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Causes and trends in pathological damage to common ash

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Abstract. Intensive dieback of *Fraxinus excelsior* L. in the Forest-Steppe zone of Ukraine has led to a significant deterioration in the sanitary condition of ash stands and increased the risk of losing their ecosystem stability, making this issue particularly urgent amid the simultaneous influence of pathogens and the activation of a complex of stem-damaging insect species. This study aimed to analyse the ecological role of common ash in forest ecosystems, as well as to assess the sanitary condition and causes of ash stand decline, particularly the impact of *Hymenoscyphus fraxineus* and *Agrilus planipennis*. The study employed methods of analytical review, synthesis of previous research, critical comparison of results obtained by different authors, and logical-structural generalisation to identify key patterns in the development of pathological processes in ash stands. It was established that common ash supports intensive nutrient cycling due to litterfall with a high content of calcium and magnesium, and the rapid mineralisation of organic matter, which supports soil fertility and understorey development. According to the analysed studies, more than 950 associated species have been recorded, including 44 obligate and 62 highly specialised organisms, demonstrating the ash's importance for biodiversity. The loss of ash reduces the rate of organic matter mineralisation and disrupts the nitrogen and carbon balances in the soil. Analysis of the sanitary condition in the Right-Bank Forest-Steppe of Ukraine showed that the most severely affected stands are located in the Cherkasy and Vinnytsia regions, where the area of dieback exceeds 600 ha. The main degradation factors include infections caused by *Hymenoscyphus fraxineus*,

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damage by *Agrilus planipennis*, bacterial diseases, and the combined influence of saprotrophic fungi. The results also indicate a strong relationship between the intensity of damage and tree age, stand density, and soil type, which enables the identification of zones at the greatest risk

Keywords: *Fraxinus excelsior* L.; *Hymenoscyphus fraxineus*; *Agrilus planipennis*; *f*orest ecosystems; sanitary condition of forests

Introduction

Forest dieback and degradation are complex processes driven by multiple factors, including long-term weakening of forest stands, stressful weather conditions, and subsequent infestation by pests and pathogens. Climate change, prolonged droughts, and unstable groundwater levels play a key role. As a result, trees become less resilient, and stress factors trigger their decline, which is further accelerated by the activity of harmful organisms. V. Tkach & O. Kobets (2025) examined the impact of climate change and military aggression on Ukraine's forests, revealing significant degradation of forest ecosystems. They highlighted how these factors, alongside environmental stressors, exacerbate forest health deterioration and lead to biodiversity loss. The study emphasised the need for urgent conservation efforts and sustainable management practices to mitigate further damage.

From the late 20th to the early 21st century, a significant deterioration in the sanitary condition of many tree species was recorded. These changes were caused by the combined influence of abiotic, biotic, and anthropogenic factors that together reduced the resistance of trees to pests and pathogens (Polk *et al.*, 2022). Since the 2000s, the issue of widespread ash dieback has become widely discussed both in scientific circles and among forestry professionals in Ukraine and beyond. According to T. Pyvovar *et al.* (2023), the degradation of ash stands has affected large parts of Europe, including the Baltic states, Poland, Norway, Sweden, Germany, Austria, Switzerland, and several other countries.

I. Matsiakh & V. Kramarets (2020) noted that the primary weakening factor is the invasive fungus *Hymenoscyphus fraxineus*, which causes ash dieback disease. Symptoms include necrotic bark lesions, disruption of the conductive system, and rapid mortality of trees of various ages. Weakened trees are easily colonised by secondary infections, such as *Armillaria* spp. and *Pseudomonas* spp., which accelerate their death. Additional pressure is exerted by invasive phyllophagous insects, among which a prominent pest is the ash leaf-curl aphid *Prociphilus fraxinifolii*. Scientists J.P. George *et al.* (2024) have established that these insects reduce photosynthetic activity and further weaken tree' resistance to diseases. The spread of harmful organisms is facilitated by intensive international trade in planting material and climate change, which enable their movement and acclimatisation.

C. Fritsch *et al.* (2024) noted that under the influence of anthropogenic changes, drought, and fragmentation of forest stands, the area of dieback centres continues to expand, the condition of ash stands continues to deteriorate, and their age structure is shifting. The combination of these factors highlights the need for more detailed research on pathological processes and the development of effective measures to preserve common ash in natural and artificial ecosystems.

