OAK DECLINES

NEW DEFINITIONS AND NEW EPISODES IN BRITAIN

Sandra Denman and **Joan Webber** provide an update on the latest developments and clarify some of the confusion surrounding this worrying problem.

Increased visibility of deteriorating oak health in Britain and media reports on 'Sudden Oak Death' have led to growing public concern about their long-term future. However, there is considerable confusion about the cause of ill-health and the names that people use to describe it. Over the past century oaks in diminishing health have been said to be suffering from dieback or decline. In Britain, periodic episodes of decline have affected populations of native oak (*Quercus robur* and *Q. petraea*), and this has been documented by Day (1927); Osmaston (1927); Robinson (1927); Young (1965); Gibbs and Wainhouse (1995); Gibbs and Greig (1997). These episodes of oak decline are of complex cause, often implicating poor site conditions, drought, excessive soil nitrogen, attack by root disease fungi such as *Armillaria*, *Collybia* and *Phytophthora*, as well as recurrent insect defoliation followed by mildew attack.

More recently, concern has also been expressed about the widespread, general decrease in crown density of pedunculate oak in Britain (Innes and Boswell, 1991; Pinchin, 1999 and Hendry, 2005). Thinning tree canopies are usually indicative of worsening overall health and between the mid 1970s and early 1980s it was thought that poor air quality and increased soil acidity, both as a consequence of heavy industrial activity, could be a cause or contributory factor (Grayson, 1985). However, by the 1990s emphasis shifted to highlighting the impacts of drought and intensive insect defoliation as major factors associated with decreasing crown quality in oak (Hendry, 2005) although cause and effect relationships are difficult to prove (Hendry, Personal Communication). Over the last decade, news of 'Sudden Oak Death' (SOD) sweeping through native coastal forests in California and causing significant levels of mortality amongst native oak and tan oak posed the possibility of another threat to native British oak species. And now, yet another disorder - called 'Acute Oak Decline' (AOD), is on the rise in Britain. In this article we will differentiate and discuss a number of causes of oak death and decline, apply an appropriate name to each then place them in context in the British landscape.

Figure 1. Chronic Oak Decline with typical symptoms of canopy thinning.

Figure 2. Acute Oak Decline: Bleeding from cracks in bark on an oak stem.

Types of oak decline

Traditionally, oak decline is described as a syndrome, which means that a suite of factors is identified as the cause of visible symptoms. The combination of factors in a suite may differ slightly from site to site. Also, the intensity of the effect each factor exercises may vary over time dependent on season, environment or other biological interactions. Factors may include both abiotic and biotic agents. To understand their role and impact in the syndrome better, individual factors require close monitoring over long periods (decades). However, when interpreting available information on oak declines to date, two distinct epidemiological patterns emerge. The first is characterised by the sudden appearance of the condition, over perhaps a five to ten year period, followed by high levels of tree mortality, and then the episode stabilises, tails off and can even disappear. This type of decline tends to be episodic and is called 'Acute Oak Decline' (AOD). The other form of decline is called 'Chronic Oak Decline' (COD), characterised by a relatively slow rate of symptom development. Symptoms may persist for many years, decades even, whereas mortality levels are generally low and some trees may recover partially or completely

Chronic Oak Decline

How is COD different from the traditional view of oak decline? The answer is probably not much, except that recently more emphasis is placed on compromised root health as a primary causal role. Chronic Oak Decline is thus not a new phenomenon, but a different interpretation of a long observed one as evidence has come to light about the role of certain root attacking pathogens.

Symptomatically therefore, COD aligns with the traditional concept of oak decline. Canopy symptoms develop over many years on mature oaks. Typically, canopies may or may not become chlorotic but thin through progressive loss of fine twigs and small branches (Figure 1). The outline profile of the canopy changes from smooth to more indented in the early stages. The once dense cross-sectional view of the canopy becomes progressively fragmented, more light is transmitted through reduced foliage cover and windows develop between the main scaffold sectors. Continued deterioration in health eventually leads to sparsely foliated canopies; branch dieback characterises advanced stages of the condition and some affected trees may become 'stagheaded'. Occasionally declining trees may also have dark, watery fluxes running down the bark. Although mortality can result from COD in localised areas, since the condition is chronic trees remain in this state for many years, and some may even show signs of recovery.

To date no single causal agent of COD is recognised although, as already mentioned, various root rot fungi and drought are thought to play major roles. The nature of COD symptoms strongly suggests root malfunction but interpretation is complicated by the time lag between the onset of root disease and the expression of its effects in the tree canopy. Understanding is made even more difficult by the confounding effects of a succession of organisms that opportunistically colonise tissues once they have been weakened by primary

invaders. Attempts to investigate the condition only provide a snapshot of the situation at a particular point in the process. Real progress in understanding COD is thus dependent on long term monitoring and development of a large database of information about trees at different stages of decline and the associated factors. In this way the various data can be analysed and linked to provide insights into the interactions between factors such as pests and pathogens and changes in climate.

