Natural Resources Canada | Ressources naturelles Canada

Frontline

Forestry Research Applications

Canadian Forest Service - Sault Ste. Marie | Technical Note No. 110

Emerald Ash Borer

The Emerald Ash Borer (*Agrilus planipennis* Fairmaire) is a highly destructive invasive pest that arrived from Asia, most likely in untreated ash wood used for packing material. In Canada it was first detected in 2002 in Windsor, Ontario; by the summer of 2009 it was found as far north as Sault Ste. Marie, Ontario and as far east as Montreal in Québec. The rapid spread of Emerald Ash Borer (EAB) has been hastened by the inadvertent human transport of beetle-contaminated firewood and other infested ash materials. The Canadian Food Inspection Agency (CFIA), under the authority of the Plant Protection Act, has since put regulatory measures in place to restrict the movement of any ash tree materials from infested areas. In addition, the Canadian Forest Service (CFS) has helped develop new international standards for the treatment of wood packing material so that any unwanted pests are destroyed in the country of origin, before they can be inadvertently transported to another continent. The impacts of EAB however have been, and will continue to be, ecologically and financially devastating as the insect spreads.

Adult emerald ash borer

EAB has already killed millions of trees in North America and may have a significant impact on the continent's remaining ash trees. All species of ash are susceptible, including exotic and native species, and the insect can kill healthy trees. Many communities have been hard hit by the arrival of EAB in North America, where ash trees have been widely planted due to their tolerance of urban conditions. The hardwood forest industry and private woodlot owners face significant economic losses, as green and white ash are important species used in the manufacture of products such as cabinetry and sporting goods. First Nations people will also be impacted if the black ash they use to make traditional baskets is not available. Economists at the Great Lakes Forestry Centre (GLFC) in Sault Ste. Marie, Ontario are working on computer modelling tools that will help estimate the value of losses.

D-shaped exit holes where the adult EAB have emerged

S-shaped tunnels where the larvae have been feeding

New shoots that sprout from the trunk are a possible sign of EAB infestation

Recognition

Adult EAB beetles lay eggs in bark crevices and under bark scales in early summer and newly emerged larvae burrow into the tree to begin feeding between the bark and the wood. The larvae can be found along the entire length of the tree's trunk and on branches more than 2 cm in diameter. An EAB infestation can be suspected if the crown of an ash tree has dead branches or discoloured foliage which can be observed during late summer, after the larvae have fed underneath the bark and cut off the flow of nutrients to these portions of the tree. Once branches in the crown start to die, it is likely that the tree is already heavily infested and will probably be killed within a few years. Close examination of the bark may reveal small D-shaped holes created where the adult beetles have emerged, which they do in spring or early summer. If the bark is peeled back, characteristic S-shaped tunnels may be visible, where the larvae have been feeding. Other possible signs of infestation include heavy woodpecker feeding on the tree trunk, discolored bark, and new shoots that sprout from the trunk or roots.

Canada

GREAT LAKES FORESTRY CENTRE RESEARCH

GLFC scientists have been studying many aspects of the EAB, including biology, improved detection methods, and possible control options, in an attempt to mitigate further ecological and economic losses. These scientists have contributed to the development of guiding principles for managing EAB and continue to provide advice to regulatory agencies, such as the CFIA. The research program continues to evolve to ensure that the most pressing needs are addressed, and to involve collaboration with other scientists and research agencies throughout Canada and the USA.

Part I. Survey and Detection

Surveying

Following the 2002 discovery of EAB in North America, forest health monitoring confirmed that the beetle was actually well established in the Detroit and Windsor areas and had likely arrived and established populations in the area over a 10 year period without having been detected. Scientists from GLFC, such as Barry Lyons, continue to refine sampling methods , and have since assisted the CFIA develop appropriate survey techniques, and have published two guides.

The fact that EAB went undetected in North America for close to a decade is attributable to the fact that low density populations are very difficult to detect, and can spread before resource managers even know the beetle is present. This challenge has been fully recognized by GLFC scientists, with considerable research being focussed on enhancing survey and detection methods. Standard visual inspections of a tree's crown and trunk are a first step to confirming the presence of EAB. A study led by GLFC scientist Krista Ryall found that one fifth (20%) of trees inspected visually in an EAB infested area appeared to have signs of infestation, while removing bark from branch samples of the same trees demonstrated that close to 80% of the sampled trees were actually infested. The ability to detect very low EAB populations will provide forest managers with lead time to make informed decisions to better manage EAB outbreaks. The probability of detection with this method is being tested in cities throughout Ontario. This method can also be used in combination with other tools, such as trapping.

