Climate change and tree health

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The presentation will assume a classic UKCIP scenario for climate change in the UK (*ca* 3°C warming in 50–80 years; warmer winters/summers; increased winter rain and summer drought; perturbations) and will concentrate primarily on pathogen and pest issues rather than abiotic stress issues.

At a simple level, climate change will have a direct effect on three factors: pathogen* activity, host activity and the host x pathogen interaction. Of these, the first two are easier to predict (or model); at least in theory, assuming that host or pathogen's responses to temperature, moisture, and radiation are already well documented. In practice, available data on a pathogen's response to these variables are often too limited to model potential climate change effects. Also, little is known about the potential for pests or pathogens to adapt to climate change. Predicting the effect of climate change on the host x pathogen interaction is the most difficult because this tends to be a highly complex dynamic. Climate change will also affect the health of the local ecosystem. Since this is the context within which the above host x pathogen interactions will occur, it is another important factor, but may be too complex to model effectively.

The relative impact of climate change is likely to be different for native versus introduced host and pathogen systems. Systems involving native hosts and native pathogens - co-evolved systems - are likely to be better ecologically buffered and therefore more intrinsically stable under climatic pressure. With an introduced plantation tree and a native pathogen, the host-pathogen system is not co-evolved and the host is out of its natural ecological context. Therefore, such systems may be potentially more unstable under climatic pressure. With a native or introduced host and an invasive (i.e. non-native) pathogen, both host and pathogen are already out of their natural evolutionary balance. The host and pathogen may also be out of their natural ecological context: e.g. natural enemies of the pathogen may be absent. Since such systems are already those most likely to lead to epidemic development (c.f. Dutch elm disease, 'sudden oak death', and Asian longhorn beetle), they may well be the most unstable under climatic pressure. Furthermore, as the frequency of invasion by non-native pests and pathogens appears to be increasing, we are likely to see interactions between two major environmental issues: climate change and invasive pests and pathogens. This could well compound the risk to our forests and natural ecosystems.

Owing to the complexity of the underlying processes and the paucity of good predictive scientific data, existing literature reviews on climate change and tree health inevitably tend to deal in generalities while stressing the uncertainties. A wide range of general points are usually made, for which there is probably a good consensus e.g.: less winter cold injury but more autumn frost injury; increased drought stress and therefore increased mortality from root pathogens (notably *Phytophthora* species) and increased attack by opportunistic pests and pathogens; wetter springs leading to an increase in foliage diseases (e.g. red band needle blight); warmer winters leading to greater survival of insect herbivores (e.g. green spruce aphid); the extension of latitudinal ranges of warm-temperature requiring pests and pathogens; alteration of the balance between pests and natural enemies; emergence of new invasives, yielding new epidemics.

A specific case study - modelling the potential impact of climate change on the activity of the globally highly destructive invasive root pathogen, *Phytophthor*a *cinnamomi*, using the CLIMEX programme, will be presented. This predicts (1) a marked increase in likely activity of *P. cinnamomi* in the UK; and more widespread activity in much of coastal Europe. (2) Globally, a marked increase in its activity in temperate zones of the northern and southern hemispheres and a reduction in activity across the tropics and sub-tropics. It is likely that the activity of many invasive tree-infecting Phytophthoras will increase with climate change. Already they are implicated in the current widespread beech and oak decline in Europe and responsible for the current death of alders along UK rivers. The zones of predicted increase in activity of *P. cinnamomi* in the UK may also be indicative of potential areas of increase in activity of the 'sudden oak death' fungus, *P. ramorum*.

General conclusions:

(1) Climate change is likely to be broadly detrimental to tree health and favour some highly damaging pathogens.

(2) Host x pathogen systems involving non-native hosts and invasive pathogens are likely to be at highest risk, a further argument for more effective controls to prevent the arrival of invasive pathogens.

(3) There is a case for planting native trees and encouraging native ecosystems, assuming these are better ecologically buffered and may have a wider gene pool for host adaptation.

* For pathogen, read pest or pathogen