

Summary

The impacts of climate change on the distribution of native woodland communities and the commercial productivity of oak are modelled using the decision support system, Ecological Site Classification (ESC). Predictions are made on the basis of climatic suitability, using the climate scenarios for the 2050s prepared under the UK Climate Impacts Programme. The simulations indicate a trend towards increasing productivity in the north and west and lower productivity in the south of Britain. The distribution of native woodland communities is predicted to change, and to a larger extent than the distribution of oak itself. This points to possible widespread changes in the structure of native woodland communities, but not necessarily to the distribution of broad woodland types.

Climate scenarios

The climate scenarios used in this analysis are the two extremes represented in the UKCIP02 scenarios (Low and High) prepared by the Tyndall and Hadley Centres for the UK Climate Impacts Programme funded by the UK Department for Environment, Food and Rural Affairs.

The Low and High scenarios are equivalent to the IPCC B1 and A1F1 scenarios, and are described in detail by Hulme *et al.* (2002). An indication of the magnitude of change of the main climatic drivers of species suitability - temperature and rainfall is shown in Figure 1.

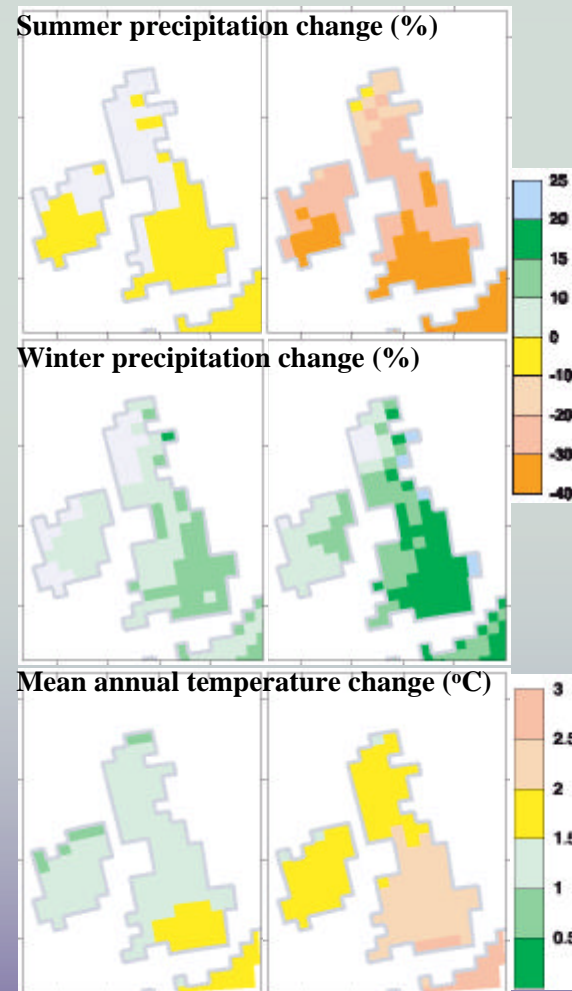


Figure 1: UKCIP02 climate change predictions for the 2050s for summer precipitation (top), winter precipitation (middle) and temperature (bottom). In all cases, the left hand panel represents the 'Low' scenario, and the right, the 'High' scenario. [Source: UKCIP].

The Ecological Site Classification Decision Support System (ESC)

ESC has been developed to support the UK forestry industry in commercial species selection and the restoration of native woodland. It is a knowledge based model in which suitability or yield class is predicted on the basis of four climatic (accumulated temperature, exposure, moisture deficit and continentality) and two edaphic (soil moisture and soil nutrient regime) factors as shown in Figure 2 (also see Pyatt *et al.*, 2002).

In the case of commercial suitability, accumulated temperature (AT) is assumed to be the principle determinant of yield, with the product of AT and the next most limiting factor providing a site level assessment of suitability. A slightly different approach is used for native woodland, in which the suitability of a woodland community is derived from soil quality estimates based on plant indicator species within the field layer, and the climatic suitability for the main tree species.

A number of assumptions have been made, that should be considered when interpreting the suitability maps and climate change (see Broadmeadow, 2002). In particular, the following have not been considered.

