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The British Uplands: Dynamics of Change

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PREFACE

'With impending de-commonisation, there is particular interest in the likely consequences for wildlife and increased recreational use. In Scotland, ski developments continue to dominate the recreation scene ... Afforestation is arguably the most controversial form of land use in Britain in the 1980s .... In relating ecological research to management the important factors to determine are the management objectives. Definitions of these are difficult, especially as there is neither guidance nor agreement on whether the objectives should be formulated 'on high' (i.e. within the EEC or by national governments) or whether they should be discussed and agreed at a more regional or local level'.

Preface to *Ecological change in the uplands* (1988), edited by M. B. Usher and D. B. A. Thompson. Blackwell Scientific Publications, Oxford.

It is fascinating to reflect how some issues change and others stay the same in the uplands. The above excerpts from the Preface to a landmark volume on research and management issues in the uplands, capture the essence of issues germane thirteen years ago. Whilst the uplands of Britain, covering around one-third of its land surface, continue to change and evolve dynamically, the profile of different land uses dip and rise over various timescales.

The recreation debate has broadened considerably from concerns about ski-ing developments in Scotland to a wider debate on the promotion of increased access to the uplands of England and Wales (supported by the *Countryside and Rights of Way Act*, 2000) and impending legislation on land reform in Scotland. The afforestation debate has moved on considerably; large-scale blanket afforestation with conifers in the uplands has all but ceased, and instead there is a move towards mixed, broadleaf/conifer woodlands supported by Woodland Grant Schemes (though there are still concerns about some forestry proposals in the uplands). The Habitats Directive, currently being implemented by the UK Government, is particularly manifest in the designation of Special Areas of Conservation (SACs) for habitats and species listed under the Directive. One challenge for the countryside conservation agencies, in particular, is now to set clear conservation and management objectives for these sites and to determine whether or not these objectives are being met. In this regard, it is perhaps telling that there is still a debate about the production of monitoring guidance, at the EU, national, and local levels, for conservation sites.

In this document we have drawn together forty-one studies concerned in different ways with the dynamics of change in the uplands. We have drawn on the experience and knowledge of some who have worked in the uplands for many decades, and others who are just beginning to tackle research, conservation or management issues. We have sought to integrate different approaches; several of the studies transcend geomorphological, ecological, landscape, planning and policy perspectives. We have divided the report into five parts:

- Facets of the uplands: perceptions and research
- Importance, sensitivity and land-use issues
- Policy issues: integrated approaches to conservation, management and use
- Modelling, processes and monitoring change in the uplands; and
- Land management issues.

In developing these five themes, we have tried to build on the approach engendered within *Ecological change in the uplands* - trying to merge work reflecting the evaluation and importance of different facets of the uplands with studies of processes and practices to help understand changes in order to manage these for the benefit of the uplands as a whole.

This report is based partly on a conference held at Hatfield College, University of Durham, in spring 1999. However, we have updated papers, and drawn on a workshop held in Edinburgh on 26 April 2002. This workshop, held by Department of Environment, Food and Rural Affairs (DEFRA) and JNCC explored linkages between land-use policy, research and advice in the uplands; and provided an opportunity to bring parts of the report markedly up-to-date. All of the papers reflect some of the more recent changes befalling the uplands.

As we go to press, we should highlight the impact of Foot and Mouth Disease. The onset of this in February 2001 triggered major policy changes regarding the future of both hill farming in the uplands and the promotion of open-air access and, indeed, tourism in rural areas. In many ways, the Foot and Mouth Disease outbreak has demonstrated in the most dramatic way possible just how intricately different land uses are linked in the uplands. No two land uses can be considered separately; rather they interact and influence the patterns of nature and land use in different parts of the country.

There are huge opportunities and challenges ahead for people who want to work in the British uplands. People need to combine the strengths of different disciplines, and to be mindful of the dynamic nature of changes in the past, and ahead. We hope this volume makes a contribution to developing our understanding of the uplands. In particular, we hope that it reflects the integrated approach that researchers and practitioners are increasingly adopting.

Finally, we should like to thank the following people for their help in organising the conference, and editing the proceedings: R. J. Allison, R. Baxter, D. L. Higgitt, B. Huntley, J Munneke and S. Johnson. We are especially grateful to Charles Gimingham for penning a Foreword to the volume, based on a visionary presentation he gave to the DEFRA/JNCC workshop in April 2002. It is refreshing to begin this volume with a spirited vision for the uplands.

Tim Burt, D. B. A. Thompson and Jeff Warburton ,
Durham, May 2002

FOREWORD

A vision for the Uplands

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I am very pleased to provide a Foreword for this publication, which draws together a substantial amount of research and thinking on the British Uplands. I want to set out a vision for the uplands.

Let me begin with three quotations. First, in 1955 Fraser Darling famously wrote 'The bold unpalatable fact is..... that the Highlands and Islands are largely a devastated terrain'. More recently, Des Thompson of SNH wrote in 1995 "The uplands hold a special appeal..... perhaps it is the scenery, the great character of the land..... these places are a living expression of nature and our culture..... with roots as much in the great geological epochs as in the tenacious grip of man". Finally, these familiar words from the Book of Proverbs are directly relevant to our theme: "Where there is no vision the people perish".

Sadly, for too long there has been little in the way of a broad vision for the uplands. True, there have been insights into particular aspects of land use such as forestry, livestock improvement, management for sport, tourism or nature conservation – but these have been only limited insights based on sectoral interests, with no inspiring vision. What has been the result? I would argue that we have had exploitation of the resource, depopulation and loss of rural communities, ecological degradation, declining productivity, reduced incomes, and reduced biodiversity.

Is this too bleak a picture? Certainly, there have been notable exceptions and localised areas of welcome improvements, but it can hardly be denied that by and large this is what has been happening in the uplands. Within our lifetime people have become increasingly aware of it, and this includes those whose livelihoods are in the uplands and those who come to them as visitors from elsewhere but value them no less.

Some values of the uplands

We need a new vision, but first I want to comment briefly on some of the attributes of the uplands which, I believe, are most widely valued, and ask whether these are being effectively maintained at the present time.

The uplands offer supreme landscapes which have an intangible value for the psychological and spiritual wellbeing of residents and visitors alike. They provide habitats for an internationally important range of fauna and flora – they are, in other words, a reservoir of biodiversity. For many generations the uplands have also been valued as a source of livelihood for people living and working there in settled communities. They provide grazing for domestic animals, fuel in the form of wood, peat, timber for buildings and boats, locations for recreation ranging from walking, mountaineering and skiing, to sports such as stalking and shooting. The uplands have become an attractive venue for tourism in all its forms.

What we have is a heritage of a wide variety of valuable attributes and benefits, some of which are there for the taking while others have been made available through active management. This management has not always been sensitive nor sustainable.

The current state of the uplands

The uplands undergo constant change. They are far from the pristine wilderness, stable and enduring, which people have sometimes thought them to be. What we now have are relatively open, treeless landscapes, certainly of great beauty and still giving a sense of wildness and remoteness. But, except at the higher altitudes, it has not always been like this. Change has gone on progressively, and has accelerated since the Neolithic period. At that time it seems there was an extensive, though patchy, woodland cover up to a potential tree limit of around 650 metres or so. In the north west Highlands, the original woodland was composed predominantly of pine and birch, but consisting elsewhere in the British uplands of various broad-leaved trees. The tree cover was interspersed with open patches, glades and clearings, and with peat bogs on poorly drained land. But now there is extremely little left of anything remotely resembling the original woods, which have now been reduced to less than 2% of their original extent.

In their place we have extensive moorlands, grasslands, and in places (especially in the wetter western areas) peatlands. There has been change, at first gradual, over at least 5,000 years. Although during this period the climate has oscillated, the landscape changes have largely been driven by human activity, through clearing the woodlands and using the heaths and grasslands at first for low intensity mixed grazing, usually by cattle and to a lesser extent sheep. The more productive grasslands on the better soils were supplemented by the rougher acidic pastures and by the heather moors. Such land use was more or less sustainable over a long period, with only very gradual further ecological change, up to about 200 years ago (e.g. Ratcliffe and Thompson 1998).

Since that time change has been much more rapid, first due to the growing flocks of hardy hill sheep, largely displacing cattle, and then to management for the increasingly lucrative sporting activities. In very recent times, with the advent of the CAP, we have seen the subsidies to hill farmers, based on headage payments, further encouraging increased livestock numbers and exacerbating the effects of over-grazing.

The outcome is there for all to see. Heather-covered moorland has been declining at a considerable rate, in Scotland by almost a quarter since the 1940s (the Moorland Working Group 2002). Moorland has been replaced by coarse grass swards, such as *Molinia* (flying bent) and *Nardus* (mat grass), or sedge moors on peaty ground, and bracken on drier hills. Even the better grasslands which can withstand heavier grazing have suffered losses of up to 40% or more, for example in Wales.

Of course, this ecological deterioration has not been uniform over all our uplands, but the trend from more productive vegetation, with greater variety in the herbage, towards large areas dominated by less nutritive, less palatable 'aggressive' species, has been widespread. We have been presiding over the progressive degradation of a valuable asset, not only for hill farming or for sporting interests, but also in terms of landscape and wildlife conservation, because with these changes go losses of biodiversity. And to add to these trends, damage has been caused by increased visitor pressure leading to erosion of footpaths, and by careless introduction of bull-dozed tracks in connection with both forestry and sporting activities.

A vision for the uplands?

A better deployment of funds to counteract these trends and to secure a more enduring future for the uplands is needed. Our aim cannot be one of preserving the present *status quo* without change, even if we wanted this, because change is continuing whether we like it or not. What we can do is to have some influence on future changes. So, we sorely need a vision in order to be clear on what we are aiming for, and on priorities. Such a vision cannot be one of passive protectionism, but it must focus on what has to be done to ensure improvements. As an ecologist, I have a broad vision, one of seeking to pass on the uplands to subsequent generations in a condition of ecological health.

My vision for the uplands in the future is of an ecologically revitalised terrain – in which all parts are functioning healthily and relating effectively one to another because of integrated management. Let me present six glimpses of the future, as part of my vision.

Glimpse 1 is directed to the high altitudes – the mountain core, where we have montane grasslands, heaths and tundra-like vegetation. Our top priority here is to conserve these areas in as near a natural state as possible, with the landscape and wildlife evolving naturally. But some management is essential, and in addition the needs of recreation will be accommodated in areas sufficiently robust to sustain it. Elsewhere the 'long walk in' principle will be maintained.

Glimpse 2 is directed to the mid and lower altitudes, revealing revitalised local communities of people, increasing modestly in numbers, and perhaps settling again in some of the glens and valleys once occupied. There will be more work here, and more and better management, as the skills of the people will include not just those of hill farmers, foresters and gamekeepers but also of those providing for tourists, and landscape managers (including restorers of degraded vegetation), conservationists and countryside rangers. Many of these skills will be combined in the same individuals so that whilst agriculture retains a very central place, production is no longer the be all and end all, and rewards for those more broadly-based occupations will allow even the smaller farms to survive and indeed prosper.

Glimpse 3 sees a countryside with more woodland cover – more of a mosaic. On the one hand, we will have more small woods, especially in the valleys and on sheltered slopes, arising where possible from natural regeneration and affording more diversity of vegetation and wildlife. This will improve not only the landscape but also the environment generally. On the other hand, we can hope to see an expansion of the larger remaining fragments of native forest. And there will be room too for commercial forestry (but not in huge uniform blocks), and for more community woodlands in the vicinity of settlements.

Glimpse 4 sees vistas of open country because we will still need grasslands for sheep walks, and moorland for both sport and its landscape and biological value. But again more diversity will be sought, through integration with woodland, so that we get away from the monotonous 'pastures' of low productivity. We will need to reduce over-grazing by sheep and restore a better mix with cattle. We will need to reduce deer numbers on moorland and halt the decline of heather. We will want to move away from subsidies geared solely to production, by rewarding sound ecologically based countryside management and conservation.

Glimpse 5 shows up better water resource management. The uplands will still need to supply good quality water to lowland areas – but our lakes, lochs and rivers, and our wetlands and peatlands will be better protected, not exploited. There will be more broad-leaved trees on river margins, and flood prevention will become not a question of engineering, but a consequence of whole catchment management. In this way fish populations – so important – and other wildlife will be enhanced.

Glimpse 6 involves a glance at the whole panorama and reveals a more attractive, diverse landscape. Habitats of special national and international conservation value will still be designated, and their protection will be strengthened with stringent penalties for damage. But these alone cannot ensure a healthy future as the area covered by such features will still be small in proportion to the whole. The rest of the country should be managed on sound ecological principles. This requires knowledge and understanding, and often needs to be bolstered by more and new research. Our vision must embrace the whole of the uplands and result in integrated management, planned on a broad, non-sectoral basis.

Land use planning is a difficult area because landowners, managers, farmers, foresters and sportsmen do not like to have interference with their particular interests or traditional activities. But if we are to arrest downward trends and to achieve a more healthy mosaic of vegetation and habitats in the uplands, we must move towards integrated management strategies which embrace not just individual parcels of land – whether farms, estates or particular hills or glens – but whole regions which have a geographical or ecological individuality, and which can support a variety of uses.

In addition, as part of this vision, communication must become more effective. Each major upland area will have its own reference literature, bringing together different perspectives on land use and management. As examples, reference may be made to the recent book *The ecology, land use and conservation of the Cairngorms* (Gimingham 2002), and to the recently published SNH 'Natural Heritage Futures' publications on 'Mountains & Moorlands' and on the 21 component geographical areas of Scotland (Scottish Natural Heritage 2002). It is important that such documents set out essential information on the ecological background and the requirements of integrated management. Such management should operate within whole biogeographical zones, and not just across individual farms or estates, and the documentation should incorporate the variety of land uses encountered.

I am not advocating hard and fast rules, but an imaginative approach to land use planning where the needs of local communities and of countryside conservation are balanced. Whilst this, in certain areas, may require the retention of quite large tracts of well-managed moorland or pasture where hill farming or sporting interests can be assured a future, we can also envisage more of a mosaic, more diversity, with contributions of semi-natural woodland, richer and more varied grasslands and heathlands, each on its appropriate soil type, where better nutrient cycling, hydrology and shelter would encourage and sustain greater biodiversity as well as a reasonable level of productivity.

All this, of course, will have its cost. But I believe we need to consider ways of diverting funding away from the concentration on production alone, towards countryside management to enhance other aspects of value. Such is my vision for the uplands. Essentially I am seeking better stewardship of our natural resources. I hope this stimulates discussion amongst those with an interest in the British Uplands – not least the dynamics of change ahead.

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26 April 2002

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SECTION 1

FACETS OF THE UPLANDS: PERCEPTIONS AND RESEARCH

In this introductory section, three authors with considerable and varied experience of the British uplands set the scene for what follows. Indeed Bill Heal's first sentence, recalling the three themes of W. H. Pearsall's seminal book *Mountains and Moorlands* - integration, diversity and change – might provide a motto for the entire publication. Heal reiterates Pearsall's view that the results of scientific research, combined with experience, can provide an integrated view of the uplands and provides a context for some of the emerging issues such as climate change and sustainable development. As befits someone representing the Association of National Park Authorities, Ian Mercer focuses on the way in which the uplands are organised – administratively, economically and environmentally, emphasising social linkages throughout. Both authors stress the need for an integrated view of the uplands, not just in relation to the areas themselves, but bearing in mind also their place within the country as a whole. Ian Simmons takes an historically longer view of environmental history in the British uplands, viewing both its ecology and economy. Intertwined in these histories are the changing attitudes of people to the uplands – from wild land, wilderness and wasteland through resource production to tourism and recreation.

1. Uplands: the research base

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The baseline

Three fundamental themes pervade W.H.Pearsall's 1950 seminal book *Mountains and Moorlands* - integration, diversity and change. He repeatedly shows how geology, climate, soil and human management interact with biology to generate landscapes. The rich upland diversity is seen not only in the species present but also in the processes, mechanisms and dynamics. Change through weathering, climatic variation, organic matter accumulation, leaching, vegetation succession, and human influences are always with us.
"Nature is never static …… the trends of soil and vegetation operating today determine what the conserved site will be in the future, and it will often be unlike what is there now. We must therefore study these trends and be prepared to guide their development if we are to reach the desired end." (p 271).

The insights which Pearsall provided fifty years ago remain as guiding principles today. He clearly used the results of scientific research, in combination with his own and others' experience and expert opinion, to formulate his vision of the mountains and moorlands. He also repeatedly drew on evidence of past conditions to understand the ecological and human responses to change. So, how strong is our research base? How has it changed over the last fifty years? Is it suitable to answer the current questions about the future of the uplands? To consider these questions a highly subjective sample of four research subjects is taken to illustrate some of the changes which have emerged and their relevance for the future.

Variations in the research base

An insect response to climate change

Neophilaenus lineatus, a sap-sucking homopteran feeding on *Juncus squarrosus* produces a foam (cuckoo spit) to protect immature stages. Following a three-year intensive study of its ecology at the Moor House NNR in the North Pennines, John Whittaker (1998) exploited the ease of sampling the spittal of *N. lineatus* to continue to follow its population performance over 37 years! There was little evidence of density-dependent regulation; weather factors explained much of the variation in numbers. Weather conditions in September when oviposition occurs, influenced change more than mean annual temperature. In marked contrast to Moor House, populations of *N. lineatus* at a low altitude site in Oxford exhibited strong density-dependent mortality through a parasitoid which does not attack *N.lineatus* above 400m.

Using cloches at Moor House, the mean annual canopy temperature was raised by about 1 °C, equivalent to 0.4 °C in September. As a result hatching was prolonged and maximum numbers were reached 15-20 days earlier than in control populations (Figure 1.1). Finally, model extrapolations indicated that a 1 °C rise would increase populations of *N. lineatus* by about 50% at Moor House and could extend the altitudinal range of a population on Ben Nevis, Scotland by about 300m.

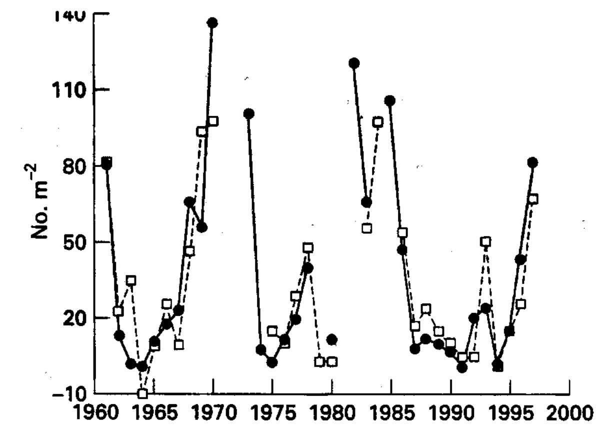

Figure 1.1 Variation in population density of *Neophilaenus lineatus* at Moor House NNR from 1961 to 1997. • measured numbers m^{-2} ; □ calculated numbers m^{-2} based on mean monthly minimum temperature and population density [2] based on mean monthly minimum temperature and population density both for the previous year (Whittaker, 1998)

Clearly, different factors control populations at different parts of the range *of N. lineatus* with dominant responses to climate occurring only at the edge of its distribution. The density-dependent regulation at lower altitudes is likely to buffer the population response to climate variability. This has important implications for determining how and where species respond to variations in climate and for conservation management of upland species. The study also illustrates how high quality fundamental research by individuals, based on theory, using a variety of approaches and over long periods, can make important contributions to understanding the potential effects of one of the new upland issues – anthropogenic climate change.

Changes in national upland biodiversity

Despite excellent descriptions of the main vegetation communities in Britain, by the 1970s we still had no good national information on their amount and distribution and no system to determine change. In response, the Countryside Survey was designed through the ecological expertise of Bob Bunce and the statistical vision of John Jeffers. Based on 32 objectively determined land classes for Great Britain, the land cover of a sample of 256 1km squares was mapped and within each square a series of quadrats generated species composition and other information. The first survey in 1978 generated national estimates of major types of land cover and species distributions. These corresponded well with and extended the agricultural and forestry estimates although the accuracy of the estimates of smaller cover types was limited by the sample size.

Subsequent surveys in 1984 and 1990 improved the accuracy through expanded sampling and also quantified changes in cover and vegetation composition (Barr *et al.* 1993). For much of the lowlands (arable and pastoral landscapes) the number of plant species declined between 1978 and 1990. In contrast, in marginal and upland landscapes, species number per quadrat tended to increase in moorland vegetation in marginal landscapes from 12.4 to 16.3 (+31.7%) and in upland landscapes from 18.9 to 20.2 (+6.6%). The change in the inherently species-poor moorlands results from an increase in species associated with disturbance and enrichment probably reflecting agricultural improvement and extension of forestry.

The Countryside Survey, developed by the Institute of Terrestrial Ecology (ITE – now the Centre for Ecology and Hydrology (CEH)), was ahead of its time. It was planned as a scientific contribution to British ecology and a framework to quantify land cover and vegetation change. However, the Department of the Environment (DOE) recognised its potential as a strategic tool for countryside management and its value was considerably enhanced with the advent of the Biodiversity Convention. Countryside 2000 is now nearing completion, with strong support from the Department of the Environment, Transport and the Regions (DETR) (Haines-Young *et al.* 2000). In the present context, it contrasts with Whittaker's study of *Neophilaenus* as a major team research project run by an Institute. The Countryside Survey quantifies the national rate and direction of change whereas Whittaker's study explores the controls of change in a particular species. The two studies represent complementary approaches to understanding change. Both provide important contributions to our research base, one through strengthened theory, the other as a major national database.

Changes at the moorland fringe: causes and consequences

In upland landscapes there is usually a core area of moorland which has remained as moorland for centuries. The associated lowlands have historically been under various forms of agriculture. It is the interface between these two distinct systems, the moorland fringe or marginal land, which has been subject to major changes in management in the past, and potentially in the future. Within the moorland fringe agriculture expanded and contracted largely in response to the frequency of climate-induced crop failures. These general finding are based on a study by Martin Parry of old maps, records, field observations and air photos in the Lammermuir hills in south-east Scotland and National Parks in England and Wales (Parry, 1976; Figure 1.2). Parry's study shows not only that changes in land use are a recurrent phenomenon, but that they are mainly focused on particular areas where climate is the main controlling factor, modified of course by soil. While upland improvement is rapid, reversion is slow. Ball *et al.* (1982) surveyed twelve upland parishes using Parry's approach; although some pastures reverted to shrub heaths within forty years, others only developed heaths similar to the adjacent moorland after more than 130 years.

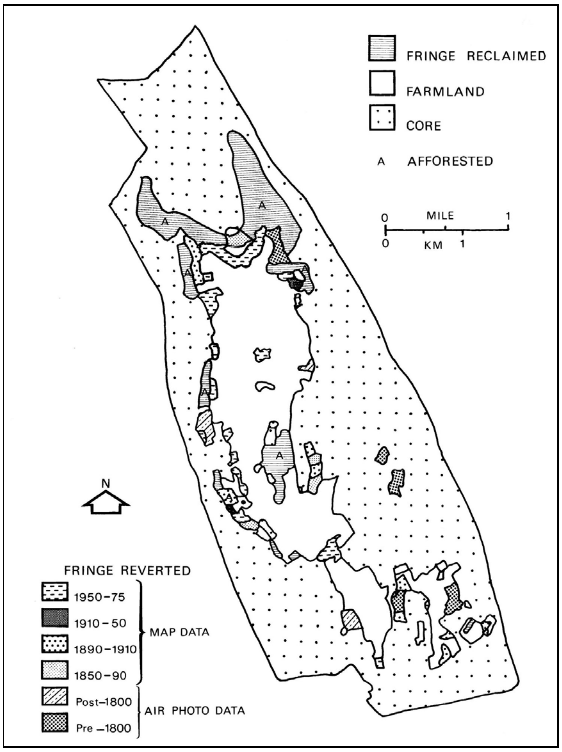

Figure 1.2 Historical changes in the moorland core, moorland fringe and farmland in Bransdale, North York Moors National Park. The majority of land use change is concentrated in the narrow interface between moorland and farmland. (Ball *et al.*, 1982)

The causes of change may not only be through the climate – land use interaction. Social factors can influence management and through that the diversity of habitats and species. For example, 'pluriactivity' i.e. employment and income within a farm household gained from non-agricultural activities, can influence farm management practices. In a combined social, economic and ecological study of pluriactivity in Scotland, the plant species diversity of improved grasslands in Grampian Region was related to various social and economic factors (Ellis *et al.*, in press). The main feature was that older farmers, with their household totally concentrated on agriculture (i.e. non-pluriactive), had pastures which contained lower number of species and fewer non-agricultural species than farms involved in various forms of pluriactivity (Figure 1.3).

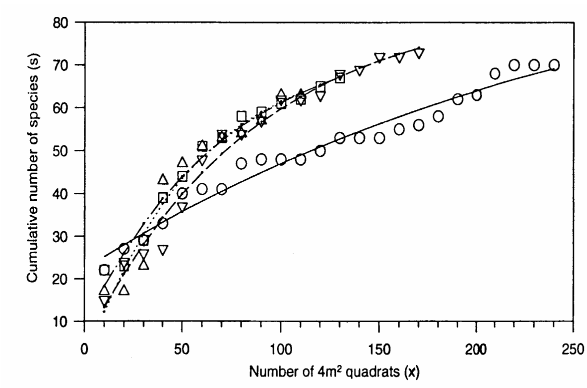

Figure 1.3 Numbers of species in grassland on non-pluriactive and pluriactive farms in Grampian Region of Scotland.
O Non-pluriactive farms (25 farms, 250 quadrats); ∇ Pluriactivity off-farm (19 farms, 170 quadrats); – Pluriactivity on-farm (13 farms, 110 quadrats); ↑ Pluriactivity both on and off-farm (14 farms, 130 quadrats). (Ellis, 1994)

The Grampian study is a microcosm of wider patterns of change in land use and management. A social survey of occupiers of land surveyed in the Countryside Survey showed that farms in upland and marginal areas tended to have been more stable in the past than in Arable and Pastural landscapes, probably due to lack of opportunity (Potter *et al.*, 1996). Ecological changes matched this pattern. In general, ecological change is taking place on a relatively small number of farms and land use change has become more farm- and location-specific in the recent past.

The above studies highlight the following:

i) Analysis of historical events using a variety of tools can explain current, and possibly future patterns of land use, land cover and ecological succession.
ii) 'Space-for-time' sampling provides a valuable complement to experimental manipulation.
iii) Much value can be added by using earlier, well documented research.
iv) Interaction across disciplines can expand understanding of factors influencing land management and biodiversity, understanding which can focus policy.

Integration and multiple effects

"Familiarity with upland vegetation leaves one impression very firmly fixed in the mind of the observer, and that is the idea that the vegetation is in a constant state of flux." (Pearsall, 1950, p 206). The main post-glacial successions of moorland plants and associated fauna, including 'degeneration', result from a combination of geological, topographic, climatic and human factors. Pearsall's initial diagrams of succession have been developed by Miles (1985) and others and subsequently translated into computerised mathematical models. The development of such models has provided a powerful tool for integration of complex information, providing spatially explicit representations, acting as testable hypotheses, and providing Decision Support Systems for managers.

The Macaulay Land Use Research Institute (MLURI) has played a leading role in the development of upland management models, based on extensive understanding of the basic processes. For example the HILLDEER model (Buckland *et al.*, 1998) encapsulates understanding and experimental evidence of the effects on vegetation composition of different grazing intensities of deer and sheep. Figure 1.4 illustrates the successional change in composition of vegetation under the extremes of no and heavy grazing. Spatial variations express the influences of patchiness of the vegetation mosaic and of topography. Thus both deer and sheep remove much less heather (*Calluna vulgaris*) when it is more than 200 cm from the edge of a grass patch, and utilisation of heather is often twice as much on the uphill edge of a heather patch than on the downslope edge.

Models such as HILLDEER integrate knowledge gained over decades by many individuals and groups of researchers. Thus the modern technology enables incorporation of current information onto the base established by previous research and field experience. The models are not new, but they now quantify and codify, in an explicit form, much of the understanding of earlier upland observers and practitioners.

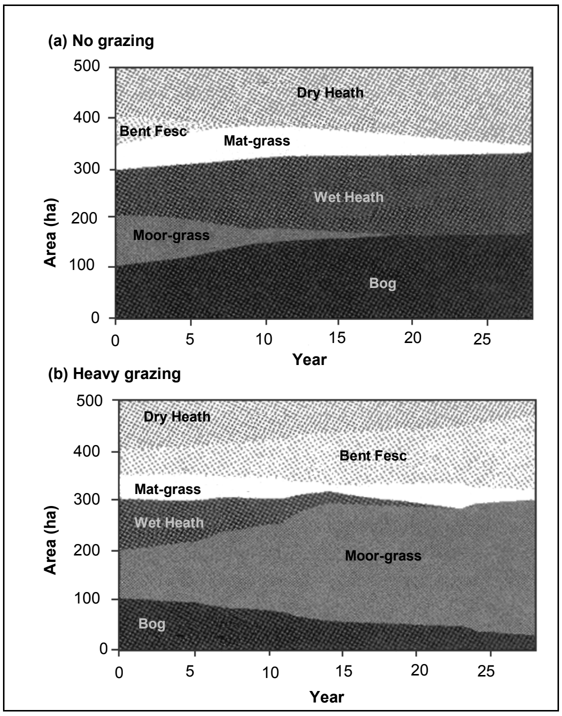

Figure 1.4 Projected change over 25 years in the extent of six upland vegetation types under two simulated management scenarios
(a) no grazing and (b) heavy grazing (MLURI, 1998)

Conclusions: New Issues, New Research

Pearsall still shows us the way forward by building on a firm foundation of research and experience. Times have changed; there are new issues and new research techniques. New issues relate to three main interacting drivers of change in the uplands:

- **Climate**
  Pearsall considered climate variation as a natural phenomenon occurring over centuries. Now we are considering more rapid climate change resulting from the addition of anthropogenic carbon to the atmosphere (Hulme & Jenkins, 1998). By 2080, annual temperatures are expected to rise by 1.2 to 2.6^{o}C in Scotland and slightly more in southeast England. Warming will be slightly more rapid in winter than in summer and annual precipitation will increase between 5 and 20% in Scotland, mainly in winter and autumn. These are major changes which represent a global influence not envisaged by Pearsall.

- The last 50 years have seen a dramatic proliferation of policy and legislation, and of sectoral interests. This Volume (and the Conference which preceded it) bears witness to the plethora of sectoral organisations, designations, directives and regulations which now impinge on land managers. At a time when the call is for a more integrated approach, policy is fragmented. Further, the environment and market forces are increasingly driven by international and global factors, while implementation policy is localised.

- **Atmospheric pollution**
  One feature which has not been considered so far in the paper, is the influence of chemical inputs from the atmosphere. Acidification, linked to high rainfall and unbuffered soils, has been a major influence on the recent ecology of the uplands. Sulphur deposition is now subject to controls and is declining but nitrogen deposition will probably continue to increase, at least relative to sulphur. Soil – vegetation – herbivore responses are complex but there is evidence of changed growth and competitiveness of *Calluna* with resulting expansion of grass on some moors (Lee, 1998; Lee & Caporn, 1998). Once again, new external factors enter the equation of upland ecology. Nevertheless, basic research and understanding of nutrient dynamics will continue to underpin any assessment of the consequences of changing inputs.

Issues which impact on the uplands have changed but the research is also changing. The research base has evolved along at least four lines, partly in response to new issues.

- **Long-term studies**
  There has been a marked shift from descriptive to experimental research and greater emphasis on long-term information. At least four trends are detectable:

(i) The 1950s and 1960s saw a major effort in establishing, for example, grazing, burning and forestry experiments. Some of these still exist and provide opportunities to determine long-term ecological responses (e.g. Marrs *et a*., 1989).
(ii) More recently, the limitations of short-term signals from experiments have been recognised and extended observations encouraged, despite the limitations of funding mechanisms.
(iii) Monitoring, an unfashionable activity until recently (Burt, 1994), has become a key policy requirement to provide quantitative information on stock and change in environmental resources – environmental accounting (e.g. Haines-Young *et al*., 1996). The Environmental Change Network, established in 1992 with integrated, standardised observations at a limited number

of sites, now has 15 participating Government Departments and Agencies, reflecting a change in attitudes (Sykes & Lane, 1996)

(iv) Palaeobotany and related historical approaches have also received a resurgence of support. Application of stable isotope, genetic and other techniques applied to soils, sediments, ice cores and other natural ‘archives’ reveal the dynamics of past change (Huntley, 1996).

- **Integration**
  The value of individual studies and accumulated experience will always be important. However, the need for more interdisciplinary and/or large-scale information has forced a trend towards team research. Again this is illustrated in the Countryside Survey. A large team of terrestrial plant ecologists and statisticians generated a national information base. This has been expanded through involvement of freshwater and soil ecologists, entomologists, vertebrate ecologists, remote sensers, land managers, sociologists, economists, etc., to provide an integrated view of change in the British countryside. Integration across disciplines is probably the greatest challenge because it represents a marriage between different research cultures.

- **Prediction**
  Changes in climate, land use and pollution, interacting with the needs of policy, have resulted in a new type of research question: “What if…..?” The ability to assess potential consequences of change in the drivers (climate, land use, pollution) and in the application of policy options, is now a major requirement of research. The climate-change scenarios developed by the Inter-Governmental Panel on Climate Change (IPCC) and the mapping of critical loads have been particularly successful in focussing research and guiding policy. The massive developments in computing have facilitated integration of information into a wide variety of models; a capability unavailable to all but the cognoscenti until recently.

- **Sustainable Development**
  The final issue on the agenda is Sustainable Development. Pearsall did not use the term but he addressed the question (p272); “…treatment of upland country, for either of these two main purposes (*conservation or utilisation*), will involve development…” He went on to consider the dynamic nature of the system and management options, concluding that “Any continued form of economic production will depend on this [the building of soil fertility] being done and upon the possibility of maintaining the improved status.” Thus, Pearsall envisaged forms of development in the uplands which were economically and ecologically sustainable. He did not argue for a particular endpoint nor did he get immersed in definitions. His approach was close to the view of Young (1998) that “Sustainable Development is an analytic framework intended to provide structure to thinking about human-environment relations”. Young adds: “It is helpful to draw a distinction between endogenous and exogenous threats to sustainability.” A particularly innovative example of the analytical framework approach is the analysis of options for change in social, economic and ecological value on the Glen Tanner estate (Moss *et al*., 1994).

Finally, it should be noted that this paper has been highly selective in sampling the vast literature on uplands, but it indicates the wealth of available information and the potential value of revisiting past results, sites and experiments. We now have a powerful array of techniques and approaches with which to address particular types of question (Figure 1.5). One of the key challenges is to overcome the disciplinary, sectoral and institutional boundaries. This is essential if research is to address the overarching issue of Sustainable Development, building on the fundamental characteristics of upland systems identified by Pearsall – integration, diversity and change.

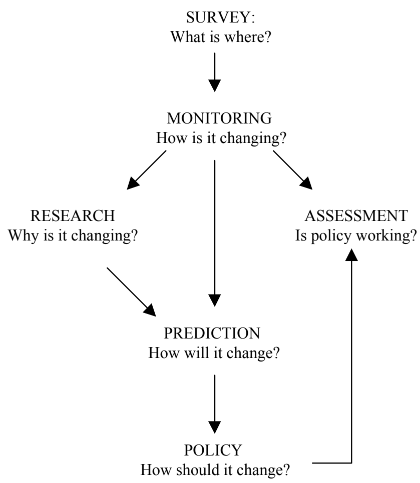

Figure 1.5 ` Different questions, different approaches.
A schematic representation of the relationships between the different questions that are addressed in understanding upland change and the approaches used. Note that the term ‘research’ is used in a limited sense to identify experimental approaches, but that it is only one component of ‘research’ in the wider sense including survey, monitoring and prediction

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2. " …the hills in order..."

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Society's organisation of the uplands in the 20th century

Long ago, it now seems, Sir Halford Mackinder divided Britain. Most geographers will remember the "Exe-Tees line", separating sheep and mist from wheat and sunshine. Fifty years on from Mackinder, in the Introduction to *Mountains and Moorlands* by W.H. Pearsall (New Naturalist series), the editors' first line is: "There are really two Britains — two different countries ….." and Pearsall's own first lines are: "A visitor to the British Isles usually disembarks in lowland England. He is charmed by its orderly arrangement ……. mellowed by a thousand years of human history. There is another Britain, to many of us the better half…. It lies now, as always, beyond the margins of our industrial and urban civilisation fading into western mists and washed by northern seas, its needs forgotten and its possibilities almost unknown". That was 1950 - half time in the 20th Century.

We must not forget in all this the more general and near-poetic attitude of others besides Pearsall's 'many of us', by whom he presumably meant other botanists and New Naturalist readers. The romantic for many more is expressed by the 'blue remembered hills', 'the mountains of longing', 'lifting up mine eyes', even the 'freeman on Sunday', and a myriad of claims like them.

Can I remind you of the three kinds of organisation which have been imposed (almost entirely in the 20th Century) upon the long-lived agricultural and estate-managing communities of the uplands. Long before the 20th century, those communities organised themselves into the (often shared as common) open hill and the enclosed hill.

My 20th Century organisational impositions are:

- socio-administrative — national and local government;
- socio-economic — first by the UK then the European Union; and
- socio-environmental (in the landscape and nature conservation senses).

Socio-administrative organisation

This has a national element of great age, but devolutionary government means it is very real again. How the Welsh and the Scots became largely confined to their hills is a matter of record, and none of our business here particularly. How they and we sub-divide our national homelands is a matter of greater importance for my brief thesis here. Without exception, we have confined no local authority area - district, county region or unitary - to the hills. All have lowland components, and where they are big enough, the administrative and dominant market centres are well into that lowland. They often coincide with the market bases historically situated at the junction of hill and lower land, where ale and fruit were exchanged for potential meat and actual fibre.

The important point is the reflection of the national population-weighted socio-political situation at the local authority level. Governance is dominated by lowland urban thinking, even when it is positively about the hills.

Socio-economic organisation

This is largely about the relatively recent recognition by the administration of the needs of the hills and especially their communities.

Over the last 50 years - starting with the Hill Cow Subsidy - the uplands have become the recipients of more and more complicated support systems for the agricultural industry and latterly for community enterprise. Public interest in forestry pre-dated the post-war farming attention, and must not be forgotten in any analysis of the hills and their ecological cover, which is the main intention here. It may not have been confined to the hills, but land prices and fiscal incentives made the hills a prime location for that particular manipulation of land use.

Since 1948 modifications and spatial application of aid and incentive have mostly flowed from the EEC, as it itself evolved into the EU. This meant that, for instance, Less-Favoured Area and Severely Disadvantaged Area status came to be applied to all the British uplands and spilled over on to a good deal of land not reaching whatever altitude we are using as a baseline today. The Highlands and lslands had Objective 1 status under the Structural Funds of the EU conferred upon them some time ago (though they lose it soon entering into what is known as a 'Special Transition' phase'), but at the same time western Wales will acquire the new Objective 1 application as will, for our purposes, Bodmin in Cornwall. On the other hand, most of the hills of England and Wales have enjoyed Objective 5b status for the bulk of the last decade and much European cash has been deployed there as a result. Meanwhile, in this country, others are attempting to influence the UK Government about the designation of the areas which will benefit from the various EU support funds. Some of the innovative use of these funds until 2001 has resulted in, or part-funded, schemes directly aimed at improving hill-farmers' balance sheets through environmental investment and revenue payment.

In the meantime, hill cow subsidies have become HLCAs and have been joined by beef suckler cow, and sheep premia, sheep quotas, and ESAs, which later became a component of the Agri-environmental zonal programmes which Directive 2078 demanded of all member states in 1992. For our purposes those programmes also included Countryside Stewardship in England, *Tir Cymen* in Wales and a Moorland scheme, a Habitats Scheme and an Organic Farming Scheme. I rehearse these things for the record, and I do not claim the list to be comprehensive.

Socio-environmental organisation

It is fair to record here that the original desire for (or recognised need for) socio-environmental protective organisation (the third layer of my palimpsest) pre-dates the other two. Just as Lords of the Manor or their equivalent ruled the division into open and enclosed hill, so royalty had protected hill country - as hunting forest - before the Conquest, and it is worth noting that the legal protection of landscape elements like woodland was purely for recreation purposes even then.

But back to the 20th Century: in 1999 we celebrated the 50th anniversary of the founding legislation for modern environmental protection in England and Wales. Only two years earlier we had nationalised land use (calling it Town and Country Planning) and cemented price reviews and subsidies (including the hill cow one) in the Agriculture Act, innocently protecting farmers from planners the while. The importance of those two things is that what followed in the 1949 Act relied upon planning for its protective base and overlooked the effect that farmers might have on land-use change (within a legal 'use class') even though the potential for dramatic change (and without hydraulic power!) had just been demonstrated over six years of war-time agriculture. John Dower's seminal essay of 1945, which first articulated a protective system, listed the maintenance of 'established' farming (did he mean 'traditional'?) as one of the intentions of national park status.

I call it "socio-environmental" protection because, of course, it was recreational aspiration - need, even demand - which forced the pace as far as the legislators were concerned. Dower had recognised that when he made the rarely quoted point that his conservation recipe would not be afforded by society unless it, society, saw an immediate personal benefit in secure access to wilder countryside. Even nature conservation formulae were written in 1949 in terms implying that naturalists were indulging a form of specialist recreation, that this kind of science was an 'interest'. The phrase 'opportunities it affords for nature study', believe it or not, persisted from 1949 into the 1990 legislation which separated English, Scottish and Welsh countryside conservation systems.

