How the global threat of pests and diseases impacts plants, people, and the planet

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Societal Impact Statement

Plants provide us with the building blocks of life—oxygen, food, fuel, clean air, and water and a stable environment. And yet, in the modern world, they are under ever-increasing threat from introduced pests and diseases. Such epidemics can have devastating impacts on human health, biodiversity, and food security, as well as contributing to environmental change. The Chief Plant Health Officer at Defra has a key role in the development of policy to protect the UK’s plants from biosecurity risks, and we explore the different approaches being taken to manage these risks and protect the UK’s plants for the future.

Summary

Plants have an essential role in addressing the great social and environmental challenges of our time. However, the risk from invasive plant pests and pathogens is also significant and constantly growing as a result of increasing globalization and environmental change. The UK’s plant health regime aims to manage that risk to protect the enormous value of plants and trees; from the value of crops and forestry products, to ecosystem services and societal benefits. We discuss the role of the Chief Plant Health Officer at Defra in advising Ministers on plant health policy, including through dialogue with stakeholders and the research community. Case studies demonstrate how plant health threats can put at risk human physical and mental health, the economic benefits of healthy plants, and food security. We discuss the UK’s risk-based approach to protecting the UK’s plant resource, and the approaches being taken to manage different kinds of risks, including import controls, management of threats once established, breeding resistant varieties, utilizing citizen science, and awareness raising.

KEYWORDS

biosecurity, Chief Plant Health Officer, Defra, plant health, risk register

1 | INTRODUCTION

This article describes the work of the Chief Plant Health Officer (CPHO) at the Department of Food and Rural Affairs (Defra). The CPHO has a background in botany and plant pathology and leads Government actions in response to major threats to plant and bee health. Defra takes a risk-based approach, with risk assessment underpinning planning and decision making and informing the design of mitigating actions. The CPHO’s role in Government is to advise Ministers on proposed solutions to the threats posed by a wide range of plant pests and diseases, sometimes involving changes in policy. The approach is collaborative and evidence based, with open dialogue between government and stakeholders, and input from the research community providing the foundation for the design of
policies and management responses to threats. The threats to plant health are growing: Figure 1 shows an upward trajectory over the last 100 years or so as an increasing number of plant (in this case, tree) pests and diseases have arrived in the UK. This is driven by globalization in trade, the movement of people and, crucially, the unprecedented volumes of international trade in plants and trees.

The UK is a net importer of plants and plant products. One kind of import with its own particular risk profile is that of mature trees (Figure 2). The olive tree is currently a regulated species. Imported olive trees have to be accompanied by a plant passport and additional declarations, which mean that it has been inspected so that the authorities can be confident that it is free of pests and diseases. However, the challenges are obvious; the trees are large, which makes inspection difficult, and they are transported along with large volumes of soil, which itself carries biosecurity risks. Olive trees are a particularly high risk, because they are hosts of the bacterial pathogen *Xylella fastidiosa*, as discussed below.

Some wood and wood products also pose a risk. They include not just sawn wood and timber, but also, for example, pallets and other forms of wood packaging, firewood and pieces of wood used for all sorts of other purposes (Figure 3). It is known that in other parts of the world pests have been moved in firewood through the practice of taking firewood on camping trips into forests. Overcoming this challenge is proving to be difficult. There are very strict regulations on wood and firewood, but constant vigilance is necessary.

Direct sales and the Internet are also introducing new risks, requiring work with the online sales community. If prohibited material is found, the online auction is instructed to take it down, but many people think that just because they can buy something on the Internet it must be acceptable and legal. Assessing the degree of risk requires a lot of work with parcel and postal depots, and a combination of online intelligence and inspectors on the ground, sometimes supported by sniffer dogs that can detect prohibited products. Figure 4 shows examples of prohibited materials intercepted by plant health and seeds inspectors.

