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Urban Tree Biosecurity for Europe's Future: A One Health Perspective

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Foreword

Imagine our European cities breathing a little easier: cooler streets, cleaner air, greener neighbourhoods, all thanks to the steadfast canopy of urban trees. That has been the vision driving the pan-European network *Urban Tree Guard* (*Safeguarding European urban trees and forests through improved biosecurity*, CA 20132, 2021-2025). Through the powerful stamp of COST (European Cooperation in Science and Technology), the network of over 250 members has brought together a rich tapestry of scientists and stakeholders, all collaborating to protect the green lungs of our cities.

In this four-year journey, we were doing more than just studying trees. We're asking: How can we help urban forests stand strong against pest invasions, diseases and climate threats? How can we build tools, awareness and policies so that every street-side tree, every park and every urban green patch becomes a resilient, thriving part of city life? To answer these questions and to find new ones, we pooled our knowledge, shared data, and developed actionable strategies for cities across Europe. With training schools, workshops and mobility we worked to empower the next generation of researchers and innovators to spark real change.

The White Paper "*Urban Tree Biosecurity for Europe's Future: A One Health Perspective*" highlights the crucial learnings from our networking activities. It calls for urban tree biosecurity to become an integral part of the One Health approach, where the health of trees, people, and the planet are deeply intertwined. The document outlines key research and innovation priorities identified by network members through workshops and meetings. It stresses that strengthening national and European funding for urban tree biosecurity is a smart and forward-looking investment, one that supports a more resilient Europe. Beyond research, dedicated funding streams are needed to ensure strong institutional support for urban tree biosecurity, inclusive education, and active citizen participation to safeguard treescapes in European cities.

It is our hope that the legacy of UB3Guard contributes to healthier, happier urban forests; communities more engaged with their green spaces; decision-makers better equipped and citizens more aware of the vital role trees play in our city-scape. In caring for the trees that sustain our cities, we invest in the well-being of generations to come. Urban tree biosecurity is, at its heart, a human story, one of care, connection, and resilience. Let this White Paper be both a guide and a call to stand for the trees that stand for us, and to nurture a greener, more resilient Europe for generations to come.

Johanna Witzell (Chair)

Roeland Samson (Vice Chair)

Executive summary

From the first trees climbed in schoolyards to the quiet shade of cemetery groves, trees accompany urban dwellers through every stage of life. Whilst planted and managed for aesthetic or landscaping purposes, urban trees are far more than adornments. Trees are vital components of urban green infrastructure, delivering essential ecosystem services to the more than 70% of Europeans who live in cities. Their presence improves air quality, provides cooling shade during heat waves, reduces energy demand, supports physical and mental wellbeing, and sustains biodiversity within densely built environments. These contributions are fundamental to the health, resilience and quality of life of urban populations.

Yet the benefits of urban trees are increasingly at risk. Rapid urbanisation, climate change and globalisation expose urban trees to unprecedented pressures. Urban environments can be harsh on trees, characterised by compacted soils, heat stress, pollution and limited rooting space. On top of these issues, urban trees are frequently exposed to pests introduced through the global movement of goods and people. Plants for planting, other nursery stock and wood packaging materials are among the most common pathways of introduction. In cities with ports, airports and transport hubs, novel organisms are regularly intercepted, some of which have the potential to become invasive and destructive. If these organisms escape into the urban environment and establish, they may spread rapidly, with consequences that extend well beyond urban areas.

These risks are real. Invasive pests have already negatively transformed European treescapes. Ash dieback and Dutch elm disease are perfect examples of introduced species that have devastated tree populations across cities and forests. The impacts go far beyond the loss of individual trees: invasive pests disrupt ecosystems, reduce biodiversity and undermine the many services trees provide, with cascading, negative effects on ecosystem resilience. They can also threaten rural livelihoods that depend on forests. Disturbances to forest ecosystems can also lead to increased breeding habitats for populations of disease-carrying vectors such as ticks and mosquitoes, raising public health risks due to illnesses like Lyme disease and West Nile virus.

Urban trees are not only a local concern but integral to broader ecological and societal resilience. With potential to act as both entry points for invasive species and as ecological firewalls that can slow or block their spread, urban trees stand at a critical interface between the city environment and surrounding natural ecosystems. Protecting their health is essential not just for cities but for Europe's forests, its biodiversity and its forest-based bioeconomy. Healthy urban trees also embody the One Health framework, which recognises the interconnectedness of human, animal and environmental health.

Urban tree biosecurity refers to the set of measures, policies and practices designed to prevent the introduction, establishment and spread of harmful pests in urban trees and forests. It encompasses prevention, early detection, rapid response and long-term management of pests. The approach necessitates coordinated surveillance, effective diagnostic tools, well-prepared contingency plans and the ability to mobilise resources quickly when threats are detected. Prevention is particularly critical, as once invasive species

establish and spread, eradication is rarely possible, and control measures are often costly, environmentally damaging and only partially effective.

Robust biosecurity is central to safeguarding urban trees and, through them, the wider environment. However, despite this urgency, Europe's urban tree biosecurity systems remain fragmented and under-resourced. Responsibility is divided across sectors—public and private forestry, plant health, urban planning and public health—while resources for monitoring and rapid response are unevenly distributed. Moreover, urban trees themselves are often undervalued, seen primarily as aesthetic features rather than as critical assets or infrastructure providing irreplaceable ecosystem services. This lack of recognition translates into insufficient investment in their protection, leaving cities vulnerable to pest outbreaks and the cascading risks they bring. To transform this trajectory, Europe needs an integrated research and innovation agenda that bridges forestry, plant health, ecology, urban planning and public health. Knowledge must be translated into prevention, preparedness and management actions that protect both trees and people.

To strengthen urban tree biosecurity, collaborative action and dedicated, interdisciplinary research, coupled with investments in education, engagement and communication, are needed. Research must generate new knowledge and innovations, and bridge disciplines and policy domains, ensuring that insights from different disciplines and sectors are integrated into coherent strategies, while also involving local communities. Such integration is fundamental to realising the potential of One Health in practice, as protecting urban tree health simultaneously protects biodiversity, supports sustainable economies and enhances human well-being.

