WOODLAND TRUST

Wood Wise

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Woodland Conservation News

Tree pests and diseases: present and future threats

Asian and citrus longhorn beetles – Chalara ash dieback – Emerald ash borer – Oak decline – Oak processionary moth – Oak wilt – *Phytophthora ramorum*

Agrilus biguttatus, linked to oak decline

Siga, Wikimedia Commons

Tree Pests & Diseases

Adult ALB emerging from tree (post autoclave) Michael Bohne, Bugwood.org

Threats to the health of UK trees are increasing and each decade seems to bring a new pest or disease that our woods, foresters and scientists must try to combat. Chalara ash dieback is the latest in a long line that includes the devastating Dutch elm disease, which resulted in the death of over 25 million of the UK's elm trees and still persists today.

Scientific advice suggests climate change could exacerbate the activity of pests and diseases, creating conditions that may encourage their spread and effects. Many others are on the horizon, and we must be vigilant against them invading our shores. Non-native pests and diseases pose a considerable threat, as their natural predators are likely to be absent from the UK and our native trees have not evolved defences against them.

Issues of trade

As commercial networks increase around the world, biosecurity is a key area on which to focus prevention efforts. Many pests and diseases have entered the UK via the trade in plants and natural materials. Britain uses around 50 million cubic metres of timber each year, and 80 per cent of this is imported from overseas. The growth of live plant imports is placing great strain on UK border controls. The value of this trade rose from £197 million in 2000 to £340 million in 2008.

In October 2011 Defra and the Forestry Commission published their ***Action Plan for tree health and plant biosecurity,*** which recognised the significant threats posed by tree and plant pests and pathogens, and the need for action. The document proposed strengthening import control and protocols, reviewing the EU Plant Health Regime, facilitating greater international collaboration, taking account of the socio-economic benefits of healthy plants and trees, understanding and adopting biosecurity measures, and acknowledging that surveillance is a vital tool in detecting and preventing pests and diseases.

A year later *Chalara fraxinea* was identified in the UK, but evidence suggests it has been here for longer. In response the government set up the Tree Health and Plant Biosecurity Expert Taskforce and the Tree Health and Plant Biosecurity Officials Advisory Group. Extra resources and commitments are being focused on tree health, with dire warnings for the future if we fail to act effectively.

As other organisations have also done, the Woodland Trust has set out plans to help safeguard woods and trees. These include using citizen science to monitor and record tree issues, working with nurseries to ensure a good supply of trees grown in the UK rather than abroad, hosting events to share knowledge and learning, working with partners, and effective monitoring and management of trees and woods across its estate.

We can all do our bit

Alongside the experts, we can all work to prevent, detect and rapidly act against threats. Choosing plants grown in the UK reduces the chance of bringing in new pests and diseases. Native plants are generally better for wildlife and more likely to be UK grown, however this is not always the case and it is advisable to check. If a diseased or infested tree/plant is found then report it as soon as possible. Having a basic understanding of the symptoms of tree pests and diseases is very useful. Forest Research's website has further advice on identification and reporting.

OPM larvae on oak leaves

Louis-Michel Nageleisen, Département de la Santé des Forêts, Bugwood.org

The following case studies give an overview of some of the pests and diseases already in the UK and actions being taken, and a few we need to prevent getting a foothold here.

Asian and citrus longhorn beetles

The non-native Asian longhorn beetle, *Anoplophora glabripennis,* and citrus longhorn beetle, *Anoplophora chinensis*, pose future threats to the UK. Infestations of both species have been found in the UK; thankfully these have so far been effectively dealt with.

The Asian longhorn beetle (ALB) is native to China and the Korean peninsula. It can cause extensive damage to broadleaved trees, and in China is estimated to cost $1.5 billion a year. In one Chinese province it reportedly killed 142 million trees in six years. It has also been accidentally introduced to the US, Canada and six European Union countries in solid wood packing material and is causing serious problems.

ALB Biology

The cream larvae of ALB are wood borers that target living trees. They tunnel thorugh the phloem and cambium layers and the sapwood, damaging the important life support systems of the tree and making the tree more susceptible to pathogen infections. As the larvae grow in size the network of feeding galleries become larger and more destructive to the tree. The larvae can reach 50mm in length. They are difficult to detect as they spend the majority of their life cycle beneath the bark.

Due to the larvae's position within the tree they are protected from predators and insecticide treatments. The lack of chemical or biological control methods means once a tree is infected with ALB the only way to get rid of it is to fell and destroy the trees themselves.

The adults tend to appear from May to October and leave large, distinctive circular exit holes in the tree bark, which can be around 10mm in diameter. They are large, 20 to 40mm in length, shiny and black, with irregular white spots. Their white banded antennae can be one to two and a half times the length of the body. Some native longhorn beetles, that are not pests, also have banded antennae but they do not have the black and white spotted bodies.