- ? the direct effects of rising atmospheric CO₂ concentrations on growth and evapo-transpiration;
- ? the effects of a possible change in the frequency of severe pathogen or insect pest outbreaks
- ? changes to the frequency of extreme climatic events
- ? the predicted increase in winter windspeed rather than mean annual windspeed
- ? changing soil moisture quality index as well as the moisture deficit.

Worked example

On a site where AT=1600 daydegrees > 5°C; MD = 180 mm; windiness = 8; continentality = 10; SMR = slightly dry; and SNR is rich, the potential yield of sessile oak is about 9 m³ ha⁻¹ yr⁻¹ reduced by the limiting factor of soil SMR to 6 m³ ha⁻¹ yr⁻¹ (9 x 0.7 = 6.3). It would therefore be classed as suitable in commercial terms. However, NVC W11 would be classed as unsuitable with AT and SMR combining to give a suitability score of 0.18 (marginal = 0.5 to 0.7; suitable = 0.7 to 1.0).

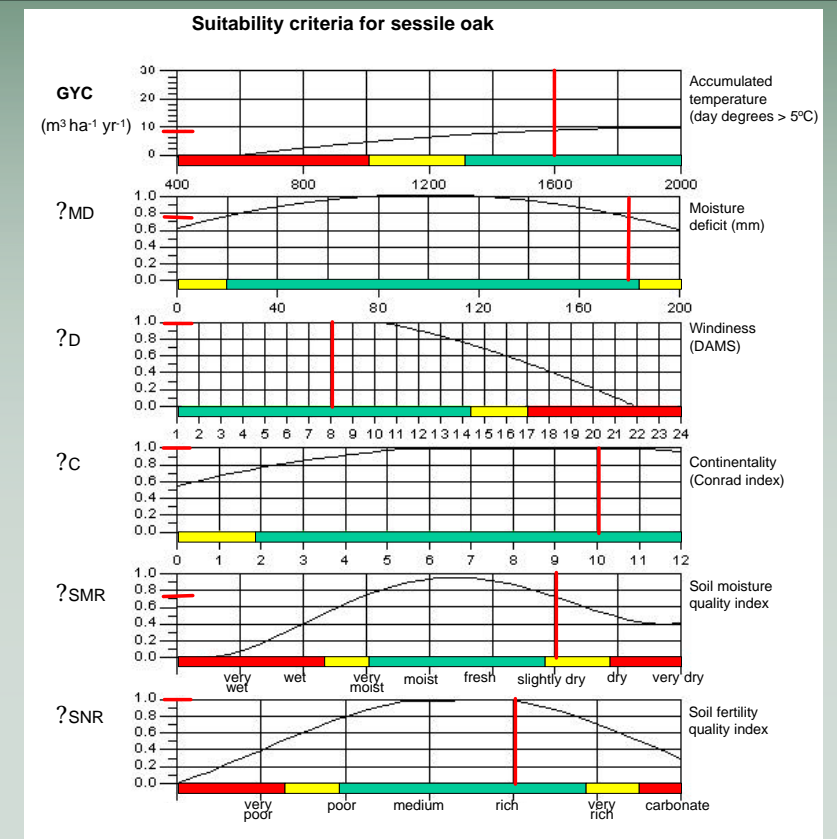
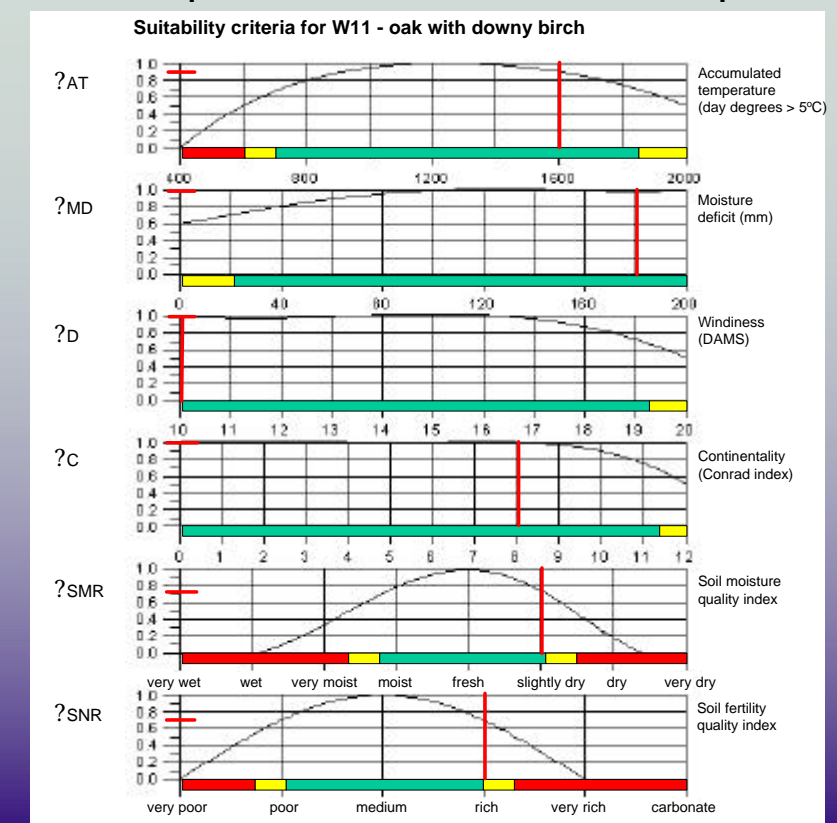