This White Paper calls on research funders, policymakers, and the scientific community to prioritise research on urban tree biosecurity as a central component of One Health. It identifies the following research and innovation topics as essential for building resilient and healthy urban forests:

1. ***Thriving under pressure.*** Turning knowledge of urban stressors into resilience strategies.
2. ***Smart prevention.*** Effective and socially acceptable measures and tools to stop threats before they spread with early warning systems, next-gen diagnosis methods, digital surveillance and adaptive biosecurity protocols.
3. ***Agile responses.*** Coordinated, cross-sector mechanisms to contain or eradicate outbreaks quickly, supported by robust contingency plans.
4. ***Resilient, future-proofed treescapes.*** Breeding strategies and improved selection methods of pest- and climate-resilient species and genotypes, ensuring diverse urban treescapes for future conditions and future-oriented planting strategies.
5. ***Sustainable integrated pest management (IPM) solutions.*** Pest management protocols tailored to cities, combining biological, cultural, technological and chemical methods that support tree vitality, with minimal ecological impact.

To fully harness the benefits of research and innovation, a reinforcement of the whole biosecurity ecosystem, including infrastructures, education, societal engagement and policy support is essential. Shared databases, monitoring platforms and coordinated infrastructures can connect efforts across countries and sectors. Equally, education and

training are needed to build expertise and awareness, while mobilising citizens, municipalities and the private sector ensures that research findings translate into practice. These efforts must be anchored in coherent policy frameworks that prioritise biosecurity and enable sustained cross-sector collaboration.

In short, safeguarding the vitality and health of urban trees is a cost-effective strategy for achieving multiple environmental, economic, and societal goals. We therefore call on the national research funders and the European Union to recognize urban tree biosecurity as a cornerstone of the One Health approach and a strategic priority across national research agendas, Horizon Europe and related policy frameworks. By integrating research, financing, and communication, Europe can secure the trees that protect our cities, strengthening resilience, well-being, and sustainability for generations to come.

Introduction

Guardians at Risk: Urban Trees in a Changing World

Trees are indispensable allies in tackling today's interconnected challenges of climate change, public health and biodiversity loss. They provide a wide range of ecosystem services that no technology or infrastructure can fully replace: filtering air and water, stabilising soils, storing carbon, sustaining biodiversity and cultural enrichment—the very foundations of resilient ecosystems. Trees also provide food, shelter, and migration corridors for wildlife, while the large-scale loss of tree cover increases the risk of zoonotic spillovers such as Ebola and SARS-CoV-2 by forcing closer contact between wildlife, livestock and people. Deforestation further creates conditions favourable to vector-borne diseases like malaria and Lyme disease.

In cities, trees function as the backbone of green infrastructure. They cool neighbourhoods during heat waves, absorb harmful pollutants that contribute to respiratory and cardiovascular diseases, provide restorative environments that reduce stress, strengthen mental health, and promote physical activity—ultimately lowering healthcare costs. Beyond these health benefits, trees have long been a source of medical innovation, with aspirin derived from willow bark being one notable example.

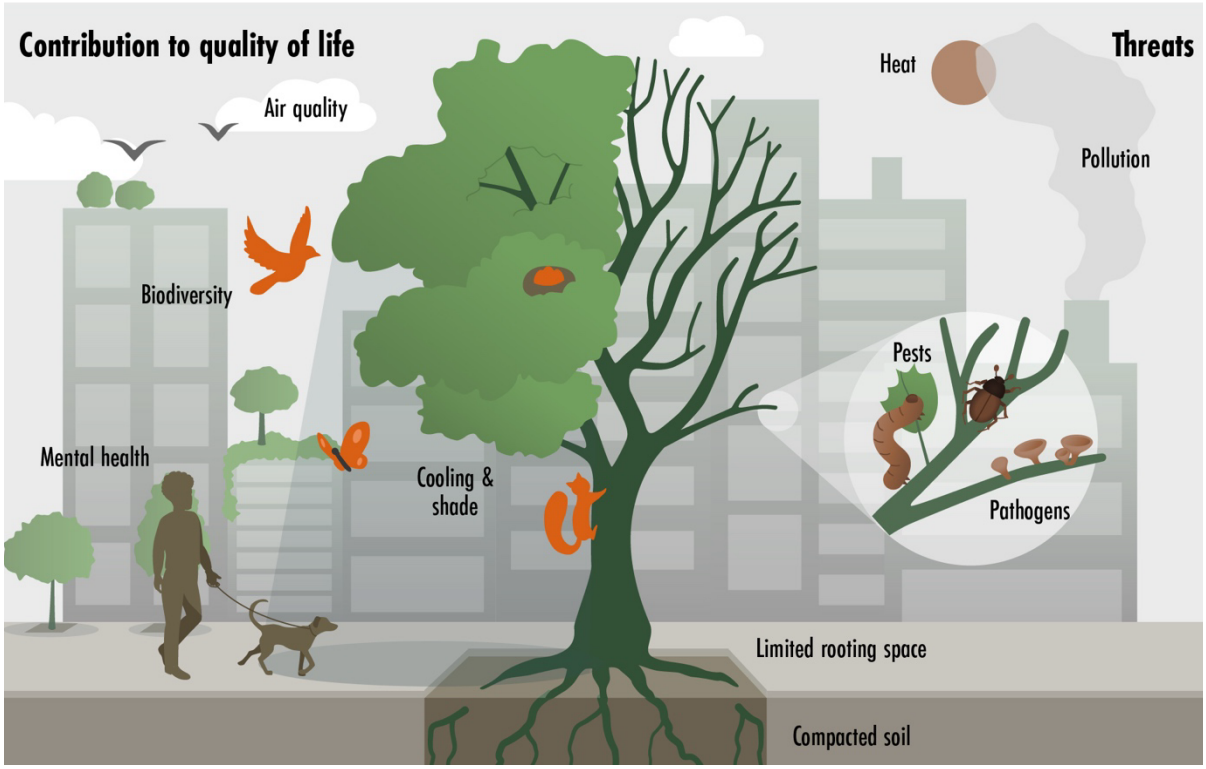

Figure 1. Urban tree's contribution to quality of life, and the threats they are facing

Globalisation and the accelerating movement of goods and people have made cities with ports, airports and transport hubs frequent entry points for invasive pests that threaten trees.

