Pests and diseases threatening urban trees under a changing climate

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Summary

The predicted change in our climate is likely to inflict particular stresses on the trees and other plants constituting urban and peri-urban greening schemes, and this may increase their susceptibility to certain pests and diseases. This review highlights the various ways in which climate change may affect the health of urban trees in Britain. In summary, climate change may alter patterns of disturbance from pathogens and herbivorous insects through physiological changes in the host plant. The expected changes in temperature and moisture availability will also directly affect the development and survival of the pests and pathogens, and their natural enemies, competitors and vectors. This may alter the impact of native pests and diseases and increase the populations of some species not currently recognized as pests to epidemic proportions. Perhaps most significantly, climate change is very likely to enhance the suitability of our climate for a range of non-native pests and pathogens, many of which are brought in unknowingly on infected planting stock sourced for new greening schemes. The global trade in ‘plants for planting’ is a recognized pathway for the accidental introduction of pests and pathogens even though plant health legislation exists to minimize such accidental introductions. The limitations of the procedures currently in place are discussed.

Introduction

Over the past decade, there has been a huge emphasis on increasing the greening of Britain’s towns and cities, supported by, among others, CABE Space’s Sustainable Cities programme (e.g. Brown, 2009), the London Mayor and various government initiatives such as ‘Cleaner, Safer, Greener’ (ODPM, 2002). Urban greenspace undoubtedly brings many benefits: enhancing the urban landscape, increasing people’s feelings of well-being (Kuo, 2001, 2003), reducing crime (Kuo and Sullivan, 2001) and providing a multitude of ecosystem services (McPherson et al., 1994; Costanza et al., 1997). The latter include diminishing so-called ‘Heat Island’ effects (Heisler et al., 1994), reduced levels of energy consumption (McPherson, 1994), alleviation of flooding events (Bolund and Hunhammar, 1999) and reductions in levels of airborne particulates and other pollutants (Nowak, 1994; Freer-Smith et al., 2004; Escobedo et al., 2008).

It is becoming increasingly apparent that new and existing plantings will need careful maintenance in the years to come given the predicted change in global climate. This change is almost certainly the result of human activities, namely the production of ‘greenhouse gases’, particularly carbon dioxide that has risen from a concentration of ~270 parts million~\(^{-3}\), prior to industrialization, to the current value of 387 p.p.m. (National Oceanic and Atmospheric Administration mean, January to October 2009). The evidence for a recent change in the UK’s climate is compelling; the Central England Temperature record shows an increase of ~1°C since the 1970s. It is difficult to predict future changes however, as this depends largely on human society, how its behaviour will alter, and the efficacy of measures currently being put in place to mitigate climate change. The UK Climate Impacts Projections (UKCIP) 2009 (Murphy et al., 2009) illustrate both ‘Low’ and ‘High’ emissions scenarios illustrating firstly what would happen given rapid uptake of new technology and adoption of sustainable policies or alternatively an ongoing heavy reliance on fossil fuels (Jenkins et al., 2009). In brief, it is expected that, over the coming century, the climate will become milder and wetter in the winter and significantly hotter and drier during the summer months. These changes in our climate are predicted to be larger and more rapid than any since the last ice age, posing real problems for society as well as our trees and woodland.

Researchers have generated predictions of how our forest tree species might react to predicted climate change (e.g. Broadmeadow and Ray, 2005; Broadmeadow et al., 2009), but urban plantings present something of an unknown. This is partly because the species used in amenity landscapes can be largely non-native in origin but also because the changes in climate are likely to be felt first in such urban environments, and changes may be both more rapid and relatively more extreme than in the countryside. This paper discusses how climate change has the potential to affect trees within our cities and change radically the nature,
How will climate change affect pests and diseases within urban plantings?

Climatic change may alter patterns of disturbance from pathogens and herbivorous insects through

- physiological changes in the host plant,
- direct effects on the development and survival of the pests and pathogens,
- indirectly through impacts on natural enemies, competitors and vectors, and
- enhancing the suitability of our climate for non-native pests and pathogens.