Trapping

Another important tool for detecting insect pest infestations and monitoring population levels is the use of sticky traps baited with a lure to capture insects as they fly between trees. GLFC scientists Gary Grant, Krista Ryall and Barry Lyons have been studying the role of pheromones (chemicals secreted by the EAB to attract a mate) and ash volatiles (chemicals emitted by the ash tree's bark and leaves), and how they can best be used in developing an effective lure to facilitate the detection of EAB. Although trapping experiments using EAB pheromones have not yielded high adult capture rates, the use of ash volatiles, particularly the green leaf volatiles, have proven to be highly effective at catching adult EAB. These volatiles show more promise for broader use because they can be readily synthesized in the laboratory. GLFC scientists have also investigated the potential of using the exotic natural product Manuka oil (a tree extract from New Zealand similar to tea tree oil) as a lure for the traps, because it contains some of the same compounds as those produced by the bark of stressed ash and is relatively inexpensive and available.

The colour of the trap is also an important factor, since EAB relies on both visual and chemical cues. Purple traps simulate colours reflected from the bark of trees, where the insects are attracted for mating and laying eggs, while green traps simulate colours emitted by the tree leaves, where the insects move to feed.

Sampling a green prism trap

Trapping experiments conducted in Sault Ste. Marie and Ottawa, following the confirmation of EAB in these cities, tested different trap types and lures, including Manuka oil-baited purple traps and green leaf volatile–baited green prism traps. These and other recent trials suggest that the most effective trap and lure combination is the light green prism trap baited with (Z)-3-hexenol (a green leaf volatile). These results have contributed to the recommendation for its use in area-wide surveys to detect early infestations of EAB.

Seasonal and climatic observations noted during ongoing EAB trapping experiments are also proving to be valuable in understanding the biology of EAB. For example, in Sault Ste. Marie, beetles were first seen on the traps in early August, after a cool, wet summer, while in southern Ontario beetles have been observed flying in early June. This information may be useful in determining how weather and ultimately climate have an effect on the timing of the insect's life cycle. Numerous observations and trials have led to a greater understanding of many aspects of the life stages of the emerald ash borer.

Part II. Control and Management

EAB presents particular challenges due in large part to the fact that it is an introduced pest and its new ecosystem lacks the predators, parasitoids and pathogens of its own native habitat. Controlling EAB is especially difficult because the insect feeds under the bark of ash trees, and by the time symptoms of damage are seen, the population may be too large to effectively manage.

Natural insecticide: TreeAzin™

TreeAzin™, developed by GLFC scientists in collaboration with BioForest Technologies Inc., is the only product currently available for control of EAB in Canada. It has been shown to be a safe and effective botanical insecticide that is injected into individual trees. The natural insecticide, which is particularly effective when used as a protective measure or on lightly infested trees (up to 30% crown dieback), interrupts larval moulting. It may also be effective in controlling attack by the insect for up to two years. TreeAzin™ contains azadirachtin, a natural product that originates from the Indian neem tree. It is injected into the trunk of ash trees using the Ecoject System®, the design of which is based on the Systemic Tree Injection Tubes (STIT) system developed by retired GLFC scientist Blair Helson. This type of tree injection poses negligible risk to workers and can be used safely in urban areas.

Environmental Fate and Effects of TreeAzin™

Dean Thompson leads a group of scientists at GLFC that works on understanding the environmental fate and effects of potential control agents on non-target organisms. Tests have shown that TreeAzin™ has a very low toxicity to mammals and birds. Various formulations containing azadirachtin have shown low-to-moderate persistence in water, soils, and foliage and do not present a significant risk to the non-target species studied to date. The botanical origin of neem products coupled with their low risk toxicological characteristics make them suitable for use in urban settings and environmentally sensitive areas. Environmental assessment studies continue to be performed, in collaboration with Ontario Ministry of Natural Resources (OMNR) and BioForest Technologies, to determine the path of azadirachtin in the environment after the leaves fall and any possible effects on other non-target aquatic and terrestrial organisms.

Ecoject System® for TreeAzin™ injection

Biological Control Agents

Natural enemies such as predators, parasitoids, and pathogens (e.g., fungi, microsporidia and nematodes) are potential biological control agents. Native natural enemies can sometimes be found in collapsing EAB populations or in association with other closely related native insects such as the bronze birch borer (*Agrilus anxius* Gory). Several parasitoids that attack the larvae of EAB were collected from EAB-infested wood in the quarantine facility at GLFC, where EAB are reared for experimental purposes. These parasitoids will continue to be studied to determine their potential as biological control agents.

GLFC scientists George Kyei-Poku and Kees vanFrankenhuyzen undertook a search for pathogens of EAB and discovered a nematode and several fungi, which are now being studied as potential biocontrol agents. Biocontrol agents may eventually provide long-term emerald ash borer control; however, they are still in the early stages of development.

