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Challenges facing the future delivery of services from woodland in Wales

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- Current forestry policy outlines many diverse and often indirect woodland benefits, beyond timber, pulp and fuel provision
- Pest and pathogen outbreaks are occurring in woodlands worldwide with increased frequency, putting these woodland benefits at risk
- International plant trade and climate change are the primary drivers of this increase

Woodland in the UK faces an uncertain future. But why is this a problem? What makes woodlands valuable, and what might be lost if woodlands decline? To answer these questions, this article first outlines the benefits of woodlands, as laid out in Welsh forestry policy. After highlighting the diverse and often indirect woodland benefits, the article explores one of the most important threats to the delivery of these benefits: pest and pathogen outbreaks.

According to Forest Research, the terms woodland and forest can be used interchangeably. In the UK they mean "land on which trees provide at least 20% of the canopy cover, or have the potential to do so. This includes open spaces, and areas awaiting restocking". Woodland covers 15% (306kHa) of the land area of Wales. The trees that make up this cover can be conifers or broadleaf, or mixtures of both, that establish either semi-naturally or through managed planting schemes. These trees may have been introduced from elsewhere or be growing in their native range. If it is recorded that an area has been consistently wooded since before 1600, then it is designated as ancient woodland. Forestry, on the other hand, is the science and art of planting, managing and caring for forests. Trees outside of woodlands also provide woodland benefits. In Wales, all trees outside woodland in both urban and rural areas are grouped with the current and future woodland, and together classified as the Welsh Forest Resource.

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Historically, the main function of woodland was to supply wood products such as timber and pulp to both domestic and international markets. Over the last decades, the understanding of woodland function has expanded and diversified, giving a broader list of things that woodlands are good for. These are captured in the Welsh Government Woodland for Wales Forestry strategy (2017) as:

- **Provisioning services**, which directly yield forestry products like timber, pulp and fuel. eg wood for a variety of purposes, including near-net zero energy to replace fossil fuels and as a substitute for more carbon intensive materials such as steel and concrete.
- **Cultural services**, which yield indirect, nonmonetary benefits such as recreational, health, aesthetic and spiritual benefits for people living near or visiting woodlands; landscapes, heritage and culture; education.
- **Regulating services**, which yield indirect, nonmonetary benefits that occur through modification of the environment, such as carbon sequestration; protecting water and soil resources within catchments; contributing to the reclamation of contaminated land; providing shelter, shade and cooling in towns, and wind breaks on farmland.
- **Supporting services**, which yield nonmonetary services such as soil formation, nutrient cycling and oxygen production; biodiversity.

Future challenges for woodland management

One of the greatest threats to the long term delivery of all woodland benefits are pest and pathogen outbreaks. Pathogens are microbes (bacteria, fungi, viruses or oomycetes) able to cause disease in other, 'host' organisms. On the other hand, pests come from the animal kingdom. While larger herbivores, such as deer, can damage woodlands, the term 'pest' usually refers to herbivorous insects. Pests and pathogens currently affecting woodland in Wales have been the subject of previous technical articles.

The UK is suffering from an ongoing major outbreak of sudden larch death on Japanese, European, and hybrid Larch, caused by the oomycete pathogen *Phytophthora ramorum*. This is not an isolated incident, instead fitting into a global trend. Pests and pathogens are invading natural and planted woodlands on a global scale with increased frequency and the consequences of these outbreaks are more severe. The same pathogen has caused widespread destruction in native oak woodlands in the USA, spreading over 2,000km^2 and requiring the removal of millions of trees.

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Another species of *Phytophthora*, *P. cinnamomi* has caused massive destruction to native woodlands in Australia over the last century. Sweet chestnut blight, caused by *Cryphonectria parasitica* has severely impacted American chestnut populations. Over two epidemics in the last century, Dutch Elm Disease, caused by *Ophiostoma ulmi* and *O. novo-ulmi,* have mostly removed Elm (*Ulmus* spp.) from Europe and North America. Another fungal pathogen, *Hymenoscyphus fraxineus*, is causing Ash Dieback on ash (*Fraxineus excelsior*), with the potential to greatly affect the distribution of another common native woodland species.

Why is there an increase in outbreaks?

In recent times the incidence of pest and pathogen outbreaks has increased. This is the result of factors, independent or combined, including the global plant trade, climate change, and the ability of microbes to adapt to new environments.

Plant trade:

Given favourable conditions, such as the absence of normal predators and competitors, populations of insects and microbes can increase very quickly. This is why introductions to new ecosystems can be dangerous; the new site may lack the elements which were keeping population numbers low. Trees in the new ecosystem become potential new hosts. The size of an outbreak rests on whether or not the new hosts are prepared for the invasion by having co-existed with the threat, or a similar threat, over an evolutionary timescale. If the tree, or woodland, has no defences for the new threat it can quickly become overwhelmed, resulting in an outbreak. Combinations of pests and pathogens can worsen outbreaks through combined stress, for example the combined stress of pests, pathogens and climatic extremes causing large-scale oak decline in Europe.