Hobhouse attempted to turn Dower's vision into a workable administrative system. His committee decided it could not cope with landscape *and* nature conservation *and* recreation at once, so sadly (I think) it spawned Huxley's Committee to deal only with nature conservation. Nevertheless, the terms of the divorce did recognise the innate relationship between wildlife's need for space and the protection of blocks of many square miles as national parks, and conversely the contribution that wildlife (and not just vegetation cover) makes to the enjoyment of landscape - or something more rounded, say, countryside.

Although the Nature Conservancy had a Royal Charter earlier in 1949 and reported to the Privy Council, it was the National Parks and Access to the Countryside Act of December that year which provided it with the tools of the trade, all still in use, as well as what it did for the landscape and access to it.

The Act invented areas (now 'Sites') of Special Scientific Interest (SSSIs), and 'Nature Reserves'. It created 'Areas of Outstanding Natural Beauty' (AsONB), which Hobhouse had called 'conservation areas', and allowed access areas to be made by agreement or order. The access business was pursued further by requiring county councils to make definitive maps of their rights of way, and inventing long-distance footpaths, now national trails. It also, of course, established national parks, and a Commission to designate them.

Within 8 years, 10 National Parks had been designated in England and Wales - all with an upland core. Even the Pembrokeshire Coast is like the peel hanging from an apple core which is the Preselli. The National Parks cover 10% of England and Wales - in Wales they cover 25% of the land surface. If you add in the AsONB which occupy upland blocks – Bodmin Moor, the Quantocks, the Mendips, the Clwydian Hills, the Shropshire Hills, Bowland, Nidderdale and the North Pennines, then a considerably greater percentage of the upland of the two southern countries of Britain is administered as protected areas (Figure 2.1).

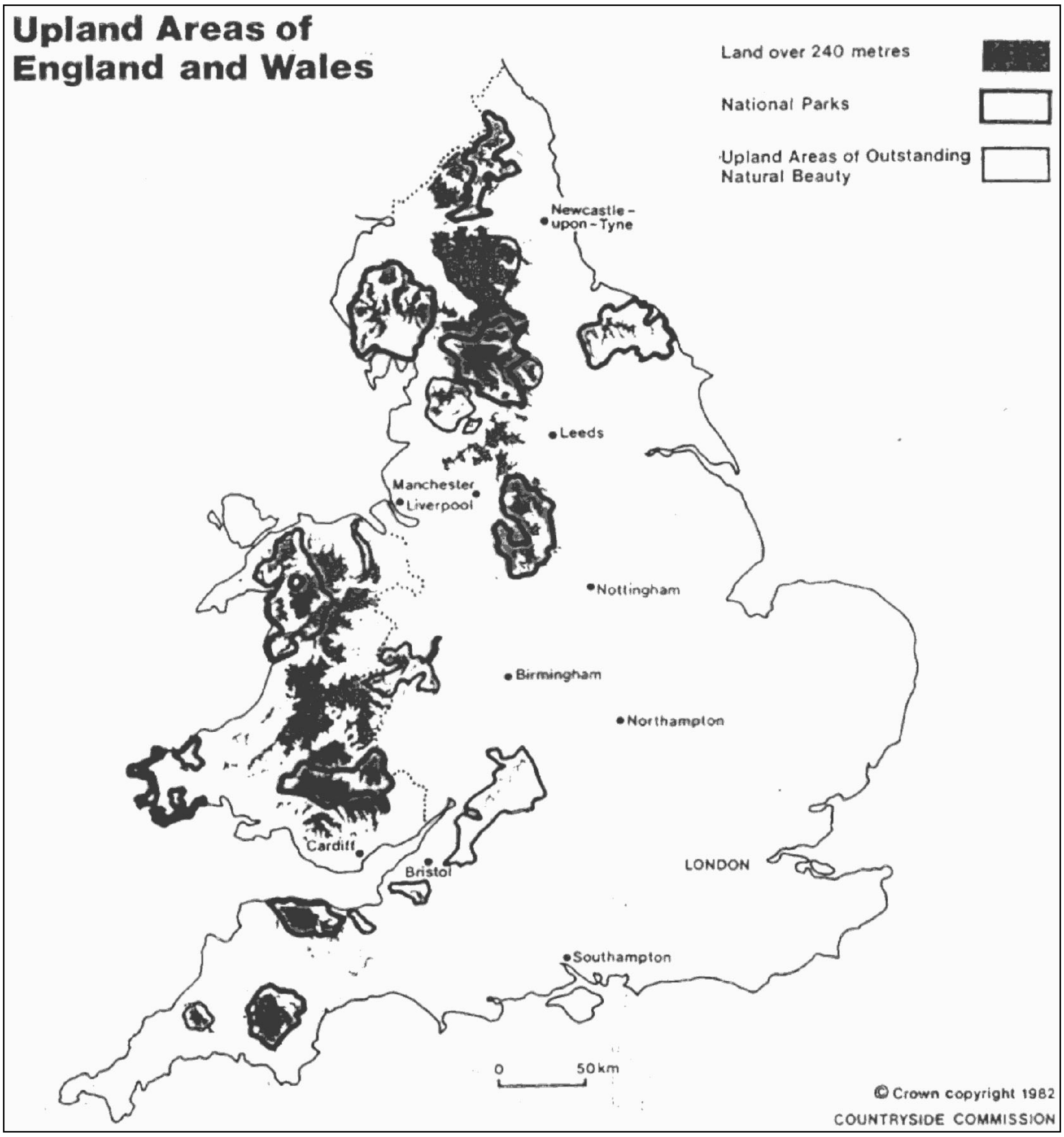

Figure 2.1 Protected landscapes of England and Wales (Source: Countryside Agency)

Adding SSSIs brings in the Berwyn, Plynlimon and the Elenydd and many other small upland 'sites' in Wales. Scotland dodged the landscape protection movement of 1949, though the nature conservation system was then applied to all of Great Britain. 'Nature knows no human boundaries' must have been the logic, though the lairds saw off those who thought that geomorphology and vegetation cover (the meat and drink of National Parks) were also 'nature'. Nevertheless Figure 2.2 shows Scotland's National Scenic Areas, and it is from these that Scotland's National Parks will spring, and the remainder will be variously strengthened. As in Wales, SSSIs and National Nature Reserves (e.g. Rothiemurchus) extend the cover in Scotland substantially.

It is also important to register in parallel with the socio-economic record, that European environmental designations overlie well-established UK ones. In the uplands, Special Protection Areas (SPAs) for birds designated under the EC Birds Directive, are either SSSIs or National Parks, and Special Areas of Conservation (SACs) under the Habitats Directive, are being effected in the UK through the SSSI mechanism.

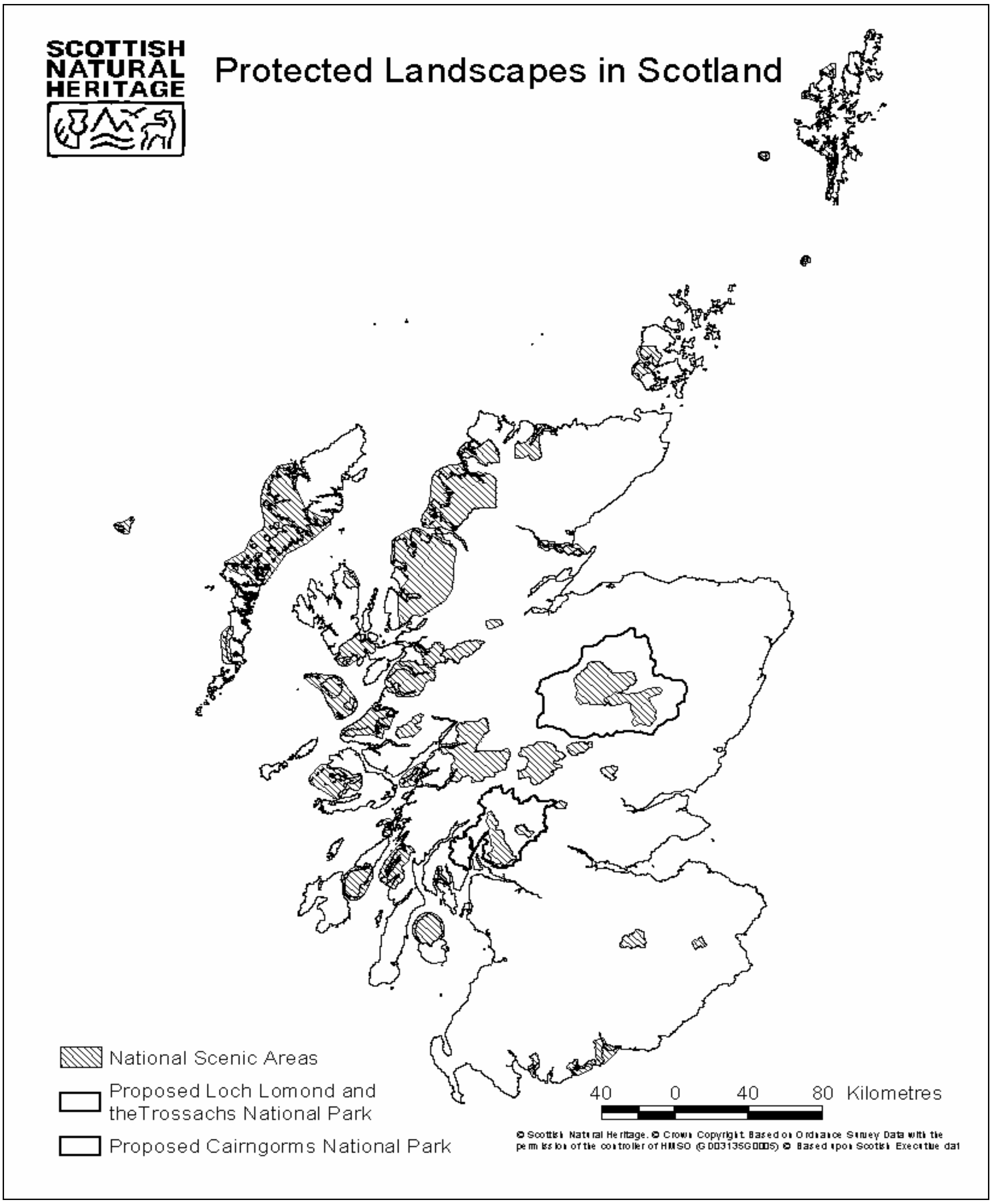

Figure 2.2 Protected landscapes of Scotland (indicating the potential Loch Lomond and the Trossachs, and Cairngorms National Parks). (Source: Scottish Natural Heritage)

Attempting an overview

How does all this add up? You may forgive me for using the Welsh situation to illustrate the totality. There are too many points I would like to make, but there are legitimate axes to grind.

The Welsh person in the street can still be forgiven for wondering why there are so many 'actors' in his / her field. Even with the virtue of a combined operation (falling to the Countryside Council for Wales (CCW)) to try to cure the Hobhouse/Huxley nervous split of 1947, and the Welsh Office decision to let CCW dominate the delivery of *Tir Gofal* (a lesser successor to *Tir Cymen*, I have to say), the tools of the trade are still confusing. *Tir Cymen* had the makings of a single tool to substitute for all those still at hand. Snowdonia National Park Authority's delivery of it (with the lowest administrative overhead in the tripartite experiment) pointed to a means of reducing the number of actors, and ensuring that those still acting were closer to the grass roots.

The Protected Area and Agri-environment maps (Figure 2.3) show an incredibly high proportion of the hills (in this case in Wales) classified somehow under, for lack of any other adequate umbrella, environmental protection codes. We should look very hard at integrating the systems that have grown up separately. For example, if you have an entity called a National Park, why not manage the entire conservation and protection effort within it as one process - while still retaining the scientific authorities at the national (designating and monitoring) level? It might then even be possible to subsume lesser (in spatial terms) designations within the overall status. But scientists are nervous of other scientists - the foreword to the Book of Common Prayer was never more true than within nature conservation: "…. nor can [we] expect that men of factious peevish and perverse spirits should be satisfied by anything which can be done in this kind by any other than themselves …. ".

While I am on this tack, is it not a shame that in the recent 'strengthening of the SSSI system', we could not return to the original statute and call these places "Areas" not "Sites", and change "Interest" to "Importance"? The second change at least does not change the acronym, of whose popular currency some seem proud, but it does get us off the hook of the real effect of "just someone's interest", or worse still "someone else's interest". Only "an interest"? We should know - and do - better by now.

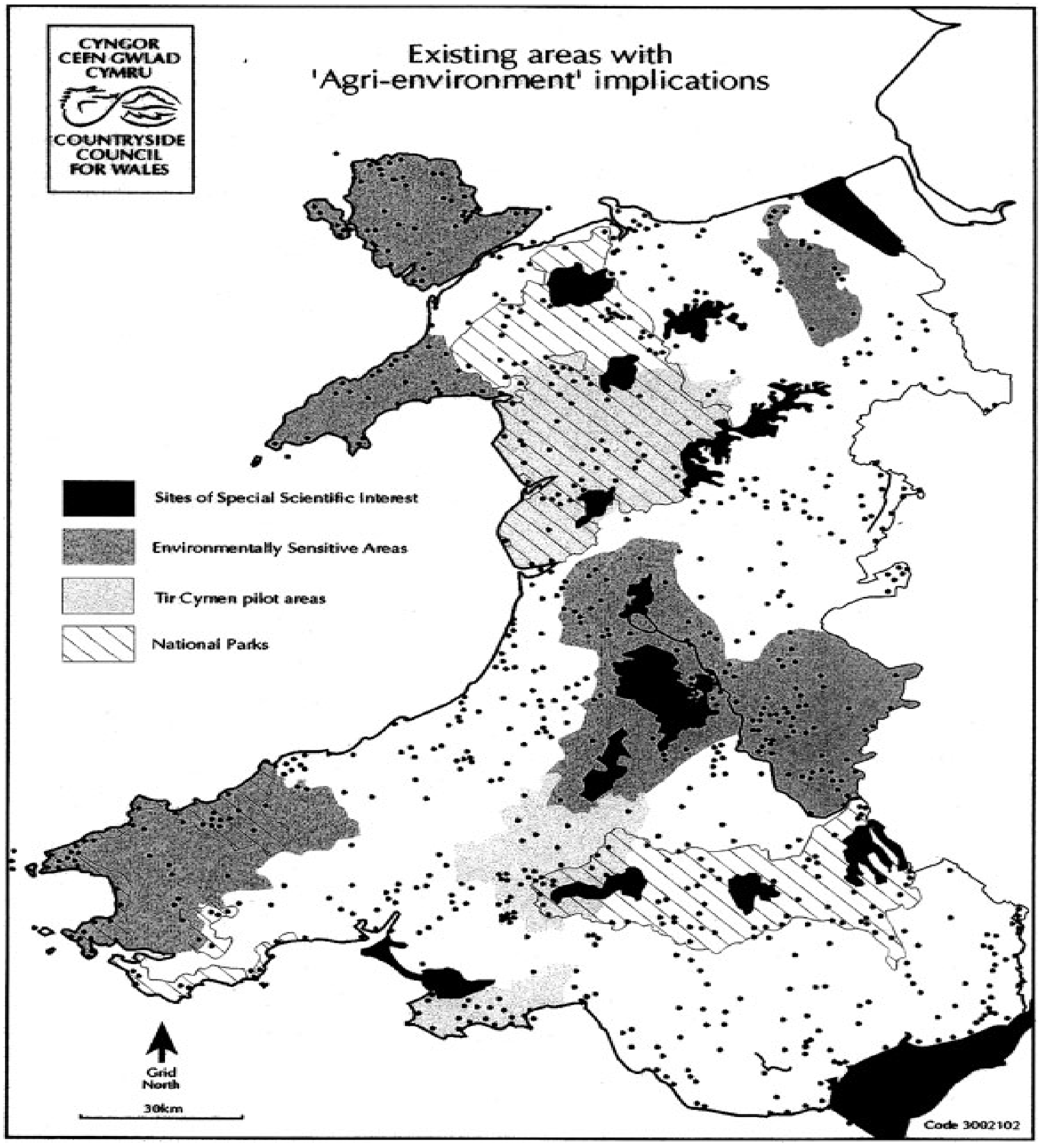

Figure 2.3 Land in Wales classified under four different "environmental protection codes" (Source: Countryside Council For Wales)

Two final points for this volume:

1. Hill farming has never had it so bad - and it is getting worse. Fewer sons are taking on, and those that are, are not going to want to survive as their fathers, let alone their forefathers of the 1930s, or the 1830s, or the 1630s did. Some National Park Authorities, the *Tir Cymen* experiments, even Stewardship and ESAs, have begun to pay for environmental goods. There is a public market for those goods. The environmental capital of the hills becomes more significant to a more sophisticated society and even Adam Smith admitted that some public goods have to be corporately paid for. The rambler needs vegetation below knee height and thus grazing, just as any species needs a habitat which needs a landscape to sit in. But the price is not just public funds, it includes a better understanding of the hill farmer's industrial psychology, and a reduction in the application of urban squeamishness to countryside matters (especially if they are to become sustainable again) through government and other social forces.

2. The upland/lowland junction, and the relationship between them, must not be overlooked. The historic patterns of rearing and finishing, of lowland pasture and hill grazing, hold two messages for future management of the 'environmental hills'. One is a serious look at the

3. principle of buffer zones for wilder cores and incorporating the marketing and finishing, adding value to the products of the hills, be they material or experiential, or even spiritual in those zones.

   The second is the Prince of Wales' "long walk in".

We have to pull back the polluting traffic, and where we can, we have to create sustainable processes in the hills - and that may demand more subsidy from the rest of us.

The slight comfort in all this is that hill farming is still the lightest touch we have ever applied in land use terms, and its re-conversion to a sustainable mode and an organic label is the easiest we can contemplate within agriculture, let alone within the rest of our industrial, commercial and managerial activity.

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3. "a grey melancholy hill..." ten thousand years of environmental history

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Preamble

The uplands of England and Wales have had at least two histories. The first is that chronicled by the would-be objective representations of disciplines like palaeoecology, historical ecology and economic history. The second is the more epistemologically loosely-structured sets of histories which deal with people's attitudes as expressed in, for example, the creative arts or in pieces of overt advocacy that urge a particular course of action. In the case of the uplands we know something of both, though rather more of the former than the latter, and, of course, rather more about both as we come nearer the present.

Key phases in the environmental history of the uplands

If we search the time since the final kick of the Pleistocene ice for the important phases in upland ecosystem evolution then there are perhaps three which can be picked out as having an enhanced significance for today's concerns. These are:

(a) the mid-Holocene, *circa* 6000 BC, when the last hunter-gatherer cultures occupied what are now the moorlands;
(b) the medieval and early modern periods, from Domesday Book (AD 1086) to 1600, when the country's economy was based on solar-powered agriculture;
(c) the recent past, from about AD 1850, when an industrial way of life arrayed around fossil fuels has dominated.

As with so many features of the British environment, the onset of industrialisation changed a great deal of the ecology of the land and water.

Evidence has accumulated to show that during the mid-Holocene, these uplands were the habitat of the last food-collecting cultures of Britain, who were superseded after circa 3500 BC by agriculturalists. The earlier (Mesolithic) groups were hunters, fishers and gatherers and the uplands were probably part of a yearly cycle of movement which enabled the people to maximise their access to food resources. The environment in which the Mesolithic cultures moved was very different from that of today. The principal dissimilarity was the presence of much more deciduous forest: the tree-lines were much higher in altitude, with even the higher summits such as Cross Fell in the Northern Pennines (893 m) being covered in a low woodland or scrub. Very exposed summits in the south-west (on Dartmoor) at 550 m were above the woodland limit but elsewhere, most summit plateaux seemed to carry some form of woodland. At these upper levels, the proportion of hazel (*Corylus avellana*) was much higher than in lower woodlands dominated by oak (*Quercus* spp), elm (*Ulmus* spp), lime (*Tilia* spp) and alder (*Alnus glutinosa*). Within this environment, the usual suite of large herbivores of the European post-glacial were found and, presumably, hunted. The actual archaeological evidence for hunting preferences is very sparse since the acidity of the upland soils means that preservation of organic materials (except in peat bogs and lakes) is very poor or, indeed, virtually absent. Extrapolation from earlier sites with good organic preservation suggests that red deer (*Cervus elephas*), roe deer (*Capreolus capreolus*) and aurochs (*Bos primigenus*) would all have been human prey, as would smaller game and birds.

Most models of subsistence, settlement and environment envisage a yearly progress in which the uplands are visited in the summer or autumn months by, probably, sub-groups of people charged specifically with hunting. These groups would be small enough not to scare game away but large enough to carry away meat to the rest of the band. A major interest, therefore, has been in trying to determine whether these small groups engaged in any environmental manipulation in order to increase their chances of hunting success. A large amount of pollen analysis and other palaeoecological investigation has been carried out to accumulate a body of evidence from which it might be possible to infer the presence or absence of such processes (Simmons 1996).

A major finding concerns the creation and maintenance of clearings which would be attractive to wild mammal herbivores. Inspection of pollen diagrams from nearby localities on the North York Moors shows a number of possible woodland disturbance phases. Radiocarbon dates of 6710 ± 50 BP and 6735 ± 45 BP were obtained from sites where pollen of open ground was accompanied by charcoal in the organic deposits. Fire is not necessarily present at the beginning of the disturbance. The inference may be drawn, therefore, that fire is not responsible for the initial creation of deforested land. Fire may have indeed been an instrument of keeping the trees at bay once an opening had been created. If humans were the agents of the initial openings in the woodland, then the processes of girdling trees or stripping them (or both) would have been possible mechanisms. Most archaeologists suggest that the bulk of resources are taken in an unmanaged form: some more or less literally as the result of opportunist encounters, others as the result of a planned expedition, as to a shellfish bed or a nesting cliff. Thus, any environmental impact is likely to have been unplanned to the point of inadvertence and only the exhaustion of a resource would have invoked any feedback. This could have happened if, for example, the less common *Bos* was hunted to extinction regionally. The New England native Americans apparently moved their villages for want of firewood as often as from any other cause and indeed thought that the Europeans had come because their own firewood was exhausted - not perhaps a transferable example to the later Mesolithic but an instructive case.

The ecological model of the hunters can be elaborated to suggest that the management of clearings and forest edge was not directed solely at *Corylus* and its production of browse and nuts. In so far as a zone of hazel scrub often succeeded the mixed oak forest upslope, there was good supply of this on most uplands. The work in the North York Moors at North Gill suggests that streamside woodlands with alder were manipulated in order to improve their attraction to mammals during the herb-grass production season. A less dense canopy together with openings would lengthen this season, for example. Deer were encouraged to visit certain places within the oak forest by the provision of leaf-fodder, which resulted in some canopy lightening. The production of edge and openings away from natural margins was carried out by ring-barking rather than fire. This process was aided by the barking propensities of concentrations of red deer especially in severe winters. Fire was important for the maintenance and production of edge. Natural openings in the mesic forest canopy were maintained by suppressing regeneration with fire: an aim of this practice was to encourage grass-herb ground vegetation as summer food for red deer; edge effects will increase the amount of browse which is an important food for deer. The grasses may encourage *Bos* as well. This burning took place in autumn when conditions might be dry enough for a controlled ground fire. This might not be every year. The incidence of fire might have interacted with gathering bracken rhizomes as a food but this seems less likely at an outlying hunting camp (unless other resources were scarce) than near a base settlement. Visiting such areas for hunting might, however, have been a longer season: if auroch was being hunted then it might have coincided with the ground flora production season in the streamside woodlands; deer were also likely visitors since this is the season when they are most likely to feed off herbaceous material. At North Gill, this type of woodland disappeared in the 6th millennium BP, replaced by encroaching blanket bog. Although the same general locality housed the mobile camps year after year, the exact same site was not used. Multiple spreads of charcoal and flints are probably evidence of repeated visits. Burned areas are not necessarily the same spots used for sleeping, tool repair and food processing, which seems logical: indeed some separation of the two would be needed to avoid scaring deer.

Overall, the story is one of limited but definite environmental management in which fire was an important tool. Subsistence was related to climate in the sense that first, the woodland vegetation was at that time largely a product of natural processes, and second, that when the woodland disappeared, blanket peat often took over, which was only possible in these cool, wet uplands.

If we contrast the foregoing account of part of prehistoric time with a more recent period, when agriculture was the mainstay of the ecology and economy of the British Isles, then there are certain differences as well as some similarities to be observed. By way of a time-slice, let us take the time from Domesday Book (1086) to about 1600, when feudalism was breaking down and the Reformation had dispersed the power (and often the estates) of the monasteries which were so prevalent in the uplands. Though not the most important use in terms of either area or value, industrial output too was a very big new element, compared with hunting and gathering times. Stone was one product, though transport problems made it less attractive than metals, which could be partially refined near the ore sources. Tin, silver, zinc, copper, and lead were all sought in the moorland regions, with foreign workers brought in to supplement native knowledge. More important than any of the above was iron, which was sought in many uplands. The chief environmental impacts were on water and on wood. The former was often diverted to power stamping mills. The latter is often charged with the increased loss of woodland in the uplands since feeding the smelting furnaces with charcoal was highly consumptive of trees. But the opposite case needs a hearing since the provision of a sustainable supply of wood was in everybody's interests. Coppicing was one means to that end and it is notable that some of the few relict deciduous woodlands in upland England and Wales are single-species stands which could be the remnants of managed woodland of that kind: the three Dartmoor oakwoods may be examples of that kind (Barkham, 1978). The moorland regions of England and Wales were the locations for some of the extensive grazing systems which were the foundation of the wool trade. The Cistercian monasteries of the north were especially prominent, and the development of wool production was aided by the turn from arable to grass generally in the 15th Century. The valleys might still produce arable crops and there might still be cattle farms but wool production was the ecological nexus in many upland regions. Some of the production came from areas previously under forest law but which had been sold by the Crown in order to raise money: Dartmoor Forest in the early 15th Century carried 6400 cattle and an unrecorded number of sheep.

As with most domesticates, the grazing habits of the animals change the vegetation on which they feed. Sheep, for instance, are selective of the species which they prefer. They are also selective spatially since most upland breeds keep to one territory, their 'heft'. Not surprisingly, the outcome is a sward which progressively contains more and more of the less palatable species. The typical grassland of acid soils under dense stocking by sheep can become a moss sward when it is wet underfoot, or a short tussocky fescue grassland in drier conditions. In wet conditions, the fescue grassland may become dominated by mat-grass (*Nardus stricta*) and this in turn may give way to purple moor-grass (*Molinia caerulea*) which is deciduous and thus provides less nutrition. Studies suggest that these transitions may all occur within 20 years. In order to try to improve conditions for sheep in the earliest part of the season, it became the custom to burn some of these uplands. Where it was wet this was partly to remove the dead *Molinia* stalks and leaves and allow light through to encourage the early leafing of the cotton-sedge *Eriophorum*. A side-effect may well have been faster runoff of water since the burning tends to clog the pores of the soils with finely comminuted material.

The control of the moorlands during the mediaeval period came through an extension of the manorial system that was typical of the lowlands. Many of the unenclosed areas were legally designated as common land. This did not mean what it said, however. The soil and mineral rights still resided with the Lordship of the manor (and still do; and it is still possible to buy lordships at auction) but rights to usufruct were divided amongst residents of nearby settlements. Usually these were the villages adjacent to the moor but in the case of Dartmoor, for example, grazing rights were extended to all the parishes of Devonshire except those of Totnes and Bideford. So grazing, turbary (the right to dig peat for fuel), the gathering of, for example, gorse bushes for fuel, were common to the peasantry and their successors. The regulation of the use of common land came via a manorial court; a few of these persist but most have disappeared and the control of, for example, grazing has largely migrated from the local court to the offices of Whitehall and Brussels.

A major pleasure of the aristocrats in medieval England was hunting. Though much encouraged by the Normans after 1066, it had also been popular in Saxon times. The Normans, however, seized large amounts of land to be devoted to the chase and termed them *Forest*, if the hunting rights belonged to the King, or *Chase*, if then bestowed to lesser nobility. The term *Forest* is legal and not ecological and so some of the upland moors were Royal Forests: The Peak, Bowland, Dartmoor, Radnor, and Pickering are examples. The prize quarry was red deer, which we encountered in the Mesolithic at the woodland edge. *Forests* in both lowland and upland Britain were quite closely managed in terms of manpower (sic), with many residents owing duties of service in the forest; some were permanent full-time employees. Their environmental effects were first of all to make sure that no land uses forbidden by forest law encroached upon the feeding and breeding grounds of the deer. This was not usually a problem in the uplands except when cultivation limits were creeping up the hillside as in the 12th and 13th centuries. Their second task was to prevent poaching, to see that the habitat was maintained (especially to see that areas for the deer to lay up were present), and to assail predators, especially the wolf. Then the proper hunt formalities could be observed, with the King taking the stags and lesser nobility undertaking such tasks as the killing of excess hinds, a process chronicled for Holy Innocents (between Christmas and the New Year) by the 14th Century author of <u>Sir Gawain and the Green Knight</u>:

They let the harts with high-branching heads have their freedom
And the brave bucks, too, with their broad antlers,
For the noble prince had expressly prohibited
Meddling with male deer in the months of close season.
But the hinds were held back with a 'Hey!' and a 'Whoa!'
And does driven with much din to the deep valleys.

(Part 3, II, 1155-1159, translated by P. Stone)

Not often noticed by commentators on our environmental history are the effects of the occupation of many upland valleys by the Cistercians after 1128, when they were founded in England. Their charters required them to settle as far as possible from the temptations of the world. In pursuit of this sanctity they often cleared manors of the lay population so that the only buildings left were those of the monastery and its granges and the only people the choir monks and their lay brethren, the *conversi* (Donkin, 1978). So an aura of sacred space was created around the abbey irrespective of the sacred qualities of the church itself; even in their currently ruined state something of the latter can, interestingly, persist.

The industrial revolution was immensely penetrative in its influence upon the economy, the ecology and the sensibilities of Great Britain. Though this period of intensified 'globalization' (not by any means the first evidence of British world-wide networks) brings the uplands into a common frame with most developed nations as far as mass use is concerned, some of the élite uses are peculiarly insular. The landscape ecology of today's moorlands exhibits strong 19th century influences. The lower edge of the, by now, open land has many broken-down fences and walls which date the expansion of the lower, enclosed, land during the period of high grain prices during the Napoleonic Wars. Many valleys have water impoundments from times when towns sought to improve their supplies for industry and or their burgeoning industrial populations: adjacent municipalities literally came to blows over who had the right to a particular valley. Later, after WWI, large state forests were established on the uplands since the land was cheap; this too was the era of increased public demand for access, especially by walkers. They came into conflict with some of the established uses of the moorlands and none more so than the hunting of the red grouse (discussed in detail below), and the use of the moors as training grounds for the armed forces, most notably the Army.

The new forests are good habitat for roe deer. A dense presence of them is inimical to the growth of young trees and there are always plenty of the latter since these forests are harvested and replanted on short (<40 year) cycles. If the food supply in the forests is restricted by low availability of soft bark and ground flora, or unavailable due to snow, then the roe will migrate to farmland and cause damage there. Control is therefore necessary and the forest staff shoot the animals from hides; in general, few licences are issued to a wider public to participate, though since many of these woodlands are now being privatised there may be changes to come. Rough terrain on the moorlands has been good territory for the rabbit (*Oryctolagus caniculus*), an introduction during historic times; these were formerly "warrened" (i.e. bred in captivity) on some moorlands but have never been a sport animal in any wide sense. Their main predator, the fox (*Vulpes vulpes*) is hunted on some moorlands for sport and for control of its predation.

The moorlands of the eastern flanks of the Pennines and the North York Moors (with a few western outliers on the hill-lands of the Welsh Marches) have been a good breeding-ground for the red grouse (*Lagopus scoticus*). In the early 19th century, grouse was shot by walking over the ground with dogs: these put up the birds and the hunters shot them from behind. The improvement of grouse density brought about an ecological revolution on these particular moors (see below). This was accompanied by a social-technological revolution, which included the development of the railways so that by the 1840s the newly rich businessmen could be in Yorkshire or Scotland overnight (just as they could go from London to the Midlands for a day's fox-hunting and be home for the night). The advent of the breech-loading shotgun in 1853 was also a significant advance. All this was serviced by a plentiful supply of cheap labour and was the preserve of the old landed classes and the newly rich of the industrial revolution (Vesey-Fitzgerald, 1946). In a normal 'good' day, a party might shoot several hundred birds but on record occasions there have been very large densities of shootable birds. One moor of *circa* 10,000 ha in Yorkshire in 1913 yielded 2843 birds to the guns on August 27th and about 5000 birds over the whole season. Another moor in the Pennines supported a season's cull of 17,078 grouse from 42,000 hectares. On one day in the late 19th century, Lord Walsingham shot 1070 grouse. The management necessary for high rates of cull starts with the knowledge that the territory of the adult pair of red grouse is determined by the quantity of feed, which is largely the heather plant, *Calluna vulgaris*. Further, a mosaic of heather of different ages provides fresh succulent shoots for younger birds as well as bushier heather for nesting. However, after about 12-15 years, a heather plant develops long woody and recumbent stems (becomes "leggy") and is of very little value to grouse. So the moor is fired in 30-50 metre wide strips at 12-15 year intervals, usually in a dry period between late winter and early spring. Minor measures may include keeping people away during the breeding season, providing grit to aid digestion in the birds' gizzards and killing ground predators like foxes. Research which shows that hen harriers (*Circus cyaneus*) may account for 91 per cent of all grouse chicks killed in their first six weeks leads to (illegal) shooting of them as well (Tapper, 1992; Hudson, 1992).

Large areas of the drier moors in England (and in Scotland as well) are still managed in this way. The management techniques produce long-term ecological change in terms of the loss of nutrients in smoke, opening of the largely podsolic soils to accelerated erosion, and the creation of monocultures which are prone to instability. Cyclic invasions of pests on both heather and grouse have been prevalent since the 1900s: the main problem is a parasitic worm that brings about a disease, *strongylosis*. This appears to cause cyclic variations in grouse populations, with a period of about 4.8 years in England; there is some variation between drier and wetter moors. But since the high figures of the 1970s, bags of red grouse have been getting lower. There are signs therefore that in the long term, this ecological relationship cannot be perpetuated and so some moor managers are feeding medicated grit to their birds.

Changes in attitude

All this empirically detectable change has been accompanied by strands of human thought which have sanctioned or forbidden different activities, or written about them from a safe distance. We know nothing about the environmental thought of the hunter-gatherers, though by analogy with near-recent examples we can be sure that their consciousness of their surroundings was acute. This did not necessarily mean that they exerted a total environmental tenderness, however, and they certainly disappeared quite quickly once agriculture had diversified their menus. The medieval and early modern periods evoked negative reactions from users and settlers but in spite of that the uplands were thought a favourable set of environments for the establishment of monasteries in whose location solitude was vital. Not until the Romantic movement of the later 18th Century was there a reassessment of the uplands, influenced especially by the oil paintings of Claude Lorraine and Salvator Rosa, associated with the ‘picturesque' and the ‘sublime' respectively (Zaring, 1977). This view of the uplands, as antithesis to the lowlands of intensive farming and of industry, seems to have informed much inter-war and indeed post-war thinking, such as the 1949 National Parks Act.

Trying to make long-term sense of both the empirical histories and the histories of ideas is difficult since facile transfers of notions from one to the other are to be avoided. In the lowland context, Joan Thirsk (1997) has provided an interesting view of agriculture since the Black Death. She divided the developments into those periods which aimed to satisfy virtually Malthusian demands for meat and grain, against periods of relaxation when the system might produce luxury goods, experimental crops and industrial materials (Table 3.1, columns 1 & 2). The uses of the uplands of England and Wales move to some extent in concert with the lowlands, providing as they do a reservoir of land to be reclaimed at times of high prices for meat and cereals. They also accrete uses that have comparable lowland equivalents: military in both, pheasants for grouse, for example. Attitudes are more difficult to relate to this chronology but we might note that the re-appraisal conducted by the Romantic movement seems to have been initiated during the period of great, and indeed insistent demand created by the burgeoning of the industrial revolution with its pressures for meat and dairy produce. The re-appraisal of the national patrimony of land that took place during and immediately after WWII was related to a period of food stress. Relatively little re-evaluation seems to be associated with times of relaxation in the agricultural field, which might have lessons for today

History lessons

There is perhaps only a non-lesson lesson: that change has been permanent and that to try to stop ecological shifts at any one moment in time involves an arbitrary decision which has no intellectual justification, pragmatic though it might be to protect heather moor for the tourists or scruffy woodland for the blackcock. If the ecology is to followed then the Carriefran movement of the Southern Uplands has got it right: we need to return whole blocks of country to mixed deciduous woodland with a wild mammal fauna and a light human presence. If the culture of the National Parks Act, with its second class of Areas of Outstanding *Natural* Beauty has the upper hand, and if we really demand these open landscapes, then grazing has to continue; if not then the threat of a reversion to wilderness becomes a promise. The ‘grey melancholy hill' near which Arthur Conan Doyle (1912) set Sherlock Holmes and Watson on their visit to Dartmoor becomes not a threat but a promise of an Otherness which the urbanised population seeks. Thus, the plasticity of the ecology of the uplands far exceeds that which any form of environmental determinism would suggest. As any post-modern literary theorist would remark: ‘Baskerville' is only a type-face after all.

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Table 3.1 Phases of 'Alternative' Uses. Source: after Thirsk (1997), with additions

	Lowland England and Wales	**Upland England and Wales**	
		Uses	**Attitudes**
Mainstream: Medieval period before the Black Death.	Cereals + meat; cereals in excess after the Black Death.	Charcoal, iron, beasts; hunting; *reclamation*.	Monastic approval of wilderness
Alternative experience 1350-1500	Land to grass: sheep; deer parks; saffron; woad.	Sheep and cattle; *reversion*.	
Mainstream	Grain sought: ploughing + fertilisers.	Common management of grazing.	Waste places: backward and not contributing to the national wealth
Alternative experience 1650-1750	Luxury foods; better horses; horticulture; woodlands	Decline of summer transhumance	
Mainstream	Cereals above all else, then meat	Water, quarries, mines, meat, *reclamation*	Romantic re-appraisal
Alternative experience 1879-1939	Grass leys; industrial crops; glass; game; orchards.	Plus grouse, military, *reversion*.	
Mainstream	Wartime production then UK + CAP (Common Agricultural Policy) subsidies	military; water; foot-recreation; *reclamation*.	
Alternative experience 1980s—	Organics; vineyards; deer, trout; game; boar; reconstruction of heaths and grasslands, rivers.	Grouse; sheep; military; vehicular recreation; EU Directives; *reversion ??*.	Scenery and recreation as commodity

4. Wildlife conservation – the need for common sense

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Change is inevitable and for mankind to have adapted to it in the way the survivors have is nothing short of a miracle, but to control its pace is the major problem for politicians in a world where education and science have become increasingly specialist and too often narrow-minded. In holidays from school where we studied Virgil's Georgics, we stooked the corn behind the binder and picked the thistle prickles from our fingers at night with our mother's eyebrow tweezers. The fields were full of poppies and chicory – and rabbits, on which we waged a ceaseless war. There were grey partridges among the turnips and the stubble, and lapwings everywhere in the braiding corn in spring. It was a time when Europe had known starvation, and there was food rationing in Britain. The call was for agricultural production, but the nation had never cast off its delusions of industrial grandeur, based since the Repeal of the Corn Laws in 1846, on cheap food to keep its manufacturing industry competitive in its need for world trade. From then until now the consumer has rarely paid the farmer the cost of food production – most certainly not in the uplands where the hill sheep and cattle farmers were largely at the mercy of the lowland finishers in the glutted store markets of autumn. Thus hill sheep and cattle subsides were introduced to keep people in the uplands. The Marginal Agricultural Production Scheme and the lime subsidy were of inestimable benefit in maintaining the fertility of the better land and increasing winter keep.

When I started work on a hill farm in Glenlyon in 1953 my wages were £1 per week and my employer could ill afford to pay them. We worked very hard and agricultural prices were low. We sowed the seed and the fertiliser out of a sheet, and scaled the lime and dung from the back of a horse and cart. Some of the harvest we cut with a scythe and bound by hand. On the first farm of my own I could not afford to buy a tractor, and my first set of harrows was a hawthorn bush cut from the hedge pulled by a grey Ferguson lent by a generous neighbour. Even with the passing of the Agriculture Acts of the late 1940s life was not easy in the hills. Rents were low and maintenance of buildings done on a wing and a prayer, but it was a countryside where life was in balance, however rough. War had seen a massive reduction in the deer herds and sheep numbers were limited by winter stocking capacity, not an efficient way of controlling the hill grass, 85% of whose growth took place each year within a short 6 weeks. Nonetheless, everywhere there were still the quantities of birds and animals we had known in our childhood. It was a system based on low output. Much of its success was due to inherited instinct and the need to survive, but it produced a seemingly timeless landscape utterly favourable to wildlife conservation and biodiversity.

