The importance of visual surveys in tree health surveillance and the role of public reporting

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Summary:
Our understanding of the health and condition of Great Britain's trees and forests is underpinned by the efforts of woodland owners, managers, volunteers, and citizen scientists who add to statutory surveillance by reporting their own observations. For arboreal pests and diseases in Great Britain, public reports are primarily gathered through the Forest Research reporting service TreeAlert (https://treealert.forestresearch.gov.uk/). Apart from designated quarantine organisms, which have designated surveillance schemes, this self-reported data forms the basis of our knowledge of the prevalence and distributions of these species. As researchers, we are indebted to those individuals who take time out of their day to observe and report observations. We set out to describe the importance of these efforts. We begin by outlining the challenge of conducting surveillance in the wider environment, both in terms of detecting new arrivals and also when we set out to define the extent of the country that is affected by established pests and diseases. Using examples from the studies of two of our native broadleaves (oak and ash) we demonstrate just how valuable TreeAlert reports are in informing our understanding of the pest and disease pressures these species face. Finally, we describe findings from our recent project, which set out to add value to TreeAlert reports by better understanding the factors that influence when and where reports are made.

Introduction

The number of newly detected invasive species that are detected has been growing, year-on-year, since the beginning of the 20th century, with more and more new species being found at ever-increasing rates (Boyd et al., 2013). The number of arrivals has been linked to increased trade in live plants and wood products (Brasier, 2008). Ash dieback caused by *Hymenoscyphus fraxineus* is a prime example of the impact that invasive species are having (Figure 1). This fungus is native to East Asia but was introduced to Europe as early as 1978 (Agan et al., 2023), where it has since spread across much of the continent, resulting in elevated mortality of European ash (George et al., 2022) by colonising leaves, branches and stems of susceptible trees. Ash dieback was first detected in Great Britain in 2012 and a large body of research has followed since its arrival (summarised in Combes et al., 2024). *Hymenoscyphus fraxineus* is now part of the landscape in Britain, and it is likely that most woodland owners and managers have had first-hand experience managing infected trees. The disease impacts on such a common native broadleaved tree are seen most directly in terms of provisioning services (such as timber and timber products), but this represents just a small fraction of the ecosystem services that are lost, from the regulating services (such as carbon sequestration and flood control) through to cultural services (such as wellbeing and amenity value) provided by trees that are vital to ecosystem function (Freer-Smith and Webber, 2017). For example, the cumulative management, replanting, and ecosystem service costs of ash dieback have been estimated at £15 billion (Hill et al., 2019). Loss of ash also has further widespread biodiversity impacts, as 953 species of birds, mammals, bryophytes, fungi, invertebrates and lichens are associated with ash trees (Mitchell et al., 2014). Despite a broad estimate from European data that around 50% of ash die within 30 years of disease arrival (George et al., 2022), ultimately it is hoped that ash will survive as a species in Great Britain. However, this is not the end of the story for ash trees, as further risks remain on the horizon; the

> "Public reports are primarily gathered through the Forest Research reporting service TreeAlert."


Figure 1. Ash dieback symptoms: (left) a diamond shaped lesion forming at the junction of a branch and stem; (right) crown dieback – this general sign of poor tree health is often the most noticeable sign of infection.

emerald ash borer (*Agrilus planipennis*) is a species native to China that has caused widespread mortality of ash trees in the United States of America (Ward et al., 2021) and is rapidly approaching the borders of the European Union from Russia and Ukraine (Evans et al., 2020).

Plant health surveillance

It is clear that there is an ever-growing need for plant health surveillance. Great Britain has set out a world class biosecurity strategy where a risk-based approach has been adopted; borders are monitored for new arrivals, trade networks are subject to passport schemes and inspections, and most challengingly the wider environment is checked for signs of invasive species (Spence et al., 2020). For tree pests and diseases, the wider environment represents an especially large and diverse landscape that spans many land uses, ownerships and terrains including commercial forestry crops, amenity planting in parks and gardens, hedgerows and conservation sites. For native species especially, the host distributions are poorly described and hard to predict at the local scale due to diversity of individual owner choices in relation to planting and species selection. Beyond this, not all trees and woodlands are actively managed, and through natural regeneration and colonisation it is possible that even landowners are not fully aware of the species composition on their land. This makes the design and implementation of robust surveys of tree health especially challenging at the national scale, and it is hard to locate and negotiate access to survey sites at the local scale.

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Within this context, every additional sighting and report is vital to address pressing questions such as the current prevalence of diseases such as ash dieback, and the certainty that trees are free of particular pests and pathogens. For example, what risk is there that emerald ash borer is already present and undetected? Retrospective analysis of trees infected by ash dieback suggests that it has been active in Great Britain since at least 2004 (Wylder et al., 2018). Epidemiologists and modellers have developed methods to estimate the probability that a pest or disease is absent from a country or region from survey data (Parnell et al., 2015; 2017) and have identified that when combined with the growth rate of an epidemic, survey effort becomes a crucial metric affecting the probability of early detection; put simply, the more we look, the more likely we are to find new arrivals quickly.

