ORGANISATION EUROPEENNE ET MEDITERRANEENNE POUR LA PROTECTION DES PLANTES

EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION

Newsletter

of the EPPO Network of experts working on surveillance, monitoring, and control of the Emerald ash borer, *Agrilus planipennis*

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The webpage of the Network:
https://www.eppo.int/RESOURCES/special_projects/agrilus_planipennis_network

Photo of *Agrilus planipennis* above: Courtesy of Eduard Jendek.

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1. Introduction

Welcome to the 5th issue of the Newsletter of the EPPO Network of experts working on surveillance, monitoring, and control of the Emerald ash borer, *Agrilus planipennis*. This Network was established by the European and Mediterranean Plant Protection Organization (EPPO) following the decision made in October 2022 by its Panel on Quarantine Pests for Forestry. The Network was established in association with an EPPO-EU project.

Following the release of the 4th issue of the Newsletter, the Network coordinator received information about exchange of specimens, new conferences, projects, dissertations and publications about *A. planipennis*. This information made it possible to prepare the 5th issue. Once again, the EPPO Secretariat would like to encourage participants to send all relevant information to the Network coordinator (Dmitrii Musolin, dm@eppo.int).

2. The Network is growing

In June 2024, the Network reached a milestone – it has now more than **250 members (subscribers)** from more than **45 countries**. The EPPO Secretariat welcome you all. These numbers indicate a strong interest in the subject. Please encourage your colleagues to join the Network via the link https://forms.office.com/e/7GxvJkS0YT (registered email addresses will not be disclosed).

3. Bulgaria conducted and published Pest Risk Analysis for *Agrilus planipennis*

Bulgaria published a paper entitled 'Analysis of the phytosanitary risk of the pest *Agrilus planipennis* Fairmaire, 1888 for tree species in Bulgaria' (N. Spasov, Risk Assessment Center on Food Chain, Sofia; see the reference and the abstract in Section 13; available online: https://doi.org/10.59496/20241PH3). The document states:

– Bulgaria falls into an area with suitable eco-climatic conditions for establishment, i.e. in case of possible penetration into the country, the risk of establishing *A. planipennis* is high.

– Given the climatic changes in Bulgaria and the trend towards warming in most regions of the country, and the forecast for milder winters in the coming decades, it is assumed that the conditions will be increasingly suitable.

– If established and spread, the pest is likely to cause major ecological losses and impacts, as well as some social effects.

– Long-distance spread will be via human-assisted pathways, and its natural spread will occur, but at a slower rate.

– In the event of the introduction, establishment and spread of *A. planipennis* in the country, it could have a negative impact, especially in the areas where the different species of ash are found, and its destruction or containment will be difficult and expensive, and it is unlikely that it would be successful.

This PRA is available as along with many other PRA documents from all over the world at the EPPO Platform on PRAs.

4. The annual international meeting of the Forest Invasive Species Network for Europe and Central Asia (REUFIS)

FAO and the Regional Centre for Forestry and Rural Development (REFORD) hosted the annual international meeting of the Forest Invasive Species Network for Europe and Central Asia (REUFIS) in Skopje (North Macedonia) on 04-06 June 2024.

The focus of the meeting this year was on invasive species in urban forest areas, exploring how urban greening can facilitate the spread of these pests. The meeting gathered over 60 participants (in person and online) from 15 countries. The three-day event featured panel discussions and country presentations on urban tree species, forest health challenges, and management strategies for invasive species.

At least two presentations provided information on *Agrilus planipennis*:

– Kateryna Davydenko (Ukrainian Research Institute of Forestry & Forest Melioration and Swedish University of Agricultural Science) discussed damage cause to ash stands in Europe by the fungus *Hymenoscyphus fraxineus*, the causal agent of ash dieback),

and

– Dmitrii Musolin (EPPO) gave a talk on invasive pests of woody plants recently added to EPPO Alert, A1 and A2 Lists and introduced the EPPO *Agrilus planipennis* Network.

The organizers of the meeting plan to upload all presentation to the REUFIS website and to the archive.

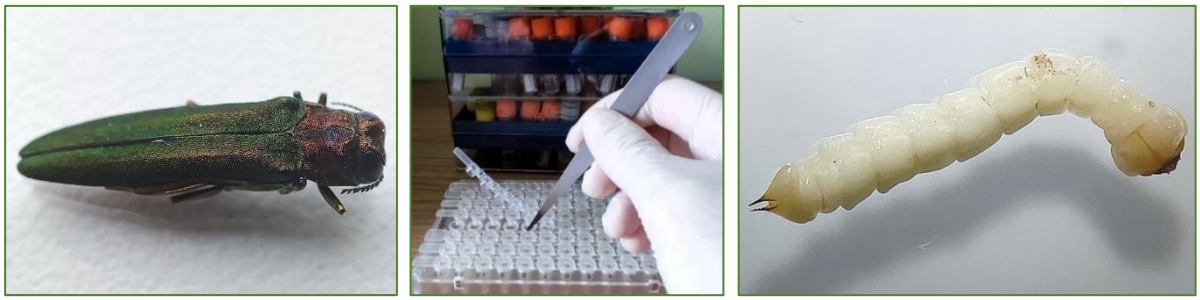
5. Presentations of the Network at other meetings

Photos from the meetings by K. Davydenko (Ukraine, Sweden) and V. Grimault (EPPO).

The activities of the EPPO Network of experts working on surveillance, monitoring, and control of the Emerald ash borer, *Agrilus planipennis* were presented by Dmitrii Musolin at the 26th World Congress of the International Union of Forest Research Organizations (IUFRO) in Stokholm (Sweden, 23-29 June 2024) and by Charlotte Trontin at the 5th Workshop of the EU Reference Laboratory on Insects and Mites in Vienna (Austria, 25 June 2024).