Trees favoured by ALB for egg laying are maples, *Acer* spp. (including sycamore, *A. pseudoplatanus*), elm, *Ulmus* spp., willow, *Salix* spp., horse chestnut, *Aesculus hippocastanum*, birch, *Betula* spp., and poplar, *Populus* spp. However they can also infest alder, *Alnus* spp., apple, *Malus* spp., ash, *Fraxinus* spp., beech, *Fagus* spp., plane, *Platanus* spp., *Prunus* species (including cherry) and pear, *Pyrus* spp.. This large range of potential hosts makes them a significant risk to many treed landscapes.

ALB in the UK

In the UK it was first identified and removed in 1994. Since then there have been around 30 other interceptions. In spring 2012 an infestation of ALB was spotted by a member of the public and confirmed in Paddock Wood, Kent by Forest Research. Young larvae were found in a sallow, *Salix* cinerea. The tree was felled and incinerated along with all potential host trees within 100m. A number of live larvae were found in the tree samples. All trees within 500m of infested trees were repeatedly surveyed and will continue to be, and a public awareness programme implemented over a 2km zone.

Asian longhorn beetle Steven Valley, Oregon Department of Agriculture, Bugwood.org

CLB damage to young tree Fera, Crown Copyright

CLB Biology

The citrus longhorn beetle (CLB) is almost identical in appearance to the Asian longhorn beetle. It too is a non-native wood borer, whose natural range is China, Japan and countries of South East Asia. However, CLB has been transported around the world via the trade in live plants, especially ornamental trees and most commonly imported maples such as Japanese maple, *Acer palmatum*. CLB has become established in Lombardy and €10 million was allocated to CLB eradication measures between 2008 and 2010.

The larvae feed on the pith and vascular systems of the lower trunks and roots of infected trees. In their native range the life cycle of CLB is one to two years, but in the UK the colder temperatures mean the life cycle is thought to be at least two years.

CLB in the UK

Before 2005 there had only been occasional reports of CLB in the UK, then CLB was reported at an ornamental nursery in Hampshire. It was initially mistaken for ALB, so investigations were focused on the wood packaging material. Once laboratory tests confirmed it to be CLB a consignment of 46,000 Japanese maples from China was found to be the source of infection - 26 adults and 12 larvae were found. The trees were summarily destroyed to prevent further beetle development. Since 2005 host trees in the surrounding area have been annually surveyed.

In 2008 a member of the public reported a live beetle emerging from a tree they had obtained via a national newspaper's free tree offer. The infection was traced back to a company in Guernsey. Around 60,000 Japanese maples had been imported from China via the Netherlands and were potentially infested.

They had already been distributed to customers around the UK. Some had received two or more trees, which increases the risk of adult beetles finding others to mate with. In spring 2009 inspectors visited 257 sites, focusing on those in receipt of four or more of the trees. Many of the trees had died following planting and were therefore of poor quality. No further infection was discovered and the level of infestation was therefore deemed to be low, but isolated findings of the beetle have been made since 2009. Continued vigilance is needed.

Both these beetles are highly destructive and could be serious threats to UK trees if allowed to establish. The Forestry Commission (FC) and FERA are asking anyone who sees signs of either of these beetles to report it immediately. Details can be found on the FC website.

CLB adult and exit hole

Fera, Crown Copyright

Chalara ash dieback at Pound Farm, canopy dieback and lesions WTPL

Chalara ash dieback

Chalara fraxinea or Chalara ash dieback is the new tree disease raising the profile of tree health issues in the UK. It has already killed a number of ash, *Fraxinus excelsior*, trees across northern Europe, including many in Germany, Poland, Norway, Sweden and Austria, and has affected around 90 per cent of all Denmark's ash since 2003. The pathogen was initially identified in Poland in 1992 after large numbers of dying ash were reported.

UK infections

The first report of it entering the UK was in February 2012, when a shipment of trees in a Buckinghamshire nursery was found to be infected. These had been shipped over from a nursery in the Netherlands, where the disease has been present since at least 2010. It was then found in a number of other nurseries, new planting sites and urban landscaping schemes across the UK. In October 2012 it was confirmed in the wider environment, mostly in Norfolk and Suffolk.

Ash is the third most common native tree species in the UK, after oak, *Quercus* spp., and birch, *Betula* spp., and a keystone species in temperate Europe. The latest estimate from the Forestry Commission (FC) puts the number of ash trees in UK woodland at 126 million, with a further 12 million found in fields, hedgerows and parks. The loss of this species would seriously change our landscapes. Ash is also an important tree for wildlife: 1058 species are associated with it, with 44 being obligate on ash, such as the larvae of the dusky thorn moth, *Ennomos fuscantaria*, and 64 highly associated.

The Woodland Trust's Pound Farm in East Anglia has pockets of ancient woodland, ponds and wildflower meadows. However, the largest proportion is new planting on previously degraded arable farmland, planted around 20 years ago. It is regularly monitored because it is a busy site for visitors and has 30-35 per cent ash coverage.

