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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Content of the Newsletter

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

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

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1. Introduction

Welcome to the 3rd 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 2nd issue of the Newsletter, the Network coordinator received an official response from the NPPO of Ukraine (see Section 3), information about new publications about *A. planipennis*, etc. This information made it possible to prepare the 3rd 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

As of December 2023, the Network has more than **220 members (subscribers)** from more than **40 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).

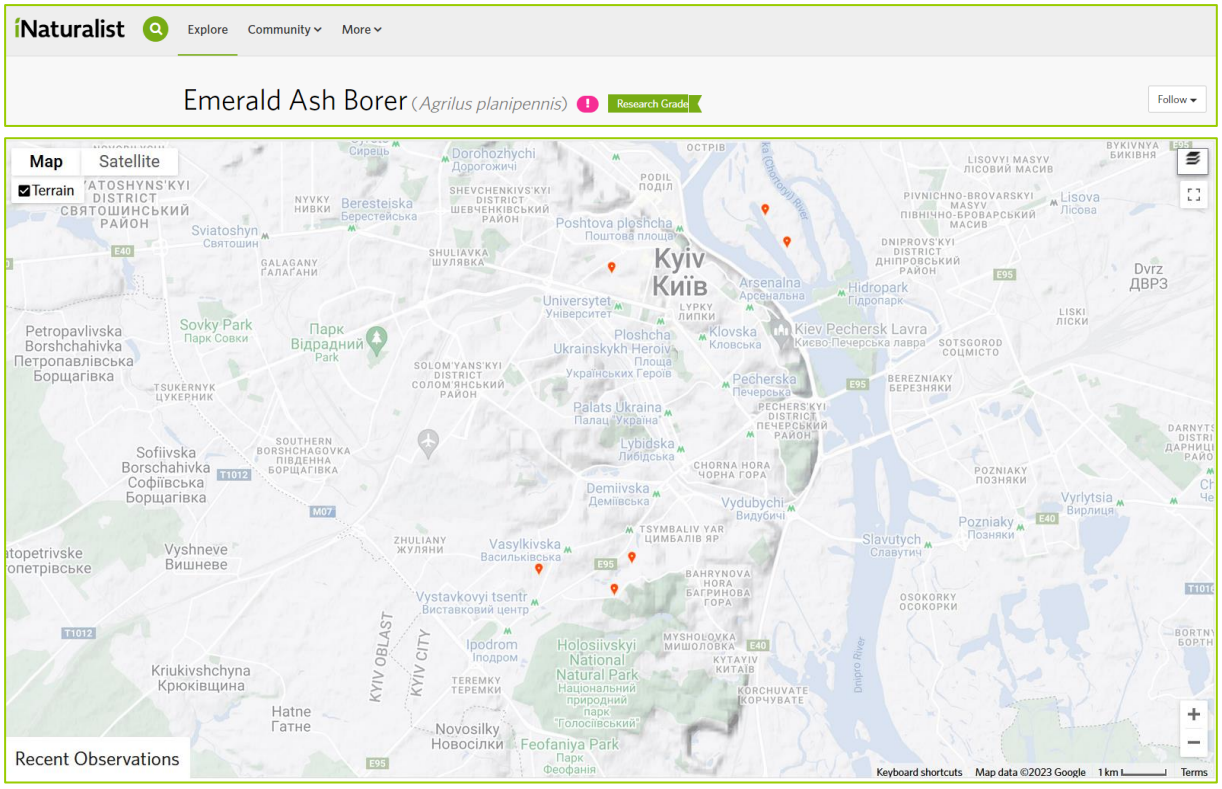
3. *Agrilus planipennis* in Kyiv, Ukraine is officially confirmed by NPPO

In the 2nd issue of the Newsletter we informed readers that on 30 May 2023, a new record of distribution of *A. planipennis* had been added to the pest's profile in iNaturalist (https://www.inaturalist.org/observations/164638313). The EPPO Secretariat contacted the NPPO of Ukraine with a request to clarify the situation of *A. planipennis* in Kyiv and received a response. The NPPO of Ukraine explained that the state phytosanitary inspectors conducted a survey using pheromone traps in Kyiv, in the Bohdan Stupka Park in accordance with the geolocation indicated in the iNaturalist record. According to the results of the survey, *A. planipennis* was not present in that location.

Five new records of the pest were published on the iNaturalist platform in June 2023 (https://www.inaturalist.org/taxa/70057-Agrilus-planipennis; see below) and two conference papers were published (Strygun et al., 2022, 2023 – see Section 12) claiming that *A. planipennis* is present in Kyiv. On 16 November 2023, the EPPO Secretariat again contacted the NPPO of Ukraine with a request to update information about *A. planipennis* in Kyiv. On 17 November 2023, the NPPO of Ukraine responded with an official letter (signed by the Deputy Head of the NPPO – the Chief Phytosanitary Inspector of Ukraine Mr. Vadym Chaikovskyi) which informed EPPO that during a regular inspection and monitoring of green spaces in the territory of Kyiv city by state phytosanitary inspectors **an outbreak of *A. planipennis* was found on ash trees**. Following a request from the NPPO, on the 27.12-ha landscape park on Solomianska Street **a quarantine regime was introduced** in accordance with the order of the Kyiv City Military Administration dated 10 October 2023 No. 790. It was further stated that as of 15 November 2023, on the territory of Ukraine a quarantine regime was introduced in the districts of Luhansk and Kharkiv regions and in Kyiv

city. In addition, a 100-km zone bordering the quarantine zones of Luhansk and Kharkiv regions and Kyiv city was established. Currently, the monitoring of green spaces on the territory of Kyiv city continues.

