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CLIMATE CHANGE AND THE MANAGEMENT OF SCOTLAND'S NATURAL HERITAGE

SUMMARY

There is a clear and urgent need to improve knowledge and understanding of the impacts of ongoing and future climate change on Scotland's terrestrial, fresh water and marine environments, through monitoring and research, and to develop a comprehensive strategy for managing Scotland's environments as climate change progresses.

Complete certainty is not possible in complex systems such as climate change and biodiversity. However, observations over several decades have, with the development of powerful computers, allowed the development of models to predict future changes. Interpretation is always vulnerable to new observations and to improvements in modelling. The present situation is that there are strong indications that over the coming century, climate change in Scotland is likely to raise summer temperatures by between 1°C and 4.5°C and winter temperatures by between 1°C and 2.5°C; decrease summer rainfall by between 30% and 50% and increase winter rainfall by between 20% and 40%; increase the length of the growing season by between 35 and 80 days; and decrease winter snowfall by between 30% and 100%.

Given these scenarios, it is unlikely that every aspect of Scotland's biodiversity can be conserved, so decisions will need to be made on management actions to conserve the largest amount of threatened diversity. Some conservation sites may also become unsuitable for certain species and habitats, whilst other sites might become more suitable. Each protected area should be assessed for the likely effects of climate change, and the methods of management and any necessary revisions of the area's boundary reviewed accordingly.

INTRODUCTION

1. Scotland's natural heritage is an invaluable resource which must be carefully protected for its own sake and for the social, cultural and economic benefits that it provides for society. Sustainable management of this natural heritage at species, habitat and ecosystem levels should, therefore, be a national priority.

2. Climate change will have a range of impacts on our environment that will seriously undermine attempts to manage our natural heritage sustainably. Climate change will have impacts on all forms of land and water use, including not only on the natural environment, biodiversity and landscape but also on agriculture, water resources and land use. It will be one of the most important issues facing us during the coming Century.

IMPACTS OF CLIMATE CHANGE

3. The concentration of carbon dioxide (CO_2) in the global atmosphere has increased from approximately 280 ppm (parts of CO_2 per million parts of air, by volume) in 1870 to 385 ppm today, and is continuing to increase at a rate of about 1.5 ppm a year. The present atmospheric concentration of 385 ppm is higher than the maximum concentrations over the past 400 thousand years during the three previous interglacial periods. Other greenhouse gases, notably methane and nitrous oxide, are also increasing and contributing to global warming.

4. Based on a number of international global climate models (e.g. General Circulation Models (GCMs)), the Intergovernmental Panel on Climate Change (IPCC) has estimated that the global average temperature will increase over this Century by between 2°C and 5°C, depending on the extent to which we are able to reduce the emissions of greenhouse gases resulting from our activities (e.g. energy generation and transport). These are conservative estimates and may yet be revised upwards in the light of new evidence. The impact of climate change on Scotland's natural heritage will depend on the level of future emissions of greenhouse gases. Under the terms of the Kyoto Protocol, most industrialised countries have agreed to reduce their emissions of greenhouse gases progressively below the emission levels of 1990.

5. How will climate change affect the environment in Scotland? Taking results from the UK Met Office, Hadley Centre GCM, the UK Climate Impacts Programme (UKCIP) has estimated that average summer temperatures will increase over Scotland by 1–2.5°C (low emissions scenario), or 3–4.5°C (high emissions, business-as-usual scenario), and winter temperatures by 1–1.5°C (low emissions), or 2–2.5°C (high emissions), by the 2080s. The average summer rainfall is expected to decrease by up to 30% (low emissions), or by up to 50% (high emissions), whereas the winter rainfall is expected to increase by up to 20% (low emissions), or by up to 40% (high emissions). Length of the growing season is projected to increase by up to 35 days (low emissions scenario), and by up to 80 days (high emissions scenario). Average winter snowfall is projected to decrease by 30–70% (low emissions scenario), or by 50–100% (high emissions scenario).The ranges given above for the projected changes arise from geographical variation across Scotland. These changes in temperature, rainfall and growing season are less than those projected for England and very much less than those projected for continental areas and most of the tropics, because Scotland's climate is strongly moderated by the influence of the Gulf Stream on the temperature of the Atlantic Ocean[1]. At comparable latitudes in the Southern Hemisphere, where there is no comparable Gulf Stream, land is covered with snow, ice and glaciers.

