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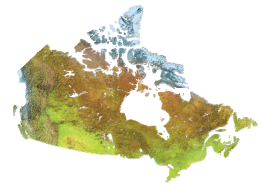

The Great Lakes Forestry Centre (GLFC)

Exposing emerald ash borer to disease may slow its spread

Overview

The emerald ash borer (EAB), a wood boring beetle, is one of the most destructive alien invasive insect pests to have been discovered in North America. It attacks all species of ash trees, and probably arrived on our continent with no parasites to keep its population growth in check. Over the past decade it has killed millions of trees and cost governments and landowners dearly. Researchers at the Great Lakes Forestry Centre (GLFC) are experimenting with fungi and nematodes that occur naturally in Canada to determine if they can be used to slow the spread and reduce the population of this highly destructive insect. Some of these disease-causing organisms are beginning to show up on these beetles, and may hold promise as alternative control agents.

The emerald ash borer (EAB), *Agrilus planipennis* Fairmaire, is a non-native pest that poses a serious threat to ash trees (*Fraxinus* spp.) in North America. It was first found in the summer of 2002 in southeast Michigan, USA and an adjacent area in Ontario, Canada. To date, millions of ash trees have succumbed to EAB in Ontario, Quebec and several states in the USA. EAB is very difficult to control because it spends its destructive larval stages entirely under the bark of the host tree. In Canada, local control measures to date have consisted of the use of a systemic insecticide (TreeAzin for individual treatment of high-value trees), silvicultural practices (tree removal and shredding) and imposed quarantines to restrict movement of infested wood.

Eradication of this invasive pest is no longer a practical option. Slowing the spread of EAB will therefore require a multi-tactic management program. Consequently scientists are seeking large-scale control strategies to manage established populations in the longer term. One promising possibility is a biological control approach using natural pathogens. These disease-causing organisms typically infect only specific species of insects, and thus pose minimal risk to non-target, possibly beneficial, insects in the ecosystem.

Several naturally occurring, indigenous entomopathogens (microbial control agents that are lethally parasitic upon insects) have been discovered on EAB in Canada, and are known to have colonized the insect after its arrival in North America. These organisms are the focus of a research study by Great Lakes Forestry Centre researcher, Dr. George Kyei-Poku.

Kyei-Poku has been on the hunt for promising fungi and soil-borne nematodes that can kill EAB following infection. His search has taken him to southwestern Ontario near the cities of Sarnia, Windsor and London. Given the rapid spread of EAB north and east from these cities, candidate organisms must be capable of tolerating climatic conditions harsher than those from where they originated. In addition, the organisms must be suited to large scale laboratory production to be useful as biological control agents.

An indigenous nematode species was found parasitizing EAB in old outbreak sites in Ontario. The nematodes were found living within dead and dried adult and larval EAB underneath the bark of infested and dead ash trees. It is believed that this nematode paralyzes and kills the EAB by injecting either a bacteria or toxic substance. Although this finding is preliminary, the nematode shows high reproductive potential on EAB and artificial media, making it a suitable candidate for mass production and subsequent use as a control agent. The next steps are to conduct other mating tests to better understand the precise mechanism by which this organism kills EAB and other insect species, information that is required to register any new natural product.

Kyei-Poku and his team have also identified four native fungi with the potential to kill EAB. These are common fungi already living in Canadian soils. A first step in examining the potential of these fungi as a large scale control method is to find out how fast they will kill this pest. Spreading these fungi among EAB populations is another huge challenge to be overcome. A method of distribution currently under consideration for fungi is placing the pathogen in traps laden with lures that only attract EAB. The contaminated EAB will fly off from the traps and mate with others, which will in turn contaminate the bodies of those mates, thereby spreading the disease. At a minimum the fungi will kill any EAB that flies into the trap, thus removing huge numbers from the population and reduce their spread into non-infested ash trees.

If successful, this research may lead to the establishment of production facilities to mass-produce the most effective pathogens that can then be safely released into the environment near known EAB infestations.

Assuming tests go well, scientists could be close to a multi-level control for EAB. One method has already proven effective and is in use: injecting a natural insecticide to save high value trees. Thanks to Kyei-Poku's research a second option may soon be available – releasing native fungi and nematodes to kill existing EAB.