In late August 2012 the site manager became concerned about a number of struggling ash trees. Areas of the site often become waterlogged and this can create health problems for trees, but now there were visible lesions developing on the struggling ash. Even healthy ash appeared to be showing signs of canopy dieback and lesions. Rideside ash coppice and regeneration was also being affected. A report was sent to Forest Research and the site continued to be closely monitored.

In September it was obvious the issue had developed further, with more signs of stress, dieback and an increase in necrotic lesions. Another report was sent to Forest Research who visited the site in early October. Tests showed the presence of *C. fraxinea*. As the ash canopies have opened up natural regeneration of other species has come through, such as pendunculate oak, *Quercus robur*, field maple, *Acer campastre*, hazel, *Corylus avellana*, hawthorn, *Crataegus monogyna*, and hornbeam, *Carpinus betulus*. The age of regeneration suggests the pathogen has been present at Pound Farm for at least three years.

Action and research

Due to the presence of the pathogen and the seriousness of the UK threat, the decision was made to use the site to assist Forest Research's work. Eight hectares of trial plots have been planted at Pound Farm and Hucking Estate, both affected by *Chalara fraxinea*, with ash strains from 11 different genetic zones. Pound Farm lends itself to scientific study because it has a variety of factors: ash dominated ancient woodland, planted ash in intermediate young woodland (20 years old), young natural regeneration, and ash coppice stools and regrowth.

There is now a great deal of research being conducted on *C. fraxinea*. Evidence from Denmark shows genetic variation between different ash trees has a significant effect on their susceptibility to the pathogen. However, natural resistance appears to be very low, perhaps less than 5 per cent of infected trees.[1] A resistant type, known as Tree 35, may hold the key for the long term future of ash.

In March 2013 UK scientists completed the first sequencing of the *C. fraxinea* genome. The data is freely available on the crowd-sourcing website OpenAshDieBack (**www.oadb.tsl.ac.uk**), allowing experts across the globe to identify specific genes and the role they play in other organisms. Hopefully this will help them understand how the pathogen attacks trees. Mapping will also be carried out on disease resistant ash.

At present mature ash trees appear to be showing most resistance to *C. fraxinea*. They can often survive for several years. This supports evidence that the pathogen is most destructive of young

Chalara ash dieback lesions

Food and Environment Research Agency

Chalara ash dieback leaf dieback Food and Environment Research Agency

plants. Once symptoms begin to show young trees die within one growing season. This will drastically change sites like Pound Farm in the future, as other species will gradually take over those spaces left by dead and dying ash.

If ash are not felted and removed from site, the amount of deadwood will increase fairly rapidly, having positive consequences for saproxylic species and the wildlife that live on them. Current advice is to leave ash to die and decay, as it offers the best option for the tree's associated species. In 50-100 years the amount of ash deadwood will have decreased, but will there still be ash in the UK countryside? Only time will tell.

[i] McKinney, L.V., et al. (2011) Presence of natural genetic resistance in Fraxinus excelsior (Oleraceae) to Chalara fraxinea (Ascomycota): an emerging infectious disease. Heredity. Available online: ***http://www.nature.com/hdy/journal/v106/n5/full/hdy2010119a.html.***

Emerald ash borer

The emerald ash borer (EAB), *Agrilus planipennis Fairmaire*, is a beetle from the family Buprestidae, distinguishable by its dark green metallic colour. Its native range is northern China, Korea, Japan, Mongolia and eastern Russia. Adults can be 7.5 to 13.5 mm long, but it is the larvae that are the real problem. The larvae are wood borers, and while many members of this beetle family favour dead or dying wood, EAB favours the phloem layer under the bark, which conducts water and nutrients to the ash tree, *Fraxinus* spp.,. Essentially, emerald ash borer larvae strangle an ash tree.

In 2002 EAB was discovered in North America, near Detroit, Michigan, and realised to be the agent causing the decline and death of many ash trees. It was initially thought to be in six counties in southeastern Michigan, but within a few months, it was discovered in numerous areas of Michigan and the neighbouring states of Ohio and Indiana, as well as the Canadian province of Ontario. The latest research indicates that EAB was present in Michigan 10 to 12 years before its discovery in 2002. The infestation currently covers over 5,000 square miles of the United States and Canada, and has already killed tens of millions of ash trees, more than 5 million of these in Michigan alone.

It is thought EAB was introduced to North America in wooden packaging imported from abroad and through ash wood used to stabilise cargo in the hold of ships. The spread of the beetle within the US has been assisted by transport of infested nursery trees, logs and firewood. The adult beetles can also fly at least half a mile from their emergence tree. Spread of EAB is estimated at 10 to 20 miles each year, primarily through human vectors.