The official statement is available online: https://dpss.gov.ua/news/v-kyievi-zaprovadzheno-karantynnyi-rezhym-smarahdova-iaseneva-vulkozlatka

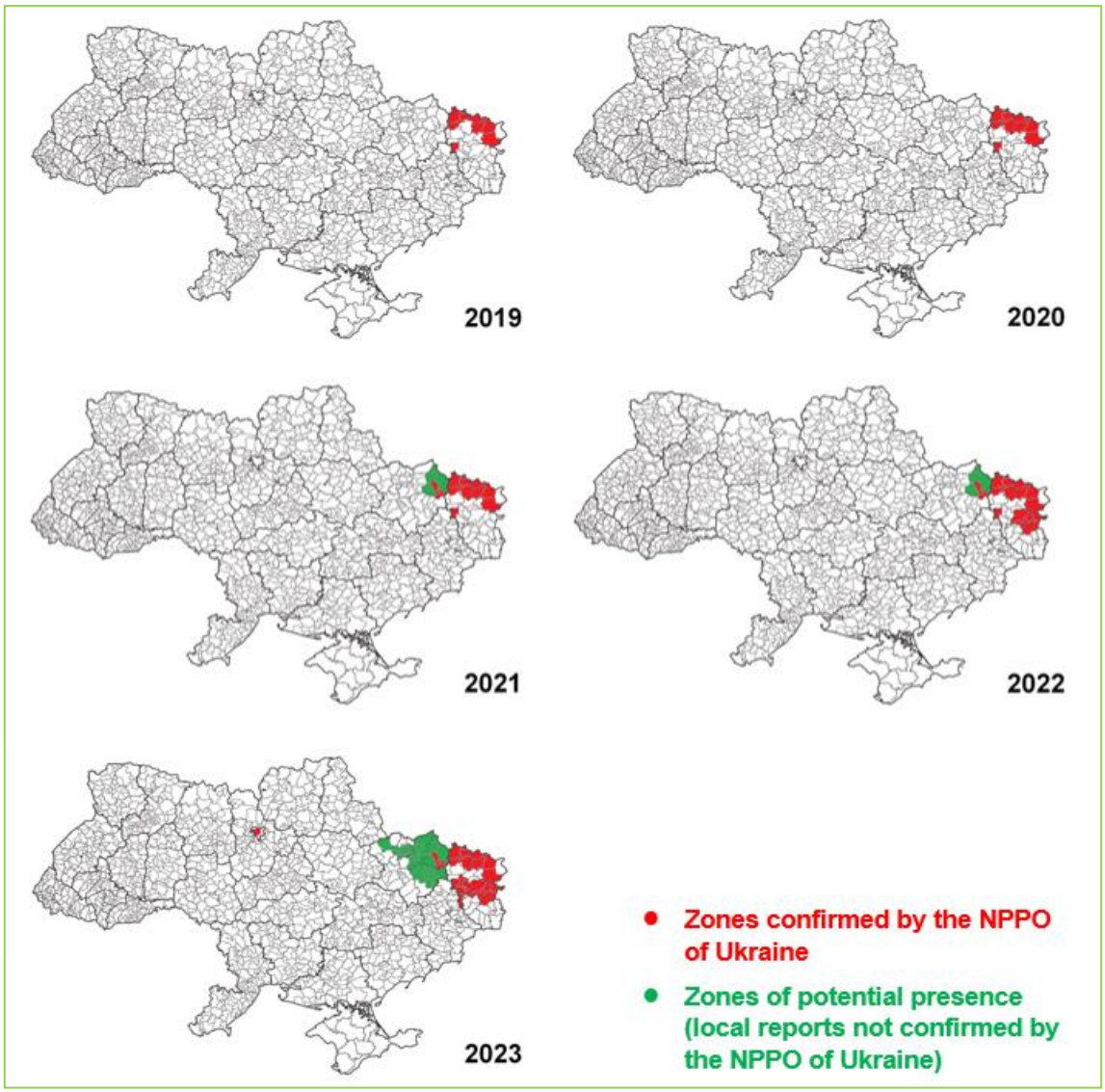


Records of *Agrilus planipennis* on the iNaturalist platform (six red symbols; https://www.inaturalist.org/taxa/70057-Agrilus-planipennis; accessed on 12 December 2023).

4. A dynamic map of distribution of *Agrilus planipennis* in Ukraine

In the previous issues of the Newsletter the members of the Network were informed that the Ukrainian State Specialized Forest Protection Enterprise DSLP "Kharkivlisozakhist" had developed and published on its webpage a dynamic map showing the change of the range of *A. planipennis* in Ukraine in 2019-2023 (https://lisozahyst.at.ua/index/agrilus-planipennis/0-17).

Recently, the map was updated and now shows not only districts where the presence of the pest is confirmed by the NPPO, but also districts with local reports that are not yet confirmed by the NPPO.



The dynamics of the invasive range of *A. planipennis* in Ukraine in 2019–2023 (Courtesy: The Ukrainian State Specialized Forest Protection Enterprise DSLP "Kharkivlisozakhist"; units: administrative districts; https://lisozahyst.at.ua/index/agrilus-planipennis/0-17; accessed on 12 December 2023).

5. Exchange of reference specimens of *Agrilus planipennis*

In the previous 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 Ukraine and the United Kingdom helped colleagues from Sweden to obtain sample adults and larvae. A few more specimens are available which can be shared with NPPOs and/or national reference collections that need them for their work.

The EPPO Secretariat is willing to continue to facilitate the process of exchange of reference specimens. 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)

6. A new EU Commission Implementing Regulation on measures to prevent the establishment and spread of *Agrilus planipennis* within the Union territory

The European Commission prepared a draft of the Commission Implementing Regulation (EU) on measures to prevent the establishment and spread of *Agrilus planipennis* Fairmaire within the Union territory (https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14026-Plant-health-measures-to-eradicate-prevent-the-spread-of-the-emerald-ash-borer-Agrilus-planipennis-_en). This document, after adoption, will regulate how to carry out risk-based surveys to detect *A. planipennis*, establish demarcated areas, perform annual surveys in demarcated areas, prepare and apply eradication measures, prepare contingency plans and annual reporting. The draft considers *Chionanthus virginicus* L. and *Fraxinus* L. (other than fruits, seeds, pollen and plants in tissue culture) as specified plants (hosts). The feedback period lasted from 10 November 2023 to 08 December 2023. It is sent for the Commission adoption.

7. A review: Emerald ash borer management and research

A comprehensive review paper will be published in the upcoming issue of *Annual Review of Entomology*:

Sun J, Koski T-M, Wickham JD, Baranchikov YN, Bushley KE (2024) Emerald ash borer management and research: Decades of damage and still expanding. *Annual Review of Entomology* 69, 239-258 (https://doi.org/10.1146/annurev-ento-012323-032231)

Abstract: Since the discovery of the ash tree (*Fraxinus* spp.) killer emerald ash borer (EAB; *Agrilus planipennis*) in the United States in 2002 and Moscow, Russia in 2003, substantial detection and management efforts have been applied to contain and monitor its spread and mitigate impacts. Despite these efforts, the pest continues to spread within North America. It has spread to European Russia and Ukraine and is causing sporadic outbreaks in its native range in China. The dynamics of EAB's range expansion events appear to be linked to the lack of resistant ash trees in invaded ranges, facilitated by the abundance of native or planted North American susceptible ash species. We review recently gained knowledge of the range expansion of EAB; its ecological, economic, and social impacts; and past management efforts with their successes and limitations. We also highlight advances in biological control, mechanisms of ash resistance, and new detection and management approaches under development, with the aim of guiding more effective management.