TreeAlert

In 2013, the web reporting application TreeAlert was launched, which feeds information directly into Forest Research's Tree Health Diagnostic and Advisory Services. This site allows anyone to report sightings of potential pests and diseases freely and quickly. Each submission is investigated by specialists who can examine the evidence and arrange for laboratory testing (when required) to confirm the identity of causal agents (Pérez-Sierra et al., 2019). Recent updates to the TreeAlert site allow registered users to query reports received to put their findings in context and enable individuals to conduct their own national, regional and local assessments of risk based on the cumulative reports held in the system. Importantly, observations of healthy trees can now be recorded, allowing individuals to declare their woodlands free from pests and diseases. This means that search effort can be better quantified and provides useful additional information for risk predictions. TreeAlert is a vital resource, but its value is dictated by how representative the reports it contains are of the true prevalence of pests and diseases on the ground. As such, its value increases with the number of records that it holds and how well we understand the factors that influence when and where a report is made.

Observatree

To enhance awareness and knowledge of pests and diseases, a citizen science initiative called Observatree was established in 2013. Observatree sets out to equip a network of approximately 200 volunteers across Great Britain with the skills to look for, identify and report several different tree pests and pathogens (Crow et al., 2020). This multi-partner project trains volunteers to identify 24 priority pests and pathogens that are of particular concern to tree health policymakers, foresters and woodland managers. The list of priority pests and diseases includes examples

Figure 2. AOD symptoms: (left) stem bleeds appear when dark liquid flows out from cracks between the bark plates; (right) emergence holes of Agrilus biguttatus are distinctively shaped like a capital D, but are very small and may go unnoticed at first.

that are not currently known to be present in Great Britain, as well as others that are present but are thought to have changing distributions. This means volunteers can contribute to both early detection of new invasive pests and diseases, and the monitoring of those that are already present to identify changes in their distributions. Volunteers can either submit ad hoc reports from one-off site visits, known as general surveys, or contribute through the regular monitoring of sentinel trees. Each sentinel tree is assessed once every few months. Most of the sentinel trees monitored are considered to be healthy, but others may show signs of a new pest or pathogen, so that monitoring can reveal whether their health declines or shows signs of improvement. All volunteer reporting is supported by TreeAlert. The Observatree programme has developed a tailored set of training material and field guides which are freely available for download to all interested parties on their web pages (https://www.observatree.org.uk/).

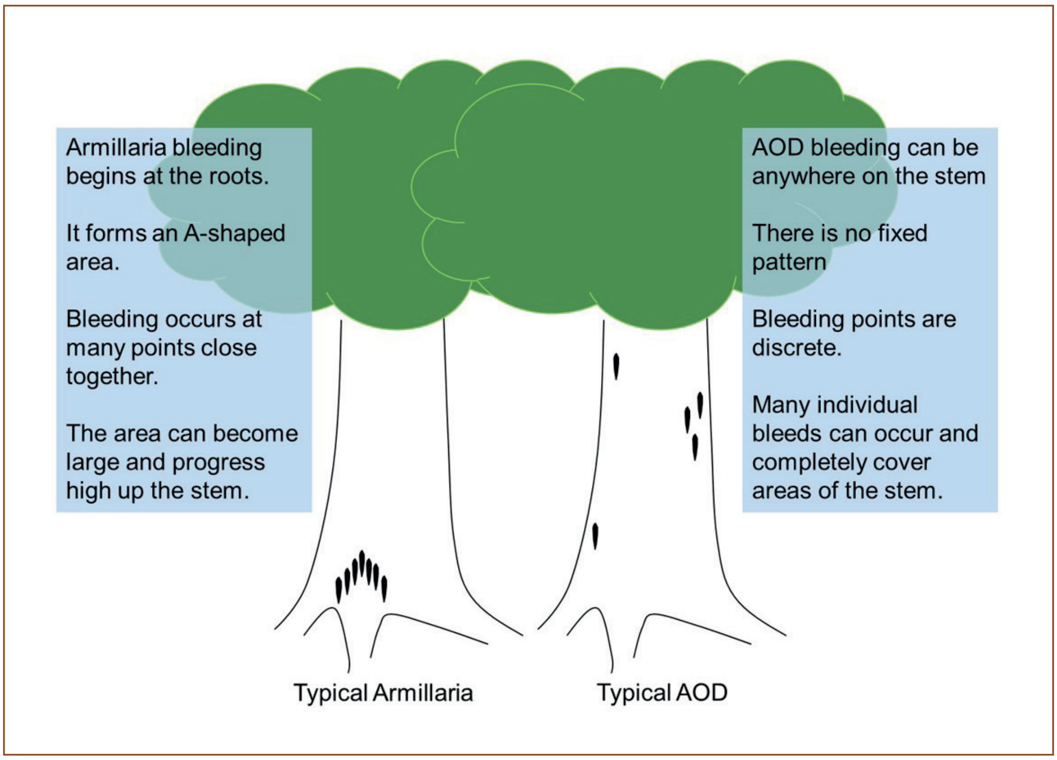

Figure 3. Typical patterns of stem bleeding on oak. Root pathogens such as Armillaria can cause a focused area of damage at the base of the stem, whereas AOD stem bleeds are distributed independently and are widely spread across the trunk and main branches.