Emerald ash borer adult Leah Bauer, USDA Forest Service Northern Research Station, Bugwood.org

Symptoms

The canopy of infested trees begins to thin above infested portions of the trunk and major branches because the borer destroys the water and nutrient conducting tissues under the bark. Heavily infested trees exhibit canopy dieback usually starting at the top of the tree. A third to a half of the branches may die in one year. Most of the canopy will be dead within two years of symptoms becoming evident.

Sometimes ash trees push out sprouts from the trunk after the upper portions of the tree dies. Although difficult to see, the adult beetles leave a "D"-shaped exit hole in the bark, roughly 3-4 mm in diameter, when they emerge in June.

Ash populations can go from healthy mature trees to total mortality in just six years. Death comes more rapidly to those trees out-shaded by others or ones already suffering from decline. When EAB populations are high, small trees may die within one to two years of becoming infested and large trees can be killed in three to four years.

Beetle life cycle

Recent research shows that the beetle usually has a one year life cycle, but this can extend to two in colder regions. Adults begin emerging in mid to late May, with peak emergence in late June. Adults live for around three weeks and feed on ash foliage, mostly in irregular patches along leaf margins. Adults are most active in the day, especially during warm, sunny weather. Females usually begin laying eggs, at least 60 to 90 in their lifetime, about two weeks after emergence. The eggs are individually deposited in the crevices of bark on the trees trunk or branches.

The eggs hatch in one to two weeks. The tiny larvae bore through the bark and into the cambium

Emerald ash borer larvae Houping Liu, Michigan State University, Bugwood.org

layer - the area between the bark and wood where nutrient levels are high. The larvae feed on the phloem and outer sapwood under the bark for several weeks, usually from late July or early August through to October. This interrupts the flow of nutrients and water up the tree. The feeding galleries created by the larvae become wider as they grow, and are filled with sawdust-like frass. An individual gallery can range from 10 to 50 cm or longer.

The larvae typically pass through four stages, eventually reaching a size of roughly 26 to 32 mm long. Most EAB larvae overwinter in a small chamber in the outer bark or in the outer inch of wood. Pupation occurs in spring and the new generation of adults will emerge in May or early June, to begin the cycle again.

Solving the problem

EAB is now considered the most destructive forest pest ever seen in North America. It is thought the economic scale of the problem will soon reach billions of dollars nationwide.

Many agencies and universities are working together to educate citizens about identification of ash trees and EAB and options for protecting valuable shade trees. State and federal agencies have programmes in

place to help restore the urban forest in cities that sustained heavy EAB damage, in the form of grants for which municipalities must submit proposals. Research is underway to learn more about the biology of EAB, its rate of spread, methods for EAB detection, predators and other natural enemies that may attack EAB, and how insecticides can be used to protect trees in infested areas.

Some work has been done on biological controls for EAB. In China its natural predators include, *Spathius agrili, Tetrastichus planipennisi* and *Oobius agrili*, each a type of stingless parasitoid wasp.

The female wasps lay their eggs in either the EAB eggs or larvae, depending on the species. These then hatch and feed on the eggs or larvae, growing inside and killing them. Once an Environmental Assessment was carried out, populations of the wasps were reared and released in 2007. There are also a couple of native predators that are being studied. Research into this is ongoing.

Damage by emerald ash borer Art Wagner, USDA - APHIS, Bugwood.org

EAB may not be in the UK at the moment, but there is a dire need for vigilance and thorough border checks to ensure it does not become another problem for our already beleaguered ash trees. It is currently around 250 km from Moscow. A lead EAB researcher in the US has done tests on the resistance of various species of ash trees from other countries to EAB. Common ash, *Fraxinus excelsior,* found in the UK did not fare well. Further information on EAB in the US can be found online: ***http://www.emeraldashborer.info***

Oak decline

The UK's native oaks are currently being affected by two forms of decline or dieback – chronic oak decline (COD) and acute oak decline (AOD). The former has a slower effect, while the latter causes more rapid death of the trees. Pendunculate oak, *Quercus robur,* and hybrids of pendunculate and sessile oak, *Q. petraea*, appear to be far more affected than pure sessile or non-native oaks. Decline of mature oaks first aroused concern in the 1920s, today most cases are in central, southern and eastern England.

COD and AOD biology

COD is thought to have been affecting oak trees for the last century. Trees can suffer for many decades before they reach a tipping point, then secondary infections, such as fungi, move in and death comes rapidly. Symptoms include canopy thinning and

COD at Valley Park Woods WTPL

branch dieback. First the foliage deteriorates; leaves may grow smaller and pale to a yellow hue. The finer twigs and branches then die off, creating a stag's head appearance such as ancient trees develop, and a dark liquid may also be exuded from the bark. Death of the larger branches can follow, and finally the whole tree. Some individuals are able to stabilise and make a partial recovery, growing epicormic shoots, although further attacks can occur.

AOD is also very concerning as trees can die within three to five years of the first symptoms appearing. It affects mature (over 50 years of age) pendunculate and sessile oak trees. Symptoms include stem bleeds of dark fluid from lesions, necrotic tissue under the bark, canopy dieback similar to COD, and larval galleries.