However, despite significant progress in studying ash dieback pathology, several important knowledge gaps remain. In particular, region-specific factors of ash stand degradation under current climate change conditions are still insufficiently explored. The interactions between *Hymenoscyphus fraxineus* and secondary pests and pathogens in Eastern European forests, especially in Ukraine, also remain poorly assessed.

In addition, there is a notable lack of long-term monitoring data on the extent of ash dieback, which would allow accurate tracking of the dynamics and intensity of these processes. The study aimed to examine the ecological importance of common ash within forest ecosystems and evaluate the health of ash stands, focusing on the factors contributing to their decline, particularly the influence of *Hymenoscyphus fraxineus* and *Agrilus planipennis*.

The article utilised scientific sources, including publications in peer-reviewed journals, monographs, and conference proceedings. The main information databases used for source retrieval were Google Scholar, Scopus, ResearchGate, Web of Science, as well as university electronic archives and open-access resources of international scientific organisations. The selection of sources was based on the principles of scientific novelty, reliability, relevance, representativeness, and thematic correspondence to the issue of pathological ash dieback. The analysis included studies addressing the aetiology, distribution, influence of biotic and abiotic factors, and conservation measures for *Fraxinus excelsior* L. stands.

Ecological role of common ash (*Fraxinus excelsior* L.) in forest ecosystems

Common ash (*Fraxinus excelsior* L.) plays a key role in the functioning and stability of European forest ecosystems. As noted by A. Kamińska *et al.* (2025), ash stands have the ability to stabilise the microclimate, regulate soil moisture and fertility, and serve as a habitat for numerous plant and animal species (Fig. 1). Owing to its rapid nutrient cycling and the high content of base cations in its litter, ash supports favourable conditions for the development of the herb layer and soil microbiota. Its root system contributes to soil structure formation, while leaf litter enriches the soil with nutrients, ensuring efficient mineralisation of organic matter.

Figure 1. *Common ash plantations*

Source: authors' photo

The degradation of ash due to dieback has significant ecological consequences: crown density decreases, light availability and the microclimate of the understorey change, conditions for herbaceous and bryophyte species deteriorate, and the biogeochemical balance becomes disrupted. Such changes can potentially lead to reduced biodiversity and the loss of ecosystem services. Although ash can grow in various soil types and climatic conditions, optimal conditions for its growth are usually observed on moist, clay-rich soils that provide sufficient moisture and nutrients. Therefore, it is most often found along forest edges, riverbanks, and lake shores (Vasaitis & Enderle, 2017). From an ecological perspective, ash also plays an important role in maintaining

biodiversity. According to R. Mitchell *et al.* (2014), 953 species associated with ash have been recorded in the United Kingdom, of which 44 are obligate – completely dependent on this tree species – and 62 are highly associated. These organisms include fungi, mosses, lichens, and invertebrates. This demonstrates the wide ecological connections of ash and its irreplaceable role in supporting various trophic levels of forest communities.

A distinctive feature of ash is its formation of mycorrhizal associations with a relatively narrow range of fungi (Vasaitis & Enderle, 2017). However, due to the low specificity of these associations, the loss of ash is unlikely to cause a drastic decline in fungal diversity, though it may affect the overall balance within soil microbial communities. Research by T. Riutta *et al.* (2012) shows that changes in stand structure, particularly the loss of ash, influence the activity of micro- and macro-organisms, altering litter decomposition dynamics and the carbon cycle. According to S. Fuchs *et al.* (2024), an important ecological function of ash is its contribution to nutrient cycling. Ash leaf litter is characterised by high calcium and magnesium content and a low carbon-to-nitrogen ratio. Ash sheds its leaves while they are still green, facilitating the rapid return of nitrogen, phosphorus, potassium, and sulphur to the soil and increasing soil fertility. Ash roots also decompose faster and contain more nutrients compared with other broadleaf species (Agan *et al.,* 2020). Due to the activity of microorganisms and invertebrates, the mineralisation of organic residues proceeds more intensively, ensuring a more complete nutrient cycle and preventing excessive accumulation of litter (Vasaitis & Enderle, 2017).