Structure of the review:

1. **Introduction: global expansion of the emerald ash borer**
   1.1. Outbreaks in the native range in China
   1.2. Introduction and expansion within North America
   1.3. Introduction and expansion to Europe
2. **Ash resistance**
3. **Emeral ash borer impacts**
   3.1. Ecological impacts
   3.2. Emerald ash borer damage: economic, health, and social impact
4. **Current detection and management practices**
   4.1. Prevention and early detection
   4.2. Chemical control
   4.3. Biological control
   4.4. Integrated pest management and other management efforts
5. **Advances in Emerald ash borer management**
   5.1. Resistance breeding: where are we now in developing Emerald ash borer–resistant ash?
   5.2. Technological advances in management and early detection
   5.3. Emerald ash borer–associated microbiota—future for emerald ash borer biocontrol?
6. **Conclusions**

An important part of the review is a Supplementary Table *Summary of currently used or previously tried EAB detection and control methods, their success, and challenges*.

Summary points:

1. Remote sensing combined with advanced imaging technology techniques will hopefully aid in early detection, the major roadblock to limiting emerald ash borer (EAB) spread, in the future. This approach could be combined with targeted on-site detection and management practices, such as branch sampling and chemical control.
2. Planting of susceptible ash species, especially as monocultures, should be avoided, given that the wide-scale presence of native (in the United States) or planting of introduced (in European Russia, Ukraine, and China) susceptible ash trees is the key reason for the spread of the pest.
3. Ash breeding to improve the resistance of susceptible species is slow, but advances in understanding the genetic basis of resistance, as well as the availability of new breeding and genetic engineering tools, will likely aid in this task in the future. Meanwhile, wider-scale use of naturally resistant trees (at least in EAB's native range), for example, as urban ornamental trees, is encouraged because ash breeding will likely not improve wide-scale EAB management in the near future.
4. The biological control program in the United States has been moderately successful in reducing EAB damage but is likely insufficient to control EAB without combining it with chemical control and use of more resistant ash trees. New parasitoid or microbial control agents and/or the emergence of RNA interference–based control may help in control efforts in the future.
5. Investigation of EAB-associated microbiota in both native and invasive ranges, incorporating microbiota from both resistant and susceptible tree species, would benefit

future biocontrol efforts, as well as improving our understanding of the role of microbiota in species invasion and management.

8. The Network was presented at a virtual meeting of the International Forestry Quarantine Research Group

In November 2023, the EPPO Secretariat presented the Network to the attendees of the virtual meeting of the International Forestry Quarantine Research Group (IFQRG; https://www.ippc.int/ru/partners/organizations-page-in-ipp/internationalforestryquarantineresearchgroup/). This group supports the International Plant Protection Convention (IPPC) Community by addressing critical forestry quarantine issues for the global plant protection community through scientific analysis, discussion and collaborative research. Its goals are to:

- Identify and respond to high priority questions that the international forest phytosanitary community face;
- Carry out collaborative independent research and analysis as required;
- Provide carefully considered advice to the regulatory community including the bodies of the IPPC.

Members of the IFQRG and attendees of the meeting were invited to join the Network.

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

Recently, one MSc and three PhD dissertations which used *A. planipennis* as a model (or one of the models) were prepared and publicly presented:

Ebersole W (2023) An examination of the effect of *Fraxinus* ash tree health on diversity and structure of the soil microbiome. Master's thesis. Bowling Green State University. OhioLINK Electronic Theses and Dissertations Center. http://rave.ohiolink.edu/etdc/view?acc_num=bgsu1692372259747792

Abstract: *Fraxinus* ash trees in North America a threatended by the invasive *Agrilus planipennis*, emerald ash borer (EAB). EAB infestation has wide ranging economic, cultural and ecological impacts upon the North American environment. This study aims to look at the biological impact that infestation of ash trees can have on the soil microbiome around the tree's roots. A previous study has already examined the possible geochemical effects of the trees sampled, and by looking at the effects on the microbiome through 16S ribosomal sequencing, we hoped to gain some estimation of the effect imposed on microbiota surrounding the tree. With a combination of alpha, beta, and network analysis, we can see some possible changes within the rhizosphere associated to the health of trees. Alpha diversity was inconclusive as there was inconsistent data amongst our sampled set of trees.

There is confounding points in the data pertaining to geographic differences in sample locations. However, when stratifying to sample locations, beta and network analyses show shifts in the microbiome are significant, with site 2 and 4 beta diversity showing a progression of microbiome makeup to change as health state changed. Differential networks between health states indicate a change in taxa between healthy and unhealthy tree rhizospheres exist. The network topography as well as the strength of edges between networks showed a difference in taxonomic makeup comparing health states with some phyla of note being Verrucomicrobia, Nitrospirae, and Acidobacteria. Because our sample size within each location was small, we recommend further studies be done to explore those differences.

Kyle K E (2023) Using eDNA to bridge the gap between species presence and detection: implications for conservation and invasive species management. A dissertation. Rutgers, The State University of New Jersey, School of Graduate Studies. ProQuest Dissertations Publishing. 30687873.
https://www.proquest.com/openview/bf91be3b8d72fcdaf7b5cf44797bc5b4/1?pq-origsite=gscholar&cbl=18750&diss=y

Abstract: The use of environmental DNA (eDNA) for the detection of rare and elusive species has boomed over recent decades, making its way into terrestrial landscapes in more recent years. Because eDNA in terrestrial landscapes can be randomly dispersed, we must be thoughtful about how to sample in an effort to maximize the probability of detection given the target species. Due to the sensitivity of these methods, they can be very useful for detecting invasive species when rare in the landscape and to aid with delimiting surveys for more effective control and management. Similarly, eDNA methods can aid in detecting species of conservation concern when they are rare or elusive. The goal of my dissertation was to broaden the utility of eDNA methods to unlock new suites of species capable of being surveyed. In doing so, we had to think about how to access new 'pools' of eDNA that we could access in these detection efforts. First, I evaluated the deployment of a published eDNA sampling method, roller aggregation, in a novel way to detect a terrestrial reptile species beneath artificial cover objects. Second, I trialed a novel eDNA sampling method utilizing a 1" increment hammer to extract tree cores from hosts infested with a woodboring beetle. Lastly, I deployed a suite of eDNA methods to observe which would work well to detect eDNA of a nocturnal invasive beetle pest in a tropical island habitat. Thus far, the use of eDNA has not been extensively used in island habitats for detection of invasive invertebrates, so we explored that utility here.

