Geo Factsheet

Number 75

Climate change and vegetation

Increasingly, human activities are influencing global climate. Between 1985 and 1994 temperatures have been about 0.2°C warmer than average compared with 1961-1990 and during the 1985-1995 decade the average global atmospheric CO_2 concentration has risen by about 5%.

The likely impacts of climate change on the UK for the 2020s are:

- temperatures are expected to increase at a rate of about 0.2°C per decade; higher rates of increase will occur in the south east, especially in summer; it will be about 0.9°C warmer than the average of 1961-1990 by the 2020s and about 1.6°C warmer by the 2050s;
- this temperature change is equivalent to about a 200 km northward shift of the UK climate, the difference in the current temperature between Oxford and Manchester;
- annual precipitation over the UK as a whole is expected to increase by about 5% by the 2020s and by nearly 10% by the 2050s; winter precipitation increases everywhere but more substantially over the southern UK;
- the contrast in the UK's climate is likely to become exaggerated, for example the currently dry south east will tend to become drier and the moist north west will get wetter. Drought in the south east and flooding in the north west will both become more common;
- sea level is expected to rise at a rate of about 5 cm per decade; this is likely to be increased in southern and eastern England by the sinking land whereas in the north it will be offset by rising land (as a result of glacial unloading);

By the 2050s average sea levels will be about 35 cm higher than 1961-1990 and the probability of storm surges will increase. By 2050 the UK will be more subject to intense rainfall events and extreme wind speeds, especially in the north. Gale frequencies will increase by about 30%.

Vegetation changes

Changing climate will change UK landscapes:

- montane plant communities may be lost.
- heaths may become subject to more frequent fires as southern Britain becomes warmer and experiences dry summers such as those in 1990 and 1995.
- wetlands may dry out more frequently with a change in species composition, especially if current water abstraction from aquifers were increased.
- coastal dunes and rocks may be invaded more rapidly by alien species such as the hottentot fig.
- salt marshes and brackish water habitats may be lost as sea level rises.
- some broadleaved woodland and dry areas of Britain may decline further in response to increased frequency of summer droughts, particularly in the south where summer droughts are forecast to be more frequent and severe.
- species confined to particular locations from which they cannot readily escape and those which are dependent on other species for pollination/food may decline.
- salt marsh vegetation may decline.

A 1°C increase in temperature may significantly alter the species composition in about half of the protected areas of the UK. A substantial number of the 506 currently endangered plant species may be lost because species-rich native communities may be invaded by competitive species and some wet, montane and coastal communities will be lost.

A 20-30 cm increase in sea level would adversely affect mud flats and some salt marshes including nature reserves that are important for birds. Climate change will occur too rapidly for species to adapt in an evolutionary sense. Mitigating measures that can be taken include the translocation and rescue of species, the provision of habitat corridors, fire control and control of eutrophication.

Fig 1. The likely effects of a changing climate in the UK

Positive effects	Negative effects
• an increase in timber yields (up to 25% by 2050s) especially the north of the UK (with perhaps some decrease in the south) • a northward shift of farming zones by about 200-300 km per degree centigrade of warming, or 50-80 km per decade, will improve some forms of agriculture especially pastoral farming in the north western part of the UK, • enhanced potential for tourism and recreation as a result of increased temperatures and reduced precipitation in the summer, especially in the southern UK .	• an increase in soil aridity, soil erosion and the shrinkage of clay soils • an increase in animal, especially insect, species as a result of northward migration from the continent and a small decrease in the number of plant species due to the loss of northern and montane (mountain types) • a decrease in crop yields in the south east of the UK • an increase in river flow in the winter and a decrease in the summer, especially in the south • an increase in public and agricultural demand for water • increased damage from storms, flooding and erosion • increased incidence of certain infectious diseases in humans and of the health effects of episodes of extreme temperature.

Impact on UK forestry

The increased frequency of warm summers and very warm years will increase destruction of lowland forest in southern areas by drought and fire but will increase productivity of upland plantations. The latter effect is because temperature rather than water is the limiting factor. Thus, warmer summers will increase the profitability of coniferous plantations in the north and uplands. However, a warmer climate will also affect timber production in the rest of Europe and it is the relative increase in yields between different countries which will determine whether UK forestry becomes more profitable.

