Climate Change: Impacts on UK Forests*

Mark Broadmeadow

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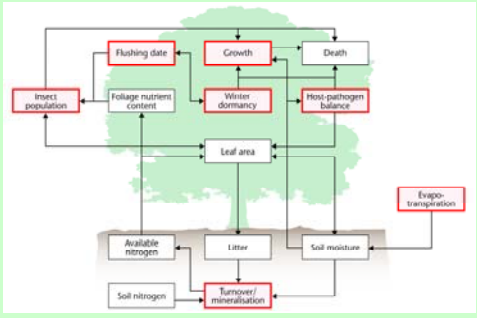
The forestry sector and climate change

By its very nature, forestry is a long term industry, and the consequences of management decisions made now may only become apparent in fifty years time. It is therefore essential that where there is compelling evidence that forestry needs to adapt, those actions are implemented now. The difficult task is to balance taking proactive decisions now with an uncertain future ahead with the potential for acting too late, but being more certain of the effects of, and necessity for those actions.

Although it is important to provide advice, and for the forestry industry to act upon it, accurate predictions of the impacts of climate change are difficult to make - even if the climate change scenarios are borne out. Although we can make predictions as to the likely impacts of climate change on the growth *potential* of individual tree species (see section on ESC), it is far more difficult to make predictions of the effects of climate change on forest ecosystems because of the number of interactions involved. In the diagram below, possible effects associated with a change in temperature are shown in red, and any of these could dramatically alter the fine balance between host tree, pathogens, insect pests, and their predators.



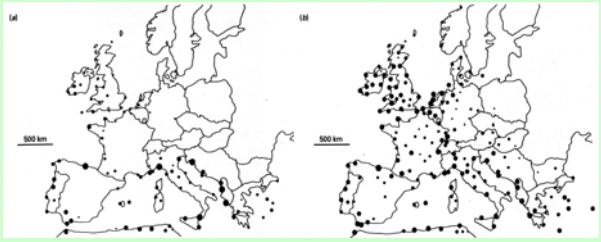
To make realistic predictions of the impacts of climate change, a sound knowledge of the impacts on each of the components within forest ecosystems is needed. Climate change impacts on disease-causing micro-organisms, insect pests and mammal species are described in the following section. The implications of changes to each of the main climate drivers of forest growth and condition are then discussed.

Impacts on pathogens

Warmer summers may favour certain thermophilic rust fungi on poplar, which are currently rare or non-native in Britain; this has important implications for poplar breeding programmes.

Insect vectors of pathogens such as the fungi causing Dutch elm disease are likely to respond to warmer summers by extending their geographic ranges and hence the ranges of disease incidence.

The effects of higher temperatures and wetter conditions have been modelled for *Phytophthora cinnamomi*, an aggressive introduced fungus which causes root and stem-base diseases of oaks, chestnuts and many other tree species. An increase in activity of this fungus across coastal areas of the UK and Europe is predicted.

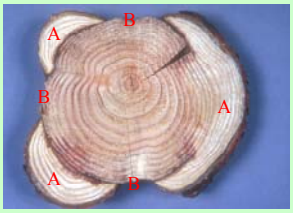


Modelled activity of Phytophthora cinnamomi *under (a) current and (b) future (+3°C) climates.*

Warmer winters may increase the activity of some weak pathogens, such as *Phacidium coniferarum,* which are active only when the host is dormant.

An increased incidence of summer drought would probably favour diseases caused by fungi whose activity is dependent on host stress, such as sooty bark disease of sycamore (*Cryptostroma corticale*).

The protective effects of mycorrhizas against various root diseases may be altered by changes in the relative fitness of different mycorrhizal fungi under conditions of altered soil temperature or moisture regime.



Sooty bark disease of sycamore (left) and cankers (B) caused by Phacidium coniferarum *(right); (A) denotes living tissue*

Impacts on insect pests

Climate change is likely to alter the balance between insect pests, their natural enemies and their hosts.