Ornamental plant imports, nursery stock and wood packaging materials are common introduction pathways. Urban trees, especially those weakened by drought, soil compaction, or pollution, are highly vulnerable to these invaders. Climate change magnifies these risks by expanding pest ranges and increasing environmental stress through droughts, floods, and storms.

Urban treescapes, situated at the interface between built and natural environments, can act as stepping stones and reservoirs for invasive organisms, facilitating their spread into adjacent forests. Once established in suitable hosts, outbreaks can cascade into biodiversity loss, ecosystem disruption and reduced resilience to climate change. The resulting damage to production and conservation forests can be profound and long-lasting, undermining both the bioeconomy and biodiversity conservation strategies that depend on healthy ecosystems. Moreover, disturbed ecosystems often support higher populations of disease-carrying vectors such as ticks and mosquitoes, heightening public health risks.

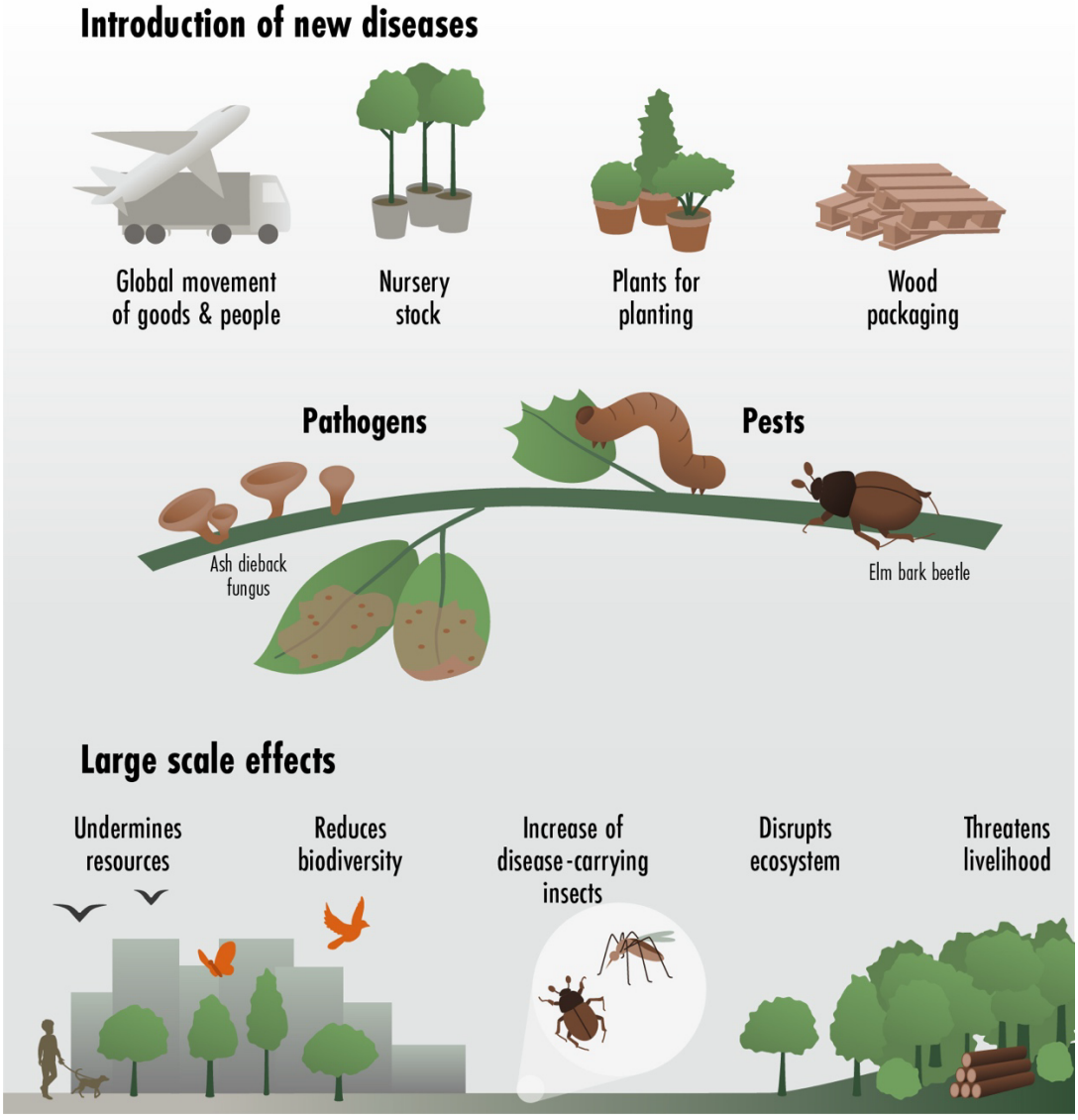

Figure 2. Paths of introduction of new diseases and their large-scale effects

Urban Tree Biosecurity: A Missing Link in One Health

The health of urban trees is inseparable from the health of people and ecosystems. Urban trees connect the benefits of thriving ecosystems to people's daily lives in cities and beyond. Urban areas are the frontline for pest introduction and the places where cascading impacts on biodiversity, economies and human well-being are most visible. Yet, the crucial role of urban trees in the larger ecological picture is often overlooked. The *One Health* framework, articulated by the World Health Organization and other international bodies, advocates an integrated, transdisciplinary approach to human, animal and environmental health. However, its implementation has largely concentrated on zoonotic diseases and food safety systems, with limited attention to the broader ecological context in which health is shaped and maintained.