Figure 2: suitability criteria for sessile oak (top) and NVC W11 upland oak woods. In each case, the top panel represents the relationship between productivity (general yield class: GYC (m³ ha⁻¹ yr⁻¹) or native woodland suitability and AT. For the other five panels, the x-axis represents the individual climatic and edaphic factors, and the y-axis, the suitability function of each. The red lines represent the values in the worked example.



The predicted impact of climate change on the suitability of oak for commercial forestry

In forestry terms, oak would be seen as highly suitable at yields over 6 m³ ha⁻¹ yr⁻¹, suitable between 4 and 6 m³ ha⁻¹ yr⁻¹, and marginal between 2 and 4 m³ ha⁻¹ yr⁻¹. Figure 3 indicates that across much of England, predicted yields fall significantly, and oak may no longer be suitable as a productive species by the 2050s in some areas. In Scotland, particularly along the east coast, the marginal range of sessile oak extends considerably for both the Low and High scenarios, while it is also apparent that oak will be suitable at higher elevation in the future. A small increase in productivity is predicted across the northern UK, but in Wales, very little change in growth rate is apparent. The model predicts a stronger regional identity for each species. The suitable range for pedunculate oak advances north, although the species remains more suited to eastern districts. The range of sessile oak also advances north and to higher elevation, with a significant improvement in growth in eastern Scotland.

Even where productivity is predicted to fall as a result of climate change, pedunculate oak remains a viable species. It should, however, be remembered that these predictions are for change up to the 2050s - beyond this, the consequences for British oak woods may be more serious.