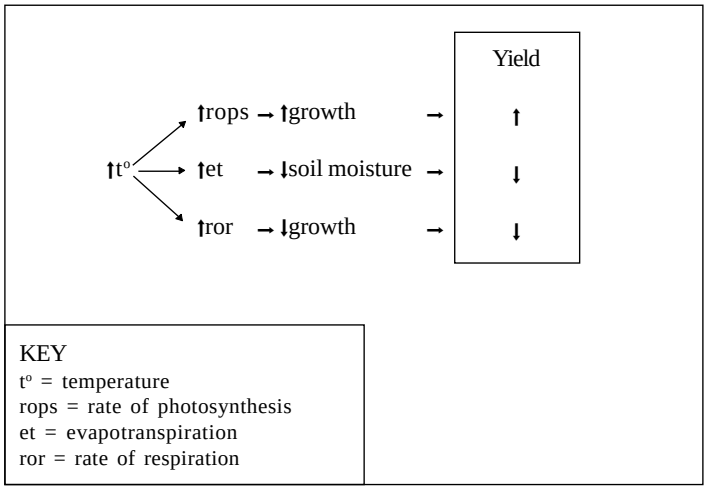
In southern Britain the risk of forest fire will increase. Most forest fires occur in the spring before the growth of new grass has covered the dead remains of the plants of the previous year. Most fires occur in young plantations. The amount and pattern of spring rainfall may therefore affect fire risk, although it should be noted that in the UK, weather is not the cause of fires (man is), but rather, weather has a catalytic effect. Decreasing spring rainfall will catalyse more fires.

Surveys of forest health conducted by the Forestry Commission (now Forest Authority) show no evidence of a long-term trend but beech trees in southern Britain deteriorated following the summer droughts of 1984 and 1990. However, drought is known to contribute to the overall harmful effect of air pollution such as acid rain and low level ozone.

UK Agriculture

It is expected that the overall effect of warmer summers on crop production will be negative - yields will fall because soil moisture will fall below critical levels and evapotranspiration will increase. However, increased temperatures affect many aspects of biological production and the net effect is difficult to predict (Fig 2).

Fig 2. Climate change and agricultural productivity

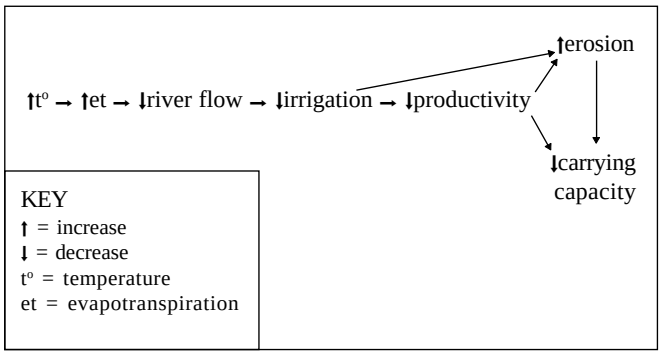


Increased carbon dioxide leads to an increased efficiency of water use by plants. If carbon dioxide concentration doubles, the amount of water used by plants to fix carbon dioxide decreases by 30%. Furthermore, the way plants use carbon to build their tissues also changes when carbon dioxide concentration changes. Some species use more of the carbon to grow their roots - which would be useful in root crops like carrots - but others use more to build their stems or leaves etc. The overall effect on crop growth is difficult to predict.

Case Study - Africa

The major impact of climate changes on agriculture in Africa would be a consequence of changing temperature and availability of soil water (Fig 3).

Fig 3. Climate change and African agriculture



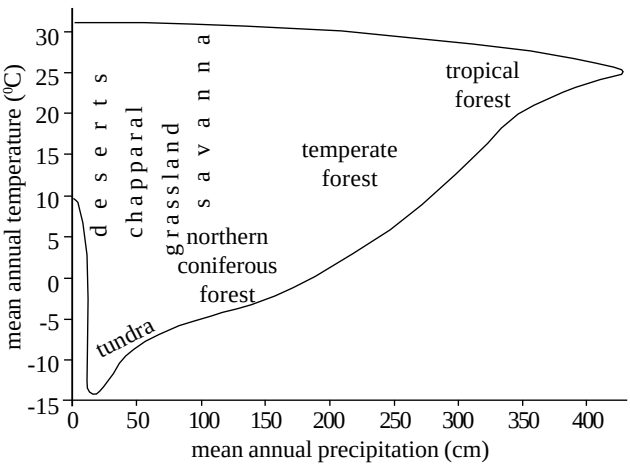
Increased carbon dioxide concentrations will also affect the species composition of forests and grasslands. Areas of subtropical forest are expected to decrease but tropical forest areas may increase. In the past, vegetation zone shifts have occurred over millennia rather than decades. Animals are able to respond to changing climatic conditions faster than plants in that they can migrate. However, in many ecosystems the interactions between stable populations of plants and animals maintains stable plant communities. If the populations of pollinating insects, soil organisms or herbivorous or seed dispersing animals change, the structure of the plant community will change.