6. Consequently, our equable climate is particularly sensitive to possible future reductions in the strength of the Gulf Stream. Should it diminish or 'switch off' as a consequence of changes to the global climate elsewhere, Scotland's climate could become much colder than presently experienced. There is already some evidence that the Gulf Stream may be decreasing in strength. This represents a major uncertainty to be borne in mind. Whether the Gulf Stream will reduce sufficiently to cool our climate in the future is uncertain at the present time, and we should proceed on the assumption of significant warming.

7. There is also increasing evidence of positive feedback mechanisms operating on the earth's climate, such as the increasing occurrence of forest and savannah fires and of melting permafrost in tundra regions, leading to the release of CO_2 and methane, so that the impacts of global warming may be felt sooner than initially thought. Furthermore, the GCMs are still fairly basic in certain respects, such as the global carbon cycle, and projections of their output to continental and regional scales are somewhat uncertain. Much more work is needed on weather and climate sensitivity, and the development of models that can be used to explore changes in Scotland's environment under various scenarios of climate change. The present limited understanding of the global sensitivity of weather and climate to greenhouse gases highlights the importance of identifying appropriate, detailed mitigation and adaptation strategies for Scotland.

8. It is possible that both the frequency and magnitude of damaging climactic events may be on the increase, although it is difficult to link the incidence of extreme events explicitly with global warming. Increases in storminess and seasonality of rainfall are likely to have large effects, leading to flooding and loss of habitats along rivers and soft coastlines. On rivers, traditional hard engineering solutions are likely to transfer the problem downstream. Consideration should be given to the restoration of naturally flooded areas, such as flood plains and salt marshes, as well as the use of soft engineering methods, which are more likely to be environmentally successful and cost- effective.

NATURAL HERITAGE MANAGEMENT IMPLICATIONS

Biodiversity

9. The pressure of climate change on biodiversity needs to be recognised[2,3]. Species diversity is likely to increase in Scotland, because of warming temperatures, although some cold-adapted species are likely to be lost. Many species with a southern distribution are likely to spread northwards through Scotland, such as the small-leafed lime (tree), dogwood (shrub), autumn gentian and cowslip (herbs), nuthatch and kingfisher (birds), small skipper butterfly and a number of insects. Tree-lines and associated species will move upwards from the present 610 metres to higher elevations and may even cover the tops of some hills. Already one can see better growth of Scots pine at the Creag

Fhiaclach tree-line in the Cairngorms. Consequently, there is a particular concern over the potential fate of arctic/alpine species, such as the dwarf willow and purple and yellow saxifrages, which may have no refuges available in the event of warmer winters and reduced snow cover. There is also concern over the future of other species with a northern distribution such as dwarf cornel (herb), ptarmigan and dotterel (birds) and the mountain ringlet (butterfly). The warmer weather may also contribute to the burgeoning red deer population, with a strong negative effect on woodland regeneration. Forest regeneration will also be hindered on the flatter landscapes in the Hebrides and north and west Highland Scotland, where the warm wet winters will result in prolonged periods where the soil will remain saturated with water.

10. Habitats are particularly sensitive to climate change. For example, some such as deciduous, broad-leaved woodlands are likely to increase as a result of a longer growing season. However, increase in extreme events such as storminess and seasonal rainfall may damage or remove habitats in river valleys and at the coast, such as machair habitats. The historic loss and fragmentation of habitats has left large areas of Scotland with impoverished biodiversity today. Currently there is an increasing number of projects by statutory agencies, NGOs and community groups acting to restore habitats. These projects are necessarily long-term, on the same time-scale as climate change, and may need help to incorporate climate change into their management plans.