Rosner S (2023) Importance des frênes pour la biodiversité dans les forêts ripariennes sous influence du castor (*Castor canadensis*) et de l'agrile du frêne (*Agrilus planipennis*). Thèse. Gatineau, Université du Québec en Outaouais, Département des sciences naturelles, 160 p. [**Rosner S (2023) Importance of ash trees for biodiversity in riparian forests under the influence of the beaver (*Castor canadensis*) and the emerald ash borer (*Agrilus planipennis*).** Thesis. Gatineau, University of Quebec in Outaouais, Department of Natural Sciences, 160 p.] (https://uqo.ca/nouvelles/52730)

Abstract: With the invasion of North America by the emerald ash borer (*Agrilus planipennis*), ash trees (*Fraxinus* spp.) are under severe threat and the vast majority are destined to disappear in the coming years. In temperate deciduous forests, ash can be a dominant genus of riparian forests. These forests are considered to be very important ecological zones, as they form the interface between two ecosystems and play numerous ecological roles. They

are also known to harbour significant plant and animal biodiversity. The sudden disappearance of a genus that may be dominant in this type of forest therefore has the potential to significantly impact the biodiversity of this type of environment and the ecosystem services that derive from it. We also know that ash is a genus that can be appreciated by beavers (*Castor canadensis*), which have a considerable influence on the structure of riparian ecosystems. Through their food selection, beavers can in fact shape forest composition, favoring species they avoid and disfavoring species they select. The pivotal role that ash trees could play in the dynamics of beaver colonies and in the maintenance of a particular biodiversity within riparian forests has not been the subject of specific studies. The disappearance of ash trees also has the potential to impact invertebrate communities, not only through a sudden change in forest structure, but also through the disappearance of ash litter, known for its lability, which could reduce the decomposition rate of the remaining litter. This question has not yet been the subject of specific studies either: in the literature, studies seem to focus mainly on the effects of structural modification of the forest, and only on certain families of invertebrates. To answer these questions, we carried out three separate studies in Parc national de Plaisance, which will be presented in three chapters of this thesis.

The first chapter of this thesis will aim to assess the exact place of ash in the beaver's diet, and how the beaver's feeding behaviour might be altered by the disappearance of ash. It has been shown that ash is indeed the most important food resource for beavers among those tested. In fact, only two other species (musclewood, *Carpinus* spp., and poplar, *Populus* spp.) were more likely to be consumed than ash, but their low abundance in the park meant that they could not be considered the most important food resource. We were also able to demonstrate that musclewood saplings could see their probability of consumption increase with the disappearance of mature ash trees. On the other hand, if the abundance of the ash saplings decreased, it is possible that the probability of consumption of mature maple, basswood and musclewood saplings could decrease. However, this latter effect could be due to a case of apparent competition.

The aim of the second chapter of this thesis was to determine whether the disappearance of ash have the capacity to reduce the densities of the beaver population. Being a social and territorial species, the population densities may be regulated by group size, territory size, or both. We were able to show that the density of ash in the territories positively influenced the size of the group, but had no effect on the territory size, which is surprising for such a territorial species. The disappearance of ash is therefore likely to reduce beaver populations in riparian forests dominated by this genus.

Finally, in the third chapter, our first objective was to determine whether ash was indeed the genus that positively influenced lability in a litter composed mainly of ash and maple (*Acer* spp.). Secondly, we wanted to determine whether, in addition to the effects of altered forest structure, altered litter had the capacity to influence invertebrate communities. We were able to determine that the rate of litter decomposition was, indeed, largely determined by the percentage of ash in the litter. We were also able to show that ash, probably through its litter, influences invertebrate communities: the family assemblages were different depending on the proportion of ash trees in the canopy, demonstrating that some ash-associated communities are singular. Finally, some families had a taxonomic diversity positively influenced by litter decomposition rate, implying that the disappearance of ash could have negative effects on biodiversity at the scale of riparian forests.

Taken together, these chapters show that the disappearance of ash trees will most likely reduce beaver population density and alter their feeding behaviour, with consequent effects on forest dynamics. Furthermore, if ash trees were replaced by trees with less labile litter, this could certainly have a negative impact on the biodiversity of soil invertebrates. Although it is not possible to precisely determine what the riparian forests of the future will look like, this thesis will have shown that in temperate forests where ash is abundant, it is a keystone for both animal biodiversity and forest composition, through its effect on beavers.

Studer EA (2023) Do species matter? Examining the niche of white ash (*Fraxinus americana* L.) and estimating potential subcanopy effects of its loss in north-temperate forests. Dartmouth College. PhD Dissertations. 174 (https://digitalcommons.dartmouth.edu/dissertations/174)

Abstract: To understand the downstream consequences of the extinction of a species, we must understand its role in an ecosystem. With the impending extirpation of ash (*Fraxinus* spp.) due to the invasive emerald ash borer (*Agrilus planipennis*), understanding the role of ash trees is critical to predicting whether its loss will precipitate further species declines and/or ecosystem functions. We evaluated whether subcanopy microbial, invertebrate, and floral communities under four tree species (white ash, American beech, yellow birch, sugar maple) and on two soil hydropedological types (Bh podzol and Typical podzol) varied in species richness, composition, and functional traits in a factorial study. There were frequent strong effects of tree species. White ash frequently differed from the other trees: e.g., lower cation exchange capacity and exchangeable acidity, thinner Oi layer, lower %C and C : N, and, from phospholipid fatty acids, more AM fungi and less gram+ bacteria. We found that the subcanopy vegetation under ash was unique in having more plants of more species compared to the other tree species in the study. We also found an effect of soil type on species richness with Bh podzol having greater richness. However, identity analyses of functional traits of the understory communities revealed few differences by canopy tree species, suggesting that subcanopy communities are functionally redundant under different trees. We also found that soil invertebrate abundance did not vary significantly with tree or soil type, but that a higher diversity of organisms was present under ash and beech trees compared to sugar maple and birch. Finally, we estimated invertebrate abundance and biomass per gram of basal resource (leaf-litter) to provide data to modelers of ecosystem dynamics aiming to incorporate invertebrate data into forest forecasting. Better understanding of the role of diversity and function associated with at-risk organismal communities is important for predicting changes to ecosystem services in human-altered landscapes.