One of the most important effects of climate change will be to alter the synchrony between host and insect pest development; the predicted rise in temperature will also generally favour insect development and winter survival, although there will be some exceptions.

The green spruce aphid is one example of an insect that is likely to benefit from the increase in winter survival, leading to more intense and frequent tree defoliation. A decline in the productivity of Sitka spruce might therefore be expected.

Modelling work suggests that under a warmer climate, exotic pests such as the southern pine beetle could establish populations in Europe, and that climatic warming could make UK forests susceptible to damage; other bark beetle species such as *Ips typographus*, which is present in some parts of Europe, but not the UK, could become a serious problem.

The planting of exotic tree species may exacerbate any climate change-driven increases in insect numbers or activity, as the natural predatory fauna may not be present to limit population growth.

The combined effects of increased global trafficking of timber and wood products, and climate change, are likely to result in other exotic pests such as Asian longhorn beetle becoming established; it is therefore essential that we remain vigilant in reporting new pests and altered patterns of damage.

*The green spruce aphid (*Elatobium abietinum*) (left), and needle death caused to a crop of loblolly pine in the USA by the southern pine beetle.*

Impacts on mammalian pests

Populations of deer and particularly squirrels are adversely affected by cool, wet weather, through increased winter mortality; climate change is thus likely to reduce winter mortality.

Increased seed production and earlier flushing of forage material as a result of climate change is likely to lead to higher fecundity and survival.

Climate change is therefore likely to result in increased population densities and ranges if appropriate control measures are not put in place.

Deer browsing on Sitka spruce

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Temperature

The likelihood of injury to trees by winter cold may be slightly lower.

It is likely that spring flushing will advance as a result of milder winters (as has already been observed), but the risk of spring frost injury is unlikely to change; unseasonal frosts will still have the potential to cause damage.

Autumn frosts may become more damaging in England because of later hardening and increases in diurnal temperature range in the south.

The planting of southern provenances in anticipation of climate change should be avoided, because of the potential for unseasonal frost damage.

'Top-dying' of Norway spruce is likely to increase in England and eastern Scotland; it could cease to be a productive species over much of England.

Increasing heat and drought in the south and east can be expected to increase losses, particularly among newly established trees and mature trees in hedgerows and urban environments. Defects in coniferous timber due to drought crack are also likely to increase in England.

Higher summer temperatures may reduce the risk of *Brunchorstia* damage to Corsican pine, enabling it to be planted more widely in the uplands.

Rainfall and water availability

Soil wetness, waterlogging and flooding are predicted to increase in winter throughout the UK; wetter soils will reduce trafficability and increase the risk of soil damage and erosion; an increased incidence of waterlogging will also reduce root survival and tree stability.

Opportunities for the restoration of floodplain woodland are likely to increase, with possible benefits of flood control.

An increased frequency and severity of summer droughts is thought likely, which would threaten tree health and survival.

An increased risk of water shortages in the south will require greater consideration to be given to the water use of trees and the need for better catchment management planning.

Atmospheric CO_2 levels

Experimental studies on young trees have shown that rising CO_2 levels increase carbon uptake; average growth increases of 50% have been reported.

Most studies have reported a reduction of 10-30% in stomatal conductance.

Significant increases in leaf area have been reported: if these are realised, implications include enhanced water use through both transpiration and rainfall interception, increased wind resistance and thus potential damage, and an altered forest floor micro-climate.

Timber quality has been affected in some studies, although the current view is that this impact is largely a result of faster growth rates.

Simulated impacts of rising CO_2 suggest General Yield Class increases of 2 (6 to 8 and 14 to 16) for oak and Sitka spruce respectively, comparing rotations approaching harvest now with new plantings.

Elevated CO_2 levels increase growth. The trees on the left were subjected to ambient levels (360 ppm), and those on the right, twice ambient (700 ppm).