Although there is a dearth of comprehensive information on the occurrence and distribution of COD in Britain, it is considered fairly widespread. It appears on a variety of landscapes from urban to woodland, parkland and farming situations and pedunculate oak is more affected than sessile oak. Accurate records on incidence of this condition would play a major role in advancing our understanding of COD and the main factors that trigger it over the long term.

Acute Oak Decline

Decline and high levels of oak mortality were reported in Britain in the 1920s and attributable to successive events of first flush defoliation by roller moth (*Tortrix viridana*) followed by mildew attack on summer recovery foliage (Day, 1927; Osmaston, 1927; Roberts, 1927). Over a number of consecutive years trees were unable to withstand this combined attack on their foliage. One explanation for the high and rapid mortality rate is that trees were progressively weakened by stunted early wood growth as a consequence of spring defoliation, succeeded by reduced late wood growth and carbohydrate reserve deposits in roots attributable to the lower productivity of mildewed leaves. Whether the weakened trees simply had no further resources to continue growth and died, or whether opportunist invaders then led to high mortality is a matter of speculation. Tree deaths peaked in 1924 but the condition abated in 1925, which coincided with a crash in *Tortrix* populations. Since the epidemiological pattern displayed by this outbreak corresponds with that of an acute form of oak decline, this event can be recognised as the first episode of AOD in Britain. However, the defining characteristic of this early episode of AOD was the focus on foliage loss that occurred for several years in succession.

But now a new episode of AOD is taking hold in Britain. The pattern of rapid deterioration in health and high levels of tree mortality that characterise this outbreak conforms to the description identified previously, although the causal factors in this case are likely to be very different with bacterial pathogens implicated as the main cause. Nevertheless, until the cause of the outbreak is certain, AOD is the most fitting name to give it.

Affected trees are characterised by symptoms of extensive bleeding emanating from longitudinal splits formed between bark plates on the stems of oaks (Figure 2). Initially necrotic patches develop beneath the bark plates (Figure 3) but these further deteriorate into fluid filled cavities (Figure 4). In spring the fluid oozes from the cavity through small (5-10 cm) longitudinal cracks that develop between the bark plates. As the season progresses the dark exudate may dry, forming shiny, sticky jewel-like drops in the bark cracks and later a hard black crust forms extending from the crack along the drip line on the bark. It is not unusual for numerous necrotic

Figure 3. Acute Oak Decline: Lesion formed in the inner bark beneath a stem bleed.

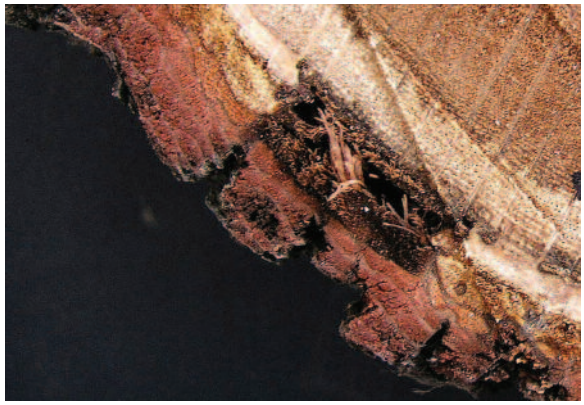

Figure 4. Acute Oak Decline: Cavity formed in inner bark beneath a bleeding point.

patches to form at close intervals around tree stems. Within 3-5 years from the onset of disease symptoms trees die. It is unknown at this stage if deaths are caused by necrotic patches coalescing, ultimately girdling trees and causing death as the vascular flow is disrupted, or whether secondary attack for example by opportunistic organisms such as the buprestid beetle, *Agrilus pannonicus*, is the final death blow.

Although this is a new disease in Britain, a similar disease has been reported to affect Mediterranean oaks in Spain (Biosca et al., 2003; Poza-Carrión et al., 2008) and scientists at Forest Research (FR) are collaborating with Spanish colleagues to discover if the same bacterial pathogens are involved. At this stage it is unknown whether the condition occurs elsewhere in Europe or further afield.

The known distribution of AOD in Britain is based largely on cases reported to the FR Tree Health Advisory Service and then validated by researchers as symptomatically typical of AOD. So far 55 sites, mostly in the Midlands but two cases from Wales and a few in the south, sum up the extent of known distribution of AOD in Britain, but it is probably much more widespread than current records suggest. Detailed survey and counts of the number of symptomatic as well as non-symptomatic trees is still required on most of these sites but estimates of the proportion of trees affected on sites range from 2-80%. Site types on which AOD is reported include urban, parkland, farmland and woodlands. Almost exclusively mature trees (dbh of 35-80 cm) are affected and a significant proportion of trees with stem bleeding also have evidence of *Agrilus* beetle activity.