Because of their generally short life cycles, great reproductive potential, sensitivity to changes in temperature and, in many cases, great capacity for dispersal, even moderate changes in climate could have significant rapid impacts on the distribution and abundance of many pests and pathogens. Trees, in comparison, are very long lived and will only be able to adapt much more slowly to changes in their local environment. Potentially, this makes them more vulnerable to the rapidly moving and changing organisms around them, even though native pests and tree hosts will have co-evolved over millennia.

Impacts on pests through physiological changes in the host plant

Tree physiology and condition are closely correlated with the immediate environment and therefore is linked to climate effects in that environment. Climate change is likely to alter the type and frequency of abiotic disturbance such as waterlogging/flooding and storms, both of which can inflict physical damage on trees. Periods of drought will become more common, especially in the south and east of Great Britain (Murphy et al., 2009). The effects of such predicted changes on trees vary between species but include advances in bud burst (an advance of at least 2 weeks since the 1950s), increased risk of frost damage to young leaf tissue (as there has been no corresponding change in late spring frosts) and, in some species, insufficient periods of cold over the winter to allow bud vernalization and breaking of seed dormancy (Broadmeadow and Ray, 2005).

Surveys of forest tree condition in Britain illustrate correlations between drought years and tree crown defoliation (Hendry et al., 2005) as drought, combined with high temperature induces stress in trees and thereby predisposes them to attacks by pests and pathogens. Such stresses are likely to be most intensely felt by street trees because of the ‘Heat Island Effect’ and also because urban trees are often planted in suboptimal conditions with little area for root expansion and frequent root disturbance from utilities operations. This stress is often found to increase susceptibility to insect pests (Foggo et al., 1994; Koricheva et al., 1998), although evidence is more limited, or at least variable, when it comes to pathogens. It appears, for example, that certain groups like canker/dieback pathogens are more likely to be positively associated with host stress, particularly drought stress, than some foliar pathogens (Desprez-Loustau et al., 2006).

Changes in the plants’ environment have the capacity to alter their palatability to pests, as they can change the way in which plants allocate available resources to growth or defence (Herms and Mattson, 1992). For example, increased CO₂ levels can make plants more palatable to some pest species through changes (increases) in soluble carbohydrates within phloem tissue (Broadmeadow and Jackson, 2000). This, therefore, has the potential to increase the pest profile of many sap-sucking organisms such as aphids in the near future. However, not all changes are favourable to herbivorous organisms as, in some plants, an increase in available carbon results in greater diversion of resources towards production of secondary metabolites (Penuelas et al., 1997), some of which have a deleterious impact on pests (Herms and Mattson, 1992).

One particularly interesting effect of climate change is its potential for turning usually harmless species into damaging organisms, through effects on the host plant physiology. Biscogniauxia species are often considered to be harmless endophytic fungi but are also described as ‘latent invaders’, as some species can be very damaging given the right conditions (Nugent et al., 2005). Biscogniauxia mediterranea (De Not.) Kuntze causes charcoal disease on drought-stressed oaks (Quercus spp.) and is predicted to advance north and westwards out of the Mediterranean region towards the end of this century (Desprez-Loustau et al., 2007). Recent observations of infection on Turkey oaks (Quercus cerris L.) in Slovenia indicate that this range expansion is already happening (Jurc and Ogris, 2005). In Great Britain, Biscogniauxia nummularia (Bull.) O. Kuntze causes strip cankers on beech (Fagus sylvatica L.) following periods of summer drought (Hendry et al., 1998) and so could become a much more common problem on amenity and woodland plantings in the future. Honey fungus (Armillaria spp.) causes decay, decline and mortality of many woody and some herbaceous plants. The main causal agent of disease, Armillaria mellea (Vahl) P. Kumm, is a well-known pathogen within the horticultural and forestry industries, but the genus is likely to increase in significance in the coming years as two other species, Armillaria gallica Marxmüller and Romagnesi and Armillaria cepistipes Velkonovsky (usually considered to be weak pathogens) can cause significant disease on drought-stressed trees of many species (Desprez-Loustau et al., 2006). Similarly, Cryptostroma corticale (Ell. & Ev.) Gregory &. Waller, the causal agent of sooty bark disease, only causes bark death and dieback on sycamore (Acer pseudoplatanus L.) suffering from drought stress or during prolonged periods of high temperatures (Young, 1978). Sphaeropsis sapinea, (Fr.) Dykkø & Sutton that causes a disease known as Sphaeropsis or Diplodia blight on many species of pine (Pinus) worldwide, is commonly found in shoots and cones as an asymptomatic infection, but drought stress predisposes
the trees to development of the disease (Paoletti et al., 2001). This disease has been more frequently reported on Austrian (Pinus nigra (Hoess) Badoux) and Scots pine (Pinus sylvestris L.) in the south of Great Britain in recent years (Brown and MacAskill, 2005). If our climate follows the projections outlined under the UKCIP high emission scenario (Murphy et al., 2009), all the above pathogens are likely to become much more of a problem within amenity plantings as many trees are likely to be subject to drought stress.