The memory of war, however, was still strong. Meat was rationed until 1954 and the edict went out to maximise production with the aid of science without a thought for the environment. There was a close relationship between research and development in those days, destroyed so thoughtlessly in the 1980s. The Hill Farming Act of 1954 and the Marginal Agricultural Production Scheme brought great benefit to a sector to which nobody had paid much attention, and where most of our economics were done on the back of an envelope – which did not mean we could not add. The setting up of the Hill Farming Research Organisation was a major step forward and it was regrettable that the Agricultural Colleges were not more successful in promoting the work of Professor Cunningham and his colleagues, much of which was based on simple reorganisation of grazing systems which could have been developed extensively at little cost. Luckily, some of those pioneers are still employed at the Macaulay Land Use Research Institute (MLURI) where the Sheep and Deer Decision Support Systems and the Environmental Impact Assessments are beginning to make a major impression on the thinking of those working in the hills.

The result of the drive for production was the reseeding of many upland pastures, notably heather moorland, and an enormous increase in the productivity of ruminants produced by the status of their food supplies, and considerably aided by veterinary research with the development of anti-clostridial vaccines. No longer was self-sufficiency the grail. Foodstuffs were imported as farmers attempted to avoid the noose of the autumn sales. The traditional structure of a stratified sheep industry was destroyed. Proven rotations based on spring oats, roots and reseeded pastures were discarded. Nitrogenous fertiliser was advised and used in increasing quantities and the strength of the commercial sheep market in Scotland and the north of England became totally dependent on the export of a growing surplus.

This was a disaster compounded by Britain's entry into the EC. The Treaty of Rome had the laudable intention of ensuring rewards for their labour to the people in the countryside were equal to those in industrial towns. Hitherto the Deficiency Payment Scheme, which underwrote a minimum price on a seasonal scale, had benefitted both farmer and consumer and avoided the build up of stocks of beef generated by the new intervention system. At the same time the introduction of a Sheep Annual Premium Scheme (SAPA) was a direct incitement to overstock on both upland and lowland farms. The result has been catastrophic: for upland farms and the discarding of rotations, reliance on bought-in feeding stuffs, and the increased productivity of the flock beyond the ability to sustain itself from home-grown resources. At the same time the hill cattle industry, which was the prime tool for limiting expanding areas of rough grazing, was gutted by the use of continental cattle with high growth rates that were incapable of making use of the swards. The use of Charollais and Simmental bulls on diary heifers of doubtful conformation, thin skin and high nutritional demands was a disaster, however high the growth rate of such calves in more favourable conditions.

None of which, you may say, has anything to do with wildlife conservation, but you would be wrong, because the result is sad and to anybody who thinks, at this late hour is an environmental disaster – as well as a human one. As I went to the lambing before light in my Dumfriesshire home, each morning I would hear first the oyster-catchers, then the larks, the wood pigeons, the robins and the thrushes; then the curlews, always in the same sequence. Then as it grew light all the other little birds would burst into song. At one time, twenty years ago there was even a corncrake by the Shinnel Water in Tynron for a season. Now there is almost total silence in the spring and at the roadside verges where the violets used to grow there are no flowers booming. The one good thing the sheep did was to eliminate the ragwort, but with a lack of self-confidence induced by the perpetual nagging of the conservation press I begin to wonder if even that was right.

Then there is forestry. Everybody knows the trail that led to where we are. The decimation of Britain’s timber stocks by two World Wars. The establishment of the Forestry Commission (FC) in 1919 to build replacement stocks. The need to reduce the import bill for timber, 92% of which was imported. The aim of providing employment in a countryside where jobs were scarce. Investment poured into the downstream processing industry. It all occurred on an *ad hoc* basis and those who complain are often those who took the Danegeld in the 1950s and 1960s when nobody else would buy their sheepwalks. Too often trees were planted in places like the Flow Country where they should never have been put. Too often they were left unthinned, but the fact remains that the growth rate of sitka spruce made it highly suitable for market needs. Nobody had done environmental impact assessments. The design of forests left much to be desired. No care was taken in the planning for deer control, save the erection of fences, which from the other side of twenty years were thought to be a perpetual barrier to entry. In the state sector, budgets were out of control and private forestry was entirely driven by tax considerations. There was no involvement in the development of native woodland and no opportunity for local communities to take an interest in what was happening – it simply was not profitable. Everything has changed. The state service is now well run. Forest Enterprise has distinct aims, and the Forest Authority is an appreciated regulator, but the pendulum has swung too far away from production woodlands to environmental forests whose management aims are far from clear in too many cases. For the private forester cash flows are driven by grant, but there is insufficient research being devoted to create markets to encourage management of the resource that is being created. Wildlife has been the beneficiary, but forest production remains unprofitable in financial terms. It comes with huge costs and too many still fail to realise there needs to be economic activity in the countryside to fund environmental aims.

Then there are the deer, nearest of all to my heart and my knowledge. They are part of Gaelic culture, known as Clann na Cheo, the Children of the Mist. From them, and the stalkers who manage them, my understanding of the wind and their relationship with their environment has come. Their expansion throughout the Northern Hemisphere is a major ecological success story, but between 1960 and 1990 the Red Deer herd in Scotland doubled owing to a succession of mild winters and the breaching of forest fences. The result was rising productivity and reduced mortality. Too many managers were reluctant to kill sufficient females and the stag:hind ratio reached 1:3 in many places instead of the advised 1:1.3. Densities became so high that there was damage to agricultural and forestry investment, as well as to the national heritage. The Red Deer Commission (Deer Commission for Scotland since the Deer in Scotland Act 1996) had been badly under-funded since its inception in 1959 and by 1992 there were demands from the NGOs for the Commission to use its compulsory powers to put landowners in their place. This was an approach which could not possibly have succeeded. By great good fortune Sir Hector Monro (now Lord Monro of Langholm) was the Minister in charge at the Scottish Office when I was appointed as Chairman of DCS. He knew about deer, had served on the Scottish Committee of NCC, and was prepared to support a common sense approach to the introduction of new legislation if agreement could be reached by all interested parties. The Bill was eventually passed after almost four years of conversation between the conservation bodies, the landowners, and the DCS, and although the words were sometimes sharp at the outset, the spirit of co-operation and the seeking of consensus was a supreme example of the way problems facing the natural heritage, agriculture, and forestry should be tackled. It is sometimes difficult for articulate people to put a bridle on their tongues, but infinitely rewarding – like giving up chocolates for Lent! The Deer Round Table continues to meet on a regular basis.

Annual culls since 1992 have been higher than all those previously recorded and, as I am certain any student of bio-dynamics could have told me, calving percentages have risen from 30% to nearer 40%. With the uptake of more and more Woodland Grant Schemes, often on deer wintering ground, it remains vitally important that numbers continue to be culled to maintain herds in balance with available food supplies. The Deer Decision Support Model developed by John Milne and his colleagues at MLURI with the aid of a massive grant from the Scottish Office (I am sure he would say not massive enough!) will give deer managers one more tool. It is not designed to tell stalkers the direction of the wind, but will give them another device with which to defend themselves from their more outrageous critics. Meanwhile Deer Management Groups, of which there are over 53 in Scotland, are working hard to produce Deer Management Plans. In much of England, however, deer remain out of control with expanding populations, and a Deer Commission is badly required.

We come to the needs for common sense:

1) A sustainable countryside which will give a reasonable living to those who work within it. It will come with a huge cost.

2) A clear definition of objectives. It is not the farmers' fault that the countryside and food production are as they are. They have done all that was asked of them since 1945 and if there is a lesson to be learnt it is that instant policy changes are mistaken – particularly in livestock and forestry. Everybody agrees that headage payments have been disastrous both for the environment and the long-term future of upland agriculture.

3) A broadening of education. Scientific specialisation can too easily lead to narrow aims and narrower minds which graduate to the tyranny of single issue pressure groups.

4) A moderation of the voice of some of those pressure groups who are often right, but in their righteousness are sometimes quite offensive to those who are doing their best in difficult circumstances.

5) The education of urban politicians, often with very disadvantaged electorates, in the advantage of supporting the uplands as a way of providing both the food and the environment to give benefit to their constituents.

6) A proper funding mechanism, with limited bureaucratic requirements, that does not destroy completely the independence of country people.

7) The realisation that species have become extinct continually since the start of time and that it is no use trying to recreate our childhood landscapes.

8) Above all, the necessity for dialogue and quiet voices to talk with people of different opinions who the Press try to teach us to hate, but who are actually very nice!

Through it all, never forget Oliver Cromwell's letter to the General Assembly of the Church of Scotland on 3rd August, 1650:

"I beseech you, in the bowels of Christ, think it possible you may be mistaken".

SECTION 2

Importance, sensitivity and land-use issues

Five chapters in this section tackle issues ranging from the science base to management. Four chapters deal with the natural resource base in the uplands, covering nature conservation (Thompson), water quality (Cresser *et al*), erosion (Burt *et al*) and climate change (Huntley and Baxter). Gordon *et al* reflect on the sensitivity of the Cairngorms' geomorphological features to disturbance, both natural and anthropogenic.

These chapters provide stand-alone information on the resource base of the uplands. It is notable that many facets of sensitivity are raised, touching on geomorphological, biological and landscape issues.

5. The importance of nature conservation in the British uplands: nature conservation and land-use changes

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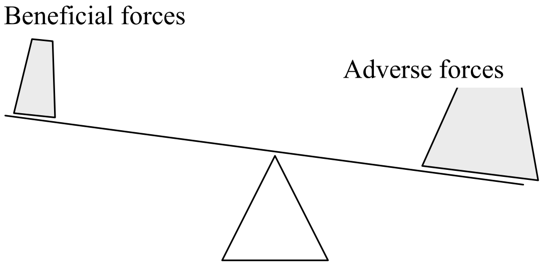
Introduction

The uplands cover around 30% of the UK land surface (Usher & Thompson 1988; Horsfield and Thompson 1997). Most of this is managed for agriculture, forestry and game management and is widely used for tourism and recreation. The landscape is predominantly semi-natural; only a few of the more mountainous parts, and some of the peatland landscapes are regarded as near-natural. Management practices over the last four centuries, in particular, have had a major impact on the habitat resource and its wildlife. This has led to losses, or changes in, more natural vegetation types towards habitats generally dominated by graminoid vegetation (e.g. Usher & Thompson, 1988; Thompson *et al* 1995, Moorland Working Group 1998). Many environmental measures are being adopted by the UK Government conservation organisations and others to protect and enhance the nature conservation interests of the UK uplands. These are now channelled largely through *Biodiversity: The UK Action Plan* (Anon 1994), notably the implementation of Habitat Action Plant (Anon, 1999), and implementation of the EC Habitats Directive (Brown *et al*. 1998), as well as wider countryside measures largely influenced through Government Departments (e.g. English Nature 1997 a, b. Thompson & Horsfield 1997; Williams *et al* 1999. Further measures include proposals to introduce National Parks to Scotland, development of the existing English Nature Wildlife Enhancement Scheme in England, an extended agri-environment scheme in Wales (*Tir Gofal*), and proposals for the integration of rural development and agri-environment schemes.

Priorities for conservation

Taken as a whole, the UK Conservation Agencies are concentrating effort on six priorities for the conservation of the UK uplands:

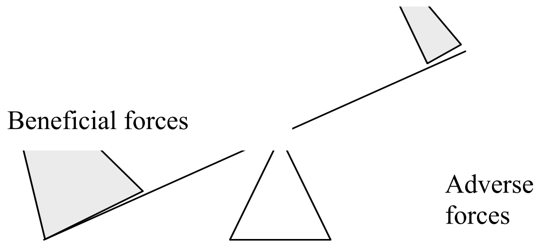
- positive management for nature, especially for the network of protected areas, in order to achieve favourable conservation status of habitats and species listed under the EC Habitats Directive;
- meeting the targets set out under the UK Habitat Action Plans;



20th CENTURY

Beneficial forces:
- SSSIs, NSAs, SPAs, SACs, NNRs, National Parks
- ESAs and wider countryside measures
- ‘Greening’ of recent forest policy
- Articulation of public concern about environmental deterioration
- Advent of UK HAPs

Adverse forces:
- Past management practices
- Post-war Agri-environment measures
- Mid 20th century forest policies
- Illegal persecution of wildlife
- Habitat fragmentation



21st CENTURY

Beneficial forces:
- Greater integration of land-uses
- Greater investment in good land-management practices
- Revised Agri-environment support
- Habitat creation/restoration through HAPs and forest policy
- SSSIs, NSAs, SPAs, SACs, NNRs, National Parks

Adverse forces:
- Climate change
- Legacy of Agri-environment support
- Habitat fragmentation
- Pollution

Figure 5.1 The changing balance in the uplands

- influencing Government policies, in particular those relating to agriculture (especially to

reduce grazing pressures, but also in relation to renewables);
- promoting best practice for habitats and species management;
- increasing public understanding and awareness of action needed, and promoting the appreciation and enjoyment of the upland countryside.

Some scientific directions for the future

This paper poses some questions regarding future directions of activity. These questions are grouped under eleven headings, which relate largely to important policy areas which the Country Agencies are considering. The paper has tried to draw on international links with other agencies and specialists, which have contributed to conservation strategies for upland habitats at the European scale (e.g. Byrkjedal *et al* 1997; Ruoss and Thompson 1999; Nagy *et al* 1999).

Conservation policy and legislation: still a need for basic information

The agencies are currently involved in concerted action to develop a UK-wide site condition monitoring programme for protected areas. There are particular challenges here in developing pragmatic but scientifically reliable methods which inform us of the nature of habitat or wildlife changes, and the causes of these. Scale issues are important here, because in many large SSSIs, just a few parts are experiencing ongoing problems, which can be difficult to detect other than through personal knowledge of sites. There are still fairly fundamental questions about use made by component parts of sites by vertebrate interests. In particular, some of the key bird and invertebrate species we know relatively little about preferred habitats or landscapes.

We have recently made progress in developing a more holistic approach to understanding the sensitivity of landscape in terms of geomorphological and ecological processes (e.g. Gordon *et al* 1998). This is proving particularly valuable in distinguishing between natural and human-related influences on nature conservation interests. Traditional views of erosion features in high mountain regions, and of patterned mires, are being challenged (e.g. Thompson 1999), and this is generating renewed interest amongst the scientific community.

Over the past 5 years we have made significant progress in classifying and then mapping different vegetation types in the uplands (e.g. Brown *et al* 1998; Horsfield *et al*, in press). Remote sensing, using satellite imagery, offers considerable promise here, particularly for the blanket bog resource (e.g. Reid *et al* 1996). Remote sensing has also been employed recently to improve other interests which are widely distributed, notably some of the wide-ranging bird species (e.g. Austin *et al* 1996). However, there are concerns about the precision of techniques employing remote sensing. We are particularly anxious to see Countryside Survey 2000 (Haines-Young *et al* 2000) developed to provide an agency-wide agreed overview of the extent and composition of broad habitats in the UK. Within the UK, Habitat Action Plans published for the uplands (Anon 1999) still require detailed, accurate maps on the distribution of individual habitats covered by the plans.

Ongoing work in selecting potential special areas of conservation in the UK has revealed lack of survey information for some habitats. For some of the scrub habitats new survey work, led by English Nature, has helped address this problem (Mortimer, 2000). In Scotland, we recently published an overview of scrub habitats (Gilbert *et al* 1997). We are particularly lacking in detailed information on some of the Annex 1 habitats, notably springs with tufa formation; Alpine pioneer formation of *Caricion bicoloris-atrofuscae*; various rock and scree habitats; tall herb communities; and sub-artic willow scrub.

Agriculture

The Country Conservation Agencies have made especially good progress in developing habitat impact assessment and land management practice advice (e.g. Thompson *et al* 1995; MacDonald *et al* 1998; English Nature 1997a). However, in terms of policy direction, there are now fundamental questions being raised about agricultural change. What will be the impacts of agricultural abandonment for nature conservation interests in the uplands? To what extent are future changes in habitat interests dictated by past influences of acid deposition and grazing? Can we distinguish between the impacts of acid deposition and grazing on upland habitats and landscapes? Some of us are beginning to form the view that some of the grass-dominated vegetation types of the southern uplands may be the product of nitrogen deposition <u>and</u> heavy grazing pressures (e.g. Baddeley *et al* 1994, Thompson *et al*, in press). Hence, a reduction in grazing pressures alone may not necessarily result in an improvement in habitats, notably towards those dominated more by mosses and lichens.

We still need to resolve issues concerning the role of muirburn and wet heath and blanket bog habitats (e.g. Hamilton 2001), and we need to clarify the science surrounding the value of habitat mosaics for different nature conservation interests. At this stage we simply do not know at what scale particular habitat mosaics benefit some of the wide-ranging bird species such as Eurasian golden plover, short-eared owl and hen harrier - all Annex 1 species which have been influenced by agricultural practices in the uplands.

Forestry and woodland development

In Scotland, where afforestation still continues in the uplands, we have faced a considerable scientific challenge in developing guidance on reasonable balance to improve the expansion of woodland over open upland areas. Here, important judgements are taken on potential impacts of various forestry schemes on open habitat and animal interests. We still need further work addressed - forest-edge impacts, straddling catchment, landscape, freshwater, and soils processes.

We need further work to develop clear guidance on the expansion of scrub-woodland over the upper reaches of upland areas, notably to accelerate the re-creation of alpine treeline, willow scrub and related remnant habitats. Here, there are actually fundamental questions over whether or not extensive areas of alpine treeline ever existed in the British uplands.

Planning and development control

As we contribute to Government strategic plans for development control, notably relating to windfarm, hydroelectric schemes and telecommunication masts, we find increasing need to have geographical data which can highlight sensitive, compared with less sensitive, areas. There is an important data handling, rather than scientific, challenge here, in marshalling the necessary information in order to inform judgement on where various developments might be encouraged or discouraged. As this volume goes to press, the windfarm issue is gaining a high conservation profile in the uplands.

Game management and related sporting activities

Considerable progress has been made in identifying the contribution of game management related sporting activities to nature conservation interests (e.g. Thompson *et al* 1997; Anon. 2000). The UK Raptor Working Group Report has provided a clear steer on research needed to resolve grouse moor-raptor and pigeon racing-raptor conflicts (Anon 2000). We have recently undertaken research trials involving diversionary feeding of hen harriers to reduce pressures on red grouse (Moorland Working Group 1999).

Landscape ecologists have recorded significant successes in restoring bulldozed tracks constructed to improve access to high altitude areas used for shooting and skiing. We still need to develop guidance on the management and use of altering vehicles, however, which are increasingly used for agricultural as well as sporting-related purposes.

Recreation, access and tourism

There are two areas of research that we should consider carefully here, and both straddle social and biological sciences. First, we need further work to identify ways of improving access but reducing impacts of people on upland nature conservation interests. There is still a hesitancy to promote enjoyment of many of our sites, yet with careful management of access and people on the ground, it should be possible to sustain more people (see Sidaway, this volume).

Invasive species

We need to have a fairly fundamental discussion on the approach needed to address the impacts of invasive species in the uplands. Britain's flora is internationally important because of its rich composition of native species compared with that found in the European mainland. When it comes to specific invasive species such as bracken there is still debate about the pros and cons of widespread eradication or control. Have we formed a clear, unified view on bracken containment in the uplands?

For sika deer, the Deer Commission for Scotland and Forestry Commission have produced a joint policy statement on controlling and managing sika-red deer hybridisation.

Natural processes, including climate change

Climate change on upland ecosystems have received a good deal of attention recently (e.g. Thompson 1999a). Several popular articles and more detailed reports on this have appeared recently (e.g. Thompson 1999b). The Environmental Change Network (e.g. Sykes and Lane 1996) will be available in detecting changes across the uplands, given that there are now three high altitude upland sites included within the network (Snowdon, Moor House and Upper Teesdale, and the Cairngorms).

Increasingly, we recognise the importance of the peatland systems as carbon sinks, but this needs to be investigated more closely in order to clarify those areas which are most important and most sensitive to change.

We still know relatively little about soil processes in the uplands, and there is an ongoing debate on the natural- versus human -influenced downturn in the fertility of upland soils, notably in the west of Britain. Is there scope for experimental work here? I stop here. Clearly, we can raise many more questions. In amany ways, the key task for the future will be to direct research to address the policy and land management issues; combining these will be a special challenge!

Acknowledgements

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6. Climate change and wildlife conservation in the British uplands

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Introduction

Climate change is not a new phenomenon; it has always been with us. The recent geological past (the last 750,000 years of the late Quaternary) has been characterised by particularly large global climate fluctuations, as glacial and interglacial stages have alternated with one another. The palaeoenvironmental record for this period provides information about the magnitude of these fluctuations, their rate and the range across which conditions have varied. These records reveal a shift of approximately 5 °C in global mean temperature and a maximum rate of warning of *circa* 2 °C per millennium. Such global figures, however, mask a series of local changes that have occurred at faster rates in sensitive areas at particular times in the past. The present is exceptional in the context of this geological period as a whole. Global mean temperature has been no more than 1-2^{o}C warmer than the recent past at any time during the last 750,000 years.

Species and ecosystem responses to climatic change

The palaeoecological record provides information on how species and ecosystems respond to large-scale and rapid climatic changes. Three principal responses are possible:

1) A species might adapt through evolutionary change to the new conditions in the area where it occurs. In practice, however, the capacity of a species to adapt in this way is limited primarily to selection amongst pre-existing genotypes. Only in the geological long-term, of hundreds of thousands to millions of years are novel, evolutionary adaptations seen and selected in response to environmental changes.

2) A species may exhibit a spatial response, migrating so as to maintain its area of occurrence in dynamic equilibrium with the changing environment. The migration rates needed to maintain such a dynamic equilibrium can be estimated from the rates of environmental change; such a procedure indicates that the rates required are between a few hundred metres and a few kilometres per year. Although such rates may seem astonishingly fast for long-lived sessile organisms such as trees, especially given the short distance over which the majority of their propagules are dispersed, the palaeoecological record demonstrates that trees have achieved such rates during their post-glacial migrations. Strikingly, the post-glacial migration rates achieved by such slow-moving creatures as snails, and recent rates of migration of more mobile organisms such as butterflies, are consistently of this magnitude. It can be argued that the capacity of any species to achieve such a rate of migration represents an evolved adaptation to natural climate fluctuations.

3) The third potential response is, in a sense, the consequence of a failure by a species to achieve either of the previous two responses. A species that fails to migrate sufficiently quickly, or has insufficient genetic flexibility to adapt to the changes, will become extinct, as indeed many species have during the late Quaternary. A species whose habitat becomes fragmented or severely reduced in area will be particularly prone to extinction. It has been argued that this mechanism lay behind the extinction of the woolly mammoth and other large vertebrates at the end of the last glacial stage.

Implications for wildlife in the uplands

Given that climate change has always been with us, and given what is now known about species' responses to climate change, it is now possible to assess the potential impacts of current anthropogenic climate, and other environmental, changes upon wildlife. The implications of these impacts for the conservation of such wildlife, especially in the uplands, can also be evaluated.

Species can be expected to exhibit spatial responses (i.e. to migrate) as the climate changes. This potential spatial response can be modelled to provide insights into its likely magnitude. The response is also amenable to monitoring, so as to gain evidence that climate is impacting upon species. Grabherr *et al.* (1994) presented evidence that showed a variety of mountain plants had extended their ranges up slope in the Austrian Alps during the 20th century as temperature had increased. These authors warned of the potential for extinctions of species found only at the highest elevations. Subsequently, Parmesan (1996) showed an overall northward and upward shift in the occupation of sites by the Edith's Checkerspot butterfly (*Euphydryas editha*) in the west of North America compared to historical records. This again indicates that species are already responding to the changing climate.

Hill *et al*. (in press), in a study of the Speckled Wood butterfly (*Pararge aegeria*) in Britain, have recently combined analyses of historical records with modelling of a species response to climate. This butterfly has expanded its range northwards in Great Britain since the early 20th century. Modelling shows that this expansion is consistent with the warming of the climate over that period (Figure 6.1). In a wider study of butterflies throughout Europe, Parmesan *et al*. (in press) have shown that a wide range of species has shown range shifts this century that are consistent with climate warming. Some 65 % of species whose northern range boundaries were examined had shifted northwards, whereas only 22 % of species whose southern range boundaries were examined had retreated northwards. Whilst ecological explanations can be advanced to account for this discrepancy, the key observation is that these shifts far outnumber shifts in the opposite direction (only 2 % and 5 % respectively). The overwhelming conclusion is that species are already responding to climatic warming.

The rate and magnitude of anthropogenic climate change relative to past changes is clearly revealed when the potential impacts upon species' ranges of the climate changes simulated for the next century are modelled. For the Speckled Wood butterfly the potential range expands northwards throughout all but the more mountainous areas of Fennoscandia. Very similar patterns of expansion are seen for other butterflies for which modelling has been undertaken, as well as for plant species. Further examples of the latter include the latitudinal shifts predicted for the cloudberry (*Rubus chamaemorus*) (Figure 6.2) and the north-eastward range expansion of the Wild Madder (*Rubia peregrina*) across Europe (Figure 6.3).

The second important finding to emerge is emphasised by the simulations presented in Figures 6.1–6.3. Climate is predicted, over the next century, to change more rapidly than at any time in the recent geological past, and also to attain a state unparalleled during that same period. In order to achieve the potential range shifts shown in the simulations, species typically must migrate at least an order of magnitude faster than they have in the recent past or during the late Quaternary. Whilst some highly mobile species may achieve such range shifts, it seems unlikely that most plants, or even mobile animals that are not seasonal migrants, will maintain their ranges in equilibrium with the changing climate. This situation is exacerbated in landscapes where species' natural habitats are fragmented and destroyed. Recent simulations predict a severe reduction in species' capacity to move across landscapes when habitat loss is substantial. Furthermore, this effect is greatest when the remaining habitat is in discrete, larger but more isolated patches, rather than scattered through a fine-grained landscape. These latter results have obvious implications with respect to conservation and especially landscape planning.

Finally, given the rate and magnitude of simulated future climate changes, and the prevalence of fragmented habitats for wildlife in our managed landscapes, we must expect the local or even regional extinction of certain species. Furthermore, we must acknowledge the risk of global extinctions. This last risk is especially great amongst those species adapted to, and restricted to, upland or high latitude habitats.

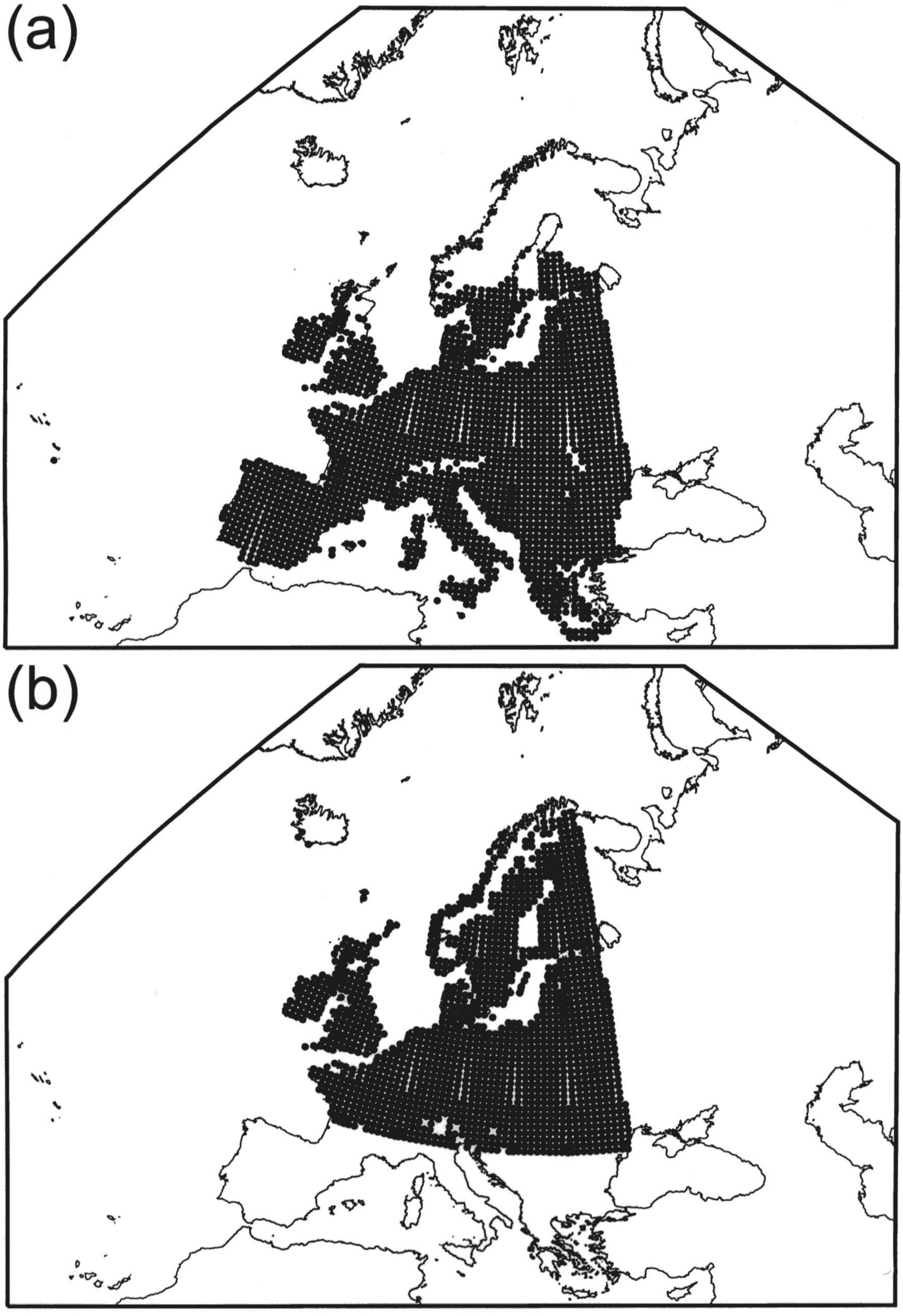

Figure 6.1 The potential 21st century range change of the Speckled Wood butterfly (*Pararge aegeria*) in Europe. (a) Simulated present distribution. (b) Simulated potential distribution under late 21st century climate conditions. Note that the southern range margin of this species is not simulated because this margin is not in Europe at the present day.

(a)

(b)

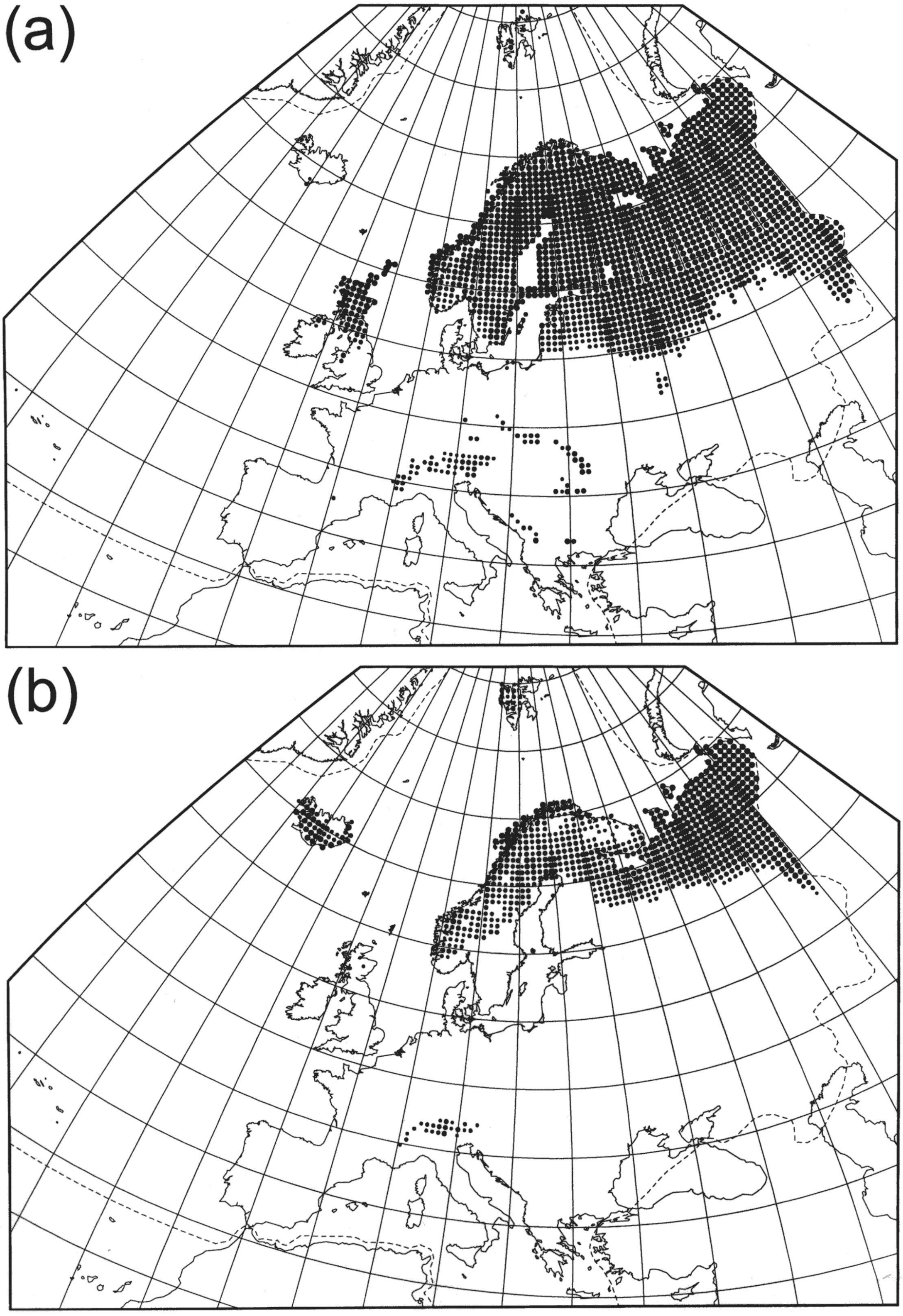

Figure 6.2 The potential 21st century range change of the Cloudberry (*Rubus chamaemorus*) in Europe. (a) Simulated present distribution. (b) Simulated potential distribution under late 21st century climate conditions

(a)

(b)

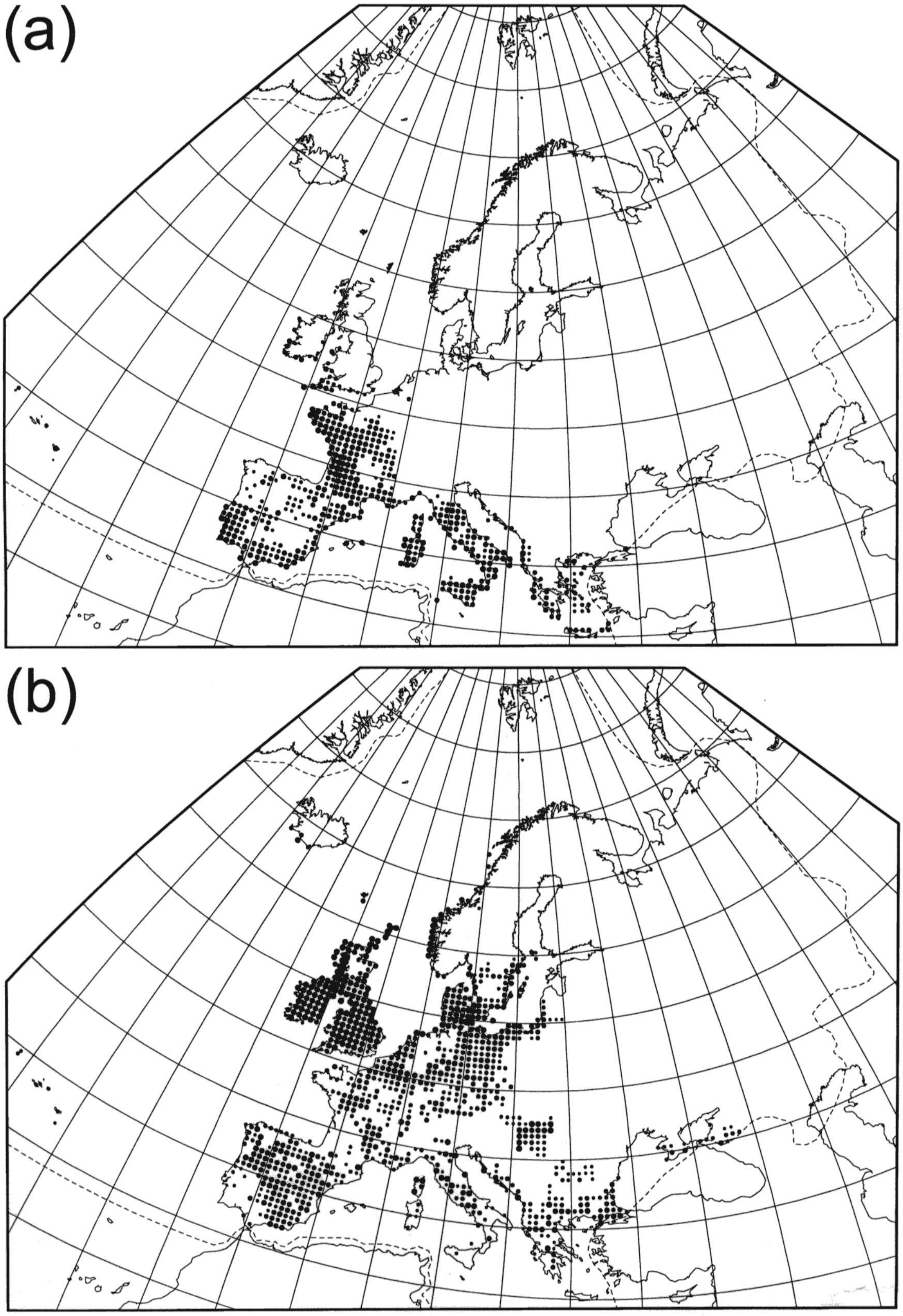

Figure 6.3 The potential 21st century range change of the Wild Madder (*Rubia peregrina*) in Europe. (a) Simulated present distribution. (b) Simulated potential distribution under late 21st century climate conditions.

Implications for conservation in the uplands

Limiting the magnitude and rate of anthropogenic climate change must be a priority. Conservation organisations that traditionally have focussed upon wildlife conservation, and taken no stance upon environmental issues of a wider nature, must begin to engage with these wider issues if the wildlife they seek to conserve is to have a future. The Worldwide Fund for Nature (WWF) and the Royal Society for the Protection of Birds (RSPB)/Birdlife International are already active in this respect; The World Conservation Union (IUCN) has also recently begun to address the issue. It is imperative that statutory bodies, as well as such non-governmental organisations (NGO's) begin to participate more generally and further develop their policies on issues such as renewable energy sources. For example, the future for certain upland wildlife may depend upon wind power as a significant contribution to reducing human dependence upon carbon-based fuels, but at present such developments are often opposed by bodies with an interest in wildlife conservation.

However fast we reduce greenhouse gas emissions, we are already committed to some significant climate warming, and thus there will inevitably be continuing tendencies for species' ranges to shift. In order for these range shifts to occur, the landscape as a whole must be planned and developed in ways that will render the landscape more suitable for the migration of species responding to environmental change. Conservation bodies have tended to focus their attention upon reserves and addressed wider landscape issues to a lesser extent. Whilst reserves are of course important, as the principal nodes in the habitat network in a landscape, it is vital that wildlife conservation bodies involve themselves more with wider landscape issues and the promotion of a more holistic approach to land-use planning that will work to develop "wildlife friendly" landscapes. Great opportunities exist to capitalise open land taken out of agriculture, etc. The NGOs and statutory bodies once again need to play a more active role.

Given that conservation bodies inevitably have limited resources, it is imperative that they be aided and guided in the prioritisation of such resource application. For example, certain upland species in Britain are on the southern margin of a boreal–Arctic range. Although they are considered rare in the British uplands, they are often widespread and abundant in Fennoscandia. Given the likely climate changes of the next century it is probable that conservation efforts focussed upon these species will be doomed to fail. Such efforts may therefore be considered a low priority. However, marginal populations may represent an important component of the intraspecific genetic diversity of a species, and so may be judged appropriate targets for other types of conservation measure. Such measures might include translocation or the collection of material with the aim of conserving the genetic diversity represented. Examples of such species in the northern Pennines of England include the Cloudberry (*Rubus chamaemorus*), and the dwarf birch (*Betula nana*) in Upper Teesdale. Both species are more abundant elsewhere in Britain and widespread in Fennoscandia.

The impacts of climate change are themselves exacerbated by the synergistic effects of other environmental changes. These effects are often most marked in the uplands. Thus, for example, many upland soils are relatively nutrient deficient and so less favourable to competitive or ruderal lowland species than to the more slow-growing stress-tolerant upland species. Increased nitrogen deposition from the atmosphere, however, will enhance the encroachment of such lowland species as climate warms. Once again, therefore, the need is for wildlife conservation bodies to work with others, including, of course, government, to reduce these additional environmental pressures.

If the wildlife of the British uplands is to be successfully conserved over the next century then it will be though the development of integrated and prioritised environmental conservation measures and landscape planning and management. Without such a holistic approach the prospects for many of the rarer upland species surviving in the British Isles to the end of the 21st Century may be bleak.

