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 Eduard Jendek.

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1. Introduction

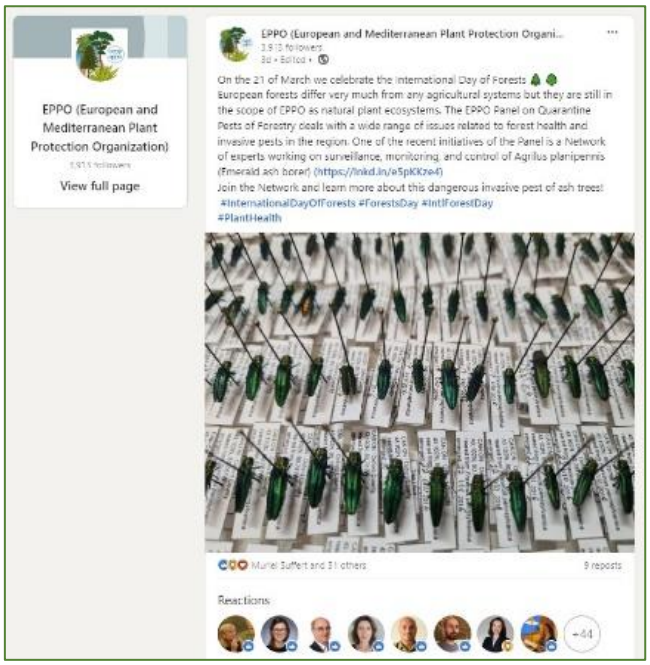
Welcome to the 4th issue of the Newsletter of the EPPO Network of experts working on surveillance, monitoring, and control of the Emerald ash borer, *Agrilus planipennis*. This Network was established by the European and Mediterranean Plant Protection Organization (EPPO) following the decision made in 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 3rd issue of the Newsletter, the Network coordinator received information about exchange of specimens, new conferences, documents, projects and publications about *A. planipennis*. This information made it possible to prepare the 4th 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 the end of March 2024, the Network has more than **240 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. The International Day of Forests and the Network in social media



Every year since 2013, by the resolution of the United Nations General Assembly, on 21 of March the International Day of Forests has been celebrated around the world. This year, EPPO highlighted the activity of the Network in its social media and invited colleagues to learn more about Emerald ash borer, and the fact it is a dangerous invasive pest of ash trees and to join the EPPO Network: see posts in Linkedin and X(Twitter).

4. Talks on *Agrilus planipennis* at a conference on Protection and Quarantine of Forests

A photo from the conference organizers (by A. Alekseenko).

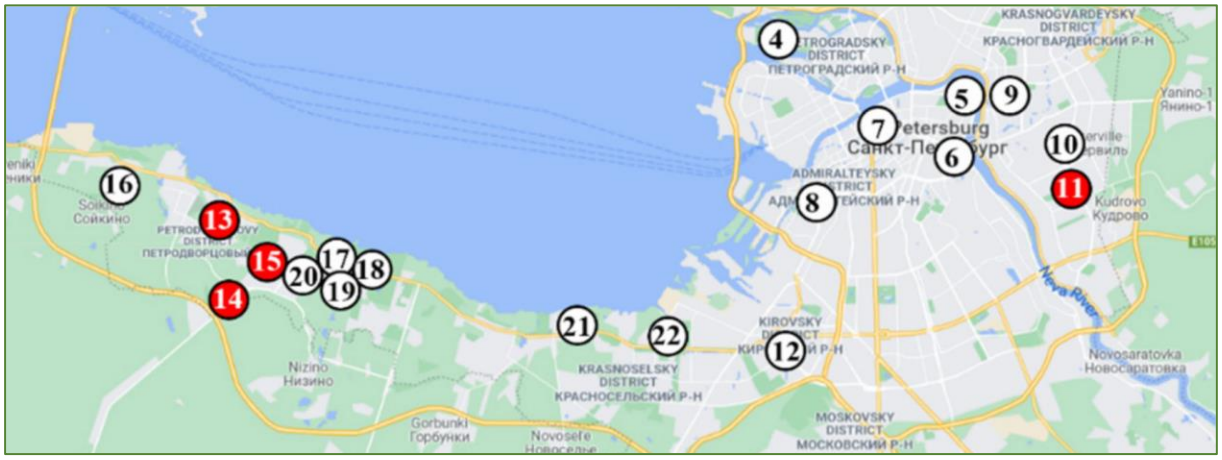
To celebrate the International Day of Forests, an international conference on Protection and Quarantine of Forests was organized on 21 and 22 of March 2024 in Moscow. It was attended in person or remotely by more than 240 participants from 8 countries. Proceedings are available (mostly in Russian). Among 70 talks on different subjects, *Agrilus planipennis* was discussed in five:

- Baranchikov Yu.N., Zviagintsev V.B., Seraya L.G. Distribution and interaction of invasive species of pathogen and wood borer of ash trees in European part of Russia;
- Gninenko Yu.I. Invasive dendrophilic organisms – a modern challenge to forestry;
- Ryaskin D.I., Kulinich O.A., Selyavkin S.N., Fedyaev R.A. On the study of some invasive and quarantine forest harmful insects in the Voronezh Region;
- Selikhovkin A.V. Invasive pests and pathogens of wood plants in St. Petersburg;
- Sinchuk A.V. Monitoring tree plantings for the purpose of identifying *Agrilus planipennis* Fairmaire, 1888 in Belarus. [*a note for readers*: in spite of monitoring the Emerald ash borer **has not been recorded in Belarus**]