Other Possible Approaches to Control

Daniel Doucet is leading a team that is studying the mechanisms of olfaction, or how EAB detects chemicals, at the molecular level. Doucet's team has succeeded in identifying genes expressed in male and female emerald ash borer antennae. These findings will help guide researchers to determine how EAB beetles decode odour cues used to find a mate. This information may be useful in the development of better EAB traps or in the development of ecologically sound pest management strategies based on olfaction, such as mating disruption (blanketing an area with high levels of pheromone to disrupt mate finding) or other methods that block the ability of EAB to locate ash trees.

Part III. Modelling of economic impacts

GLFC modellers Dan McKenney, Denys Yemshanov, John Pedlar and others have been developing models that can be used as tools to better understand and quantify the effects of invasive pests, including EAB. A long term goal is to provide a broad perspective on the costs of damage and losses caused by invasive alien species and quantify the benefits of control options for decision makers. Significant losses of trees in natural stands and in urban settings have not only economic impacts but also result in lost ecosystem benefits such as carbon uptake, shade provision and wildlife habitat.

Native parasitoid *Phasgonophora sulcata*

Each of the various approaches to controlling invasive species, whether it be prevention, removal of host trees, biological control, or slow-the-spread measures, require some form of expenditure. A cost-benefit analysis can aid decisions about the best way to spend limited budgets as well as help prioritize research efforts. In the case of EAB for example, a significant investment might be warranted to slow the expansion of isolated infestations, because the costs of treatment or tree removal and replacement would be even higher if the insect spread to new areas.

Data Collection

Due to the interest in quantifying potential losses from EAB and other invasive species, economists at GLFC have started collecting and collating various baseline data. One of the first steps is estimating the number, size and species of trees currently established in urban settings; a survey was designed to gather this information. Data sources can include existing tree inventories and new surveys.

Results from the areas surveyed to date show a direct linear relationship between the number of urban trees and the length of road network, which could allow these data to be readily extrapolated to other cities. The proportion of ash trees was relatively consistent for the cities sampled and averaged 6%. In Sault Ste. Marie for example, there are almost 400 km of roads, and the number of ash trees within 10 metres of the road edges is close to 2,500. Such data are being combined with cost estimates of tree removal and replacement to refine models to aid decision making.

Practical Applications

While a model that predicts economic losses from EAB cannot take into account every value, it will be a useful tool in understanding the impacts of this invasive pest and help determine the best course of action in its control. The data will also be useful to other communities and for future models, such as estimating the economic impacts of other invasive alien species. Forest managers and city arborists need accurate information on which to base their management decisions, thus there is a strong desire and need to integrate cost-benefit analyses into these decision-making tools.

FUTURE PLANS

GLFC scientists will continue to provide advice to regulatory agencies and managers on the best strategies for detecting, controlling and mitigating losses from EAB. They will also continue their successful outreach activities, which include programs such as training workshops for pest surveyors. Early detection of new infestations and cost effective survey methods may lead to timely control measures where necessary and thus help slow the spread of this insect.

While high value urban trees can be treated with TreeAzin in the early stages of an infestation, researchers continue to investigate the biology of the insect to seek new ways to better manage outbreaks. These new control methods may disrupt the insect's life cycle or reduce population survival. Environmental testing of control products will ensure they are not harmful to the ecosystem or people. To enhance their research efforts, collaboration will continue with colleagues within federal and provincial agencies, municipalities and universities in Canada and the USA.

Contact information

Barry Lyons
Great Lakes Forestry Centre
1219 Queen Street East
Sault Ste. Marie, Ontario, Canada
P6A 2E5
Phone: 705-949-9461
Fax: 705-541-5700
http://cfs.nrcan.gc.ca/regions/glfc
E-mail: GLFCWeb@nrcan.gc.ca

CFS Publications

de Groot, P.; Biggs, W.D.; Lyons, D.B.; Scarr, T.A.; Czerwinski, E.J.; Evans, H.J.; Ingram, W.A.; Marchant, K. 2006. A visual guide to detecting emerald ash borer damage. Natural Resources Canada, Great Lakes Forestry Centre, Sault Ste. Marie, Ontario, Ontario Ministry of Natural Resources. 16 p.

Lyons, D.B.; Caister, C.; de Groot, P.; Hamilton, B.; Marchant, K.; Scarr, T.A.; Turgeon, J.J. 2007. Survey guide for detection of emerald ash borer. Natural Resources Canada, Great Lakes Forestry Centre, Sault Ste. Marie, Ontario, Canadian Food Inspection Agency. 52 p.

Canadian Forest Service, Great Lakes Forestry Centre
1219 Queen St. East,
Sault Ste. Marie, Ontario, P6A 2E5
(705) 949-9461

Catalogue No. Fo123-1/110E-PDF
ISBN 978-1-100-14923-3
ISSN 1717-6980