It is acknowledged that there are some very good Internet businesses; understanding how better to regulate them to manage risk is necessary for them to be able to trade in this new way. Sources of risk can be unexpected. Figure 5 shows a headboard that a family complained kept them awake at night because they could hear a scratching sound in it. They contacted the local council Pest Inspector and eventually a Plant Health Inspector became involved. The cause was familiar: the larva of the Asian Longhorn Beetle. These beetles lay their eggs in wood and their larvae, which are up to 5 cm long, noisily feed on the wood until they pupate, eventually emerging as adult beetles.

1.1 | The UK Plant Health Risk Register

The requirement for a way of assessing risk and managing it has led to a unique initiative, the development of the UK Plant Health Risk Register (Figure 6). It was started in 2013 in the wake of the first report of Ash dieback in the UK. The aim is to be more proactive about the assessment and prioritization of risk and the preparation of contingency plans thereby maximizing the chances of early detection and response in order to avoid large-scale losses.

A team of Pest Risk Analysts led by the CPHO scours the world for new and emerging threats. The team works with scientists and practitioners to give every potential threat a risk rating based on the likelihood of it getting to the UK via known pathways and assessing what would happen if it did arrive. Among the questions it seeks to answer are: could it establish? Could it complete its lifecycle? Is it going to spread? How many years would it take to complete its lifecycle? What impacts would it have (covering economic, social, and environmental impact categories)? How severe would the impacts be?

Every risk is given a rating, on a scale of 0 to 125, which allows the portfolio of risks to be prioritized. The portfolio is large, about 1,050 at the moment, but many of them are low risk. There are about 60 entries in the highest risk category. It is significant that, since the Risk Register was launched, the rate of increase in the number of threats...
has gradually reduced (Figure 7), suggesting that the authorities are getting on top of at least knowing what is out there. But of course there are always new risks, particularly in trees where declines and different types of unknown syndrome arise that require investigation.

The procedure for active management of risks identified in the Register is as follows. Risks are reported to Ministers via a Monthly Biosecurity Meeting, anything new and emerging is flagged up, and then decisions are made about what measures to take including if regulation is recommended. We also consider whether there should be a public awareness campaign, whether industry can manage the risk and whether there are effective pest control products available. The reason for such an active management process is that, as estimates show, the value under threat is huge (Figure 8). The total annual ‘value at risk’ from forestry and healthy crops is around £9bn. This includes an estimate of the social and environmental value, which is more difficult to monetize. We are always considering how the understanding of the wider societal risks and benefits be improved. Plants in the food and drink industry are worth about £20bn and it is estimated that the social and environmental benefits are of the same order. The asset value of the nation's trees and woods is estimated as £175bn. Economists and statisticians are working with researchers to develop, review and refine these figures, because we need to understand and value what is at risk in order to make the case for funding, for research and for action to mobilize the community to act.

The question as to the wider impacts of plant health on people and the planet is a very interesting area. The evidence base is an emerging one, but it is worth considering what the important elements are and how the research community can contribute to improving it. It is likely that most readers of this article appreciate the value of trees, but what do other people think about trees and plants? There are very strong emotional connections to, and urges to protect wildlife, and particularly animals, but as a recent issue of *Plants, People, Planet* on Plant Blindness (https://nph.onlinelibrary.wiley.com/toc/25722611/2019/1/3) shows, trees and other plants are often taken for granted. Botanists and plant pathologists have been trained to observe: take them anywhere and they will be looking up, looking down, looking for plants and the problems they may be facing; but a lot of people do not notice or value trees and plants.

### 1.2 Plant health and public health

The social value of healthy plants is extensive and underlines the need to protect plant health in the UK. Research focused on trees, woods, and forests in the UK has shown that they include a whole range of wellbeing factors, such as physical and mental health, the connections between people, landscapes and nature, education and learning, the role that plants play in supporting local economies, and the importance of plants for social and community development (O'Brien & Morris, 2013). People attach very strong cultural meanings to plants and trees, and this varies from country to country. For example, there is much interesting work going on in New Zealand around the cultural and symbolic significance of certain plants and trees, but you only have to think about the oak tree to appreciate its historical and artistic significance and its role in shaping British identity.