Urban tree biosecurity encompasses the policies, measures and practices that prevent the introduction, establishment and spread of harmful organisms. It includes early detection, risk assessment, monitoring and management strategies to safeguard tree health and ensure longevity of ecosystem services. Strengthening research and innovation on urban tree biosecurity is not an abstract, academic exercise but a practical necessity to prevent escalating costs, ecological disruption and health risks (Table 1). Yet, despite its direct relevance to climate resilience, biodiversity protection, and public health, urban tree biosecurity remains underrepresented in both policy and investment strategies aligned with the One Health framework. Better integration of urban tree biosecurity research, incorporating multiple disciplines and sectors and innovation efforts into a One Health perspective would ensure that strategies to protect trees also safeguard biodiversity, rural livelihoods and public health across Europe and beyond, advancing the goals of the EU Green Deal, Biodiversity Strategy and climate resilience agenda.

Table 1. Interconnected problems related to urban tree biosecurity.

Problem	Key Impact	Reference
Widespread invasion	Urban ecosystems in Europe are among the most invaded by invasive alien species: invasion has been recorded in nearly 68% of the areas occupied by urban ecosystems.	Polce, C., *et al*. (2023). Invasive alien species of policy concerns show widespread patterns of invasion and potential pressure across European ecosystems. *Sci. Rep. 13, 8124*.
Rising pest alerts	The number of pest notifications in EU Member States and Switzerland has more than doubled from 2019 (441) to 2021 (969).	European Commission (2023) https://data.europa.eu/doi/10.2875/54118
Economic costs	Between 1960 and 2020, biological invasions caused an estimated total economic loss of about €116.6 billion across 39 European countries.	Haubrock, P., *et al*. (2021) Economic costs of invasive alien species across Europe. In: Zenni, R.D. *et al*. (Eds.). The economic costs of biological invasions around the world. *NeoBiota 67, 153-190*.

Urban entry Points	The vast majority of first records of insect pests –89% for Europe overall and 88% for individual European countries–were detected in urban or suburban areas.	Branco, M. *et al*., (2019). Urban trees facilitate the establishment of non-native forest insects. *NeoBiota 52, 25-46*.
Tree loss risk	Urban tree inventories indicate that a combined outbreak of certain pests could cause up to 98% loss of trees in worst-case scenarios, emphasizing the need for a proactive approach and increased diversity to enhance resilience.	Sjöman, H. & Östberg, J. (2019) Vulnerability of ten major Nordic cities to potential tree losses caused by longhorned beetles. *Urban Ecosyst. 22, 385–395*.
Reduced human wellbeing	The loss of trees caused by the emerald ash borer was associated with over 21,000 additional deaths from cardiovascular and respiratory diseases across 15 U.S. states.	Donovan *et al*., (2013). The relationship between trees and human health: evidence from the spread of the emerald ash borer. *Am. J. Prev. Med. 44, 139-145*.

From research to resilience: Strengthening the urban tree biosecurity through research

The effective design and management of urban green spaces resilient to pests necessitates an integrative understanding of tree species functional traits, their ecophysiological requirements, the spectrum of current and emerging biotic threats, the values, attitudes and behaviours of a broad range of actors and the epidemiological pathways through which pests disperse. However, such an integrated perspective is hindered by the fact that research on urban tree biosecurity remains fragmented across disciplines, such as ecology, pathology, entomology, social sciences, economics and forest sciences, with limited exchange even between urban and production forestry. To address the complex challenges of invasive pests in urban environments, transition to an interdisciplinary approach is needed–one that connects research, policy and practice. This change necessitates close collaboration among researchers, practitioners, policymakers and community stakeholders.

In this White Paper, compiled by participants of COST Action "Urban Tree Guard" (CA20132), we propose strategic priorities to strengthen urban tree biosecurity in the European context. We point out thematic research topics that should be given priority in funding decisions. We emphasise the importance of a strong *biosecurity ecosystem*– comprising infrastructures, education and societal engagement–that is essential for enabling and adopting research findings and innovations for the benefit of human health and wellbeing, biodiversity and ecosystem integrity. Importantly, we propose placing urban tree biosecurity research within the broader One Health framework, to recognise that pests and diseases are not only problems for trees, but also challenges with cascading effects on ecosystem integrity, human and animal health and socio-economic stability.

Integrating urban tree biosecurity into research and innovation funding priorities

Research will light the way forward for urban tree biosecurity but without the right investment priorities and broad support even the best ideas cannot lead to improvements. Increased and targeted investments from both national and EU funding schemes are crucial to advance urban tree biosecurity research and innovation, securing the foundations of Europe's green and healthy cities. Although often seen as a niche topic, urban tree biosecurity encompasses diverse scientific, social, and technological dimensions, making it a cross-cutting priority within multiple funding priorities and frameworks. For instance, it cuts across all six Horizon Europe clusters (Table 2), with relevance to health, society, security, technology, climate, and the environment. This highlights the broad potential to enhance investment in tree biosecurity research by ensuring the topic is more prominently featured within diverse research and innovation funding frameworks.

Table 2. Relevance of urban tree biosecurity to Horizon Europe clusters.

Cluster	Focus	Relevance of Urban Tree Biosecurity	Example Contribution
1. Health	Human & environmental health	One Health link, well-being, ecosystem health	Studying effects of urban tree health on public health
2. Culture, Creativity & Inclusive Society	Governance, inclusion, values	Citizen engagement, social innovation, perception of trees	Co-creation of biosecurity actions with communities
3. Civil Security for Society	Resilience, risk management	Biosecurity preparedness, disaster resilience	Integrating tree pest monitoring into resilience planning
4. Digital, Industry & Space	Innovation & digital tech	Sensing, modelling, data for tree health	AI tools, monitoring platforms
5. Climate, Energy & Mobility	Climate & adaptation	Green infrastructure for adaptation	Urban cooling, carbon capture
6. Food, Bioeconomy, Natural Resources, Agriculture & Environment	Ecosystems, biodiversity	Tree health, pests, ecosystem resilience	Urban tree biosecurity, One Health, biodiversity links

Research and innovation priorities

To strengthen urban tree biosecurity and fill important knowledge gaps, research and innovation must move beyond isolated studies toward an integrated agenda that anticipates risks, accelerates detection, and builds resilience across urban ecosystems. In the following section, we present a set of interconnected research priorities designed to fill

critical knowledge gaps and guide progress in urban tree biosecurity within the One Health framework.

