National Forests, Brush Creek/Hayden Ranger District in Saratoga, Wyoming.

Forest Service | **Rocky Mountain Research Station** | Research Note RMRS-RN-83 | February 2019

ACKNOWLEDGMENTS

We thank Steve Munson and John Lundquist for their review and valuable comments on an earlier draft of this paper; Scott Baggett for statistical support; and Dani Riker, Lance Broyles, Kevin Everhart, and Jon Halverson for field implementation of the project and study.

INTRODUCTION

The spruce beetle, *Dendroctonus rufipennis* Kirby, utilizes various species of spruces, *Picea* spp., as hosts for development and reproduction. In Colorado's spruce-fir forests its main host is Engelmann spruce, *Picea engelmannii* Parry ex Engelm. A native insect in Colorado's forests, it is commonly present at low-level populations colonizing primarily stressed and downed host trees. Periodically, populations reach outbreak levels and extensive tree mortality can occur. These high-level populations usually occur after windstorms and blowdowns where fallen trees provide a rich and abundant resource suitable for beetle population increases, as this is their preferred habitat (Massey and Wygant 1954). Emerging adults invade the surrounding standing green spruce trees, and as populations expand they affect large tracts of vulnerable forests. Perhaps the most notable outbreak in Colorado occurred in the White River National Forest where 3.8 billion board-feet of spruce were killed by the insect between 1939 and 1951. That outbreak followed a blowdown event in 1939 (Massey and Wygant 1954). Since 2002, infestations have been increasing in Colorado, particularly in southwestern Colorado.

The spruce beetle is a natural disturbance agent in Colorado's spruce forests. Extensive tree mortality, however, can be in conflict with forest management objectives. This is particularly the case in high-value settings such as administrative sites, campgrounds, and ski areas where tree mortality is less tolerable. As a result, there are situations in which direct control strategies are implemented to mitigate mortality levels. Control of large outbreak populations is a futile endeavor, but mitigating tree mortality for individual trees (Fettig et al. 2006) or in small isolated infestations may be possible (Bentz and Munson 2000).

Options for managing spruce beetle populations, when appropriate, include insecticide applications. Formulations of carbaryl or various pyrethroid-based insecticides have proven to be very effective when applied correctly and are often used in high-value sites (Fettig et al. 2006). The timely removal of infested trees during sanitation or salvage operations before populations emerge can help suppress localized populations (see Jenkins et al. 2014). Infested trees can be felled and the insects killed on site by strategies such as debarking or burning infested trees (Gray et al. 1990; Lister et al. 1976; Munson 2010) or using solar radiation to kill insects in infested logs (Mitchell and Schmid 1973).

Pheromone traps baited with attractants can be used to remove beetles from the area, although improvements of this strategy are needed (Bentz and Munson 2000; Hansen et al. 2006). The spruce beetle utilizes a sophisticated chemical communication process that uses aggregation pheromones to concentrate attacks on a tree to overcome the defenses of the tree and anti-aggregation pheromones that arrest additional beetles from attacking the tree when it is fully colonized. The anti-aggregation pheromone for the spruce beetle is MCH (3-methylcyclohex-2-en-1-one). This chemical has been used to reduce attacks in downed trees but has not been successful in protecting live trees (Furniss et al. 1976; Hansen et al. 2017; Lindgren et al. 1989; Ross et al. 2004). However, recent research suggests that using MCH combined with an Acer kairomone blend may be efficacious for protecting individual trees (Hansen et al. 2017).

A traditional method that has been used for many years for managing spruce beetles is the use of trap trees (Nagel et al. 1957). These are large-diameter trees that are felled to attract beetles as they favor this environment. Once colonized, trees are removed or treated before insects emerge. For example, treatment strategies can include removal of the tree's outer bark to expose life stages to an inhospitable environment that leads to insect mortality such as solar radiation or burning the infested trees.