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7. Water quality in the British uplands

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Introduction

There has been a substantial escalation in interest in the chemical quality of upland freshwaters over the past 10–20 years. Partly of course this is because of intrinsic interest in water chemical quality *per se*, and subsequent potential impacts upon dependent freshwater biota and associated food chains (including the human food chain in the context of potable water). A greater urgency has, however, been triggered by increased realisation of the regional and global scales of impacts of atmospheric and terrestrial environmental pollution, and of the interactions between land use and surface freshwater quality. An encouraging consequence of this concern over environmental pollution and environmental change issues has been a growing awareness of the benefits of developing an integrated overview of the functioning of the soil/plant/drainage water system. This has resulted in a widening national and international acceptance of the merits of the concepts of ICM - integrated catchment management (Cresser and Pugh, 1998).

The functionality of upland streams

Within the context of ICM, upland streams are multi-functional. Most obviously, they function naturally as receptors for ground and/or soil water, and conduits for transport of solute and particulate species to lakes and/or the oceans. They also function as support systems for aquatic biota and, directly and indirectly, terrestrial biota. As a consequence of in-stream chemical, physical and biological processes, these functions may be highly interactive and spatially and temporally highly variable. This variability, in turn, poses problems to environmental scientists involved in quantitative assessment of the status of surface freshwaters, especially in the uplands. The purpose of this paper is to explain the science underpinning some approaches to water/catchment quality assessment, with particular emphasis on progress recently made by the authors and their colleagues in the UK.

The chemistry of upland rivers

The major solute species in upland rivers are the base cations, Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}, the anions Cl^{-}, SO_4^{2-} and HCO_3^{-}, silicate, dissolved organic matter (DOM), and, sometimes, H^{+}, which is discussed later. These species tend mostly to be present at around 0.5 mg l^{-1} or above (see Table 7.1), and sometimes and in some catchments can exceed 10 mg l^{-1} (although this would be very unusual for K^{+}). Weathering and cation exchange reactions in upland soils tend generally to increase the concentrations of these ions as precipitation infiltrates through soils (*e.g.* Burt, 1986).

As can be seen in Table 7.1, and will be discussed further later, the parent material from which the catchment soils are derived strongly influences the absolute and relative concentrations of base cations in their drainage waters (*e.g.* Walling and Webb, 1986; Billett and Cresser, 1995; Smart *et al.*, 1998). For example, low Ca^{2+} concentrations will be found in unlimed catchments with soils derived from quartzites or granites, such as the Allachy in Table 7.1, especially at high river flow. If such a catchment contains even a small amount of limestone or dolomite, however, as in the Allt Glas Choile in Table 7.1, concentrations of Ca^{2+} may well be an order of magnitude higher. Serpentine, as in the Meall Dubh (Table 7.1) increases Mg^{2+} concentration. The DOM concentration is related to the occurrence of organic soils in the catchment and their distribution relative to the river channel (Hope *et al.*, 1997). The DOM is anionic, which needs to be taken into account when considering cation/anion charge balance of the solute species in river water samples.

The water may also contain very low (<1mg l^{-1}) concentrations of ammonium and nitrate, especially in winter months when plant nutrient uptake is much reduced. Higher nitrate concentrations will be found if the catchment contains a significant proportion of agricultural land (e.g. the Feugh in Table 7.1), in which case fertiliser N applications and liming may both have a substantial impact. Phosphate-P concentrations are generally very low (ca. 10 ng l^{-1}), and often transport of P and N in organic forms as part of the DOM may exceed that in inorganic forms (Ron Vaz *et al.*, 1993; Yesmin *et al.*, 1995). Agricultural practices such as liming also increase Ca^{2+} concentrations, and to some extent concentrations of other base cations as a consequence of cation exchange reactions.

Other trace elements present, usually at <200 ng l^{-1}, and often at much lower concentrations, include B, Zn, Cu, Al, Mn and Fe. For the last three elements especially, organic complexation plays an important role in their transport in upland catchments, and their total concentrations in water often increase at high discharge when DOM concentration increases (Reid *et al.*, 1981). The link between soil parent material, geology and river water trace element chemistry is seen much more clearly in maps of river sediment element concentrations than it is in maps showing distribution of water solute composition (BGS, 1991).

Hydrogen ion concentration may be highly variable in upland rivers, both spatially, on progressing down stream, and between catchments, depending upon their soil parent material(s). In many catchments, however, it varies most markedly with discharge.

The flashy nature of upland rivers

Streams in the UK uplands are generally highly flashy in nature, discharge rising rapidly in response to heavy precipitation events or rapid snow melt, then subsiding rapidly once the input of water ceases. Associated with these periods of high discharge there are often quite dramatic changes in water chemical quality (Cresser and Edwards, 1987; Blakar *et al.*, 1990; Jenkins *et al.*, 1990; Wheater and Beck, 1995).

The most widely recognised chemical issue associated with the highly dynamic nature of upland streams is the occurrence of acid flushes during periods of high discharge. These result in strong negative correlations between river water pH and discharge. These flushes generally are associated also with substantial increases in dissolved organic carbon (DOC), and often in Fe, Mn and Al concentrations, and decreases in concentrations of elements such as Ca^{2+} and Si, associated with biogeochemical weathering. The effects are due primarily to changes in hydrological pathways during storm events, with water draining over, or more commonly laterally through, more acidic, often heavily leached, surface organic horizons starting to make a relatively greater contribution to total river discharge. Potassium concentration often increases at high flow, possibly because of the combined effects of relatively greater influences of secondary mineral formation in underlying mineral soil horizons under base flow conditions, and of leaching of foliar potassium during precipitation events. Burt and Park (1999) have observed marked differences in the spatial distribution of exchangeable potassium in soils of upland catchments compared with the distributions of other exchangeable base cations. This may also help explain the marked differences between potassium and other base cations in concentration/time relationships during storm events.

Unless the rain is very prolonged, the period of high discharge, and hence the period over which baseflow water chemistry changes significantly, may last from a few hours to a day or slightly longer, depending upon the catchment size and topography, and upon antecedent soil moisture conditions. Flow duration curves, which are plots of discharge against the percentage of total time that discharge is equalled or exceeded, show that upland rivers are mostly at or near baseflow conditions for about 90% of the year. A typical example, for the Brocky Burn in north-eastern Scotland, is shown in Figure 7.1. From a sequence of 12 monthly samples, only one sample is likely to correspond to even moderately high flow conditions. Thus sampling rivers to obtain water representative of high discharge conditions requires a carefully planned sampling strategy (Edwards *et al.*, 1984). The question that must be asked, therefore, is: “Just how important are the changes in water chemical quality which occur during high discharge flushes?”.

Unfortunately the biological impacts of acid episodes upon fish, aquatic invertebrates and other freshwater biota are not fully understood, as pointed out by Havas and Rosseland (1995) in their useful review of acidification effects. It is virtually universally accepted that fish and invertebrate kills may result from sustained exposure to water of low pH. However, more research is needed to establish just how long, how severe, how frequent, and at what time of the year exposure to acid water needs to be for damage at various growth stages of different species. Moreover, while fish will migrate away from acid waters towards water of higher pH, this is not always possible in upland river systems over a short to medium time scale. Even where it does prove possible, mixing of water at low and high pH may result in production of colloidal hydrated aluminium species which may still be highly toxic to fish (Havas and Rosseland, 1995). The interactions between H^+, inorganic Al^{3+} and other environmental parameters are complex , especially in terms of assessing likely toxicity response, so it is difficult to draw precise, or even useful, conclusions about safe chemical limits.

Bulger *et al.* (1995) noted for stream systems subject to both baseflow and episodic acidification in the Shenandoah National Park in the US that the magnitude of acid neutralising capacity (ANC) depressions during episodes was a linear function of the antecedent base flow ANC. This could suggest that baseflow ANC data alone are potentially capable of providing a meaningful risk assessment, once suitably calibrated. However, Dalziel *et al.* (1995) concluded for Norwegian lakes that ANC was not necessarily the most useful diagnostic parameter if used in isolation.

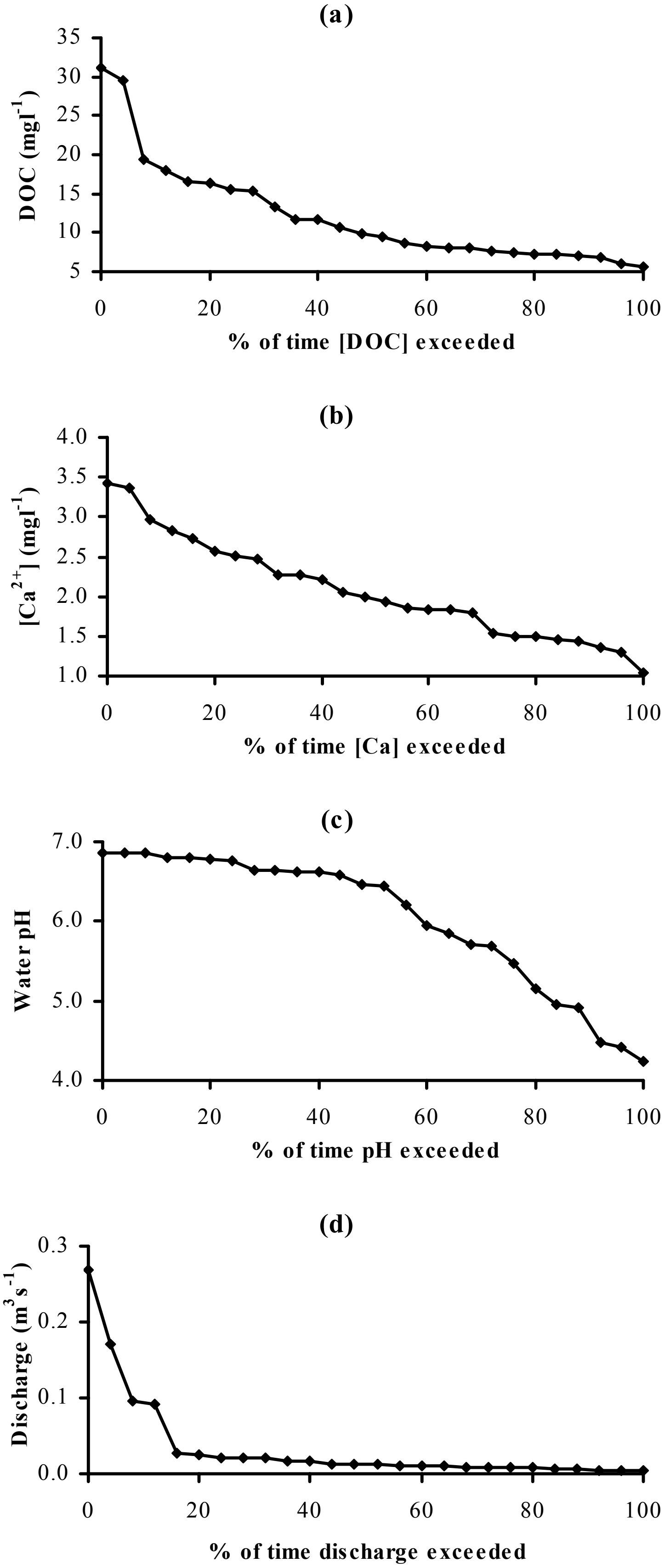

Figure 7.1 Selected flow and chemical duration curves for the Brocky Burn, in Glen Dye, north east Scotland. a, dissolved organic carbon (DOC); b, Ca^{2+} concentration; c, River water pH; and d, discharge. The horizontal axis in each case shows the % of total time the parameter value plotted is equalled or exceeded. Plots are bassed upon 26 samples collected over 12 months at 2-week intervals.

Seasonal variations in upland water quality

In addition to the changes in river water chemical quality associated with individual precipitation or snow melt events, it is common to see marked seasonality effects within years, and seasonality differences between years. Soils in British uplands tend to stay cooler and wetter longer in autumn and winter, for example, than they do in late spring and summer. Thus the probability of water draining over or through surface soils is higher in autumn and winter, and flushes of water with low pH and high DOC tend to be both more likely and more severe in these seasons. This is especially true in a very wet autumn, such as that which occurred in north-eastern Scotland in 1984 (Cresser and Edwards, 1987). Seasonality effects on nutrient ion concentrations may also be due in part to nutrient uptake by plants being higher in the summer period. This effect most often can be clearly seen for nitrate (Whelan *et al.*, 1995). Conversely, evapotranspiration is higher in summer, which tends to increase the concentration of mobile anions such as Cl^- in the soil solution, and hence in drainage water to stream channels. This, in turn, tends to increase the concentrations of associated cations. For example, the authors have found that the pH of water drained from peat moorland microcosms tends to be most acidic in summer months.

The importance of soil and its parent material and management to water quality

Soils in some catchments, for example those derived from quartzite, granite or old acid sandstones, quite naturally will have low mineral biogeochemical weathering rates. Such soils will tend to have low concentrations of soluble Ca^{2+} (in relative terms the most mobile element from weathering), and will produce relatively little natural alkalinity. Thus the soils themselves, and the waters draining from them, will be susceptible to acidification from natural causes and as a consequence of acid rain effects or afforestation effects. Two adjacent catchments, only a few hundred meters apart but with slightly different soils, may naturally therefore have very different water chemical composition (Rees *et al.*, 1989).

In addition to naturally occurring soil parent material effects, soil management practices and land use may significantly influence water chemical quality in the uplands. Liming, for example, may increase pH and Ca^{2+} concentration, but may also mobilise K^+ or Mg^{2+} by cation exchange reactions. Furthermore it may enhance or induce mineralisation of organic N reserves in the soil, resulting in small flushes of ammonium and nitrate. Even salting of roads in upland catchments in winter may contribute to acid flushes in streams down slope from the road, as added Na^+ displaces H^+ ions from cation exchange sites, and these move to the stream accompanying the mobile Cl^- ions. Sodium and Cl^- contamination from heavy use of road salt can be seen in the Cairnwell Burn (Table 7.1), which is at the Glen Shee ski resort. However the dolomite here prevents significant acid flushes (Table 7.1). Afforestation, especially with conifers, increases the trapping of sea salt aerosols from the atmosphere, thus increasing Na^+, Cl^- and SO_4^{2-} concentrations in rivers draining the forest. This can be seen in Table 7.1 for the Meall Dubh catchment.

So what do we mean by “water quality” in the uplands?

We have seen that water chemical composition in British upland streams may change spatially, and drastically over periods of only a few hours in response to sudden water inputs. There is an inextricable link between soil parent material/underlying geology and water composition, but this may be influenced by land use and soil management practices. How then should we define water quality, or indeed, set acceptable water quality criteria for upland rivers? Data from a single spot sample will clearly be of limited value in isolation. If background climatic and river discharge data at time of sampling are available too, and catchment characteristics are known, the analytical data from the single sample may be a little more informative, but even then little can be inferred from a baseflow sample about what the water quality would be like under high discharge conditions. Of course, a whole series of samples could be collected and chemically analysed for each site of interest, but this would prove very expensive, particularly for remote areas. What is required is an approach which allows key water quality parameters to be predicted, under diverse flow regimes, from readily available data. Even then we still need to be able somehow to relate chemical quality quantitatively to biological effects to meet water quality assessment objectives.

If our understanding of key toxicity effect mechanisms was sufficiently rigorous, we might be able to define a set of chemical duration curves, such as those included in Fig. 5.1, which we could confidently state would support a selected desirable organism throughout every stage of its life cycle with no adverse effects. In the authors’ view, we have much research to complete before this approach could be used with any confidence. Moreover, even a pH duration curve does not fully describe the temporal variation in pH of a stream at the level of detail which may be required.

Table 7.1 Parent materials and land use in six Scottish upland catchments, and the associated river water pH and cation and anion concentrations (mg l^{-1}, except pH, and gran alkalinity, which is in $\mu mol_c\ l^{-1}$)

Catchment	Parent material	Land use		pH	Ca	Mg	Alkalinity	Na	K	SiO_2	Cl^-	SO_4^{2-}	PO_4-P	NO_3^--N
Allachy	Granite	*Calluna*	mean	6.35	1.24	0.54	7.96	4.39	0.49	7.76	5.94	4.35	0.003	0.08
		Moorland	min	5.17	0.78	0.28	0.69	3.17	0.32	5.53	4.94	3.32	0.000	0.01
			max	7.06	1.75	0.72	67.4	5.09	0.56	10.5	7.05	5.29	0.005	0.20
Allt Glas Choile	Leucogranite	*Calluna*	mean	7.37	10.5	1.49	524	5.62	0.32	11	9.9	3.19	0.010	0.04
	Schists	Moorland	min	6.35	3.14	0.65	59.1	4.22	0.20	4.72	8.32	2.11	0.005	0.01
	Limestone		max	8.33	20.4	2.8	1003	6.89	0.38	14.3	14.5	6.01	0.040	0.11
Feugh	Feldspathic gneiss	*Calluna*	mean	6.82	4.2	1.09	144	5.91	0.67	8.7	9.05	5.99	0.005	0.34
	Granite	Moorland	min	6.04	2.89	0.69	31.9	4.37	0.54	6.39	8.03	4.51	0.004	0.05
		Some woodland	max	7.2	5.97	1.54	226	7.23	1.26	10.8	11.5	6.96	0.005	0.67
		Improved grass												
Corriemulzie Burn	Dolomite	*Calluna*	mean	7.69	11.9	1.38	631	3.23	0.77	6.36	4.44	4.79	0.005	0.03
	Pelite	Moorland	min	7.05	3.84	0.62	151	2.39	0.43	3.25	3.66	2.34	0.005	0.01
	Psammite	Some woodland	max	8.43	20.8	2.4	1117	4.27	1.16	8.04	5.42	6.23	0.005	0.05
	Quartzite Schist													
Cairnwell Burn	Quartzite	*Calluna*	mean	7.72	17	1.37	874	12	0.61	3.55	18.8	4.09	0.008	0.12
	Graphitic schist	Moorland	min	7.12	5.6	0.6	281	4.48	0.31	1.94	7.36	2.34	0.005	0.05
	Dolomite		max	8.55	27.8	2.56	1435	21.9	1	5.12	28.8	5.91	0.018	0.25
Meall Dubh	Pelite	Spruce forest	mean	7.62	5.26	8.20	841	7.56	0.87	15.3	14.5	10.6	0.004	0.09
	Psammite		min	7.07	2.73	5.21	241	5.68	0.47	9.40	11.40	6.19	0.001	0.01
	Metagabbro		max	8.34	9.21	13.4	1735	8.63	1.47	22	16.9	13.3	0.011	0.29
	Serpentine													

For example, do two one-day periods of water at pH 4.0 have the same effect as one two-day period at this pH? Is the time of the year when acid episodes occur important? In addition, an adverse effect may be a consequence of more than one critical determinand simultaneously being above (or below) a prescribed limit of acceptability. Chemical duration curves provide no indication of coincidence or otherwise in time of critical conditions.

One possible way to quantitatively characterise a river system is to develop a model of how its important water quality parameters change over time, and might change in response to changes in land use, climate or atmospheric pollutant deposition. The many excellent models which have been developed over the 1980s and 90s have been summarised in a useful comprehensive review by Ball and Trudgill (1995). Many of these are data-intensive, and thus expensive to calibrate for individual catchments. Thus there is a need in the UK to be able to predict water quality for upland streams from readily available data, for example from published maps or published literature, or from data sets held on GIS.

The critical load concept

The critical load concept was introduced to provide a single measured parameter for a component of an ecosystem, such as a soil or a body of freshwater, to guarantee its protection. Thus, provided the critical load of a specified pollutant was higher than the total atmospheric deposition of that pollutant to the system, the system would not be damaged according to present knowledge (Nilsson and Grennfelt, 1988). For freshwaters, critical loads are effectively calculated from the acid neutralising capacity of lake waters. The ANC depends upon the non-marine (*i.e.* weathering-derived) base cation concentration of the water. For upland rivers, however, the situation is again complicated, because ANC is itself a function of discharge. Even if total ANC estimation for a river was based upon, for example, 52 weekly sample analyses over 12 months, there could be short periods where ANC was exceeded by pollutant deposition load. Such periods could be associated with potentially damaging acid flushes.

It might, quite reasonably, be argued that the critical load concept was not conceived with rivers in mind, but in the absence of a better approach to pollution abatement strategy planning, it is likely to remain the method used in Europe, even for rivers, for several years to come.

The importance of riparian zones when predicting water quality

As discussed earlier, an upland river's water chemistry is closely linked to its catchment's soils and land use/soil management practices. It should therefore be feasible to predict river water quality from appropriate soil and catchment topographic characteristics. Of particular importance are the soils in the riparian zone, which water from upper slopes passes through to a greater or lesser extent on route to the stream channel. It has been shown by Billett and Cresser (1992), for example, that appropriate mapped riparian zone soil horizon chemical characteristics may be used to predict key water quality parameters such as Ca^{2+} concentration or pH under diverse flow conditions in rivers in NE Scotland. A key feature of their approach was to weight the "contribution" of each key riparian zone soil horizon according to its estimated (primarily from catchment topography) zone of influence on water entering the river channel. The second key feature was the use of % Ca^{2+} saturation of the cation exchange sites in upper or lower horizon soils, rather than exchangeable Ca^{2+}, as an index of potential Ca^{2+} mobility. Using a similar approach, % exchangeable acidity was used for pH prediction. This modelling approach, known as the ASH (Aberdeen Soil Horizon) model, was very attractive in that it allowed prediction of key water quality parameters under a range of flow conditions from readily available soil and catchment data. Such predictions of soil water quality from existing data sets are attractive to land use planners interested in water quality on regional scales, because they obviate the need for sampling at remote sites on numerous occasions.

The GBASH model

Attempts to extend the ASH model more widely using existing Scottish Soil Survey soils maps rather than results of dedicated surveys met with limited success due to the limited resolution of the maps, which were of course produced with very different aims in mind. However, it recently has been shown that geological maps and published data sets may be an excellent surrogate for soil maps and soil analysis (Smart *et al.*, 1999). It is still necessary to use flow pathway-weighting, but of riparian zone geological parent material distribution and composition. If, for example, the weighted square root of rock calcium oxide concentration is used as a predictor, the agreement between measured and predicted Ca^{2+} concentrations, under a complete range of flow regimes, is excellent (Cresser *et al.*, 2001). The predictive equation for river water calcium concentration, $[Ca^{2+}]$, takes the form:

$$[Ca^{2+}] = a + b\sqrt{\{CaO\}_R}$$

where a and b are empirical regression constants and $\{CaO\}_R$ denotes flow routing-weighted CaO concentration of riparian zone rock types, taken from rock composition data in the literature. Where catchments have areas of improved grazing or arable land in the riparian zone, the percentages of these types of land use in this zone are used as a modifier in the predictive equations. Figure 7.2 shows the strength of the predictive equations for [Ca^{2+}] when validated for 24 upland moorland catchments and catchments with mixed land use in north-eastern Scotland. The predictive equations were derived using 26 sets of samples collected over 12 months from 30 independent catchments, also in north-eastern Scotland. Equations were derived using mean data, baseflow data (data for 3 lowest flows), high flow data (data for 3 highest flows) and using data at maximum and minimum observed flow. Fuller details of the equations used and how they were derived for Ca^{2+} and other determinands may be found in the work of Cresser *et al.* (2000).

Calcium is interesting in its own right in the present context, because of potential problems of very low Ca^{2+} concentration in acidification-sensitive waters. However, the same approach may also be used to predict alkalinity, and indeed critical load, under high and low flow conditions, as well as for mean values. The authors perceive the ability to predict critical loads of upland streams from existing readily available data sets as a significant advance. Current critical load maps for UK freshwaters are primarily based upon spot samples taken from the standing water thought to be the most sensitive in each mapped unit square. There are areas where running waters may be appreciably more sensitive to acidification, especially under high discharge conditions. Moreover, there are strong seasonal variations in critical load in many upland river systems, for reasons explained earlier. The geology-based variant of the ASH model (GBASH) allows prediction of minimum, maximum or mean alkalinity or critical load, and should remain useful regardless of what is found about the relationship between acid episodes and biological responses of organisms of interest.

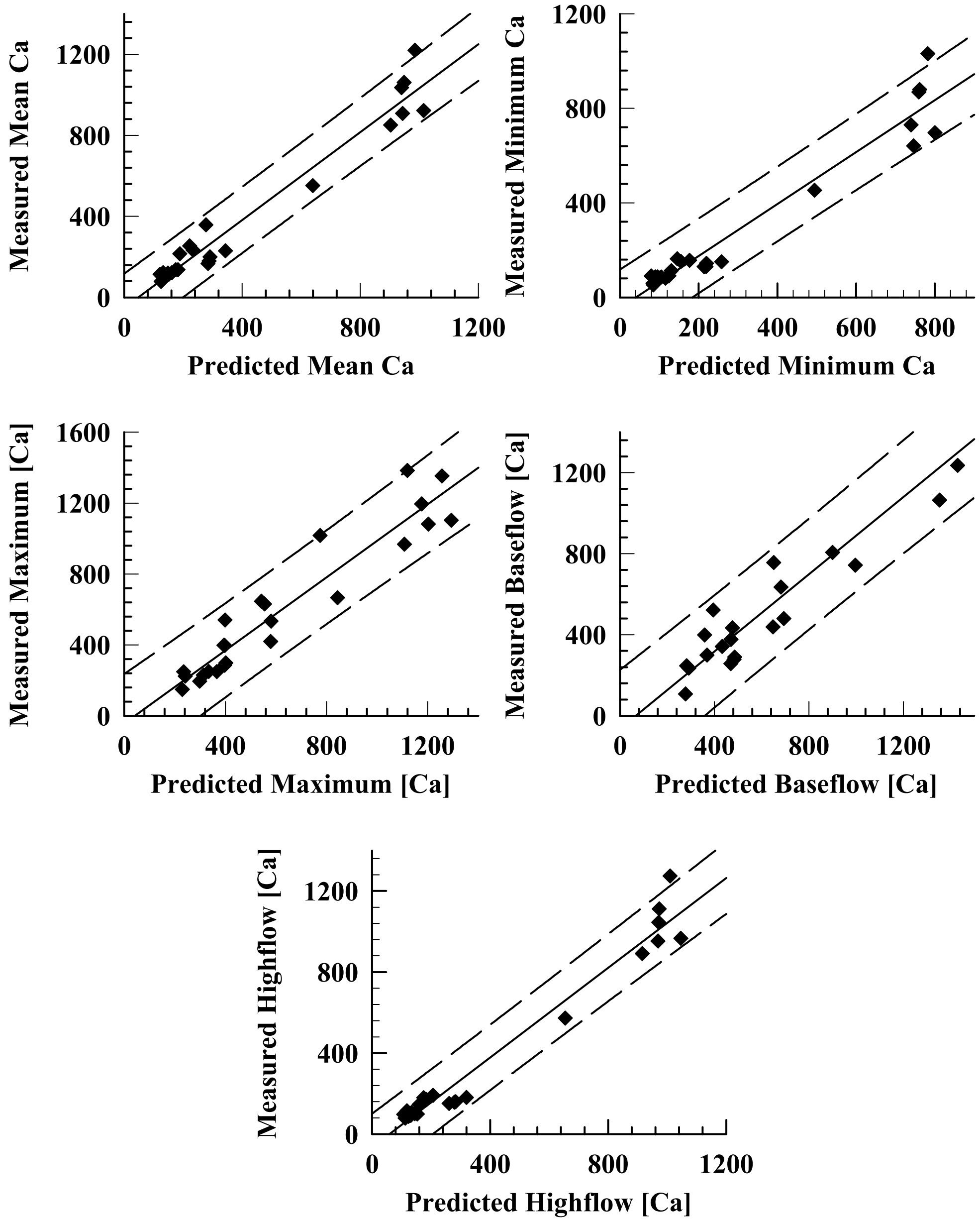

Figure 7.2 GBASH validation plots for $[Ca^{2+}]$ using data from 24 upland catchments in north-eastern Scotland. The predictive equations were derived using 26 sets of samples collected over 12 months from 30 independent catchments. Predictive equations were derived, and validations performed, using mean data (top left), base flow data (data for 3 lowest flows, centre right), high flow data (data for 3 highest flows, bottom) and using maximum (centre left) and minimum (top right) flow data. The lines are 1:1 plots. Broken lines show 95% prediction intervals.

An alternative index for upland stream water quality

Another very effective way of assessing susceptibility of upland surface freshwaters to acidification, and indeed of predicting their critical loads under diverse flow conditions, is to exploit the impact of atmospheric sea salt deposition effects upon surface water quality (White *et al.*, 1999). The strong maritime influence is most readily seen in waters draining from ombrotrophic peat soils (Rees *et al.*, 1989; Dawod and Cresser, 1997). In such waters, as would be expected, the relative amounts of Na^+, Ca^{2+} and Mg^{2+} in river water and in precipitation are virtually identical at a given site. This can be readily demonstrated by plotting % Na, % Ca and % Mg contributions to ΣNa + Ca + Mg (all in $mmol_c\ l^{-1}$) on a triangular diagram (Figure 7.3). On organo-mineral soils, Ca^{2+} becomes progressively more important as the weathering rate of the mineral component increases, and there is thus a shift towards the Ca^{2+} apex of the triangle. Thus Na^+ dominance of river water provides an excellent indication of integrated catchment soil weathering rate upstream of the sampling point.

Our recent studies have also shown that, if coupled with catchment altitude as a modifier, Na^+ dominance provides an extraordinarily good prediction of critical load under low flow and peak flow conditions. Figure 7.4 shows relationships, for mean flow, base flow (3 lowest flows) and high flow (3 highest flows) conditions, between directly measured critical loads (CLs), and CLs calculated simply from % Na^+ dominance and catchment maximum altitude, as described in detail by White *et al.* (2000). Although this approach still requires some chemical analysis, the amount is minimal. Even Na^+, Ca^{2+} and Mg^{2+} concentrations in a single baseflow spot sample may be used to provide a very good measure of CL under a diverse range of flow conditions.

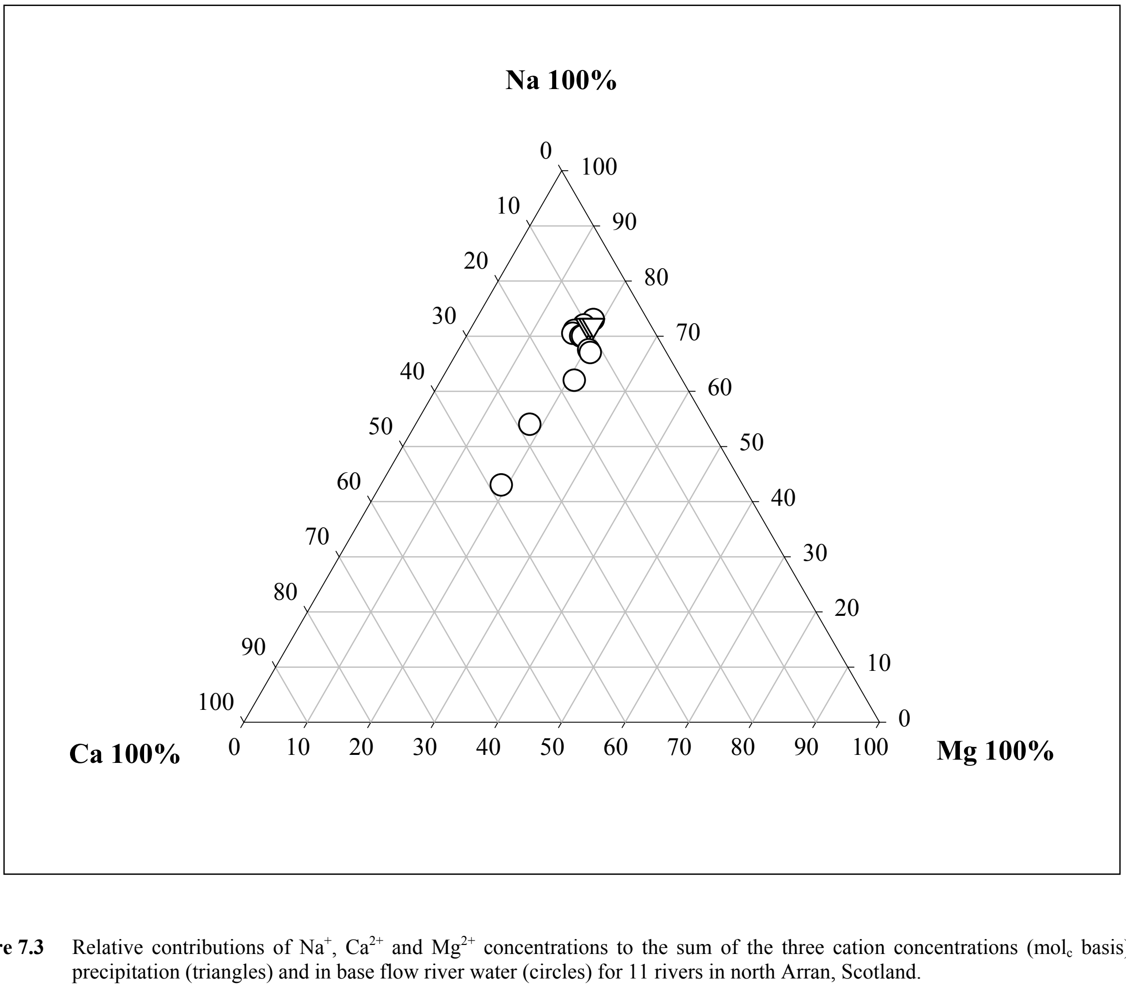

Figure 7.3 Relative contributions of Na^+, Ca^{2+} and Mg^{2+} concentrations to the sum of the three cation concentrations (mol_c basis) in precipitation (triangles) and in base flow river water (circles) for 11 rivers in north Arran, Scotland.
The three points displaced towards the 100% Ca apex had appreciable areas of podzols and some cambisols. The other eight streams drain peat soils.

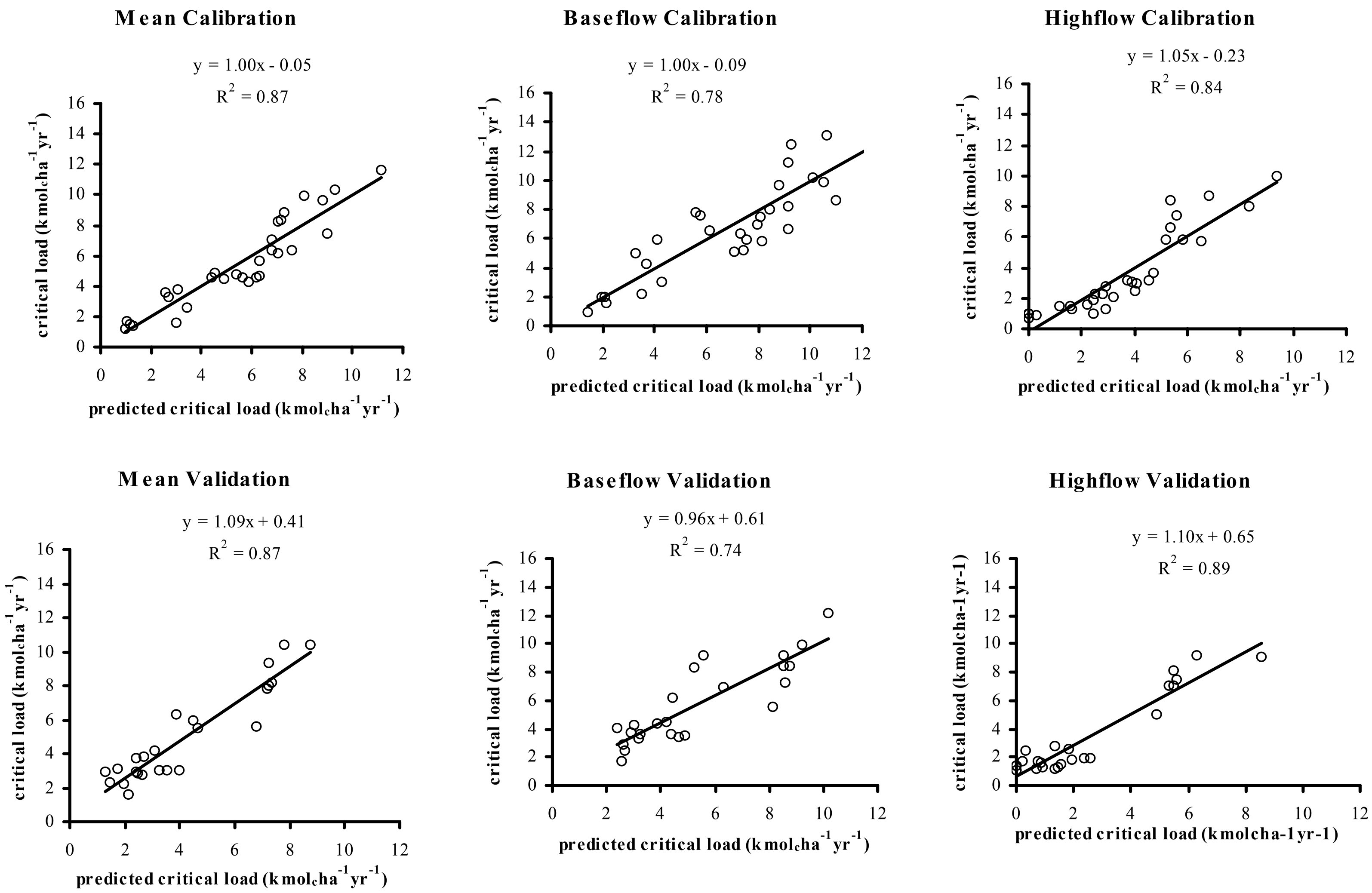

Figure 7.4 Relationships, for mean values, base flow (mean values for 3 lowest flows) and high flow (mean values for 3 highest flows) conditions. Between directly measured critical loads (CLs), and CLs calculated simply from % Na^+ dominance and catchment maximum altitude. The upper three graphs are for the 30 catchments of the calibration data set, and the lower three for the 24 catchments of the validation data set

Conclusions

It is a relatively simple matter to take a spot sample of water from a river and analyse it chemically. However, if used conventionally, the resultant data only provides an indication of the water quality at a particular moment in time at a particular sampling site. This may not be enough to assess the biological significance of chemical results. Even if the critical load of the spot sample is calculated in the conventional way, this will not necessarily allow meaningful conclusions to be drawn about the biological risks associated with water quality for the river as a whole. This contribution therefore has stressed how difficult it is to define water quality in a way which is meaningful for those concerned with assessing water quality effects on aquatic biota. It has concentrated upon chemical aspects of water quality, but especially on prediction of base cations, acidity, alkalinity and critical loads of upland rivers under diverse flow regimes. The methodology suggested, based as it is upon water quality prediction from available data sets and critical load prediction from Na^+ dominance, is very promising, although it needs validation over larger regional scales. Moreover, the approach adopted is also applicable to DOC in river water (Hope *et al.*, 1994, 1997), and very probably to DON. Over coming months the authors will be evaluating similar approaches for the prediction of losses of N and P from upland soils.

Acknowledgements

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8. Eroding upland landscapes? Past, present and future perspectives

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Key concepts

Throughout the last millennium, the combined effects of changes in climate and changes in land use have had considerable impact on landform systems in the British uplands. Such impacts include both on-site (hillslope) impacts such as soil erosion and off-site effects (downstream, generally within the river channel network) such as floodplain sedimentation. Our paper outlines six key concepts as a basis for understanding the behaviour of landforms in the upland environment:

- *Contingency*: what happens at one point in time is very much dependent on the immediate history of events locally. We need to consider a range of timescales: major landforms may reflect long periods of development throughout the Tertiary Period (last 65 million years) with, in some places, major modifications during the Pleistocene ice ages of the last 1.6 million years. During the Holocene (last 10,000 years), changes tend to be more localised and increasingly reflect the impact of people within the landscape.
- *Thresholds*: a small change in one critical variable may force the system to adjust to a radically different condition. Threshold may be crossed as a result of external triggers (e.g. climate change) or internal changes (e.g. overgrazing in relation to soil material strength).
- *Complex response*: the result of disturbance is likely to be complex in time and space and may lead to a considerable diversity of landform response. Changes may be reversible (negative feedback) or irreversible (positive feedback), and localised or ubiquitous. It is of particular interest to see how disturbance at one location is propagated through the landscape.
- *Landscape sensitivity*: sensitive parts of the landscape respond quickly to change, whereas insensitive parts respond slowly, or not at all. It is important to identify sensitive locations within the landscape (e.g. floodplains, alluvial fans) where the effects of any changes will be quickly seen. One common approach to sensitivity analysis is to borrow the concept of *factor of safety* from civil engineering, comparing the balance between resisting and disturbing forces.
- *Frequency and magnitude*: changes in the frequency of occurrence and/or magnitude of extreme events may have considerable effect on the landscape, especially if adverse climate change is coincident with lowering of landscape resistance. If thresholds are crossed more frequently, erosional features such as gullies may become a permanent fixture in the landscape rather than an ephemeral result of extreme events.
- *Taking an integrated approach*: We cannot consider one part of the landscape in isolation; changes in one place can have widespread effects and the impact of change may be long lasting.