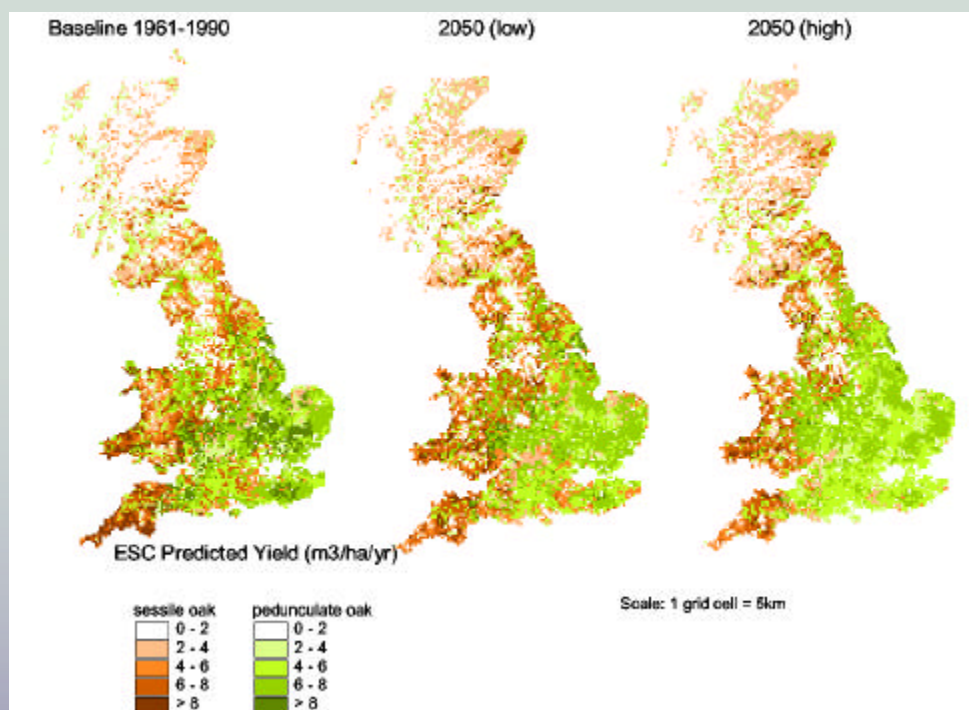


Figure 3: ESC simulations of productivity (General Yield Class: GYC) for sessile (*Quercus robur*: brown) and pedunculate (*Q. petraea*: green) oak. For each 5 km x 5 km grid square, GYC of the most suitable species is shown.

The predicted impact of climate change on native oak woodland communities

The extent of sites suitable for W10 lowland oak woodland (pedunculate oak, bracken and bramble community) appears to change little as a result of the effects of climate change, and indeed, there appears to be an extension of the range in parts of Scotland and Wales. However, the community is predicted to become less suitable, particularly in the High scenario (Figure 4). Many areas currently suitable for W10 in central and eastern England will become marginal. The nature of Woodland classed as marginal is likely to be at risk from change as a result of external pressures, and the community structure may not remain as currently defined. The rate and extent of any change will be highly dependent on the response of individual species to climate change.

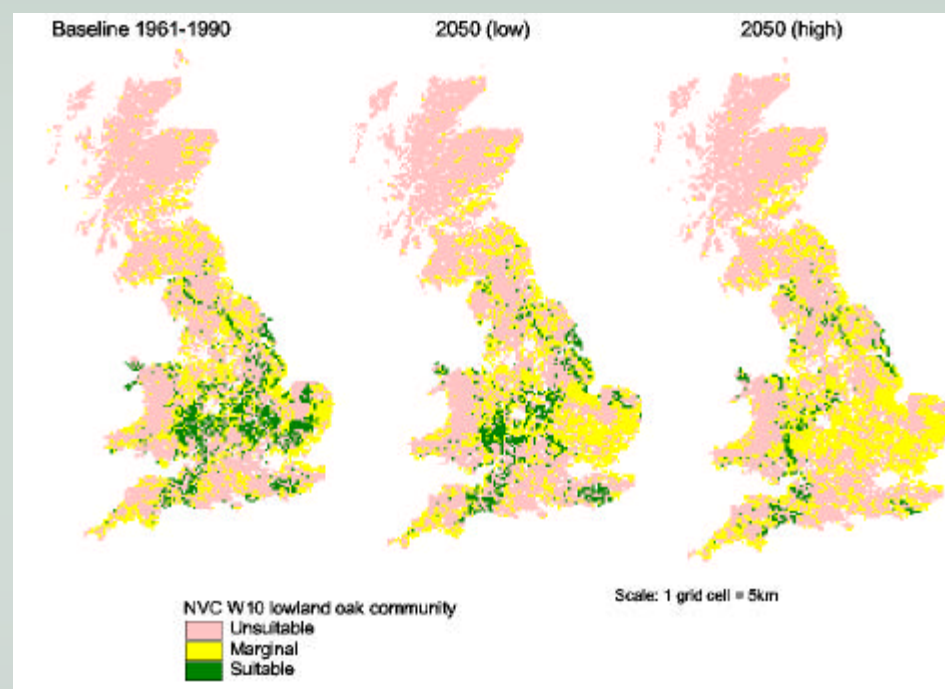


Figure 4: ESC simulations of suitability for NVC W10 (oak - bramble birch) lowland oak woods. Suitable indicates a suitability score of over 0.7, and marginal, between 0.5 and 0.7.

