Climate change and upland biodiversity – targeted research and strengthening the science-policy interface

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Overview

The aim of this paper is to take a broader look at the relationship between scientific research and the development of policy that aims to conserve biodiversity during climate change. Such issues are directly relevant to all environments, but may be particularly relevant to the uplands, which are an important biodiversity resource and focus for research, and within which the impacts of climate change might be significant and severe. Much of what is written below is based upon opinion. I have, however, tried to reflect not just my own opinion but also that of the numerous researchers and policy makers to whom I talked during the development of this presentation.

Background

It is clear that climate change is already impacting upon biodiversity within the uplands, throughout the UK and around the globe. Changes have been detected in phenology – the timing of biological events – for example bud burst and flowering in plants and mating and nesting in birds (Parmesan & Yohe 2003). These phenological changes are then having knock-on effects in terms of the interactions between species, for example altering the competitive balance between species within plant communities (Dunnett & Grime 1999), or producing asynchronicity of breeding and the availability of prey in birds such as the Capercaillie (Moss *et al.* 2001). Both through phenological changes and through direct effects on individuals (e.g. through altered wintertime mortality) climate change is also leading to altered survival, growth and reproductive success. In some cases this may lead to range contraction as a species is unable to maintain a viable population at a particular site. In other cases it may lead to range expansion, where a species that was previously limited by environmental conditions is now able to survive and reproduce successfully. When migration is not restricted a balance between such processes can result in range shifting, which has already been detected in a number of more mobile species groups (Warren *et al.* 2001). Species loss and gain will lead to changes in the local abundance of species and the composition of communities, and although the link between diversity and ecosystem function is as yet unclear, there are likely to be consequences for ecosystem services as (at the very least) keystone species may be lost from the system.

In the face of such changes it is clear that there is the need to develop policies to deal with the impacts of climate change on biodiversity. Two main categories of policies are commonly considered: mitigation policies, which are aimed at reducing the absolute impact of climate change (e.g. through reduction in the emissions of greenhouse gases - GHGs), and adaptation policies, which accept that despite even radical cuts in GHGs some climate change is now inevitable and attempt to make systems “climate proof”. It is this latter category which is of particular interest with respect to biodiversity conservation in the uplands, the question for policy makers being how can we alter our conservation policies to account for the current and likely future impacts of climate change?

The scientific basis for policy development

Adaptation strategies will need to answer this question. It is widely agreed that the development of adaptation strategies should be based upon the best available scientific information. With respect to climate change impacts on biodiversity in the uplands (and more broadly) such information can come from three main sources – environmental monitoring, experimental manipulations and ecological modelling. All of these resources have associated pros and cons.

Environmental monitoring

Environmental monitoring provides the capacity to detect trends in natural systems and to relate these to similar trends in potential drivers, e.g. trends in climate or nitrogen deposition. With respect to climate change, long-term monitoring has been central in demonstrating that long-term environmental changes are underway and that recent rapid changes in climate may be an important driver. However, monitoring has limited capacity in terms of enabling us to predict the future impacts of climate change. Future climate will involve combinations of drivers that have hitherto not been experienced – so-called zero-analogue environments. It is not possible to predict how ecosystems will respond to such combinations of environmental drivers from past changes in climate.

Experimental manipulations

Experimental studies provide some limited capability to assess how future climatic conditions will affect communities and ecosystems. For example warming experiments enhance local temperatures in an attempt to simulate one component of future climatic conditions. They employ a range of techniques including open top chambers - effectively mini-greenhouses that heat both the air and soil surface (e.g. Figure 1), and within which the response of species and communities can be observed. However such studies, although both useful and interesting, are limited in terms of the area which they can encompass. Furthermore they can be perceived as costly, although ecological studies in general tend to be relatively inexpensive and thus conclusions concerning cost can be very subjective.

Figure 1. An artificial warming experiment using open top chambers (OTCs) currently being run at Invercauld Estate, Deeside, by Andrea Britton, Macaulay Institute. Photo courtesy of A. Britton.