Further discussion of these concepts may be found, *inter alia*, in Brunsden and Thornes (1979), Schumm (1979), Thomas and Allison (1993). Following Brunsden (1993), it is possible to identify several types of resistance (or barriers to change) within the landscape:

- Strength resistance describes the inherent ability of a material to respond to stress in a liquid, plastic or brittle way depending on circumstances. Some soil and rock types are naturally more resistant than others and this will introduce spatial variation into the landscape. For example, scree formation within the Lake District reflects not only climatic variation but also local geology.
- Morphological resistance recognises the importance of location, the (potential) energy of position, in relation to slope, relief and elevation. For example, the high incidence of landslides on steep slopes reflects the low factor of safety in such situations.
- Locational resistance describes the proximity of sensitive elements within a system to the processes initiating change. The impact of river channel change on adjacent valley-side slopes is an obvious and important example: renewed undercutting by a river can reactivate old landslides.
- Filter resistance describes the strength of coupling between individual elements of the system and the consequent ability of the system to transmit kinetic energy. Certain locations may be especially sensitive therefore, for example footslopes adjacent to a river channel. If intact, these may provide effective buffers between hillslope and channel systems,

but if disturbed, they may become conduits for sediment transport rather than barriers to movement.

Variation in these resistances through time and space introduces a great deal of complexity into the way which systems respond to external forces. In terms of scale, it is clear that both the individual component and its position within the landscape must be considered.

Brunsden and Thornes (1979) identify two end-members in the spatial response characteristics of a landscape to change:

- Mobile or labile systems have high sensitivity to external forces: they react quickly, relax to new system states with facility, and rapidly propagate effects downstream. These areas are morphologically complex because they are not only subject to rapid change and therefore exhibit transient forms, but (provided that low resistance is matched by high resilience) they are also capable of rapid restoration and the achievement of new stable states. Stream heads or slopes being actively undercut by a river are good examples.

- Slowly responding or recalcitrant systems are insensitive to change: they have a ratio of stress to resistance that rarely exceeds unity. They lie far from the initial point of impact and changes only filter slowly through the system because of poor linkage, high storage capacity and intermediate buffering. Being insensitive to external effects, these areas change but slowly. Interfluves or stable ridges are good examples.

Upland geomorphology – a brief introduction

Upland landscapes cover approximately one-third of Britain. Regional differences in the character of these areas arise due to increasing maritime influence from east to west and decreasing temperature from south to north. Superimposed on this pattern are local variations resulting from differences in geology, topography and land use (Ratcliffe and Thompson, 1988). Such differences produce distinct geomorphological regimes with characteristic suites of erosional and depositional processes and landforms. This variety will be illustrated with two contrasting case studies from northern England: the Lake District (igneous and metamorphic rocks, steep slopes, and mainly mineral soils) and the Northern Pennines (interbedded sedimentary rocks, large plateaux with widespread blanket peat).

Table 8.1 shows the characteristics of two small upland catchments from these two areas. Generally speaking Lake District catchments are wetter and steeper, which results in greater potential energy for erosion and sediment transport; thus, bedload transport potential is greater in small headwater catchments in the Lake District. However, erosivity (the potential for erosion) does not always correlate with sediment production because the erodibility of surficial materials differs; gully erosion is more widespread in the North Pennines due to the occurrence of large areas of blanket peat. In both areas, the legacy of earlier conditions provides the context for current and future landform response. The broad form of the landscape is mainly inherited from the Ice Ages (the Pleistocene) but finer-scale changes and adjustments have gone on throughout the last 10,000 years (the Holocene). In places the impact of human activity has been severe, for example, the effects of overgrazing and mining.

Table 8.1 Characteristics of two contrasting upland catchments

	Dale Beck, Northern Lake District	**Rough Sike, North Pennines (Moor House NNR)**
Area (km^2)	1.95	0.83
Stream order	3rd	2nd
Rainfall ($mm\ yr^{-1}$)	2500	2000
Relief (m)	360 - 710	560 - 720
Stream slope	0.19	0.05
Drainage Density ($km\ km^{-2}$)	3.03	2.46
Work per t (joules)	3433	1569
Stream Power	1.86	0.47

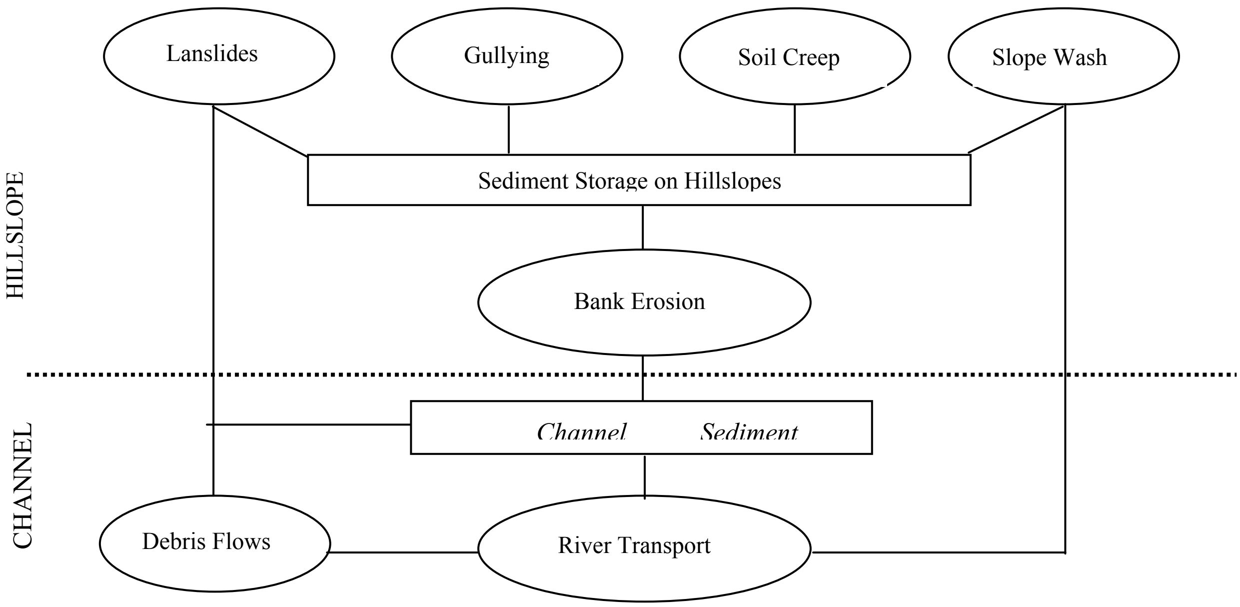

Figure 8.1 Simple sediment budget framework for characterising upland sediment systems

Is it possible to forecast how landscapes will respond in the future, given the current geomorphological complexity? We argue that the geomorphological setting and strength of linkage between hillslopes and river channels is of particular importance in controlling off-site impacts down-valley.

Because of the complexity of erosion processes linkages between geomorphological processes and source areas of sediment in upland landscapes are best studied through a sediment budget approach (Figure 8.1). Sediment budget analysis provides an account of the sources and disposition of sediment as it travels from its source to its eventual exit from a catchment or landscape unit. This approach provides a means of predicting erosion and a context for understanding longer-term landform development. However, full specification of upland sediment budgets in the UK is hampered by incomplete measurements of the range of geomorphological processes currently operating. Given this inadequate knowledge of process rates, we argue that research must develop along two complementary lines:

1. Field monitoring of geomorphological processes. This must include long-term studies, such as those operated by the UK Environmental Change Network at Moor House and other sites, as well as short-term experimental work. Field studies should have regard to both spatial and temporal patterns of change.
2. Development of catchment-scale models capable of providing land managers with reliable forecasts of erosion, sediment transport and deposition for various scenarios of changing climate and land use.

Lake District Case Study

Lake District upland catchments are generally developed in areas of igneous and metamorphic rocks. The resulting relief is characterised by steep slopes that have been heavily modified during Devensian glaciation. Over the last 10,000 years the Lake District landscape has been relatively stable. Human impacts such as forest clearance and the introduction of grazing animals have locally accelerated natural erosion processes adding to spatial variability in geomorphological activity. The present-day environment is characterised by high precipitation, relatively low temperatures and high winds, yet geomorphological processes operate at relatively slow rates. Extensive vegetation on all but the highest mountains limits runoff and sediment transport on slopes (Boardman, 1996). Geomorphological events generally show weak temporal regularity related to diurnal and seasonal cycles. Large episodic events occur at irregular intervals on timescales of 10^2 – 10^4 years.

Figure 8.2a shows a schematic sediment budget for a small Lake District mountain catchment. In the UK, erosion in mountain stream catchments has been a neglected topic, despite its importance for the geomorphological evolution of upland streams and hazard to upland communities. In the Lake District, numerous mountain streams (torrents) exist. These are characterised by steep stream channels, abundant sediment supply (from eroding side slopes), and often fan deposits at the slope base (Eisbacher, 1982). In such a setting, streams have steep channels and side slopes with small intervening floodplains. On hillslopes gullying, soil creep and slope wash operate at relatively slow rates. Hillslope sediment storage is relatively high. Bed-load sediment transport dominates and floodplain sediment storage is relatively minor. Most sediment is stored in the channel. Sediment movement occurs during floods when streams rise rapidly. The physical processes governing erosion range from stream flow to debris flow mass movements. Linkage between slopes and channels tends to be high because of steep gradients and narrow fragmentary floodplains.

Iron Crag in the Northern Lake District demonstrates many of these features. This stream is currently being monitored in order to construct a sediment budget, which accounts for the sources and disposition of sediment as it travels from its point of origin to the exit from the catchment. Preliminary results of this study (Johnson *et al*., this volume) clearly demonstrate the relatively slow operation of contemporary processes. Sediment released from the side slopes during precipitation and freeze-thaw events is slowly accumulating in the stream channel. This process will continue until the next large flood flushes out the stored channel sediment from the gully system.

Northern Pennine Case Study

Some 7.5% (22,500 km^2) of the total land surface of the British Isles, mainly in the upland north and west, is covered by blanket mire. Indeed much of the special character of upland Britain and Ireland is determined by this extensive covering of blanket peat which comprises a large part of the land used for water catchment, hill farming, shooting and many other uses. These blanket mires form the largest single contribution (10-15%) to a globally scarce resource – less than 3% of the world's peatlands are blanket mires (Tallis *et al*., 1997, page 1). Degradation of these blanket mires is therefore of international as well as national significance. Peat erosion has been studied extensively in the southern Pennines where severe erosion is obvious, with widespread areas deeply gullied and devoid of vegetation. In the northern Pennines (for example at the Moor House NNR within which lies the Rough Sike catchment), the erosion has been no less dramatic, but revegetation has masked the effect, making the landscape <u>appear</u> less degraded. In relation to Figure 8.2b therefore, the sediment 'stored' on hillslopes in the northern Pennines is an *in situ* deposit rather than depositional material.

Erosion of peat moorland is notable for both on-site and off-site reasons. On site, erosion has been associated with loss of species diversity and reduced conservation value. Severe erosion may reduce the productivity of the moorland ecosystem and interfere with attempts to manage the area for both wildlife and livestock. Eroded peat is difficult to walk across and, for some, unsightly. Erosion also prevents recovery of the mire system since the hydrological integrity of the peat mass has been irrevocably destroyed. Off-site, the eroded material (both the peat itself and the mineral sediment eroded from gullies that cut through the peat into the substrate below) may be deposited in lakes and reservoirs, in some cases significantly reducing available storage. Coloured water draining from the eroded peat mass is a major cause of customer complaint for companies like Northumbrian Water.

Tallis (1997) provides an overview of blanket mire degradation for the southern Pennines. He lists many agents of erosion, of which the most widespread and important are probably overgrazing, climate change (desiccation) and air pollution. Burning, bog bursts, artificial drainage and trampling (along footpaths) may be locally significant. There has been much speculation about the history of gully erosion in blanket peat. Tallis (1997) suggests that the gully systems may have formed gradually, over considerable periods of time. A drier and warmer period between AD 1250 and 1450 may have triggered erosion by drying out the mire surface, decreasing the permeability of the surface peat layers, and channelling increased quantities of runoff over the surface. There remains doubt, however, about the role of air pollution from about AD 1700: the wholesale disappearance of *Sphagnum* would have reduced the ability of the peat surface to withstand the other agents of degradation, and resulted in the formation of areas of bare peat. Erosion rates from blanket peat catchments are certainly high enough to account for the complete erosion of gully systems within the last 200 years or so (Labadz *et al*., 1991). Probably both arguments have some truth in them: there will be more erosion during drier periods but the severe gullying we see today may well be different in extent to that which develops naturally. Air pollution and, more recently, overgrazing may therefore have shifted the blanket peat system across an important threshold. Before the time of significant human impact, erosion during drier periods would have been balanced by accretion of peat in wetter phases. Today, the gullying may be so extensive that recovery of intact mire systems may never be possible. Even so, the revegetation of severely eroded peat at Moor House suggests that this view may be too gloomy and that blanket peat might regenerate under suitable conditions, particularly if air pollution levels and grazing pressure are both reduced. It is not yet known when the erosion at Moor House took place, or for how

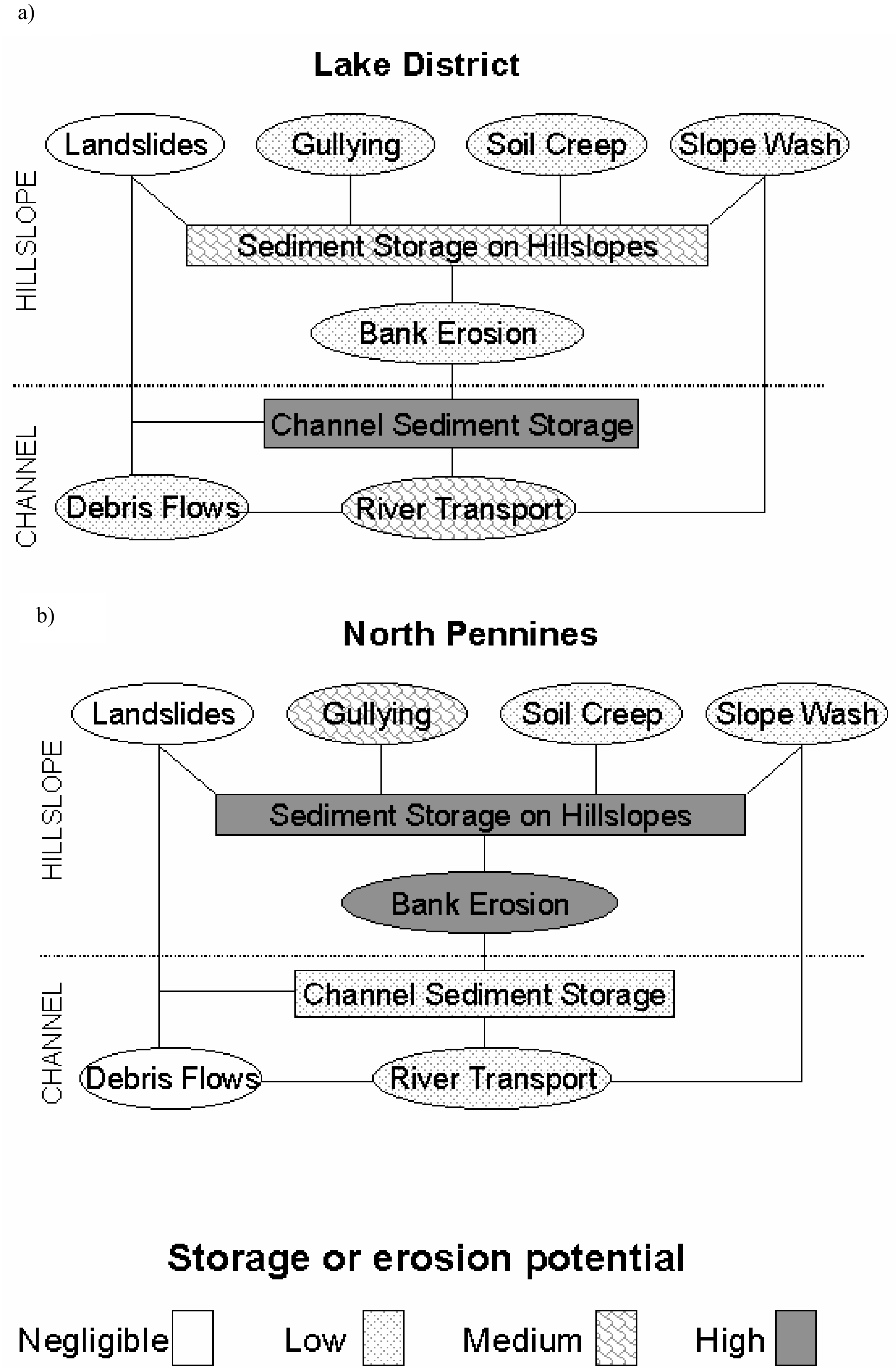

Figure 8.2 Sediment delivery systems for (a) a small Lake District mountain catchment, and (b) the northern Pennine peatlands.

long the revegetation has been in progress; research currently in progress aims is addressing these questions. Nor are the reasons for recovery clear – reduced grazing pressures, less acid rain, a warmer climate, or some combination of these and other factors?

Figure 8.2 summarises the sediment delivery system for the northern Pennine peatlands. Potential for gullying is very high, but despite the ease with which eroded particles of peat may be transported in overland flow, there is some potential for deposition before sediment reaches the perennial channel system. In many instances, gullies do not link directly to the channel and small alluvial fans have built up where the gullies open out on the floodplain. Research is progress to quantify the role of fans within the sediment budget of blanket peat catchments. In other cases, usually the outer bank of meanders, where the channel is cutting into the peat face, tributary gullies discharge directly to the main channel (Evans and Burt, 1998). Over time, floodplain sediments are eroded as the channel shifts its course, and by this mechanism the stored fan material is eventually introduced into the channel sediment system.

There are two other important sources of sediment within north Pennine streams. In some locations landslides may contribute significant amounts of sediment directly to the channel. Shallow failures of weathered regolith, usually where the river channel is undercutting valley-side slopes provide an important source of sediment in valleys downstream of the blanket peat. Failures can also occur within the peat itself (These are sometimes called bog bursts or peat slides.). Though not a common feature, they can have a dramatic impact on the mire landscape locally (Carling, 1986a, 1986b). Large quantities of peat blocks can enter the channel system but preliminary work by Warburton and Evans (1998) shows that these blocks are soon completely broken down during in-stream transport. The precise hydrological conditions leading to peat landslides are still unclear and are the subject of ongoing research. A second source of sediment in north Pennine valleys is mine waste. Macklin (1997) has shown that floodplain channel systems may be severely disrupted by mining debris and it may take many decades or even centuries before the sediment is moved downstream and the channel system recovers.

Perspectives

Two case studies cannot hope to cover the variety of upland landscapes found within Britain. Even so, some general conclusions can be made:

1. The diversity of geomorphology found in the British uplands means that there is great variation in the sensitivity of landscapes to geomorphological change. Analysis of sensitivity at the landscape scale is still a relatively new approach and more case studies and the development of suitable modelling techniques are both needed to take this approach forward. Even within a single landscape unit, there will be significant variation in geomorphological sensitivity, a point made by Gordon *et al.* (this volume) in their study of the Cairngorms. Further development of techniques for mapping and analysing landscape sensitivity would seem to be a fruitful use of resources.

2. We emphasise the need for an integrated approach. It is not profitable to consider in isolation an individual slope or section of river channel. Changes at one location will have impacts further down the system so that landscape management must encompass entire landform systems not just parts of the whole. It is especially important to recognise linkages within landform systems and to identify locations where filtering of upstream impacts can take place. Such sites may require just as much protection as the source areas for erosion themselves. Once initiated, the impact of erosion can be complex and long lasting. Though management may enable eroded sites to be restored, eroded sediments may continue to disrupt floodplains and channels downstream for long periods to come.

3. In many cases upland landforms seem to have crossed important thresholds or else lie very close to them. For example, in the Lake District, some steep slopes are actively eroding, with scree formation, gullying and shallow planar landslides evident. However, appearances can deceive and it may be that actual rates of erosion are lower than they appear and that such slopes are not as vulnerable to degradation as they seem. Wastwater screes are an obvious and dramatic example, but even here there are clear spatial variations in erosional activity with some parts being very active but other sections totally inactive and covered in vegetation. Further field study is needed and a full range of techniques should be brought to bear, including investigation of slope-foot deposits using palaeoenvironmental methods and repeat photography using archival material. Nor is it clear what the downstream impacts of such erosion might be, particularly disruption to river channel stability. In the meantime, limits on grazing pressure may be sensible in such locations and there should be protection of slope-foot locations that may act as buffers between eroding slopes and the channel system. In the Pennine peatlands too, erosion

thresholds are easily crossed but earlier pessimism that, once started, erosion is irrevocable may be tempered by observations at Moor House which suggest that recovery is possible if vegetation can re-establish itself.

4. Many of the factors that lead to landscape degradation are amenable to management, especially those that influence the land surface directly like grazing or trampling. Other causes of erosion like climatic deterioration or air pollution are much less easy to control, but at least their effects may be relatively easy to anticipate. Gordon *et al.* (this volume) note that climatic deterioration may be more important than anthropogenic influence in the Cairngorms, which may limit the effectiveness of management schemes. Ultimately, however, the stability of upland landscapes depends on social, economic and political factors. Erosion management can only be possible and effective if government policy can be translated into a local framework that acknowledges the spatial variation in landscape sensitivity and acts accordingly. This suggests the need for local decision-making integrated across the landscape and across the range of relevant stakeholders. Without local flexibility, climate change may remain the least of our worries with government policy continuing to be the main influence on upland land use, and therefore the main determinant of erosion potential.

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9. Geomorphological heritage and sensitivity in the uplands: a case study from the Cairngorm Mountains, Scotland

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Abstract

The diversity of landforms in the Cairngorm Mountains provides an exceptional record of mountain landscape evolution and environmental change in a maritime, mid-latitude setting in the northern hemisphere. The area is potentially highly sensitive in terms of geomorphological and ecological responses to environmental change and human activities. The degree of sensitivity of the landscape and its fragile soils and habitats is determined by the resilience to change and by the many links and interdependencies between soils, vegetation, geomorphological processes and climate. In particular, the properties of the regolith and soils are fundamental to an understanding of landscape sensitivity since they determine thresholds for change. The most sensitive sites are on steep slopes, *e.g.* leading down into cols or on the flanks of spurs, and in hydrologically active areas with deep regolith. Truncated podzols on the plateaux and cols indicate a period of greater stability in the past over all except the most severely exposed locations, followed later by erosion. The distribution of eroded areas is best explained by climatic exposure, so climatic deterioration seems likely to be a more important cause than anthropogenic influence. These boundaries have clearly shifted in the past, and they are potentially sensitive at present.

Introduction

The Cairngorm Mountains incorporate a wealth of information about past environmental change and landscape evolution through periods of tropical, ice-age and temperate climates. The diversity of the geomorphology not only represents a precious scientific, educational and environmental resource in its own right, but also provides the foundation for valuable montane habitats, landscapes and recreation. The importance of the area is recognised in its inclusion in the UK Tentative List of World Heritage sites on the strength of the natural features.

The Cairngorm Mountains are located on the maritime fringe of north-west Europe. They form the nearest analogue to an arctic landscape in Britain today and this is reflected in the character of the high montane zone, notably in terms of its arctic-alpine plant communities, species, geomorphological processes and soils. The climate reflects a unique combination of oceanic and continental influences, characterised by wet and windy conditions rather than by extreme cold. As oceanic, mid-latitude mountains with continental affinities, the Cairngorms represent an area that is potentially highly sensitive in terms of geomorphological and ecological responses to environmental change and human activities (Gordon *et al*., 1998).

The aim of this paper is to outline the internationally important geomorphological heritage of the Cairngorm Mountains, and to set out the elements of a management framework based on geomorphological sensitivity. Such a framework involves:

1) inventory;
2) impact assessment;
3) monitoring; and
4) management response.

In this paper we focus on the second of these elements.

The geomorphological importance of the Cairngorm Mountains

The geomorphological features of the Cairngorm Mountains and their importance have been reviewed elsewhere (Gordon, 1993; Brazier *et al*., 1996; Gordon *et al*., 1998) and only a summary is presented here. The Cairngorm Mountains comprise the largest continuous area of high ground above 1000 m in Britain and include most of the highest summits in Scotland. They are characterised by extensive plateau surfaces and glacially sculptured features. The diversity of

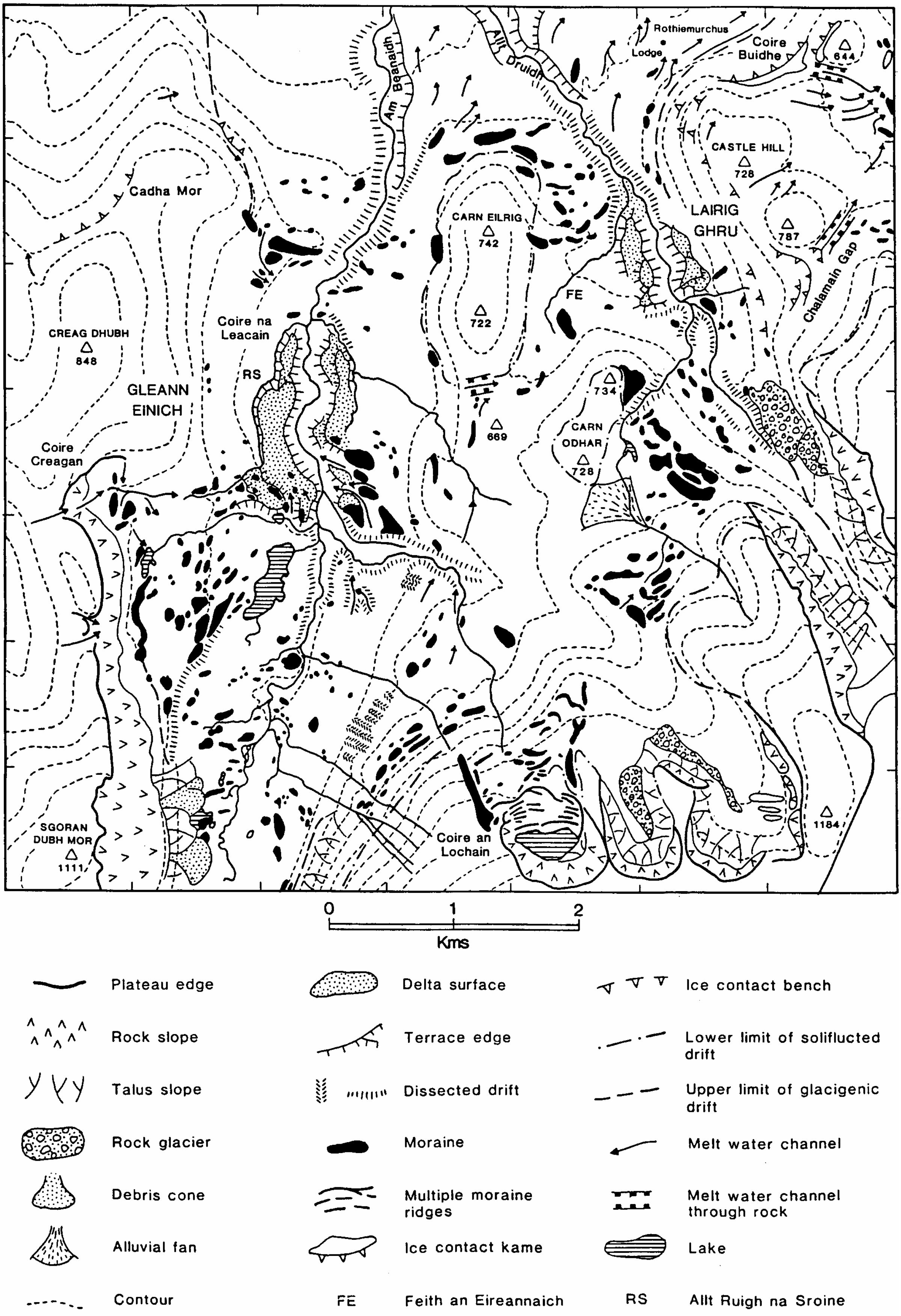

Figure 9.1 Geomorphology of part of the northern Cairngorm Mountains. Reprinted from 'Active ice-sheet deglaciation and ice-dammed lakes in the northern Cairngorm Mountains, Scotland', by V. Brazier, M.P. Kirkbride and J.E. Gordon, from *Boreas*, www.tandf.no/boreas, 1998, 27, 297-310, by permission of Taylor & Francis AS.

landforms present (Figure 9.1) provides exceptional insights into long-term processes of mountain landscape evolution and environmental change in a maritime, mid-latitude setting in the northern hemisphere. This geomorphological development spans the latter part of the Tertiary period with its warm humid climate, through the ice ages of the last 2.5 million years, to the present day.

The landforms of the Cairngorm Mountains include both relict and active features and reflect episodic evolution during the Quaternary. Geomorphological change has played an important role in the evolution of the landscape. Relict landforms, which at least in part pre-date the onset of glaciation, are unusual for their scale of development in a glaciated mountain area; they include tors, weathered bedrock and plateau surfaces. These features stand in sharp contrast to glacial cliffs, corries and deeply dissected glens. Together they form an outstanding example of a landscape of selective glacial erosion. They show how the erosional effects of glaciation were focused in particular areas and had minimal impact in others. The adjacent glens support a diverse assemblage of glacial deposits and meltwater features, notably moraines, meltwater channels, eskers, kames, kettle holes, terraces and lake deposits. On the northern flanks of the mountains there is evidence for active recession of the last ice sheet during the Dimlington Stadial, while several corries contain excellent examples of moraines formed during the Loch Lomond Re-advance. Periglacial landforms, illustrating the effects of cold-climate conditions on the bedrock and soil, are extensively developed on the higher slopes and plateau surfaces and add further to the landform diversity, as do several rock slope failures, some associated with fossil rock glaciers. The landscape is still dynamic, although changes today occur on a smaller scale than in the past. Examples of contemporary change include soil erosion, snowpatch erosion, and a variety of slope processes such as debris flows. River terraces and gravel-bed rivers reveal the pattern of post-glacial landscape changes. The history of climate change and vegetation development during the Devensian Late-glacial and the Holocene is contained in the records of plant remains and pollen grains preserved in lochs and peat bogs. The montane zone is also notable for the links between geomorphological processes, soils and vegetation patterns and their sensitivity to contemporary environmental change. The occurrence of such a diverse assemblage of features in a relatively compact area is exceptional on an international level.

Current pressures and impacts

Impacts on the geomorphology of the Cairngorm Mountains may arise from local land use and other human activities (recreation, grazing animals, predation, afforestation, river management and other land management activities such as drainage) and from global processes (climate change and atmospheric pollution) (Gordon *et al*., 1998). This distinction is important since the former tend to be more localised and may be more readily addressed by local management responses; the latter may potentially have much more widespread effects, producing greater changes, but require management responses to be co-ordinated at a broader scale. Human activities may result in:

1) physical damage or loss of landforms;
2) fragmentation of landform assemblages;
3) change of landform activity, for example through reactivation of formerly stable features or stabilisation of active systems; and
4) loss of naturalness and visibility of landforms.

Local land use and human activities

In the Cairngorm Mountains the principal activities which have affected the geomorphology are afforestation, river management, recreation and changes in grazing intensity. As a broad generalisation, the overall impact is localised (Figure 9.2) and confined to limited trampling disturbance of patterned ground and some accelerated erosion on steeper slopes. On the lower slopes and in the glens, afforestation with dense commercial plantations of conifers has concealed many of the landforms of deglaciation. Such landforms are not destroyed but their surface expression is effectively obscured,

Stream processes may also be modified by afforestation and deforestation through consequent changes in runoff patterns and sediment budgets. Conversely, natural regeneration of the native forest, involving mosaics of trees and reflecting the natural conditions of soils, hydrology and topography, may visually enhance the geomorphological interest. River management, particularly where this has involved heavily engineered solutions, has altered and constrained the natural characteristics of parts of river and stream courses, as in the case of the River Feshie alluvial fan (Brazier and Werritty, 1994) and the Allt Mor (McEwen and Werritty, 1988).

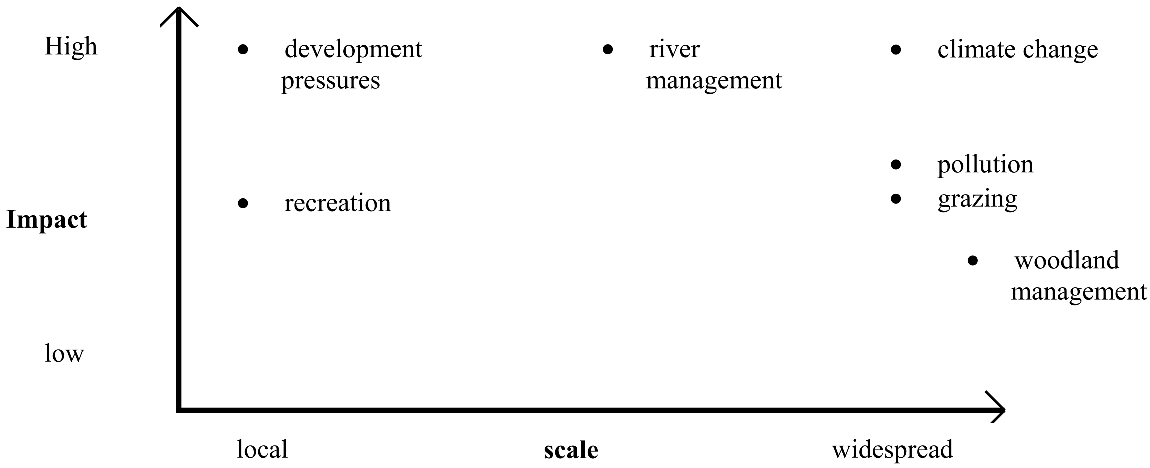

Figure 9.2 Schematic representation of the potential scale and impact of different pressures on the geomorphology of the Cairngorms (from Thompson *et al*, 2001)

Bulldozing of hill tracks may damage relict landforms and activate slope erosion. Similar impacts may arise from recreational activities, such as trampling disturbance to sensitive periglacial landforms on the plateaux, or from the construction of supporting infrastructure such as roads and buildings. Such impacts are of concern since numbers of people on the plateaux have increased following improved access (Watson, 1991). The proliferation of eroding paths and increases in vegetation damage, bare ground and soil erosion, due to trampling by people, reduce habitat quality and detract from the pristine nature of the high montane zone (Watson, 1985; Cairngorms Working Party, 1993). Increased grazing pressure from deer has also been implicated as a primary cause of accelerated slope erosion during the last few hundred years.

Global pressures

The Cairngorm Mountains experience a climate of considerable variability and a unique combination of oceanic and continental influences (Conroy and Johnson, 1996). The high montane ecosystem, in particular, may be very sensitive to global warming (Bunce *et al*., 1996). The balance of evidence now supports the contention that there is a human influence on global climate (Houghton *et al*., 1996). However, it is much more difficult to predict changes at the scale of an individual area such as the Cairngorm Mountains. Nevertheless, some broad generalisations may be made from the predictions for the 21st century for the UK (UK Climate Change Impacts Review Group, 1996; Hulme and Jenkins, 1998):

- warmer, wetter winters;
- warmer, wetter summers;
- increased precipitation intensity;
- increased wind speeds.

Possible impacts of such changes on the geomorphology were summarised by Gordon *et al*. (1998). They may be confined principally to active features; the larger relict landforms may be considered to be relatively robust to the effects of climate change over the timescale of a century. In summary, resultant changes in geomorphological processes may involve increased slope and soil erosion, particularly if accompanied by an increase in storms. Topoclimate zones may change in altitudinal distribution, accompanied by vegetation changes.

Vegetation expansion, especially of the moss heaths, would possibly have a greater indirect effect, reducing frost penetration and needle ice activity. Similarly, the dynamics of turf-banked terraces and wind-related forms would be sensitive to any changes in vegetation cover as well as to wind speeds. Altitudinal and seasonal changes in the pattern and duration of snow cover (Harrison and Kirkpatrick, 2001) are also likely to influence soil freezing and processes dependent on soil moisture. The present geomorphological system of the Cairngorm plateaux has evolved under the changing climate of the Holocene and may be regarded as relatively robust. However, it is still uncertain whether future climate change will exceed the limits of past changes and whether any critical process thresholds will be crossed. The presence of truncated podzols with a higher organic content than expected, underlying present-day *Juncus* communities, suggests that the extent of more closed vegetation communities may have been greater in the past, particularly the *Racomitrium* moss heaths. However, it is uncertain whether their reduction is the result of grazing pressure or more severe (windier and snowier) climate during the Little Ice Age, or both. The present more open *Juncus* communities may be potentially sensitive to ameliorated climate conditions, if accompanied by less windy and less dry conditions.

Pollution from distant sources may also impact indirectly on the geomorphology through effects on the montane ecosystem, particularly through damage to vegetation and increased risk of accelerated soil erosion. Palaeolimnological studies (Jones *et al*., 1993; Battarbee *et al*., 1996) show that some of the high corrie lochs of the Cairngorm Mountains have undergone significant acidification from atmospheric pollution over the last 100 years, and there has been a marked increase in the extent and intensity of acidic (notably nitrate) deposition (Baddeley *et al*., 1994). The Cairngorms are particularly prone to atmospheric pollution because of their high elevation, the low buffering capacity of soils derived from acidic granite, and the dependency of much of the vegetation on nutrients in cloud, rain and snow. Snow in particular concentrates pollutants from the atmosphere and then deposits them on the vegetation (Dollard *et al*., 1983). About 30% of snowfalls have been found to contain large particulates and have pHs of *c*. 3.0 (Conroy and Johnson, 1996). The snow-bed bryophytes are particularly sensitive to nitrogenous air pollution, owing to the high scavenging potential of snow (Woolgrove and Woodin, 1996).

Sensitivity of key features: the example of the Cairngorm plateau

Assessment of geomorphological sensitivity

The principal geomorphological features on the Cairngorm high plateaux are a variety of relict and active periglacial landforms which are strongly linked to the degree of exposure, the duration of snow cover and the distribution of vegetation communities. It is helpful to recognise a distinction between relict landforms and active processes. The former, if damaged or modified, cannot be reinstated (at least in the short term) since the formative processes are no longer active. Evaluating potential damage to relict landforms is relatively straightforward, as each landform represents a finite resource that formed during past environmental conditions, such as glaciation. These relict landforms may be ascribed a degree of vulnerability to damage or destruction from particular activities. This is expressed in terms of loss of Earth science conservation interest (Table 9.1).

Generally, large-scale glacial features are robust, except to development pressures as illustrated in Table 9.2. However, even within this group of landforms, the larger forms (*e.g.* landforms of glacial erosion) will be robust to all but the largest-scale changes, whereas smaller features (*e.g.* eskers and small meltwater channels) may be more vulnerable to disturbance.

Table 9.1 Assessment scale for degree of damage and loss of Earth science interest for relict features (Source: after Werritty and Brazier, 1991)

Scale	Degree of damage from an activity
1	not generally applicable
2	activity obscures or masks the surface and stratigraphic exposures of the landform
3	activity causes localised disruption or destruction of part of the landform surface or stratigraphy
4	activity causes general disruption or destruction of the surface and/or stratigraphy of the landform
5	activity causes destruction of individual or groups of landforms, permanently interrupting morphological and stratigraphic relationships within the landform assemblage

Table 9.2 Examples of potential impacts on relict landforms

	Quarrying	Afforestation	Trampling
esker	4/5	2	1
rock glacier	5	1	1
meltwater channel	4/5	2	1
tor	5	1	1
glacial trough	3	1/2	1

Where processes are still active, the properties of the regolith and soil are fundamental to an understanding of landscape sensitivity since they determine thresholds for change within the force/resistance relationships of the geomorphological system. In upland areas, processes are often episodic, being dependent on extreme events, so that information is also required on the magnitude and frequency of forces which are capable of overcoming soil/regolith resistances. The degree of sensitivity of the landscape and its fragile soils and habitats is determined by the resilience to change and by the many links and interdependencies between soils, vegetation, geomorphological processes and climate (Tables 9.3 and 9.4).

The concept of geomorphological sensitivity (Schumm, 1979; Werritty and Brazier, 1993) provides a useful starting point from which to consider landscape sensitivity, which we define in terms of the response to externally imposed change. Some systems are subject to frequent change but operate within overall limiting (extrinsic) thresholds through the action of negative feedback and so maintain a dynamic equilibrium over time; for example, small-scale stone stripes reform after disturbance, and so the overall landform and process system remain recognisable. Such systems may be described as *robust*. *Sensitive* systems are those which are susceptible to crossing a limiting threshold into a new process regime, for example, where change in internal strength of the regolith produces slope failure, or a change from wind stripes to bare deflation surfaces occurs through loss of vegetation cover and soil. Whether or not a significant change will occur, depends on the thresholds which determine the behaviour of the geomorphological system. Forces promoting change include extreme weather events, long-term climate change and an alteration in human activities.