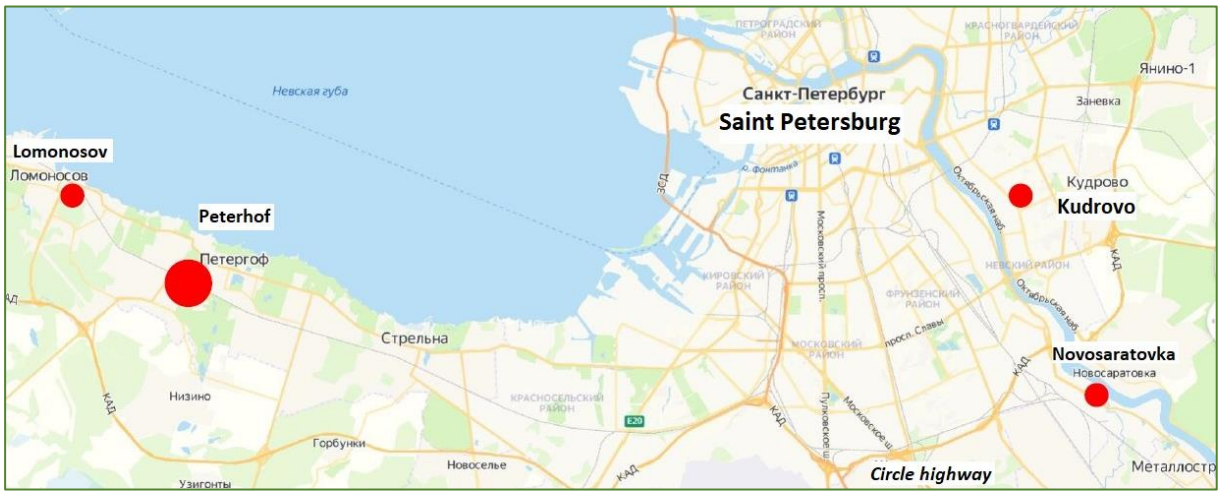
The activity of our Network and importance of international collaboration forest quarantine was highlighted in the talk of D. Musolin (EPPO Secretariat).

5. An update on the situation of *Agrilus planipennis* in St. Petersburg, Russia

At the conference in Moscow (see Section 4), Andrey Selikhovkin (Saint Petersburg State Forest Technical University) presented an update on the situation of *A. planipennis* in St. Petersburg. The pest was detected in the city in 2020 (Selikhovkin et al. [2022]. Invasive populations of the Emerald ash borer *Agrilus planipennis* Fairmaire, 1888 (Coleoptera: Buprestidae) in Saint Petersburg, Russia: A hitchhiker? *Insects* 2022, 13, 191. https://doi.org/10.3390/insects13020191) in two districts (the data on the map is for 2020 and 2021; red circles indicate locations at which the beetle was detected, while white circles represent locations at which it was not detected; see further details in the paper):



Three years later (in summer 2023) and after some control measures taken in the city in 2022 (including removal of infested trees), *A. planipennis* was still present in the same two districts of the city where it was found in 2020, and has spread southward, outside of the city circle highway (see on the lower part of the map; the pest is recorded in the settlement Novosaratovka):

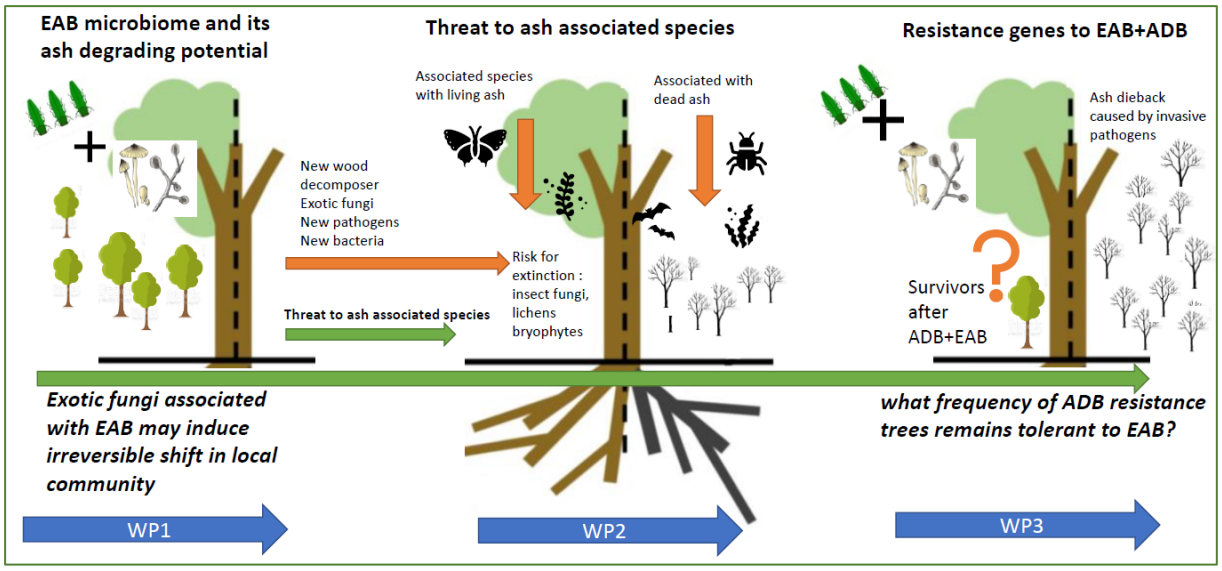


Galleries of *A. planipennis* in ash trees in Nevsky District of St. Petersburg. Photos by B.G. Popovichev (Saint Petersburg State Forest Technical University), 2022 and 03-2024.

6. A new research project on *Agrilus planipennis*

A research team from the Swedish University of Agricultural Sciences (SLU) received a grant from *Formas*, the Swedish Research Council for Sustainable Development. The main applicant, **Kateryna Davydenko** (Department of Forest Mycology and Plant Pathology at SLU), was awarded SEK 4 000 000 for a 4-year period for the project starting in January 2024 and entitled '***Meet Me Halfway: Preservation of forest biodiversity in the face of alien species invasions***'.