In contrast to W10, the range of W11 upland oak woods (sessile oak, downy birch, wood sorrel community) contracts significantly (Figure 5), with the result that many areas of the Britain become unsuitable. The W11 community is currently associated with a cool, moist climate, and it is important to note that the ESC prediction does not indicate a disappearance of oak woods, but a change in the community structure. This new association may no longer fit the current NVC definition of the W11 community (Rodwell, 1991).

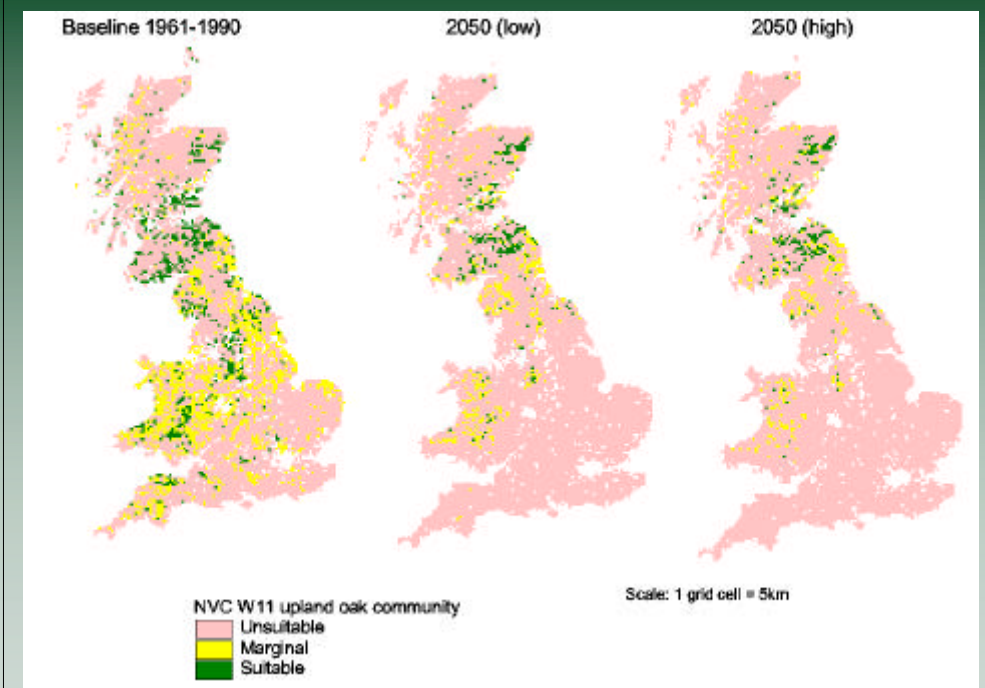


Figure 5: ESC simulations of suitability for NVC W11 (sessile oak - downy birch) upland oak woods. Suitable indicates a suitability score of over 0.7, and marginal, between 0.5 and 0.7.

Conclusions

- ?By the 2050s, the commercial productivity of oak is predicted to fall significantly in the south and east of Britain, but increase in parts of northern England and eastern Scotland;
- ?changes to the suitability and distribution of native oak woods are unlikely to result in major changes to the distribution of the main tree species components over the next 50 years;
- ?biophysical factors that influence plant species distributions and which, in turn, define the NVC native oak wood communities will change in the future. The NVC oak wood communities and sub-communities will need to be reviewed;
- ?beyond the 2050s, the climate of parts of the UK may move outside the natural climatic envelope for oak - a debate over the definition of native woodland communities and native woodland zones in the light of climate change predictions should therefore be opened.

Acknowledgements

Thanks are due to Pam Berry and Nathalie Butt for the provision of processed scenario data.

References

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