Direct effects of climate change on pests and pathogens
Climate change will of course have significant direct effects on pest and pathogen behaviour and population dynamics. It therefore has the capacity to affect the severity and timing of outbreaks and change the distribution and range of many species.

Many pests will be able to extend their current geographical range as increases in temperature tend to affect flight behaviour and increase feeding. Therefore, the impact of many pests could increase on amenity plantings across the country. A possible consequence may be range expansion of, among others, the oak pinhole borer Platypus cylindrus Fabricus, a bark beetle associated with acute oak decline (Denman and Webber, 2009; Denman et al., in press) and two non-native defoliating moths, the oak processiory moth (Thaumetopusa processionea L.) and the gypsy moth (Lymantria dispar L.).

The predicted climate changes are likely to increase developmental rates and reduce winter mortality for many insects, leading to multi-voltinism in some species. The increased number of generations will also enable pests to evolve and adapt muc much more effectively to climatic change than their tree hosts, through enhanced dispersal as well as phenotypic and genotypic plasticity. Native pests may become more damaging and problematic, but such changes may also increase the significance and profile of native species not currently perceived as pests. Many aphids for example will be able to undergo multiple generations throughout the year and even remain active during the winter. Currently, some pests, for example the cypress aphid (Cinara cupressi (Buckton)), already cause major damage to conifer hedging, and others, particularly agriculturally significant pests such as the peach – potato aphid (Myzus persicae Sulzer), have the potential to vector viruses. However, the simple cosmetic damage and honey dew deposited by many relatively innocuous aphid species may also become more extensive, significantly reducing the amenity value of street trees planted largely for their appearance.

There is perhaps a higher level of uncertainty associated with the profile of fungal pathogens. Pathogens will also be directly affected by changes in temperature, rainfall and moisture availability, but as fungi exhibit pleomorphy, i.e. they can exist in two or more distinct forms during their life cycle, it can be very difficult to predict exactly how individual species might react. The complicated life cycle of macrocyclic rusts is a particularly good example as they have the capacity to produce many different spore types (basidiospores, aceciospores, uredinospores and teliospores) each with differing optimal requirements for temperature and moisture availability. This makes it extremely difficult to predict what effect climate change might have. CLIMEX modelling, a climate matching system (Sutherst and Maywald, 1985), can be used to balance conflicting requirements and generate predicted range expansion or pest establishment. A recent model has illustrated that warmer winters across Europe will probably favour the spread of one of the world’s most destructive plant pathogens, Phytophthora cinnamomi Rands, which is currently limited by its low tolerance to frost. This pathogen causes root necrosis leading to tree decline on chestnut (Castanea sativa Mill.) and, more recently, has been found to cause bleeding trunk cankers on oaks (Brazier et al., 1993). Both diseases are called ‘ink disease’. The CLIMEX model suggests that the root disease, being more physically ‘protected’ from climatic extremes, may be able to increase its range further than the stem disease (Desprez-Loustau et al., 2007). Our own climate will probably continue to restrict the spread of this pathogen, although it certainly has the potential to cause devastating disease on many woody species along the western coast of Great Britain in the future (Brazier and Scott, 1994; Brazier, 1996).