Due to the global trade and climate change, forests are exposed to unprecedented threats from invasive pests and pathogens. Irreversible economic and ecological losses of ash (*Fraxinus*) species have been predominantly related to ash dieback fungus, *Hymenoscyphus fraxineus* in Europe and the Emerald ash borer, *A. planipennis* in North America, both of which originate from Far East Asia. These pests have inflicted extensive damage upon ash populations in North America and Europe, resulting in irretrievable losses in biodiversity and ecosystem functionality. Recently, ranges of these invasive species overlapped in Europe (e.g. in Ukraine). As the spread of Emerald ash borer towards western Europe seems inevitable, we expect that *Fraxinus* species, in particular *F. excelsior*, and their associated flora and fauna species in Europe will be at risk of further decline or even extinction. To address this pressing issue, a collaborative effort involving researchers from Sweden, Ukraine, Poland, Latvia, and Lithuania has been proposed by a scientific society.



A conceptual model of the Work Packages (WPs). The WP1 will identify the microbiome associated with Emerald ash borer (EAB) beetles and EAB galleries with a special focus on wood decomposers and their wood degrading potential and new knowledge on insects role in ash dieback fungus (ADB) spread. The second WP will list ash-associated species and cumulative impact assessments of multiple host loss from ash dieback fungus. Data from WP1/WP2 will help to study and model interaction effects of newcoming species on local biodiversity before Emerald ash borer arrival to EU. The third WP will identify gene loci and develop a set of markers for traits related to tolerance to ash dieback fungus and Emerald ash borer.

This multidisciplinary project aims to investigate various aspects of the Emerald ash borer and ash dieback fungus invasion, including the fungal diversity associated with Emerald ash borer, the cumulative impacts of ash dieback fungus on biodiversity, and the search for genetic markers related to resistance to both pests.

Identifying fungal diversity associated with Emerald ash borer: The first work package focuses on understanding the composition and functional role of fungal communities associated with Emerald ash borer galleries in ash trees. By examining wood decomposition potential and the impact of Emerald ash borer -associated fungi on local biodiversity, researchers aim to gain insights into the mechanisms underlying ash decline and mortality.

Assessing cumulative impacts of ash dieback fungus on biodiversity: The second work package seeks to assess the cumulative impact of ash dieback fungus on ash-associated biodiversity within the same ecosystem. By studying ash-dominated woodlands in Sweden, researchers aim to identify changes in species composition and functional redundancy in response to ash decline induced by *Hymenoscyphus fraxineus*.

Searching for gene models and markers related to resistance: The third work package focuses on identifying genetic markers associated with resistance to both ash dieback fungus and Emerald ash borer. By analysing ash leaf samples from affected regions, researchers aim to develop a genotyping panel for screening resistance traits in ash populations. This research will provide valuable insights into the genetic basis of resistance and inform breeding programs aimed at developing resilient ash varieties.

We will keep readers informed about development of the project.

7. A request for *Agrilus planipennis* samples from native and invasive ranges

The Network received the following request from Canada:

I am a Research Scientist with the Canadian Food Inspection Agency investigating the adaptation genomics of the Emerald ash borer. I have been able to procure many specimens from EAB's North American invasive range, but am currently looking for specimens that have been sampled from European and Asian portions of its range, and am looking for assistance with collection efforts in these regions. I can supply pheromone lures for traps, send supplies to help with specimen collection, and cover shipping charges associated with transportation of samples to Canada. This project is focused on sampling populations of EAB, so I am hoping to be able to procure between 15 and 20 specimens per location, and have samples preserved in such a way as to be usable for whole genome sequencing. I can work with any life stage (except for eggs), though the sampling considerations for larvae/pupae are different than for adults. If you think you may be able to help with specimen collection, please contact me for more details, I am happy to work out an arrangement that benefits all parties as best as possible.

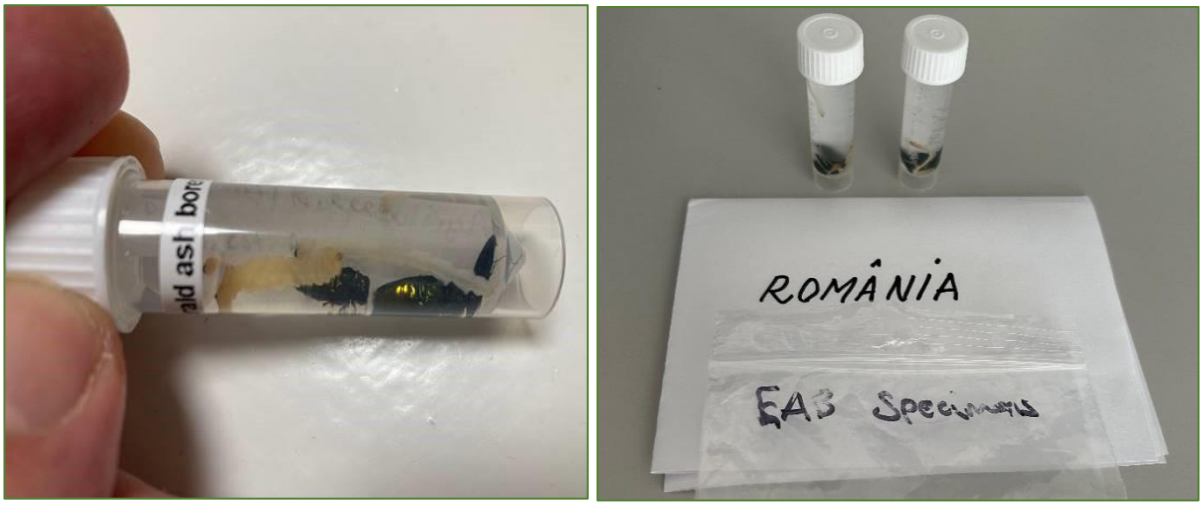
Thank you very much,

Erin Campbell, email: erin.campbell@inspection.gc.ca

Please, contact Erin Campbell if you can help with specimens from Eurasia.

8. 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 Sweden and Romania 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.



Samples of *A. planipennis* from the United Kingdom received by Sweden (left) and Romania (right). Photos by N. Björklund (left) and M. Cena (right).

We also received an email from Chris MacQuarrie (Canadian Forest Service) who kindly and very generously offered a box of adults of *A. planipennis* to the EPPO Network for distribution to NPPOs and/or national reference collections who need them.