6. A new study on phylogeography of *Agrilus planipennis*

A new study was recently initiated within our Network. Natalia Kirichenko (Sukachev Institute of Forest, SB RAS, and All-Russian Plant Quarantine Center, Russia) and her collaborators are running a phylogeographic research on Emerald ash borer in its secondary range in the European part of Russia. This study will identify invasive haplotypes, which continue to spread in Russia. Furthermore, it will help clarify if the Moscow Region, where *A. planipennis* was recorded for the first time in 2003, served as a main source for further pest expansion through the so-called 'bridgehead effect'. The latter explains the process of an ongoing invasion from an established range to new areas through intermediate locations. Such a phenomenon is often observed in invasive species, particularly insect pests.



Samples of *A. planipennis* prepared for DNA barcoding. Photos by N. Kirichenko.

The study will be based on DNA barcoding of A. planipennis samples stored in institutional and private collections as well as freshly collected specimens in the European part of Russia. To ensure representative sampling in various regions, the team invites other colleagues and volunteers to help collect specimens. This approach, involving citizen science, has become increasingly common in studying biological invasions, particularly to allow coverage of large territories within a single season.

For comparison, specimens of *A. planipennis* from its native range (East Asia, in particular the Russian Far East, China, and Japan) will be included into the analysis. Furthermore, for more comprehensive coverage, the original genetic dataset will be analyzed together with DNA barcodes of the species from its primary and secondary ranges (in Europe and North America), publicly available in genetic platforms such as BOLD (Barcode of Life Data System) and GenBank.

Researchers and volunteers are invited to contribute to the sampling of the Emerald ash borer (larvae, pupae and/or adults of this species) from its native and secondary ranges in Eurasia or share specimens collected previously. For further information, questions or comments, please contact Natalia Kirichenko (nkirichenko@yahoo.com).

7. Exchange of reference specimens of *Agrilus planipennis*

In earlier issues of the Newsletter, members of the Network were invited to share spare reference specimens of *A. planipennis* with colleagues from **NPPOs and/or national reference collections** of the countries where this pest is not present. Since then, Network members from the United Kingdom helped colleagues from Estonia to obtain samples of adults and larvae, and also adults were sent from the EPPO Secretariat to Malta. A few more specimens are available which can be shared with NPPOs and/or national reference collections that need them for their work.

Samples of *A. planipennis* provided by experts from the United Kingdom received by Estonia (left and centre) and Malta (right). Photos by M. Kinkar (left and centre) and D. Vella (right).

Please write to the Network coordinator if you or your colleagues have spare reference specimens which you would be able **to send** to colleagues in other countries or if you need specimens for your national reference collection. **Contact email:** Dmitrii Musolin (dm@eppo.int).

8. *Agrilus planipennis*: the situation in the USA

USDA U.S. Department of Agriculture

Emerald Ash Borer Program Report

A new issue of the USDA's Emerald Ash Borer Program Report Update was issued on 13 March 2024. It states that by March 2024 *A. planipennis* has been recorded in 36 states and the

District of Columbia: Alabama, Arkansas, Colorado, Connecticut, Delaware, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, West Virginia, and Wisconsin.

The Report also includes information on biological control and contains a few updated maps (an interactive infested counties map, a time series spread map, and an ash range map).

The data are available online: the website of the USDA updates and the USDA website.

9. *Agrilus planipennis*: the situation in Canada

Government of Canada Gouvernement du Canada

The Canadian Food Inspection Agency (CFIA) reported on 3 May 2024 that *A. planipennis* was confirmed in Vancouver, British Columbia. The CFIA has put movement restrictions in place to protect Canada's landscape and economy by preventing the spread of Emerald ash borer to non-infested areas of Canada. Effective from April 2024, the movement of all ash material such as logs, branches, and woodchips, and all species of firewood from the affected sites, is restricted. The property owners in the affected area have been notified of these restrictions.

The CFIA is conducting surveillance activities to determine where *A. planipennis* may be present, and is collaborating with the City of Vancouver, the Vancouver Board of Parks and Recreation, the Province of British Columbia, and other stakeholders to respond to the detections and slow the spread of this pest.

10. The first EPPO webinar on *Agrilus planipennis*: 5 December 2024

In October 2023, the EPPO Panel on Quarantine Pests for Forestry agreed to organize, in the framework of the this Network, the first half-day online workshop in a form of webinar. The webinar will focus on the current distribution of *A. planipennis* in the EPPO region, control measures undertaken by the EPPO countries in which this pest is already present, and preparedness of other EPPO counties to possible arrival of this pest in their country in the near future. The webinar is planned for **half a day on 5 December 2024**. For the first

webinar, EPPO invites presentations from NPPOs of the countries in which *A. planipennis* is present (the Russian Federation and Ukraine) and the countries located near the current limits of the distribution of *A. planipennis* in the EPPO region (Belarus, Finland, Estonia, Latvia, and Kazakhstan).

The target groups of the webinar will be NPPOs, contingency planning specialists, pest risk management experts and decision making authorities; however it will be open to all interested participants. The working language of the webinar will be English. We expect a 15-min presentation and plan 5 min for questions/answers per country followed by a general discussion at the end of the webinar.

The programme and all details will be published later in the Newsletter and on the webpage of the Network.