Sudden Oak Death

Since 1995 mortality of native American oak (*Quercus agrifolia*, *Q. kelloggii*; *Q. parvula* var. *shrevii*) and tan oak (*Lithocarpus densiflorus*) in California has increased significantly. Typically affected trees suffered from symptoms of stem bleeding. By 2000 *Phytophthora ramorum* was shown to be the cause of these tree deaths and to date more than a million trees have died in California and Oregon's Curry County as a result of this pathogen. Professor Emeritus at Forest Research, Clive Brasier, was the first to realise that the American oak killer and a *Phytophthora* species causing foliage necrosis and shoot tip dieback of ornamental plant species in European nurseries, mainly rhododendron and viburnum, were the same pathogen. The link between the diseases on the two continents was made and has proved fundamental to understanding the epidemiology of SOD, which is extremely complex. In 2002 *P. ramorum* was identified in Britain, first on ornamental nursery stock, then on garden plants and wild *Rhododendron ponticum*. By 2003 the first tree infections were found in Britain and The Netherlands but these were on beech (*Fagus sylvatica*) (Figure 5) and red oak (*Quercus rubra*) and not on native British oak species, which have proven less susceptible to this devastating pathogen compared with North American oak species.

Part of the complexity of *P. ramorum* is that it causes different types of disease. When it attacks foliage and young shoots it causes leaf necrosis and shoot-tip dieback (Figure 6); this is referred to as 'Ramorum leaf blight and shoot dieback' (Hansen et al., 2005). If tree stems are infected, the inner bark is killed and symptoms of stem bleeding occur. This disease is called 'Ramorum bleeding canker', and it is lethal on most of the trees it affects. 'Ramorum leaf blight and shoot dieback' is not usually deadly to infected hosts unless the attack is extreme, but is the lynch pin to the development of outbreaks because it is in this phase that inoculum is produced, which

Figure 5. Sudden Oak Death: A beech tree (*Fagus sylvatica*) with a bleeding stem canker caused by *Phytophthora ramorum*.

Figure 6. *Rhododendron ponticum* leaf with Ramorum blight.

drives epidemics and leads to stem infection on susceptible trees.

Although some trees have been killed or debilitated by Ramorum bleeding canker in Britain, numbers of affected trees remain low (less than 100), and trees are only placed at risk if they are in close proximity to infected rhododendrons. To date therefore, the impact on woodlands has been limited and should remain this way providing infestations on affected foliar hosts, such as *R. ponticum*, are eradicated quickly. Currently this process is being managed through a Defra and Forestry Commission Phytophthora programme that started in April 2009.

Conclusions

Over centuries oak in Britain and elsewhere have periodically been suffering from episodes of various pest and pathogen attacks. We can only look back, evaluate and learn lessons from episodes that have been documented. Sophisticated technology is available nowadays so that detailed records and relevant site data, carefully and thoughtfully acquired can be accumulated for a large number of trees providing the resources are there to do this. Such data will increase in value over time as it allows us to track the factors associated with decline and manage the health of oak accordingly.

The likelihood is that native British oak will continue to be affected by dieback and decline, expressed in the form of Chronic Oak Decline. There is also the strong possibility that this condition will worsen over time as drought episodes become more frequent through climate change. Scientists in the Forestry and Climate Change Centre of Forest Research are currently engaged in research investigating how the behaviour of some root attacking organisms may alter in response to changing temperatures associated with anticipated changes in climate. Information from this project may shed some light on the nature of the relationship of these pathogens with oak and how this may change in the future.

However, the current episode of the bacteria-mediated Acute Oak Decline has the potential to pose a very serious threat to native oaks. At present the evidence points to a growing problem whilst the number of affected sites continues to increase, and high levels of tree mortality are already apparent in some locations. The most immediate needs are to establish the identity of the bacteria associated with diseased trees and to confirm its causal role. But also necessary is an

understanding of how AOD spreads, how frequently infection ends in tree mortality, and the best practice for dealing with affected trees and sites. Much of this understanding rests on determining the current distribution of the disease in Britain, but also on the spatial aspects of diseased trees and associated factors, especially insects. Moreover, that the two forms of decline are not mutually exclusive, trees with existing Chronic Oak Decline could become infected with AOD and their death hastened under these circumstances, also requires investigation.

In the past Britain's mighty oak has survived and adapted in response to pest and disease attack. However, the increasing numbers of new pests arriving in Britain (the most recent example is oak processionary moth, *Thaumetopoea processionea*) coupled with climate change place even more demands on this iconic tree. Work by FR is committed to safeguarding the future of oak in Britain.

For more information about AOD and the work of Forest Research on this disorder see: www.forestry.gov.uk/website/forestresearch.nsf/ByUnique/INFD-7B3BZU.

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Sandra Denman* is a senior pathologist at Forest Research leading the research on diseases of oak.

Joan Webber is the principal pathologist at Forest Research leading research on Phytopthora.

Forest Research, Alice Holt Lodge, Farnham Surrey GU10 4LH.

* Contact author.
sandra.denman@forestry.gsi.gov.uk