Ecological modelling

Ecological modelling encompasses a wide range of techniques that attempt to predict future responses of communities and ecosystems. One of the most widely-used forms of ecological model is climate envelope models. These models relate current distributions to a range of climate parameters and, using future climate scenarios, attempt to project the future potential distributions of the species (Brooker 2006). Such modelling enables scaling up to wide geographic areas and a broad range of species and functional types. However, such models have been criticised for a lack of realism compared to the complexity of natural ecosystems (Hampe 2004).

From these brief examples it is clear that there are no fool-proof methods for precisely predicting the future impacts of climate change on biodiversity, and thus enabling the development of risk-free adaptation policies, but also that (despite their drawbacks) such approaches can helpfully inform policy development, test policy proposals or monitor their impacts. The optimum strategy might therefore be for policy development and research activity to move forward together. However, significant current debate is focussed on whether the development of policy is outstripping the provision of information from scientific research.

Is policy development outstripping research?

Let us take one example and examine it in more detail. The European Commission recently published a communication on "*Halting the Loss of Biodiversity by 2010 – and beyond. Sustaining ecosystem services for human well-being*" (COM (2006) 216 *, adopted 22nd May 2006). Within this communication Policy Area 3 "Biodiversity and climate change" contains the following objective (objective 9): "To support biodiversity adaptation to climate change" which states that "Policies will … be needed to help biodiversity adapt to changing temperatures and water regimes. This requires in particular securing coherence of the Natura 2000 network". This is a clear policy target but there are a number of currently unanswered scientific questions that arise from it, for example:

- *Why should we focus on Natura 2000 sites?* Are current protected areas suitable as future refuges for biodiversity? Do hotspots of biodiversity overlap between taxa?

- *How do we create networked landscape?* What changes to management might be necessary? How should we switch from maintaining the *status quo* to managing for change? How can we realistically link increasingly fragmented upland populations by altering the landscape mosaic?

Before embarking on such a policy of integrating Natura 2000 sites it is surely worth asking what the scientific basis is for such a policy. Is there currently a strong scientific basis for it, or does it stem in part from an understandable desire to adhere to the Natura 2000 network into which a vast amount of effort has already been invested?

A recent informal review of the scientific literature (C. Beale, Macaulay Institute, *Pers. Comm.*) also suggested that policy development was pushing forward without a strong scientific underpinning. The review found that, out of a total of 761 references within the scientific publications database Web of Science selected using the search phrase "climate change AND adaptation", only 17 suggested possible adaptation strategies, 11 are reviews or commentaries, and none test the efficacy of proposed adaptation methodologies.

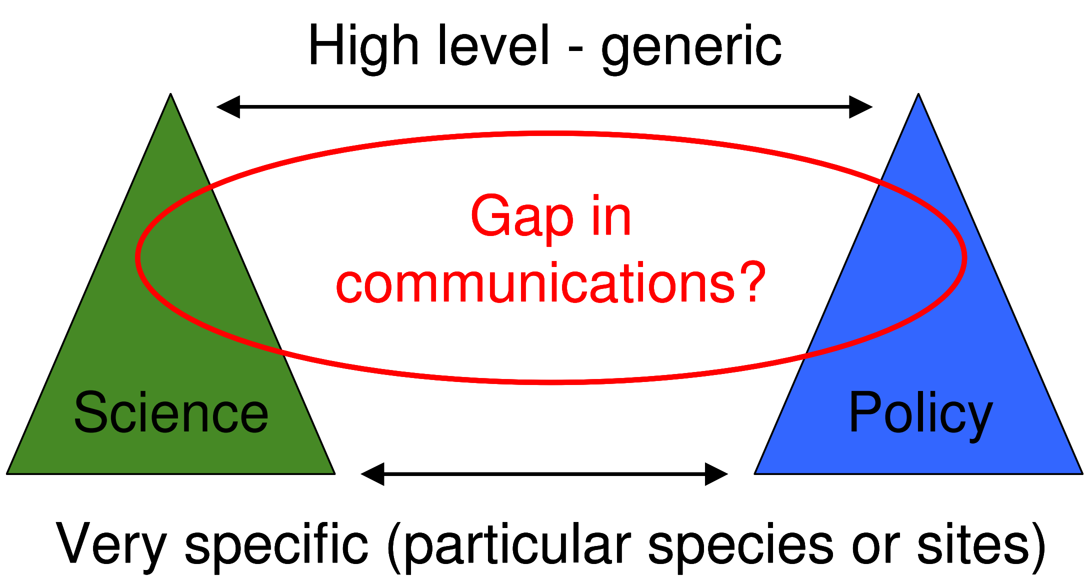
Why is policy outstripping science?