If one can generalize, reviews of climate change and pathogen behaviour seem to indicate that canker/dieback pathogens are likely to be favoured by the predicted changes (e.g. Botryosphaera, Sphaeropsis, Cytospora and Biscogniauxia spp.; Desprez-Loustau et al., 2006), probably through impacts on the host, as described above. It is less certain how foliar and some root pathogens might behave. Foliar pathogens are directly exposed to fluctuations in air temperature and humidity and ultra violet radiation and this may make them more immediately responsive to climate change than many other pathogens. Most fungi require free water at some point for spore germination and dispersal, and so those diseases needing repeated cycles of infection, such as rusts, would be hampered by prolonged periods of drought. In contrast, given the wetter periods in the spring forecasted in western parts of the country, the impact and frequency of many other foliar pathogens such as Venturia spp. (causing blackening and death of leaves and shoots on willows and poplar, resulting in scab) and several bacterial diseases may increase. The bacterium Erwinia amylovora (Burr.) Winsl. et al., for example, affects many Rosaceae spp. used in amenity plantings, causing fireblight, blossom wilt, cankers and even tree death in very susceptible species such as Sorbus. Change in annual rainfall is already known to affect the incidence of such pathogens (Tubby et al., 2006), and so sustained, anthropogenic change in our climate may cause heavy infestations of these pathogens year on year, with great potential to affect the vigour and appearance of amenity trees.

Periods of wet weather actually hamper the development of some pathogens such as the cosmically damaging powdery mildews. Spore germination of Erysiphe albitoides Griffon & Maubl., one of the pathogens implicated in the development of oak decline, is inhibited by
water (Hossain and Manners, 1964). However, subsequent development is greatly enhanced by higher temperatures and so, given sufficient rain-free periods during the spring, this pathogen has the potential to contribute greatly to the decline in health and vigour of Quercus robur L. and to a lesser extent Quercus petraea (Mattuschka) Lieblein in Britain.

Root pathogens such as Armillaria spp. and Heterobasidion annosum (Fr.) Bref. (previously Fomes annosus Fr.) have optimum temperatures for growth of ~25°C and so will generally be favoured by increases in soil temperatures. Where this is combined with an increased frequency of storm events and flooding, one may also expect a significant increase in problems due to Phytophthora spp. as the spores are largely water borne and many species (e.g. Phytophthora cactorum Lebert & Cohn, Phytophthora cambivora (Petri) Buisman and Phytophthora citricola Sawada that cause root and collar rot and bleeding cankers) have optimum growth temperatures ~22–25°C. In addition, some species of Phytophthora have the capacity to produce chlamydospores that can remain dormant for years in dry soil or other resilient spore forms such as oospores. This gives Phytophthora spp. the potential to survive prolonged droughts. Some of the newly identified species (e.g. the non-native Phytophthora kernoviae Brasier, Beales & S. A. Kirk and Phytophthora ramorum Weres, de Cock, & In’t Veld, highly significant pathogens of ornamental plants - see below) have also proved to be aerial pathogens, adapted to infect above-ground plant tissue, and so will be highly exposed and responsive to climate change.

Indirect effects of climate change via natural enemies, competitors and vectors

Pest distribution and abundance will also be indirectly affected by climate change where climate affects pest vectors, parasites and natural enemies. For example, changes in climate in Japan are thought to have resulted in a recent increase in oak mortality caused by an ambrosia fungus Raffaelea quercivora Kubono & Shin. Ito. This fungus is vectored by a bark beetle Platypus quercivorus Murayama, which has recently been able to extend its range to encompass areas planted with exotic oak species susceptible to R. quercivora (Kamata et al., 2005).

Similarly, the progression of Dutch elm disease northwards across Britain has been partially influenced by the impact of climate on vector. Elms (Ulmus) used to be common woodland trees as well as popular in amenity plantings, until the outbreak of disease in the 1960s caused by the introduction of a very aggressive new species of Ophiostoma, Ophiostoma novo-ulmi Brasier (Brasier, 1991). Until recently, the colder climate in northern and western Britain restricted progression of the disease by reducing the number of generations per year and reducing the number of days during which the bark beetle vectors, species of Scolytus, could fly and thus infect trees while feeding (Fairhurst and King, 1983). The drought years of 1975 and 1976, however, resulted in major northwards expansion, and more recently, the disease has become well established in an area around Nairn to the east of Inverness, where several hundred trees are known to be affected.