10. New publications on *Agrilus planipennis*

After the release of the previous Newsletter, information on **19 new publications** on *A. planipennis* (14 journal papers, 4 conference abstracts, 1 collection of papers) has been received (data on new dissertations see in Section 9). The range of topics is very wide and includes the following:

– Dynamics of spread of *A. planipennis* in Russia (Zhuravleva & Karpun, 2023), Ukraine (Kucheryavenko, 2022; Skrylnyk et al., 2023; Strygun et al., 2022, 2023) and USA (Hauer, 2023; Zobrist et al., 2023);

– Induced host defensive response to larval infestation (Stanley et al., 2023);
– Transcriptome profiling of *Fraxinus excelsior* genotypes infested by emerald ash borer (Doonan et al., 2023);
– A pattern of the body size change of *A. planipennis* to water quality in North America (Nalepa et al., 2023);
– Physiological responses of *A. planipennis* adults to short-time high-temperature conditions (Dang et al., 2023);
– Testing of heat treatment dose for *A. planipennis* prepupae (Noseworthy et al., 2023);
– Choice of trap type for the recently spreading jewel beetle pests (Matula et al., 2023);
– Modelling of the impact of introduction of *A. planipennis* to water quality in North America (Maze et al., 2023);
– Association between *A. planipennis* residence time and accumulation of invasive plants (Gougherty et al., 2023);
– Change in forest tree composition due to the invasion of *A. planipennis* and invasive plants (Land et al., 2023);
– General issues of conservation of the common ash (*Fraxinus excelsior*) (Steinhart & Burzlaff, 2023);
–A review of global expansion, impact, and management practices (Sun et al., 2024);
– Distribution of invasive pathogen of ash dieback disease *Hymenoscyphus fraxineus* in Russia (Zviagintsev et al., 2023).

A reference list and a short summary of each of these publications are given at the end of this Newsletter and also on the Network's homepage on the webpage of EPPO (www.eppo.int/RESOURCES/special_projects/agrilus_planipennis_network). Most of the papers are available as full text via the provided links; others may be made available on request to the authors.

11. A closing remark

That is about all for the 3rd 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. Feel free to inform your colleagues in your country and around the world about the Newsletter. The email for correspondence is dm@eppo.int (Dmitrii Musolin).

12. References received (December 2023; with original abstracts when available)

Dang Y, Wang X, Zhang Y, Wei K, Cao L (2023) Physiological responses of *Agrilus planipennis* adults to short-time high-temperature conditions. *Scientia Silvae Sinicae* 59(2), 112–120. doi: 10.11707/j.1001-7488.LYKX20210691

Objective: This study aims to explore the cause of heat tolerance formation in *Agrilus planipennis* (emerald ash borer, EAB) adults from the physiological level, so as to provide guidance for revealing the formation mechanism of insect resistance to environmental stress.

Method: EAB male and female adults were incubated in different high temperature (30, 33, 37 and 41 °C) and 25 °C (served as the control) conditions for 4, 8 and 12 h, respectively, and the

insects were collected to measure the water content, fat content, and glycogen, glucose, trehalose, and protein content.

Result: With the increase of temperature and the extension of the duration of high temperature, the contents of water and fat in both male and female adults of EAB showed a downward trend. With temperature increasing, the glycogen content was increased, while the contents of glucose and trehalose increased first and then decreased, reaching the highest level at 33…37 ºC. The contents of glycogen, glucose and trehalose in the male and female adults all generally showed an upward trend with increasing time under high temperature. The protein content in the male and female adults increased with fluctuation with the increase of temperature, but gradually decreased with the extension of high temperature duration. The contents of water, fat and glycogen in EAB male adults were significantly higher than those in the female adults, while the contents of trehalose and protein were relatively lower than those in female adults.

Conclusion: Under short-time high-temperature conditions, the fat content, and various sugars and protein contents of EAB adults have changed obviously to some extent. The water and fat contents are less affected by temperature and the treatment duration, while the sugar and protein contents are significantly influenced by temperature and the treatment duration. Many stress-resistant substances, such as sugar and protein, play an important role in regulating the resistance of EAB adults against high temperature conditions.

Doonan JM, Kosawang C, Eisenring M, Ladd T, Roe AD, Budde KB, Jørgensen HJL, Queloz V, Gossner MM, Nielsen LR (2023) Transcriptome profiling of *Fraxinus excelsior* genotypes infested by emerald ash borer. *Sci Data* 10(1), 680. https://doi.org/10.1038/s41597-023-02588-z

European ash, *Fraxinus excelsior* is facing the double threat of ongoing devastation by the invasive fungal pathogen, *Hymenoscyphus fraxineus* and the imminent arrival of the non-native emerald ash borer (EAB), *Agrilus planipennis*. The spread of EAB which is currently moving westwards from European Russia and Ukraine into central Europe, poses an additional substantial threat to European ash, *F. excelsior*. While the molecular basis for resistance or variation in resistance among European ash genotypes is heavily investigated, comparatively little is known about the molecular ash traits involved in resistance against EAB. In this study we have gathered transcriptomic data from EAB inoculated genotypes of *F. excelsior* that have previously shown different levels of susceptibility to EAB. Resultant datasets show differential gene expression in susceptible and resistant genotypes in response to EAB infestation. This data will provide important information on the molecular basis of resistance to the EAB and allow the development of management plans to combat a pending threat of a culturally and ecologically important European tree species.

Gougherty AV, Elliott JM, LaRue EA, Gallion J, Fei S (2023) Positive association between Emerald ash borer residence time and accumulation of invasive plants. *Ecosphere* 14(12), e4719. https://doi.org/10.1002/ecs2.4719

Invasive forest pests can affect the composition and physical structure of forest canopies that may facilitate invasion by non-native plants. However, it remains unclear whether this process is generalizable across invasive plant species at broad spatial scales, and how other landscape characteristics may simultaneously facilitate non-native plant invasion. Here, we assembled a dataset of over 3000 repeatedly measured forest plots and quantified the impact of emerald ash borer (EAB, *Agrilus planipennis*) residence time, land cover, and forest structure on the accumulation and coverage of invasive plants. We show plots in counties with longer EAB residences tended to accumulate more invasive plants than plots with shorter EAB residences. On average, nearly half of the plots with ash (*Fraxinus* spp.) in counties with EAB accumulated an additional 0.48 invasive plant species over the 5- to 6-year resample interval compared to

plots with ash in counties without EAB at the time of sampling. Increases in invasive species coverage were also evident in counties with EAB—although residence time did not have a strong effect, while forest gap fraction and vertical complexity were each negatively associated with increased coverage. This work has implications for understanding how invasive forest pests can facilitate the spread of non-native plants.