The replacement of ash by tree species with more acidic and slowly decomposing litter, such as beech or oak, may lead to reduced nutrient availability and a decline in plant species with high soil-fertility requirements. This, in turn, affects the species composition and functioning of the ecosystem, decreasing the diversity of ground vegetation (Langer, 2017). Studies by T. Hultberg *et al.* (2020) confirm that the loss of ash results in noticeable changes in soil processes and nutrient cycling. The authors found that the disappearance of ash reduces the rate of organic matter mineralisation, disrupts the nitrogen and carbon balances, and influences the formation of soil microbial communities. J. George *et al.* (2022) noted that due to its combination of characteristics of both a pioneer species and a stable component of forest stands, ash can participate in both primary and secondary succession, serving as an important intermediary element in forest regeneration and the formation of forest structure. In mature forests, ash often grows within mixed stands, where it may be a dominant species or a component of communities with beech (*Fagus sylvatica*), pedunculate and sessile oak (*Quercus robur*, *Q. petraea*), small-leaved and large-leaved lime (*Tilia cordata*, *T. platyphyllos*), birch (*Betula pubescens*), alder (*Alnus glutinosa*, *A. incana*), and other species. Thus, common ash is one of the key tree species that shape ecological balance, trophic interactions, and biogeochemical processes within European forest ecosystems. Its dieback and gradual decline may have long-term consequences for forest structure, productivity, and biodiversity, necessitating the development of strategies for the conservation and restoration of this species.

As shown by J. Richter *et al.* (2025), ash-dominated forests are characterised by higher understorey species diversity compared with communities dominated by beech or alder. Under ash canopies, favourable light and moisture conditions develop, supporting numerous shade-tolerant and moisture-dependent herbaceous species. The authors analysed over 1,900 phytosociological descriptions from northern Germany, creating an ecological baseline prior to the onset of widespread ash dieback. The results demonstrated that an increasing proportion of ash in the upper canopy is directly associated with higher understorey diversity. They identified 43 vascular plant species closely associated with ash forests, including

Veronica montana, *Paris quadrifolia*, *Sanicula europaea*, and *Carex sylvatica*, among others. Many of these species have limited distributions and are sensitive to changes in microclimate and light conditions, which makes them highly vulnerable to ash decline. Research by K. Turczański (2020) confirms that common ash (*Fraxinus excelsior* L.) is an important component of European forest ecosystems, significantly influencing soil conditions, understorey dynamics, and biocoenotic stability. The authors found that soil acidity (pH) and organic matter content are directly linked to the intensity of ash defoliation. In areas with more neutral pH and higher organic matter content, trees exhibited better physiological condition, and the understorey supported greater plant species diversity. The results indicate that ash strongly affects soil processes – through its litter, root system, and chemical composition of its leaf litter, it regulates soil fertility and the growth conditions of other plants. Changes in ash condition (particularly due to dieback) lead to alterations in understorey structure, reduced species diversity, and deterioration of soil trophic status.

Thus, *Fraxinus excelsior L*. performs a multifunctional ecological role in forests, including maintaining soil fertility and chemical balance, supporting understorey diversity, and influencing the structure and stability of forest ecosystems. From an ecological standpoint, the loss of ash leads to changes in forest structure, decreased soil fertility, and the disappearance of associated microorganisms, fungi, and invertebrates. Its weakening or death may trigger long-term shifts in trophic chains and the structure of biogeocoenoses.

Early detection and geographic spread of ash dieback

The first cases of ash dieback were recorded in 1990 in Poland (Kowalski, 2006). This disease, known as ash dieback (ADB), is caused by the pathogen *Hymenoscyphus fraxineus* and has spread extensively across Europe over the past 30 years, advancing at a rate of 30 to 70 km per year. Ascospores of *Hymenoscyphus fraxineus* were found up to 100 metres ahead of the disease front, indicating that the fungus often becomes well established in an area long before visible symptoms appear (Orton *et al.,* 2018). ADB affects European ash throughout its natural range; the pathogen has been detected in the United Kingdom and Ireland since 2012 (Coker *et al.,* 2019). Long-term studies have shown that *Hymenoscyphus fraxineus* may have been present in Poland as early as the 1960s, where the disease went unnoticed due to a lack of knowledge about its symptoms.