Trap trees can also be used as “lethal trap trees” by applying pesticides to kill the beetles. In the past, standing trees were treated with chemicals that translocated along the bole and were then felled (Buffam 1971; Lister et al. 1976). Beetles would be killed soon after entering the treated tree. The use of arsenic-based herbicides or chemicals proved to be an effective treatment; however, due to their toxicity to non-target organisms and exposure effects on workers, these chemicals are no longer available for this purpose.

Lethal trap trees have not been used extensively, yet inquiries sometimes arise related to their effectiveness and are, on occasion, used operationally. To our knowledge, the efficacy of lethal trap trees with present day insecticides such as carbaryl and pyrethroids, which are registered and effective for protecting live trees from bark beetle attacks, has not been evaluated.

In 1997, a large blowdown in the Routt National Forest in Colorado triggered a spruce beetle outbreak that caused extensive spruce mortality. Large infestations developed at the Steamboat Ski Resort, which is a highly valuable site and the heart of the economy of north central Colorado. The resort provides winter recreation for thousands of skiers annually and bicyclists and hikers during the summer. Aggressive suppression efforts implemented to mitigate tree mortality within the ski area included tree removal, trap trees, pheromone traps with attractants, and felling and debarking of infested trees. Lethal trap trees were used operationally in an area just east of the ski area in an effort to minimize movement of the beetle population into the adjacent ski area. In conjunction with these operational treatments, a study was conducted to evaluate the efficacy of lethal trap trees using carbaryl.

METHODS

The study was conducted in 2003–2004 in conjunction with an operational lethal trap tree project at the Routt National Forest in north central Colorado. Forest personnel felled and treated about 250 healthy trees in an area of about 130 acres with insecticide. Trees ranged from 25 to 40 inches d.b.h. Twenty-three of the cut trees were randomly selected for this study. These were divided into three sections: a 10-ft section from the butt of the tree, a 5-ft buffer section, and the next 10-ft section of the tree (hereafter experimental trees). The two 10-ft sections were the experimental sections of the tree. One 10-ft section, selected at random, was treated with insecticide and the other one left untreated. This protocol was used to minimize tree effect in the study. In addition, 20 trees that were sprayed completely as part of the larger control project were selected at random and also evaluated (hereafter operational trees).

The insecticide used was carbaryl (trade name Sevin XLR Plus, Bayer Corporation, Kansas City, MO). The material is 44.1 percent by weight of its active ingredient, (1-naphthyl N-methylcarbamate) and was mixed with water to a 2 percent solution. The treated section of the tree was sprayed to the point of runoff on all bole faces with a backpack sprayer. Trees were sprayed on October 6, 2003. Air temperature was in the mid-60s °F with a relative humidity of 20 percent and there was no precipitation for at least 48 hours following treatment. (www.wunderground.com, Station KSBS, Steamboat Springs Airport).

A commercial spruce beetle attractant consisting of frontalin and 1-methyl-2-cyelohexen-l-ol (Phero Tech Inc./Contech Enterprises Inc., Canada) was attached to the underside of every experimental tree bole at the middle of the buffer between sections to assure insect pressure. During August 16–17, 2004, after beetle flight was complete, we visited all experimental trees and collected bark samples using a battery-powered cordless drill with a 4-inch in diameter hole saw, collecting a total surface area of 12.6 in^2. Four samples were taken from the bottom side (or as close as possible) of the treated and the untreated sections of the experimental trees. We also collected five bark samples from underside of 20 of the operationally treated trees. Samples were kept cool in ice coolers and transported to the laboratory at the Rocky Mountain Research Station, Fort Collins, Colorado. In the laboratory, samples were examined and data taken on the number of adults, larvae, and pupae; these were summed to obtain the total spruce beetle life stages present. We also recorded the number of attacks and egg galleries present in the sample. Data were analyzed using mixed general linear models using trees as random effect and spray or no spray as fixed effect.

RESULTS

We observed attacks, egg galleries, and life stages in our samples and observed no differences in any of the variables measured between the sprayed and unsprayed sections of the experimental trees and the operationally treated trees (table 1). In addition, just about all trees had some attacks: 20 of the 23 sprayed sections and 22 of the 23 of the unsprayed sections of the experimental trees, and 16 of the 20 operationally treated trees.