Hauer R (2023) Emerald ash borer two decades later. *Tree Care Industry Association Magazine*. https://tcimag.tcia.org/tree-care/plant-health-care/emerald-ash-borer-two-decades-later/

Kucheryavenko TV (2022) Characteristics of infestation of ash stands by the emerald ash borer in the forests of the state unit Starobilsk LMG depending on the types of forest conditions. In: Plant Protection and Quarantine in the 21st Century: Problems and Prospects. Materials of the International scientific-practical conference dedicated to the anniversaries of the outstanding phytopathologists doctors of biological sciences, professors V. K. Panteleev and M. M. Rodygin (Kharkov, October 20–21, 2022), Kharkiv, 2022. 244 p. (ISBN 978-614-581-554-6), p. 119–121 (in Ukrainian)

In the summer of 2019, the presence of *Agrilus planipennis* was confirmed on the territory of the Luhansk region. During 2020, the pest was found at a distance of 32–52 km from the first detection point.

Land E, Kutschbach-Brohl L, Kane DD (2023) Change in forest tree composition on the Lake Erie Islands due to the invasion of the Emerald ash borer (*Agrilus planipennis*) and invasive plants. *Northeastern Naturalist* 30(4), 449–466; https://www.eaglehill.us/NENAonline/articles/NENA-30-4/15-Land.shtml

Since its initial invasion in 2002, *Agrilus planipennis* (Emerald Ash Borer [EAB]) has devastated *Fraxinus* (ash) species in forest communities of the Midwestern United States. The forests of the Lake Erie Islands have a unique composition that is typically divided into 2 categories: upland forests, which have rockier soil and bedrock above lake level, and lowland forests, which have deeper soil and bedrock below lake level. We used plot-sampling methods in selected wooded preserves of both upland and lowland forests on South Bass and North Bass islands, OH. We compared our findings with data collected on those 2 islands as well as Middle Bass and Kelleys islands in previous studies from before infestation, during initial infestation in the 2000s, and approximately one decade later to monitor ash loss and to determine which species were regenerating in these new canopy gaps. We calculated importance values and subsequent Boerner values through determination of relative frequency, relative coverage, and relative density of individual tree species within study plots. *Fraxinus pennsylvanica* (Green Ash) was most negatively impacted by the EAB while *Fraxinus quadrangulata* (Blue Ash) was still important in upland forests due to regeneration seen in small saplings. *Lonicera maackii* (Amur Honeysuckle) began filling in canopy gaps in upland forests and lowland forests, while invasive species like Morus alba (White Mulberry), *Rhamnus cathartica* (Common Buckthorn), and *Elaeagnus umbellata* (Autumn Olive) filled in the canopy gaps of lowland woods. The decline in ash populations due to the EAB has allowed for further growth of numerous invasive plant species and transformed the composition of Lake Erie Island forests.

Matula E, Bozsik G, Muskovits J, Ruszák C, Jávorszky L, Bonte J, Paulin M, Vuts J, Fail J, Tóth Á et al. (2023) The optimal choice of trap type for the recently spreading jewel beetle pests *Lamprodila festiva* and *Agrilus sinuatus* (Coleoptera, Buprestidae). *Insects* 14, 961. https://doi.org/10.3390/ insects14120961

Background: Two jewel beetle species native to Europe, the cypress jewel beetle, *Lamprodila* (*Palmar*, *Ovalisia*) *festiva* L. (Buprestidae, Coleoptera), and the sinuate pear tree borer, *Agrilus sinuatus* Olivier (Buprestidae, Coleoptera), are key pests of ornamental thuja and junipers and of orchard and ornamental rosaceous trees, respectively. Although chemical control measures are available, due to the beetles' small size, agility, and cryptic lifestyle at the larval stage, efficient tools for their detection and monitoring are missing. Consequently, by the time emerging jewel beetle adults are noticed, the trees are typically significantly damaged.

Methods: Thus, the aim of this study was to initiate the development of monitoring traps. Transparent, light green, and purple sticky sheets and multifunnel traps were compared in field experiments in Hungary.

Results: Light green and transparent sticky traps caught more *L. festiva* and *A. sinuatus* jewel beetles than non-sticky multifunnel traps, regardless of the larger size of the colored surface of the funnel traps.

Conclusions: Although light green sticky sheets turned out to be optimal for both species, using transparent sheets can reduce catches of non-target insects. The key to the effectiveness of sticky traps, despite their reduced suitability for quantitative comparisons, may lie in the behavioral responses of the beetles to the optical features of the traps.

Maze D, Bond J, Mattsson M (2023) Modelling impacts to water quality in salmonidbearing waterways following the introduction of Emerald Ash Borer in the Pacific Northwest, USA. Preprint (a paper is under review). https://www.researchsquare.com/article/rs-3396608/v1

Oregon ash (*Fraxinus latifolia* Benth.) wetlands and riparian forests are an important economic, cultural, and ecological resource in the Pacific Northwest, USA, and are threatened by the invasive insect, emerald ash borer (*Agrilus planipennis* Fairmaire) (EAB). Following the discovery of EAB in Forest Grove, Oregon in June of 2022, concern has focused on EAB-induced ash mortality that has the potential to alter vegetation communities and modify wetland hydrology by elevating the water table. Of primary concern is an increase in solar loading of waterways and wetlands that are already degraded beyond meeting their beneficial uses for Endangered Species Act-listed salmonids and other cold-water species following canopy dieback of Oregon ash. Our study, begun before the first detection of EAB on the West Coast, models potential impacts of EAB-mediated Oregon ash canopy loss to temperature-related water quality on two waterways in the vicinity of Portland, Oregon. Our results indicate a significant increase in solar loading with likely negative impacts to aquatic Endangered Species Act-listed salmonids, other aquatic wildlife, and associated habitat. We forecast greater impacts to these resources outside our study scope and include management considerations and recommendations for entities with water quality-related regulatory obligations.

Nalepa CA, Bohannon GR, Oten KLF (2023) Size of emerald ash borer in North Carolina, USA: Preliminary evidence for a sawtooth cline? *Agricultural and Forest Entomology*, 1–8. https://doi.org/10.1111/afe.12598

1. We test the hypothesis of Marshall et al. (2013) that in the United States there is a converse Bergmann's cline in body size of *Agrilus planipennis* (emerald ash borer, EAB), with the largest females (x = 12.6 mm length) collected at the most southern latitudes tested (37 °N).