The observations that are gathered and validated through TreeAlert enable landowners, managers, as well as wider volunteers and citizen scientists, to identify the causes of ill health within the trees and woodlands they report. These observations form a crucial information source for researchers, plant health authorities and policy makers. For example, we have used reports of acute oak decline (AOD) received through TreeAlert to complement official surveys and make risk predictions (Brown et al., 2017). AOD is a decline disease (Figures 2 and 3) typified by two stem symptoms: weeping black exudate or 'stem bleeding' that runs from cracks between the bark plates of affected trees (Denman and Webber, 2009) and the emergence holes of the native beetle *Agrilus biguttatus* which can be seen on approximately one third of infected trees and are distinctively shaped like a capital D with one flat edge (Brown et al., 2015). This emerging disease is caused by a pathobiome of bacterial species which cause localised necrosis within the inner bark (Denman et al., 2014). Bacterial species including *Brenneria goodwinii*, *Gibbsiella quercinecans* and *Rahnella victoriana* interact to cause oak cell degradation and form larger lesions when *Agrilus* larvae are also present in the tree (Denman et al., 2018). Recent studies have shown that larval action can alter bacterial gene expression (Doonan et al., 2020) and cause increased growth rates for bacterial populations (Cambon et al., 2023). As a decline disease, the occurrence of AOD is thought to rely on the initial predisposition of hosts enabling later colonisation by biotic contributing factors (insects and bacteria) (Denman et al., 2022). The combined survey and TreeAlert reports have allowed the role of various environmental predisposition factors to be investigated through analysis of spatial

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correlations, revealing significant trends with areas of low rainfall, low elevation, higher temperatures and nitrogen deposition (Brown et al., 2018). Without the contribution of these 255 additional observations from TreeAlert, this work would not have been possible.

Adding value to observations

During the last year, we have been involved with a Defra Future Proofing Plant Health project to investigate the impact of visual detection accuracy on pest and disease reports. Visual detection is the cornerstone of plant health surveillance. It influences all the reporting submitted through TreeAlert, and more widely it influences where plant health officials collect their samples. However, the accuracy of reporting has rarely been considered. In essence, visual observations are a form of diagnostic test. If an observer views a tree that is symptomatic for a pest or disease, there is a chance they will spot its symptoms, but also a chance they will walk past without noticing (the probability of spotting something when it is there is known as the sensitivity of the test). Equally, there is a chance that an observer will see something on a tree that is not a symptom of disease, but they will mistakenly report the tree as being infected (the likelihood of correctly identifying trees as asymptomatic is known as the specificity of the test) (Combes et al., 2025). By understanding the sensitivity and specificity of reporting, we can make more accurate predictions of disease distributions and assessments of disease freedom. This understanding also allows the design of optimised surveys to detect and delimit pest and disease occurrence (Alonso Chávez et al., 2025).

To understand reporter behaviour and quantify sensitivity and specificity, we arranged eight workshops at four sites across southern England in Autumn 2024 (Figure 4). We had 164 participants and each spent a day assessing a set of eighty oak trees for signs of AOD stem bleeds and *Agrilus* emergence holes (in total we had 11,328 observations of stem bleeds and 9,621 observations of *Agrilus* emergence holes). Attendees had diverse motivations for attendance; 59% of attendees had no prior experience with tree pests and diseases and we were able to engage with many different perspectives on tree health. The large quantity of data and diverse cohort of attendees helped us gather a robust dataset to quantify important patterns in the effectiveness of different training methods and the impact of prior experience on the likelihood of accurate TreeAlert reports being made. Overall, we could see clear patterns in the data. Unsurprisingly, symptoms were more likely to be noticed when they were more frequent on tree stems, but by quantifying these patterns, we have gained greater insight in understanding when and where reports will be made. We

Figure 4. Volunteers search for AOD symptoms after training at detection workshops.

could also see differences between groups depending on their previous experience and the type of training provided. First-hand observation of symptoms during training increased the likelihood of detection, and experienced surveyors also had greater sensitivity, although there was no impact on the likelihood of falsely reporting a sign or symptom that was not there. There was also a distinct difference between the chance of spotting AOD stem bleeds and the very small *Agrilus* emergence holes, which were seen more rarely, although the same patterns in relation to training and experience remained for both symptoms. We have already used this information to show that Observatree detections make a large impact on the probability of detecting new arrivals (Brown, 2025 in prep).

Conclusion

The message is clear – training just 200 people through the Observatree programme has had a significant impact on the chance of detecting arboreal pests and diseases. A small but dedicated group can make a huge difference. By contributing to their efforts and submitting reports through TreeAlert you can increase this impact. In 2025, it would be great to showcase what a larger group of people can achieve together.

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