For more information on emerald ash borer research please contact Great Lakes Forestry Centre.

Can assisted migration help mitigate climate change impacts on forest resources?

Overview

Assisted migration, the human-assisted movement of organisms outside their traditional geographic range limits, may have potential to help mitigate climate change impacts on forest resources. The role for assisted migration in biodiversity conservation and forest management is subject to debate. While assisted migration has been used in forest management to move seeds and seedlings within the current geographic range of a given species, historically, there are examples of ecological calamities that have accompanied species translocations. Canadian Forest Service scientists at the Great Lakes Forestry Centre are involved with a number of projects related to assisted migration.

Assisted migration refers to the human-assisted movement of organisms outside their traditional geographic range, and has been used in forest management to move seeds and seedlings within the current geographic range of a given species. Given the prospect of rapid climate change over the course of this century, this approach has been suggested as a means to help vulnerable species remain within suitable climate conditions. Climatic conditions play a significant role in species distribution and adaptability. Proponents of assisted migration note that the rapid pace of projected climate change surpasses the natural migration rates of many species – a situation made worse by the high levels of habitat fragmentation in human-impacted landscapes. However, critics point out that these efforts could cause more harm than good; citing the long history of ecological calamities that has accompanied species translocations. This difference of opinion has led to heated debate around the appropriate role, if any, for assisted migration in biodiversity conservation efforts and forest management.

In operational forestry, the concept of assisted migration takes on a distinctly different flavour; here the focus is on moving genetic material (e.g., seeds or seedlings) within the current geographic range of a given timber species to establish productive forests over the course of a cutting rotation (i.e., 40-80 years). Because this does not involve the translocation of species to new locales, and is in fact consistent with long-standing forest improvement practices, there is considerably less contention around the practice of assisted migration in this context. For many major timber species, data from existing provenance trials can be used to help guide decisions around the movement of planting stock. Provenance trials involve planting genetic material from a wide range of populations (or provenances) at a number of test sites (or in common gardens). If well designed, provenance trials can result in data that provides a nearly complete profile of climatic preferences for populations distributed across the geographic range of a species – thus allowing optimal planting stock to be identified for any given planting site under current and/or future climate conditions.

Members of the Landscape Analysis and Applications Section (LAAS) at the Great Lakes Forestry Centre (GLFC) are involved with a number of projects related to assisted migration of trees in the context of a changing climate.

For nearly two decades, a major focus of the section has been the generation of climate surfaces (i.e., maps) for a wide range of climate variables and time steps. This effort has produced climate maps for North America dating back as far as 1900 and, based on output from a number of general circulation models (GCMs), dating forward to the end of the current century. Another major endeavour of the section has involved the generation of a North American plant distribution database, compiled using data from government agencies, non-governmental organizations (NGOs), and the general public. These data have allowed the climate envelopes of more than 3000 plant species to be elucidated and mapped (see http://planthardiness.gc.ca/). An understanding of plant climatic requirements and maps of future climate are fundamental support materials for assisted migration efforts.

Experiments have been established at Pickering, Ontario that explore the potential for: 1) southern hardwood provenances to survive and grow north of their current range, and 2) northern conifer provenances to survive and grow south of their current range. The hardwood plantation consists of a mixture of 6 species (red oak, white oak, bur oak, black walnut, shagbark hickory, and sugar maple) from 3 southern provenances. The conifer plantation includes 3 species (jack pine, black spruce, and white spruce) from 5 northern locations. This work will help to elucidate the potential response of northern provenances to climate change and the extent to which southern provenances can already be successfully moved northward. The hardwood and conifer plantations are 2 and 3 years of age respectively; early measurements indicate relatively high rates of survival, even for the most distant provenances.

Another GLFC contribution to this topic is the Seedwhere computer program, which is designed to help match planting stock to both current and future climate conditions. The program works by calculating a climatic similarity index between the target location (i.e., planting site or seed source) and each grid cell in the study window. Any number of climate variables can be used in the analysis and the final index value ranges between 0 and 1 – with a value of 1 indicating a perfect match in the climate between two locations. Seedwhere has been used extensively for matching seed sources and planting sites under current climate conditions in Ontario and is currently being developed as a web application with expanded capacity to incorporate climate change into seed transfer decisions.