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Table 9.3 Sensitivity matrix for different geomorphological contexts of the Cairngorm high plateaux (source: Haynes *et al.*, 1998)

Location	Sensitive to	Influencing characteristics	Overall sensitivity
Plateau surfaces	Climate change (windiness, snow-cover); vegetation change (climate change, pollution, grazing, trampling)	blockfields, deflation surfaces, episodic processes	relatively robust, thresholds crossed occasionally in Holocene.
Summits	ditto	"honey-pot" location, more concentrated trampling	trampling may spoil appearance, but geomorphological change minimal
Crests of corrie headwalls	ditto	"honey-pot" location, more concentrated trampling; steep edge may enhance regolith wastage; wind acceleration increases exposure	more sensitive than broad summits
Exposed spurs	climate change (especially windiness and rainfall intensity); vegetation change; trampling	popular routeways; steep slopes increase sensitivity to regolith wastage; wind acceleration over convexity	sensitive
Cols	climate change (especially windiness, winter snow cover); vegetation change; trampling; grazing	popular routeways; often flanked by sensitive steep slopes; may have pockets of deep regolith; wind funnelling	sensitive; include transitions between vegetated/unvegetated ground
Plateau valleys and hollows (medium-lie snow patches)	moisture supply; intense trampling, especially when wet; very large changes in snow-cover, possibly rainfall intensity; grazing	turfy vegetation; more organic soils; deep regolith	mostly quite robust, though sensitive sites exist around paths over deep regolith on moderately steep slopes with a copious moisture supply; mainly sensitive in spring and early summer
Long-lie snow patch hollows	snow duration, climate change, especially spring weather; trampling especially during thaw	may be "honey-pot" locations (novelty in summer, snow-holing in winter)	sensitive

Table 9.4 Summary sensitivity matrix of Cairngorms landforms (R denotes relict; A denotes active) (Source: Haynes *et al.*, 1998)

Landform	Importance	Occurrence in Cairngorms	Occurrence nationally	Factors affecting sensitivity	Overall Sensitivity
Ice moulded rock - R		very localised	widespread		low
Tors - R	national → international; special feature of Cairngorms	unusually frequent for glaciated area	localised	?heavy trampling of surrounding regolith	low
Blockfields and blockslopes (openwork & matrix-rich) - R		common	common	construction of paths and pistes; on slopes >c.30^{o} (matrix-rich) - trampling, increased run-off & moisture content (snow-melt or intense rainstorms)	low; but may be moderate for matrix-rich blockslopes on steeper slopes
Boulder lobes - R	national; ecological mosaic	common; particularly finely developed in Cairngorms	mainly found in E. Grampians	construction of paths and pistes	low
Solifluction sheets (medium sized) - R	local (often help control snowpatch distribution)	common except on Braeriach	common	trampling round snow patches	moderate
Ploughing boulders - A	local	quite common except on Braeriach	common in uplands	snow distribution (could be enhanced with more transient snow)	low
Sorted patterned ground	national	very common on B. a' Bhuird/B. Avon, localised elsewhere	localised in mountains		
Large - R				path construction	low
Medium - marginally active				soil moisture change; reduction in depth of freezing; trampling; vegetation expansion; progressive change in regolith grain size, by wind erosion & deposition	moderate
Miniature - A				extent of bare ground (i.e. vegetation change, especially moss-heath); progressive removal or dilution of regolith fines by wind action	conditional; fine balance - bare ground with moderate exposure

Table 9.4 contd

Landform	Importance	Occurrence in Cairngorms	Occurrence nationally	Factors affecting sensitivity	Overall Sensitivity
Hummocks - ?A	local	numerous on B. a'Bhuird/B. Avon; localised on Cairn Gorm; rare on Braeriach	widespread in uplands	soil moisture changes (especially snow cover) - could be enhanced by more transient snow; could be degraded by trampling, but likely to be avoided	low - moderate
Solifluction terracettes & small lobes - A		around late-lie snow patches on Cairn Gorm/ B. Macdui & B. a'Bhuird/B. Avon	widespread in uplands	late-lie snow patch distribution (spring weather); trampling especially when wet	high
Deflation or turf banked terracettes - A	ecological mosaic	very widespread	widespread in uplands	vegetation change, including trampling & grazing; windiness	probably fairly robust; may be equilibrium forms (robust); or due to vegetation erosion or colonisation (sensitive)
Deflation scars **A**		common	common	vegetation change; grazing; trampling; windiness & possibly other climate change ('moderate' exposure)	high
Deflation surfaces **A**	local; part of essential character of Cairngorms	common	localised; characteristic of granite and sandstone mountains	climate change, especially wind, and possibly snow cover, frost severity; vegetation degradation or vegetation encroachment (especially moss heath); grazing; trampling	processes normally episodic, probably fairly low sensitivity, but conditional; threshold has been crossed in both directions in the past but possibly only occasionally
Wind stripes **A**	national; ecological mosaic; characteristic feature of Cairngorms	localised, especially where prostrate woody communities occur on fairly exposed gentle surfaces	localised	decadal/century scale climate change, especially windiness; vegetation disruption or expansion; species changes; trampling, grazing or pollution	may be equilibrium forms - moderately robust; but may be a delicate balance on a timescale of decades to centuries
Wind crescents **A**	?national - ecological; characteristic feature of Cairngorms	common on summit plateaux & exposed cols	localised in exposed granite & sandstone uplands	maintenance of communities of tussock forming plants, especially *J. trifidus*; encroachment of moss-heaths; windiness	moderately robust

(R = relict; A = active)

Forces promoting change include extreme weather events, long-term climate change and an alteration in human activities (*e.g.* large-scale afforestation and/or deforestation, changes in grazing regimes or infrastructure developments) (Table 9.5). Sensitivity is also spatially variable. The most sensitive sites are on steep slopes; for example, the slopes leading down into cols or on the flanks of spurs, and in hydrologically active areas with deep regolith (Table 9.3). Accessibility means that the slopes around Cairn Gorm and its surrounding cols and spurs are particularly vulnerable to human disturbance by trampling. Truncated podzols were found to be widespread on the plateaux and cols, indicative of a period of greater stability in the past over all except the most severely exposed locations, followed later by erosion (Haynes *et al.*, 1998). These periods have not been dated, though the soil characteristics suggest soil development over timescales of an order of magnitude of 10^3 years and a period of disturbance lasting for centuries. The distribution of eroded areas is best explained by climatic exposure, so climatic deterioration seems likely to be a more important cause than anthropogenic influence, though the role of increased deer grazing cannot be entirely discounted. Recycling of eroded sand and gravel occurs across the ground surface at present in features such as ‘vegetation islands’, wind-stripes and possibly terracettes, which may be in dynamic equilibrium. In cols there is frequently a clear boundary between vegetated areas, which have remained stable over the long term, and areas of truncated soils and patchy vegetation. These boundaries have clearly shifted in the past, and they are potentially sensitive at present. Examples of possible changes are illustrated in Table 9.6.

Table 9.5 Triggers for geomorphological change

Trigger	Effect
climate change	change in vegetation cover, soil moisture, snow cover
pollution	damage to vegetation cover
extreme weather	rainfall intensity; wind erosion of vegetation and soil
trampling	damage to vegetation cover, soil compaction
grazing	reduced vegetation cover and root hold

Table 9.6 Possible impacts of change on sensitive features

	More extreme weather			**Increased trampling**		
	Process rate	extent	recoverable with management	process rate	extent	recoverable with management
actively eroding surface	accelerated	widespread	no	accelerated	local	yes
wind stripes/ stressed vegetation	accelerated	widespread	no	accelerated	local	yes

Conclusion

The concept of geomorphological sensitivity provides a useful approach to understanding the effects of human activity on the landscape and potentially provides a basis for assessing different management approaches. However, more integrated approaches linking geomorphology, soils, vegetation and climate are required (see Gordon *et al*., 2001; Thompson *et al*., 2001). The sensitivity analysis also lends itself to further development, particularly through modelling the likely effects of individual activities and the potential for recovery under different management regimes.

The present landforms and soils of the Cairngorms have evolved through periods of environmental change during the Holocene. On the plateaux, the presence of alpine podzols suggests a degree of stability and robustness in many areas. Other areas, however, such as cols and plateau edges appear to be intrinsically dynamic. Evidence in the form of truncated podzols suggests that these dynamic areas are increasing in extent, at least locally. There is a clear need for better understanding of palaeoenvironmental record in the area, particularly in relation to the range of past variability and the extent to which human activity may be moving systems closer to geomorphic thresholds. This is particularly important since the cumulative effects of atmospheric pollution and local-scale pressures are adding additional stress. Human impacts may be controlled by management options, whereas climate change may produce more widespread effects that are less subject to control. Thus, while Holocene analogues may show how different features could respond, these additional factors also need to be considered. Of course, this all assumes that the recent past has been relatively stable, and therefore represents the desirable state, whereas conditions in the future will be more unstable, and therefore less desirable. One welcome outcome of additional research on the palaeoenvironmental record would be confirmation of landform stability in the recent past as a benchmark against which future changes may be assessed.

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SECTION 3

Policy issues: integrated approaches to conservation, management and use

The papers in this section encompass a range of issues relating to policy.

Yeo and Keenleyside consider new opportunities for integrating nature conservation and agriculture in the uplands.

Several contributions emphasise the need for effective policies underpinned by adequate funding to address a diverse range of land uses in the uplands. Arnold-Forster (now Chief Executive of English Nature) considers the use of EU structural funds in the North York Moors National Park, while Simpson reviews the Countryside Agency's aims and priorities. Maidment and Britton introduce the topic of upland forestry and woodland, focusing on the use of long-term planning to achieve significant change in woodland structure. Sidaway addresses integrated management in the uplands, asking whether it is possible to reach consensus. He argues that the sectoral nature of government, rather than a lack of understanding of key problems, may hinder progress. Duff reminds us that tourism in the uplands is a much more important activity – economic, environmental and social – than is often realised. If properly directed, it offers one of the best means of safeguarding existing jobs, especially farming, and the quality of the landscape.

Finally, the late John Miles provides an overview of the whole section, highlighting the nature of the resource (focusing on rural land uses and designations) before turning to policy benefits and constraints. Throughout the section, the challenge of managing multiple land uses in the uplands is addressed. The need to integrate land uses within the wider rural economy, in order to increase the environmental, social and economic sustainability of the uplands is emphasised throughout.

As Simpson concludes, there have long been multiple land uses in the uplands, and this is unlikely to change in the future. The challenge for the future is to develop and implement new thinking on ways to integrate upland land uses with the wider economy.

10. Integrating nature conservation and agriculture in the uplands of Wales: long-standing problems and new opportunities

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The Welsh uplands - a cultural landscape

Much of Wales is distinctly upland in character, with large areas of land lying above 250 m altitude. Prominent upland ranges extend from the mountains of Snowdonia in the north, through the Cambrian Mountains in mid Wales, to the Brecon Beacons in the south.

Although the Welsh uplands may give the impression of being an untouched wilderness, they actually represent a cultural landscape, shaped by many centuries of human influence. In particular, the uplands have a long history of use as rough grazing land for domestic livestock (Hester, 1996). At the present day, they are predominantly utilised for rearing sheep, but in the past a more diverse mixture of animals (including cattle, horses and goats) would have been present. This long-standing use as grazing land, with associated activities such as burning and drainage, has had a profound effect on the landscape and vegetation. Before the influence of people, the uplands were largely wooded, with open ground only on the higher summits and plateaux, but agricultural management has led to the development of a distinctive open moorland landscape, comprising extensive tracts of heath, bog and grassland (Birks, 1988).

Many upland areas in Wales are considered to be of high value for nature conservation, and contain important examples of scarce or declining habitats (e.g. dwarf shrub heath, blanket bog) and associated species (e.g. hen harrier, red grouse). Large areas of upland are protected as Sites of Special Scientific Interest (SSSIs) (Blackstock *et al.*, 1996), and several sites are also included within sites identified under the EU Habitats and Birds Directives. Many of the features that are considered to be important for their wildlife interest have developed in response to anthropogenic influence, and continued low-intensity agricultural management is essential for their survival.

Although extensive light grazing is generally beneficial for nature conservation, more intensive management, such as heavy grazing and severe fires, causes deleterious ecological changes. These include the conversion of dwarf shrub heath to impoverished acid grasslands, loss of *Sphagnum* and other sensitive species from blanket bog, and a decline in the cover of bryophytes and lichens in fragile summit heath communities (Ratcliffe, 1959; Hobbs & Gimingham, 1987; Miles, 1987; Thompson & Baddeley, 1991). Substantial habitat degradation has occurred over the past 50 years in several parts of the Welsh uplands (Hunting Surveys, 1986; Hester, 1996). Such changes in land cover can be attributed largely to the intensification of farming practices, at least partly in response to the introduction of production-related agricultural subsidies as part of the Common Agricultural Policy (CAP). Other factors, such as afforestation and atmospheric pollution, have contributed to the decline in quantity and quality of semi-natural upland habitats.

However, it would be a mistake to assume that changes in vegetation composition are purely a recent phenomenon. In some parts of Wales there is evidence that habitat degradation is a long-term feature of the upland landscape. Major losses of heathland from the Medieval period onwards have been demonstrated by Stevenson & Thompson (1993), and damage to some Welsh blanket bogs also dates back several centuries (Yeo, 1997). Changing land cover patterns in the Welsh uplands therefore present a complex picture, with various changes taking place over a range of time-scales. It is also apparent that there is a fine balance between the levels of agricultural management necessary to maintain or enhance wildlife interests, and levels which are likely to threaten the survival of these interests.

Environmental objectives in the Welsh countryside

In order for the Countryside Council for Wales (CCW) to develop effective conservation strategies, it is essential that environmental objectives are clearly stated. CCW's key aims for the Welsh countryside can be summarised as follows:

- Conservation and enhancement of the full range of semi-natural habitats and associated species, especially in relation to commitments contained in the UK Biodiversity Action Plan and EU Directives.
- Protection and enhancement of the landscape.
- Preservation of the cultural and archaeological heritage of the countryside.
- Provision of a countryside of high value for recreation and amenity.

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These broad aims can be translated into a series of objectives for land management in the Welsh uplands:

- Introduction and/or maintenance of environmentally sustainable farming regimes, and in particular sustainable grazing management of semi-natural habitats.
- Introduction and/or maintenance of extensive mixed farming systems, in order to create a diverse landscape, with mosaics of moorland, woodland, improved pasture and arable fields.
- Retention of farming systems that provide rural employment and support the local economy.
- Maintenance of the rural infrastructure, e.g. farm buildings, field boundaries.
- Provision of opportunities for public enjoyment of the countryside.

These objectives are all underpinned by the need to maintain viable farming systems in the Welsh uplands.

Reform of the Common Agricultural Policy (CAP)

The CAP is a major factor driving the intensification of farming practices in the uplands of Wales. CCW and the other statutory conservation agencies in Britain are therefore committed to seeking fundamental CAP reform in order to deliver environmental benefits.

The 15 EU Member States finally agreed the latest reform measures (the Agenda 2000 package) in March 1999. Regrettably, progress towards ‘greening’ the CAP has been disappointing, and there are few opportunities to support the type of upland agricultural systems we wish to see. Shifts towards decoupling financial support from production have been limited to support for Less Favoured Areas (LFAs), and initiatives to reduce grazing levels in the uplands will be hampered by the decision not to reform the sheepmeat regime, which funds the bulk of livestock headage payments in upland Wales.

The Rural Development Regulation

Despite the limited scope of CAP reform in Agenda 2000, there are some changes which have the potential to benefit wildlife conservation in the uplands. The introduction of an integrated Rural Development Regulation is particularly welcome (English Nature, the Countryside Agency & the Countryside Council for Wales, 1999). The new Regulation brings together agri-environment, forestry, LFA support, training, marketing, and other rural development measures. It provides a simplified framework for developing integrated rural policies in Wales, and offers opportunities for tailoring policies to meet local requirements. The revised agri-environment measures are simpler and more flexible, and include higher ceilings on payments.

A seven-year Rural Development Plan has been produced for Wales but unfortunately the bulk of the CAP budget is still directed to production subsidies, and the effectiveness of the Regulation will therefore be limited by financial constraints. Some additional funding for rural development measures has been made available by the application of modulation to direct payments[2].

LFA support

One of the most important elements of the new Rural Development Regulation is LFA support. This is particularly important in Wales, where the LFA area is 77% of the total area of agricultural land. Within the LFA additional agricultural support was provided by Hill Livestock Compensatory Allowance (HLCA) payments until the end of 2000. In 1995/96 HLCA payments to LFA sheep and cattle farmers in Wales accounted for 21% of net farm income, but in poor years this figure can be much higher (Midmore *et al.*, 1998).

The revised LFA support system shows a significant move towards decoupling support from production. The objectives have been redefined in the Rural Development Regulation to include the promotion of sustainable farming systems as an explicit aim, and headage-based HLCA payments have been replaced by area payments. From 2001 this will help to discourage excessive stocking of the uplands, although the impact will be limited because the sheepmeat regime has not been reformed. There are also opportunities for Member State discretion in deciding how payments should be made, and for attaching environmental conditionality (cross-compliance) to direct subsidies. Perhaps most importantly, these changes are likely to set a precedent for the next round of CAP reform, when there may be pressure for other agricultural support to be switched to area-based payments.

Various options are available for calculating the new LFA area payments (English Nature, the Countryside Agency & the Countryside Council for Wales, 1999):

- Payments based on past entitlement – ‘locked-in’ area payments set separately for each farm. This would avoid any farmers receiving

[2] The budget for the Rural Development Plan in Wales has been increased by modulating direct CAP subsidy payments, rising to a rate of 4.5% by 2006. The money generated will be match-funded by the Treasury and used, *inter alia*, to increase the *Tir Gofal* and Organic Farming Scheme budgets.

reduced subsidies but goes against the principle of introducing area-based payments.

- Flat-rate area payments - a fixed payment per hectare paid at the same level across Wales.
- Variable payments - a basic level of income support with top-up payments (‘environmental premiums’) to encourage mixed farming systems.

The third option is preferred by CCW, as this offers the greatest opportunities for environmental gain[3].

Tir Gofal - a new agri-environment scheme for Wales

Another important element of the Rural Development Regulation is agri-environment, which is the only compulsory component. In Wales a new whole-farm agri-environment scheme (Tir Gofal) was launched in 1999, and is available throughout the Principality. This replaces the previous disparate mixture of schemes (including Environmentally Sensitive Areas, Tir Cymen, the Moorland Scheme and the Habitats Scheme), although the Organic Farming Scheme will continue to run independently. Tir Gofal is delivered on behalf of the National Assembly for Wales by CCW, in partnership with the Farming and Rural Conservation Agency[4] and the Snowdonia National Park Authority.

Applications for Tir Gofal are assessed using a simple scoring system, and priority is given to those applications which are likely to deliver the greatest environmental benefits. The scheme uses a detailed habitat classification based on Phase I and BAP categories. This allows management to be tailored to the requirements of specific habitats, and also facilitates reporting against BAP targets. The effectiveness of Tir Gofal in achieving environmental benefits will be evaluated through the assessment of farm-specific objectives, based on performance indicators. These indicators are attributes of each habitat which describe its condition in relation to management (e.g. percentage cover of dwarf shrubs in heathland). They will be used to prepare quantified objectives for each farm upon entry to the scheme, against which progress can be assessed in succeeding years.

Tir Gofal includes a whole farm code, which requires compliance with several general prescriptions. These include a requirement to maintain field boundaries, to protect archaeological, historical and geological features, to manage land in accordance with Codes of Good Agricultural Practice, and to provide public access to all unenclosed land.

There are mandatory management prescriptions for the conservation of existing semi-natural habitats, including woodland, heathland, grassland and peatland. Prescriptions cover grazing levels, burning regimes and other management practices. These are supplemented by optional prescriptions for habitat restoration/expansion, such as the establishment of new broadleaved woodland and the expansion of heathland on acid grassland. Capital payments are available to deliver various aspects of these mandatory and optional components, including bracken spraying and the erection of grazing exclosures.

Conclusions

There is clearly a close relationship between agriculture and nature conservation in the Welsh uplands, and the delivery of environmental benefits is highly dependent on maintaining viable farming systems using appropriate grazing regimes. There are increasing opportunities for developing initiatives which will benefit wildlife conservation across the uplands of Wales. CCW believes that these opportunities should be maximised in order to attain the environmental targets contained in the UK BAP and EU Directives.

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[3] The new LFA support scheme in Wales, Tir Mynydd, consists of flat-rate area payments with small top-up payments to encourage sustainable farming.

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11. Benefits to environment and economy through EU structural funds, with special reference to the North York Moors National Park

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Introduction

The North York Moors National Park covers 1435 km^2 including 500 km^2 of open moorland, over 300 km^2 of woodland, arable farming on limestone and hill farms in remote dales, 42 km of coastline, and an active rural community (villages and smaller settlements) of some 25,000 residents. The National Park attracts 13 million day visits per annum, contributing significantly to the regional tourism economy.

The National Park Authority (NPA) has two statutory purposes to:

a) Conserve and enhance the wildlife, natural beauty and cultural heritage of the area;
b) Promote opportunities for the understanding and enjoyment of the special qualities of the area by the public; and,

In pursuing these purposes, the NPA has a duty to seek to foster the social and economic well being of local communities.

The National Park Authority needs to maintain a balance between the demands of landscape and wildlife conservation and growing social, economic and recreational pressures. With care, major successes can come from linking environmental benefits to economic activity. The National Park Authority believes that a healthy economy and a healthy landscape are complementary and by sustaining the area's diversity, it can help to sustain the economy, life and landscape for future generations.

The core budget of just under £3 million per annum from Government is insufficient alone to promote major programmes of environmental and economic benefit, but substantial use is made of external funding.

EU Structural Funds: the Northern Uplands Objective 5b Programme

Amongst the external funding which has been particularly important to the National Park is the English Northern Uplands Objective 5b Programme, which covers parts of Cumbria, Lancashire, Northumberland, Durham and Humberside as well as North Yorkshire. Objective 5b funds are for rural areas requiring structural adjustment and development.

Under this programme, between 1994 and 1999, EU Structural Funding can be applied to projects which tackle the identified needs of the Northern Uplands rural area. The region has a high share of agricultural employment in total employment, low agricultural income and low population density. The three Structural Funds accessed through the programme are:

a) The European Regional Development Fund (ERDF), which can be used particularly for benefits to the economic infrastructure, including communications, tourism, business, research, development and transport;
b) The European Social Fund (ESF), which provides support for training, equal opportunities, social exclusion issues and combating unemployment;
c) The European Agricultural Guidance and Guarantee Fund (EAGGF), which provides support for agricultural businesses enabling structural adjustments and diversification.

These fund sources are allocated across four broad priorities:

a) Economic development and diversification;
b) Tourism;
c) Community development; and
d) Environmental enhancement and conservation.

The availability of funds for these priorities is shown in Table 11.1. The 5b area in total covers over 14,000 km^2, with a population of 374,000 people. It was designated for Objective 5b support in 1994 in recognition of its poor economic performance across all sectors. The 5b programme aims to co-ordinate a comprehensive package of social and economic support that will help to create sustainable economies and sustainable communities.

The National Park Authority has drawn down 5b funding from all the Structural Funds, to benefit its primary conservation and recreation purposes, whilst also fostering the social and economic well being of the local community. Key messages from the experience of the National Park Authority are that:

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a) The environment and economy can both benefit from carefully targeted schemes;
b) External funds are needed as a catalyst for concerted action;
c) Value for money and sustainable solutions come from local schemes developed from an *à la carte* menu of the kind referred to by Lord Selborne in his opening statement at the Uplands conference.

Objective 5b Project Examples from the National Park

The *Moorland Regeneration Programme* has drawn together a partnership of over 120 farmers and 26 estates, with numerous statutory agencies and other conservation bodies working together to improve the economy of sheep and grouse businesses and the quality of the moorland resource.

The moorland economy was on a downward spiral, with mortality and quality problems amongst lambs and grouse, caused largely by tick-related diseases. The sheep tick is not only debilitating for its host, but carries disease which can afflict sheep, grouse and other wildlife. Tick-borne disease lowers the lambing rates and lamb quality of the moorland sheep flocks and decimates grouse broods, as well as impacting upon moorland wildlife that is of conservation importance, such as populations of Merlin, Golden Plover and Curlew which justify the area's status as a Special Protection Area (SPA) and proposed Special Area of Conservation (SAC).

The Moorland Regeneration Programme has tackled the tick problem mostly through 70% grant aid for sheep dipping, sheep handling and dipping facilities, louping-ill vaccination and other measures.

In addition, the Programme has addressed problems such as invasive bracken on the heather moorland, moorland regeneration opportunities and marketing opportunities for sheep and grouse.

The main achievements to date are:

a) 26 estates and 124 farmers working together in a firm partnership with statutory agencies;
b) Encouragement of good environmental practice and sustainable management to enhance the moorland habitat and biodiversity through 4-year work programmes covering 43,500 hectares of moorland (96% of the National Park moorland total);
c) A Sheep Health Scheme;
d) The launch of the Quality Sheep Association for the North York Moors;
e) Work on opportunities for retailing moor lamb and grouse;
f) Bracken spraying (6,000 hectares);
g) Heather burning (9,400 hectares);
h) 53 sets of sheep handling/dipping facilities built or improved;
i) 405 hectares of moorland fenced for regeneration;
j) Approximately 85,000 sheep treated for ticks 3 times per year, with a fourth voluntary dip available;
k) Training events;
l) Communication initiatives including newsletters and evening talks;
m) Employment of additional estate workers (8 full-time equivalent).

Monitoring is an essential part of the programme. Collecting and analysing information is not only essential for assessing the progress of the programme, but for directing future work. The discipline of the Objective 5b process has been helpful in giving clear targets and reporting requirements, maintaining a clear focus for those involved.

The programme has been run by a steering group of all interests, which has developed an ownership of the programme and an enthusiasm for maintaining many of its benefits beyond the

Table 11.1 Funds available in the Northern Uplands Objective 5b Area

	ERDF £m	ESF £m	EAGGF £m	Total £m
Economic Development & Diversification	24.24	7.66	5.31	37.21
Tourism	11.47	1.28	3.19	15.94
Community Development	6.38	1.91	4.25	12.54
Environment/Conservation	7.65	1.59	7.98	17.22
Technical Assistance	1.28	0.32	0.53	2.18
Total	51.02	12.76	21.26	85.04

end of the present Objective 5b funding period. In the long term, there should be the following benefits:

a) A significant increase in the percentage of lambs that survive to weaning and a reduction in chick losses from grouse broods;
b) An enhanced economic value of the moorland which will increase employment in the area, safeguard land-based businesses, help the viability of associated businesses and strengthen the community;
c) An environment in which the moorland wildlife, culture and landscape are secured for the future.

This programme unquestionably benefits the local economy and communities, whilst meeting the first statutory purpose of the National Park to conserve and enhance the outstanding moorland habitat.

The *River Esk Regeneration Programme* aims to protect, conserve and enhance River Esk habitats for fish and other wildlife so as to increase the economic value of the river to the rural community.

Running from July 1997 to April 2001, the programme addresses issues on Yorkshire's only, and the East Coast's southernmost salmonid river, where the quality of fishing has declined in recent years. This has partially been due to low water levels as a result of dry summers, but there are many habitat and river management issues that have contributed to decline. These include the loss of river bank habitat, siltation and erosion leading to additional problems such as wide, shallow sections of river which are inhospitable for fish and unsuitable for fishing, siltation of spawning gravels and implications for farm stock welfare and safety from river bank erosion. The River Esk supports a rich variety of habitats and wildlife including Biodiversity Action Plan species such as otter, water vole and kingfisher.

Fishing has benefits for local tourism-related industries and brings revenue to the area through the sale of permits and rentals of fishing rights. Excluding expenditure on fishing permits and licences, it was calculated during the feasibility study for the project that an angler spent on average £40 in the local economy per day's fishing.

Protecting and enhancing the river channel and margin habitats will greatly increase the conservation and fishing value of the river and can help improve conditions for grazing stock. Works under the programme include riverbank fencing, introduction of weirs and stones improving river flow and fish habitat, management of bank-side vegetation, tree planting, stock watering points and a limited amount of restocking of fish. The programme provides:

a) Grant aid for work on the river and its tributaries aimed at improving wildlife habitats, the fishery and stock management of the river banks;
b) Advice and training in river management for farmers, land owners and fishery managers;
c) Support for research into populations and requirements for fish and Biodiversity Action Plan species e.g. otters;
d) Support for an agreed salmon stocking programme.

Like the Moorland Regeneration Programme, the programme was founded on local community wishes and concerns. The River Esk Action Committee had considered what could be done to enhance the river and the programme has helped that Committee to work with riparian owners, farmers, fishing clubs and statutory agencies to bring about substantial improvements. Grant aid is generally payable at a rate of 65%.

The programme has brought together fishermen, farmers, landowners, statutory agencies and conservation interests in a partnership that has implemented practical enhancement schemes, is benefiting the economy and will be sustained beyond the end of the 5b period, even though the full benefits of the programme will take longer to emerge.

Main achievements to date include:

- 33 Management Agreements with fishing clubs, farmers, riparian owners;
- 21 km of riverbank managed;
- 9 km of river channel habitat improved for fish;
- 36.5 days conservation training delivered to farmers, fishing clubs, riparian owners;
- Enhanced monitoring of fish and otter populations including installation of a fish counter at Sleights Weir;
- Stocking of approximately 130,000 native Esk salmon fry; and
- Promotional events and leaflets.

The *Upper Derwent Enhancement Project* has very similar objectives to the River Esk Project, but has been funded through a slightly different EAGGF pot, geared more to environmental benefit than the Ministry of Agriculture Fisheries and Food EAGGF funds which have been applied to the Moorland and River Esk projects. The Upper Derwent contains a National Nature Reserve and important recreational areas, which have suffered through lack of funds for woodland management, river siltation and recreational pressures.

The Derwent project has been started in partnership with local community, land owning, fishing and conservation interests and has outputs linked to biodiversity, recreation and conservation objectives. Like the River Esk project, it will benefit Biodiversity Action Plan species, in particular the native White-clawed Crayfish. The river has no migratory fish, but is an important and valuable trout fishery, the potential of which can be improved by methods similar to those on the Esk, such as river bank fencing, and additional work such as de-siltation and the protection of the river banks by willow planting.

The *Esk Valley Rail Partnership* built upon strong community interest in the Esk Valley Railway Line running from Middlesbrough to Whitby. Passenger traffic and the frequency of services on this small rural line had steadily declined, but the availability of Objective 5b funding enabled a project officer to be employed and various initiatives commenced to increase community, recreational and business use of the line. These included special events and guided walks, station enhancement projects, improved information provision, residents' rail cards and integrated ticketing initiatives, promoting sustainable transport access to the National Park.

The programme has seen an increase in passenger traffic on the line of 30% and generated local interest and initiatives which have been maintained beyond the end of the Objective 5b funding period. The project also helped to act as a catalyst for thinking that has led to successful bids for funding from other sources, for example to develop an integrated travel centre in Whitby.

The *Brigantia Art and Craft Producers Association* was one of the first Objective 5b projects applied for by the National Park Authority. It was based on research into the potential for linking tourism, recreation and economic benefit by promoting small craft businesses which also represent part of the cultural heritage of the National Park. The association now has over 90 members and attended numerous craft and trade fairs in 1998/99, demonstrating the extent to which partnership working can achieve a much greater geographical presence and market profile. The association boundaries have been extended beyond the National Park, in order to provide a critical mass of members, but it remains an important means of assisting small businesses within the National Park area.

On the *Heritage Coast*, Objective 5b has funded a project officer and work that has included tree planting around obtrusive caravan sites, improvements to coastal access points, and village enhancement schemes. The project officer has played a leading role in various community appraisals that have developed ideas for future projects to enhance the environment and economy of the coastal area.

Objective 5b funding has injected £235,000 enabling a comprehensive £½ million redevelopment of the National Park's *Sutton Bank Visitor Centre*. This has resulted in substantial increases in visitor numbers to the centre and in bed bookings from there in the surrounding area, fulfilling the National Park's second recreation purpose and its duty towards the local economy.

A further project which is just beginning concerns *Access for the Less Able*. Drawing funding from voluntary sources as well as Objective 5b and hopefully the Lottery, the project aims to improve access to the countryside for the less able, their families and carers. Not only does this help to tackle social exclusion issues, but it can benefit the economy by opening up a new potential niche market for tourism operators.

Objective 5b has made a real difference to the National Park Authority's effectiveness and ways of working. It is achieving substantial benefits for economy, environment and community.

Future Programmes

The Objective 5b funding programme comes to an end in December 1999, although project work can continue thereafter, provided it has been authorised before that date. Attention has therefore been focused on the EU Agenda 2000 package, with its implications for future Structural Funding and opportunities for European support for integrated rural development. The new Structural Funding package will combine the previous Objective 2 and Objective 5b strands in a single Objective 2 measure, with urban, industrial, rural and fisheries strands. Rural Objective 2 status is being sought for the National Park area, with fisheries strand status being sought in addition for the coastal zone.

The population to be covered by Objective 2 is not to exceed 18% of the total population of the European Community; 10% industrial, 5% rural, 2% urban and 1% fisheries.

The European criteria for designation under the Rural Strand judge rural need on the basis of population density, agricultural employment as a percentage of total employment, the average unemployment rate and declining population. Under these criteria, relatively few rural areas of England would be designated, but salvation lies in a safety net in the regulation which means that in each member state the population covered by Objective 2 in the period 2000 to 2006 should be no less than two thirds of the population covered jointly by Objective 2 and 5b in 1994 to 1999. The safety net can be allocated in accordance with national criteria.

The North York Moors National Park economy is characterised by:

a) Low levels of economic activity and income;
b) Agricultural and tourism dependence;
c) Social exclusion;
d) Sparce population;
e) Environmental sensitivity and physical disadvantage.

The case for Objective 2 designation shows upland agriculture to be in crisis, with the North Yorkshire Uplands area characterised by negative management investment income, indicating that the net worth of farm businesses is declining and heavily dependent upon subsidy. Figures for upland and hill farms are shown on Tables 11.2 and 11.3.

Incomes from off-farm activities are critical to the survival of farming families, on average adding £7,000 to total family income, whilst environmental payments comprise a further £5,000 on average.

The case for designation of North Yorkshire's Uplands for Objective 2 could be summarised as depending upon:

a) Agricultural dependency significantly above EU average;
b) Marginal farming activity dependent upon subsidy;
c) Very low population density;
d) An ageing population and loss of young people;
e) Low GDP and low earnings;
f) Narrow economic structure and low private sector activity;
g) Low market problems;
h) A vulnerable but internationally important environment;
i) Poor access to services.

Objective 5b has brought great benefit, but it takes longer to see the real benefits in the countryside than is the case for Structural Fund programmes in urban areas. Partnerships have taken time to form and environmental benefits take time to emerge. In essence, it takes time to grow things in the countryside, not like bricks and mortar in the town.

Economy and environment go hand in hand in the uplands. If the farming economy collapses, so does the present landscape. From loss of landscape comes the loss of the very asset that visitors come to see and investors prize for the environmental quality of the region.

Research has shown that our well-managed moors, rivers, semi-natural grassland and woods produce a rich crop of biodiversity and landscape, admired by visitors from all over the world. Structural Funds are giving a new lease of life to our landscapes, finding new solutions to improve quality of life, quality of food and quality of income to put our National Parks on a sustainable footing for the future. We need the next round of Structural Funding designation under Objective 2 and are working closely with North Yorkshire County Council and others to secure it.

In addition to the Structural Funds, opportunities lie in the "Second Pillar" of the Common Agricultural Policy. Widely heralded by events such as the Cork Conference, the new Rural Development Regulation in fact ended up having far less money and attention devoted to it than had been hoped for by the UK Government and others. Nevertheless the opportunities are there for integrated rural development funding and a potential mechanism for additional money to enter this measure is contained in the Regulations through provisions that would allow for modulation of support payments to farms with the "savings" going into Rural Development Regulation measures.

Table 11.2 Typical farm subsidies as a percentage of net farm income

	Upland Farms	**Hill Farms**
1996/97	142%	99.9%
1997/98	382%	159%

Table 11.3 Typical upland management investment income (MII)

	Upland			**Hill**		
	1995/96	*1996/97*	*1997/98*	*1995/96*	*1996/97*	*1997/98*
MII Inc Subsidies	5934	10804	-4153	9152	12345	-438
MII Exc Subsidies	-18838	-13217	-24898	-21390	-13158	-23577

The Rural Development Regulation menu is an attractive one that includes as "accompanying measures":

a) Agri-environment schemes (ESAs, Countryside Stewardship, Organic Aid);
b) Early Retirement;
c) Less Favoured Area compensatory allowances (Hill Livestock Compensatory Allowances - HLCAs);
d) Afforestation of agricultural land.

The “non-accompanying measures” in the Rural Development Regulation have been brought together from various Structural Fund Regulations and concern:

a) Investment in agricultural holdings;
b) Aid for young farmers;
c) Training;
d) Marketing and processing grants;
e) Other forestry;
f) General rural development measures including:

    i. Land improvement and re-parcelling;
    ii. Farm relief and farm management services;
    iii. Marketing of quality agricultural products;
    iv. Basic services for the rural economy and population;
    v. Renovation and development of villages and protection and conservation of the rural heritage;
    vi. Diversification of agricultural and similar activities to provide multiple activities or alternative incomes;
    vii. Agricultural water resources management;
    viii. Development and improvement of agricultural development infrastructure.
    ix. Encouragement for tourist and craft activities;
    x. Protection of the environment in connection with land, forestry and landscape conservation;
    xi. Improvement of animal welfare;
    xii. Restoring agricultural production potential damaged by natural disasters;
    xiii. Financial engineering.

Whilst this measure is likely to be inadequately funded in its early years, the Rural Development Plans which will emerge can provide a beacon for future integrated rural development support and for a re-channelling of Common Agricultural Policy funding.

In parallel with this Rural Development Regulation opportunity, other changes have been introduced to agricultural support, of which the changes to the Hill Livestock Compensatory Allowances regime from payments on headage to an area basis will have particular implications for upland areas. The new payment scheme could have both threats and opportunities. We have suggested that the scheme should:

a) Establish a stocking density figure with a sliding scale for reduced payments to penalise both under- or over-grazing, in particular so that large subsidies could not be claimed on land which remains ungrazed (grazing being beneficial in environmental terms) and to help maintain the social structure of upland areas.
b) Introduce an element of modulation to favour smaller farms characteristic of the cultural heritage of upland areas.
c) Include a modest level of environmental conditionality, without confusing the aims of HLCAs with those of agri-environment schemes or penalising those with a disproportionate amount of environmental features to maintain.
d) Give areas such as woodlands special consideration, in order to remove the current disincentive under extensification premia to stockproof woodland, but without accidentally creating an incentive for mass afforestation.

The North York Moors National Park runs its own *Farm Scheme* on 110 farms. Each farm signed up to a 5-year whole farm management agreement making revenue payments for the maintenance of particular features of environmental value, with very modest payment levels even for more intensively managed areas and capital payments for specific improvements. The Farm Scheme, which is essentially a contract between the farmer and the National Park Authority, has provided a basis for developing a new Farm and Rural Community Scheme embracing the concepts in the new Rural Development Regulation and the opportunities for integrated sustainable development thinking. The field visit for the Uplands 99 conference involved visits both to a Farm Scheme farmer and to those involved in developing the new Farm and Rural Community Scheme which will introduce a new community dimension into the Park’s own agri-environment operations.

Conclusion

European funding has been a catalyst for change, partnerships and progress in programmes of benefit to the environment and economy of the North York Moors National Park. The new Structural Funding programmes provide new opportunities, as do the changes in the Common Agricultural Policy and further elements of European funding. The future of the hills and uplands will depend upon such external funding support. If it is withdrawn, the landscapes and livelihoods which have come depend upon it will change or disappear, with broader impacts on the environment and economy, not least the substantial tourism economy that is based upon the fine landscape of our National Parks.

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12. Supporting diverse and beautiful upland landscapes - use them or lose them? The need for effective integrated policies and land use

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Introduction

The role of the new Countryside Agency (1999) is to achieve balanced management of the England's countryside, including the uplands. Its aims are to:

- conserve and enhance the countryside;
- promote social equity and economic opportunity for the people who live there; and
- help everyone, wherever they live, to enjoy this national asset.

One of the priorities in its first year is to look at the future of the countryside and how it could be in 10-20 years time if all those who influence its management work together.

Thinking about the future of the uplands, home to many of our most wild, dramatic and beautiful landscapes will be an important part of this work.

The continuing need for integrated policies and multiple land use

England's uplands are one of our great national assets. They provide a unique combination of diverse scenery and nature, natural resources, upland farming systems, communities and traditions, opportunities for recreation and are economically important, especially for tourism. This means that multi-purpose land management is part of everyday life in most parts of the uplands and integrated rural policy has long been seen as fundamental to effective management there.

There have been concerns about problems in the uplands for decades. Much of the 1984 report *A better future for the uplands* (Contryside Commission 1984) could have been written yesterday, for example, the introduction highlighting that:

'The challenge of the uplands is not finding solutions to individual issues such as hill farming, landscape protection or industrial development. It is to get the balance right between these ... and other economic, social and environmental policies.'

Multi-purpose land management through better policy coordination was at the heart of the solution it proposed.

Since then, there has been considerable action to try to resolve upland problems, including:

- *Less Favoured Areas support:* annual compensation through Hill Livestock Compensatory Allowances per head of sheep and beef cattle. In 1998 this provided around £27 million to hill farmers.
- *Agri-environment schemes*, such as Environmentally Sensitive Areas (ESAs), Countryside Stewardship, Tir Cymen (and its replacement Tir Gofal) and National Park-funded farm schemes have pioneered new approaches to environmentally sensitive land management and input substantial funds to some areas. ESA payments alone in National Parks accounted for some £14.1 million per year in 1998 (ERM 1998). Monitoring (CCW 1998) suggests that funding for agri-environment schemes can provide a significant input to the rural economy and help to maintain and increase employment.
- *Funding for National Park Authorities* has increased significantly and their statutory role strengthened enabling them to initiate conservation and recreation related action and to foster and coordinate socio-economic initiatives.
- *Tourism and recreation in the uplands* has grown bringing more visitors (and traffic) and a wider range of recreational activities. Tourism is now one of the main contributors to the economy of many upland rural areas.
- *European schemes* such as Objective 5b, LEADER and LIFE have provided significant funding to many upland rural areas for a range of socio-economic and environmental projects.