Samples were offered to experts who attended the 10th Meeting of the EPPO Panel on Diagnostics in Entomology which was held in Paris in March 2024. The experts were very enthusiastic and happily took samples to enrich their national reference collections. More reference specimens are still available at the EPPO Headquarters. Thank you, Canadian Forest Service!

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).

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

On 5th of February 2024, the European Commission published a new Commission Implementing Regulation (EU) 2024/434 on measures to prevent the establishment and spread of *Agrilus planipennis* Fairmaire within the Union territory. This regulation describes 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 carry out annual reporting. The draft considers *Fraxinus* L. and *Chionanthus virginicus* L. (other than fruits, seeds, pollen and plants in tissue culture) as specified plants (hosts).

10. News from of the European Union Reference Laboratory

Raphaëlle Mouttet (Deputy Head) and Pascal Rousse (Scientific project leader in Entomology) from the European Union Reference Laboratory for insects and mites (EURL), a consortium of ANSES (France) and AGES (Austria),informed the Network about their news:

Work on *Agrilus planipennis* comprises a major part of the 2024 working program of the EURL. The EURL conducted an internal validation study on the EPPO PM 7/154 (1) diagnostic protocol. This was to ensure the robustness of the method when applied to a range of *A. planipennis* specimens and closely related species. The study was carried out for the morphological part of the protocol with both adults and larvae. The results, which will be presented at the next EURL workshop, showed that some points in the document may be improved. These will be proposed to the EPPO Panel on Diagnostics in Entomology for inclusion in the next version of the protocol.

Having tested the method, the EURL is now testing the ability of the EU National Reference Laboratories (NRLs) to use it. This is the objective of the 2024 Proficiency Test (PT). Each of the 26 NRLs will be sent a panel of 12 coded adult samples, including *A. planipennis* and other species of Buprestidae. This morphological PT will be followed later in the year by a molecular PT on the same target. The participation of the NRLs is an obligation set by the European Commission to ensure that they are able to enforce the current regulation, and therefore to detect and monitor any introduction of the pest into Europe. Third countries, especially EFTA members, are also invited to participate.

Our Network also contributed to this important work by providing some samples which we had received from Canada:

11. The EFSA Pest survey card on *Agrilus planipennis* has been updated

Version 2 of the EFSA Pest survey card on *Agrilus planipennis* was recently published online.

Suggested citation: EFSA (European Food Safety Authority), 2023. Pest survey card on *Agrilus planipennis*. EFSA supporting publication 2023:EN-8479. Available online: https://efsa.europa.eu/plants/planthealth/monitoring/surveillance/agrilus-planipennis.

Details of the last update and a pdf version.

Heading picture: © I. Graziosi / Forest Entomology Lab University of Kentucky (*Agrilus planipennis* larval galleries on ash timber, KY, USA).

12. News dissertation using *Agrilus planipennis* as a model

Recently, a new MSc dissertation in which *A. planipennis* was used as a model was prepared and publicly presented in Canada:

Newell J (2024) Ash tree regeneration & decline in Lake Simcoe Watershed. Master's in Forest Conservation. University of Toronto, Canada. https://hdl.handle.net/1807/131068

Abstract: The invasive emerald ash borer (*Agrilus planipennis*, EAB) is currently a major threat to ash trees throughout southern Ontario. We examined 20 plots in the Lake Simcoe Watershed in the years 2017 and 2023 to determine the effect that EAB had on the regeneration of the three major ash species in the region: white (*Fraxinus americana*), black (*Fraxinus nigra*), and red ash (*Fraxinus pennsylvanica*). Analysis was conducted to determine if there were declines in any of the canopy, sub-canopy, shrub layer, ground layer, and basal area of ash trees over the period of six years. Significant decreases were found in both the canopy and basal area but not in the sub-canopy, shrub layer, or ground layer. EAB was found to be having a significant negative effect on only the most mature trees. However, the lower levels were found to have remained the same, indicating that seed production from the top layer has not been significantly hindered by EAB infestation.

13. 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 (*Agrilus anxius* and *Hymenoscyphus fraxineus*) has been received (12 journal papers, 2 conference abstracts, and 2 assessment reports; in addition to the data on a new dissertation see in Section 12). The range of topics is very wide and includes the following:

- Dynamics of spread of *A. planipennis* in Ukraine (Kucheryavenko, 2022);
- Effect of the forest site and stand structure on distribution of *A. planipennis* in Eastern Ukraine (Meshkova et al., 2024);
- Environmental consequences of the invasion of *A. planipennis* into the Lower Volga region of Russia (Sergeeva, 2023);
- Tree regeneration after *A. planipennis* (Abella et al., 2024);
- A threat of *A. planipennis* to lichen community (Clayden et al., 2023);
- Impacts of *A. planipennis* on stream shading and hydrologic processes in a riparian forest (Kimball, 2024; Krzemien et al., 2024);
- Parasitoid-induced changes in metabolic rate and feeding activity of *A. planipennis* and implications for biological control (Dang et al., 2023);
- Spread management priorities to limit *A. planipennis* impacts on street trees (Hudgins et al., 2024);
- Economic costs of invasive non-native species in urban areas, including *A. planipennis* (Heringer et al., 2024);
- Assessment of invasive alien species and their control (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES], 2023);
- Development of novel LAMP and qPCR assays for rapid and specific identification of *Agrilus anxius* (Peterson et al., 2023);
- Efficacy of trapping protocols for *Agrilus* jewel beetles (Santoiemma et al., 2024);
- Provision of horizon scanning and analysis of pathways of spread of invasive species into Scotland (UK Centre for Ecology and Hydrology, 2023) (*A. planipennis* is mentioned);
- Conservation of green and white ash germplasm using the cryopreservation of embryogenic cultures (Richins et al., 2024);
- A review of ash dieback in Europe (Carroll & Boa, 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.

14. A closing remark

That is about all for the 4th 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).