11. New dissertations using *Agrilus planipennis* as a model

Recently, two Bachelor theses and two MSc dissertations, in which *A. planipennis* was used as a model, were prepared and publicly presented in Canada and the USA:

Easton PI (2024). Comparison of *Spathius agrili* vs. *Spathius galinae* host seeking abilities in the context of *Agrilus planipennis* control. A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Honors Bachelor of Science in Wildlife Ecology and Conservation with Distinction. University of Delaware, USA. Available at: https://udspace.udel.edu/items/8f335f3b-8f48-413b-b213-c9c4c049040b

Abstract: *Spathius agrili* Yang (Braconidae) and *Spathius galinae* Belokobylskij (Braconidae) are two larval parasitoid wasps used in biological control to manage emerald ash borer populations, *Agrilus planipennis* Fairmaire (Buprestidae), (hereafter EAB) because of the invasive insect's harmful impact on ash trees across the United States and Canada. According to recent studies, *S. galinae* has had better success in establishing across northern climates in which EAB is most commonly detected. This study is meant to investigate olfactory cues and host selection behavior to potentially determine additional factors that explain why one species has been more successful than the other. Olfactometer assays were conducted with both species in competitive and non-competitive settings. Choice decisions and average run times were recorded and compared between wasps. When given olfactory cues emitted by the host complex, *S. agrili* was more likely to make a choice within the time limit and was quicker on average than *S. galinae* in making several host selection decisions in both competition environments. While these traits do not explain *S. galinae* establishment success, they reaffirm that the parasitoid's success is due to temperature tolerance and host synchronization rather than behavior.

Godin L (2024). Les activités humaines sont-elles un véhicule d'invasion de l'agrile du frêne (*Agrilus planipennis*) en Outaouais? [Are human activities a vehicle for the invasion of the emerald ash borer (*Agrilus planipennis*) in Ottawa?]. A thesis submitted to the Département de biologie, Université d'Ottawa, Canada. Available at: https://mysite.science.uottawa.ca/gblouin/theses/thesis_2024_Godin.pdf

Abstract: Human activities are responsible for several major changes to the environment, including the loss of global biodiversity. The introduction of exotic invasive species due to

cargo transport and is an important cause of biodiversity loss. The Emerald ash borer (*Agrilus planipennis*) is an invasive beetle from Asia that has been decimating ash trees (*Fraxinus*) in forests and urban areas in Canada and the USA for over two decades. Knowing that this insect does not typically travel great distances on its own, I tested the hypothesis that human activities are responsible for the dispersal of the Emerald ash borer in the Outaouais region. I documented the level of infestation of ash trees at 35 sites to calculate an infestation index. I then calculated the human population density in a 2 km radius of each site to assess if population density has an impact on the infestation index of ash trees, but the relationship was not significant. Because measures were put in place to control this invasion in highly urbanized areas, however, the trees that were evaluated were often younger or had multiple trunks which can affect the observed level of infestation in these areas.

Hood J (2024). Emerald ash borer, *Agrilus planipennis*, in Arizona: a management guide and identification key. A professional paper submitted in partial fulfillment of the requirements for the Degree of Master of Forestry. Northern Arizona University, USA. Available at: https://nau.edu/wp-content/uploads/sites/140/2024.HoodEmeraldAshBorerOnline.pdf

Abstract: Emerald ash borer (EAB, *Agrilus planipennis* Fairmaire), an invasive insect, has destroyed millions of ash trees (*Fraxinus* spp.) since its US arrival. EAB habitat in Arizona is relatively limited, as Arizona's climate slows development and establishment in a sizable portion of the state. While relatively small, we found Arizona's ash range to overlap significantly with the suitable EAB habitat. A present ash population with a large crossover in suitable EAB habitat (78.20% overlap) necessitates land managers be knowledgeable to protect Arizona's ash trees. Plenty of past research into EAB management is available for application in Arizona. Prevention is the most cost-effective management option. Among the prevention techniques identified, purple double-decker prism traps baited with (Z)-3-hexanol successfully reduce EAB introduction at low densities. If prevention fails, damage mitigation, rather than EAB eradication, is the most practical strategy. Among the most successful damage mitigation techniques are systemic insecticides (Emamectin benzoate trunk injections) and biological controls (*Spathius galinae*).

Hull C (2024). A valley without ash: exploring strategies for forested wetland restoration post Emerald ash borer invasion in the Willamette Valley, Oregon. A project submitted to Oregon State University in partial fulfillment of the requirements for the degree of Master of Forestry in Forest Ecosystems and Society. Oregon State University, USA. Available at: https://ir.library.oregonstate.edu/concern/graduate_projects/3j333b36w?locale=en

Abstract: Emerald ash borer (EAB) is a non-native wood-boring beetle that specifically targets and kills ash trees. EAB was first detected in the upper Midwestern United States in 2002, and over the following two decades, has reduced native North American ash populations by up to 99%. Oregon ash is the only native ash species to the Pacific Northwest and a major structural component of forested wetland systems in the region. The recent identification of EAB in the northern Willamette Valley raises concerns over the susceptibility of Oregon ash to this insect and over the future ecological status of ash-dominated valley wetlands. An estimated 80% of bottomland forests have been lost in the Willamette Valley (Moss et al. 2022). This number is expected to increase due to Willamette Valley forested wetlands being often completely dominated by Oregon ash (*Fraxinus latifolia*) which are now under threat with the arrival of the emerald ash borer (*Agrilus planipennis*) in Oregon. This capstone investigates the historic and current status of forested wetlands in Oregon's

Willamette Valley to develop a robust state-and-transition model to assess possibilities for management and restoration following widespread invasion of the emerald ash borer.