Table 1—Means (standard error) of number of spruce beetle life stages, spruce beetle egg galleries, and spruce beetle attacks per 12.5 in^2 in treated and untreated sections of trees and in fully treated operational trees. Experimental trees had a 10-ft section treated with carbaryl and a 10-ft section untreated; operational trees were sprayed completely. No significant differences were observed for any of the variables, Tukey-Kramer Test, $p<0.05$.

Variable	Experimental trees treated section	Experimental trees untreated section	Operational trees	*P*
Number of samples	96	101	100	–
Spruce beetle life stages	0.6 (0.2)	0.3 (0.1)	0.4 (0.1)	0.53
Spruce beetle egg galleries	0.6 (0.1)	0.8 (0.2)	0.5 (0.1)	0.22
Spruce beetle attacks	0.6 (0.1)	0.8 (0.1)	0.5 (0.1)	0.15

DISCUSSION

In this study, the use of lethal trap trees to attract and kill the beetles was not effective. The study was conducted during an extensive outbreak of spruce beetle and the plurality of sample trees were attacked by spruce beetles. However, the local population in the area treated may have been low as the numbers of insects, galleries, and attacks were relatively low. For example, Schmid and Frye (1977) indicated that in windthrown trees, spruce beetle attacks are higher in the underside of the tree and reported a range of 1.5 to 5.9 attacks per ft^2, which is higher than in our samples. The number of attacks, however, can be influenced by factors such as insect population levels and exposure to sun, shade, or competing species of bark beetles such as *Ips pilifrons* Swaine.

Our results contrast with a study by Hansen et al. (2016). They examined area protection of standing trees using lethal trap trees sprayed with carbaryl and surrounding areas within the treated blocks treated with repellent semiochemicals. They did not evaluate efficacy of the lethal trees at the individual tree level, but indicated that only one of 74 sprayed trees had one spruce beetle attack and that attack was not successful. A study by Gray et al. (1990) had mixed results; lethal trees were sprayed with monosodium methanearsentate, which was effective in a British Columbia site, but not in an Alaska site. This chemical is no longer available for use as a pesticide.

When insecticide sprays have failed to protect standing trees from bark beetle attacks, it has been attributed primarily to inadequate coverage of the bark surface or improper preparation of the insecticide solution (Fettig et al. 2013). Anecdotal reports from experienced forest health scientists have also confirmed this. The water used to mix the insecticide in this project was pumped from a nearby creek, therefore, it may not have been adequate for this purpose. This may have resulted in an inadequate insecticide mix. Incomplete coverage of the trees when sprayed may have also contributed to failure.

Carbaryl has been proven effective for protecting standing trees from bark beetle attacks when used as a preventive spray prior to exposure to insect populations (Fettig et al. 2006). Laboratory studies with mountain pine beetle, *Dendroctonus ponderosae* Hopkins, indicate that beetles die when they come in contact with the pesticide (Fettig et al. 2011), and this is likely the case with spruce beetles. Hansen et al. (2016) indicated that while this is the case in the laboratory, it had not been confirmed in the field and protection may result from a repellent effect of the chemical. If the insecticide has a repellent effect it may have influenced the likelihood of attacks in the untreated portion of the experimental trees due to the proximity to the treated portion of the tree. However, Hansen et al. (2016) placed funnels under trap trees treated with carbaryl and under untreated trees to determine if a lack of attacks was indicative of beetles being killed or due to a repellent effect. They observed significantly more dead beetles caught in funnels under treated trees compared to untreated trees suggesting that beetles were killed by the insecticide and not repelled by it. This being the case, if the lethal trees in our study were effective, the untreated portion of the experimental trees should have been more heavily attacked, and no attacks should have occurred in the treated portion of the experimental trees or in the operational trees.