15. References received (March 2024; with original abstracts when available)

Abella SR, Menard KS, Schetter TA, Hausman CE (2024) Species and landscape variation in tree regeneration and 17 years of change in forested wetlands invaded by emerald ash borer. *Forest Ecology and Management* 557, 121750, https://doi.org/10.1016/j.foreco.2024.121750, https://www.sciencedirect.com/science/article/pii/S0378112724000628

Understanding variation in tree regeneration among species and sites, and how well forest size class distribution (seedlings, saplings, and trees) portends long-term species compositional change, may assist managing forests during contemporary global change rapidly altering forests, such as after invasion by introduced pests. In northwestern Ohio, one of the North American regions longest invaded by emerald ash borer (EAB, *Agrilus planipennis*), we 1) examined variation in size class abundance among tree species and sites in 22 forested wetlands in 2018 and 2021; and 2) assessed how closely size class distribution of tree species in 2005, at the onset of EAB invasion before *Fraxinus* trees died, forecasted observed forest change during the next 17 years. In 2018 and 2021, three major groups of tree species emerged with respect to their frequency across size classes: 1) species commonly in all three, or at least two, size classes on a site, 2) species frequent in only one size class, which varied but was often seedlings, and 3) species almost always present only as trees, with little advance regeneration. Shade tolerance correlated with species occurring in all three size classes. Among sites in 2018 and 2021, abundance of regeneration and similarity of species composition across size classes varied between years (largely from fluctuations in seedlings) and with site factors. Sites with the least regeneration had high soil available water capacity and high cover of graminoids. On long-term sites after the onset of EAB invasion in 2005, all seedling-to-sapling and sapling-to-tree advancements recorded through 2021 were from species already present in 2005, and only shade-tolerant species (e.g., *Ulmus americana*) advanced. Results suggest that there is substantial variation in advance regeneration availability among species and sites in forested wetlands across the EAB-invaded landscape. Portions of this variability were structured into well-demarcated groups of similarly responding species and sites, were associated with species traits such as shade tolerance and site factors such as soil texture, and were prognostic of forest changes within the first two decades after EAB invasion.

Carroll D, Boa E. (2024) Ash dieback: From Asia to Europe. *Plant Pathology* 73, 741–759. https://doi.org/10.1111/ppa.13859

Ash dieback is a disease caused by the fungal pathogen *Hymenoscyphus fraxineus*. Since its emergence in the 1990s, this pandemic disease has spread throughout much of the native range of its host species, the European ash (*Fraxinus excelsior*). Where present, it can kill up to 85% of ash trees. The loss of these trees has had an enormous impact, particularly in Britain and Ireland where they formed an integral component of wood and farmland, supporting complex communities of other species. Thanks in part to widespread public interest, the ash dieback pandemic has also had a large political impact, leading to changes in the management of plant diseases. Now, three decades after the emergence of the disease, ambitious projects to breed tolerant plants, and evidence of natural selection for resistance, give hope for the recovery of European ash. The aim of this review is to provide an overview of the history of the ash dieback pandemic, from its emergence to current efforts to mitigate its effects. We discuss the emergence of ash dieback and the wide body of research that has led to our current understanding of the disease. We question which aspects of the disease have led to it holding a particular interest to the public. With a focus on the islands of Britain and Ireland, we discuss how this has driven changes in the management of plant diseases, which may give hope for the control of emerging pathogens in the future.

Clayden SR, Driscoll KE, Harries H (2023) The lichen genus *Rinodina* (Physciaceae) in New Brunswick, Canada. *Canadian Field-Naturalist* 137(1–2), 32–63. https://doi.org/10.22621/cfn.v137i1.3193

Fifteen species of the crustose lichen genus *Rinodina* are confirmed in New Brunswick, Canada. We report four corticolous species, *Rinodina pachysperma*, *Rinodina populicola*, *Rinodina septentrionalis*, and *Rinodina tenuis*, and the saxicolous *Rinodina tephraspis* in the province for the first time. A previous report of *Rinodina granuligera* is based on a specimen that we have re-identified as *Rinodina cinereovirens*. We note distinguishing characteristics, habitats, substrata, relative abundance, and biogeographic relationships of each species and provide an identification key and distribution maps. The most frequently occupied phorophytes (tree substrata) are Sugar Maple (*Acer saccharum*), Yellow Birch (*Betula alleghaniensis*), and Eastern White Cedar (*Thuja occidentalis*). Some species are closely associated with particular habitats, phorophytes, or both. For example, we found *R. pachysperma* only in floodplain forests dominated by Silver Maple (*Acer saccharinum*), and *R. tenuis* only on Eastern White Cedar in wet cedar-dominated stands. In contrast, we recorded *Rinodina freyi* on numerous phorophyte species in a relatively wide range of habitats. Other than Eastern White Cedar and Balsam Fir (*Abies balsamea*), conifers are rarely colonized by *Rinodina* species in New Brunswick. Most *Rinodina* species are probably not currently of conservation concern in the province. However, *R. cinereovirens* is known from only two collections, one dating from 1902. The other, from 2007, was on Black Ash (*Fraxinus nigra*) in a swamp forest next to an active peat-mining operation. The expected devastation of ash species by the invasive Emerald Ash-borer (*Agrilus planipennis*) is a further threat to this occurrence and to any lichens for which ash may be an important phorophyte.