Vegetation, temperature and precipitation

Vegetation type is influenced by three interactions between temperature and precipitation:

1. The minimum temperature below which a species dies
2. The minimum number of days of a certain temperature after which a species dies
3. The minimum precipitation below which a species dies

When these three are mapped and compared with the present day distribution of vegetation types there is good general agreement. By predicting how these three will change in the next fifty years biogeographers can predict the changes that may occur in vegetation types.



Case Study - The effect of climate change on Wytham Wood

Wytham Woods, near Oxford (Fig 4), is one of the most intensively studied areas of woodland in the world. Wytham has been monitored very closely for at least forty years and is one of eleven sites worldwide being used as an indicator of the effects of climatic change. Wytham consists of 1000 acres of protected woodland located in a meander in the River Thames. It covers two low hills, formed of Jurassic Corallian limestone, which rise about 100 m above the river. The area was previously owned by the Fennel family, who in 1940 gave the woodlands to the University on the condition that their natural beauty was preserved for all time.

Flora and fauna

Over 3800 species of animals and 600 species of vascular plant have been recorded at Wytham which is a SSSI. Many long-term ecological studies in Wytham Wood have examined the energy flow of the ecosystem (Fig 5)

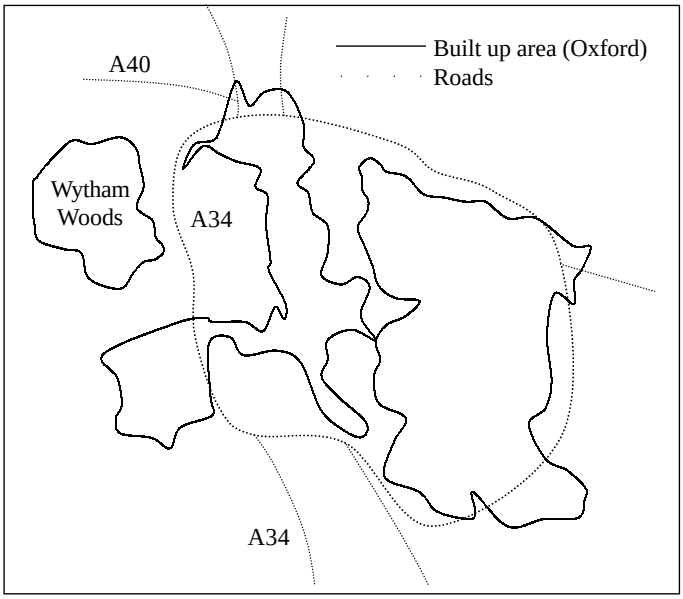
Change over time

Changing climate will affect insect distribution; this in turn will affect the ecology of the tree species at Wytham. These are an important part of the surrounding hedgerows and field edges, and support a wide range of insect species (Table 1).

Table 1. Insect species associated with common trees and shrubs

Tree or shrub	Number of insect species
Oak	284
Willow	266
Birch	229
Hawthorn	149
Blackthorn	109
Poplar	97
Crab Apple	93
Scots Pine	91
Alder	90
Elm	82
Hazel	73
Beech	64