AOD seems to transfer easily between individual trees.

'A decline, as opposed to a disease, typically involves a number of agents acting either sequentially or simultaneously, the overall effect being a loss of health and vitality over a relatively short time,' says Dr Sandra Denman of Forest Research. 'The disorder we call Acute Oak Decline is probably due to a combination of factors: there's no single cause that has yet been identified and we are still very much in the investigative stage of research. We can't just go in there with chainsaws roaring as a solution to the condition: we need to have a clear understanding of the agents involved and how they interact so that we can develop the best management practices to prevent it spreading. But our oaks are under serious attack.'

There are several biotic and abiotic factors linked to oak decline: honey fungus, *Armillaria;* two-spotted oak buprestid beetle, *Agrilus biguttatus*; root rot fungus, *Collybia fusipes;* drought and high winds; oak defoliators such as oak leaf roller moth, *Tortrix viridana*; oak mildew, *Erysiphe alphitoides*; oak pinhole borer, *Platypus cylindrus*; and several *Phytophthora* species. Trees may have been stressed by various factors before any symptoms become apparent.

Oak decline in UK woods

At the Woodland Trust's Valley Park Woods, Hampshire, signs of dieback in mature oak trees were first recorded in October 2010. Extensive dieback of a large number of oaks was then reported in the summer survey of 2011. Annual autumn and summer surveys have been carried out since on 119 individual trees; 65 have had to be felled, five reduced and 45 are still being monitored.

Acute oak decline stem bleeding Forestry Commission

Forest Research has diagnosed the problem as COD, because, although symptoms have only appeared in the last two years, close inspection of the growth rings of a felled tree shows growth to have been stunted for around the past 20 years. This is consistent with the current understanding of COD; the tree struggles for several decades before succumbing to further infection and then rapidly declines.

The Woodland Trust's Stratfield Brake, Oxfordshire, and Bisham Woods, Berkshire, have trees afflicted with AOD. Forest Research is currently conducting research on both sites into the effects of the jewel beetle *A. biguttatus* (see image on front cover). A selection of trees were felled and cut into sections for analysis on site and further work carried out on samples taken back to the laboratory.

AOD has been known for longer at Stratfield, here the oak trees appear to be containing the disease and death is not necessarily inevitable. However, the oaks tested at Bisham were in a much worse condition and were deemed to be losing the battle against AOD. The route of bacterial infection appears to closely follow the galleries created in the wood by the larvae of *A. biguttatus*.

Knowledge of the complexity behind oak decline is growing, but further research is needed to understand the factors causing this syndrome and the way they interact to bring about the death of so many trees. Further information is available from the Forestry Commission website.

Oak processionary moth

Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org

Oak processionary moth

Oak Processionary Moth (OPM), *Thaumetopoea processionea*, is a small brown moth whose larvae cause serious plant and human health issues. In Europe the caterpillars of OPM are major oak defoliators, feeding on the leaves of a range of European *Quercus* species. In large enough numbers they have also been found to attack trees neighbouring oaks, such as hornbeam, *Carpinus betulus,* and birch, *Betula* sp..

An adult, female OPM can lay an egg plaque with up to 200 eggs from July to September, with larvae hatching from mid-April the following year. After the 3rd instar (growth phase), the caterpillars congregate in large, brown silk-web nests on the main trunk or under the main scaffold branches and feed together on the leaves on the outer canopy, following each other in a procession – hence their common name.

Unlike most other tree pests and diseases, OPM is also a serious human health problem. During their third to sixth instars the larvae grow thousands of hairs that contain thaumetopoein, a powerful toxin. These hairs readily break off into the air and can cause skin rashes, conjunctivitis and respiratory problems, such as pharyngitis and asthma, if they come into contact with human skin or eyes, or are breathed in. Shed skins and abandoned nests also contain these hairs.

OPM infecting UK oaks

In the UK, OPM nests were first located in 2005 on newly transplanted fastigiated oak trees at a development site near the Royal Botanic Gardens, Kew. In 2006 three nests were discovered on two *Q. cerris* oak trees at Kew. The decision was made to act fast and remove them, but there was very little information available at the time as to effective means to do this.

They chose to fix the hairs of the caterpillar with hairspray, peel the nests from the trees into a bag and burn them. Flames were then put over the tree where the nests had been to destroy any leftover hairs.

Nest removal using heavy duty vacuums was carried out for three years, but was found to be ineffective as it did not ensure the eradication of all OPM individuals. The caterpillars are so small when they first hatch that they are almost impossible to spot, while the adults are also small and well camouflaged. Therefore OPM continued to spread across the site. In 2010 Kew changed tack and began to use insecticide as a means of control.