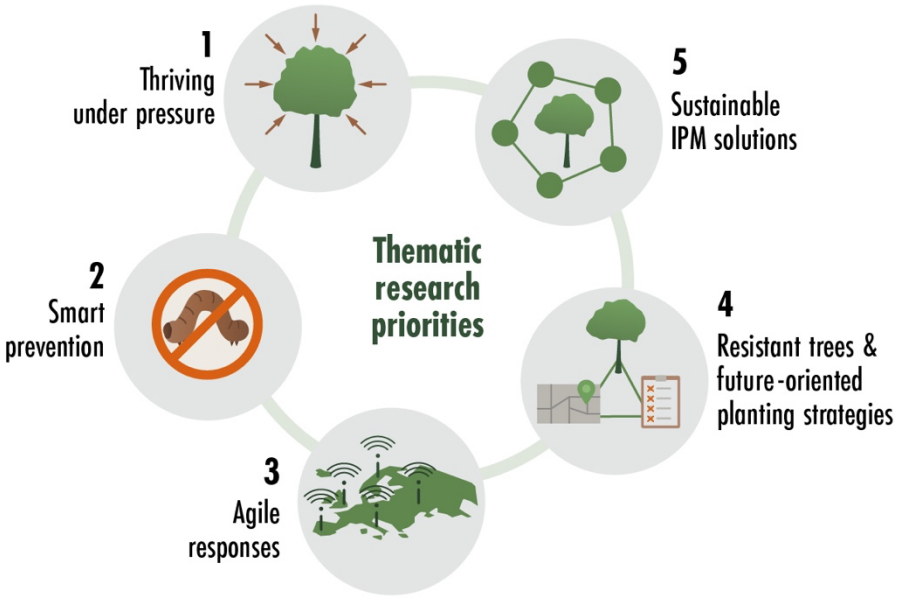

Figure 3. Thematic research priorities to strengthen urban tree biosecurity

1. Thriving under pressure - from stressors to resilience strategies

Urban environments expose trees to multiple stress factors that interact in complex ways, weakening vitality and resilience. Compacted and sealed soils restrict rooting space, water infiltration and oxygen availability, while heat islands intensify drought stress and increase evaporative demand. Pollution from traffic and industry adds chemical stress, and mechanical injuries from construction or human activity create entry points for pests. At the same time, the inadequate surveillance of imported plants and plant products heightens the risk of pest introduction and outbreaks.

New research is needed to disentangle how these stressors interact to influence tree physiology, defence capacity, vulnerability to pests and the wider environment. Priorities include quantifying thresholds for soil and water conditions that support resilience, modelling how heat, drought and pollution jointly affect tree health, and identifying management practices that mitigate stress under a broad range of future climate scenarios. Innovative research is also needed to translate this knowledge into practical tools for urban planning, species selection and site design, ensuring that urban trees remain healthy providers of ecosystem services despite the challenges of the built environment.

2. Smart prevention and early detection

Prevention is the most effective strategy to limit the introduction of pests and to reduce their impact on trees. Yet, increasing global trade in plants, together with climate change and urbanisation, accelerates biological invasions, adding new layers of complexity to their management. Major research gaps include mapping pest pathways with urban-specific risk models through which invasive pests are introduced, with particular emphasis on urban

environments where concentrated human activity and diverse plantings create multiple entry points. Understanding the relative risks of these pathways from a variety of actor perspectives is critical to guide targeted prevention and control measures.

Early detection and rapid diagnosis are equally essential to prevent outbreaks from escalating. These approaches, together with improved eradication and containment strategies, are crucial when prevention alone is insufficient. Advanced technologies, such as environmental DNA (eDNA) analysis combined with machine learning have recently emerged, promising rapid and accurate identification of invasive species and fast assessments of tree health. A key innovation challenge is to translate cutting-edge research into practical, scalable solutions that practitioners, policymakers and society can willingly and easily adopt.

Advances in monitoring technologies represent another major research priority. Cost-efficient and user-friendly tools are needed to detect emerging pests across diverse environments. AI-powered systems, including drones and remote sensing, can survey large areas with high precision and generate real-time data to support timely interventions. Citizen science platforms, such as *iNaturalist,* can further expand monitoring capacity by engaging the public, enriching datasets with community observations and enhancing early warning systems at scales unattainable by experts alone.

It is important to embed these advances into integrated urban biosecurity systems, ensuring that prevention, detection, and monitoring research translates into effective on-the-ground protection for Europe's trees.

3. Agile responses

Transparent regional and international information exchange is a vital element of robust urban tree biosecurity. Efficient cross-border early warning systems and harmonised protocols for surveillance and data sharing between countries and municipalities would significantly improve preparedness. Innovative research is needed to design interoperable monitoring tools, data standards and modelling approaches that can function across governance levels and environmental contexts. Equally important is social innovation, with involvement of citizens, professionals and policymakers in shared monitoring and response frameworks, supported by education, communication and participatory platforms. Embedding these efforts in coherent policy frameworks would ensure coordinated approaches and strengthen transparency, trust and collective responsibility for safeguarding urban trees and the ecosystem services they provide.

4. Resilient planting material and future-oriented planting strategies

Pest outbreaks in urban green areas arise from a complex interplay of factors – among them the resistance and tolerance of trees, which are determined by genetic, biological, and environmental influences. Therefore, building resilient urban forests requires applying the principle of *"the right tree, in the right place, for the right purpose."* This means matching species to site conditions while also ensuring they contribute to ecological functions, social

and economic values and climate adaptation goals. Research should focus on identifying the combinations of tree traits, site conditions and planting designs that maximise resilience, and on co-developing practical decision-support tools to guide planners and managers in applying these insights.

