Current factors affecting UK woodlands and forestry industry: Pathogens

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The global trade of plants and trees has facilitated the movement of numerous harmful pests and diseases, some of which are now established in the UK and are likely to be difficult to eradicate. Such introduced species have the potential to negatively impact the UK forestry industry and could change the current shape of the British landscape by severely reducing the abundance of certain natural and iconic tree species such as the oak and ash, permanently altering the structure and nature of UK broadleaf woodlands.

In recent years there has been a notable increase in the introduction of pests and pathogens to the UK which could negatively impact tree species. These threats come from a broad spectrum of organisms, from microscopic species to large mammals, which can affect trees in numerous ways, both independently and also through interactions between species. In this context, pathogens are microscopic species which cause disease and pests are larger organisms such as insects. This article will focus on the microscopic pathogens: fungal infections, oomycetes and bacteria.

Fungus species

Chalara ash dieback (*Hymenoscyphus fraxineus*, formerly *Chalara fraxineus*) is perhaps the most famous emerging tree disease of recent times, as this pathogen has the potential to devastate UK ash tree populations, as has been the case across much of Europe. Chalara spores can be spread tens of miles by the wind, which gives it a high dispersal potential and makes it very difficult to contain; however trees must be exposed to a high dose of spores for infection to occur. Since first confirmation in Poland in 1992, Chalara has spread widely across Europe and was first recorded in the UK in 2012. This fungus has two phases to its life cycle: sexual and asexual. The asexual stage attacks the bark, twigs and branches of the trees, resulting in dieback. The sexual stage occurs on infected stalks of the fallen leaves from the previous year, producing spores between June and September typically in the year after infection. Differences in life cycle phases are the reason behind the taxonomic revision to *Hymenoscyphus fraxineus* from *Chalara fraxineus,* as the two stages were originally classified separately but are in fact the same organism.

Dutch elm disease has been responsible for the loss of 60 million elm trees in the UK since the 1920s, in two separate epidemics. The first was caused by the fungus *Ophiostoma ulmi*, the second by the related fungus *Ophiostoma novo-ulmi* in the 1970s. These two fungi species also spread across North America, Asia and Europe in these two separate migratory events. The fungi are spread by elm bark beetles mainly from the genus *Scolytus*. Infected large Elm

specimens can still aid the spread of this disease for up to two years after death, as they remain a suitable site for beetle breeding. Thus, standing deadwood of formerly infected specimens can also act as a disease source in the short term. In recent years, the development of a treatment for this disease has focussed on using a virus specific to *O. novo-ulmi* to target and reduce the virulence of this pathogen directly, which has been shown to be an effective method to reduce elm tree infection rates.

Dothistroma Needle Blight (DNB), sometimes referred to as red band needle blight due to the colourful nature of visible symptoms on pine trees, is caused by two species of fungi (predominantly *Dothistroma septosproum*, but also *Dothistroma pini*), particularly in years with higher than average rainfall. Water is believed to be a key component in dispersal via the spread of spores in films of water or in water droplets, as they fall from needle surfaces onto lower branches of neighbouring trees. This disease is recognised as a problem in the southern hemisphere, but has also spread widely across Europe and the UK since the 1990s. Whilst only fatal in some cases, these fungi can have significant influence on the economic yield of timber crops, although major losses are only observed after several consecutive years of infection.

Conifer root and butt rot develops as a result of infection by the fungus *Heterobasidion annosum*, which attacks the roots, stems and butts of most commercially grown conifer species. Whilst less severe in Britain, Europe-wide this pathogen is responsible for economic losses estimated to be in the hundreds of millions of Euros per year. Current treatments include a biological control agent which contains spores of another fungus *Phlebiopsis gigantea*, which doesn't attack the tree, but effectively reduces tree infection rates by competing with *H. annosum* for available resources.

Sirococcus blight is caused by the fungus *Sirococcus tsugae* which is a problem primarily for Atlas cedar, causing shoot blight and defoliation. A few closely related species of *Sirococcus* also have the potential to threaten UK conifer species. *Sirococcus conigenus* and *S. piceicola* have both been widely reported in the northern hemisphere, from North America to Europe, but as yet are not present in the UK. *Sirococcus tsugae* can be dispersed by rain splash or high winds, with the latter mechanism suggesting it has the potential for distribution over large distances. This disease has only been present in the UK since 2013, but in this short time has spread countrywide. There are currently no specified methods for control beyond suggestions for good hygiene practice for prevention.