In the few other studies that have examined lethal trap trees, trees were sprayed before adult emergence in the spring and evaluated after beetle flight the same year. To our knowledge, our study was the first one to treat the lethal trap trees in the fall and evaluate the treatment the following year. Data to date suggest that carbaryl can provide protection for 2 years in standing trees (Fettig et al. 2006), but no studies have evaluated the effect of the pesticide on downed trees sprayed in the fall and then exposed to winter conditions. However, applications of insecticide for protection of trees from spruce beetle attack are commonly applied in the fall without negating effectiveness.

The objective of trap trees is to concentrate beetle attacks in the downed trees and in the case of lethal trap trees to kill beetles as they attempt to colonize the downed tree. Either method is designed to reduce the number of beetles available to attack live standing trees in the area. Hansen et al. (2016) used lethal trap trees to examine area protection and examined the probability of spruce beetle attacks in trees in the vicinity of the treated trees. Results indicated that the probability of beetles attacking surrounding lethal trees was only marginally lower than that of attacking trees in the vicinity of untreated trees. Based on that, the authors did not recommend the use of lethal trap trees for area protection, but indicated that the method may be a viable treatment for smaller accessible, isolated infestations.

Additional studies need to be conducted to better examine the utility of lethal trap trees to mitigate spruce beetle. This study could have been improved by sampling for dead beetles on the ground to better assess the effect of a downed lethal trap tree. In addition, future studies should compare separately treated and untreated trees instead of using a sprayed and unsprayed portion of the same tree to eliminate any potential repellency. If proven effective, lethal trap tree treatment could be a tool for treating isolated small populations or used in combination with other strategies such as sanitation, pheromone trapping, and insecticide applications to standing trees (Gillette et al. 2012; Progar et al. 2014). An example of this approach was the successful suppression of a small, isolated outbreak using a combination of infested tree removal, trap trees, and pheromone traps with attractants in an experimental spruce-fir forest in Utah (Bentz and Munson 2000). However, other issues that need to be considered include the cost of spraying trees, site access, environmental effects of insecticide use, effect on non-target organisms, and human exposure to pesticides. These factors may negate the benefit of a small reduction in overall tree mortality. Based on the available data, we do not recommend operational use of downed lethal trap trees until further data can be collected regarding treatment efficacy on treated trees and a reduction in mortality of adjacent standing green uninfested trees, or its utility in combination with other strategies.

MANAGEMENT APPLICATION

The study presented here evaluated spruce beetle attacks on trap trees sprayed with an insecticide to reduce the number of insects available to attack standing green trees. Sprayed and unsprayed sections of experimental trees and fully sprayed operational trees were attacked by spruce beetles. Previous studies show mixed results. Until additional data assessing the effectiveness of lethal trap trees are available, the use of this strategy is not recommended.

REFERENCES

Bentz, B.J.; Munson, A.S. 2000. Spruce beetle population suppression in northern Utah. Western Journal of Applied Forestry. 15: 122–128.

Buffam, P.E. 1971. Spruce beetle suppression in trap trees treated with cacodylic acid. Journal of Economic Entomology. 64: 958–960.

Fettig, C.J.; Allen, K.K.; Borys, R.R.; [et al.]. 2006. Effectiveness of bifenthrin (Onyx) and carbaryl (Sevin SL) for protecting individual, high-value conifers from bark beetle attack (Coleoptera: Curculionidae: Scolytinae) in the Western United States. Journal of Economic Entomology. 99:1691–1698.

Fettig, C.J.; Hayes, C.J.; McKelvey, S.R.; [et al.]. 2011. Laboratory assays of select candidate insecticides for control of *Dendroctonus ponderosae*. Pest Management Science. 67: 548–555.

Fettig, C.J.; Grosman, D.M.; Munson, A.S. 2013. Advances in insecticide tools and tactics for protecting conifers from bark beetle attack in the Western United States. In: Trdan, S., ed. Insecticides—Development of safer and more effective technologies. Rijeka, Croatia: InTech: 472–492. https://www.fs.usda.gov/treesearch/pubs/44852

Furniss, M.M.; Baker, B.H.; Hostetler, B.B. 1976. Aggregation of spruce beetles (Coleoptera) to seudenol and repression of attraction by methylcyclohexenone in Alaska. Canadian Entomologist. 108: 1297–1302.

