USDA FOREST SERVICE NORTHERN RESEARCH STATION

Research Review

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Emerald Ash Borer: Control May Be on the Horizon

A tiny, brilliant green wood-boring beetle—the emerald ash borer (EAB), *Agrilus planipennis,* has become a substantial threat to the existence of ash species growing in the Northeast, Midwest, and eventually the South as well. Ash trees infested with larvae of the EAB usually die within 3 years. The non-native EAB was first detected in Detroit, MI, and Windsor, Ontario, and has since been found at sites throughout Michigan (2002), Ohio (2003), and Indiana (2004). It has also been found at isolated sites in Michigan's Upper Peninsula (2002), Illinois (2006), Maryland and Virginia (2003), and most recently in Pennsylvania and West Virginia (2007). Movement of ash logs is quarantined in infested counties in the United States and Canada. State and federal officials have been working to slow down or contain the infestations, hoping to give scientists time to develop an effective treatment or find natural enemies for controlling the EAB. Forest health officials in states bordering the infested areas are preparing for the inevitable and eventual discovery of EAB in their area.

ASH TREES ARE A VALUABLE COMPONENT OF URBAN, RURAL, AND NATURAL FORESTS

Ash trees are found in streetscapes and suburban yards as well as in rural woodlots, along fence rows, and in forests. They are an important component of urban forests, having been extensively planted as replacements for trees killed by Dutch elm disease and the gypsy moth. So now, sadly, many homeowners may find themselves suddenly deforested, again.

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Debbie Miller, USFS

The ecological and economic impacts of EAB on urban areas, ash resources, and forest biodiversity in North America could be profound.

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Ashes also are valued as timber trees, especially coveted for tool handles, baseball bats, snowshoes, furniture, cabinetry, and flooring; black ash is the basis for Native American basket crafts. In the eastern United States, a net annual volume of 300 million board feet of ash sawtimber is harvested, forming the basis of a $115 million industry.

There are six species of ash in eastern North American—white, *Fraxinus americana;* black, *F. nigra;* green, *F. pennsylvanica;* blue, *F. quadrangula;* water, *F. caroliniana;* and pumpkin, *F. profunda*. Each species is adapted to slightly different habitats, making members of the genus important components of many different rural and natural forests. They have been heavily planted in shelterbelts and supply browse and thermal cover for deer and moose, as well as bark and seeds for food and cavity-nesting habitat for birds.

The Forest Service's Forest Inventory and Analysis Program estimates that there are about 80 billion ash trees on U.S. timberlands. The USDA Animal and Plant Health Inspection Service (APHIS) has predicted that the establishment of EAB nationally would result in the loss of 30 to 90 million trees in urban forests—equivalent to 2 percent of total leaf area and valued at $20 to 60 billion. In addition, local governments and homeowners will be faced with the costs of removing dead trees and replacing them. The Forest Service estimates that these costs could reach about $7 billion (present dollars) over the next 25 years. At present, managers estimate that EAB has killed about 25 million trees in Michigan alone, only a fraction of the more than 800 million ash trees in Michigan timberlands. The area of land infested with EAB now measures more than 100,000 km^2 in Michigan, Indiana, Ohio, and Ontario, Canada.

The EAB has been particularly troublesome to manage because of lack of effective monitoring and treatment options. In addition, it attacks seemingly healthy trees. To date, no sex pheromones have been discovered for EAB, thus pheromone traps, like those used to survey for or control many other insects (the gypsy moth, for example), are not effective. Options for widespread treatment (aerial sprays with environmentally acceptable products such as *Bacillus thuringiensis,* or *Bt)* are not available at present. The currently strategy for eradicating isolated infestations of EAB is removal and destruction (by chipping and burning) of infested trees. Unfortunately, many eradication cuts have not been successful because of the difficulty in detecting EAB and delimiting the entire area that should be cut. Although most infested trees are found very near to the point of EAB introduction, the actual dispersal capability of EAB and true distribution of the beetle may be considerably greater. EAB has been found to be an obligate migrant and females carrying fertilized eggs flew as much as 2.8 km/day and as far as 9.8 km in 4 days in laboratory studies. In addition to this natural dispersal, human-assisted movement of infested firewood, timber, and nursery stock has greatly extended and accelerated the movement of the beetle. Furthermore, quarantine regulations and educational campaigns haven't always worked— the infestations in Maryland and Virginia resulted from (illegal) shipping of infested nursery stock.