Dang YQ, Duan JJ, Li AY (2023) Parasitoid-induced changes in metabolic rate and feeding activity of the emerald ash borer (Coleoptera: Buprestidae): implications for biological control. *Sci Rep* 13, 22663. https://doi.org/10.1038/s41598-023-50147-8

Parasitoid-host interactions form the foundation of biological control strategies against many agriculture and forest insect pests. The emerald ash borer (EAB), *Agrilus planipennis* (Coleoptera: Buprestidae), is a serious invasive pest of ash (*Fraxinus* spp.) trees in North America. *Tetrastichus planipennisi* (Hymenoptera: Eulophidae) is a gregarious, koinobiont endoparasitoid, attacking late (3^{rd} to 4^{th}) instars of EAB larvae, which feed in the live phloem of ash trunks or branches, making serpentine-like galleries filled with larval frass. In the present study, we tested the hypothesis that *T. planipennisi* regulates the host metabolism and feeding activity to optimize its offspring development and fitness. We first compared the respiration rate of parasitized and unparasitized host larvae at different times after parasitism, and then measured feeding activity of both parasitized and unparasitized host larvae inside their feeding galleries. Although parasitized host larvae increased metabolic rate and feeding activity in the first few days of parasitism, *T. planipennisi* parasitism induced an overall reduction of the metabolic rate and decrease in feeding activity of parasitized host larvae over their development period. In addition, there was a negative relationship between feeding activity of parasitized hosts and brood sizes of the parasitoid progeny—i.e., the more parasitoid progeny a host larva received, the less feeding activity the host had. These findings suggest that *T. planipennisi* has limited ability to optimize its offspring development and fitness through regulations of the host metabolism and feeding activity and its parasitism reduces feeding damage of parasitized EAB larvae to infested ash trees.

Heringer G, Fernandez RD, Bang A, Cordonnier M, Novoa A et al. (2024) Economic costs of invasive non-native species in urban areas: An underexplored financial drain. *Sci Total Environ*. 917: 170336. doi:10.1016/j.scitotenv.2024.170336

> Urbanization is an important driver of global change associated with a set of environmental modifications that affect the introduction and distribution of invasive non-native species (species with populations transported by humans beyond their natural biogeographic range that established and are spreading in their introduced range; hereafter, invasive species). These species are recognized as a cause of large ecological and economic losses. Nevertheless, the economic impacts of these species in urban areas are still poorly understood. Here we present a synthesis of the reported economic costs of invasive species in urban areas using the global InvaCost database, and demonstrate that costs are likely underestimated. Sixty-one invasive species have been reported to cause a cumulative cost of US$ 326.7 billion in urban areas between 1965 and 2021 globally (average annual cost of US$ 5.7 billion). Class Insecta was responsible for >99 % of reported costs (US$ 324.4 billion), followed by Aves (US$ 1.4 billion), and Magnoliopsida (US$ 494 million). The reported costs were highly uneven with the sum of the five costliest species representing 80 % of reported costs. Most reported costs were a result of damage (77.3 %), principally impacting public and social welfare (77.9 %) and authorities-stakeholders (20.7 %), and were almost entirely in terrestrial environments (99.9 %). We found costs reported for 24 countries. Yet, there are 73 additional countries with no reported costs, but with occurrences of invasive species that have reported costs in other countries. Although covering a relatively small area of the Earth's surface, urban areas represent about 15 % of the total reported costs attributed to invasive species. These results highlight the conservative nature of the estimates and impacts, revealing important biases present in the evaluation and publication of reported data on costs. We emphasize the urgent need for more focused assessments of invasive species' economic impacts in urban areas.
>
> ['… The five costliest species, according to reported costs in the database, were … the emerald ash borer (*Agrilus planipennis* US$ 3.7 billion [1.1 %], n = 13']

Hudgins EJ, Hanson JO, MacQuarrie CJK, Yemshanov D, Baker CM, Chadès I, Holden MH, McDonald-Madden E, Bennett JR (2024) Spread management priorities to limit emerald ash borer (*Agrilus planipennis*) impacts on United States street trees. *Conservation Science and Practice*, e13087. https://doi.org/10.1111/csp2.13087

> The invasive emerald ash borer (*Agrilus planipennis*) causes damage to street trees which is estimated to reach US$ 900 million over the next 30 years. Although millions of dollars are spent annually to control this species, spatiotemporal management plans are often based on rules of thumb that ignore future pest dispersal. Here, we reveal an optimal management strategy to protect urban trees in North America from *A. planipennis*. To achieve this, we embedded a pest dispersal model within a mixed integer programming framework. We discovered that optimized strategies consistently outperformed those based on rules of thumb, potentially resulting in the protection of an additional nearly 1 million street trees and savings of $ 629 million. Critically, the best management strategies always relied on quarantines and biological control (constituting 98–99% and 1–2% of the project budget, respectively), in contrast with current practices, where federal spending has been diverted to biological control. Our findings serve to inform future pest control efforts and can help protect many more trees from this invasive species.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2023) Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy HE, Pauchard A, Stoett P, Renard Truong T (eds.). IPBES Secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.7430682

> IPBES is an independent intergovernmental body comprising over 140 member Governments. Established by Governments in 2012, IPBES provides policymakers with objective scientific assessments about the state of knowledge regarding nature and the contributions it provides to people, as well as options for actions to protect and sustainably use these vital natural assets. The Assessment of Invasive Alien Species and their Control was initiated by a decision from the IPBES Plenary (decision IPBES-6/1) at its sixth session (IPBES 6, Medellin, Colombia, 2018), based on the scoping report (annex III to decision IPBES-4/1) approved by the Plenary at its fourth session (IPBES 4, Kuala Lumpur, Malaysia, 2016). The Assessment was produced in accordance with the procedures for the preparation of the Platform's deliverables set out in annex I to decision IPBES-3/3. The Assessment of Invasive Alien Species and their Control was considered by the IPBES Plenary at its tenth session (IPBES 10, Bonn, Germany, 2023), which approved its summary for policymakers, and accepted its chapters. All material can be found here: https://www.ipbes.net/ias

Kimball V (2024) Potential impacts of emerald ash borer (*Agrilus planipennis*) on stream shading from riparian plant communities in Pacific Northwest ash-dominated forested wetlands. Urban Ecology & Conservation Symposium 2024 (11th March, 2024). https://pdxscholar.library.pdx.edu/uerc/2024/Presentations/2/

> With the arrival of the emerald ash borer (*Agrilus planipennis*) in the Pacific Northwest, it is suspected that a substantial portion of forested wetlands in the Willamette Valley may transition to scrub-shrub communities with significantly reduced canopy heights. This is due to the expected functional extirpation of Oregon ash (*Fraxinus latifolia*) and a lack of suitable replacement native tree species adapted to the poorly drained clay soils commonly found in low-lying areas throughout the region. Reduced canopy height will presumably influence the amount of stream shading provided by wetland vegetation in riparian communities, which could negatively impact salmonids and other temperature-sensitive aquatic species. We examined how shading in stream-wetland complexes may be affected by a reduction in local canopy height by taking canopy cover measurements at the thalweg and comparing that to the vegetation height from the most recently published LiDAR data. We found that canopy height was moderately correlated with canopy cover over smaller streams (average wetted width of 8.6 ft) with an R2 of 0.265. These statistical analyses, along with some site-by-site comparisons, indicate that though canopy height is predictive of canopy cover to some extent, it is likely that a mature scrub-shrub community can produce a level of shade comparable to that provided by a forested wetland community for small stream systems.