Given that so much has been done, why are we still discussing the need for integrated policies and multiple land use in the uplands today? The upland economy and its communities remain vulnerable to changes and upland farming is now in crisis. The problems are clearly not easy to solve but there are signs that thinking and approaches are changing and that the uplands have assets which can now be built on.

A new approach - key questions we need to address

1. What farming and other land uses will be viable and sustainable in the long term?

Most land in the English uplands is farmed but the harsh environment will always make farming less competitive than in the lowlands. There are few farming alternatives to beef and sheep. There has been significant structural change in the uplands: there is a steady decline in the numbers of people employed full-time in farming and increases in farm size, whereas the number of people living in hill areas is rising. This means that the relative importance of agriculture is declining. These trends are likely to be hastened as upland farmers reach retirement age - around half of them are over 55. Agenda 2000 CAP reforms may speed up these changes. How can upland land uses evolve and become more integrated into the wider economy of upland areas?

2. How can upland communities make the most of their values and natural assets?

Although “less favoured” agriculturally, the uplands are “favoured” environmentally, in the opportunities they provide for recreation and tourism and in the economic value of these resources. How can the range of support available to the uplands be integrated more effectively? How can we ensure that this environmental value is not degraded by the very recreational pressures which it encourages?

3. What do we want upland countryside to look like in future?

Technical improvements mean that the food we need can be produced on less land and, increasingly, food production is being concentrated on the most productive lowland areas. The uplands are likely to see even more extensive farming methods such as ranching, and land becoming available for other uses, such as forestry and woodlands, or being managed for environmental reasons. The English uplands contain over 40 different Countryside Character areas. The regional countryside character assessments (Contryside Commission 1998/1999) provide an opportunity to guide land use changes to strengthen their distinctive character.

The Countryside Agency’s objectives for the uplands

The Countryside Agency wishes to see the uplands evolve so that:

a) they have viable, diverse and sustainable rural economies;
b) the quality of their landscape and other aspects of the environment are maintained and, where possible, enhanced;
c) they provide appropriate opportunities for recreation and access.

Table 12.1 sets out the Countryside Agency’s objectives for sustainable rural policy. Achieving this will mean developing all aspects of the rural economy not simply diversifying farming and changing farming practices.

Table 12.1 The Countryside Agency’s objectives for sustainable rural policy.

Sustainable management of the basic resources of soils, water and air. The future prosperity of rural areas and our survival depend on their quality.
Landscapes rich in local character and distinctiveness whose quality and differences help to reflect and strengthen local natural and cultural identity and to support diverse economies.
High-quality food, fibre and other primary products whose production meets high animal welfare and environmental standards.
Viable rural communities underpinned by a local economy that supports a wide range of job opportunities and continuing development of skills, particularly those related to the sustainable management of rural land and diversification into activities that depend on, and help to support, a high quality local environment.
Opportunities for public enjoyment through open-air recreation and visual appreciation.
A rich resource of historic and archaeological features from which we can continue to learn about the longstanding relationship between people and the land.
Maintained and enhanced biodiversity through protection and enhancement of wildlife habitats and species.

Opportunities for change

Until recently, agricultural policy has tended to dominate in the uplands, with farmers there, as elsewhere, encouraged to concentrate on increasing production. Other public benefits, such as hay meadows, traditional field boundaries or recreational value tended to be incidental by-products. The growth of agri-environment schemes has begun to recognise the importance of such "products" and has begun to reward farmers for producing them.

Organisations such as the OECD, the European Commission and MAFF[6] are now talking about multi-functional agriculture (Centre for Rural Economy 1999) (its contribution to shaping the landscape and the socio-economic viability of rural areas, preserving biodiversity, and providing natural resources, as well as supplying food and fibre). This is seen as a central characteristic of the European Commission's so-called "European model" of farming. Such changes in terminology suggest a change of attitude and, through Agenda 2000, the beginnings of policy change that recognises this as part of a rural development policy.

Opportunities for change include:

1) *The potential of regional strategic planning for rural areas to begin to integrate rural policies and co-ordinate support measures in upland areas.*

For the first time, the Rural Development Regulation (European Commission 1999) brings agricultural support measures and rural development measures are together in the same Regulation. This covers aspects such as Less Favoured Areas, agri-environment, marketing and processing of farm and forest products, training, and measures to help the adaptation and development of rural areas. Non-farmers are eligible for support under some of the measures, as well as farmers and foresters.

Although funding for the Regulation appears limited in the short term, it provides the framework to support long-term restructuring of the rural economy. Although the geographical scale of planning is yet to be agreed, the Countryside Agency hopes that the opportunity will be taken to produce a single rural development plan for each Government Office region enabling the package of measures to be tailored to regional needs and characteristics. To use available funding for rural development effectively, it will be important to integrate these plans as closely as possible with Structural Funds programmes and with the regional economic development strategies being prepared by the Regional Development Agencies.

2) *Developing and promoting products from upland areas that will generate added value for the local economy and help to maintain local distinctiveness of the landscapes.*

We value the uplands for their different and distinctive character and products - the Yorkshire Dales with their Swaledale sheep and Wensleydale cheese, for example. The Countryside Agency is working to support local products, which are directly linked to environmentally sustainable land management, which open up and exploit new markets and which strengthen the link between farmers and local communities. For example:

- Developing the links in each region between countryside character, the farming and land management systems that maintain it, and associated local products. We are looking for ways of creating more opportunities for consumers to buy local products and therefore help to sustain local character.
- Looking for new products that support environmental management. Most work so far has been in the lowlands (for example, the development of woodland products, such as furniture or charcoal making). More work is needed on identifying similar potential in the uplands.
- Adding value through developing high quality local products and better marketing. The Countryside Agency is helping to fund the development of the new National Association of Farmers' Markets. There may also be potential to increase upland organic farming. Research has shown (Countryside Commission 1998) that this can have long-term landscape benefits.

3) *Developing sustainable tourism and access*

Tourism is now one of the most important elements of the rural economy in many upland areas. Holiday-makers staying in upland National Parks spend between £5.10 and £17.60 a day (Countryside Commission 1996) (excluding accommodation). In the North Pennines Area of Outstanding Natural Beauty (AONB) tourism generates more jobs (35%) than the agricultural sector (25%) (Countryside Commission 1997).

The Government is keen to secure access to open countryside, much of which is in the uplands. With proper safeguards this could benefit the local economy. Our research shows that the South West

[6]The former Ministry of Agriculture, Fisheries and Food, all functions of which are now being carried out by the newly-formed Department for Environment, Food and Rural Affairs (DEFRA).

Coast Path benefits local businesses by over £15 million a year. National Trails such as the Pennine Way and Bridleway, and Hadrian's Wall will also benefit upland areas.

The Government has also announced plans to boost tourism (Department for Culture, Media and Sport 1999) - with a blueprint for sustainable tourist development, development of niche markets 'to unlock the potential of Britain's unique cultural and natural heritage' and better promotion of these assets. Upland areas can use their unique identity and features as a marketing tool (and in so doing, strengthen that identity) - as has been shown by partnership projects in Dartmoor, the North Pennines and the Peak District (Countryside Commission 1995).

4) Integrating upland farming systems and the rural economy

A high-quality environment is beginning to be recognised as one of a variety of products, both on- and off-farm, from which the land managers can earn money. It underpins much of the economy of rural areas and is an important part of the quality of life for the people who visit and for the people who live and work there. However, policies for agriculture and the rural economy tend to have evolved separately and are not well integrated, and many farmers have not yet recognised that a good environment can be a market product.

Philip Lowe has proposed (Lowe 1999) that the challenge is how to put agriculture back into the rural economy from which it seems to have become detached. This is something which we hope that the new Rural Development Regulation regional plans, the RDA regional economic development strategies and the Rural White paper will address.

The Countryside Agency is developing ways to encourage integrated policies and practices. Working with local communities and other partners, we have set up an experimental national programme of twelve Land Management Initiatives (LMIs) in arable, upland, lowland pastoral and floodplain areas. We plan to launch upland projects in the North York Moors and Northumberland this year and background work for a possible project in the Peak District is underway. The projects will explore how the farming and other aspects of the rural economy can become better integrated and more environmentally and economically sustainable. The LMIs will include improving environmental land management, stronger links between farmers and other parts of rural communities, looking at the needs of rural communities, exploring scope for adding value to farm products and developing new markets. We will use the findings to help influence future UK policies and reforms of the Common Agricultural Policy. We are also seeking to learn lessons from other initiatives trying to improve integration.

Challenges for tomorrow's uplands

There has long been multiple land use in the uplands. The challenges for tomorrow's uplands are to:

- develop and implement the new thinking on ways to integrate upland land uses with the wider rural economy. The Countryside Agency believes that the objectives should be to:
- Seek to increase the environmental, social and economic sustainability of rural areas and support landscape, natural and cultural diversity;
- Pursue rural development that is responsive to local needs and at the same time supports landscape, natural and cultural diversity;
- Recognise the uplands as favoured environmental areas and use them wisely and creatively, rather than concentrating on their disadvantages for agriculture, as is currently the case. We need to build on their assets and work creatively to maintain and enhance them.

If properly implemented, the move towards a more integrated approach to rural policies is an important step forward that offers new potential to help the uplands, and other rural areas, to survive and thrive, whilst protecting their unique character and values.

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13. The challenge of protecting and expanding England's upland woodland resource

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Introduction

This paper looks at the forestry policy changes which have affected upland woodland creation and management in recent years, focussing on the use of challenge funds for new native woods and long-term planning (often referred to as forest design planning) to achieve significant change in woodland structure. It uses examples from the Forestry Commission's Northumbria and Yorkshire Conservancy, the principal management unit for north-east England. Both habitat and species action plans are used to illustrate how multiple forestry land use is contributing to the UK Biodiversity Action Plan.

Government's Forestry Strategy for England

The England Forestry Strategy was published in December 1998 (Forestry Commission, 1998a) and represents a real opportunity for forestry to expand its role and benefits in England. It will ensure multi-benefit forestry practice is the norm in England. It sets out the Government's priorities and programmes and includes a series of actions that the government intends to take over the next few years. The strategy does not deal with quick fixes. It will focus discussion on how woodlands can help deliver a range of environmental, social and economic benefits for people who live and work in, or visit, England.

There are four main strategic programmes:

- Forestry for Rural Development
- Forestry for Economic Regeneration
- Forestry for Recreation, Access and Tourism
- Forestry for the Environment and Conservation

Key actions under each of the four programmes are described as follows:

1) Forestry for Rural Development:

- Influence policies for agricultural reform;
- Support strategic development of woodland resources;
- Develop understanding of the rural economy;
- Encourage diversification.

2) Forestry for Economic Regeneration:

- Promote forestry for land regeneration;
- Support regional programmes;
- Promote forestry through land use planning;
- Promote environmental improvements.

3) Forestry for Recreation, Access and Tourism:

- Increase access to woodlands;
- Improve the quality of information about access;
- Enhance the nation's forestry estate;
- Promote better understanding.

4) Forestry for the Environment and Conservation:

- Protect existing woodland;
- Promote the environmental benefits of trees and woodlands;
- Use the Biodiversity Action Plan to guide nature conservation;
- Protect cultural heritage.

The England Forestry Strategy contains 42 specific actions and targets that will be addressed by the Forestry Commission, other departments and non-government partners over the next 5-10 year period. In recently publishing its first Corporate Plan for England the Forestry Commission took full account of these proposed actions. Its proposed spending plans amount to £32 million and have been presented in terms of linkage to Forestry Strategy outputs. The programmes for enhancing economic value and improving the environment are the two largest budgeted areas of work for the Commission, amounting to 72% of total expenditure.

The UK Forestry Standard

Forestry operations in the UK must be sustainable. In public and private sectors this is monitored by the Forestry Commission to the standards detailed in The UK Forestry Standard, published in January 1998 (Forestry Commission, 1998b). It is key to the Government commitments made at summits in Rio and Helsinki in 1992-3, and is linked to developing international protocols for sustainable forestry. It has an important underpinning role in respect of the recently agreed UK Woodland Assurance Scheme, devised to help owners obtain certification of their wood products for markets that are increasingly demanding a label of source, such as the Forest Stewardship Council's 'tick-tree' logo.

Woodland Grant Scheme

The Forestry Commission pays grants under the woodland grant scheme (WGS) for establishment and management. Proposals must meet the UK Forestry Standard for acceptance into the scheme. Increasingly, proposals are also being judged against their scope to deliver forestry strategy targets and more targeted funding is now being used to direct woodland change into priority areas. The National Forest in the Midlands, England's 12 community forests, and the South West Forest in north Devon are all examples of this trend.

In the northern English uplands the Forestry Commission is the lead body for Habitat Action Plans for the principal native woodland types (e.g. upland mixed ashwoods) and is developing its grant support mechanisms to address specific targets for habitat restoration.

Challenge funding

Under the umbrella of the WGS there are two competitive challenge schemes currently running in Northumbria and Yorkshire Conservancy. These schemes focus on the protection and expansion of upland woodlands, particularly traditional and native broadleaved woods. Both challenge schemes were set up in 1997 to run for three years and pay up to 100% of costs, and are now entering the final bid year.

The first of these, the New Native Woodland in National Parks Challenge, is to encourage the creation of significant areas of new native woodland in these designated areas of England and Wales. It involves close collaboration with the National Park Authorities and English Nature. In terms of priorities within the Forestry Strategy, this challenge scheme is helping to address the creation of larger new woodland (some applications have exceeded 50ha) and reversing fragmentation of ancient woodland. Tables 13.1 and 13.2 show the results from the first and second years respectively of this new scheme.

The second scheme is the Woodland Management Challenge. This is open to under-managed or neglected woodlands of 10 ha or less within the EU Objective 5b area of North Yorkshire. Results from the first two years are shown in Table 13.3. It is specifically designed to complement the work of the Yorwoods initiative that is covered later in this paper.

Table 13.1 Challenge fund - new native woodland in national parks: First year results (1997/98)

FC REFERENCE	NAME	AREA(ha)	NAT. GRID REF.
Northumberland			
012002351	Kilham Hill	41.6	NT 887307
012002358	Ramshope Farm	70.1	NT 747053
012002372/356	Barrow Woodlands	60.7	NT 899062
Yorkshire Dales			
012002338	East Stonesdale Gill	7.0	NY 897016
012002342	Blea Gill, Grimwith	33.0	SE 050657
012002339	Cotterdale Gill	37.0	SD 830942
North York Moors			
012002353/355	Fryup Dale	21.0	NZ 724031
012002328	Kepwick Estate	5.5	SE 470910
012002345	Thackdale	21.5	NZ 510010
012002357	Harfa Bank	5.0	SE 496996
012002344	Rosedale	28.1	SE 724990
GRAND TOTAL		**330.5**	

Table 13 2 Challenge fund - new native woodland in national parks. Second year results (1998/99)

FC REFERENCE	NAME	AREA (ha)	NAT. GRID REF.

Northumberland			
012002741	Ilderton Dodd	27.75	NT 990206
Yorkshire Dales			
012002763	Bolton/Apedale Gill	21.70	SE 042941
012002754	Grimwith Reservoir	16.90	SE 051653
North York Moors			
012002748	Clitherbeck, Danby	6.19	NZ 718090
012002739	Caley Becks Farm	17.90	NZ 856061
GRAND TOTAL		**90.44**	

Table 13.3 Woodland management challenge results in EU Objective 5b area of north Yorkshire 1997 - 1999

YEAR	No. OF SCHEMES	SIZE RANGE (ha)	TOTAL AREA (ha)
1997/98	12	1.7 - 10.0	79.3
1998/99	13	1.0 - 10.0	64.6

Note: Results for the final round (1999/2000) were not available when submitting this paper but a similar outcome is anticipated

Forest design planning

Forest design planning is the process which ensures that plans for change in the structure of existing woods, or the creation of new ones, will meet the requirements of the UK Forestry Standard. The Forestry Commission has produced a Forestry Practice Guide (Forestry Commission, 1998c) detailing the design process for forest planners and managers.

Detailed, holistic plans are usually required for large or sensitive schemes. Both private and public sectors are required to produce them, although the formats tend to differ. Private sector plans recently submitted within Northumbria & Yorkshire Conservancy include Glaisdale Woods, Weardale Forest, Cotterdale Woodlands and Wooler Common Woodlands. To varying degrees all involve reducing areas of coniferous plantations and increasing areas of semi-natural vegetation, general conservation, or landscape gain. This usually involves establishing large native woodlands or higher yield plantations on alternative sites, linked to multi-benefit objectives. This latter compensatory planting can take place on the same land holding or on land owned elsewhere in Great Britain.

The Wooler Common plan was enabled by an innovative land swap deal brokered by the Forestry Commission. Lilburn Estates in Northumberland purchased 123 hectares of farmland with vacant possession within the Tees Community Forest area. This land was then swapped for 157 ha of conifer plantation owned by the Forestry Commission at Wooler Common, enabling the Commission's Forest Enterprise agency to create a large, new community woodland close to Stockton-on-Tees. Lilburn Estates wishes to encourage reversion to heather moorland at Wooler Common by removing the low yield class conifer areas which were established, with varying degrees of success, on heather-dominated ground approximately 20 years ago. Negotiation with the Forestry Commission is proceeding to create around 125 ha of new multi-benefit woodlands in exchange, to include better quality sites for tree growth and landscape, yielding higher growth rates and greater use of native species. At Weardale Forest and CotterdaleWoodlands reduction in the total area of mainly low quality, poorly designed conifer areas has been allowed in return for restocking appropriate areas with native species and genetically improved conifer stock. In addition, new areas of native woodland and black grouse habitat have been created

Forest plans

Proposals to develop the concept of Forest Plans for the private sector were first submitted to Forestry Ministers on 22 October 1997, with a public announcement in December that year. An extensive public consultation exercise followed and the views received were used to create a framework for the development process. In order to examine the real costs to owners, and to identify the best procedures for the development of the plans, a pilot exercise involving sixteen sites throughout Great Britain was run in 1998/99.

Private forest owners are being encouraged to look much further ahead for their woodland management under this new initiative to be launched in autumn 1999. It represents something of a return to the plans for dedicated woodlands that were recommended to many forestry estates in the 1970s. However, these new long-term plans will be linked closely to the UK Forestry Standard and incorporate all the best modern practice in terms of landscape design and other environmental considerations.

This new extension to the Woodland Grant Scheme will allow owners of larger forests to benefit from a more streamlined approval system. In return, the Forestry Commission will expect applicants to take a more holistic and longer-term view of how their forests will be managed. They will be expected to collate information from the site into a plan that accommodates the various needs and objectives, and reduces conflict. It will include drawing up and agreeing a programme to cover phased harvesting and replanting for large forest areas (at least 50 ha), or whole estates, over a twenty-year period. A Plan Preparation Grant will be offered as an incentive to encourage owners to undertake the type of planning embodied by a Forest Plan, designed to contribute to realistic costs of the preparatory work.

Partnerships in the Northern Uplands

Yorwoods is a partnership of organisations who have come together who promote woodland management and marketing of wood products in upland North Yorkshire. In addition to the partners, funding comes from the uropean Agricultural Guidance and Guarantee Fund (Objective 5b) and the Government.

Yorwoods is helping owners of smaller woodlands in particular, or those thinking of planting new woodlands, with advice on grants and techniques, contacts with contractors and advisors, grant aid towards training in woodland-related skills and in managing existing woodlands. In general, the woodland and/or applicant concerned need to be located within the European Union Objective 5b Area of North Yorkshire to be eligible for assistance.

Currently the advisory package relating directly to management and planting comprises a free initial visit and written report, and up to £150 towards preparation of a WGS. Other aid and advice can be offered for environmental work, harvesting cost subsidy, marketing advice, native tree supply and design plans for non-commercial forestry projects.

A similar project is now being set up to cover the Northumberland and Durham Objective 5b areas, to be known as the Northwoods initiative. Once this project is fully established it will mean that the North of England is well-served with woodland initiatives (with the Cumbria Broadleaves partnership operating in the Lake District) designed to assist the management of smaller, low-productivity woods.

Black Grouse

The North Pennines and small areas at Otterburn and Kielder in Northumberland contain the total and rapidly declining population of Black Grouse in England. The latest best estimate is 800 lekking males; it is almost impossible to get a reasonably accurate measure of the female population.

One of the main causes of this alarming decline is habitat loss. The Forestry Commission in the Northern English uplands is taking a pro-active approach whenever possible in promoting the Woodland Grant Scheme to landowners in order to assist in the creation and management of appropriate woodland habitat. This recognises the status of Black Grouse in the UK biodiversity programme in terms of species' action plans.

For new planting this work is likely to include:

- Woodland creation ideally within gylls or on valley slopes or along the edges of existing plantation and shelter belts;
- Suitable species to be native and likely to include birch, alder, willow, rowan and hawthorn, with up to 10% aspen, juniper and scots pine in certain circumstances;
- Up to 20% open ground may be utilised along woodland boundaries and to protect existing valuable habitats (closer plant spacing may enable additional open space to be created);
- Appropriately sited and visually marked new fencing.

For the management of existing woodlands:

- Management plan preparation;
- Small-scale respacing, uneconomic thinning and felling of plantation edges associated with new Black Grouse "friendly" edge planting;
- Coppicing and pollarding of existing broadleaved trees and shrubs along woodland edges;
- Creation, restoration and management of dwarf shrubs, wet flushes and bogs within the woodland area, including drain blocking;

- Stock exclusion, including fence replacement and marking.

Summary

A forestry perspective on managing multiple land use is presented in this paper, whereby the new government Forestry Strategy for England is described and related to delivery mechanisms involving grant support, forest planning, partnership projects and species action plans. The modern requirement for forest and woodland management to meet the full range of economic, social and environmental standards described in the UK Forestry Standard means that a multiple use approach tends to be a normal expectation. This increasingly puts foresters in a position of being able to demonstrate best practice to other land managers who are beginning to experience the pressures and opportunities that demands of multiple use can bring.

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14. Integrated management in the uplands: is it possible to reach consensus?

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Abstract

A holistic approach to the varied problems of the Uplands has been the basis of successive initiatives to integrate agency policies and practice. It appears to combine the best of several worlds suggesting firm political leadership, administrative efficiency, democratic involvement and the delivery of public services geared towards the consumer. Yet progress towards the Holy Grail of integration is remarkably patchy. Is the fundamental premise of integration sound or is it based on false assumptions and are there systematic barriers to its attainment?

The paper investigates some parallels between attempts to set up rural partnerships among the responsible agencies to address the problems of the Uplands and a range of initiatives in social work and rural development. It draws on theories of consensus building and group dynamics to comment on the effectiveness of rural partnerships, based partly on the author's recent experiences as a consultant.

The desire for integration

Integrated policy and concerted action by the agencies of government appeal to the rational mind. Indeed, many of the papers in this volume advocate such thinking but also express frustration with previous and current attempts to develop an integrated approach to dealing with the problems of the Uplands. A number of closely related themes can easily be detected:

- **The need for integration**

  Heal (this volume) recounts how policies have proliferated, yet remain fragmented and asks how do we put the jigsaw together? Mercer (this volume) sees many of the problems stemming from [too many] organisational levels, and also asks why there are so many actors, adding to confusion of the laypeople. Thomas (Conference presentation) echoed recent political thinking in stressing the value of 'joined-up thinking'.

- **The need for dialogue between competing interests**

  It is evident that something is lacking from the discourse of integration. Gordon-Duff-Pennington, for example, (this volume) sees a need for genuine dialogue and to listen to the quiet voices. Meanwhile, Lord Selborne in his opening address to the Conference, recognised that consensus is easy to propose but difficult to achieve and argued for "bottom-up" solutions, greater public trust and transparency in public decision making.

- **The problems of uncertainty**

  We heard from Arnell (Conference presentation) of the problems of dealing with the uncertainty of climate change and how the science appears easy to unravel compared to the politics of the situation.

- **The value of partnerships**

  Gordon-Duff-Pennington's plea (this volume) to reach for the common ground is echoed by Thompson (Conference presentation); they see genuine partnerships as the key to a better future, not a continuation of sectoral policies. Thompson also stresses the need for being clear about objectives.

- **The repeated failure to achieve integration**

  If all this is familiar, Simpson (this volume) expresses the frustrations of many when she asks why we are still discussing the need for integrated policies and multiple land use. She concludes that there must be a new approach.

The need to focus on decision making

It is the basis of a new approach that I wish to examine and to question certain of the assumptions on which previous attempts at integration have been based. In a scientific approach (which many of the presentations here adopt), it is not surprising that the problems (or ways of dealing with uncertainty) have been perceived or portrayed as technical ones, to be solved by acquiring information and specialised technical expertise. Such a diagnosis inevitably leads to a plea for more scientific research.

Yet we already know a great deal about the physical, biological and socio-economic problems of the Uplands, as so many authors have ably demonstrated. While we can only benefit from further application of the scientific approach to a variety of issues, I would contend that the missing ingredient which appears to defy investigation is the confining nature of decision-making processes. We recognise that the problem is both multi-faceted and complex and that the solution must lie within a programme of co-ordinated action. Yet we fail to address the issue of exactly how the energies and resources of hopefully co-operating parties are to be harnessed to the common good.

The value of partnerships has been widely recognised in the official literature, as indeed it has been by other authors. The political rhetoric of partnerships is compelling and the benefits are spelt out in many good practice guides aimed at rural communities. For example, Slee and Snowdon's (1997) description of such benefits is set out in Table 14.1.

Similar arguments for partnership can be found within the social work literature, arguing for the clarification of roles and responsibilities which will lead to more efficient use of resources, the reduction of duplication and the delivery of comprehensive services (e.g., Hallet and Birchall, 1995). However, if comparative analysis shows that the benefits attributed to inter-agency working in both the rural development and social work sectors are very similar, so too are the difficulties encountered in changing the delivery system.

The realities of attempting to adopt alternative approaches to decision making are spelt out by Slee and Snowdon (1997) as a series of changes in working practice that have to be adopted if rural partnerships are to be effective. Namely:

- participating organisations may have to delegate some authority to the partnership;
- compromise may be required concerning attitudes and issues on which partners are used to being partisan;
- sharing power may be both uncomfortable and time-consuming for partners;
- the aims of a partnership may not fit the more limited remits of some member agencies; and
- partners need to be open about their objectives and indicate aims that are non-negotiable and potential areas of disagreement.

The elements of consensus building

Many of these elements appear, albeit in slightly different form, in more theoretically-based analyses of decision making and the conditions which lead to consensus, as shown in Table 14.2.

Table 14.1 Benefits of rural partnerships (based on Slee and Snowdon, 1997)

- Shared vision: *scope for creating agreements with broad base of support*
- Strategic thinking: *agreement on long-term goals, priorities and targeting of resources*
- Stimulus: *co-ordinated action attracts funding*
- Skills development: *sharing of skills leads to greater efficiency and cost saving*
- Synergy: *better links between sectors and local community and opportunity to tackle all aspects of the problem*

Table 14.2 Conditions for consensus in decision-making (based on Sidaway, 1998)

Terms of Reference and Agenda	Agreement between all parties on the purpose and form of the exercise. Balanced agenda covering the full range of issues.
Representation of stakeholders	All relevant communities of interest represented.
Accountability	Representatives fully accountable to their constituents.
Authority and power in decision making	Delegation of authority to a representative negotiating group or a clear understanding of its sphere of influence. Power balanced or the interests of weaker interests are fully respected.
Information	Free access to information, which covers all issues and has been gathered in an impartial way.
Openness and involvement in the process of decision making	All phases of decision making are open to all interests to the extent that they require.

Table 14.3 The contrasting worlds of committee culture and consensus building

Characteristic	Committee Culture	Consensus Building
Agenda	Selective and limited to soft options	Mutually agreed
Representation	Exclusive and inconsistent attendance	Inclusive and consistent attendance
Accountability	Left to individual discretion	Responsible to constituents
Authority and power	Discretionary with scope for unilateral action Power differentials maintained	Clearly defined delegation or sphere of influence Equal respect for all stakeholders
Information	Selectively gathered and presented	Impartially gathered with open access
Process of involvement	Late involvement with 'consultation' on firm proposals	Early involvement in formative stages

Thus, the key constraints for bureaucracies attempting to adopt a consensual framework concern the limitations set by their remits and their unwillingness to delegate authority to a group of stakeholders, in the face of what they see as challenges to their autonomy and power. Yet, when confronted by the risk of conflict, agencies in the rural development sector fall back on familiar models of committee culture which facilitate the exercise of institutional power. The archetypal committee relies on the authoritative chairman, who is ruthlessly pursuing his own goals, aided and abetted by a secretary who controls the agenda and re-writes history (in the form of the minutes) when necessary. Members are selected to rule out divergent views as there is no agreed method of handling disagreement; indeed there is little advance discussion of procedure and process. Propositions are concealed in papers produced at short notice by officers so that they are rarely read and participation is reduced to 'rubber stamping' their recommendations. While it would be grossly unfair to represent all committees in this light, the analysis has been developed elsewhere (Forester, 1989) and the elements are sufficiently familiar to draw our attention on the attractions of the more democratic processes of consensus building. The contrast is highlighted in Table 14.3.

Whilst consensus building is increasingly seen to be advantageous to its conventional alternatives, either to resolve conflict through mediated negotiations (notably in inter-personal and community relations and in the commercial world) or through more participatory planning, it has both advantages and limitations (see Table 14.4).

Given the difficulties of reaching consensus, as recognised by Lord Selborne in his opening address, it is necessary to give full attention to the underlying principles of consensus building and to design a process which will be effective and appropriate to the circumstances of the situation. Indeed, the differences between the sectors within this comparison lie in the attention paid to processes of decision making and the more deliberate attempts made, particularly in social work teams, to address difficult issues. For example, teams function effectively when they:

- have a written purpose, goals, policies and guidelines;
- strive for consensus but acknowledge dissent;
- avoid hierarchical structures, being non-threatening and supportive of members; and
- develop plans or recommendations that include measurable, attainable and time-related objectives which state who will be accountable for their achievement.

Table 14.4: The pros and cons of consensus building (Sidaway, 1998)

Advantages

- Increased understanding of the issues involved
- The voluntary and less formal procedures allow the parties to explore the problem and consider a range of possible solutions
- Improved relationships between the interested parties make it more likely that they trust each other and less likely that they disagree in future
- The interested parties have greater commitment to and control of the outcome
- There are savings in time and money, over the longer term

Limitations and constraints

- Deeply held beliefs are non-negotiable and consensus may be difficult to obtain
- The informal process can be manipulated by markedly more powerful parties
- The interests of the less powerful need to be safeguarded by legally binding procedures
- Lack of formal organisation may preclude some interests from being represented in negotiations
- Reaching consensus is time-consuming and may be difficult to sustain over time.

Defining the extent of co-operation

In the environmental field, the application of the participatory approach has been limited to attempts to use Arnstein's "ladder of participation" to analyse the relationship between one specific agency and the community but not to examine or define relationships between agencies. One such adaptation sets out levels of community involvement in forest management, which range between the poles of full community control to agency control. The intermediate steps include 'full community involvement' in which 'the agency takes a back seat' to local groups, and 'partial involvement', in which members are involved in 'appropriate' aspects of management; but, interestingly, this modification doe not envisage equal partnership between the agency and the community (Argeman, 1996).

In my experience, partnerships between rural development agencies rarely consider in a constitutional way the extent of their planned co-operation. There are many models of co-operation which could be considered, as suggested by Liddle and Gelsthorpe (and depicted in Table 14.5). Agency preferences are often for an unthreatening world of co-existence rather than exploring the unfamiliar territory of fuller forms of co-operation. Many of the long-standing debates concerning the empowerment of the powerless (non-elites) by the powerful (elites) in urban communities (e.g. Van Til and Van Til, 1970) recognised the dangers of tokenistic responses to the transfer of power. With a co-author, I have argued elsewhere that these lessons apply equally in any sector of government as they do to inter-agency partnerships (Barry and Sidaway, 1999).

Conclusions

Any failure to find solutions to the multiple problems of the Uplands is as likely to stem from institutional politics as from further technical specification of either problems or solutions. This is not to suggest that it is the obstinacy of individuals that is to blame but rather the sectoral nature of government in which departments and agencies are engaged in a struggle for survival. This struggle to maintain autonomy and to compete for finite resources is typified by demarcation disputes, the failure to delegate power, unrelated initiatives and unconnected levels of decision making. Underpinning this is a system of accountability which rewards performance based on narrowly focused and short-term criteria, such as readily quantifiable 'products', rather than longer term processes of developing relationships with external bodies, which are intrinsically difficult to assess.

If 'joined up government' is to become more than fashionable rhetoric, changes to these reward systems are needed which benefit co-operation,. If this cannot be achieved, then it would be as well to jettison the rhetoric of integration and to concentrate on clarifying objectives and setting realistic limits to intended co-operation. If we are sincere in our aspirations and genuinely wish to achieve integration then political direction has to be matched by a cultural shift. The move beyond power-brokering within committees to genuine consensus will not be easy to accomplish. It will entail an unfamiliar degree of balance and openness in decision making. Instead of improvisation, which favours institutional power, we will need carefully designed strategies which ensure that interests are represented on their own terms and respected in the ensuing dialogue. Sadly this is not the familiar landscape of the Uplands but it is one that we must create if we wish to achieve integration by consensus.

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Table 14.5 Models of co-operation (based on Liddle and Gelsthorpe, 1994)

Type of working	Autonomy	Focus	Resources
Merger	Indistinguishable	Range of mutually defined problems	Collective resource pool
Federation	Distinctive with central focus	Shared central focus	Integrated services
Co-ordination	Systematic working	Joint action on specific problems	Joint project funding
Co-operation	Separate identities	Joint action or agreed lead agency	-
Communication	Maintained network	One or two way disclosure	-

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15. Tourism in upland areas: benefits in the balance?

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Abstract

Whilst it offers no panacea, tourism can assist economic diversification in the uplands. The impact of tourism in sensitive rural environments can, however, be high, bringing visitor management pressures in its wake. This paper considers some of the challenges and opportunities for tourism in the uplands, drawing upon examples in the North of England, and considers whether it is possible to achieve benefits through a balanced approach. Whilst some of the points considered apply to many rural areas, other tourism issues such as landscape imagery are specifically "upland" in their nature and application.

What do we know about tourism in the uplands?

Whilst it is difficult to be exact about the value of uplands tourism[(a)], due to the complex structure of the tourism industry and a lack of detailed and consistent local area data, we can form a reasonable picture from a combination of national and local area studies. For example, a study by the Rural Development Commission and the Countryside Commission in 1997 (Broome *et al*., 1997) showed that countryside tourism in the three northern regions supported 69,900 jobs (Table 15.1[8]).

Looking further at data for Northumbria, although calculated in different ways, an estimated 10,460 tourism-related jobs in the countryside can be compared with an estimated 55,000 jobs across the region as a whole (English Tourist Board, 1997). With rural Northumbria accounting for around 10% of the region's population, this provides a perspective on the relatively greater role of tourism in the countryside.

At a local level this role can be even more pronounced, as for example in the Kielder area in Northumberland, where 37% of employment is now related to tourism (Purves, 1997). From the limited data available for Northumbria, the importance of tourism to the upland economy is certainly clear, helping to support local services, providing employment and improving the quality of life both for the local community and visitors.

We also know from national and local studies that visitor spending extends across a wide range of services such as transport, shopping, entertainment, eating and drinking. This tourism spending circulates widely within the community, creating demand for other supplies and services, and supporting a range of different types of jobs. Whilst much employment within rural tourism is of a self-employed, part-time or seasonal nature, this offers flexible work opportunities which can match the changing needs and aspirations of the workforce (e.g., farm diversification, job sharing, family commitments).

Comparisons of local and national data do, however, reveal differences in the proportions of such spending (Table 15.2). In the North Pennines, for example, a much greater proportion of spending went on accommodation (about half) and retail compared with all-England countryside tourism and the region of Northumbria as a whole. Conversely, spending on eating out is proportionally much lower, no doubt reflecting the relative lack of facilities for eating out in more remote upland areas.

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[7] Current address: English Tourism Council, Thames Tower, Black's Rd, Hammersmith, London W6 9EL

[8] These statistics were current at the time of the Conference in 1998. Please see the new joint Tourist Boards' research website http:\\www.staruk.org.uk for up to the minute tourism statistics.

Table 15.1 Tourism spending and jobs in the countryside (source: Broome *et al* 1997)

	Countryside Tourism Spending (£m)	Employment Estimate
Cumbria	375	16000
Northumbria	263	10460
Yorkshire	1060	43440
All England	8969	354040

Table 15.2 Distribution of Tourism Spending (sources: Broome *et al*., 1997; English Tourist Board 1997; North Pennines Tourism Partnership 1992)

What tourists spend money on: (NB: data collection and analysis methods vary)	*All-England Countryside % share*	Northumbria (whole region) % share	North Pennines % share
Package trip	-	6	-
Accommodation (non package trip)	10	25	51
Travel	17	20	7
Buying clothes/ Other shopping	12	16	19
Eating and drinking	50	26	16
Attractions/entertainment	11	5	5
Other expenditure	-	3	2

Environmental, cultural and social impacts of tourism

Tourists are attracted to an area by a perception of the combined quality of the natural and built environment and the specific natural, historical and cultural features which it offers. The expectations of visitors in upland areas thus increase the interest in, and demand for, the protection and enhancement of these intrinsic assets. Tourism can also enhance the viability for cultural, sports and leisure facilities that contribute to the quality of life in upland areas. This can stimulate investment from other industries and encourage local people to spend their leisure time within the area, further supporting the economy of upland areas.

Some examples may be given to illustrate this potential:

- Growing tourism interest in the Hadrian's Wall World Heritage Site has triggered further conservation and interpretation work, requiring relevant specialist skills within the local population.
- Under-used or derelict historic buildings have been converted into quality accommodation, ensuring their long-term conservation and access to the public e.g., Langley Castle in Northumberland.
- Tourism potential has helped to justify townscape regeneration schemes in places such as Barnard Castle and Haltwhistle.
- Visitor patronage helps to justify or support investment in arts, social and leisure facilities, e.g., Alston Town Hall, Bellingham Golf Club.
- Demand for local craft and food traditions helps to conserve regional identity and specialist skills e.g., revived interest in the Northumbrian small pipes.

Landscape and image

Upland landscape imagery features prominently in tourism destination branding and representation for the North of England. Research for marketing campaigns has shown that such images are recognised as regionally distinctive, helping to differentiate this region from other parts of Britain.

There is, however, an intricate relationship between tourism and the landscape and natural heritage of the Northern uplands, overlapping with other land-use and environmental management considerations. Thus:

- Visitors may buy nights in a local hotel, but they come to experience a wider product that is not part of the responsibility of the hotel proprietor.
- Conversely, the product of agriculture extends beyond 'farm gate' outputs, to the creation and maintenance of particular characteristics of land use and landscape that are intrinsic to the tourism product.

Clearly the landscapes and wildlife of the uplands, often seen to be under threat from changes in the agricultural economy, are also assets with potential to cater for further tourism activity. There is demand for more access to open country, woodlands and waterways, whilst farm-based tourism, cottage rentals especially, can help farming families and their employees to survive as custodians of the countryside. There is also potential for the re-use of redundant farm buildings, which are often significant features in the landscape, for visitor facilities.

Sustainability

Attention is often focussed upon the problems that can be caused by tourism in upland areas. Popular films and TV series which feature rural people and places, such as ‘Herriot Country’, ‘Last of the Summer Wine’, ‘Heartbeat’, etc., have made some areas instantly popular. The blessings are invariably mixed. Thus whilst other areas aspire to being similarly ‘discovered’ in some future series, those experiencing a new ‘urban’ invasion become aware of the impact of traffic congestion, indiscriminate parking and too many people crowding into a small number of well-known places. Inconvenience for local residents, erosion of paths and loss of tranquillity are just some of the possible costs to be weighed against the boost to local hotels, restaurants and other traders.

Studies carried out in parts of Northumbria, which has less experience of high-volume visitor activity, suggest a generally supportive attitude within the host community (Figures 15.1 and 15.2). It would be unwise to presume upon this in the future, however, and care will be needed to involve local representatives in consideration of future strategies.