NORTHERN RESEARCH STATION SCIENTISTS SEARCHING FOR EFFECTIVE TREATMENTS

Forest Service entomologists at the Northern Research Station's (NRS) laboratory in East Lansing, MI—Therese Poland, Leah Bauer, and Robert Haack, along with their colleagues at Michigan State University (MSU), APHIS, and the Canadian Forest Service—have been deeply involved since the discovery of EAB in the United States in studying its biology and population dynamics. Poland has helped to develop trapping methods using volatile chemicals emitted by ash bark and leaves, which may greatly improve detection, monitoring, and control efforts. Bauer has studied several natural enemies of the EAB in its native range in China, where it is only a minor pest, and has released two species of tiny parasitic wasps for field tests this summer. Haack's current work supports national and international efforts on improving the detection rate of non-native insect species in cargo inspections at seaports and land border crossings.

BETTER WAYS TO MONITOR EAB POPULATIONS

In early work on the basic biology of the EAB, Poland led a team of NRS, MSU, and Canadian Forest Service scientists that developed trapping and detection techniques. These have been used to establish quarantine boundaries and implement eradication and control measures. They discovered that ash trees stressed by girdling (removing all the bark in a band around the trunk) were about 10 times more attractive to EAB than were healthy ash trees, leading to the use of girdled trap trees for survey programs. They identified potential attractive chemicals from healthy and stressed ash trees using gas-chromatographic electro-antennal detection. They discovered that trees stressed by girdling or insect feeding emitted higher levels of certain volatile compounds compared to healthy trees and that EAB antennae responded to more than 20 such compounds. In field experiments, traps baited with blends of ash leaf volatiles captured significantly more EAB than

This trap in the latest design not only trapped EABs, it did so in an area where none had previously been found.
Deb McCullough, Michigan State University

did unbaited traps. They developed a multi-component trap that incorporates all of the known attractive stimuli for EAB, including visual silhouette, color (APHIS scientists have found that EAB prefer purple!), texture, and leaf and bark odors. These traps were field-tested in places with known populations and also in places where EAB had not previously been found. EAB were collected in these traps in both situations, indicating that these traps can be a successful tool.

EAB CONTROL USING NATURAL ENEMIES

In collaborative studies with scientists from MSU, Bauer has determined that few natural enemies attack EAB in Michigan. Working together with scientists in China, she has studied several EAB populations and their natural enemy complexes and they have discovered two new species of tiny endoparasitic wasps that kill EAB life stages: *Tetrastichus planipennisi* (attacks larvae) and *Oobius agrili* (attacks eggs). In Jilin Province of China, where their ranges overlap in an ash forest, these wasps together reduced EAB populations by 74 percent. These parasitoids have been brought to the quarantine laboratory at MSU, where Bauer and her co-workers studied their biology, developed laboratory rearing and storage methods, and determined host specificities for both species. Now, in 2007, APHIS approved the release of these parasitoids, and 2,000 of each species were released in selected Michigan research sites to evaluate establishment, monitor spread rates, and determine effects on EAB population dynamics and ash survival. These parasitoids have been found to be host-specific to EAB and are extremely tiny (maximum adult size of *Tetrasticus* = 5 mm, of *Oobius* = 0.9 mm) and do not interact with humans and other mammals. APHIS itself is also testing a third wasp parasitoid of EAB. Next spring NRS scientists will begin surveys to determine if these insects have become established.

NRS scientists also are studying the potential use of insect pathogens for management of EAB. Host-specific pathogens found infecting EAB in China may also prove useful as biocontrol agents. These could be released to infect wild EAB populations, possibly resulting in population crash (epizootic) or decline (enzootic). BotaniGard®, a microbial insecticide formulated with the insect-pathogenic fungus *Beauveria bassiana* GHA, also is being tested for suppression of EAB populations. This research began in 2002, when the importance of fungal pathogens as natural enemies of EAB in Michigan was discovered. Expanded field trials were initiated in 2006 in collaboration with scientists from U.S. Department of Agriculture, Agricultural Research Service (ARS) and Cornell University (Ithaca, NY). Research on a *Bt*–based microbial insecticide that would target adult EAB via aerial application currently is being developed.

HOW CAN WE SLOW THE ARRIVAL OF PESTS LIKE THESE?

NRS researcher Robert Haack currently is participating in several international efforts such as the International Forestry Quarantine Research Group, which focuses on methods to reduce the number of tree pests associated with wood packing materials used in international trade.

Although we have not yet discovered a magic bullet for eradicating the emerald ash borer, several approaches are showing promise.

Adult Emerald Ash Borer
Debbie Miller, USFS

Forest insect pests, especially non-native species, can have tremendous negative impacts on tree health and related forest industries. When new non-native insects are first detected, the USDA often imposes a federal quarantine in an attempt to stop human-assisted movement of the pest. Currently, there are federal quarantines for three recently discovered non-native borers in the United States: Asian longhorned beetle, emerald ash borer, and pine shoot beetle. Research on newly discovered exotic forest insects is important to ensure that quarantines are biologically sound and minimize economic impacts. In addition, research on risk assessments and treatments of wood packing materials is important to reduce the risk of new pest introductions worldwide.