Amongst a wide range of possible explanations (all of which could be contributory factors) two reasons are commonly given as to why policy development with respect to biodiversity adaptation to climate change may be outstripping current scientific knowledge.

Firstly the rate of acquisition of ecological knowledge is slow relative to the rate of climate change, i.e. by the time we have undertaken the research necessary to fully underpin policy development, climate change will have happened and it will be too late to implement the adaptation strategies. This represents a "Catch 22 " for policy makers – as biodiversity impacts are already happening they have no choice but to develop policy now, despite a possible information deficit. However, it should be noted that one of the major factors restricting the rate at which we acquire ecological knowledge is funding. Funding for applied studies in particular is in extremely short supply, and is not considered by many researchers to reflect appropriately the magnitude of the problem with which ecologists are faced.

Secondly science-policy maker communication is likely to play an important role. If we consider both the science and policy worlds as having a "pyramidal" structure, it seems to be the case that good lines of communication exist at the extreme altitudinal limits of the pyramids (Figure 2).

Figure 2. Schematic representation of the hierarchical structures of the science and policy communities (the green and blue triangles respectively), existing lines of communication (high level generic communication and specific communication about particular sites or species), and the area within the hierarchy where there may be a gap in communications (red text).



High level communication exists with respect to broad generic themes, for example the need to develop strategies to conserve biodiversity during climate change. However, such broad themes may not be broken down into questions that can be readily tackled by scientific research (Sutherland *et al.* 2006), and so scientists may undertake research within a particular field but which may not be what is actually required by the policy makers. At the other end of the spectrum there is considerable communication about small-scale scientific projects, for example understanding the ecology of a particular species or developing a management strategy for a particular site. However, such studies are rarely synthesised to produce more widely-applicable generic ecological and management rules. The gap in communication may be perpetuated by a lack of recognition of its existence and a lack of time or (perhaps more importantly) money to do anything about it.

There seems to be general agreement that such a communication deficit is a genuine problem. Furthermore it might be addressed by recognition of the benefits of better communication, which could include:

- Better definition of questions that can be addressed by scientists.

- Recognition by more researchers of genuine policy needs (compared to pursuing topics that are of personal interest).

- More realistic expectations on the part of policy makers about what science can deliver (as discussed above).

- The capacity for an iterative policy – science link, i.e. using implemented adaptation strategies as experiments whose results can then be fed into further rounds of policy development.

This might ultimately deliver more targeted research, i.e. research that is directly focussed towards policy needs, which is in itself likely to lead to improved communications between scientists and policy makers.

How else could such improved communication be achieved? Possibilities include: better communication at the intermediate level within organisations, e.g. policy development working groups including researchers on particular clearly defined topics; development of research programmes in conjunction with policy makers operating at a relevant organisational level; better communication within organisations; the realignment of “organisational philosophies”, in particular the recognition that applied research can equate to excellent science.

In summary, therefore, adaptation strategies should have a scientific underpinning if possible, as science can deliver information that is able to help with adaptation policy development. However, for a number of reasons policy development appears currently to be outstripping science. One of the major causes of this would appear to be science-policy communications. The science and policy worlds could work together to resolve this, and may benefit from improved communication through the iterative and joined-up development of research and policy.

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