Changes in climate naturally affect all components of an ecosystem, and in many cases, this may result in some form of equilibrium between a pest and its vectors, natural enemies, competitors and parasites. It will be interesting to see, for example, whether the same climatic changes that favour the Dutch elm disease vector, and growth rates of the O. novo-ulmi pathogen, also favour a species of the fungus Phomopsis which can act as a competitor of the bark beetle vectors. Phomopsis is a common rapid invader of the bark of newly dying Wych elm (Ulmus glabra Huds.), competing for resources with the elm bark beetles that normally breed in the bark. Phomopsis has been quite significant so far in exerting a strong natural biological control of the beetle populations in the north and west of Britain (Webber, 1981). This example illustrates the potential difficulty in predicting how external factors might influence pest behaviour.

Climate change and increased threats from non-native pests and pathogens

The discussion above predominantly illustrates how some native British pests and pathogens might react to changing climate. One of the most significant threats to our trees, however, is the potential invasion of exotic pests and pathogens from Europe and even further afield. In the past, Great Britain has been fortunate in not having many of the major pests and pathogens that are prevalent on the European mainland, as the sea formed a significant barrier to natural colonization. Recent increases in the global trade of goods including live plants and plant products (e.g. timber- and wood-based packaging material), however, have opened up new pathways for the movement of non-native flora and fauna. It is likely that climate change may enable a growing number of non-native pests and pathogens to become established in Great Britain.

While all trees and woodland in Britain are at risk, especially if they have no co-evolved resistance against the invasive organism, it is frequently the urban landscape that is the first point of contact with exotic pests. Such organisms can, for example, passively ‘hitchhike’ on vehicles, goods (plant related and otherwise) and people. Centralized incentives to increase and enhance the linkage between areas of greenspace in urban areas, large new schemes like the 2012 London Olympic Games-related developments and recent public interest in gardening/landscaping connected to activity in the housing market all combine to increase this risk.

Many pest and disease problems can be related to the type and quality of actual planting stock used in greening programmes. Low-risk options include the use of native species or local propagation of exotics from imported meristem cultures or seeds. However, an increasing proportion of plant material is grown abroad and then imported as living material or what is commonly termed, ‘plants for planting’, greatly increasing the likelihood of introducing pests and pathogens. Indeed, a lot of plant material
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originates from Asian countries and is then imported into the European Union via Holland or Italy and exported from those countries to Great Britain and to other EU Member States. Once the plants have entered the open trading zone of the EU, there is little or no further control or inspection for potentially damaging organisms, except those that are specifically regulated. Many growers employ the use of fungistatic compounds during propagation and, as these can mask disease symptoms temporarily, many pathogens can be inadvertently imported on such ‘Trojan horse’ plants. Other pathogens are brought in on carrier hosts that are non-susceptible but then are able to disseminate onto more susceptible hosts. There is also increasing potential for the development of novel pest or patho-systems, i.e. encounters between pests or pathogens and naive hosts with no co-evolved history. The problem with this scenario is that it is usually impossible to predict which associations will occur and which will present problems in the future.