12. New publications on *Agrilus planipennis*

After the release of the previous Newsletter, information on **16 new publications** on *A. planipennis* and on other relevant species has been received (14 journal papers, a conference abstract, and an assessment report; in addition to the data on new theses and dissertations see in Section 11). The range of topics is very wide and includes the following:

- Novel oviposition trap for studying egg-laying behaviour (Duan, 2024);
- Detection methods of *A. planipennis* (Zhou et al., 2024);
- Spatial distribution pattern in different forest types (Ge et al., 2024);
- Distribution and biology in the Kursk Region, Russia (Klimov, Poluyanov, 2024);
- The state of planted stands of Pennsylvania ash after the invasion (Trofimov, Trofimova, 2024);
- Suitable habitat area analysis and niche assessment (Sheng et al., 2024);
- Modelling the potential range in Europe (Rossi et al., 2024);
- Gene flow of *Fraxinus* and resistance to *A. planipennis* (Abhainn et al., 2024);
- Conservation of genetic diversity in-situ or ex-situ during tree pandemics (George et al., 2024);
- Biological control of *A. planipennis* and parasitoids (Wilson et al., 2024);
- Morphometrics of the parasitoid wasp *Tetrastichus planipennisi* (Christina, 2024);
- Field phenology of parasitoids in New York State (Morris et al., 2024);
- Fungal community in ash trees (Koski et al., 2024);
- PRA for Bulgaria (Spasov, 2024);
- Application of satellite imagery for urban tree species identification (Thapa et al., 2024);
- Major themes in forest invader research and policy (Hudgins et al., 2024);

A reference list and a short summary of each of these publications are given at the end of this Newsletter. Most of the papers are available as full text via the provided links; others may be made available on request to the authors.

13. A closing remark

That is about all for the 5th issue of the Newsletter. The EPPO Secretariat looks forward to receiving your news and publications, links to recently published papers and conference abstracts by you and your colleagues, any other relevant pieces of information and announcements on Emerald ash borer so the Network can distribute them via these Newsletters.

Please inform your colleagues in your country and around the world about the Newsletter. The email for correspondence is dm@eppo.int (Dmitrii Musolin).

14. References received (June 2024; with original abstracts when available)

Abhainn EA, Shirley DL, Stanley RK, Scarpato T, Koch JL, Romero-Severson J (2024) Gene flow from *Fraxinus* cultivars into natural stands of *Fraxinus pennsylvanica* occurs range-wide, is regionally extensive, and is associated with a loss of allele richness. *PLoS One*. 19(5)e0294829. https://doi.org/10.1371/journal.pone.0294829

> In North America, a comparatively small number of *Fraxinus* (ash) cultivars were planted in large numbers in both urban and rural environments across the entire range of *Fraxinus pennsylvanica* Marsh (green ash) over the last 80 years. Undetected cultivar gene flow, if extensive, could significantly lower genetic diversity within populations, suppress differentiation between populations, generate interspecific admixture not driven by long-standing natural processes, and affect the impact of abiotic and biotic threats. In this investigation we generated the first range-wide genetic assessment of *F. pennsylvanica* to detect the extent of cultivar gene flow into natural stands. We used 16 EST-SSR markers to genotype 48 naturally regenerated populations of *F. pennsylvanica* distributed across the native range (1291 trees), 19 *F. pennsylvanica* cultivars, and one *F. americana* L. (white ash) cultivar to detect cultivar propagule dispersal into these populations. We detected first generation cultivar parentage with high confidence in 171 individuals in 34 of the 48 populations and extensive cultivar parentage (23-50%) in eight populations. The incidence of cultivar parentage was negatively associated with allele richness (R2 = 0.151, p = 0.006). The evidence for a locally high frequency of cultivar propagule dispersal and the interspecific admixture in eastern populations will inform *Fraxinus* gene pool conservation strategies and guide the selection of individuals for breeding programs focused on increasing resistance to the emerald ash borer (*Agrilus planipennis* Fairmaire), an existential threat to the *Fraxinus* species of North America.

Christina A (2024) Morphometrics of Emerald ash borer parasitoid wasps. The University of Vermont Student Research Conference 2024. College of Agriculture and Life Sciences. https://scholarworks.uvm.edu/src/2024/completepresentationlist/178/

> Classical biological control can be important for managing invasive species, such as the emerald ash borer (EAB), *Agrilus planipennis*. Emerald ash borer preys on ash tree populations and has had a severe impact on ash tree prevalence, thus increasing ash tree mortality. Although, parasitoids of the emerald ash borer have been found to act as a biological control method for the ash tree-killing pests. In this research study, the morphometrics of EAB parasitoid wasps, *Tetrastichus planipennisi*, were investigated. The parasitoid wasps were reared from the USDA-ARS BIIRU Laboratory and placed in experimental jars, uncovered (control) or covered (treatment), at three plots in the Jericho Research Forest. The individuals in the uncovered/covered jars experienced different photoperiods/ shading, which was hypothesized to influence the growth and development of the wasps. Experimental jars were collected after overwintering and wasps were labeled where they were found, inside or outside of the ash tree log. Wasps were examined using Leica Biosystems imaging software and morphometric values were measured using Image J software. A series of 12 measurements were taken for each wasp (notum length, total body length, right-wing length, right hind tibia length, notum width, right-wing width, pronotum length, pronotum width, ovipositor length, head; right-left, dorsal-ventral, and anterior-posterior). Analysis of variance and TUKEY tests were done using R Studio Software, where the relationship between variables was shown through boxplots and correlation plots. Treatment and control (amount of shading/photoperiod) conditions displayed a significant difference in 9 of the 12 morphometric measurements observed, hence there is evidence that supports the hypothesis of photoperiod influencing the development of EAB parasitoids. There were no differences in morphometric values found for individuals found inside or outside the Ash tree branches, where further investigation and data collection are

needed to properly conclude potential morphometric differences. These findings are a step towards understanding the impact of morphometric differences in *T. planipennisi* and how these differences may influence the species' role as a biological control agent for emerald ash borer populations across the U.S.

