EVALUATION OF FIREWOOD BAGGING AND VACUUM TREATMENT FOR REGULATORY CONTROL OF EMERALD ASH BORER

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ABSTRACT

Since its discovery in Detroit, Michigan, in 2002, the emerald ash borer, *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), has caused extensive mortality of ash (*Fraxinus* spp.) as it has spread across southeast Michigan, Ohio, and Ontario, Canada (Haack et al. 2002, Poland and McCullough 2006). In addition to this core infested area, numerous outlier populations have been found throughout Michigan's Lower Peninsula, Ohio, Indiana, and Ontario, Canada, as well as isolated infestations in Maryland, Illinois, Pennsylvania, and West Virginia. Spread of *A. planipennis* is a result of natural dispersal and human-assisted movement of infested materials, including movement of ash nursery stock, logs, and firewood. *Agrilus planipennis* can survive and emerge from logs cut from infested trees; therefore, movement of ash logs from infested to uninfested counties is regulated by a federal quarantine (USDA APHIS 2003). In the case of firewood, all hardwood species are regulated because inspectors cannot easily identify the species of tree that was cut. Nevertheless, *A. planipennis* has continued to spread, and new outlier infestations, possibly due to human-assisted movement of infested material prior to enactment of the quarantine, have been detected each year.

Movement of firewood is extremely difficult to regulate and enforce. Unlike nursery trees and wood products that are produced and moved by licensed businesses, firewood is often moved by the general public. Despite extensive outreach efforts, many individuals are unaware of regulations prohibiting movement of firewood from infested areas. It is estimated that, of outlying infestations in Michigan with known origins, approximately 80% originated

in campgrounds, state parks, lakes and recreational areas, or cottage communities, suggesting they were the result of firewood movement. In order to prevent the spread of *A. planipennis* through movement of firewood, state regulatory and natural resource agencies are enforcing quarantine regulations by conducting inspections for firewood at campgrounds, rest areas, and key transportation gateways. Guidelines for treating and certifying wood to allow safe movement and for storage and handling of confiscated firewood are urgently needed to prevent new establishments of *A. planipennis.* We evaluated two regulatory treatments for infested logs: 1) bagging firewood to prevent emergence and escape of *A. planipennis*, and 2) vacuum treatment to kill *A. planipennis* inside infested wood and logs.

We conducted two experiments to evaluate the efficacy of bagging firewood to prevent emergence of *A. planipennis*. In the first experiment, 30 infested logs were randomly assigned to one of three treatments: 1) unbagged control logs placed in horizontal rearing tubes, 2) logs sealed inside two plastic bags and then placed in horizontal rearing tubes, and 3) logs sealed inside two plastic bags and then placed in vertical rearing cans. For the second experiment, 16 infested logs were randomly assigned to one of two treatments: 1) unbagged control logs in horizontal rearing tubes, or 2) logs that were sealed inside two plastic bags and held in the open on a bench top in the laboratory. Plastic bags used were clear, 24 × 48-inch, 4-ml-thick poly bags (BrownCor, Milwaukee, Wisconsin). For both experiments, logs were held in the laboratory and checked every other day for emerging adults. The bagged logs were examined by carefully inspecting the bag for holes and looking through the transparent bag wall to note any beetles inside.

Once beetle emergence was complete (i.e., no new beetles were collected for six days), the experiments were ended and the results noted. Logs were removed from their rearing containers and/or bags. All dead adults found inside the rearing containers and bags were tallied. The number of new emergence holes on each log was also tallied. A subset of logs were dissected to determine the number of dead adults and larvae that remained inside (N = 4 replicates for Experiment 1, and N = 2 replicates for Experiment 2). In both experiments, several new emergence holes were found and many live *A. planipennis* adults emerged from the control logs; however, no adults escaped from the double-bagged logs.

There were no significant differences among treatments in log length, log diameter, number of exit holes at the start, number of new exit holes at the end, and number of dead adults and larvae found inside the logs at the end of the experiment. All of the *A. planipennis* that emerged from the unbagged control logs were collected live in the rearing tube or collection jar, whereas all of the *A. planipennis* that emerged from the double-bagged logs held in rearing tubes, rearing cans, or in the open on laboratory benches were found dead in the bags by the end of the experiment. There was no evidence of beetles attempting to chew through the inner or outer bags.

We evaluated vacuum treatment for efficacy in killing *A. planipennis* larvae either exposed or inserted into wood. Exposed larvae were placed individually in open Petri dishes inside the vacuum oven. Ten larvae were treated in the vacuum oven at a time and all larvae were weighed before and after treatment. One larva from each treatment group was placed on the load cell of an analytical balance inside the vacuum oven that was connected to a datalogger and recorded weight every 5 seconds. Larvae were subjected to different temperatures and pressures to determine desiccation rates and lethal percentage weight loss. Some *A. planipennis* larvae died at 26% weight loss, and all were dead at approximately 40% weight loss, the latter of which required at least 15 hours at 20 mmHg and 20° C. The desiccation rate of *A. planipennis* larvae under vacuum at 20 mmHg and 20° C was 2.395% weight loss per hour.

Temperature, pressure, and relative humidity affected desiccation rate. Larvae desiccated slower at cold temperatures; no larvae had died after 36 hours of vacuum treatment at -10° C and 20 mmHg, and weight loss was approximately 5%. Desiccation and mortality were also lower for larvae when inserted into blocks of wood (10 cm wide by 10 cm long by 2.5 cm thick) made from 5.1 cm × 10.2 cm (2" × 4") Douglas fir lumber with a moisture content of 16.6%. After 28 hours of vacuum treatment at 20 mmHg and 20° C, mortality of larvae inside wooden blocks was only 13% and weight loss was only 26%. We also evaluated vacuum treatment of naturally-infested logs with greater than 30% moisture content. Infested logs were approximately 15 cm in diameter and 60 cm long. For each replicate, five infested logs were placed inside a vacuum treatment bag at 20 mmHg and 20° C, and one log was held in the laboratory at ambient conditions. The experiment was replicated four times. Logs were checked every day, and a small area was dissected to determine if larvae inside were dead or alive. If a live larva was found, the logs were returned to the vacuum bag for continued treatment.

After 10 days, the treatment was ended, and all logs were completely dissected to determine the total number of live and dead larvae remaining. After 10 days of vacuum treatment, mortality of *A. planipennis* larvae inside the logs was greater than 98%. The final moisture content of logs following treatment was 18.7%. The conclusion was that at least 10 days of vacuum treatment would be required to kill *A. planipennis* in infested logs.

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