Despite significant media attention, monitoring, and responses to suspected signs of decline, the causes of the disease's spread remain incompletely determined (Kirisits *et al.,* 2010; Chandelier *et al.,* 2016). At early stages, the disease is difficult to detect because it can easily be confused with several other tree disorders (Vasaitis & Enderle, 2017). Studies by R. Becker *et al.* (2020) conducted in the United Kingdom revealed that some trees already exhibited pronounced ADB symptoms before 2012. Using dendrochronological methods, it was established that the infection of these trees could have occurred in 2004-2005. Initial cases of ADB may be highly localised or spread slowly due to factors such as mating-type incompatibility, environmental conditions, and the isolation of ash trees in agricultural landscapes. The lack of targeted ADB surveys before 2012 and low public awareness of the disease's symptoms resulted in its spread remaining undetected for a long time.

Ash leaves become infected by ascospores that are dispersed by wind. The fungus then enters through the petiole and branches into the tree tissues. Repeated infections result in rapid crown dieback, often leading to tree death within a few years. Detecting new infections is difficult because the damage can remain unnoticed for up to three years. Symptoms of infection include wilting of branches in the upper crown and vertical bark cracks (Liziniewicz *et al.,* 2022). Norwegian researchers O. Díaz-Yáñez *et al.* (2020) have been monitoring the spread of *Hymenoscyphus fraxineus* in southwestern Norway since 2008 and

estimated its spread rate at 51 km per year. They also recorded a 74% increase in ash mortality after the disease became widespread. Although the proportion of ash in Norway's national inventory plots is very low, these results indicate a high invasiveness of the pathogen, which does not depend on host density. Alternative hosts were identified – living or dead trees of several species, including *Acer platanoides, Alnus* spp., *Betula* spp., *Corylus avellana, Fagus sylvatica, Juniperus communis, Picea abies, Pinus sylvestris, Populus tremula, Prunus* spp., *Quercus* spp., *Salix* spp., and *Sorbus aucuparia*. This knowledge may contribute to the conservation of biodiversity associated with ash.

In 2022, European scientists published a large-scale study on ash dieback across Europe. They identified 407 sites in 27 countries where ash occurs. The study period covered 1987-2020. It was found that between 1987 and 2000, tree mortality was moderate and sporadically recorded in Spain, France, Romania, Slovakia, Italy, Lithuania, and Moldova. Between 2000 and 2010, mortality accelerated mainly in Poland, Lithuania, Belarus, Sweden, Denmark, Germany, the Czech Republic, and some regions of France. Although mortality remained low (1%-3%) in most countries, significant losses (10%-100%) were recorded at certain sites in Poland and Sweden. Between 2010 and 2020, mortality increased sharply across Europe. The most striking example is southern Scandinavia, where all ash trees died at eight of the surveyed sites (Marçais *et al.,* 2022).

German researchers S. Fuchs *et al.* (2024) conducted a study showing that ash dieback, caused by the fungus *Hymenoscyphus fraxineus*, is closely linked to environmental conditions and stand structure. Based on observations of 1,365 trees across eleven monitoring sites throughout Germany, they found that the most severe damage occurred on wet hydromorphic soils, in stands with high ash density, and among younger and thinner trees. Moreover, severe basal infections proved to be a reliable indicator of probable tree mortality. The study also indicated that despite a general trend of stand decline, the condition of individual trees improved at six of the eleven sites, suggesting the natural selection of more resistant genotypes. The researchers concluded that, to preserve ash, it is necessary to avoid establishing pure ash stands, especially on waterlogged sites, and instead focus on selecting less susceptible populations and promoting mixed stands. The study by M. McMullan *et al.* (2018) on the spread of ash dieback in Europe significantly expanded understanding of the disease's dynamics and the factors influencing its progression. The authors emphasised that *Hymenoscyphus fraxineus* had spread across much of the continent before it was officially identified as the causative agent of ash dieback.