Those responsible for implementing urban greening schemes are increasingly sourcing exotic species, for example drought-tolerant plants such as the Canary island date palm (*Phoenix canariensis* hort. ex Chabaud), olive (*Olea europaea* L.) and holm oak (*Quercus ilex* L.). Although modifying species choice to accommodate climate change is sensible in many respects, such trees are increasingly being brought in as specimen plants, designed to have maximum and immediate impact. Such large exotic plants also happen to present a large potential surface area available for exotic pests. This is especially significant in plants with intact root balls and associated soil medium as these are very difficult to inspect and, especially in light of recent restrictions on the use of methyl bromide, difficult to sterilize before importation. Key soil-borne root-infecting pathogens include many species of *Phytophthora*. The now worldwide *P. cinnamomi* is capable of long distance dispersal in contaminated soil. It is the cause of Jarrah Forest Dieback in Western Australia and now, as a result of repeated droughts throughout the 1980s, is implicated in the serious oak decline being seen in Spain, Portugal and other Mediterranean countries (Brasier, 1996). *P. cinnamomi* was first introduced into Europe in the nineteenth century and caused a major epidemic on chestnut (*Castanea sativa* Mill.) in the US in the early 1900s and in southern Europe in the 1940s. Chestnut and oak species are also susceptible to *Cryphonectria parasitica* (Murrill) Barr that causes chestnut blight and can be transmitted on infected plants, wood and bark. This pathogen was introduced into North America at the end of the nineteenth century and has gone on to devastate the main chestnut-growing areas. It was introduced into southern Europe (Italy) in 1938 and quickly established, spreading northwards. CLIMEX modelling suggests that it is favoured by increased spring precipitation and warmer, drier summers (Desprez-Loustau et al., 2007) and so climate change is likely to make many parts of northern France and southern Britain much more hospitable.

Over the past decade, several new pests and diseases have been found in Britain, and some have established with serious economic consequences. The discovery of the non-native *P. ramorum* and *P. kernoviae* in a wide range of shrubs and trees in Britain are two examples illustrating how infection of ornamental plants within the urban and horticultural world can act as a conduit to the wider rural environment, where mature trees have more recently succumbed to infection. *Phytophthora ilicis* Buddenhagen & Young is another introduced *Phytophthora*, highly specific to holly (*Ilex aquifolium* L.) on which it causes serious foliage blight. In contrast to many other *Phytophthora* species, it has a lower temperature requirement for growth and a warming climate might mean a decline in infections in the south of the country, but an expansion of its range northwards.

Horse chestnut (*Aesculus hippocastanum* L.) is a valuable ornamental tree widely used in amenity planting but has recently suffered a number of pest and disease problems. A new species of *Pseudomonas*, *Pseudomonas syringae* pv *aesculi* (ex Durgapal & Singh) Young, Bradbury et al. (Webber et al., 2008), has recently had a very high profile as the cause of bleeding canker on horse chestnuts. Very little is yet known of its environmental requirements, although its very rapid movement across Britain has probably been aided by a recent series of milder wetter winters. In addition, the horse chestnut leaf miner (*Cameraria ohridella* Deschka & Dimic) is a non-native insect pest causing unsightly foliar damage and premature defoliation and is now widely reported across Britain (Straw and Bellett-Travers, 2004). First described in Macedonia in 1985, the leaf miner was detected in Great Britain in 2002 in Wimbledon and has spread rapidly over the last 4 years. Indeed, horse chestnut is currently suffering from several other introduced pests. These include a new mildew species, *Uncinula flexuosa* Peck (Ing and Spooner, 2002) which has so far failed to have a significant impact, although it is possible that it has simply been overlooked in the face of the more obvious leaf discolouration cause by the leaf miner and the cosmically damaging fungus *Guignardia aesculi* (Peck) V. B. Stewart. The latter was first found in Britain in 1935 and is thought to have been introduced from the US.

The oak processionary moth (*Thaumetopoea processionea*), originating from southern Europe, was found in several locations across London in 2006. This species is a major defoliator of oak (*Quercus robur*, *Q. petraea* and *Q. cerris* among other broadleaf species) and, perhaps more significantly, the larvae possess irritating hairs and can cause adverse reactions in people following contact. The citrus and Asian longhorn beetles (*Anoplophora chinensis* Forster and *Anoplophora glabripennis* Motschulsky, respectively) continue to be intercepted throughout the British mainland, although they are not yet thought to have established. Both species can be extremely damaging to a range of broadleaf trees and shrubs, and the US is currently running expensive mass eradication programmes in New York, Massachusetts and New Jersey following the introduction of Asian longhorn beetle from its origin in Northeast Asia on infested wood pallets and other wood packing material.