GLFC researchers Isabelle Aubin, Dan McKenney and John Pedlar are part of a Task Group that has been commissioned by the Canadian Council of Forest Ministers (CCFM) to write a report on the state of the knowledge of assisted migration in Canada. This report, and the projects outlined above, illustrates the valuable role that GLFC scientists are playing in helping to contribute to the debate, knowledge and practice around this issue. For more information on assisted migration research please contact Great Lakes Forestry Centre.

Novel technique proving effective for monitoring watershed health

Overview

The development and refinement of sustainable forest management regulations require an understanding of watersheds and the processes that may pose a risk of harm to organisms living in water bodies. In particular, where forest management regulations emphasize the emulation of natural disturbance patterns on the landscape, it is essential to understand whether those regulations will result in watershed impacts beyond the effects of natural disturbance. Dr. Dave Kreutzweiser of the Great Lakes Forestry Centre has been investigating methods for monitoring aquatic ecosystem health in relation to forest disturbances, and has adapted an effective technique for use in boreal forests.

Forested watersheds provide clean water from both surface- and ground-water sources, and contribute to sustaining healthy aquatic ecosystems across forest landscapes. Because of strong ecological linkages between forest water bodies and their surrounding terrestrial watersheds, industrial activities such as logging could affect water quality, aquatic habitats, and biological communities.

To assist in understanding these risks and processes, ecologically relevant indicators of aquatic ecosystem responses to watershed disturbance are required. The Bioindicators of Forest Stream Health project is a collaborative study testing a potential bioindicator that could be used for monitoring the effectiveness of regulations, namely an indicator of forest stream health that combines assessment of ecosystem function with measures of aquatic community structure. It focuses on the decomposition of organic matter (a critical ecosystem process linked to food webs in forest streams) and the associated microbial and aquatic invertebrate communities. The project is being conducted in and near the White River Forest Management Unit in northcentral Ontario.

The objectives of the project, which began in 2009 under the direction of Dr. Dave Kreutzweiser, are to:

- compare riparian (shoreline) and stream habitat characteristics in logged watersheds under current best management practices, burned watersheds to determine natural disturbance patterns, and undisturbed watersheds for baseline conditions;
- apply the bioindicator approach using standardized leaf packs (mesh bags containing leaf material) deployed in streams across the three treatment groups, with a focus on biodiversity of invertebrates and microbes;
- measure dissolved and particulate organic matter inputs to streams and their characteristics across the treatment groups;

- apply a modeling approach to determine which riparian and watershed characteristics across the treatment groups are most associated with in-stream conditions and communities;
- and link to larger projects investigating the role of forests in the recovery of aquatic ecosystems that have been impacted by forest harvesting and other land use activities and how forests can be used for bioremediation.

Work has been underway over the past two field seasons across 28 sites: 10 streams in undisturbed, 12 in logging-disturbed, and 6 in fire-disturbed watersheds. Stream water levels and temperature are being monitored. Water samples for characterization of dissolved oxygen content (DOC), which can be a limiting factor on the growth of aquatic populations, are being collected and sent for analysis by collaborators at Wilfrid Laurier and Trent universities. Riparian and stream habitat surveys have been completed, leaf packs are being deployed, and organic matter deposition in streams is being monitored.

The leaf pack technique involves placing known quantities of natural leaf material in mesh bags on stream beds to mimic natural accumulations of leaf material and monitoring their subsequent colonization and decomposition by aquatic invertebrate and microbial communities. The variety and relative abundance of species found on the leaf packs (a measure of aquatic biodiversity) and the rate of decomposition (a measure of ecological function) are being evaluated as potential bioindicators. The approach has been used previously to assess impacts of other watershed disturbances but has rarely been applied to assess forest management and natural disturbance impacts. Early testing shows it to be a sensitive, efficient and ecologically relevant indicator in this new application. In fact, the leaf pack technique used by Kreutzweiser has recently been adopted by University of British Columbia ecologists, who also found it to be an effective watershed monitoring method in interior B.C.

The bioindicators tested in this three-year study will be used to monitor the effectiveness of new logging regulations, and to influence the continuing development of forest management policies and practices that emulate natural (fire) disturbance in boreal watersheds. The technique could also assess the ecological impacts of insect infestations such as the emerald ash borer, and work has recently begun to investigate this potential application.