A. Agan *et al.* (2020) highlighted that the intensity of tree infection depends on the biological characteristics of ash, particularly tree age, and site conditions, which determine its vulnerability. These findings confirm that the population dynamics of the pathogen are complex, and the scale of its spread requires long-term monitoring and the development of adaptive management strategies. Studies within the German FraxForFuture programme demonstrated that disease severity depends on site conditions, stand structure, and tree age. Ash dieback was more pronounced in areas with high tree density and on hydromorphic (wet) soils, whereas large, dominant trees were more resistant to the pathogen. This indicates selective natural survival – the gradual persistence of more tolerant individuals may form the basis for species recovery.

In many countries, measures have been implemented to limit the spread of ash dieback and to preserve ash trees. These measures include the felling and burning of infected trees, the establishment of plantations using genetically clean seed material, monitoring the spread of the disease, and conducting scientific research to identify effective control methods (Nielsen *et al.,* 2022). Key measures to control the spread of the disease and conserve ash trees include:

- mechanical control methods;
- identification and selection of genetically resistant trees;

- monitoring programmes for disease spread;
- development of new, effective control strategies.

European countries have implemented national research programmes on ash dieback, focusing on various aspects of the biology and ecology of this disease. Only through the shared utilisation and synthesis of existing knowledge has it been possible to achieve a comprehensive understanding of ash dieback and develop modern practical recommendations for the sustainable management of *Fraxinus* stands in Europe. These measures have been carried out using an innovative interdisciplinary approach involving plant pathologists, breeders, and foresters (McKinney *et al.,* 2011; Lenz *et al*., 2016).

In addition to ADB, another significant threat to *Fraxinus excelsior* L. is the Emerald Ash Borer (EAB) (*Agrilus planipennis*), an invasive insect from Asia that kills ash trees (Fig. 2). EAB was first detected in the United States in south-eastern Michigan in 2002. According to estimates by the U.S. Department of Agriculture, EAB had been present in the region since the 1990s (Petter *et al.,* 2020).

Figure 2. *General appearance of the EAB*
Source: David Cappaert, Michigan State University

In the United States, the response to EAB has been coordinated by the Animal and Plant Health Inspection Service (APHIS), the U.S. Forest Service, and the Agricultural Research Service. Key measures have included biological control, monitoring using traps, and the search for effective methods to regulate pest populations. Research has focused on identifying biocontrol agents, particularly parasitic wasps, and assessing the ecological and economic impacts of the EAB spread (Jonsson & Thor, 2012).

Ash dieback is an example of a serious pathogen-induced disease that reduces the commercial value of timber and has negative consequences for forestry and forest conservation. The scale of biological invasions has increased significantly, with no signs of this trend slowing down. It is evident that greater efforts are required to control and prevent the introduction of new pests and pathogens. However, the global scale of spread and the anthropogenic movement of plants and plant products pose challenges to the effectiveness of such measures.

Since the 1990s, ash mortality has sharply increased and has already reached catastrophic levels in northern Europe, where most trees had disappeared from study sites by the end of 2020. Research provides critical information on the impact of *Hymenoscyphus fraxineus* (ash dieback, ADB) and the EAB (*Agrilus planipennis*) on ash stands. Scientific data indicate the widespread occurrence of both ADB and EAB in Europe and Ukraine. ADB has been recorded across significant parts of Europe, including the United Kingdom, Ireland, Spain, Sweden, and Ukraine (Davydenko *et al.,* 2022). Researchers have emphasised the difficulty of early disease detection, as symptoms may be inconspicuous or easily confused with other tree pathologies. This complicates the delineation of disease spread and the implementation of necessary control measures, highlighting the high potential for further pathogen expansion into new regions. The importance of systematic monitoring and the application of appropriate control measures is strongly emphasised.

Sanitary conditions and causes of degradation of *Fraxinus excelsior* L. stands in the Right-Bank Forest-Steppe of Ukraine

According to the State Forest Resources Agency of Ukraine, common ash plantations cover an area of 151.6 thousand hectares, which accounts for 2.4% of the forested lands of the forest fund. In particular, in

the Cherkasy region, ash plantations occupy 12 thousand hectares (Meshkova, 2019). During the 1980s and 1990s, before the outbreak of the epidemic in the early 2000s, foresters consciously aimed to increase the proportion of ash in many regions of Europe.