Plants and trees are at the heart of communities and society. Consider physical health. Physical inactivity causes 9% of premature deaths globally and is the cause of 6%–10% of the major non-communicable diseases (Lee et al., 2012). Encouraging people to use the natural environment can
have a considerable positive impact on physical health and well-being (Morris & O’Brien, 2019; Ward Thompson et al., 2012). More detailed analysis is needed, but it is estimated that there could be more than £2bn annual savings in terms of averting public health costs if people would get out into the natural environment (Lovell & Maxwell, 2016).

At a time of temperature extremes, when more than half the world’s population live in cities, trees have a critical part to play in improving the urban environment by cooling due to evaporation of water from leaves, by providing shade and protection from UV, and by reducing heat-related stress and illness (Edmondson et al., 2016; Doick et al., 2014; Gill et al., 2007). To get a sense of the seriousness of this problem, the extreme heat in Europe during the summer of 2003 was responsible for 2,000 deaths in the UK.

Whilst the effects of trees on air quality is small, some trees are effective in removing pollutants from the air and the health effects can be significant. For example, the annual value of air quality regulation performed by woodland in the UK was valued at £0.77bn by one study in 2015, based on avoided health costs (Jones, 2017). The World Health Organization estimates that air pollution is responsible for 7.6% of deaths worldwide. The London Plane is an example of a common species that can have real benefits in the urban environment. It absorbs particulates into its bark, which is shed and can be gathered and removed, thus eliminating pollutants from the air (Figure 9).

Trees can be a source of relief from chronic stress and psychiatric disorders, particularly associated with urban lifestyles. They can screen elements of city environments that act as stressors, such as high-rise buildings and urban sounds, and can help mental restoration (Brown et al., 2013, Van den berg, Jorgensen & Wilson, 2014; Hauru et al. 2012; Takayama et al. 2014). Direct experiences of trees and views of trees are associated with wellbeing in schools and education centers, and are linked to positive learning and behavioral outcomes (Hodson & Sander, 2017). Proximity to, and views of, trees have been related to lower rates of criminal behavior and behavioral problems and to higher test scores, reading performance, and graduation rates (Matsuoka, 2010).

1.3 | Case study: ash dieback

It is now recognized that plants have an essential role in addressing the great social and environmental issues of the age. The impacts of plant health can help illustrate how pests and diseases seriously impact on the ecosystem services that plants provide to society. The first example
is the ash dieback crisis. Ash dieback, caused by the fungal pathogen *Hymenoscyphus fraxineus*, made the headlines in the UK about six or seven years ago as it became apparent that the disease was in the UK and having an impact on ash (*Fraxinus excelsior*) trees. Unprecedented public and media interest prompted a wave of social amplification and there was widespread concern about what could happen (Urquhart et
al., 2017; Pidgeon & Barnett, 2013). In the worst case some reports suggested that we were facing the loss of all of our ash trees. It was an important moment for plant health, because people realized that they identified with ash and cared about its future.

The disease has been a very difficult problem to manage and is now established in the UK. It can take many years for symptoms of ash dieback to develop, and it has probably been in the UK since the early 2000s (Woodward & Boa, 2013). The devastation caused by the disease was exacerbated by importing infected ash trees, but it is now known that it also arrived by windblown spores from across the Channel (Defra, 2013). A great insurgence of spores occurred around Suffolk, Norfolk, and Kent, which is where the highest impacts have been felt to date.