By moving plants around the world, international horticulture has been implicated in many of the recent outbreaks. International phytosanitary regulations aim to prevent introductions by putting quarantine measures in place for insects and microbes identified as posing a high risk of causing outbreaks. However, many pathogens, including *P. ramorum*, can infect plants without causing symptoms ('asymptomatic infection'). This has often led to pathogens being introduced through asymptomatically infected seedlings and seeds. Many pests and pathogens can also survive in potting medium for extended periods of time, or in other exported products. For example *Scolytus* beetles carrying the Dutch Elm Disease fungus is thought to have hitch-hiked from Canada on infected timber. Also, many pests and pathogens

only become known to science once a new outbreak is caused. Because of all these factors, it is difficult to ensure that all infections or infestations are detected and that all affected plants are contained.

Climate change:

Pest and pathogen outbreaks occur against the backdrop of climate change. A changing climate can stress woodlands through increased incidence of extreme weather events such as drought, wildfire and flooding. This goes two ways, with outbreak stress exacerbating weather events, as seen when the increased amount of standing dead wood as a result of the *P. ramorum* epidemic in California increased the severity of subsequent wildfires. While a single extreme weather event is unlikely to cause great changes, climate change causes extreme weather events with increased frequency. At the same time, long-term gradual changes in climate mean that many woodlands find themselves growing in an environment for which they are not adapted. The combination of pest and pathogen outbreaks, together with climate change, are called mega-disturbances. These events can lead to woodland decline in two ways: by directly altering the species present, or by rendering them more susceptible to pest and pathogen outbreaks:

1) Climate change can cause numbers of some species to be pushed below the point of recovery. Even without extinctions, this can alter the proportions of different species present, or lead to changes in dominant species. A dramatic drop in numbers of one species in a natural woodland will often be compensated by an increase in numbers of another species. However, although they may eventually pick up again once the new mix of species stabilises, ecosystem services such as carbon sequestration or water management are likely to be disrupted in the meantime.
2) With less time to recover between extreme weather events, and increasing numbers of species lost or weakened, the whole ecosystem can become less resilient to repeats of the same disturbance, or to different types of disturbances. This can make outbreaks more likely and worsen their impact.

Microbes adapt fast to new environments:

The ability to respond and adapt quickly in the face of change can give pests and pathogens the upper hand in a changing environment. Trees, with a generation time at least decades long, cannot adapt as fast as microbes. With a short generation time and a diverse range of strategies for adaptation, microbes can quickly adapt to new environments. Crossing between

closely related pathogens, creating hybrid pathogens with increased pathogenicity, has been at the root of several outbreaks.

Although not enough is known about woodland microbial communities, pathogenicity can undergo some surprising changes when a microbe is introduced to a new location. When a pathogen develops the ability to infect a new host that it could not previously infect, this is known as a 'host switch'. A host switch started the *P. ramorum* plantation epidemic in the UK: initially known in the EU only as a pathogen of ornamental *Viburnum*, *Pieris* and *Rhododendron* in the nursery network, it first escaped from nurseries onto *Rhododendron ponticum*. While it was known to be able to infect a broad range of plant species, none of the known hosts were timber species. Then, in 2010, it was found on Japanese Larch, and has since gone on to infect 11,200ha in Wales alone, approx half (46%) of the total area of Larch in Wales at the start of the epidemic. By also being able to infect bilberry, *P. ramoru*m poses a risk to natural upland ecosystems.

Summary

Pest and pathogen outbreaks can cause massive ecological damage, incur huge economic cost, and impair the ability of woodlands to deliver their many, diverse benefits. The spread of insects and microbes through international horticulture is not expected to slow. Many past outbreaks were unforeseen, and have caused permanent change to woodlands, and are expected to continue to do so. Containing an outbreak once it starts can be expensive and ineffective, meaning prevention is better than cure.

Securing the benefits provided by woodlands is closely tied in with the objectives of the Environment (Wales) Act 2016, which legally bind the WG to reduce emissions by 80% from their pre-1990 levels by 2050. Supporting woodlands is one of the main ways to achieve this, and the Woodlands for Wales policy includes a pledge to plant 2,000ha of trees annually from 2020.

The task of preventing introductions by quarantine and movement restrictions is difficult. Instead, outbreaks can be better managed by prevention than cure, by restricting movement of "high risk" materials such as live plants, wood chip and untreated wooden pallets, rather than attempting to control specific pests, pathogens or hosts, and by managing woodlands to improve their resilience to a range of future stresses. The management actions best for

improving general resilience are not yet clear; the effect of different actions are highly variable across tree species, pest and/or pathogen species, woodland type, scale and geography. More studies are needed on a wider range of woodland management tools, woodland types and services to identify evidence-based best practices for improving woodland resilience to future outbreaks.