Tree breeding and propagation programmes must prioritise pest and disease resistance alongside climate tolerance and ecosystem service provision. Diversification strategies—broadening the mix of both native and carefully selected non-native species to avoid overreliance on a few vulnerable taxa—remain a cornerstone of resilience. Innovative solutions (e.g., digital twin modelling) are needed to evaluate which species and provenances are best suited for future urban environments, accounting for climate scenarios, pest pressures and local ecosystem dynamics.

Increasing communication and collaboration between nurseries and municipal planners is also critical. Ensuring that appropriate species are propagated and available at scale requires innovations in nursery practices, supply chains and long-term planning. Research and innovation should therefore target nursery production systems, certification schemes and scalable decision-support systems that connect scientific recommendations with practical implementation in cities.

5. Sustainable Integrated pest management solutions

IPM protocols tailored to urban environments provide a strategic and environmentally responsible framework for safeguarding tree health. They combine preventive, cultural, mechanical, biological and, only when necessary, low-impact chemical methods to minimise risks to people and biodiversity. In cities, IPM must give particular attention to resilient and diverse species selection, improved soil and water management, and the reduction of environmental stressors that weaken tree defences. At the same time, urban IPM protocols need to account for public health considerations, such as allergenic pests, and align with One Health objectives to ensure that ecological, human and animal health are addressed together. Despite its potential, urban IPM remains underdeveloped. Research is urgently needed to design adaptive frameworks that reflect the unique stressors of urban environments, such as heat islands, soil compaction and fragmented habitats. Innovation should also target decision-support systems that integrate ecological data, risk assessments and socio-economic factors, providing planners and managers with actionable guidance for long-term resilience.

A central element of urban IPM is the use of Nature-based Solutions (NbS). In urban settings, these include, for example, diversifying tree plantings to reduce vulnerability to pests and diseases; enhancing soil health through compost or mulching to promote soil physical quality and support beneficial microbes; and creating habitats such as flowering strips, hedgerows, or green roofs that attract natural enemies of pests. Urban NbS also encompass water-sensitive designs like bioswales and permeable surfaces to reduce drought stress, as well as increasing canopy cover and vegetation diversity to regulate microclimates and strengthen tree resilience. New research should focus on the biosecurity benefits and potential risks in urban NbS. It is also important to describe how biosecurity measures align

with the 3-30-300 principle, which recommends that every resident should see at least three trees from their home, live in a neighbourhood with minimum 30% tree canopy cover, and reside no more than 300 meters from the nearest public green space.

Biological control methods that protect trees without harming people or associated biodiversity remain an important research topic. Augmentative biological control, which involves the temporary release of beneficial organisms to suppress pest outbreaks, and classical biological control, which establishes long-term populations of natural enemies, both offer sustainable alternatives to chemical pesticides in urban settings. Natural predators, such as ladybirds, entomopathogenic nematodes and fungi and parasitic wasps can play significant roles in reducing harmful insect populations. However, these beneficial organisms are declining in many areas as a result of habitat loss, pollution and other human-driven pressures, which underscores the need for renewed research and conservation of natural enemies in urban ecosystems.

Microbe-based treatments, including the use of beneficial soil bacteria, or injection treatments to induce tree defenses to strengthen valuable city trees also provide highly targeted control options that limit collateral impacts on non-target species and urban biodiversity. Emerging innovations in microbial engineering represent another promising frontier for enhancing tree resilience in urban environments. By tailoring microbial consortia and supporting beneficial plant–microbe interactions, it may be possible to strengthen tree defences against pests while simultaneously reducing dependence on chemical pesticides. Further research is needed to develop robust and reliable biocontrol strategies that integrate microbial solutions with broader IPM frameworks, ensuring resilient, sustainable and healthy urban forests.

System for solutions

Science alone cannot safeguard Europe's urban trees–resilience is built through people, institutions, and collaboration. This chapter highlights the practical foundations of effective biosecurity: empowering local professionals, connecting diagnostic infrastructures, securing stable financing, and aligning governance across sectors. By reinforcing these systems, Europe can turn knowledge into action and ensure that cities are ready to protect the trees that protect them.