There are large numbers of ash trees in the landscape and they are a common sight by road sides as amenity trees (Maskell et al., 2013). There are at least 120 million mature ash trees in the UK, providing valuable habitat and ecosystem services (Forestry Commission, 2013; Maskell et al., 2013; The Tree Council, 2015). Mortality rates are uncertain, but 70%–90% losses of native European ash are probable (Vasaitis & Enderle, 2017; Coker et al., 2019). It is clear from this that ash dieback will have severe economic consequences. A recent publication (Hill et al., 2019) estimated that the cost might be as much as £15bn over 100 years (£7.6bn expected within 10 years), taking into account the loss of the trees' biodiversity benefits. Ash supports nearly 1,000 species, about 45 of which are obligate on this tree species (Mitchell et al., 2014). The cost of removing diseased ash trees from the environment where they pose risks, with implications for flood protection, climate change, air quality also needs to factored in. When they become a health and safety hazard by a road or railway, diseased trees have to be felled at an estimated final cost of £4.8bn (Hill et al., 2019).

In an effort to tackle the disease, Defra has commissioned £6 million of research on ash to date. This has included research into the genomes of ash and the pathogen, the basis of tolerance and susceptibility, treatment and containment options, public risk concerns, and the ecological role of ash, among others topics. Working with industry and other departments, Defra has helped produce an ash dieback toolkit to help advise landowners how to assess the state of their trees and when to make the decision to fell (https://www.treecouncil.org.uk/Portals/0/Chalara%20docs/Tree%20Council%20Ash%20Dieback%20Toolkit%202.0.pdf?ver=2019-09-10-140012-347).

Development of resistant varieties of tree species through modern tree breeding techniques is one of several strategies included within the Adaptation pillar of the government’s recent Tree Health Resilience Strategy (Defra, 2018). It is considered as an option when a pest or disease has established such that a tree population is unable to recover, and where a genetic basis for resistance is demonstrable in a proportion of the tree population. Ash dieback is one such example, and Defra funded the largest experimental ash screening in the world. To identify sources of resistance, 155,000 ash seedlings from 15 provenances over 14 sites in the UK were screened, leading to the first archive of putatively tolerant trees, which will be planted in 2020. There is reason to be optimistic, therefore, that there will still be ash in the landscape in the future. Tolerant trees will set seed and regenerate, supplemented by a breeding program to reinstate them. Similarly, a range of resistant cultivars of elm have recently been developed, and it is hoped that these will soon start to re-establish this species as well.

### 1.4 Case study: emerald ash borer

A further threat to ash is the emerald ash borer (EAB), a pest in the highest risk category of the Plant Health Risk Register. It is native to Asia but has been in North America since 2002 to devastating effect (Donovan et al., 2013; Klooster et al., 2014). It has wiped out billions of ash trees, and has been particularly evident in urban environments. For several years, it has also been established in Russia and may now have...
mediately activated, including removal of host species and dead trees that an evidence-based contingency plan was in place, which was immediate and significant impacts on public health. Similar effects may be occurring with other tree health epidemics elsewhere.

1.5 | Case study: Xylella fastidiosa

Olive trees have already been mentioned as an example of the difficulties associated with the movement of whole mature trees, but there are specific and significant threats facing the species itself. Figure 10 shows an olive grove in the Puglia region of Italy in which every single tree is dead because of Xylella fastidiosa, a bacterial plant pathogen native to the Americas. Xylella is spread by the common meadow spittlebug Philaenus spumarius, which is a native species present throughout the UK. The disease has a wide host range—about 500 susceptible species, not just olive—and there have been multiple findings in Europe. First found in Italy in 2013, it is now established in Italy and the Balearics, and has been found in France and mainland Spain and intercepted in the Czech Republic. It was declared eradicated in Germany in 2018, Switzerland in 2015 and Portugal in 2018. The UK has both the vector and many host species, so Xylella is one of the highest risks and everything is being done to keep it out of the UK.

1.6 | Tree health research and policy

Research plays a critical role in shaping policy, helping to decide on appropriate actions against plant health threats. In recent years, scientific evidence has contributed to the ongoing development of pest risk analyses and contingency plans, to ensure that any restrictions and actions taken against interceptions are evidence-based. An example of this is the outbreak of Ips typographus, the eight-toothed spruce bark beetle, that was discovered in 2018 in a woodland in Kent (Forest Research, 2019). The pest risk analysis for I. typographus in the risk register (which is based on findings from the scientific literature) indicated that the beetle had the potential to cause significant damage to spruce populations and thus to UK forestry and timber industries. This meant that an evidence-based contingency plan was in place, which was immediately activated, including removal of host species and dead trees from the vicinity of the outbreak. The pest’s official status remains ‘under eradication’, but this approach, making use of the best available evidence, should give the highest likelihood of success.