2. In 2020, we employed three techniques to collect EAB at a North Carolina (NC) site located at 35.64 °N (purple prism traps [PPTs], log emergence, *Cerceris fumipennis* biosurveillance). The study was repeated in 2021, but with green funnel traps replacing log emergence. EAB collected by *C. fumipennis* in three altitudinally disparate regions of NC were also measured.

3. Overall, EAB collected in 2020 averaged 12.02 mm, with those emerged from logs significantly smaller than those from PPTs. Length of females collected from *C. fumipennis* at

three elevations was not significantly different and averaged 12.01 mm. In 2021, females collected from funnel traps, PPTs and *C. fumipennis* were not significantly different and larger (x = 12.41 mm) than in 2020; eliminating the smaller log-emerged EAB from the 2020 data set did not change the outcome.

4. Mean EAB size in NC never reached the reported 12.6 mm at 37 ºN, regardless of the technique or altitude tested. Our expansion of the latitudinal range in which EAB body size has been studied may shift the proposed converse Bergmann's cline to that of a sawtooth or other non-linear model, likely associated with a transition in EAB voltinism at or near NC latitudes.

Noseworthy MK, Souque TJ, MacQuarrie CJK, John EP, Gray M, Roberts J., Allen EA (2023) Testing the heat treatment dose for *Agrilus planipennis* (Coleoptera: Buprestidae) prepupae using the Humble water bath. *Journal of Economic Entomology*, toad211, https://doi.org/10.1093/jee/toad211

The lethal heat treatment dose (time and temperature) for the prepupal life stage of *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), emerald ash borer (EAB), was determined through an in vitro application using a carefully calibrated heat treatment apparatus. The lethal and sublethal effects of heat on *A. planipennis* prepupae were assessed through a ramped heat delivery application, simulating industrial kilns and conventional heat chamber operations, for treatments combining target temperatures of 54 ºC, 55 ºC, and 56 ºC, and exposure durations of 0 min (i.e., kiln temperature ramp only), 15 min, or 30 min. Prepupal EAB larvae did not survive exposure to 56 ºC for 15 min or longer, or to 55 ºC for 30 min. Sublethal effects were observed for all other treatments. Sublethal effects included delayed development and failure to complete the pupal and adult life stages.

Skrylnyk YY, Kucheryavenko TV, Zinchenko OV (2023) Distribution of the emerald ash borer *Agrilus planipennis* Fairmaire, 1888 (Coleoptera: Buprestidae) in the Kharkiv region. In: Plant Protection and Quarantine in the 21st Century: Problems and Prospects. Materials of the International scientific-practical conference dedicated to the anniversaries of the outstanding phytopathologists doctors of biological sciences, professors V. K. Panteleev and M. M. Rodygin (Kharkov, October 20–21, 2022), Kharkiv: 2022. 244 p. (ISBN 978-614-581-554-6), p. 142–145 (in Ukrainian)

Stanley RK, Carey DW, Mason ME, Doran A, Wolf J, Otoo KO, Poland TM, Koch JL, Jones AD and Romero-Severson J (2023) Emerald ash borer (*Agrilus planipennis*) infestation bioassays and metabolic profiles of green ash (*Fraxinus pennsylvanica*) provide evidence for an induced host defensive response to larval infestation. *Front. For. Glob. Change* 6, 1166421. doi: 10.3389/ffgc.2023.1166421

Introduction: Larvae of the invasive emerald ash borer [EAB, *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae)], kill over 99% of green ash (*Fraxinus pennsylvanica* Marshall) trees they infest, yet a small percentage of green ash ("lingering ash") survive years of heavy EAB attack. In the face of an ongoing invasion that threatens multiple North American *Fraxinus* species with extinction, any evidence for reproducible defensive responses in the native species merits investigation.

Methods: We evaluated the capacity of three families of green ash F1 progeny to kill EAB larvae when challenged in greenhouse studies by infestation with a uniform density of EAB eggs followed by dissection 8 weeks post-infestation and comparison of the host metabolomic profiles.

Results: The mean proportions of host-killed larvae in the two families of F1 progeny from lingering ash parents were significantly higher than that of host killed larvae in the family of

F1 progeny from susceptible ash parents ($p < 0.001$). Untargeted metabolomics comparing F1 progeny in the quartile with the highest percent host-killed larvae (HHK) to F1 progeny in the quartile with the lowest percent host-killed larvae (LHK) and to the uninfested F1 progeny within each family revealed evidence for induced biochemical responses to EAB. Infested trees produced significantly higher levels of select secoiridoids than uninfested trees, and LHK progeny produced significantly higher levels of select secoiridoids than the HHK progeny. HHK progeny produced significantly higher abundances of three metabolites annotated as aromatic alkaloids than the LHK and uninfested individuals.

Discussion: Based on these results, we hypothesize that green ash responds to EAB infestation. However, only certain trees have the genetic capacity to tailor a response that kills enough EAB larvae to prevent lethal damage to the vascular system. Rigorous tests of this hypothesis will require 15–20 years of additional crossing, phenotyping, and omics analyses. The results of this investigation will encourage the establishment and continuation of breeding programs that, in concert with biocontrol and management, could provide trees that slow, if not halt, the decimation of the *Fraxinus* gene pool. At the same time, ongoing work on host-insect interaction will contribute to our understanding of how forest trees recognize and defend themselves against phloem-feeding insects.

Steinhart F, Burzlaff T (2023) FraxForFuture – Erhalt der Gemeinen Esche (*Fraxinus excelsior*) als Wirtschaftsbaumart. Tagungsband im Rahmen der 63. Deutschen Pflanzenschutztagung am 27.09.2023 in Göttingen (Berichte Freiburger Forstliche Forschung Heft 106) [Conservation of the common ash (*Fraxinus excelsior*) as a commercial tree species (Proceedings of the 63rd German Plant Protection Conference hold on 27.09.2023 in Göttingen] https://www.fva-bw.de/fileadmin/publikationen/fff_bericht/Tagungband_FraxForFuture_final.pdf

Strygun O, Chumak P, Anyol O, Kivel Y (2023) Invasive and common arthropods – pests of plants of the genus *Fraxinus* L. in cenoses of Kyiv and Kyiv region. In: Shust OA et al. (eds). Actual Problems, Ways and Prospects of the Development of Landscape Architecture, Horticulture, Urban Ecology and Phytoremediation: Materials of the 3rd International Scientific and Practical Conference (Bila Tserkva, September 21, 2023). Bila Tserkva: BNAU. P. 54–57 (in Ukrainian) https://science.btsau.edu.ua/sites/default/files/tezy/actual_probl_landsh_arhitek_21.09.23.pdf

Route inspections of parks and squares were carried out in 2021–2023. The condition of the ash trees growing in the parks of Kyiv and the Kyiv region has deteriorated significantly due to a number of reasons: abiotic (climate change), anthropogenic (increasing recreational load) and biogenic factors (increasing the harmfulness of autochthonous species and increasing the number of invasive species of biota). Among the native pests, *Hylesinus fraxini* was the most harmful, and among the invasive ones – *Agrilus planipennis* and *Prociphilus fraxinifolii*. The simultaneous influence of these three phytophagous species in stands of ash can be a potentially real threat which can cause elimination of these trees from the urban phytocenoses.