Fig 4. Location of Wytham Woods, near Oxford

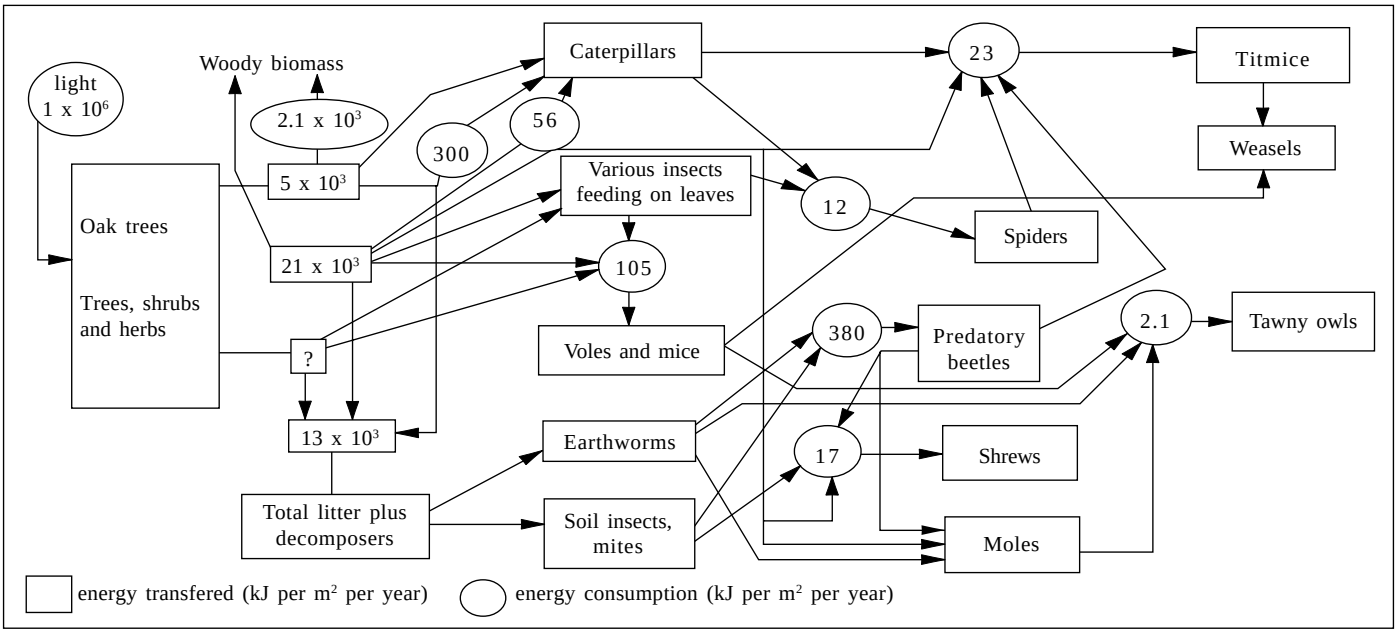


Global warming is already having an effect on the biogeography of Wytham Woods. Scientists at Oxford University predict that by 2050 grasslands will become infested with weeds, common species of birds will become rarer and wetlands will dry up.

The changing availability of carbon dioxide and water and changes to the average temperature and length of the growing season will affect different tree species unequally; competition between some plant species will increase and some will become out-competed and become locally rare, restricted or extinct. Increasing summer temperatures will change the numbers and species diversity of pollinating insects and will also influence the activity of herbivores which, in turn, will influence the reproductive success of tree saplings.

*Thus, climate change will alter the pattern of **succession**; some species will suffer greater herbivory and some will suffer reduced pollination. The overall effect of theses interactions is very difficult to predict but it is likely that species frequency will be altered.*

Fig 5. Energy flows in Wytham Wood



Practice Questions

1. Describe the trophic structure of Wytham Woods.

2. Fig 5 shows a food web from Wytham Woods in Oxfordshire. Identify the autotrophs and top carnivores in Fig 5.

3. Suggest some of the pressures that threaten areas of deciduous woodland both now and over the next fifty years.

4. What effects will changes in climate have on vegetation?

5. What is the likely impact of climate change on the ecology of Wytham Woods?

Answers

1. Wytham Woods is an excellent example of a deciduous woodland and as such it shows a model trophic structure. Oak trees, other trees, shrubs and herbs make up the primary producers (the autotrophs or first trophic level), caterpillars, insects, voles, and mice are the herbivores or second trophic layer. Spiders, predatory beetles, shrews and moles are the next level (primary carnivores) while titmice, owls, weasels and foxes are the top trophic layer (secondary and tertiary carnivores).

2. The autotrophs are oak trees, other trees and shrubs and herbs. The top carnivores are owls and weasels.

3. The increased demand for housing, and the lack of space in southern Britain means that there will be increased pressure to develop housing in some areas that are currently woodland. In addition, demands for recreation and tourism will mean that many areas of woodland will experience increased visitor pressure. Balancing the needs of visitors and trying to manage the woodland naturally may lead to conflicts of interest.

   Natural pressures include climate change. As we have seen from Wytham streams may dry up; there may be fewer frogs, insects and ground vegetation; parched soil will produce fewer earthworms and this will have a negative impact on populations of foxes and badgers.

4. There are a number of impacts. Positive ones include

- an increase in timber yields (up to 25% by 2050s) especially the north of the UK (with perhaps some decrease in the south)

Negative effects include a small decrease in the number of plant species due to the loss of northern and montane (mountain types). Moreover, it depends on the scale of the increase in temperature. If there is an increase of temperature of 0.5°C

- disappearance from the British Isles of a few niche species, e.g. alpine wood fern: oak fern.

- inmigration of some continental species and expansion of some species, e.g. Red Admiral and Painted Lady butterflies, Dartford Warbler.

- increase in plant productivity by 3%.

- By contrast, if the temperatures increase is 1.5°C, increased disappearance from the British Isles of several alpine and temperate species.

- in-migration of several Mediterranean or tropical species.

- plant productivity may increase by 15%.

5. The impact of climate change on the ecology of Wytham is likely to be negative. The changes are explained in the last paragraph of this Factsheet. There will be decreases in the populations of worms, badgers, foxes, butterflies, caterpillars and birds. On the other hand, there may be increases in the number of species that are drought tolerant. Changes to the populations of pollinating insects and herbivores, along with changes to average temperatures etc. will alter the pattern of succession. The relative numbers of different tree species may change.

Acknowledgements;

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