In the first year Deltamethrin, a pyrethroid ester insecticide, was used because of the sheer numbers of OPM caterpillars present. This is very aggressive, attacks the nervous system and kills rapidly, and it was found to be highly effective. Dimilin Flo was used during the following two years as it is more selective, targeting only Lepidoptera. Bartlett Tree Experts were hired to carry out the spraying work as they have the specialist equipment needed, such as large rigs to allow trees to be sprayed from the ground. Spraying was carried out as early as possible to limit the collateral damage to native species.

Spraying the Turners oak, Kew Tony Kirkham

Oak Processionary Moth defoliating leaves Tony Kirkham

Prophylactic spraying has been carried out at Kew for the last two years, targeting species of European oak known to be food sources for OPM. These include pedunculate oak, *Quercus robur,* sessile oak, *Q. petraea*, turkey oak, *Q. cerris,* holm oak, *Q. ilex,* cork oak, *Q. suber*, chestnut leaved oak, *Q. castaneifolia*, and Hungarian oak, *Q. frainetto*. Pheromone traps did capture adult moths in 2011, but no further OPM nests have been found at Kew.

Therefore Kew has suspended spraying for 2013 to assess the situation. Close monitoring will continue and if outbreaks are discovered they will be eradicated immediately. Monitoring is key to prevention and rapid, effective action. Monitoring has also been carried out on native biodiversity, to ensure spraying was not having a detrimental effect on non-target species. Results showed no significant declines in biodiversity.

OPM control in London

OPM has been found outside Kew and a local stakeholder group was created, including the London Borough of Richmond upon Thames Council and Royal Mid Surrey Golf Course. The group is raising awareness, and sharing information and advice on monitoring and tackling OPM at other sites.

The Forestry Commission has recently carried out aerial spraying of Herridge's Copse and Broom Copse, near Pangbourne, Berkshire, as part of a £1.5 million pilot project to eradicate OPM from Britain. At present it has only been found in areas of London, including Richmond Park. A bacterial agent, *Bacillus thuringiensis* (Bt), occurring widely and naturally in the soil was used; officials say it poses no risk to human or animal health. Natural England has authorised the operation.

The conservation charity Butterfly Conservation voiced concern over this action, as Bt can also kill non-target, native species of Lepidoptera. They are planning to monitor the impact to see how populations recover following spraying.

The extra funding committed to OPM control shows the growing concern over this pest. If it does become established in Britain it could pose a significant problem for woodland management, native oak trees and human health.

Rhododendron ponticum infestation

Wikicommons, Franz Xaver

Oak wilt

Oak wilt is a disease not yet in the UK and it is one we must strive to prevent reaching our shores, but it is already causing considerable damage in areas of the US such as Michigan. It is caused by the fungus *Ceratocystis fagacearum*, which results in a devastating vascular wilt disease of oak trees. Although it acts like an introduced pathogen, the fungus is thought to be native and was first discovered in the 1920-30s. It is not as epidemic as Dutch elm disease, but it is locally destructive and costly to control. Dr David Roberts from Michigan State University has been researching the disease.

Life cycle and symptoms

The fungus resides short term in killed oak trees as fungal mats, also known as pressure pads. Various sap beetles are attracted to the fruity odour given off by the fungal mats. They pick up some of the fungal matter before haphazardly visiting live oak trees that have been recently injured. Injury usually occurs from storms and inappropriate pruning of oak trees during the warm season. Upon visiting recently injured oak trees, sap beetles may inadvertently transfer some of the fungal matter to the wounded oak tree.

The primary time for oak wilt transmission via sap beetles is in the spring, but some experts in the US believe that the disease may also be spread during other times of the warm season. Once a tree becomes infected, the fungus may spread through root grafts to other nearby oak trees. This spread in a radial pattern is called an epicenter and is difficult to stop.

If oaks are in close proximity to one another, the disease may spread from tree to tree through the interconnecting root systems. Generally, in woodlots and dense oak landscapes, one tier of trees is killed every year as the fungus moves out from the original infection center in a radial pattern. The disease may be confused with other oak diseases; numerous recent

Oak wilt symptoms Joseph O'Brien, USDA Forest Service, Bugwood.org

inquiries suggest that oak wilt is often confused with anthracnose on white oak species. Lab tests to confirm oak wilt are often inconclusive.

In the US, members of the red oak family are found to be more susceptible than members of the white oak family. The UK's two native oaks, pendunculate oak, *Quercus robur,* and sessile oak, *Quercus petraea*, are both white oaks. The symptoms of infection are premature leaf fall during the summer months, the leaves may also wilt, turn brown and hang on the tree, and the ultimate symptom is death. In red oaks death is usually rapid, taking 4-6 weeks or less, whereas white oaks tend to die more slowly or may recover.

Management and control

Once introduced into a landscape, oak wilt is lethal to oak trees and is usually quite costly and difficult to

control. Here are some ways in which the US is trying to manage the disease:

Prevention: No warm season pruning: owners of oak trees need to be well advised that if necessary, pruning should only be done during the dormant, cold season. If trees must be pruned during the warm season, wounds should immediately be dressed with tree paint or wound dressing that acts as a barrier to transmission by sap beetles.