There remain important knowledge gaps across plant health where future research can help to shape policy. Key gaps include understanding the true value of plants and trees to society; the impacts of multiple pests and diseases on individual plant species and the wider environment; and providing evidence for improved methods of prevention, detection, and control of pests and diseases. Defra plays an important leadership role in coordinating and commissioning new plant health research. The Action Oak partnership (actionoak.org) is such an example of research coordination. In this initiative, Defra, together with the other partners, has set out the state of the art of current scientific knowledge of oak, and the most pressing research needs and priority areas for action to protect our native oak trees from invasive pests and diseases.

1.7 | Public awareness and the role of citizen science

What can people do to help the plant health effort? Anyone flying in to a UK airport this (2019) summer might have seen the DEFRA ‘Don’t Risk It’ messages in light-boxes. They represent a ‘nudge strategy’ approach, to get the message over to the public ‘Don’t bring back any plant material—plants, seeds, flowers, fruit, vegetables back to the UK’. Of course, many botanists collect plants in the wild in a completely responsible way, with the necessary permits and quarantine procedures. But most people do not stop to think that the cutting they got when they went on holiday, or the olive tree they brought back, could be the start of introducing Xylella into the UK. There is a need for much greater public awareness about plant health. A recent success in raising the profile was the gold medal-winning Resilience Garden exhibited at the Chelsea Flower Show, the UK’s major annual horticultural event which attracted much media interest and public debate. The United Nations has designated 2020 as International Year of Plant Health and across the nation there will be a range of science and public events, a National Plant Health Week and a major science conference.
People can also play a role in helping to spot and report plant health problems. Figure 11 provides an overview of one initiative, “Observatree,” a citizen science approach to tree health reporting. Two hundred expert volunteers have been trained to identify 25 tree pests and, by working with a range of partners such as the Woodland Trust and Forest Research, they report occurrences through an online tool called TreeAlert. One of the successes of this network of observers has been the second finding of Oriental Chestnut Gall Wasp, reported by a volunteer and her daughter. Finding two occurrences was significant because it alerted the authorities to the fact that it might be not an isolated instance but the start of an outbreak.

Forest Research’s tree health reporting tool, Tree Alert (https://treealert.forestrystudy.gov.uk/) is a way in which anyone can upload a report of a sick-looking tree. A triage process behind the reporting tool may be followed by a visit from inspectors to a tree of concern to establish what might be happening.

Another development is the launch of a Biosecurity Standard which, by working with industry, should lead to a plant health standard that will apply to plants in garden centers and nurseries so that customers will know whether the plants they are buying have been either UK sourced and grown, or properly imported and inspected, and are biosecure. The Plant Healthy website (planthealthy.org.uk) provides information about plant health and a self-assessment tool for businesses.

2 | CONCLUSION

The risk from invasive plant pests and pathogens is significant and constantly growing as a result of increasing globalization and environmental change. The UK’s plant health regime aims to manage that risk to protect the enormous value of plants and trees; from the value of crops and forestry products, to ecosystem services and societal benefits. There is also a role for industry and society through risk and responsibility sharing and risk reporting. Volunteers and citizen science initiatives can also help to identify and report threats so that timely action can be taken. Together we can help protect our plants and trees so that they can continue to deliver extensive economic, environmental, and social benefits to society.