Krzemien S, Robertson WM, Engelken PJ, McCullough DG (2024) Observations of reduced ET and persistent elevated water table beneath a riparian forest gap following emerald ash borer invasion and tree mortality. *Hydrological Processes* 38(4), e15117. https://doi.org/10.1002/hyp.15117

> Emerald ash borer (EAB) (*Agrilus planipennis* Fairmaire), an invasive, phloem-feeding beetle native to Asia, has killed millions of ash (*Fraxinus* spp.) trees in North America since it was detected in southeast Michigan in 2002. Consistently high mortality of black ash (*Fraxinus nigra*) and green ash (*F. pennsylvanica*) which often occur in riparian forests is a concern given their role in regulating soil moisture and shallow groundwater levels. We monitored and compared hydrologic processes in a riparian forest impacted by EAB invasion and an adjacent unimpacted riparian forest site in southwest Michigan. From 2018 to 2022, we recorded soil moisture, depth

to groundwater and meteorological variables at 15-min intervals throughout the growing season in a canopy gap following EAB-caused ash mortality and in adjacent, unaffected forest in the Augusta Creek riparian zone. Groundwater contributions to evapotranspiration (ETG) were estimated using a groundwater level fluctuation (WLF) method. Significant differences in volumetric soil moisture content (16%–26% higher in the gap than forest), average depth to water (10 cm in the gap vs. 70 cm below land surface in the forest) and mean daily ETG (0.6 in the gap vs. 3.0 mm per day in the forest) persisted across four growing seasons. Within the gap, prolonged saturation of the near surface may be contributing to a shift from a forested riparian ecosystem to herb and sedge-dominated wetland. These differences have implications for an array of riparian zone ecosystem services, a concern given the extent of ash mortality already sustained in much of eastern North America.

Kucheryavenko TV (2022) Dynamics of emergence of emerald ash borer *Agrilus planipennis* beetles in Luhansk Region. *Forestry and Forest Melioration* 140, 64–70. (in Ukrainian with English summary) https://doi.org/10.33220/1026-3365.140.2022.64

In the stands of the Mistkivsky forestry of the Svatove State Forest and Hunting Enterprise in Luhansk Region, the dynamics of the emergence of emerald ash borer (*Agrilus planipennis*) from model trees of common ash (*Fraxinus excelsior*) and green ash (*F. pennsylvanica*) were studied. In particular, common ash trees were selected in dry and fresh fertile forest site conditions. The first exit holes were found on June 14, and the last ones on July 4 on the trees of both ash species. The dynamics of the emergence of emerald ash borer from the trees of two ash species significantly correlated and had three waves. The correlation coefficients between the proportion of beetles that emerged on different dates from the model trees of common ash and green ash and relative air humidity are not significant. A greater number of beetles emerged from the green ash model trees than from the common ash model trees. In the second half of the observation period, from common ash trees growing in fresh fertile forest site conditions, significantly more beetles emerged from trees in dry fertile forest site conditions (59.0% of the total number of beetles that flew out of these trees).

Meshkova V, Borysenko O, Kucheryavenko T, Vysotska N, Skrylnyk Y, Davydenko K, Holusa J (2024) Forest site and stand structure affecting the distribution of emerald ash borer, *Agrilus planipennis* Fairmaire, 1888 (Coleoptera: Buprestidae), in Eastern Ukraine. *Forests* 15(3): 511. https://doi.org/10.3390/f15030511

The Emerald ash borer (EAB), *Agrilus planipennis* Fairmaire, 1888 (Coleoptera: Buprestidae), an invasive phloem-boring beetle, was first detected in the Luhansk Region of Ukraine in 2019. Subsequently, it rapidly expanded its presence to encompass a significant portion of the Kharkiv region and the parks of Kyiv. Previous research has established that the climatic conditions in Luhansk and its neighboring regions are conducive to the EAB, and the absence of a host plant (*Fraxinus* sp.) does not act as a deterrent to the pest's expansion in Ukraine. Recognizing the urgency of identifying infested trees, our current research aimed to identify the most attractive EAB forest subcompartments based on forest site conditions and stand structure. Utilizing the MaxEnt model, we achieved an average performance in predicting the potential distribution of the EAB (AUC = 0.842). The six most impactful variables, contributing to 88.2% of the model, include "age of trees, years", "area of forest subcompartment, ha", "mean height of trees, m", "proportion of *Fraxinus excelsior* in the stand composition, %", "hygrotope index (humidity level), point", and "number of neighboring-non-forest subcompartments". Most likely, EAB occurrence is expected in the driest forest site conditions; the well-lit and warmed-up parts of stands, in particular; small subcompartments surrounded by non-forest landscapes; and forest shelter belts near roads and fields. However, the data obtained can be considered preliminary. To enhance the accuracy of our forecasting, it may be imperative to consider data on road localization, along which the pest can spread passively, as well as dominant wind speed.