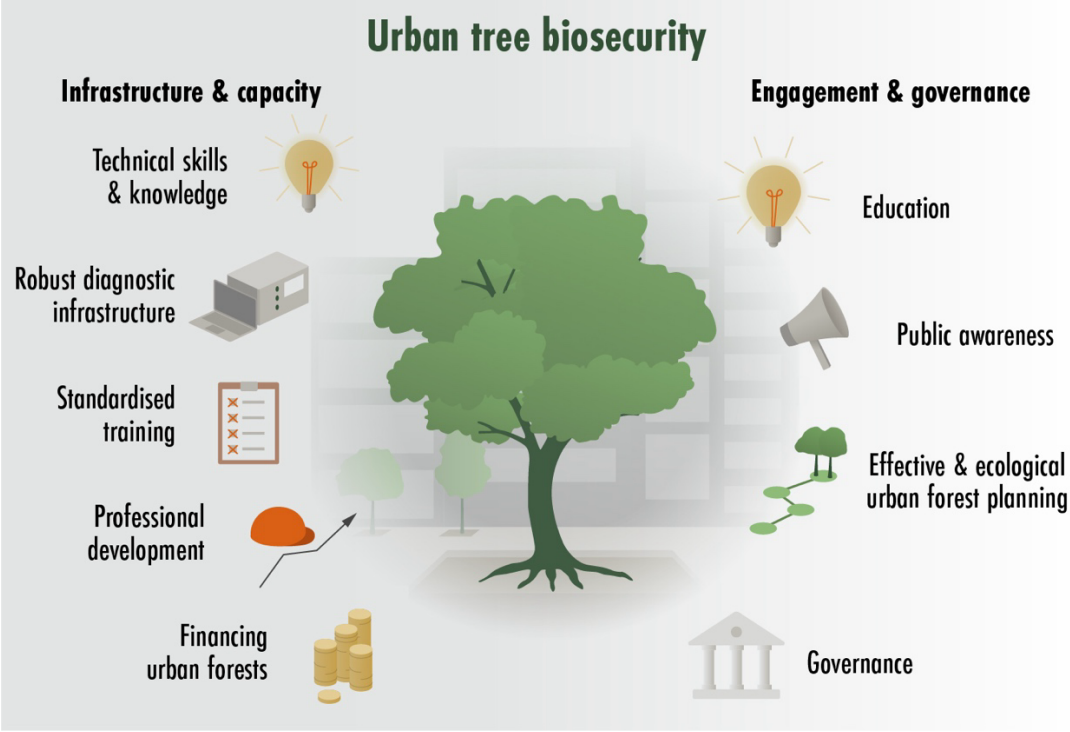

Figure 4. Systems for solutions towards urban tree biosecurity

1. Strengthening local capacities and professional skills of the workforce

A shortage of technical skills and knowledge is widely recognised as a major barrier to effective urban forestry. Strengthening local biosecurity capacities requires structured training and certification for urban foresters, municipal tree officers, pest inspectors, landscape architects and park managers. These frontline professionals are often the first to notice and respond to early signs of pest outbreaks or tree decline, yet their roles are frequently under-resourced and fragmented.

Standardised training focusing on pest identification, early detection, risk communication and IPM will significantly improve the ability of society to act quickly and effectively. Such training should ensure consistency across jurisdictions while allowing adaptation to local ecological and administrative contexts. At the EU or national level, certification programmes

that explicitly integrate urban biosecurity and biological invasion risks—such as an expanded version of the European Tree Worker (ETW) framework—could help to harmonise practices and raise the professional profile of urban tree care. Incorporating biosecurity principles, early detection and pest/pathogen management into existing arboricultural certifications would increase their relevance in addressing current and future threats.

Continuous professional development is crucial for upholding high standards of prevention and resilience in urban green infrastructure management, thereby advancing the objectives of the One Health framework. At the same time, assessing the working conditions of urban tree managers is critical for developing best practices. Harmonising definitions, standards and data collection protocols provides the foundation for efficient biosecurity strategies. Finally, investing in local nursery production and national breeding programmes will help to secure a healthy plant supply and strengthen preparedness for environmental and biosecurity challenges.

2. Diagnostic infrastructure and collaborative networks

A robust diagnostics infrastructure is critical for effective urban tree biosecurity, especially in smaller municipalities that often lack diagnostic staff. Mobile diagnostic units, equipped with molecular tools such as qPCR, LAMP, or emerging CRISPR-based systems, can provide rapid, on-site identification of pests, enabling timely responses and reducing the risk of spread. However, to ensure equitable access to these capabilities across regions and for small and medium-sized cities, collaborative agreements should be encouraged between municipalities and external actors such as universities, public research institutes and certified private laboratories. These partnerships can support sample processing, provide technical expertise and offer training opportunities for municipal staff. Establishing regional diagnostic networks will help build a responsive biosecurity infrastructure that is inclusive, scalable and aligned with One Health objectives.

3. Financing resilience of the broader biosecurity ecosystem

Beyond securing long-term funding for research and innovation, it is equally important to build financial resilience throughout the broader biosecurity system. To build a resilient urban tree biosecurity system, financing must extend beyond initial planting projects to cover the full cycle of planning, establishment, maintenance and long-term management of urban forests. This approach requires dedicated and sustained funding mechanisms that support municipalities and practitioners in delivering healthy and resilient green spaces. A recurring barrier is the lack of long-term financial support for ongoing management, even though funds are often available for tree planting and park creation. Current funding streams remain limited, relying mainly on international, national and municipal sources, with only minor contributions from private actors. Strengthening the financial base therefore calls for innovative funding models, such as public–private partnerships, green bonds, or ecosystem service payments, as well as better integration of urban tree biosecurity into broader policy agendas on health, climate adaptation and urban resilience. Concurrently, research infrastructure requires substantial reinforcement, as evidenced by persistent funding gaps, fragmented research initiatives, and a limited critical mass. Overcoming these

structural deficiencies is crucial to establishing a robust knowledge base capable of informing effective investment strategies and evidence-based governance in urban tree biosecurity.

4. Governance and policy integration

The governance aspect of urban forest management is crucial for the implementation of all activities in urban green areas. This aspect includes structures, processes, policies and relationships that determine how decisions about urban forests are made, who makes them, how different actors are involved and how responsibilities and resources are distributed. To safeguard our green spaces, it is imperative to have national and regional governments and authorities equipped with strong biosecurity expertise and the capacity to take evidence-based decisions.

Effective urban tree biosecurity requires robust legal frameworks that mandate prevention, early detection, and rapid response measures. The EU Plant Health Regulation (2016/2031) provides a foundation for preventing the introduction and spread of plant pests across member states, yet its implementation at the urban level remains inconsistent. Many municipalities lack clear legal authority or resources to enforce biosecurity measures in public and private green spaces. Harmonizing national and local regulations is essential to close these gaps, ensuring that urban tree managers have both the legal mandate and practical tools to act decisively. Furthermore, cross-border cooperation mechanisms must be strengthened through bilateral agreements and regional protocols that facilitate information exchange, coordinated surveillance, and joint emergency responses. Legal instruments should also address liability and responsibility for biosecurity breaches, clarifying the roles of nurseries, importers, property owners, and public authorities in preventing pest introductions and managing outbreaks.