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REFERENCES
Baranchikov, Y., Mozolevskaya, E., Yurchenko, G., & Kenis, M. (2008). Occurrence of the emerald ash borer, Agrilus planipennis in Russia and its potential impact on European forestry. EPPO Bulletin, 38, 233–238. https://doi.org/10.1111/j.1365-2338.2008.01210.x
Brown, D., Barton, J., & Gladwell, V. (2013). Viewing nature scenes positively affects recovery of autonomic function following acute-mental
stress. *Environmental Science & Technology*, 47(11), 5562–5569. https://doi.org/10.1021/acs.est.0c00190

Coker, T., Rozsypláek, J., Edwards, A., Harwood, T. P., Butterf, L., & Buggs, R. J. A. (2019). Estimating mortality rates of European ash (*Fraxinus excelsior*) under the ash dieback (*Hymenoscyphus fraxineus*) epidemic. *Plants, People, Planet*, 1(1), 48–58. https://doi.org/10.1002/ppp3.11

Commission, F. (2013). NFI Preliminary Report: NFI preliminary estimates of quantities of broadleaved species in British woodlands, with special focus on ash. Edinburgh, Scotland: National Forest Inventory, Forestry Commission.

The Tree Council. (2015). *Chalara in non-woodland situations: Findings from a 2014 study*. London, UK: The Tree Council.

Defra. (2013). *Chalara management plan*. London, UK: Defra.

Defra. (2016). *Tree health resilience strategy*. London, UK: Defra.

Doick, K., Peace, A., & Hutchings, T. (2014). The role of one large green space in mitigating London’s nocturnal urban heat island. The *Science of the Total Environment*, 493C, 662–671. https://doi.org/10.1016/j.scitotenv.2014.06.048

Donovan, G. H., Butry, D. T., Michael, Y. L., Prestemon, J. P., Liebhold, A. M., Gatzios, D., & Mao, M. Y. (2013). The relationship between trees and human health: Evidence from the spread of the emerald ash borer. *American Journal of Preventive Medicine*, 44(2), 139–145. https://doi.org/10.1016/j.amepre.2012.09.066

Droguvalenko, A., Orlova-Bienkowskaja, M. & Bieńkowski, A. (2019). Record of the Emerald Ash Borer (*Agrilus planipennis*) in Ukraine is Confirmed. *Preprints*.

Edmondson, J. L., Stott, I., Davies, Z. G., Gaston, K. J., & Leake, J. R. (2016). Soil surface temperatures reveal modulation of the urban heat island effect by trees and shrubs. *Scientific Reports*, 6, 33708. https://doi.org/10.1038/srep33708

Forest Research (2019). *Eight-toothed spruce bark beetle (Ips typographus)*. https://www.gov.uk/guidance/eight-toothed-european-spruce-bark-beetle-ips-typographus

Gill, S., HANDLEY, J. F., ENNOS, R., & PAULEIT, S. (2007). Adapting cities for climate change: The role of the green infrastructure. *Built Environment*, 33, 115–133. https://doi.org/10.2148/benv.33.1.115

Hauru, K., Lehvävirta, S., Korpela, K., & Kotze, J. (2012). Closure of view to the urban matrix has positive effects on perceived restorativeness in urban forests in Helsinki, Finland. *Landscape and Urban Planning*, 107, 361–369. https://doi.org/10.1016/j.landurbplan.2012.07.002

Hill, L., Jones, G., Atkinson, N., Hector, A., Hemery, G., & Brown, N. (2019). The £15 billion cost of ash dieback in Britain. *Current Biology*, 29(9), R315–R316. https://doi.org/10.1016/j.cub.2019.03.033

 Hodson, C., & Sander, H. (2017). Green urban landscapes and school-level academic performance. *Landscape and Urban Planning*, 160, 16–27. https://doi.org/10.1016/j.landurbplan.2016.11.011

Jones, L. (2017). Developing estimates for the valuation of air pollution removal in ecosystem accounts. Final report for Office of National Statistics. Office for National Statistics.