According to the National Forest Inventory (n.d.), the total area of ash (*Fraxinus excelsior* L.) stands in the Right-Bank Forest-Steppe of Ukraine is 50,011 ha. The largest share is in Vinnytsia Region, with 18,369.7 ha, accounting for 37% of the total area. A slightly smaller but comparable area is found in the Cherkasy Region, with 18,202.2 ha, or 36%. The smallest area of ash stands is in the Kirovohrad Region, where they occupy 13,439.1 ha (27%) (Fig. 3).

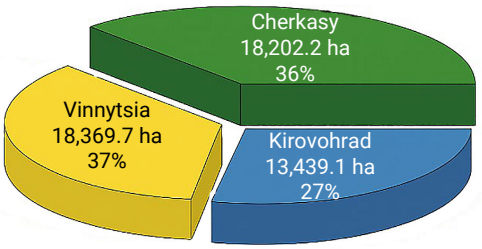

Figure 3. *Area of common ash (Fraxinus excelsior L.) stands in the Right-Bank Forest-Steppe of Ukraine*

Source: compiled by the authors based on National Forest Inventory (n.d.)

most critical situation. Other enterprises also show considerable degradation (260-280 ha), while the lowest values are observed in Chyhyrynske and Smilianske forestries. Overall, the chart demonstrates an uneven yet widespread pattern of ash dieback throughout the region. This confirms that the dieback of common ash has a large-scale and regionally extensive character, affecting substantial areas in all forestry enterprises. The most severe levels of degradation indicate a critical condition of ash stands and highlight the need for urgent restoration and protection measures.

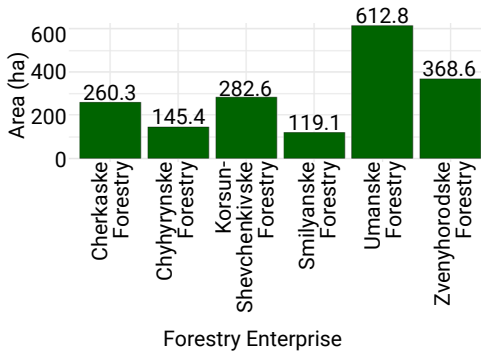

Figure 4. *Ash dieback area in the Cherkasy Region in 2024, according to forest protection enterprises*

Source: compiled by the authors based on K. Davydenko *et al.* (2019)

The first signs of ash dieback in Ukraine were observed in 2010. Prior to 2010, limited attention was paid to the sanitary condition of ash stands in Ukraine, as there were no reports of wilting symptoms. Morphological signs of ash dieback were recorded in the eastern part of the country and included uneven bud break, isolated shoot necroses, discolouration of the wood, and premature leaf fall (Davydenko *et al.,* 2019). Figure 4 shows the area of ash dieback in the Cherkasy Region in 2024. The chart illustrates the areas of dieback of common ash stands across various forestry enterprises in the region. The largest dieback areas are recorded in Umanske Forestry (612.8 ha) and Zvenyhorodske Forestry (368.6 ha), indicating the

The main causes of common ash dieback include (Matsiakh & Kramarets, 2014): the ash dieback pathogen (*Hymenoscyphus fraxineus*); EAB (*Agrilus planipennis*); damage by other pests; and bacterial infections. Ash dieback (*Hymenoscyphus fraxineus*) is one of the most serious diseases threatening the survival of European ash (*Fraxinus excelsior* L.) across Europe. According to a study by R. Vasaitis & R. Enderle (2017) conducted in the Left-Bank Forest-Steppe of Ukraine (Sumy and Kharkiv regions), the disease was widespread in both natural and artificial stands. The intensity of infection was found to depend on site conditions, stand age, density, site quality class, and the proportion of ash in the stand

composition. A.N. Drogvalenko *et al.* (2019) reported that the highest frequency of infection occurred in stands up to 80 years old, with 40%-70% ash composition and a density greater than 0.5. The disease was most prevalent in fertile, fresh site conditions, which are also the most favourable for ash growth. These findings indicate the high prevalence of ash dieback and the complex interaction of factors influencing disease development, underscoring the need for further research to develop effective measures for the conservation of ash stands in Ukraine. These results are consistent with findings that affected trees host a significantly higher diversity of pathogenic and saprotrophic fungi, which intensify necrotic processes and accelerate wood degradation. Researchers also note the presence of a wide range of accompanying pathogenic fungi (including *Venturia fraxini*, *Alternaria alternata*, *Cytospora* spp., and *Aureobasidium pullulans*), which exacerbate the damage and accelerate tissue mortality.