Duan JJ (2024) A novel oviposition trap for studying the egg-laying behavior of emerald ash borer. *J Pest Sci* (2024). https://doi.org/10.1007/s10340-024-01770-5

The emerald ash borer (EAB), *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), is one of the most destructive invasive forest pests in North America, where it has killed hundreds of millions of ash (*Fraxinus* spp.) trees since its first detection in 2002. Native to Asia, female EAB adults lay their eggs between bark crevices or under loose bark of their host trees. Because of this cryptic egg-laying behavior, field detection of EAB eggs has been extremely difficult, resulting in knowledge gaps of EAB egg-laying behavior. In the present study, I tested the potential use of strips of burlap fabric (0.03 m × 1 m) or polypropylene curling ribbon (0.005 m × 2 m) to induce female EAB adults to lay eggs on the trunks or branches of ash covered with these materials in the field. The burlap trap tested in this study detected more than twice as many EAB eggs (4.9 ± 1.1 eggs per burlap trap) as did the polypropylene ribbon trap (1.9 ± 0.5 eggs per ribbon trap). When the surface area of each trap is standardized to one square meter, however, both burlap fabric and polypropylene ribbon traps are equally effective in inducing female EAB adults to lay eggs onto the covered surface of ash trunks or branches. Potential applications of the oviposition traps for effective detection and control of EAB and other jewel beetles are discussed.

Ge W, Hu A, Wang D, Xu Z, Liu C, He M, Tang Y, Wang P, Wang S (2024) Analysis of the spatial distribution pattern of *Agrilus planipennis* in different forest types. *Xinjiang Agricultural Sciences* 61(4): 964-970 (in Chinese, with English summary). http://www.xjnykx.com/EN/abstract/abstract7339.shtml

To clarify the geostatistical spatial patterns of *Agrilus planipennis* Fairmaire under different ash types in the hope of providing theoretical guidance for the prevention and control of *A. planipennis* under different ash types. Under four different forest types, the number of *A. planipennis* was determined by using the *A. planipennis* feathering pores as the investigation index, and the spatial patterns of *A. planipennis* under different forest types were studied. The results showed that the fitting model of *A. planipennis* urban green forest and highway green forest was Gaussian model, the fitting model of park mixed forest was exponential model, and the fitting model in street forest was linear model. The spatial distribution patterns of green forest, park mixed forest and highway green forest were clustered distribution, and the spatial distribution pattern of street forest was random distribution. Through the geostatistical investigation and analysis of the population of *A. planipennis* under four forest types, it is shown that when the harm of *A. planipennis* reaches a certain level, the stand type could not change the aggregation habit of *A. planipennis*, but it has an impact on the parameters and Variogram function values of the fitted model. The urban green forest and highway green forest in the contour map reflect the hazard of *A. planipennis*, which is the trend *of A. planipennis* spreading from the edge to the inside. The mixed forest in the park shows a strip-like distribution according to its planting characteristics. The street forest shows the characteristics of random distribution. The different hazard characteristics of *A. planipennis* are related to the forest stand type.

George J-P, Rusanen Mi, Beuker E, Yrjänä L, Timmermann V, Potocic N, Välimäki S, Konrad H (2024) Lessons to learn for better safeguarding of genetic resources during tree pandemics: the case of ash dieback in Europe. Preprint. https://arxiv.org/abs/2405.13305

Ash dieback (ADB) is threatening populations of European ash (*Fraxinus excelsior* & *F. angustifolia*) for more than three decades. Although much knowledge has been gathered in

the recent past, practical conservation measures have been mostly implemented at local scale. Since range contraction in both ash species will be exacerbated in the near future by westward expansion of the emerald ash borer and climate change, systematic conservation frameworks need to be developed to avoid long-term population-genetic consequences and depletion of genomic diversity. In this article, we address the advantages and obstacles of conservation approaches aiming to conserve genetic diversity in-situ or ex-situ during tree pandemics. We are reviewing 47 studies which were published on ash dieback to unravel three important dimensions of ongoing conservation approaches or perceived conservation problems: i) conservation philosophy (i.e. natural selection, resistance breeding or genetic conservation), ii) the spatial scale (ecosystem, country, continent), and iii) the integration of genetic safety margins in conservation planning. Although nearly equal proportions of the reviewed studies mention breeding or active conservation as possible long-term solutions, only 17% consider that additional threats exist which may further reduce genetic diversity in both ash species. We also identify and discuss several knowledge gaps and limitations which may have limited the initiation of conservation projects at national and international level so far. Finally, we demonstrate that there is not much time left for filling these gaps, because European-wide forest health monitoring data indicates a significant decline of ash populations in the last 5 years.

