TREE PESTS AND PATHOGENS

A GLOBAL REVIEW OF THEIR IMPACTS IN URBAN SETTINGS

FEATURE

Raum, S. Collins, C. M., Urquhart, J., Potter, C., Pauleit, S., Egerer, M.

Introduction
The ability of urban trees to provide their myriad benefits is increasingly threatened. Insect pests and fungal pathogens are currently among the greatest threats to urban trees, with international trade, human movement and climate change all likely to further increase risk.

Increasing awareness of these threats and developing tree management strategies that account for these risks is paramount. These mounting pressures also highlight the need for tree management professionals to implement measures that increase urban forest resilience.



Felled ash trees, due to ash dieback (Rosenheim, Germany)
Photo: Susanne Raum, 2019

What we did
To investigate this area, we gathered the published literature on tree insect pests and pathogens from cities around the globe. One-hundred articles were selected, published between 1976 and 2021, and represent research in both urban and peri-urban fringe settings.

What we found
The study capture a wide range of insect / pathogen impacts from 28 countries. Ecological and environmental impacts dominate with social and cultural and economic impacts also mentioned (Figure 1). Most studies (72) addressed impacts of insect infestations and one-third (32) refer to pathogens. Among insects, most studies focused on beetles (Coleoptera) (35) and moths (Lepidoptera) (20), whereas pathogen-related studies were dominated by fungi (38) with only one on bacteria.

FIGURE 1

Summary of the impacts of urban tree insects / pathogens reported in the different studies

Ecological / Environmental Impacts (95 studies)		**Social / Cultural Impacts** (35 studies)		**Economic Impacts** (24 studies)	
Tree damages	**87**	**Reduced aesthetic value**	**15**	**Pest management costs**	**15**
Tree mortality	**49**	**Human health impact**	**11**	Economic losses	4
Reduced tree growth	8	Hazards, affecting human safety	8	Structural damage	2
Changes in tree function	6	Loss of cultural / heritage value	3	Loss in ornamental value	2
Weakened / stressed tree	5	Nuisance due to larvae / litter	3	Loss of property value	2
Changes in soil composition	4	Impact on tourism	2	Human health related costs	1
Changes in ecosystem services	3	Changes in sound / noise level	1	Changes in fibre availability	1
Indirect tree damage (due to predators of beetle larvae)	2	Changes in crime rates	1		
Loss of tree canopy cover	1	Reduced thermal comfort	1		
Changes in biodiversity	1	Pest management action affects	1		
		Alteration of agroecosystem	1		

**Number in brackets () is the number of this type of impact reported in all reviewed studies*

Ecological / environmental impacts
The majority of ecological and environmental impacts reported on various tree damages and on tree mortality. Tree damages included changes in colour / discolouration (39), dieback (33), defoliation (30), lesions / cankers (19), larval galleries (16), and wilting / withering (14). Of the 49 studies reporting tree mortality, the earliest (from 1976) is on canker stain of planes (*C. platani*) in southern France. The disease killed more than 1,800 well-established plane trees in the streets of Marseilles over a 12-year period. Dutch elm disease (*O. ulmi*), another deadly pathogen led, in combination with elm yellow disease (*Candidatus phyloplasma ulmi*), to a complete loss of the American elm tree species in the Central New York. In 1997, we saw a growth in studies of introduced beetle species, especially in the US, Europe, and Russia, with potential to cause widespread tree mortality. The extent of ash loss due to the non-native emerald ash borer (*A. planipennis*) in both urban and rural areas in Russia, for instance, was reported in 2013 at up to one-million trees.