11. It will not be possible to conserve every aspect of Scotland's or Europe's genetic biodiversity, so decisions will need to be made on management actions that can conserve the largest amount of threatened biodiversity or, in some situations, the largest amount of useful biodiversity. To set these priorities, information will be needed about the present state of biodiversity, about how it is changing and, by using models, about how it is likely to change.

12. Species and habitat action plans for the conservation of many of our rare and threatened species and habitats of national or international priority have already been prepared in relation to biodiversity concerns. The Nature Conservation (Scotland) Act 2004 calls for a list of Scotland's priority species and habitats to be prepared. In planning for the conservation of these priorities, the effects of climate change need to be taken into consideration. Methods for collecting and integrating data need to be addressed at the European Community scale to ensure that regional-scale analyses of ecological change can be integrated across national boundaries.

Conservation areas

13. In the face of climate change, some conservation sites may become unsuitable for certain species and habitats, whilst other sites might become more suitable. New sites might, therefore, have to be designated to reflect the climate changes, while others may require to be denotified as the intrinsic value of the sites declines. There may also be a need for greater acceptance of buffer zones around sensitive sites. Each protected area should be assessed for the likely effects of climate change, and the methods of management and any necessary revisions of the area's boundary reviewed accordingly. In undertaking these reviews, it will be important to be clear whether or not the protected area is conserving (or will conserve) what it was designed to achieve. Practical methods for relocating rare species to sustainable habitats may need to be devised and implemented.

Environmental damage

14. Long-term monitoring of major industrial locations along the Scottish coasts has shown that natural fluctuations in habitat conditions, populations and biodiversity are greater than the discernible effects of single pollution events from industrial discharges. In some cases there will be difficulty in defining the cause of environmental damage, if damage has occurred when bad weather, or disease outbreaks, or higher ambient sea water temperatures have produced a natural reduction in particular species. Long-term monitoring will therefore be essential to understand the changes due to a changing climate and those due to other causes, such as pollution, land use change, or indeed conservation actions.

15. An important aspect is the effect of non-native species on local biodiversity. The International Union for the Conservation of Nature (IUCN) has recognised that invasive, non-native species constitute, after habitat fragmentation, the largest global cause of the loss of biodiversity. More vigilance is needed on the introduction of non-native species, as well as practical methods for eradicating those alien species already present, such as the North American signal crayfish and the Japanese knotweed. Climate change is likely to increase the spread of pests, weeds and diseases, if introduced from more southern locations.

Avoiding positive feedback mechanisms

16. Scotland's soils and peatlands comprise a huge stock of organic carbon that must be conserved. Agricultural and forestry practices, such as draining, ploughing and mounding, lead to oxidation of soil organic matter with the release of CO_2 to the atmosphere, thus enhancing global warming. Agricultural and forest management practices should be developed to minimise this transfer of CO_2 to the atmosphere and, conversely, to maximise the stocks of carbon in farm and forest soils. The stocks of carbon in trees in Scotland's forests are now significant and measures should be taken to ensure their long term maintenance through the management cycle.

17. Soil is also a vital resource to agriculture and forestry and is susceptible to degradation through erosion. An increase in extreme rainfall events may increase run-off and soil erosion, especially on blanket peats in upland areas. In addition, changing agricultural practices may also increase soil erosion, particularly in a warmer climate. For example, a higher intensity of cultivation in lowland areas, such as the use of winter arable, in combination with higher rainfall, is likely to promote increased soil erosion. There needs to be better co-ordination of soil protection strategies to minimise erosion and carbon emissions.

In conclusion

18. Overall, Scotland's obligations as a part of the UK in relation to the Kyoto Protocol, to the Convention on Biological Diversity, and to aspirations for a sustainable future, will be needed to help to protect Scotland's natural heritage and the benefits it provides.

GLOSSARY & ABBREVIATIONS

Biodiversity:	The variability among living organisms, including diversity within species, between species and of ecosystems
CO_2	Carbon Dioxide
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
GCM	General Circulation Model
NGOs	Non-Governmental Organisations
Positive feedback:	Feedback that results in amplification or growth of the output.
ppm	Parts per million
UKCIP	UK Climate Impacts Programme

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