Prompt Storm Repair: If limbs are damaged during storms, they should be repaired within 12-24 hours. Repair includes clean-cutting jagged edges, possibly one to several feet from the injury, depending on time from the incident, followed by immediate application of a wound dressing barrier to prevent fungal transmission by sap beetles.

Fungicide Injections: Injection of the fungicide propiconizole, using high volumes has proven to be effective in protecting red oak family trees from infection by root grafts. The fungicide will "cure" some white oak family members infected with the oak wilt fungus but will likely not cure infected red oak family member trees.

Trenching: Deep trenching, 3-4 feet in heavy clay soils and 5-6 feet in light sandy soils, can be a highly effective method to stop the spread of oak wilt through interconnecting root systems (natural grafts), particularly in red oaks. Placement of trench lines can be an art and in order to cause as little damage as possible while obtaining the maximum efficiency from trenching, it is advisable to seek professional assistance.

UK relevance

If this fungus reaches the UK it could cause serious damage to our already threatened oak trees. The UK's oaks are currently facing problems caused by acute oak decline and chronic oak decline. The Atlas of British Flora shows pendunculate oak to be widespread throughout the UK and sessile oak to be almost as extensive. They are also hugely important species for wildlife, timber and are emotionally significant for many people. The UK needs tough border controls and checks to keep oak wilt from becoming the next tree health issue.

Oak wilt foliar symptoms on northern red oak

D.W. French, University of Minnesota, Bugwood.org

Phytophthora ramorum

Phytophthora ramorum is a fungus-like pathogen that infects a range of trees and other plants, causing extensive damage and ultimately death. It is possibly native to Asia, but has also been found in the UK, US and Canada, where it is causing serious problems, and on nursery stock in several European countries. In the US it is know as "Sudden Oak Death" and has been causing the widespread death of oaks since the 1990s. It was first identified in California in 2000 and then in Oregon.

UK infections

How and when *P. ramorum* entered the UK is unknown, but infection was first found in February 2002 on viburnum at a nursery in Sussex. Then in November 2003 it was recorded on a mature tree, a 100 year old southern red oak, *Quercus falcata*. Other susceptible trees include beech, *Fagus sylvatica*, turkey oak, *Q. cerris*, holm oak, *Q. ilex*, sweet chestnut, *Castanea sativa*, horse chestnut, *Aesculus hippocastaneum*, Douglas fir, *Pseudotsuga menziesii,* Japanese larch, *Larix kaempferi,* and sitka spruce, *Picea sitchensis*. Some species, such as ash, *Fraxinus excelsior*, are leaf hosts but are not susceptible to bark infections. Across the globe the pathogen is known to have over 150 host species.

P. ramorum was first identified in Cornwall in 2002 on rhododendron and other shrubs of stately gardens. Water run-off is believed to have washed spores from these infected plants onto adjacent trees. The pathogen appeared to be having a limited effect on a small number of trees.

Then in September 2009 a mystery disease infecting and killing a large number of Japanese larch was confirmed as *P. ramorum*. This is the first global occurrence of it lethally infecting a commercial conifer species. Larch enables the pathogen to have a much higher spore production rate than rhododendron, increasing its ability to spread.

Symptoms and spread

Spores are produced on leaf lesions and spread by droplets of water from wet or humid conditions hitting the leaves and splashing spores onto adjacent trees, infecting them through the bark. However, *P. ramorum* is not able to sporulate on all tree species. The spores

P ramorum under larch bark

Mike Townsend

appear to act together to infect new trees, this is only possible if the concentration of spores is high enough.

Symptoms on trees include large bleeding cankers that appear brown to black on the outside of the bark and exude a dark-red sap. Leaf infections on broadleaved trees usually appear as necrotic brown areas. On larch, needles turn ginger and black and fall off prematurely. Shoot dieback is also typical. If broadleaved trees are pruned during early infection they can recover, but Japanese larch dies quickly regardless of any action taken.

The Woodland Trust's Kings Wood, near St Austell, is a mix of ancient semi-natural woodland and plantations on ancient woodland sites (PAWS). The broadleaf element includes mature oak, *Quercus* sp., beech, *Fagus sylvatica*, birch, *Betula* sp., and ash, *Fraxinus excelsior*. The plantations areas are composed of non-native species such as Douglas fir, *Pseudotsuga menziesii*, sitka spruce, *Picea sitchensis*, Japanese larch, *Larix kaempferi,* and western hemlock, *Tsuga heterophylla*.

In June 2010 the Forestry Commission identified a single larch tree in the canopy showing signs of *P. ramorum*, during an aerial survey. By September it was evident that far more trees were actually infected - some individuals show symptoms sooner than others. The site was served with a compulsory plant health notice by the Forestry Commission (FC), ordering the felling of all infected trees.