Other relatively recent interceptions include southern European cicadas in Tunbridge Wells and plane lace bugs (*Corythucha ciliata* (Say)) damaging plane trees...
(Platanus spp.) in Bedfordshire. This North American heteropteran has been spreading on plane species throughout southern and central Europe since 1964 and leads to cosmetically significant leaf damage, chlorosis and defoliation, while severe infestations have resulted in tree death. Like C. obridella, this insect is so light it can easily be distributed long distances in air currents and has the potential to cause devastating damage in cities like London which have heavy reliance on planes as street trees.

Non-native plant species, often dispersed from gardens, can cause significant problems as well as insect pests, fungal and bacterial pathogens. A notable example is Japanese knotweed (Fallopia japonica (Houtt.) Ronse Decraene which was introduced as an ornamental plant in the early nineteenth century and is now causing major problems through rapid invasion of habitats, exclusion of other plants, eroding river banks and damaging buildings. It has no natural enemies in Britain, although CABI scientists are investigating the potential efficacy of a species of psyllid, Aphiathara itadori Shinji (Shaw et al., 2009). Its release is planned under experimental conditions during 2010. Eradication by traditional means is difficult and involves repeated treatment with herbicide, physical removal of plants, monitoring and further treatment to ensure it does not grow back. Giant hogweed (Heracleum mantegazzianum Sommier & Levier) is another invasive weed whose sap can cause third degree burns when affected skin is exposed to sunlight. Imported in the late 1800s, it is a huge plant, reaching up to 4 or 5 m. It is an offence to plant or disseminate either species in the wild under the UK Wildlife & Countryside Act 1981 and The Environmental Protection Act 1990 also places a ‘Duty of Care’ on anyone disposing of soil or other material contaminated with Japanese Knotweed or Giant Hogweed as it automatically become a controlled waste which can only be taken to licensed landfill sites.

More recently, Australian swamp stonecrop or New Zealand pignyweed (Crassula helmsii (Kirk) Cockayne) escaped from gardens in the 1920s and grows in dense stands choking waterways, costing the British economy £3 million year−1 (Leach and Dawson, 1999). Other invasive non-native species include floating pennywort (Hydrocotyle ranunculoides L. Fil.) and Himalayan balsam (Impatiens glandulifera Royle). It could be argued that Rhododendron ponticum L. is another example of an invasive weed although its flowers and evergreen foliage are appreciated by many. R. ponticum was found growing wild outside gardens some time after its introduction from southern Europe in the 1700s and now colonises mild moist habitats with acidic soils throughout Britain. An issue that has recently come to light is its capacity to act as a host for P. ramorum (the cause of Sudden Oak Death in California), so forming a pool of inoculum which has the potential to threaten Britain’s native trees. However, it probably poses much less risk to urban trees than many other introduced Phytophthora species. A more relevant example of an introduced Phytophthora species is probably Phytophthora alni Brasier et al. which attacks commonly planted alder species such as Alnus incana L. and Alnus cordata Desf. (Gibbs et al., 2003).

None of the above plant, insect, fungal and bacterial species is native to Britain and in total, invasive non-native species are thought to cost the British economy £2 billion year−1 (Joan Ruddock, Minister for Climate Change and Biodiversity, 2009). The list of intercepted and, more significantly, newly established pests and pathogens grows each year and is extending in parallel with the expansion in global trade.

**Biosecurity legislation and its limitations**

Global plant health legislation (1951 International Plant Protection Convention and the World Trade Organisation’s Sanitary and Phytosanitary Standards Agreement) exists to ensure that traded plants are pest free. Despite this, the global trade in plants is a recognized pathway for the accidental introduction of pests and pathogens. Member States are required to have phytosanitary measures based on an assessment of risk to plant health, most commonly by producing a so-called pest risk analysis (PRA). This would ideally be drawn up when a particular pathway is identified as a potential pest hazard or following a change in phytosanitary policy. However, the PRA is most commonly a reactive document drawn up following the discovery of a severe disease/pest problem elsewhere. The system has a number of weaknesses in that it is usually limited to recognized named taxa, and it also assumes that the new threat is homogeneous and genetically stable, which may not be the case (Webber, 2010). It takes no account of the potential for organisms such as C. parasiatica that are non-damaging in their native Far Eastern habitat (e.g. Qin et al., 1999) to cause serious damage on new hosts in new areas such as the USA and, more recently, Europe. There is no capacity to recognize newly discovered pathogens or pathogen hybrids – an increasing risk where plants and their associated pathogens are brought together in large European nurseries (Webber and Brasier, 2005). Overall, the lack of forward planning for such potential new threats (Brasier, 2008) presents a major biosecurity problem.