Policy integration across sectors—urban planning, public health, agriculture, trade, and environmental protection—is crucial for operationalizing urban tree biosecurity within the One Health framework. This process requires embedding biosecurity considerations into existing policy instruments such as the EU Green Deal, Biodiversity Strategy 2030, and Urban Greening Plans. National and regional governments should develop dedicated urban forest biosecurity strategies with measurable targets, accountability mechanisms, and adequate funding streams. Incentive schemes, such as tax breaks for certified biosecure nurseries or grants for municipalities implementing IPM protocols, can drive compliance and innovation. Moreover, public procurement policies should prioritize pest-free planting material and support local production of climate-resilient, disease-resistant species. By aligning biosecurity goals with broader sustainability and resilience agendas, Europe can create coherent policy landscapes that protect urban trees while advancing climate adaptation, public health, and ecosystem integrity.

From awareness to action: Mobilizing society for tree biosecurity

A robust biosecurity system begins with identifying who can and should contribute and understanding the capacities they bring. The operational and financial resources of laboratories, managers, and planners at local, national and EU levels ultimately determine what can be achieved. Designing an effective biosecurity strategy therefore requires mapping awareness, roles, priorities, and budget frameworks of urban tree managers, planners, landscape architects, and other relevant actors. Regional urban forest strategies should build on existing consensus about environmental threats while addressing key management and governance challenges.

Education on urban trees, biodiversity, pests, their pathways of spread, and ecological consequences should be integrated across all levels of learning – from early childhood education to vocational and academic training. Establishing long-term community-based monitoring plots or observatories, in collaboration with schools, NGOs, or botanical gardens, can increase public engagement while generating valuable ecological data.

Public involvement and citizen science are central to improving tree biosecurity. Collaboration between researchers, local authorities, and citizens foster shared responsibility and supports collective data gathering, analysis, and mapping. Knowledge transfer benefits from shared standards and terminology across disciplines and can be enhanced through digital tools such as e-learning, and virtual or augmented reality demonstrations. Vocational training is most effective when it combines high-quality content with practical, hands-on activities that encourage cooperation and problem solving.

Public awareness of biosecurity risks, the actions citizens can take to prevent pest and disease spread, and the recognition of the unique values of urban greenery are crucial for effective management. Communication should be inclusive, transparent, and audience-specific, connecting relevant organisations and clarifying strategic and operational responsibilities. For example, campaigns for children could use interactive tools and games, while those for property owners might highlight cost savings and value gains through better biosecurity practices.

Effective and ecologically grounded urban forest planning is needed to strengthen resilience against environmental stresses and climate change, ensuring the long-term health of urban green spaces. Planning frameworks must integrate biosecurity considerations to anticipate and mitigate pest and disease risks rather than reacting to them. Accessible Decision Support Systems (DSSs) that integrate real-time data, pest risk indicators, and ecological priorities can help guide planning and maintenance. Open data platforms, shared methods and protocols across municipalities, and government awareness of existing tree stocks are vital to coordinated management. Comparative analyses of biosecurity implementation across EU and non-EU countries could further highlight best practices and promote collective learning.

Connecting the Dots: Urban Tree Biosecurity for One Health

Urban trees are far more than ornamental features. They provide a wide range of ecosystem services that significantly enhance the quality of life in cities. An important function of urban trees is their capacity to moderate local microclimates by attenuating wind speed and providing shade, which can reduce the urban heat island effect. During 2022–2024, the estimated number of heat-related deaths in Europe ranged from about 50,000 to 67,000 annually. Thus, the role of urban trees in public health is increasingly critical as extreme heat becomes a major health risk. Protecting urban trees through biosecurity is therefore directly aligned with One Health. However, more research is needed to describe the connections between health of people, animals and ecosystems, for example, by quantifying how tree decline translates into physical and mental human health risks due to reduced cooling, poorer air quality, limited opportunities for engaging with nature, and by developing models that integrate ecological, epidemiological and socio-economic data.

Equally important are innovations in urban tree care and biosecurity practices that enhance resilience under climate stress, which includes testing the effectiveness of preventive measures, such as optimised watering, soil health management and physical protection against mechanical damage, alongside monitoring and early-warning systems for pests and diseases. Future research should therefore explore how integrated biosecurity strategies can be designed and evaluated within the One Health framework, ensuring that the protection of urban trees is properly recognised as a public health and societal priority.

Call for Action

Safeguarding urban trees is safeguarding One Health. Through coordinated investment, scientific innovation and collective responsibility, Europe can secure resilient treescapes that sustain biodiversity, protect public health and strengthen communities for generations to come. We call for urgent actions to:

1. **Recognize urban tree biosecurity as a strategic One Health priority**. Urban tree health underpins climate resilience, biodiversity, public well-being, and sustainable economies. It must be acknowledged as an essential component of Europe's One Health framework and integrated into relevant EU and national strategies.
2. **Increase and coordinate investment in research, innovation, and capacity building**. Strengthen national and European funding for urban tree biosecurity through dedicated research calls, shared infrastructures, and interdisciplinary, long-term research projects and programs that link subjects such as forestry, ecology, tree physiology, urban planning, and public health.
3. **Build a connected and informed biosecurity ecosystem**. Develop coordinated monitoring, diagnostic, and data-sharing systems across cities and countries, ensuring

early detection and rapid response to emerging threats while enabling transparent exchange between researchers, policymakers, and practitioners.

4. **Empower people through education, training, and citizen engagement.** Integrate biosecurity education into all learning levels, support vocational and professional training, and promote citizen science and awareness campaigns that foster shared responsibility for urban tree health.
5. **Mainstream biosecurity into urban planning and governance.** Embed pest and disease prevention, monitoring, and response into urban forest management and planning frameworks, supported by accessible decision-support tools, harmonized standards, and cross-sector cooperation.

Europe must recognize urban tree biosecurity as a cornerstone of the One Health approach and a strategic investment in climate resilience, biodiversity, and public well-being. Strengthened national and EU-level funding, coordinated monitoring systems, and cross-sector collaboration are essential to anticipate and manage pest and disease risks. Integrating biosecurity into urban planning, education, and citizen engagement will ensure lasting protection of urban green infrastructure. By investing now, Europe can secure the trees that secure our cities, strengthening resilience, sustainability, and quality of everyday life for generations to come.

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