Gray, D.R.; Holsten, E.; Pascuzzo, M. 1990. Effects of semiochemical baiting on the attractiveness of felled and unfelled lethal trap trees for spruce beetle, *Dendroctonus rufipennis* (Kirby) (Coleoptera: Scolytidae), management in areas of high and low beetle populations. Canadian Entomologist. 122: 373–379.

Gillette, N.E.; Mehmel, C.J.; Mori, S.R.; [et al.]. 2012. The push-pull tactic for mitigation of mountain pine beetle (Coleoptera: Curculionidae) damage in lodgepole and whitebark pines. Environmental Entomology. 41:1575–1586.

Hansen, M.E.; Munson, A.S.; Blackford, D.C. [et al.] 2017. 3-Methylcyclohex-2-en-1-one for area and individual tree protection against spruce beetle (Coleoptera: Curculionidae: Scolytinae) attack in the southern Rocky Mountains. Journal of Economic Entomology. 110: 2140–2148.

Hansen, E.M.; Munson, A.S.; Blackford, D.C.; [et al.]. 2016. Lethal trap trees and semiochemical repellents as area host protection strategies for spruce beetle (Coleoptera: Curculionidae, Scolytinae) in Utah. Journal of Economic Entomology. 109: 2137–2144.

Hansen, E.M.; Vandygriff, J.C.; Cain, R.J.; [et al.]. 2006. Comparison of naturally and synthetically baited spruce beetle trapping systems in the central Rocky Mountains. Journal of Economic Entomology 99: 373–382.

Jenkins, M.J.; Hebertson, E.G.; Munson, A.S. 2014. Spruce beetle biology, ecology and management in the Rocky Mountains: An addendum to Spruce Beetle in the Rockies. Forests. 5: 21-71.

Lindgren, B.S.; McGregor, M.D.; Oakes, R.D.; [et al.]. 1989. Suppression of spruce beetle attacks by MCH released from bubble caps. Western Journal of Applied Forestry. 4: 49–52.

Lister, C.K.; Schmid, J.M.; Minnemeyer; C.D.; [et al.]. 1976. Refinement of the lethal trap tree method for spruce beetle control. Journal of Economic Entomology. 69: 415–418.

Massey, C.L.; Wygant, N.D. 1954. Biology and control of the Engelmann spruce beetle in Colorado. Circular 944. Washington, DC: U.S. Department of Agriculture, Forest Service. 35 p.

Mitchell, J.C.; Schmid, J.M. 1973. Spruce beetle: Mortality from solar heat in cull logs of Engelmann spruce. Journal of Economic Entomology. 66: 401–403.

Munson, S. 2010. Management guide for spruce beetle. Washington, DC: U.S. Department of Agriculture, Forest Service, Forest Health Protection. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5187555.pdf [last accessed April 2018].

Nagel, R.H.; McComb, D.; Knight, F.B. 1957. Trap tree method for controlling the Engelmann spruce beetle in Colorado. Journal of Forestry. 55: 894–898.

Progar, R.A.; Gillette, N.; Fettig, C.J.; [et al.]. 2014. Applied chemical ecology of the mountain pine beetle. Forest Science. 60: 414–433.

Ross, D.W.; Daterman, G.E.; Munson, A.S. 2004. Evaluation of the antiaggregation pheromone, 3-methylcyclohex-2-en-1-one (MCH), to protect live spruce from spruce beetle (Coleoptera: Scolytidae) infestation in southern Utah. Journal of the Entomological Society of British Columbia. 101: 145–146.

Schmid, J.M.; Frye, R.H. 1977. Spruce beetle in the Rockies. Gen. Tech. Rep. RM-GTR-49. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 38 p.

To learn more about RMRS publications or to search our online titles:

www.fs.fed.us/rm/publications

www.treesearch.fs.fed.us