Peterson DL, Pecori F, Luchi N, Migliorini D, Santini A, Kyle KE, Rutledge C, Sallé A, Kaya SO, Ramsfield T, Cleary M (2023) Development of novel LAMP and qPCR assays for rapid and specific identification of Bronze birch borer (*Agrilus anxius*). *Environmental DNA* 5, 1177–1190. https://doi.org/10.1002/edn3.503

> Buprestids are an emerging threat to broadleaf forests across the world. Bronze birch borer (*Agrilus anxius*, BBB) poses a serious threat to European birch species if the insect were to be introduced. Due to their cryptic lifestyle feeding on the vascular tissue of their host plants, buprestids and other wood borers can be difficult to observe or detect. Early detection tools are vital to swiftly implement eradication measures and prevent the establishment of introduced species. In this study, we developed novel qPCR and LAMP assays for BBB and investigated the specificity and sensitivity for their use as early detection tools in European forests. Plant chemicals may limit these assays, so we conducted sensitivity testing with extracted foliage and plant vascular tissues to determine potential inhibition effects on DNA amplification. Both assays were specific to the target species when tested against the DNA of 17 other European *Agrilus*/buprestid species, two Scolytinae, and five Cerambycids (N = 24). Both assays varied in sensitivity with the qPCR assay amplifying at a concentration as low as 20 fg/μL, whereas the LAMP assay amplified as low as 3.2 pg/μL. Plant chemicals in DNA extracts from leaves did not impact the sensitivity of either assay, reaching similar detection levels. In contrast, vascular tissue reduced the sensitivity of the LAMP assay, amplifying as low as 0.04 ng/μL compared with 0.008 ng/μL in the control. These results demonstrate that both assays are highly specific and sensitive tools that can be used to detect frass and identify larvae as well as monitor the spread of A. anxius. qPCR resulted in more sensitive than LAMP overall. Thus, if results are needed quickly to make fast management decisions or as an initial screening of samples, the LAMP method is optimal. However, if fine detection is critical, then qPCR is preferential.

Richins M, Montes C, Merkle S (2024) Conservation of green and white ash germplasm using the cryopreservation of embryogenic cultures. *Plants* 13, 352. https://doi.org/10.3390/plants13030352

> Green ash (*Fraxinus pennsylvanica*) and white ash (*F. americana*) populations are currently experiencing major declines across their native ranges in North America due to infestation by the exotic insect pest emerald ash borer (*Agrilus planipennis*). The development of a reliable method for the long-term storage of green and white ash germplasm in the form of embryogenic cultures using cryopreservation would be a considerable aid to ash conservation efforts. We compared recovery percentages of cryopreserved green and white ash embryogenic cultures using vitrification versus slow cooling methods. Three Plant Vitrification Solution 2 (PVS2) exposure durations (40, 60, and 80 min) for vitrification and three DMSO concentrations (5%, 10%, and 15%) for slow cooling were tested for their effects on the percentage of cultures that regrew following cryostorage. Vitrification resulted in a higher overall culture recovery percentage (91%) compared to cultures that were cryostored using the slow cooling approach (39%), and a more rapid initiation of regrowth (5 days versus 2–3 weeks) resulted. Recovery from cryostorage by cultures using the slow cooling approach varied significantly ($p < 0.05$) between experiments and with genotype ($p < 0.05$). The recovery of vitrified tissue from cryostorage did not vary with genotype, species, or PVS2 exposure duration ($p > 0.05$). The vitrification cryopreservation protocol provides a reliable and versatile alternative to the traditional slow cooling method, strengthening our ability to preserve valuable ash germplasm for conservation and restoration.

Santoiemma G, Williams D, Booth EG et al. (2024). Efficacy of trapping protocols for *Agrilus* jewel beetles: a multi-country assessment. *J Pest Sci*. https://doi.org/10.1007/s10340-023-01728-z

> The genus *Agrilus* is one of the most diverse insect genera worldwide. The larval feeding activity causes extensive damage in both forests and orchards. In addition, more than 30 species have been introduced outside their native range so far, including the emerald ash borer *Agrilus planipennis* Fairmaire. Thus, the availability of efficient trapping protocols for early detection of *Agrilus* species at entry points is of utmost importance. In this study we tested whether trapping protocols developed for surveillance of *A. planipennis* in North America were also effective for other *Agrilus* species. In particular, through a multi-country assessment we compared the efficacy of detecting Agrilus species on: (i) green glue-coated prism traps vs. green Fluon-coated multi-funnel traps when baited with the green leaf volatile (Z)-3-hexenol or left unbaited; and (ii) green multi-panel traps vs. green multi-panel traps baited with dead adult Agrilus beetles (decoys). A total of 23,481 individuals from 45 *Agrilus* species were caught. Trap design significantly affected both species richness and abundance of *Agrilus* species in several of the countries where the trapping experiments were carried out, and green prism traps outperformed green multi-funnel traps in most cases. On the contrary, the addition of a (Z)-3-hexenol lure or dead adult beetle decoys on to traps did not improve trap catches. Our study highlights that reliable trap models to survey *Agrilus* species are already available, but also that there is the clear need to further investigate chemical ecology of *Agrilus* species to develop semiochemical lures that can improve detection efficacy.

Sergeeva ES (2023) Environmental consequences of the invasion of the emerald ash borer, *Agrilus planipennis* (Coleoptera: Buprestidae), into the Lower Volga region. Kurazhkovsky Readings. Materials of the II International Scientific and Practical Conference. Astrakhan, May 18–21, 2023. Compiled by A.N. Barmin. Astrakhan, 2023, p. 18–21 (in Russian with English summary). https://www.elibrary.ru/item.asp?id=54207179

> The ash emerald borer is an aggressive alien species that invades the ecosystems of the European part of Russia. The article discusses the possible environmental consequences of invasion into the territory of the Lower Volga region.

UK Centre for Ecology and Hydrology (2023) Provision of horizon scanning and analysis of pathways of spread of invasive species into Scotland. Published by The Scottish Government, 66 p. https://www.gov.scot/publications/provision-horizon-scanning-analysis-pathways-spread-invasive-species-scotland/

> A horizon scanning study involving analysis of pathways of spread of invasive non-native species into Scotland. It considers species having the highest likelihood of arrival and establishment and the magnitude of their potential negative impact on biodiversity and ecosystems over the next 10 years.