Research by V. Meshkova *et al.* (2021) found that ash dieback is often associated with butt rots and, to some extent, bark beetle infestations, with the most dangerous fungi being *Hymenoscyphus fraxineus*, *Cytospora* spp., and *Diplodia* spp. The authors concluded that the weakening of ash trees is a complex process caused by the interaction of multiple pathogens and pests. The study established that ash dieback in Ukraine results from the combined impact of the fungal pathogen *Hymenoscyphus fraxineus* and the invasive insect *Agrilus planipennis*. *Hymenoscyphus fraxineus* causes necrosis, shoot dieback, and gradual tree weakening, while *Agrilus planipennis* destroys the conductive tissues of the trunk, leading to rapid dieback. The research highlighted that the interaction of these two factors significantly accelerates the degradation of ash stands.

In 2019, the EAB was detected for the first time in Ukraine, in the Luhansk Region. However, the variability of larval developmental stages and the presence of exit holes indicate that the pest likely entered the region as early as 2017 or even earlier, probably from the nearby Voronezh region of Russia. Within two years, EAB had spread over 300 km westward from the initial detection site, affecting hundreds of *Fraxinus excelsior* L. and *Fraxinus pennsylvanica* trees. By the end of 2021, the pest had been recorded across most of Luhansk and in parts of the Kharkiv Region. In 2022, EAB was observed in parks in Kyiv, and by 2023, it had spread to large areas of the Kharkiv Region. Field studies in 2022-2023 were significantly limited due to ongoing hostilities. It is likely that EAB entered Ukraine via wooden crates used for transporting goods. Since then, the pest has spread in all directions, establishing itself in eastern Ukraine by 2019 and showing potential for further expansion westward toward Europe (Meshkova *et al.,* 2024).

N. Puzrina *et al*. (2025) conducted a detailed study of ash responses to EAB infestation, paying particular attention to morphological changes in buds as an early diagnostic criterion. The authors found that larval damage to conductive tissues disrupts nutrient flow to apical buds, resulting in underdevelopment, premature drying, and asymmetric bud break. These symptoms correspond to other signs of infestation and confirm that bud condition changes can serve as an early and reliable indicator of the onset of invasion. H. Mazurchuk *et al.* (2025) showed that rapid, critical ash dieback is the result of a complex interaction between *Agrilus planipennis*, stem-boring insects, and fungal and bacterial pathogens, which has a significant impact, particularly on larger-diameter trees. The study by I.M. Kulbanska (2015) found that tubercular disease is the most widespread and harmful infectious disease of ash (*Fraxinus excelsior* L.), caused by the bacterium *Pseudomonas syringae* pv. *savastanoi*. The research reported that the disease manifests as tumour formation on trunks and branches, followed by cracking and cambium death, which significantly weakens the trees. The pathogen affects trunks, shoots, inflorescences, and samaras, while leaves remain resistant even under artificial infection. Isolation of bacteria from affected organs confirmed their pathogenicity, and the detection of

Pseudomonas in ash gall wasps suggests a possible role of insects in spreading the infection.

Ash dieback in Ukraine is driven by the combined effects of the invasive fungus *Hymenoscyphus fraxineus*, the EAB, and associated pathogens. Damage is mostly observed in stands of particular age and composition, while climatic stresses further exacerbate degradation. This situation indicates a significant deterioration of the sanitary condition of ash forests and underscores the urgent need for measures to preserve and restore them. The only effective countermeasure against ash dieback is the implementation of sanitary thinning.