The science delivery team consists of the Canadian Forest Service, Laurentian University and the Ministry of Natural Resources. Additional partner organizations are: EACOM Timber Corporation., Wagner Forest Management Inc., Trent University, Wilfrid Laurier University, York University, the Natural Sciences and Engineering Research Council (NSERC), and Vale Inco Ltd.

A Frontline Express bulletin will soon be released outlining this project in greater detail. For more information on Natural Resources Canada’s Great Lakes Forestry Centre research related to bioindicators, please contact Great Lakes Forestry Centre.

International research collaboration, spotlight on the Great Lakes Forestry Centre

Overview

Ground-breaking research is being conducted by staff at the Great Lakes Forestry Centre (GLFC), who are increasing their knowledge and understanding of forest research through collaborative work with international colleagues. In 2010 a number of post-doctoral fellows and graduate students are working with scientists at GLFC to help answer questions and solve problems facing the forest sector and forest-reliant communities in Canada. These include studying the interaction of emerald ash borer (EAB) with bird communities, the effect of fungal pathogens on EAB, and analyzing pesticide residues.

The Great Lakes Forestry Centre (GLFC) has a long history and reputation as a leader in forestry knowledge and research dating back to the mid 1940s. The GLFC, located in Sault Ste Marie, Ontario, is one of five Natural Resources Canada, Canadian Forest Service (CFS) research centres. The success of the Centre has certainly been influenced by constant national and international collaboration with researchers and academics throughout the science community. GLFC is often host to postdoctoral and visiting fellows, graduate students and other visitors on work placements, who are gaining valuable hands-on experience and sharing their knowledge with GLFC staff.

Nineteen years ago a GLFC employee began to coordinate practical training placements for foreign students who were seeking experience in Canadian forest research. The aim of this program is to provide students with practical hands-on experience with Natural Resources Canada experts. At the end of their contract the participants have a better understanding of, and perspective on, forestry in Canada and receive certificates of completion. Over the years students have come from many countries such as India and Brazil and across Europe.

A student from Tours, France recently came to GLFC on a six-month contract to study the impacts of emerald ash borer (EAB) on bird communities in southern Ontario. EAB, originating from Asia, is a highly destructive pest that is a serious threat to ash trees in North America. He also contributed to a database holding information on the relationship between spruce budworm and forest birds. This researcher worked alongside experts in the field and lab; his experiences at GLFC will assist him to achieve his master's degree. Another guest student, who came to GLFC from Brazil to work on her doctorate, successfully completed the experiments required for the completion of her doctoral degree. While she was here, she also did some research on controlling the gypsy moth with the bacteria *Bacillus thuringiensis*, a naturally occurring control microorganism. Another student, from India is researching fungal pathogens that may be effective in controlling EAB.

A visiting researcher who works on pesticide residue analysis in a laboratory in Spain is sharing her knowledge and experience and gaining new skills at GLFC.

The GLFC is benefitting from the wealth of national and international knowledge and experience that has come to the Centre. With this collaboration Canada maintains linkages to the global research community and gains a better understanding of forestry issues. The collaborative nature of the work and the research will facilitate the development of new analytical methods which will benefit the GLFC, the forest community and Canadians alike.

For more information on international collaboration please contact Great Lakes Forestry Centre.

GLFC recent publications

If you would like to order any of the publications listed below, please contact Publications at the following e-mail address: glfc.publications@nrcan.gc.ca

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Parker, W.C.; Pitt, D.G.; Morneault, A.E. 2010. Influence of woody and herbaceous vegetation control on leaf gas exchange, water status, and nutrient relations of eastern white pine (*Pinus strobus* L.) seedlings planted in a central Ontario clearcut. Forest Ecology and Management 260: 2012-2022.

van Frankenhuyzen, K.; Espinasse, S. 2010. Observations on the feeding behaviour of late-instar larvae of *Choristoneura fumiferana*. Canadian Entomologist 142: 388-392.

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Yemshanov, D.; Koch, F.H.; Ben-Haim, Y.; Smith, W.D. 2010. Detection capacity, information gaps and the design of surveillance programs for invasive forest pests. Journal of Environmental Management 91: 2535-2546.

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