Hudgins EJ, Leung B, MacQuarrie CJK, McCullough DG, Francis A, Lovett GM, Guo Q, Potter KM, Cullingham CI, Koch FH, Bergman JN, Binley AD, Robichaud C, Henry M, Chen Y, Bennett JR (2024) Five organizing themes for invasive forest insect and disease management in Canada and the United States. *Forest Ecology and Management* 566: 122046 https://doi.org/10.1016/j.foreco.2024.122046

Forests provide crucial support for ecological communities and play a vital role in human well-being and livelihoods. Protecting forests from the impacts of invasive species is a challenge that spans epistemologies, governmental levels, and academic fields. Yet, sharing new information, existing practices, and challenges among relevant groups has often been limited in Canada and the United States. To address this challenge, we began with a review of all academic and Canadian and US grey literature to reveal major published themes in forest invader research and policy. We refined these through a survey and workshop with participants encompassing Indigenous knowledge holders, government scientists, non-government organization employees, and academic researchers based in Canada and the US. Our deliberations resulted in five organizing themes for research and practitioner action to address species invasions: 1) Overcoming barriers to knowledge sharing, for instance, through the employment of governmental liaisons, 2) Assessing risks and benefits of alternative forms of management, for instance through scenario models of spatial management decisions, 3) Making effective use of new technologies, such as advancements in genomics tools and sentinel plots, 4) Broadening the focus on invasion pathways, especially related to urban forests and the nursery trade, and 5) Considering equity and making space for differing epistemologies, for example through the improved engagement of Indigenous Peoples in forest invader management. We elicited semi-quantitative scores for the importance, uncertainty, feasibility, complexity, and time requirements of tactics aligned with these major themes. We also identified discrepancies in public attention and funding compared to forest experts' priorities, including in the role of the nursery trade as a pathway of secondary invader spread. We illustrate how these themes can inform priorities for management in three important areas of North American biosecurity: solid wood packaging, and emerald ash borer (*Agrilus planipennis*) and Asian longhorned beetle (*Anoplophora glabripennis*) management. This work provides organization to the growing set of tools and outlines priority management tactics for invasive forest pests.

Klimov AV, Poluyanov AV (2024) Features of distribution and biology of the Emerald ash borer on the territory of the Kursk Region. *Vector of Scientific Thought* 5(10): 52-56 (in Russian). https://disk.yandex.ru/d/f8OnoYKEZTdPyQ

> This article describes the biological characteristics of the emerald ash borer, its habitat, analyzes the causes and consequences of the spread of this invasive species of beetle in the Kursk region, its harmfulness to local ash species, and describes measures to combat this pest.

Koski T-M, Zhang B, Mogouong J, Wang H, Chen Z, Li H et al. (2024) Distinct metabolites affect the phloem fungal communities in ash trees (*Fraxinus* spp.) native and nonnative to the highly invasive emerald ash borer (*Agrilus planipennis*). *Plant, Cell & Environment* 1–19. https://doi.org/10.1111/pce.14996

> Emerald ash borer (EAB, *Agrilus planipennis*) is an invasive killer of ash trees (*Fraxinus* spp.) in North America and Europe. Ash species co-evolved with EAB in their native range in Asia are mostly resistant, although the precise mechanism(s) remain unclear. Very little is also known about EAB or ash tree microbiomes. We performed the first joint comparison of phloem mycobiome and metabolites between a native and a nonnative ash species, infested and uninfested with EAB, in conjunction with investigation of larval mycobiome. Phloem mycobiome communities differed between the tree species, but both were unaffected by EAB infestation. Several indicator taxa in the larval gut shared a similarly high relative abundance only with the native host trees. Widely targeted metabolomics revealed 24 distinct metabolites in native trees and 53 metabolites in nonnative trees, respectively, that differed in relative content between infested and uninfested trees only in one species. Interestingly, four metabolites shared a strong relationship with the phloem mycobiomes, majority of which affected only the native trees. Collectively, our results demonstrate a complex interplay between host tree chemistry and mycobiome, and suggest the shared relationships between the mycobiomes of the native host tree and EAB may reflect their shared co-evolution.

Morris TD, Gould JR, Fierke MK (2024) Field phenology of emerald ash borer (Coleoptera: Buprestidae) parasitoids in New York State. *Environ Entomol*. 20nvae047. https://doi.org/10.1093/ee/nvae047

> Emerald ash borer (EAB), *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), has caused extensive mortality of ash across North America. Biological control offers a potential long-term management option, allowing for long-term survival of ash. Careful monitoring of populations of biocontrol agents is necessary to understand their relative impacts. Understanding the emergence and flight phenology of these species allows for the optimization of monitoring schemes and improves our understanding of host-parasitoid interactions. We used yellow pan trapping data to assess the adult phenology of both EAB and its associated native and introduced parasitoids in 3 New York counties. We monitored 2 introduced larval biocontrol agents, *Tetrastichus planipennisi* Yang (Hymenoptera: Eulophidae) and *Spathius galinae* Belokobylskij & Strazanac (Braconidae), for 3-4 years post-release, as well as the native parasitoid *Phasgonophora sulcata* Westword (Chalcididae). Results indicate a single discrete emergence event for both EAB and *P. sulcata* in all monitored counties, which is consistent with previously reported results. Our results also suggest there are 4 generations per year of *T. planipennisi* and 3 generations of *S. galinae* in the monitored counties. We recorded an additional generation of *T. planipennisi* that had not previously been reported in New York, and both *T. planipennisi* and *S. galinae* appeared to emerge earlier than previously documented.

Rossi J-P, Mouttet R, Rousse P, Streito J-C (2024) Modelling the potential range of *Agrilus planipennis* in Europe according to current and future climate conditions. *Trees, Forests and People* 16, 100559. https://doi.org/10.1016/j.tfp.2024.100559

Agrilus planipennis, the emerald ash borer, is a species native to East Asia that was accidentally introduced to North America and Eastern Europe. In North America, it is responsible for tremendous damage. In Europe, its range has quickly expanded from the east where it was introduced in 2003, and it threatens the species of the genus *Fraxinus*. We developed an ensemble modelling approach to model the potential range of *A. planipennis* according to current climate conditions and four scenarios of climate change: SSP1-2.6, SSP2-4.5, SSP3-7.0 SSP5-8.5 in the period 2041-2060. We used three algorithms; random forest, boosted regression trees and Bayesian additive regression trees with occurrence data from both native and invaded ranges. The results indicate that most of the European continent is climatically suitable for *A. planipennis*. In Western Europe, the northern limit of the range is located in the British Isles and southern Scandinavia. The projection of the models according to estimates of future climate conditions shows that climate suitability would mostly remain unchanged in 2041-2060. During that period, the potential range is expected to slightly shrink in the south, around the Mediterranean Basin, and expand at its northern limit. Our results confirm that *A. planipennis* is, and will remain, a major threat to forest and ornamental ash tree health across Europe.