As the plantations were undergoing work to restore them back to native woodland they had already been thinned twice, and a healthy amount of natural broadleaf regeneration was coming through. The decision was taken to fell the larch to waste, leaving it on the ground and not removing from the site. This protected the native regeneration from damaging harvesting works. At this time sawmills also did not have licences to take infected larch, as these were not brought in until early 2011.

P ramorum lesion on beech Mike Townsend

The spores were still present in the wood but were now at ground level and quickly covered by bramble regrowth. Posters were put up to inform the public of the presence and problem of P. ramorum, to raise awareness and encourage the washing of boots following visits to infected sites. The public was never denied access to the wood as the pathogen had already been found across the south west and other areas of the country.

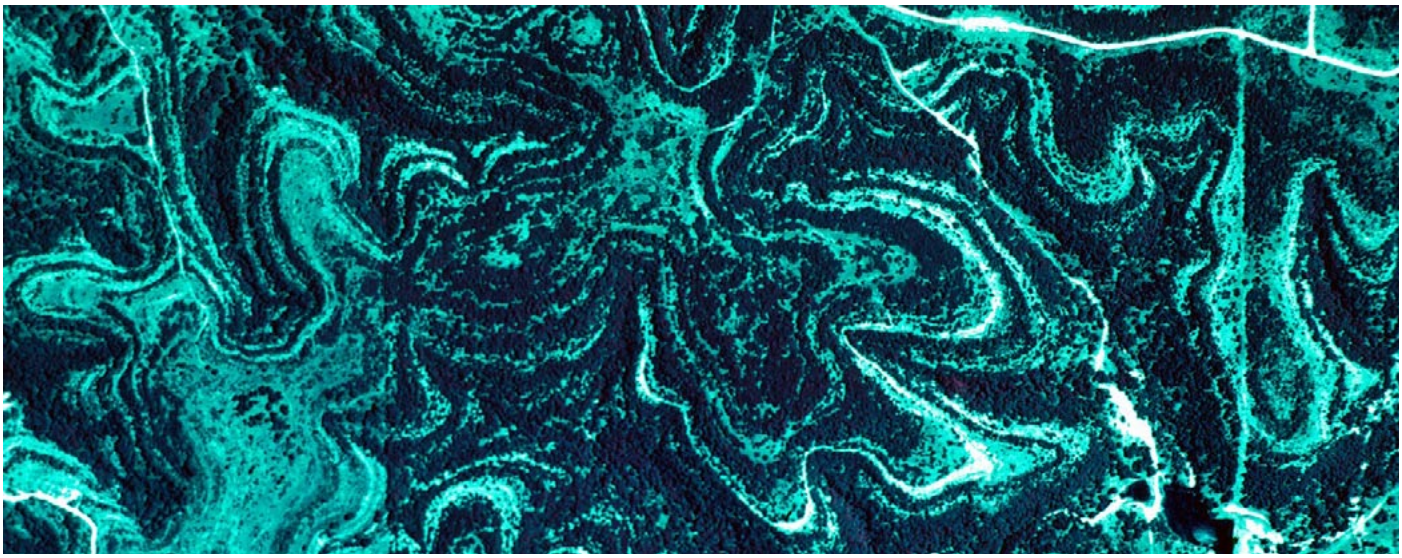
Commercial risks and actions to take

P. ramorum has had devastating consequences for commercial timber growers. Many once lucrative crops have had to be felled and, although the timber can now be sent to sawmills, the market is flooded with larch, seriously reducing its value. Clear felling has also had implications for biodiversity where PAWS have been infected. Gradual thinning is accepted as being the best method of ancient woodland restoration on most sites. This allows remnant species, such as sensitive ground flora, to expand slowly into thinned areas. Clear felling creates a sharp change in habitat and light levels, often allowing more ruderal species, such as bracken, to take over.

The FC has identified three risk zones, those areas of highest risk (e.g. west England and Wales) are in Risk Zone 1 and the lowest risk (e.g. east Scotland) in Risk Zone 3. A map is available from the FC website. The wetter west side of Great Britain appears to provide more optimum conditions for the proliferation and spread of *P. ramorum*. Since 2001 surveillance and monitoring of woods, gardens, parks, garden centres and ports has been carried out by the FC and Fera Plant Health and Seeds Inspectors.

Wherever the pathogen is identified statutory action is taken to eradicate or contain the problem. It is not possible to control it with chemicals, so clear felling is being actioned to control the spread.

The pathogen is currently most prolific in the south west of England and south east of Wales, but there are confirmed cases in west and south east England, northern Wales, parts of western Scotland, and Northern Ireland. Biosecurity measures are being promoted to help prevent the spread. The FC advises woodland workers and visitors to wash and disinfect footwear, vehicles, bicycles, tools and equipment, and to destroy any material removed by washing. We must all play a part in helping to stop the spread of this pathogen and all tree pests and diseases.



Colour infrared aerial image of trees killed by oak wilt (US) William M. Ciesla, Forest Health Management International, Bugwood.org

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