Socio / cultural impacts
Thirty-five studies reported socio-cultural impacts, most related to the loss of aesthetic value, increased hazards and reduced human health. For instance, a loss of ornamental value of between 2–2.5 million Euros was attributed

Beetle infestation of willow (Freising, Germany)
Photo: Susanne Raum, 2021





Beetle infestation of pine trees (Kelheim, Germany)
Photo: Susanne Raum, 2022

to the death of 164 mature Canary Palms (25% of the cities' total) in the Italian city of Bari, caused by the red palm weevil (*Rhynchophorus ferrugineus*). Periodic outbreaks of cicadas (*Magicicada septendecim and M. cassini*) in urban forests in northeastern Illinois in the US, on the other hand, caused significant damage to the main trunk of younger trees, resulting in breakages. Twigs weakened by ovipositional wound damage, especially, were more likely to die later in the summer and break during windstorms, subsequently littering the ground. Other studies were more health-related; especially allergic reactions due to exposure to oak processionary moth caterpillars (*Thaumetopoea processionea*), pine processionary moths (*Thaumetopoea pityocampa*) or European gipsy moths (*Lymantria dispar*) have become an increasing public health problem worldwide. In one example from Germany, 165 patients were reported over a period of only six days to have sought medical treatment for dermatitis during a local oak processionary moth (*T. processionea*) outbreak.

Economic impacts
A quarter of studies reported economic impacts or estimates of the potential costs of urban tree insects / pathogens. The majority examined the costs associated with pest control and management, including tree removal and replacement costs. Most emphasise the costs to municipal authorities, which can be substantial. Removing trees affected by the beech leaf-mining weevil (*Orchestes fagi*) in the Canadian town of Halifax, for instance, cost $474±66 per tree in 2018, leading to overall cost estimates averaging $1934 per resident. In the US region of Minneapolis-Saint Paul, 76–266,000 trees were anticipated to become infected by oak wilt disease (*Ceratocystis fagacearum*); their discounted removal cost estimated to be $18–60 million. The spread of sudden oak death, caused by Phytophthora ramorum, led to property value losses to single family homes in Californian communities, estimated at $135 million. These costs are thus accruing in cities around the world and are rising through time. However, it is to be expected that the costs associated with tree insects / pathogens decrease with an increase in tree diversity, as less trees are likely to be infested in one location or neighbourhood.

Suggestions for policy, practice, and research
To reduce the impacts of tree insects / pathogens in urban areas, our review also gathered suggestions for policy and practice in urban contexts (Figure 2). These include using risk maps and surveillance alongside tree density and diversity maps, greater stock diversification and control measures. Our study also suggests areas for further research (Figure 2).

This project received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 101023713



Leaf damage caused by insects (Freising, Germany)
Photo: Susanne Raum, 2022

Conclusion
Our work reveals the geographic scope and volume of the literature over time, as well as the various impacts, especially the environmental impacts of tree damage and tree mortality. Social impacts reported focussed on aesthetics, health, hazards and economic impacts on the costs of pest management and control.

The importance of further practical measures, including improved funding for both general tree management and pest management, sanitary practices and the overall improvement of tree growing conditions, will become increasingly apparent.

FIGURE 2

Summary of suggestions for policy, practice and research

Policy	Practice	Research
✔ urban tree inventories	↑ species diversity	✔ repeat in regions;
✔ urban tree risk maps	↑ genetic diversity	✔ monitor enemies;
✔ regional lists of dangerious tree pests	↑ tree resilience	✔ develop methods for impact evaluation;
✔ adequate funding	↑ pest monitoring	✔ impacts on erosion,
✔ info, advice, education	✔ monitor tree diversity	✔ temperature,
✔ educate tree & medical staff	✔ improve tree conditions,	✔ water retention, &
✔ monitoring & info systems	✔ sanitary practices, &	✔ recreation benefits;
	✔ tree management;	✔ studies on nuisance, property damages,
	✔ involve private owners	✔ human wellbeing,
	✔ involve community	✔ hazard liability

Full details, including the underpinning literature, of the study can be found in: Raum, S. Collins, C. M., Urquhart, J., Potter, C., Pauleit, S., Egerer, M. (2022) 'Tree insect pests and pathogens: a global systematic review of their impacts in urban settings' in *Urban Ecosystems* (February 2023, issue 1), Springer Nature.