Massaria disease, believed to be caused by the fungus *Splanchnonema platani*, attacks plane trees, resulting in large legions on the upper side of branches which can cause branch drop. This disease is particularly a problem for urban areas where plane trees are frequently planted as they can reduce the effects of pollution through their habit of bark shedding, making infected trees a potential public health and safety issue. Whilst not currently a major issue in the UK, in the future the Massaria problem may grow as the most severe effects of this disease are only observed in warmer climates such as the Mediterranean. As the climate warms over

the coming decades, the influence of this disease on UK plane trees would therefore be expected to increase.

Oomycetes

Phytophthora species are typically considered to be fungal pathogens, however this group are in fact Oomycetes (water moulds). Oomycetes are eukaryotic microorganisms with a similar filamentous structure to fungi, but are more closely related to brown algae (heterokonts). Over 100 species of *Phytophthora* have been described, the majority of which are harmful to plant species across a broad spectrum of life histories. For UK trees, five species are of particular importance: *Phytophthora alni. P. austrocedri, P. kernoviae, P. lateralis* and *P. ramorum.*

Phytophthora ramorum is perhaps the most famous of the tree attacking oomycetes in the UK, commonly referred to as sudden oak death, which is somewhat misleading as this organism rarely affects UK oak trees. The name of this disease originates in America where it has had a significant impact on native oak species. In the UK, Larch trees are perhaps the most susceptible, with large numbers of these affected countrywide, but other woody plants such as rhododendron and bilberry are also vulnerable. *Phytophthora alni* is a disease specific to alder trees and has caused the death of thousands of trees UK wide since its discovery in 1993. The spread of this disease appears to be correlated to disturbance, both natural, from events such as flooding, and also from the influence of human activity, particularly along riverbanks where alder is a common species. *Phytophthora austrocedri* is a recent addition to the UK, first reported in 2011, and is recognised as a threat primarily to juniper, but can also infect Lawson and Nootka cypress. This disease is of particular concern as juniper is a priority species for conservation and juniper woodlands are some of the rarest woodland types in the UK. *Phytophthora kernoviae* was first identified as a new species in 2003 and is accepted to be highly aggressive and virulent, with the potential to affect several UK species including beech and pedunculate oak. It can be spread by wind or splash dispersal and therefore has the potential to be highly mobile. *Phytophthora lateralis* can also affect Lawson cypress trees, proving fatal in most cases of infection. In addition, this disease has been observed to affect western red cedar, northern white cedar and Sawara cypress and may also potentially be a threat to numerous other species including Douglas fir.

Bacteria

Bleeding canker of horse chestnut is a disease predominantly caused by infection from the bacterium *Pseudomonas syringae* pv *aesculi*. This disease has had a dramatic increase in incidence rates, from four cases in 2000 to approximately half of all UK horse chestnut trees infected by 2007. Whilst not always fatal, it has the potential to significantly affect UK horse chestnut populations as the pathogen can be spread by wind and rain and consequently is now considered widespread across the UK. The bacterium infects horse chestnut trees

through discontinuities in the bark, including lenticels, leaf scars, nodes and artificial wounds. There is currently no known cure, however simple management, such as the removal of branches with the characteristic cankerous lesions, may slow the effects of the disease and allow infected trees to continue to survive.

Acute oak decline has affected thousands of oak trees across the UK. Causes of tree mortality are accepted to be bacterial, but exact mechanisms are unclear. It is currently considered to be the result of multiple factors working simultaneously. This disease has been linked to the influence of a species of UK beetle, *Agrilus biguttatus* the two spotted oak buprestid, which is suspected of being the principal agent of bacterial infection of these oak trees, as there is a high correlation with the presence of larvae of this species and disease incidence. Much remains unclear about the spread of this disease however, such as whether the beetles are in fact infecting trees or simply targeting already infected trees due to their reduced potential for resistance to attack. Further research is necessary to determine the nature of these interactions fully.

Management

The potential ease with which tree pathogens can jump borders or geographical barriers makes the need for careful management with regard to biosecurity of considerable importance. Currently, human activity is primarily responsible for the spread of pathogens between woodland sites, but this can be managed through greater caution with regard to hygiene. Contaminated material can be carried to new sites on clothing, footwear, tools and machinery. Thoroughly cleaning soil or plant material from equipment before moving to new locations, with special attention paid to the tread on footwear, can significantly limit the spread of pathogenic organisms between woodlands.

For Wales and the UK there are certain inherent practicality issues with regard to effective biosecurity. Much of our woodland resources, both plantation or otherwise, are attractive to the general public for the purposes of recreation, thus visitation rates are typically high. In addition, by virtue of the limited woodland or tree coverage in the UK (only 13% tree cover compared to an average of 37% across Europe), visitor burden or footfall is more concentrated, increasing the risk of introduction and spread. Consequently, improving awareness amongst the general public of the importance of biosecurity for the health and wellbeing of UK woodlands would be advantageous.

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