Klooster, W. S., Herms, D. A., Knight, K. S., Herms, C. P., McCullough, D. G., Smith, A., ... Cardina, J. (2014). Ash (*Fraxinus spp.*) mortality, regeneration, and seed bank dynamics in mixed hardwood forests following invasion by emerald ash borer (*Agrilus planipennis*). *Biological Invasions*, 16, 859–873. https://doi.org/10.1007/s10530-013-0543-7

Lee, I. M., Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., Katzmárzyk, P. T., & Lancet Physical Activity Series Working Group. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. *Lancet (London, England)*, 380(9838), 219–229. https://doi.org/10.1016/s0140-6736(12)61031-9

Lovell, R., & Maxwell, S. (2017). Evidence Statement on the links between natural environments and human health. Department for Environment, Food and Rural Affairs.

Maskell, L., et al. (2013). *Distribution of ash trees (*Fraxinus excelsior*) in countryside survey data*. Wallingford, UK: Centre for Ecology and Hydrology.

Matsuoka, R. (2010). Student performance and high school landscapes: Examining the links. *Landscape and Urban Planning*, 97, 273–282. https://doi.org/10.1016/j.landurbplan.2010.06.011

Mitchell, R. J., Beaton, J. K., Bellamy, P. E., Broome, A., Chetcuti, J., Eaton, S., ... Woodward, S. (2014). Ash dieback in the UK: A review of the ecological and conservation implications and potential management options. *Biological Conservation*, 175, 95–109. https://doi.org/10.1016/j.biocon.2014.04.019

Morris, J., R. O’Brien, E. (2011). Encouraging healthy outdoor activity amongst under-represented groups: An evaluation of the Active England woodland projects. *Urban Forestry & Urban Greening*, 10, 323–333. https://doi.org/10.1016/j.ufug.2011.05.006

O’Brien, L., & Morris, J. (2013). Wellbeing for all? The social distribution of benefits gained from woodlands and forests in Britain. *Local Environment*, 19(4), 356–383. https://doi.org/10.1080/13549839.2013.790354

Pidgeon, N., & Barnett, J. (2013). *Chalara and the social amplification of risk*. London, UK: Defra.

Takayama, N., Korpela, K., Lee, J., Morikawa, T., Tsumetsugu, Y., Park, B., ... Kagawa, T. (2014). Emotional, restorative and vitalizing effects of forest and urban environments at four sites in Japan. *International Journal of Environmental Research and Public Health*, 11, 7207–7230. https://doi.org/10.3390/ijerph110707207

Urquhart, J., Potter, C., Barnett, J., Fellenor, J., Mumford, J., & Quine, C. P. (2017). Expert risk perceptions and the social amplification of risk: A case study in invasive tree pests and diseases. *Environmental Science & Policy*, 77, 172–178. https://doi.org/10.1016/j.envsci.2017.08.020

Valenta, V., Moser, D., Kapeller, S., & Essl, F. (2017). A new forest pest in Europe: A review of Emerald ash borer (*Agrilus planipennis*) invasion. *Journal of Applied Entomology*, 141, 507–526. https://doi.org/10.1111/jen.12369

Van den Berg, A. E., Jorgensen, A., & Wilson, E. R. (2014). Evaluating restoration in urban green spaces: Does setting type make a difference? *Landscape and Urban Planning*, 127, 173–181. https://doi.org/10.1016/j.landurbplan.2014.04.012

Vasaitis, R. & Enderle, R. (2017). *Dieback of European Ash (Fraxinus spp.) – Consequences and Guidelines for Sustainable Management*. s.l.:FRAXBACK.

Ward Thompson, C., Roe, J., Aspinall, P., Mitchell, R., Cloud, A., & Miller, D. (2012). More green space is linked to less stress in deprived communities: Evidence from salivary cortisol patterns. *Landscape and Urban Planning*, 105, 221–229. https://doi.org/10.1016/j.landurbplan.2011.12.015

Woodward, S., & Boa, E. (2013). Ash dieback in the UK: A wake-up call. *Molecular Plant Pathology*, 14(9), 856–860. https://doi.org/10.1111/mpp.12084

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