Implementation of these international regulations also depends on the state of knowledge, and the differing economic policies between Member States and, for it to be workable, biosecurity legislation have to be tailored to suit those States with the least experience. Detection of pests on imported material still relies heavily on visual inspection for known pests, something that is becoming increasingly difficult given the sheer quantity of imported plants. There are no financial incentives to encourage effective surveillance and no penalties to punish poor implementation of controls. An importer must rely largely on the thoroughness of an exporter in establishing that the plants are free from disease (Brasier, 2008). In addition, once plants are established in their new positions, there is very little subsequent assessment for any developing biosecurity threats. Because of the limitations of the PRA system as it stands, in addition simply to raising the profile of such biosecurity threats across the industry and among legislators, it is hoped that there will soon be a move towards regulating the actual pathways.
(e.g. plants for planting and wood packaging material) by which organisms can disseminate (Webber, 2010).

On the positive side, awareness of plant biosecurity in Britain does seem to be increasing. Many involved in trading non-native plants have taken the decision to stop selling those that are potentially invasive and are actively promoting good practice in their industry and among clients. The Government’s recently launched ‘Be Plant Wise’, campaign should also help raise awareness of the deleterious impact on the local ecosystem of dumping invasive pond plants in the wild. Customers are also becoming increasingly aware of the further implications of using imported stock and, it is hoped, will react favourably to initiatives such as The Royal Botanic Gardens at Kew’s recent proposal to install foot and mouth disease-style dips for visitors to prevent the spread of P. ramorum from contaminated footwear.

Despite such legislative procedures and voluntary measures, our ability to identify and manage problems as they emerge within Britain’s urban environment is greatly hampered by an unclear policy remit and lead on urban trees within Government departments. Although several agencies have a partial remit to tackle urban trees and imported plants, there is currently no central policy lead. Local authorities in particular have a keen interest in urban trees and retain management responsibility through a network of Tree Officers, but they have no remit beyond their boundaries and are unable to take an overview. There are also some rather arbitrary demarcation lines between bodies: the Department of Environment, Farming and Rural Affairs has Plant Health responsibility for nursery trees and imported planting stock, while the Forestry Commission has similar responsibility for forest trees once they are planted. The lead responsibility for urban trees is less clear. Moreover, as budgets are stretched in other directions, there is continuing pressure to withdraw resources from the peripheral area of urban trees if covered to some extent by others.

Conclusions

Urban trees are likely to increase in importance to society as their value in enhancing people’s sense of well-being as well as the direct economic impacts felt through the provision of shade and shelter are increasingly recognized. However, climate change is likely to lead to increased physiological stress in trees growing within urban areas that, in turn, will predispose trees to attack from a range of pests and pathogens. Climate change will also present physiological stress in trees growing within urban areas. Climate change will also present physiological stress in trees growing within urban areas. Climate change will also present physiological stress in trees growing within urban areas.

Given these scenarios, early detection of emerging threats is vital. In many ways, urban greenspace represents an extended form of ‘Sentinel Planting’ (Fagan et al., 2008) where many organisms with the capacity to devastate sections of our environment will be most likely to have a visible impact and therefore be picked up during the initial stages of establishment. This is highly significant as early detection offers the only realistic prospect of eradication of pioneer populations. What is needed now is an appropriate infrastructure within which representative stakeholders concerned with the health of trees are able to interpret and influence EU plant health legislation and initiate horizon scanning and contingency planning to deal with any introductions. At a more local level, increased monitoring and knowledge transfer between plant health specialists, the arboriculture and horticulture trade, local authorities and the wider public is needed, with raised awareness of the risks posed by introduced pests and how the risks can be countered by changes in behaviour.

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Conflict of Interest Statement

None declared.

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