Sheng Z. H, Chen HY, He S, Gao GZ, Chen JH, Li R, Li JG, Zhang LY (2024) Suitable habitat area analysis and niche assessment of the invasive emerald ash borer (*Agrilus planipennis*) in native and invasive ranges. *Applied Ecology And Environmental Research* 22(2): 1885-1902. http://dx.doi.org/10.15666/aeer/2202_18851902

The emerald ash borer, *Agrilus planipennis*, is a bark beetle native to Asia that has caused significant forest resource losses in North America since its introduction in the early 21st century. In this study, we used the niche assessment R package 'ecospat' and the integrated model 'biomod2' to compare 19 bioclimatic variables for *A. planipennis* in its native range (China) and part of its invasive range (the United States). Future data predicted for the 2050s and 2070s were utilized to forecast potential habitat regions for *A. planipennis* in China and the United States under two representative climate scenarios (SSP126 and SSP585). We revealed low niche overlap between *A. planipennis* populations in these ranges, with significant differences in bioclimatic variables. This indicates that *A. planipennis* has adapted to a range of climatic conditions in the United States. In upcoming times, the suitable habitat region for *A. planipennis* is expected to significantly decrease in the United States but considerably increase in China. Our study provides insights that can be used to prevent further *A. planipennis* spread, for economic loss assessment of and developing management strategies against *A. planipennis*, and as a methodological reference for niche analysis of other invasive species.

Spasov N (2024) Analysis of the phytosanitary risk of the pest *Agrilus planipennis* Fairmaire, 1888 for tree species in Bulgaria. *Bulgarian One Health Journal* 1 (8): 89-105. https://doi.org/10.59496/20241PH3

Bulgaria is characterized by the fact that it is one of the richest countries in plant diversity in Europe - more than 4,200 higher plant species and about 3,700 species of algae and mosses have been described. On the country territory you can see the last deposits in Europe of a number of rare plant species, as well as another 170 Bulgarian and 200 Balkan endemics. For this reason, the introduction, establishment and spread of new species of plant enemies is a critical moment for the conservation of our nature. Precisely such a species is *Agrilus planipennis*, which is an East Asian species for which there is currently no evidence of being present in the European Union (EU) territory and in the analyzed threatened area. *A. planipennis* spreads naturally and through human-assisted routes, such as infested ash logs, firewood and nursery plants. Other potential routes of entry have been identified, such as:

wood, sawdust, mulch (composted and uncomposted), and the probability of entry of this enemy is considered moderate. *A. planipennis* has been added to the A2 list of pests recommended for regulation as quarantine for the EPPO region, meaning that the pest is locally present in the EPPO region. It is also a Union quarantine pest listed in Part A of Annex II to Commission Implementing Regulation (EU) 2019/2072 and a priority pest under Commission Delegated Regulation (EU) 2019/1702, which obliges Member States to carry out annual surveys. Bulgaria falls into an area with suitable eco-climatic conditions for establishment, i.e. in case of possible penetration into the country, the risk of establishing *A. planipennis* is high. Its current distribution in N. America and European Russia, as well as its native range in Asia, suggests that this species can survive winter at temperatures well below freezing. For this reason, low temperatures in winter are not expected to have a negative impact on the establishment and spread of *A. planipennis* in Bulgaria, since this species has established itself in areas with much lower temperatures than those in the country (for example, the Moscow region). Given the climatic changes in Bulgaria and the trend towards warming in most regions of the country, and the forecast for milder winters in the coming decades, it is assumed that the conditions will be increasingly suitable. If established and spread, the pest is likely to cause major ecological losses and impacts, as well as some social effects. Long-distance spread will be via human-assisted pathways, and its natural spread will occur, but at a slower rate. In the event of the introduction, establishment and spread of *A. planipennis* in the country, it could have a negative impact, especially in the areas where the different species of ash are found, and its destruction or containment will be difficult and expensive, and it is unlikely that it would be successful.

Thapa B, Darling L, Choi DH, Ardohain CM, Firoze A, Aliaga DG, Hardiman BS, Fei S (2024) Application of multi-temporal satellite imagery for urban tree species identification. *Urban Forestry & Urban Greening* 128409. https://doi.org/10.1016/j.ufug.2024.128409

Accurate tree inventories are critical for urban forest management but challenging to obtain, as many urban trees are on private property (backyards, etc.) and are excluded from public inventories. Here, we examined the feasibility of tree species identification in large heterogenous urban area (>850 km^2), by using multi-temporal PlanetScope images (3.2 m resolution, multi-spectral) and inventory data from more than 20,000 ground observations within the urban forest of the Greater Chicago area. Our approach achieved an overall classification accuracy of 0.60 and 0.71 for 18 species and 10 genera, respectively, but varied from moderate to high for certain species (0.59–0.92) and genera (0.61–0.91). In particular, we identified key host tree species (*Fraxinus americana*, *F. pennsylvanica*, and *Acer saccharinum*) for two damaging invasive insects, emerald ash borer (EAB, *Agrilus planipennis*) and Asian longhorn beetle (ALB, *Anoplophora glabripennis*), with over 0.80 accuracies. In addition, we demonstrated that images from autumn months (September–November), either within a single season or across multiple seasons, improved identification accuracy of temperate deciduous trees. Further, the high classification accuracy of support vector machine (SVM) over random forest (RF) and neural network (NN) approaches suggest that future work might benefit from comparing multiple classification methods to select the approach that maximizes species classification accuracy. Our study demonstrated the potential for the application of multi-temporal high-resolution images in urban tree classification, which can be used for urban forest management at a large spatial scale.