Strygun OO, Fedorenko VP, Chumak PY, Vygera SM, Honcharenko OM, Anyol OH (2022) Emerald ash borer (*Agrilus planipennis* Fairmaire) in Kyiv parks. In: Plant Protection and Quarantine in the 21st Century: Problems and Prospects. Materials of the International scientific-practical conference dedicated to the anniversaries of the outstanding phytopathologists doctors of biological sciences, professors V.K. Panteleev and M.M. Rodygin (Kharkov, October 20–21, 2022), Kharkiv: 2022. 244 p. (ISBN 978-614-581-554-6), p. 189–201 (in Ukrainian).

https://scholar.google.com/citations?view_op=view_citation&hl=ru&user=U2vU8_oAAAAJ&sortby=pubdate&citation_for_view=U2vU8_oAAAAJ:Fu2w8maKXqMC

> It was established that in the park of the National Technical University of Ukraine KPI named after Igor Sikorskyi, the plantations of common ash are completely degraded due to the influence of the emerald ash borer *Agrilus planipennis* Fairmaire. In the near future, we should expect the appearance of this dangerous pest in other localities (botanical gardens, parks, squares) where plants of the genus *Fraxinus* L. are grow in Kyiv.

Sun J, Koski T-M, Wickham JD, Baranchikov YN, Bushley KE (2024) Emerald ash borer management and research: Decades of damage and still expanding. *Annual Review of Entomology* 69, 239–258 https://doi.org/10.1146/annurev-ento-012323-032231

> See the abstract above, in Section 7

Zhuravleva YN, Karpun NN (2023) The first record of the emerald ash borer (*Agrilus planipennis* Fairmaire) in Stavropol. *Subtropical and Ornamental Horticulture* 85, 169–178 (in Russian) https://journal.subtropras.ru/archive/85/13/ ; DOI: 10.31360/2225-3068-2023-85-169-178

> A phytosanitary survey of urban forests in Stavropol was conducted in February 2023. *A. planipennis* was found in plantations of Roundwood, Chlin forest, and mountain area "Tamanskaya lesnaya dacha". In the lower and middle part of the trunks under the bark, characteristic, highly convoluted, spiral larval passages and larvae clogged with frass were found, as well as D-shaped flight holes with a diameter of about 4–5 mm typical for the emerald ash borer at the exit points of the beetles. The structure of the larvae and the shape of the flight holes made it possible to identify the species of the pest. The results of the survey suggest that the reason for ash's desiccation in the urban forests of Stavropol was the emerald ash borer. This record is the first for Stavropol and Stavropol Krai. Most likely, the settlement of the emerald ash borer occurred no later than 2020.

Zobrist K, Bomberger RA, Darr MN, Glass JR, Hulbert JM, Roberts ES (2023). Emerald ash borer and its implications for Washington state. Washington State University Extension. https://doi.org/10.7273/000005546

> The emerald ash borer (EAB), *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), is a destructive invasive insect native to eastern Asia that was accidentally introduced to North America in the Detroit, Michigan, area in the 1990s. Since then, EAB has caused almost 100% ash mortality in the areas it has spread in North America. Despite quarantine and control measures, EAB continues to spread across the US and parts of Canada. In June 2022, EAB was found in northwest Oregon near the Washington border. Oregon ash (*Fraxinus latifolia*), the Pacific Northwest s (PNW) only native ash species, is highly susceptible to EAB and could experience significant mortality throughout the region. Susceptible ash species native to Europe and eastern North America are commonly used as ornamentals in Washington cities, so urban and community forests could also be significantly impacted. This publication is intended for Extension professionals, Master Gardeners, public agency personnel, tree care professionals, and those who are interested in an in-depth review of the current state of knowledge about EAB and the implications for potential damage and mitigation strategies in Washington State. A separate publication, Managing Emerald Ash Borer in Washington State (Zobrist et al. 2023), is available for readers looking for a summary of EAB identification, distribution, impacts, and management recommendations.

Zviagintsev VB, Demidko DA, Panteleev SV, Pashenova NV, Seraya LG, Yaruk AV, Baranchikov YN (2023) Distribution of invasive pathogen of ash dieback disease

Hymenoscyphus fraxineus in European part of Russia. *Izvestia Sankt-Peterburgskoj Lesotehniceskoj Akademii* 244, 88–117 (in Russian with English summary). DOI: 10.21266/2079-4304.2023.244.88-117 https://elibrary.ru/item.asp?id=54476740; https://spbftu.ru/science/general-science-information/publications; https://disk.yandex.ru/d/RuW8fAEPlMdQZg

As a result of the three-years long fixed-rout survey ash back disease caused by invasive ascomycete *Hymenoscyphus fraxineus* (T. Kowalski) Baral, Queloz, et Hosoya was detected on the territory of 31 subjects of the Russian Federation for the first time. This territory is one fifth part of European range of *Fraxinus excelsior*. Ash dieback appeared to be widespread pathology of ash at all examined regions of Russia. Genetic material of this pathogen was found in 163 from 178 analyzed samples with disease symptoms. Overall occurrence of the disease was 96,7%. Ash forests of Central and Southern Federal Districts were characterized by relatively low level of ash trees infestation (19,7 and 13,6% accordingly) in comparison with Northern Caucasus and Volga Districts were tee infestation has reached 27,9 and 29,0% accordingly. Levels of tree infestation of the most common ash species F. excelsior and *F. pennsylvanica* are not significantly different: 17,8 and 21,2% accordingly. The luck of information about this prominent pathology of ash can be partially explained by masking of its symptoms by damage of ash trees caused by emerald ash borer *Agrilus planipennis* Fairmaire, distributed on the territory of 20 European subjects of the Russian Federation and also by often ground fires. There is an urgent need of including this pathogen into the list of partially distributed quarantine organisms on the territory of the Eurasian Economic Union. The main efforts should be concentrated on discovery of pathogen resistant genotypes and populations of ash for producing resistant plant forms, creation of genetic reservation zones and seed orchards.