## Climate Change Impacts and Grassland

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Climate change is becoming a major environmental issue with potentially serious implications for world food production and for the management of agriculture and other land use activities in the UK. While climatic variability over time is a natural phenomenon, the warming trends observed in recent decades are now generally considered to be outside the range of normal long-term climatic variability, and to be largely due to increased concentrations of greenhouse gases (GHG) in the atmosphere. These act by trapping a higher proportion of the sun’s energy, an effect called radiative forcing. The most important GHG is carbon dioxide (CO₂), the

Fig 8.1 Will climate change affect grassland production and the appearance of the grassland landscape?
atmospheric concentration of which is now about 30% higher than before the Industrial Revolution. By burning increasing amounts of fossil fuel over the past 200+ years, mankind has been releasing CO₂ previously fixed by plants and fossilised as coal, oil and gas many millions of years ago. The massive increase in the world’s use of fossil fuels means that further increases in CO₂ concentration appear almost certain. In addition, methane, nitrous oxide and chlorofluorocarbons are also important GHGs and, as with CO₂, have been increasing as a result of recent human activity.

The effects of climate change cannot easily be predicted, but a number of scenarios based on the rate of increase of CO₂ and other GHGs, at different timescales, have been developed and used in climate change research, the scenario data being available through the United Kingdom Climate Impacts Programme (UKCIP) (www.ukcip.org.uk). The predictions from these scenarios are that, in the UK, annual average temperature could increase by 2-4°C during the present century (the main effect being in summer) and rainfall could show a net reduction of about 10%, with an increased proportion falling during the winter months. While this may imply climate changing towards that presently experienced in other warm temperate countries, the reality is far less certain, largely because of the additional effects of increased frequency of extreme events such as summer droughts and winter storms. There are also uncertainties associated with changes in prevailing wind patterns and possible effects on ocean currents which in turn affect the UK’s climate.

**Effects on grassland production**

What do these effects mean for agriculture, and for grassland in particular? Grassland production in the UK is already strongly influenced by temperature and rainfall. IGER trials have shown that identical sward types can vary in production yield by over 100% between different localities, depending on length of growing season and rainfall distribution, as well as soil type; the same sward can also vary between years on the same site by over 100%. Thus, under the climate change scenarios that have been developed, grassland production is likely to be influenced by increasing temperatures and changing seasonal patterns of precipitation. In addition, increased CO₂ concentrations can have a forcing effect on crop growth (artificially raised CO₂ concentration in glasshouses is commonly used to increase crop production). Understanding how climate change might impact on grassland agriculture is therefore a very complex problem.

IGER has recently carried out several studies for the Department for Environment, Food and Rural Affairs (DEFRA) on the effects of climate change on UK agriculture, in partnership with researchers at other institutes and universities. These have focused on both modelling and experimental approaches to define the effects of temperature and CO₂ on grass growth, as well as studies on how the agricultural industry perceives climate change and the types of response it might need to make.

**Experimental approach**

Creating similar climate environments to those described in the UKCIP climate change scenarios, and measuring the effects on grass growth is one approach that can help us understand how grassland might respond to future changes in temperature and CO₂ concentration. In collaboration with the Centre for Ecology and Hydrology at Bangor, which has a specialist solar
dome facility, replicated treatments enabled us to study the effects of enhanced CO₂ and temperature, singly and in combination, on the growth of swards. Under frequent cutting, CO₂ and higher temperature increased grass yield, the greatest effect occurring when both were applied simultaneously. Higher concentrations of CO₂ also affected the chemical composition of grass, resulting in increased water soluble carbohydrate (WSC) and reduced N concentrations. It is uncertain how swards would respond in the longer term, or how seasonal water deficits would interact with these effects, and indeed whether different swards (e.g. clover-based or hill grazings) would react differently.

**Modelling**
In collaboration with researchers at the Scottish Agricultural College we applied the climate change scenarios developed for UKCIP to predict the effects on eight grassland areas of England and Wales. The approach used an existing grass
growth model in conjunction with a weather generator to simulate the effects on seasonal forage yield for grass and different forage legume crops under both cutting and grazing. The modelled geographical areas represented the major upland and lowland grassland areas in northern and western Britain, as well as some grassland areas in the predominantly arable parts of southern and eastern England. The results of the model runs showed relatively small regional differences, and in the short-to-medium term (2020s/2050s) it was considered likely that grassland would remain as a valid land-use option in most of the UK. Overall, it was predicted that the forcing effect of CO₂ in combination with higher temperatures, would result in 10-20% more herbage yield by the 2020s/2050s for the same amount of fertiliser use. However, the modelled outputs suggested that legume-based swards (grass plus white clover, red clover or lucerne) would show a better response than N-fertilised grass, with better legume yield in early summer. The results suggest a greater role for legumes, assuming that climate change results in higher average temperatures, and their role as protein crops would be further enhanced if, as expected, world protein crops became in short supply due to droughts elsewhere.

In the longer term, the effects of extreme events such as serious summer droughts are considered likely to offset these advantages, at least in some years. The need for farmers to make more conserved feed as an insurance against low yields in particularly dry summers, or to enable a longer period of indoor feeding during wetter winters, is therefore considered likely.

Knowledge Transfer

It is the uncertainties surrounding the issue of climate change that have warranted the subject being taken seriously. On the face of it, warmer temperatures and a longer growing season, combined with a possible growth benefit from higher CO₂ concentrations, might be beneficial for grassland production and UK agriculture in general. But there are other issues, including the effects of increased summer droughts that might have longer-term deleterious effects, and increased winter rain poses other problems, including utilisation of pasture in spring and autumn, flooding and erosion. Changes to temperature can also affect the life cycle of pests and diseases, weed problems, heat stress in animals, etc.

In a further DEFRA-funded project, IGER arranged a series of meetings with stakeholders from different sectors of the agricultural industry and grassland organisations to inform and gauge the level of understanding of climate change and research issues. A number of priority areas were identified and, while there were wide variations in the level of understanding of the problems, there was a degree of optimism that UK grassland agriculture could adapt well, at least in the short-to-medium term, and also contribute to options to mitigate some of the causative effects of climate change (see www.iger.bbsrc.ac.uk/Practice/climatechange.htm for a detailed report).

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