Haack currently is analyzing wood packing material as a pathway for international movement of bark- and wood-associated insects and methods to lessen this threat. In addition, he is initiating projects to determine the most outbreak-prone forest insects in countries that are currently our major trading partners, such as Brazil, China, and India; and to prepare a list of major forest insect pests that have affected North American trees when planted in foreign countries. He also is serving as a technical editor for the English version of the book "Forest Insects of China."

ECOLOGICAL AND ECONOMIC RESEARCH

In addition to work by NRS entomologists, other NRS scientists have been involved in studying EAB effects. Cooperating scientists from Ohio State University along with NRS scientists from Delaware, OH and Morgantown, WV, studied 31 forest stands in southeastern Michigan to determine if any site factors influence EAB invasion and how EAB-induced ash mortality influences forest composition and succession. They found that only the distance from the EAB invasion center had any effect, meaning that it is only a matter of time until other stands suffer complete ash mortality. Matthew Bumgardner, an NRS forest products technology researcher in Delaware, OH, surveyed 200 Ohio communities to provide baseline data on ash density and the possible costs of ash replacement and removal.

Green ash killed by EAB showing D-shaped exit holes.
David Roberts, MSU

Biographies

Dr. Robert A. Haack (above left) received his bachelor of science in forestry (1974) and master of science in entomology (1980) from the University of Wisconsin and his Ph.D. in entomology (1984) from the University of Florida, Gainesville. He then worked as a post-doc at Michigan Sate University before beginning his Forest Service career in 1986 as a research entomologist. He has worked almost exclusively on non-native forest pests since 1992.

Dr. Therese Poland (above center) has worked as a research entomologist with the U.S. Forest Service in East Lansing, MI, since 1997 and served as project leader from 2005 to 2007. She received her master's degree in pest management (1993) and doctoral degree (1997) from Simon Fraser University in Burnaby, British Columbia. She has worked on biology, management, and regulatory issues related to invasive forest insects, including the pine shoot beetle, Asian longhorned beetle, and emerald ash borer.

Dr. Leah S. Bauer (above right) received her bachelor of science in natural resources from the University of Michigan (1974), her master of science in entomology from the University of Maine (1977), and a Ph.D. in entomology from the University of Kentucky (1987). She began working for Forest Service Research in 1979 and as a research entomologist in 1982, with an emphasis on insect pathology and, more recently, with biological control of insects. She has worked on several invasive forest insects, including gypsy moth, Asian longhorned beetle, and emerald ash borer.

IN CLOSING

Urban foresters, conservationists, naturalists, ecologists, baseball players and bat manufacturers, basket weavers, and all those who love trees and recall what happened to the American chestnut and the American elm can only hope that the efforts of NRS scientists and their colleagues to detect and manage the emerald ash borer will enable ash species to survive in North America. The EAB is a frightening pest at the moment, but hopefully the natural enemies currently being tested will help to keep population levels of EAB under some degree of control. Work is under way to collect and store ash seeds in several seed banks and to understand mechanisms of resistance of Asian ash species in order to develop resistant varieties for possible restoration activities. ■

Web References and Resources

www.stopthebeetle.info
www.emeraldashborer.info

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www.invasive.org/browse/subject.cfm?sub=7171
www.inspection.gc.ca/english/plaveg/pestrava/agrpla/agrplae.shtml

Proper ash seed harvest methods from the FS National Seed Lab and good pictures for distinguishing major ash species (PowerPoint):

www.nsl.fs.fed.us/

Ash genus *(Fraxinus)* facts on preliminary website for Woody Plant Seed Manual:

www.nsl.fs.fed.us/nsl_fsstc.html
www.invasivespeciesinfo.gov/animals/eab.shtml

Contact the Northern Research Station:
www.nrs.fs.fed.us

Michael T. Rains
Station Director
11 Campus Boulevard #200
Newtown Square, PA 19073

610-577-4017
mrains@fs.fed.us

Rebecca G. Nisley
Newsletter Editor

203-230-4338
rnisley@fs.fed.us

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Our research themes are (1) Managing Forests with Disturbance, (2) Urban Natural Resources Stewardship, (3) Sustaining Forests, (4) Providing Clean Air and Water, and (5) Natural Resources Inventory and Monitoring.

There are 157 NRS scientists working at 20 field offices, 22 experimental forests, and universities located across 20 states, from Maine to Maryland, Missouri to Minnesota.

Northern
RESEARCH STATION
USDA Forest Service

11 Campus Boulevard, Suite 200
Newtown Square, PA 19073