Wind speed

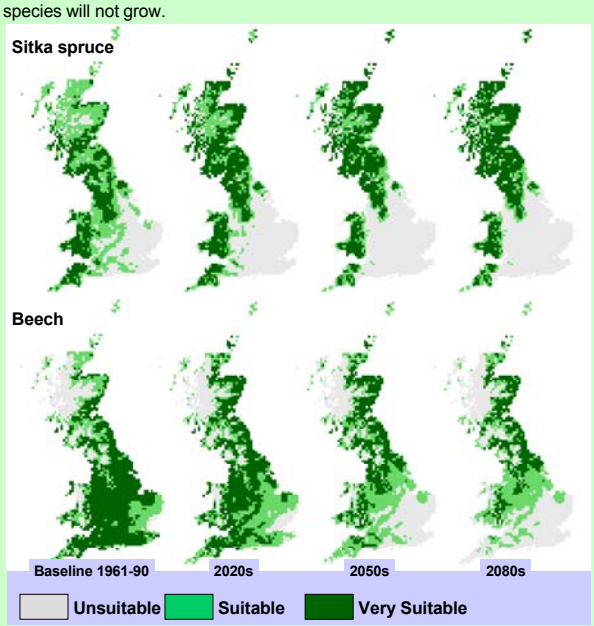
There is great uncertainty over the predictions of changes in mean wind speed or storm events.

Possible changes in the distribution of wind speed or the track of depressions would be of concern.

Forestry in the UK is already adapted to a windy climate, and woodland management tools such as ForestGales enable management decisions to be made if predictions change.

Modelling future species suitability using Ecological Site Classification

Ecological Site Classification (ESC) assesses the commercial suitability of forest tree species as a function of climatic and edaphic factors (accumulated temperature, moisture deficit, continentality, wind exposure, and two soil quality descriptors). Suitability is defined as Very Suitable, Suitable and Unsuitable if predicted yields are above 75%, between 50 and 75% and less than 50% of the maximum yield achievable in the UK, respectively. The simulations shown below represent responses to climatic change alone, based on the UKCIP98 climate scenarios. They do not account for the CO_2 fertilisation effect on growth, or the predicted reduction in stomatal conductance and thus water use as atmospheric CO_2 concentrations rise. These simulations therefore represent a worse case scenario, and moreover, where a species is predicted to be unsuitable, this is in terms of commercial returns and does not mean that the species will not grow.



ESC simulations of suitability for Sitka spruce (top) and beech (bottom) incorporating the UKCIP98 'Medium-high' climate scenarios

A summary of findings for some of the main commercial species is as follows:

Sitka spruce will become more suitable across the cooler uplands of Scotland and northern England, and also the eastern side of Scotland; the Suitable area in parts of the south west and west Midlands of England may become Unsuitable; the south west peninsula and Wales should, at least, remain Suitable.

Corsican pine will become Very Suitable up the eastern side of Scotland where it is currently Suitable, while growth rates will increase across southern England.

Douglas fir will remain, at least, Suitable across most of south and east England, and Very Suitable in the west Midlands and much of the south west and east Wales; the climate is predicted to become more suitable for Douglas fir across the whole of Scotland, but particularly in the east.

Beech is likely to become Very Suitable across much of eastern Scotland, where it is currently marginally Suitable; in England, the areas where it is currently Suitable and Very Suitable are likely to contract northwards, and in areas of southern England, beech may no longer be Suitable as a timber crop.

Conclusions

Rising CO_2 levels and a longer growing season are likely to increase forest productivity across large areas of the UK, where growth is not limited by water or nutrient supply. Changes in the activity, identity and population densities of pathogens and insect and mammal pests are more difficult to predict and may modify these predictions significantly. Commercial species suitability will change, particularly in the south east, where drought may limit species choice. In addition, the character and composition of native woodland ecosystems is also likely to change. However, it is likely that socio-economic factors will play a larger part than climate change in determining the extent to which the character of plantation forests will change.

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

Contact: *mark.broadmeadow@forestry.gsi.gov.uk*