Conclusions

Ash (*Fraxinus excelsior* L.) provides significant ecosystem services and plays a key role in maintaining biodiversity. Analysis of ash distribution shows that the largest areas of ash forests in the Forest-Steppe are concentrated in Vinnytsia and Cherkasy regions, where they occupy an important share of the forest estate. However, since 2010, there has been a rapid increase in the area affected by dieback, accompanied by characteristic symptoms such as uneven bud break, shoot necroses, and premature leaf fall. The key factors driving degradation are the invasive fungus *Hymenoscyphus fraxineus* and the EAB (*Agrilus planipennis*). The impact of these organisms is complex: *Hymenoscyphus fraxineus* causes necrotic lesions and weakens trees, while *Agrilus planipennis* destroys vascular tissues, accelerating their death. Additional complicating factors include bacterial infections, such as ash tubercular disease, and associated fungal pathogens (including *Cytospora*, *Diplodia*, *Venturia*, and others), which form complex infection syndromes. The most vulnerable are stands up to 80 years old, growing in fertile, moist conditions, with a high proportion of ash in the canopy.

European studies also confirm the severity of the threat posed by ADB and the EAB. *Hymenoscyphus fraxineus* spreads both through airborne ascospores and via the movement of infected planting material, while EAB rapidly expands its range in various countries. Data from Austria, Poland, Scandinavia, and other regions indicate a continuous increase in infection intensity, the emergence of new foci, and negative consequences for forest ecosystem stability. The loss of ash leads to a deterioration of forest structure, reduced biodiversity, and weakened ecosystem functions. Thus, the degradation of ash stands results from the combined effects of invasive pathogens, pests, and climatic stresses. Existing data confirm the critical condition of ash forests in the Right-Bank Forest-Steppe of Ukraine and many European regions, highlighting the urgent need for conservation measures, monitoring, and management of invasions.

Future research prospects include expanding knowledge of ADB and EAB interactions under different ecological conditions, establishing long-term monitoring programmes, identifying resistant ash genotypes, studying the impact of climate change on pathogen spread, and developing integrated strategies for the protection and restoration of ash ecosystems. These research priorities will determine the effectiveness of future measures for ash conservation in Ukraine and Europe.

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Причини та тенденції патологічних уражень ясена звичайного

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Анотація. Інтенсивне всихання *Fraxinus excelsior* L. у Лісостепу України призвело до значного погіршення санітарного стану ясеневих насаджень і підвищило ризик втрати їхньої екосистемної стабільності, що робить цю проблему особливо актуальною на тлі одночасного впливу патогенів та активізації комплексу стовбурових комах. Метою дослідження було проаналізувати екологічну роль ясена звичайного в лісових екосистемах, а також оцінити санітарний стан і причини всихання ясеневих насаджень, зокрема вплив *Hymenoscyphus fraxineus* та *Agrilus planipennis*. У дослідженні застосовано методи аналітичного огляду, синтезу попередніх досліджень, критичного порівняння результатів різних авторів та логіко-структурного узагальнення для виявлення основних закономірностей розвитку патологічних процесів у ясеневих деревостанах. Встановлено, що ясен звичайний забезпечує інтенсивний колообіг поживних речовин завдяки підстилці з високим вмістом кальцію та магнію і швидкою мінералізацією органічної речовини, що сприяє підтриманню родючості ґрунтів та розвитку підліску. Згідно з аналізом досліджень, зафіксовано понад 950 видів асоційованих організмів, серед яких 44 облігатних та 62 високоспеціалізованих, що демонструє значущість ясена для біорізноманіття. Втрата ясена знижує швидкість мінералізації органічної речовини та порушує баланс азоту й вуглецю в ґрунті. Аналіз санітарного стану ясеневих насаджень Правобережного Лісостепу України показав, що найбільш уражені насадження знаходяться в Черкаській та Вінницькій областях, де площа всихання перевищує 600 га. Основними факторами деградації є інфекції *Hymenoscyphus fraxineus*, пошкодження *Agrilus planipennis*, бактеріальні захворювання та комплексний вплив сапротрофних грибів. Результати також вказують на тісний зв'язок інтенсивності ураження з віком дерев, густотою насаджень і типом ґрунту, що дозволяє прогнозувати зони найбільшого ризику

Ключові слова: *Fraxinus excelsior* L.; *Hymenoscyphus fraxineus*; *Agrilus planipennis*; лісові екосистеми; санітарний стан лісів