Trofimov VN, Trofimova OV (2024) The state of planted stands of Pennsylvania ash *Fraxinus pennsylvanica* Marsh in the Moscow region after the invasion of the Emerald ash borer *Agrilus planipennis* Fairmaire (Coleoptera, Buprestidae). *AgroEcoInfo* 2 (in Russian). https://agroecoinfo.ru/STATYI/2024/2/st_227.pdf

Various types of Pennsylvania ash planted areas that survived the Emerald ash borer infestation in 2005–2012 were studied. No undamaged trees were found. Surviving trees (25%) had crown

reduction pruning. Assessment of their condition demonstrated that their state corresponded to the criterion of 'weakened' in 2017-2018 and 'severely weakened' in 2018-2022. The improvement of the condition in 2014–2018 followed by deterioration since 2021. The best condition was observed in squares and multi-row plantings, the worst - in single-row plantings along the streets. During the next decade, most of the planted stands along the streets will degrade, but other types of planted stands will remain. In the central part of the metropolis, trees in the park partially restore their crowns and overgrow the old galleries of the beetle. Damage of multi-row plantings along transport routes by *A. planipennis* in 2006-2008 provoked an outbreak of the small ash beetle *Leperesinus varius* (= *Hylesinus fraxini*). The synergy of two pests has caused the rapid decline of Pennsylvania ash trees throughout the region. Trees of the 'weakened' category, which had crown reduction pruning up to 1/3 of the crown, live for at least 8 years, and trees of the 'severely weakened' category – for at least 5 years. It is advisable to remove from 1/3 to 2/3 parts of the crowns only from the trees in the 'weakened' category. Removal of more than 2/3 of the crown and removal of the top and skeletal branches leads to death.

Wilson CJ, Petrice TR, Poland TM, McCullough DG (2024)Tree species richness and ash density have variable effects on emerald ash borer biological control by woodpeckers and parasitoid wasps in post-invasion white ash stands. *Environmental Entomology* nvae060. https://doi.org/10.1093/ee/nvae060

Emerald ash borer (EAB) (*Agrilus planipennis* Fairmaire) (Coleoptera: Buprestidae) is the most destructive insect to invade North American forests. Identifying habitat features that support EAB natural enemies is necessary to enhance EAB biological control. In many forest ecosystems, tree species diversity has been linked with reduced pest abundance and increases in natural enemy abundance. We assessed the influence of tree species richness, ash density, and proportion of total ash basal area on ash canopy condition, EAB larval densities, and biocontrol by woodpeckers and parasitoids in pairs of healthy and declining overstory (DBH > 10 cm) and recruit-sized ash (DBH 2–10 cm) in 4 post-invasion forests in Michigan, USA. Tree species richness and ash density were not significantly associated with EAB larval densities, ash canopy dieback and transparency, and woodpecker predation of EAB larvae. In declining and healthy overstory ash, woodpeckers killed 38.5 ± 3.9% and 13.2 ± 3.7% of larvae, respectively, while the native parasitoid *Phasgonophora sulcata* Westwood killed 15.8 ± 3.8% and 8.3 ± 3.0% and the introduced parasitoid *Spathius galinae* Belokobylskij & Strazanac killed 10.8 ± 2.5% and 5.0 ± 2.6% of EAB larvae. Parasitism by *P. sulcata* was inversely related to ash density while parasitism by *S. galinae* was positively associated with ash density. Ash density, but not tree diversity, appears to differentially influence biological control of EAB by parasitoids, but this effect is not associated with reduced EAB densities or improved canopy condition.

Zhou Q, Yu L, Zhang X, Qi R, Tang R, Ren L, Luo Y (2024) Detection of emerald ash borer damage using an improved change detection method: Integrating host phenology and pest life history. Ecological Indicators 166: 112240, https://doi.org/10.1016/j.ecolind.2024.112240

Invasive Emerald Ash Borer (EAB) damage pose significant challenges for sustainable forest management, necessitating accurate mapping of damaged ash trees. Traditional change detection methods, using time-series imagery, are essential for monitoring forest disturbances but complicated by abnormal fluctuations in original time-series features. Tree phenology also complicates this process by masking the reflectance characteristics indicative of EAB infestation. To address these challenges, we propose an improved change detection method integrating patterns from host tree phenology and EAB life history. This improved method includes: (1) select the indices with time stability to enhance detection reliability by partial least squares method (PLS); (2) correction on negative change values before and positive

change values after the phenological peak based on known patterns of tree phenology and EAB life history. Result confirms that this method effectively reflects the seasonal growth and decline dynamics of ash trees, revealing the impacts of phenology and EAB infestation. EAB-damaged trees exhibited slower growth in May and premature decline in July compared with healthy tree, with the damage severity influencing the rate of leaf decline. This proposed method achieved an overall accuracy of 53.4%-76.7% across different months for ash trees with health, light and severe damage. This study highlights the capabilities of integrating pest life history and phenology in change detection method and provide a new method to monitor individual tree health across large areas by high-resolution satellite imagery.