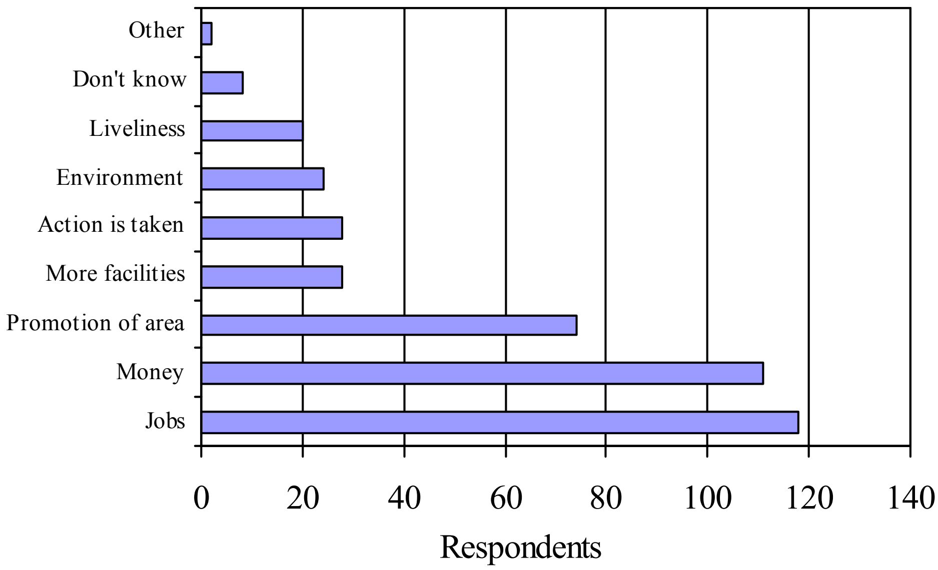

Figure 15.1 Perceived benefits of tourism: Till Valley, Northumberland (1995). Source: Dronsfield (1995)

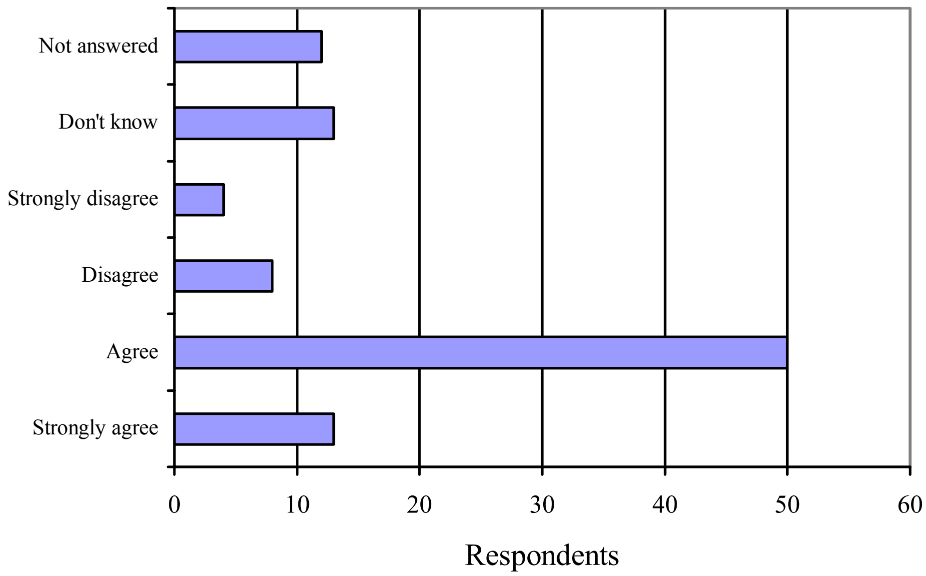

Figure 15.2 Do advantages of tourism outweight disadvantages? Till Valley, Northumberland (1995). Source: Dronsfield (1995)

Challenges for tourism businesses

Any consideration of the potential for tourism to further contribute to the uplands economy must also take account of the challenges intrinsic to the nature of tourism enterprises. These are liable to impinge upon their ability to respond adequately to development opportunities or initiatives.

We have already noted that the tourism product is not 'made' or managed by any one supplier, and outputs/benefits are more complex than for most industries. Some of the particular challenges for tourism businesses in the uplands are:

- The fragmented structure of the tourism industry in rural areas, comprising mostly small owner-operated enterprises in the accommodation and catering sector, whilst most visitor attractions and infrastructure facilities are in the care of local public sector, semi-commercial and voluntary bodies.
- Most tourism enterprises employ less than five people.
- Many businesses which have front-line contact with visitors (e.g., retailers, catering) do not see themselves as part of the tourism industry.
- The low income base and net worth of small tourism enterprises and farm businesses acts as a constraint to investment in improvements and the development of new tourism ventures.
- Recent difficulties in the farming sector appear to have made it even more difficult to raise resources for diversification.
- Labour or skills shortages may affect tourism businesses in some remote areas.

The challenge of remoteness

Whilst the image of a particular upland district and awareness of the attractions it has to offer will influence levels of tourism, the main determinant is the area's proximity to, and accessibility from, large urban concentrations of population.

Apart from Devon and Cornwall, Northumbria is probably the English region most affected by remoteness from the large conurbations. The population within two hours of, say, Stanhope in Weardale is about 2.5 million, a fraction of that within similar range of Helmsley or Settle in Yorkshire. This has a fundamental influence upon visitor numbers, especially day-trippers, and also upon the willingness of the private sector to invest in new projects. On the other hand, it may spare Northumbria some of the challenges in managing large peak flows of day visitor traffic.

Trends and opportunities

Changes in lifestyle and technology are reshaping the tourism marketplace, and this will have implications for rural tourism.

Family structures are changing, with a wider range of two-parent families, one-parent families, couples and single people, and more diverse social and cultural expectations. There is no longer a mass market that can be addressed as one single entity. Meanwhile, advances in information and communication technologies make it possible to identify and target markets in increasingly sophisticated and personalised ways. Marketing in the new millennium may well mean communicating with the ultimate "market of one".

Tomorrow's tourists can therefore be expected to be individualistic, highly informed, and have high expectations of value for their time off. Faced with a wide choice of destinations and experiences they will be more capricious, deciding how these measure up in terms of image, environmental quality, accessibility, packaging and price. Awareness and perception of these features will be crucial.

The tourism product in the uplands will inevitably be affected by these changes. Several directions or trends might be predicted:

- Whilst the car will become increasingly ostracised from city streets, more people than ever will want to use them to access and explore upland areas.
- Where the right transport infrastructure is available, more people may be persuaded to use bikes and public transport instead, and this could become a bigger trend in the longer term.
- Healthier lifestyle attitudes will result in more demand for outdoor activities.
- More people will want to become 'permanent tourists' and take up opportunities to move into upland areas on a full or part-time basis. They in turn will seek to restrict further tourism development.
- The boundary between 'work' and 'play' will become more blurred, with professionals keeping in touch with business from the remotest locations, and a growth market for 'tele-working breaks'.
- Increased awareness of disability access issues will stimulate improvements in facilities and services, leading to more people with disabilities taking more ambitious breaks, on their own or with family or friends.
- Digital media open up new markets to more integrated real-time product inventory and rapid response booking and payment mechanisms.
- Database marketing will facilitate closer and more informed relationships with individual visitors, but increased sophistication in marketing will leave many small enterprises at a disadvantage.

These trends beg the question: will tourism keep its 'personal' touch? The answer seems likely to be a potential increase in demand for products offering a highly individualised approach. Small rural enterprises could be well placed to respond.

Upland tourism growth products

Demand for participation in outdoor leisure activities seems likely to continue growing for the foreseeable future, particularly in relation to long-distance walking, riding, climbing, watersports, fishing and field sports. The hills, forests, farms, rivers and reservoirs of the uplands provide a considerable range of opportunities to accommodate such activities.

The 'C2C' cycle route and the Reivers long distance cycle route through the North Tyne Valley are examples of developments to meet these new markets. Meanwhile, at Kielder Reservoir, the Calvert Trust has been developing a holiday centre with facilities and experiences accessible to people with disabilities, within a well-managed landscape setting.

It seems likely that tourism products will become ever more diverse and segmented, including new combinations of cultural, learning and sporting activity holidays, short breaks and '24 hour' mini-breaks. Most people visiting upland areas will, perhaps, still want simply to relax in a stress-free environment. Farm-based tourism has potential to accommodate some of this activity, as part of more diversified land-based businesses, provided adequate support is available to assist farmers seeking to re-structure their operations in this way.

Interest in environmental, wildlife and archaeological heritage also seems likely to increase, with better-informed visitors having higher expectations for the quality of their visit. It is interesting to note that many uplands are now marketed as wilderness areas, yet 100 years ago these were busy industrial landscapes. Restoration of the lead mines at places like Nenthead and Killhope provides for many people a surprising contrast to the remote moorland nearby.

New directions

If the uplands are to benefit from further development of tourism, a proper integration of tourism and environmental activities is required, to maximise long-term benefits for the local economy and community and the conservation of environment and heritage resources of the region.

There will be a need to spread the benefits of tourism, both geographically and in terms of seasonality, and to make more efficient use of existing capacity and provide greater continuity of employment.

It will be important to build on environmental strengths, combining this with a commitment to quality which includes environment, product and customer service. Above all, we need to maintain the key values of sense of space, tranquillity and regional distinctiveness.

The Government's national strategy, "Tomorrow's Tourism" (Department of Culture, Media and Sport, 1999) includes a welcome endorsement for the principles of sustainable development, improving accessibility and the need to harness new technologies. These basic values are also increasingly to be found in local and regional tourism strategies, such as the Strategy for Tourism in Northumbria 1998-2002 (Northumbria Tourist Board, 1998). The latter recognises that tourism offers the opportunity not only to protect but also to enhance the 'core values' of the region's upland areas, such as the tranquil countryside, open moorland, heritage and wildlife. We should note that the Tourism Society considers 'tourism' to be "the temporary short-term movement of people to destinations outside the places where they normally live and work, and their activities during their stay at those destinations".

The Northumbria strategy emphasises the importance of encouraging local solutions and in particular the role of local partnerships for the development of more sustainable approaches to tourism development, management and marketing. The Strategy recognises the potential to employ market segmentation methods to target types of tourism related to the region's cultural, landscape and leisure resources. It also promotes the use of new technology to improve awareness of the region, makes products easier to find and to purchase, and helps businesses to develop appropriate commercial skills using the Internet.

Conclusions

Rural tourism and outdoor activities in the uplands seem likely to enjoy continuing demand from UK and overseas visitors. Whilst tourism alone will not solve the economic challenges facing our upland areas, it offers one of the best, and most readily influenced, prospects for growth. In addition, if properly directed, it can help to underpin existing enterprises, especially farming, in ways that will help to safeguard both existing jobs and the quality of the landscape.

Maintaining a good tourism image for upland areas will also assist in improving perceptions of their attractiveness as a location for other forms of development, e.g. tele-cottaging, new technology, farm produce, craft industries, etc.

Tourism's demands upon our rural areas reflects a wider aspiration for a better, healthier, quality of life, but the impact of tourism can sometimes be high, bringing visitor management pressures in its wake.

It is important that strategies and plans for upland areas reflect the potential for tourism to contribute to rural regeneration and the quality of community life in the uplands. In those areas where visitor pressures are likely to be a constraint, careful and imaginative approaches to visitor management and the quality of facilities will be needed, with the tourism industry, custodians of landscape and heritage, and the host community working together in imaginative partnerships.

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16. Policy benefits and constraints in the uplands of Scotland

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Introduction

This paper is written from an ecologist's perspective, though the brief was set for the author. It sets the scene, highlights the nature of the resource, focuses particularly on rural land uses and designations, then finally turns to policy benefits and constraints, but seeks no conclusions. The views expressed are personal and should not be taken as reflecting those of Scottish Executive Ministers or Management. All figures quoted for the extent of different designations were for September 1999.

The title includes two terms that it may be helpful to define. First, a 'policy' is here taken to be a course of action adopted by government, whether at a local, national or international level. In a developed country, policies nowadays touch on most aspects of everyday life. In Britain, published policies include a plethora of bye-laws and of national codes of practice and of conduct, Regulations, Statutory Instruments, Acts of Parliament, EC Directives and Regulations, and international Conventions. A policy can also be just 'the way we do things', and often be unwritten and/or unknown to outsiders, though the UK Government has promised a greater right of public access to its information (Cm 3818, 1997). Statutory policies currently bear on such matters as controlling the time of day, the quality of the air we breathe and the water we drink, where and how we can build houses, and even how few clothes we can wear. All policies are designed to confer some advantage to the public good, but inevitably involve trade-offs of benefits and disadvantages.

Second, 'uplands' is a term widely used but rarely defined. It implies land at higher altitudes. However, a problem with this from an ecologist's perspective is that many species found on mountains in England and Wales occur at or near sea-level in the north of Scotland, as does vegetation which elsewhere would be thought of as upland in character. For example, mountain avens *Dryas octopetela* grows at sea level in Sutherland, while dwarf willow *Salix herbacea* occurs at 150 m in Shetland, not high enough to be montane, nor sufficiently northerly to be tundra. Some authors treat such lowlands as honorary uplands, but this gives ill-defined boundaries that make it difficult to estimate any statistics involving land area. Hence Bunce (1987) could write: 'Despite the many conferences on the uplands, the difficulties inherent in producing an adequate definition have led to no generally accepted figure being available for the area involved.' Bunce circumvented this problem by devising a system of land classes defined by land attributes (Bunce *et al*. 1983). This system is used here, with the explicit definition of uplands as the aggregate of 13 out of 32 of land classes in Britain (Barr *et al*. 1993, and see Table 16.2).

This paper has space only to focus fuzzily on the main rural land uses in the uplands and so touches only on a few policies. Land use is determined by many factors, including tradition, but is always constrained by the nature of the land resource. In thinking of land-use options, natural constraints of soil and climate, and the inheritance of ecological degradation, arguably outweigh all present policy benefits and constraints.

The upland resource

By the definition of uplands used here, Scotland has 56,393 km² of upland, or 72% of the land area (Figure 16.1). However, an enduring difficulty facing those who try to make a living from this land is that the mostly infertile, acid soils and cool, wet summers severely limit the extent and nature of farming and, to a lesser extent, of forestry (Dodgson 1988; Langan *et al*. 1996; Merrilees 1985). Ecological degradation, a process beginning with the loss of the natural tree cover, adds further constraints. Darling (1955) was one of the first to draw attention to these. Mackay (1995) neatly summarised Darling's views as follows:

"His thesis was that the problems of the uplands, which he characterised as a 'wet desert', had been exacerbated by centuries of exploitation and neglect. He saw the root problem as ecological – the systematic removal of those elements (deciduous forest, grazing cattle, and finally the native population) which helped to maintain fertility: and then the steady expansion of sheep and deer, whose effects in excessive numbers – with associated muirburn – were generally to reduce species variety to the minimum and to impoverish already poor soil."

Darling amassed mainly qualitative data to support his views, but McVean and Lockie (1969) adduced more quantitative data, as have others since. Tipping's (1994) review of palynological and archaeological evidence concluded that much of Scotland had been subject to considerable deforestation by the time of Roman incursions (see also, Simmons, this volume). Woodland destruction, overexploitation and neglect continued, so that little natural tree cover apparently remained by the mid-nineteenth century (Anderson 1967). Accelerated soil acidification, podsolisation and loss of fertility (Miles & Young 1980, Miles 1985) resulted as a consequence of heather *Calluna vulgaris* in particular replacing trees in the uplands.

Post-medieval farming in the uplands, with transhumance common, was arguably destabilised by population growth, not any intrinsic unsustainability of its farming practices (Dodgson, 1988). Perhaps the main caveat to this is that stripping of turf for use as fuel and bedding for livestock, with subsequent use of the ash and muck as field manure, improved the arable land at the expense of degrading the nearby moorlands (Davidson & Simpson 1984, 1994). The extent of such turf stripping has never been examined, but visual evidence for it is not uncommon where peat banks are rare or absent (eg on Harris and Eriskay). However, after voluntary and forced depopulation earlier crofts and farms were replaced by widespread sheep ranching. Later, falling revenues from sheep and the establishment of railways led to most of the uplands being developed for sport (Eden 1979; Tapper 1992), and being indeed called in the Highlands either "grouse moors" or "deer forest".

Ecological decline has apparently not stopped, because there has been a decline in upland game (Tapper 1992, Hudson 1995) even since the last century. It would no longer be possible, for example, to get the game bags recorded at Inverewe in 1868 (Mackenzie 1921). Hence, despite uncertainty about its precise scale and extent

(Thompson & Miles 1995), there is compelling evidence for ecological degradation in most of submontane uplands. These are now mainly cultural landscapes, not natural ones. This heritage of degradation is an enduring backdrop to all policies attempting to keep people in the uplands.

Nevertheless, despite millennia of use and abuse, and extensive and often severe ecological degradation, the uplands of Scotland are widely

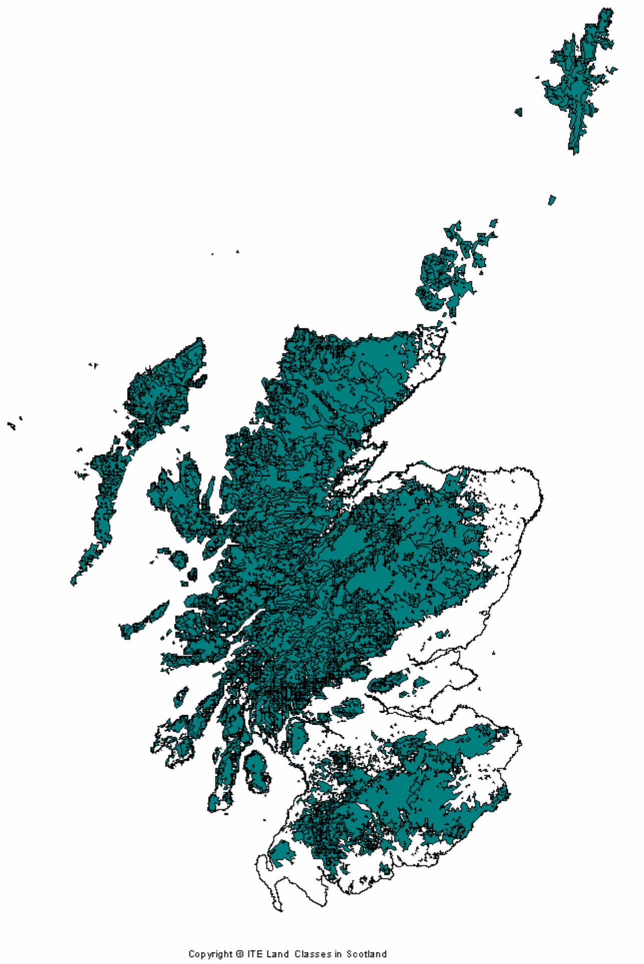

Figure 16.1 The distribution of uplands (ITE land classes 17-24 & 28-32) in Scotland (Source: Barr *et al*., (1993)

regarded as internationally important for their wildlife. This curious contradiction is certainly not unique in the world. For example, the EC Habitats Directive officially approves a special status for some forty ecologically degraded 'habitat types of Community interest whose conservation requires the designation of Special Areas of Conservation'! The contradiction creates dilemmas, and tensions and misunderstandings among those who would prefer either to maintain the *status quo* or to make good past damage.

Upland uses and designations

The main upland land uses are listed in Table 16.1; most are not mutually exclusive. Though rarely visible, probably the most economically essential use is to supply water to the lowlands. Some 96% of Scotland's supply comes from lochs, reservoirs, streams and rivers (Government Statistical Service 1998), mainly from upland catchments. Hydroelectricity generation is also a significant socio-economic activity. Nevertheless, it is farming and forestry that have largely created today's tapestry of landscape colour and texture, draped over the varying upland reliefs, and farming has traditionally kept a core population in the countryside. Some 78% of the uplands are farmed, mainly extensively, and agricultural subsidies are payable, with 98% of the area being classed as Less Favoured Area (LFA) (Table 16.2). In addition, grant aid to support forestry is available where soils and climate allow trees to be grown. Perhaps 60% of Scotland grew trees naturally by 5000 BC, though natural woodland was reduced through human activity to a recent nadir of 1.1% (Mackenzie, 1987). Much of Scotland grows trees very well, but even with twentieth-century afforestation, woodland cover in 1988 was still only *c.*15% (Macaulay Land Use Research Institute, 1993).

Much of the uplands are also used for field sports (probably >50%, though no good estimates of the total area involved seem to exist), in particular for stalking red deer *Cervus elaphus* and shooting red grouse *Lagopus lagopus scoticus*, and for other recreational activities, in particular hill-walking. There is occasional use for military training, local use for peat cutting, and very local use for quarrying. The submontane moorlands are rich in archaeology, and have numerous Scheduled Ancient Monuments. Only a minority of the uplands are designated for natural heritage purposes: 16.5% as National Scenic Areas (NSA), and some 13.3% as Sites of Special Scientific Interest (SSSI) for wildlife and geology. Taken with the candidate areas to become Scotland's first 2 National Parks, the Cairngorms and Loch Lomond and the Trossachs, this covers 33.1% of the uplands.

Table 16.1 Matrix of land-use interactions, showing uses which clash frequently (+) or rarely (-)

	Archaeo-logical conservation	**Farming and forestry**	**Landscape protection**	**Military training ground**	**Nature conservation**	**Recreation, field sports, and educational use**	**Water catchment; hydro-electricity**
Archaeological conservation	.	+	-	+	+	+	+
Farming and forestry	+	.	+	+	+	+	+
Landscape protection	-	+	.	+	+	+	-
Military training ground	+	+	+	.	-	+	-
Nature conservation	+	+	+	-	.	+	-
Recreation, field sports, and educational use	+	+	+	+	+	.	+
Water catchment, hydroelectricity	+	+	-	-	-	+	.

Table 16.2 Extent of certain designated areas within upland Scotland

Feature	Area in km²	% of feature in the uplands	% of uplands occupied by feature
Scotland*	78 790	—	—
Uplands†	56 393	(72% of Scotland)	—
Environmentally Sensitive Areas‡	14 511	82.8	21.3
Sites of Special Scientific Interest§	9328	80.5	13.3
Special Protection Areas (including proposals)§	2227	66.2	2.6
Special Areas of Conservation (currently all candidates)§	7209	56.5	7.2
National Scenic Areas‡	13 783	67.7	16.5
Less Favoured Areas‡	69 020	80.2	98.2
Cairngorm Working Party Area§	3316	99.8	5.9
Loch Lomond & Trossachs WP Area§	1571	75.7	2.1
Woodland Grant Scheme, 1994-99¶	1705	74.5	2.1
Agricultural Land‖	60 024	73.2	77.9
All natural heritage designations	24 638	75.8	33.1

Sources: *Ordnance Survey Strategic data, 1:250 000, 1997 (Government Statistical Service 1998); †Institute of Terrestrial Ecology Land Classes 17-24 & 28-32 (Barr *et al*. 1993); §Scottish Natural Heritage; ‡Scottish Executive Rural Affairs Department; ¶Forestry Commission; ‖Land Cover of Scotland 1988 (Macaulay Land Use Research Institute (1993).

Policy benefits and constraints

Policy benefits and constraints are always interlinked. Agricultural subsidies and grant aid for forestry help people to make a living from the land, but inflate land prices (though much less than planning laws inflate the price of land where building is allowed) so that unsubsidised activities (eg voluntary nature conservation) may find it hard to compete. The Less-Favoured Areas (LFAs) are justified under EEC Directive 75/268 partly as being farming areas in danger of depopulation, but the labour employed on farms has declined in the uplands as in the lowlands, while without subsidies few if any hill sheep farms would now have any net income. These matters have often been discussed (e.g. Mowle, 1986; Munton *et al*., 1992; Whitby, 1987), and little seems to change. Without hill sheep farms, many rural populations would further concentrate, and the appearance of upland landscapes would change within a few decades, with gains and losses to wildlife whether or not afforestation occurred (Miles, 1985; Miles *et al*., 1997).

A long-standing complaint of conservationists has been that the Common Agricultural Policy (CAP) has driven farmers towards increasing production at the expense of associated damage to wildlife and the rest of the environment. Steps are being taken to address this, and Agenda 2000 stresses the need for more cross-compliance, i.e. giving subsidies with environmental conditions attached. Also, Scotland's 10 Environmentally Sensitive Areas cover 21% of the uplands, much of the rest the rest falls within the scope of the Countryside Premium Scheme, while the new Rural Stewardship Scheme also covers most of the uplands. Both schemes allow extra payments to be made to farmers to promote wildlife interest, to conserve scenery and archaeology, and to promote access. These Agri-Environment measures, and their equivalents south of the border, have been widely welcomed, but as yet only a tiny percentage of CAP funds has been transferred from direct support of production.

The uplands are seen as particularly important for hosting many boreal species at the southern edge of their geographical ranges. This is reflected in the citations for and extent of SSSIs in Scotland (currently under review), which occupy 13.3% of the uplands, with 15% of this area designated as National Nature Reserves. The European importance of these uplands is reflected by the designation of 20% of the area of upland SSSIs as Special Protection Area (SPA) under the EC Wild Birds Directive, and of 54% as proposed Special Areas of Conservation (SAC) under the EC Habitats Directive. SSSI designation puts certain constraints on land use, especially where land is also SPA or SAC, but payments for positive management can be made. The implementation of the UK's Biodiversity Action Plan also bears heavily on the uplands. However, in today's increasingly developed world, having SSSIs is increasingly seen as an accolade to owners and managers for good past management. Property consultants claim that their presence can enhance the capital value of upland estates. Indeed, there is growing evidence for the socio-economic benefits of protected areas and biodiversity (e.g. Dixon & Sherman, 1990; Pearce & Moran, 1994).

National Scenic Areas (currently under review) cover 16.5% of the uplands and constrain land use through the planning laws. However, their protection of scenic values maintains a public benefit and helps to support tourism. In addition, Government has identified two areas as potential National Parks, the Cairngorms and Loch Lomond and the Trossachs, 5.9% and 2.1% of the uplands, respectively. It is hoped that any National Parks will bring not just enhanced protection but also enhanced – and sustainable – socio-economic activity.

While most of the uplands are still deforested, many existing environmental designations and obligations constrain the scope for reforestation (though some encourage it). Also, while the uplands would seem ideally windy places to put wind farms to generate electricity (there is a substantial scheme near Douglas), there are cost constraints of access and proximity to power lines. Also, apart from the obvious difficulties of locating wind farms in NSAs, two recent applications were eventually refused on the grounds that they might kill significant numbers of wintering Greenland white-fronted geese. Such conflicts of interest have existed for many years (Table 16.1). Thus farming, forestry, landscape protection and nature conservation have all, in effect, competed for the uplands during most of the last 50 years. Though there is now a greater consensus about relative priorities in different areas, dilemmas still exist. For example, with current arable land values, native woodland can usually only regenerate at the expense of moorland, which is also valued for its wildlife and cultural interests. As a subset of this, in the candidate Cairngorms SAC, the area of Caledonian forest can only be expanded at the expense of wet and dry heath, which are also qualifying features of Community importance. Promoting the former should favour the capercaillie and Scottish crossbill, both Birds Directive Annex I species, but at the expense of the merlin, golden plover and short-eared owl, which are also listed on the same Annex!

There are tensions between field sports and wildlife conservation. Grouse moors were created from the mid-nineteenth century partly by eliminating all predators. Raptors are now protected by law, but illegal killing of them on grouse moor and deer forest is still widespread (Scottish Raptor Study Groups 1998). Many gamekeepers and moorland owners fear that their moors would not be viable (in the sense of producing enough grouse to make a driven shoot worthwhile) unless these practices continue (and unfortunately there is little hard evidence either way on this question). The alternative, of walking the moor to shoot lesser numbers of grouse (but perhaps a greater variety of game), is unfashionable. There are also sport/farming tensions. Thus, on one grouse moor, 48% of the heather cover was lost during 1948-88 because of heavy grazing by sheep (Redpath & Thirgood, 1997).

Future prospects?

So, what could the future hold? Upland farming exists in its present form only with large subsidies, and occurs on what are often termed 'marginal' lands. Climatic deterioration seems to have been why our Bronze Age ancestors stopped farming these. However, this is intrinsic to the 'marginality' of the uplands, and the agricultural 'revolution' of the late seventeenth century allowed farmers again to cultivate higher up the hills. If Scotland's rainfall increases with global warming (Mann *et al*., 1998), the balance could swing further from farming to forestry. The remaining deer forests and grouse moors might disappear if public opinion swung further against blood sports (though red deer populations will still need culling if upland woods are to regenerate naturally, and if incursions on to agricultural land are to be limited). Current management of upland ecosystems is largely underpinned by public fiscal support for farming and forestry, and by private support for field sports. If these supports were withdrawn, there would be further depopulation and erosion of the infrastructure that supports local communities and tourism. There would also be changes, perhaps dramatic, in wildlife and scenery, though it is unlikely that any species would become regionally extinct.

Experience suggests that economic activity tends to clump rather than spread out relatively evenly, which promotes urbanisation. 'Telecottaging' does not depend on use of the land and could in principle support widely dispersed populations, but it is still the exception rather than the rule, perhaps because few people relish such isolation. Present patterns of land use largely reflect mid-nineteenth century choices, but are these appropriate today? A cultural heritage can be cultural inertia. Holiday homes can be unpopular with permanent residents, but, since the Bronze Age abandonment of upland farms, much of the uplands may have experienced only seasonal use and habitation. Scotland's earliest known settlements were merely summer homes for Mesolithic hunter-gatherers (Wickham-Jones, 1990). Later transhumance to summer sheilings was probably a sustainable land use. Though now ended in Scotland, it continues in parts of continental Europe, where the public will pay a premium for cheese from summer pastures.

There still a widespread feeling that it is wrong not to crop the land in some way, but why should we feel obliged to use the uplands other than as water catchments and areas for recreation and cellulose production? Only time may supply answers, but, as always, the opportunities are largely constrained by the limits of human imagination.

Acknowledgements

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SECTION 4

Modelling, processes and monitoring change in the uplands

Here we have shorter articles (originally presented as conference posters) illustrating a wide range of interest in the upland environment. We begin with Adamson's account of the UK Environmental Change Network - a suite of monitoring sites in the uplands. Several themes emerge in the ensuing papers:

- runoff and erosion
- water quality
- vegetation dynamics (including management schemes)
- indicators of change, and
- policy initiatives.

Together, these short articles demonstrate Pearsall's (1950) view that the results of scientific research, allied to experience, can provide a sound basis for understanding issues affecting the uplands, and thus a means of moving towards effective management of upland areas. The abiding message from these papers as a whole, however, is the need to integrate disciplines to tackle policy and management issues.

17. Monitoring UK uplands - the Environmental Change Network

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The Environmental Change Network (ECN) is the UK's long-term integrated environmental monitoring programme and it was launched in 1992 by the Minister for the Environment and Countryside. ECN is designed to collect, store, analyse and interpret long-term data on a set of key variables which drive and respond to environmental change It is sponsored by a consortium of government organisations with an interest in the environment.

Monitoring sites are selected to give a good geographical distribution, covering a wide range of environmental conditions and the principal natural and managed ecosystems of the UK (Figure 17.1).

Of the 12 sites where terrestrial monitoring currently takes place, five are defined as upland by the UK Countryside Information System. These are located in Snowdonia, the Pennines, the Cheviots, the Grampian Highlands and the Cairngorms. The majority of rivers and lakes where freshwater monitoring takes place have their sources in the uplands but six have catchments that are entirely upland in character. These are located in Snowdonia, the Lake District, the Pennines, the.

Figure 17.1 Environmental Change Network (ECN) long-term environmental monitoring sites in the UK. Terrestrial sites are indicated by circles, river sites by triangles and lake sites by squares. The named sites are in the uplands.

Southern Uplands, the Grampian Highlands and the Cairngorms

ECN monitoring is based on published protocols to ensure that measurements are undertaken in a uniform way. Terrestrial monitoring includes vertebrates (birds, rabbits, deer, bats, frogs), invertebrates (moths, butterflies, spittle bugs, ground beetles, crane fly), vegetation, soil properties, meteorology, surface water discharge and the chemistry of the atmosphere, precipitation, soil solution, and surface water. Freshwater monitoring includes fish, macrophytes, phytoplankton (lakes only), zooplankton (lakes only), periphyton, invertebrates, discharge (rivers only) and water chemistry. Strict quality control is applied to measurements. ECN data are being used in research projects that address a wide range of upland issues, for example, climate change, land management impacts, biodiversity loss, acidification, water quality and the impact of diffuse pollution.

Findings are presented in reports to government departments and in scientific papers. ECN sites are available for research by universities and institutes and ECN data is available for scientists to place their own work in a wider context. Extensive use is made of the World Wide Web to communicate information about ECN to the wider public (www.ecn.ac.uk). The web site includes site profiles, measurement details, summary data and real time weather data (e.g. Moor House, North Pennines).

18. Upland vegetation dynamics and the impacts of aerial nitrogen deposition

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This paper summarises work being undertaken on the development of a model for predicting the long-term impacts of nitrogen deposition on upland acid grasslands and heathlands.

Concerns over the harmful effects of gaseous pollutants are not new but in the past much of this concern has been directed towards emissions of sulphur dioxide. Nitrogen pollution exists in two main forms: oxidised nitrogen, which is emitted from motor vehicles and industry, and reduced nitrogen which predominantly comes from animal wastes. Critical loads for nitrogen pollution have been established above which it is believed that damage may occur to the environment. In many upland sites these loads are being exceeded.

Nitrogen pollutants can effect individual plants by altering their relative growth and survivorship. To enable the impacts of the pollutants at the individual plant and species level to be up-scaled to the landscape scale models have been developed at three hierarchically linked scales, the species scale, community scale and landscape scale, see Figure 18.1.

The species scale model is a growth model in which growth is considered in terms of use of space within a three dimensional grid. The model is initialised by filling a number of cells which represent an individual plant, or clump of plants of the same species so they can be visualised in terms of a number of building blocks, see Figure 18.2. Changes in grid cell occupancy are then determined by a series of growth and competition rules.

At the end of each model run the percentage cover occupancy of each species is determined and the technique described by Rushton *et al.* (1996) used to assign the species model output to a National Vegetation Classification (NVC) community. In brief this involves the creation of artificial quadrats from the data given in Rodwell, 1991 & 1992. These quadrats define an ordination space into which the species level model outputs can be placed.

Changes in habitat occurring at the landscape scale can be assessed using remote sensing data provided by the Institute of Terrestrial Ecology. Matrices allocating NVC communities to landcover types on a proportional basis can be calculated and used to determine the areas affected by changes predicted by the species and community models.

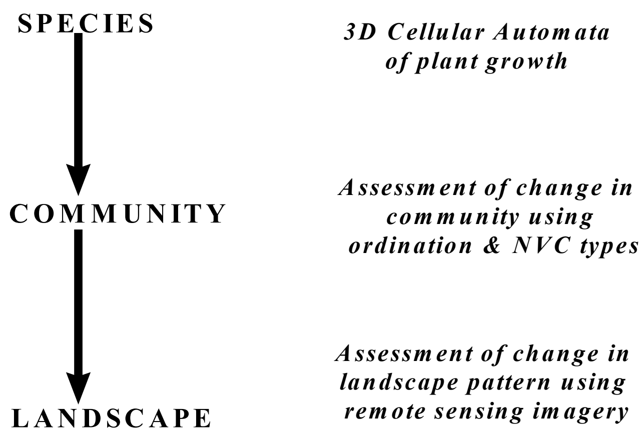

Figure 18.1 The Hierarchical Link between 3 Models at Different Scales

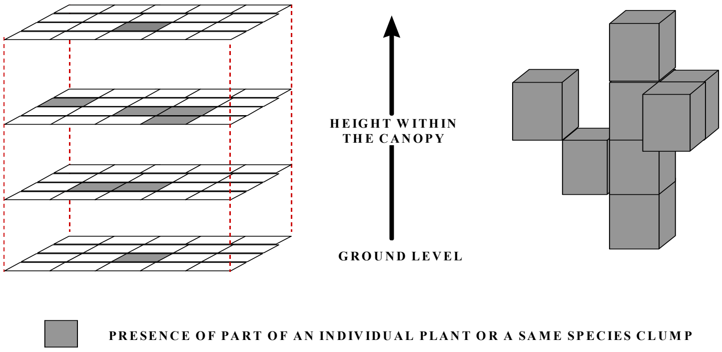

Figure 18.2 A plant represented by cell occupancy within a 3D grid

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19. A comparison of the effects of burning and flailing on the regeneration of heather moorland in Northern Ireland

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Introduction

Heather moorland has been traditionally managed by rotational burning of small patches of older heather to create a mosaic of uneven aged stands. A combination of mature heather and young developing heather is recognised as the most desirable combination for production of biomass and species conservation. Flailing has been introduced more recently as a management tool with the same objectives as burning (eg Thompson et al 1995). There is little history of controlled heather management in Northern Ireland and there is concern over some of the practical limitations attached to both techniques. Burning is labour intensive, potentially hazardous and dependant on weather conditions making flailing a more attractive option to some farmers. It is therefore important to establish whether the heath regeneration and species composition vary significantly between treatments.

Method

Sites burned (8) and flailed (6) in 1996 were monitored in 1997 and again in 1998. Percentage cover of each plant species was recorded within four, equidistant, $1m^2$ nested quadrats along a 40m transect through each site and its adjacent unmanaged control, any additional species were recorded in an outer $2m^2$ quadrat. Transects were marked with a compass bearing taken from a permanent marker to allow relocation the following year. Soils samples were taken from each site for pH and chemical analysis. Measurements of heather age height were also noted along with any indications of grazing.

Results and discussion

Between 1997 and 1998 there was little difference in the regeneration of *Calluna vulgaris* on burned and flailed sites, and after a second growing season (1998) there was still no significant difference in the proportion of heather re-growth between burned and flailed sites. In 1997 species diversity on managed sites (both burned and flailed) did not vary significantly from that on the unmanaged control sites. By 1998 however the number of species present on the managed sites had increased and there were significantly more species on both flailed ($P = <0.05$) and burned ($P = <0.01$) sites. The comparatively high increases in percentage cover of *Calluna vulgaris* obtained on burned sites in 1998 confirms other work which suggests dominance of heath is not normally re-established for at least two growing seasons (Mallik & Gimingham 1983).

Burning removes most of the above ground vegetation and while the 'trash' from the flailing process was removed from each of the sites, a ground layer of mosses and lower heather stems was left behind. There was significantly more bare ground ($P = <0.01$) and less moss ($P = <0.05$) on burned than on flailed sites.

The differences in species composition created by burning and flailing are probably a result of the different micro-habitats created by the management types, favouring the re-generation of particular species. The trials give an indication of the speed of recovery after management. At least two years are required for significant change and by the second year after management, the difference between flailed and burned sites had widened with flailing showing a delayed increase in regeneration.

Grazing is an important factor in the regeneration of *Calluna* after management. Levels of grazing within the study area varied considerably. Some sites were under Environmentally Sensitive Area agreements and underwent relatively low levels of grazing pressure (0.3 LU ha^{-1}) with winter exclusion. Others were under higher and more constant grazing pressure, which encouraged the colonisation of unpalatable grasses e.g. *Nardus stricta* at the expense of heather.

Any heather management is as yet fairly uncommon in Northern Ireland and site selection for this study was based largely on availability of suitably managed areas. Over the coming season, further sites will be selected and monitored for impacts of both management regimes to provide further comparative information.

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[9] Now at National Trust, 60 Causeway Road, Bushmills, Co. Antrim. N.Ireland.

20. Techniques to investigate the recent rise to dominance of *Molinia caerulea* in environmentally sensitive areas (ESAs)

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Introduction

A characteristic of some moorland areas in Britain is the widespread dominance of *Molinia caerulea* (purple moor grass). The overwhelming local supremacy of this species is of concern to farmers, owing to its relatively low palatability for grazing stock, and to conservationists, owing to the monotonous, species-poor landscapes that often result under Molinietum. In some Environmentally Sensitive Areas (ESAs) in England and Wales, Molinietum is believed to have ousted Callunetum in recent decades.

Project aims

Pilot palaeoecological studies have been conducted in Exmoor (Chambers, Mauquoy & Todd, 1999) and in South Wales to (a) verify *Molinia*'s recent rise and to assess its status in moorland; (b) test the utility of the techniques for such research; and (c) inform conservation and management policy.

Methods

Peat profiles were sampled and subjected to recently developed techniques of plant macrofossil counting, using QLCMA (Quadrat Leaf-Count Macrofossil Analysis), and to conventional pollen analysis. *Molinia caerulea* has distinctive epidermal tissues, which potentially can be identified in peat. Dating of profiles employed a range of methods, including conventional radiocarbon dating, AMS dating, and the counting of spheroidal carbonaceous particles to attempt to delimit horizons of recent peat growth. A full account of the methods is given in Chambers, Mauquoy & Todd (1999), which contains a full bibliography.

Results

Pollen and macrofossil data, when compared with age indications in the peat profiles, confirm the recent ousting of *Calluna* and rise to dominance of *Molinia* at a number of sites (see for example, Chambers, Mauquoy & Todd, 1999). In some profiles the dramatic recent rise of *Molinia* parallels the rise in spheroidal carbonaceous particles. There are several possible explanations for this, amongst them being the possibility of accompanying nutrient loading to the bog system, which may have given *Molinia* a competitive advantage. However, the palaeoecological data also indicate that *Molinia* has a greater antiquity in moorland than is sometimes appreciated, implying that traditional methods of grazing may help to keep the species in check.

Conclusions

These pilot studies show that palaeoecological techniques can have application in conservation management of the uplands; the findings have significant implications for restoration targets in 'degraded' moorland.

Acknowledgements

Thanks are due to the British Ecological Society, for a small ecological project grant; The Heather Trust Ltd, for funding initial sampling; Dr Pamela Todd for collaborative research; Dr Marcus Yeo and the Countryside Council for Wales, for information on Welsh sites; Kathryn Sharp, for poster design and layout; and Dr Bas van Geel, for comparative plant macrofossil material.

Reference

Chambers, F.M., Mauquoy, D. & Todd, P.A. (1999) Recent rise to dominance of *Molinia caerulea* in Environmentally Sensitive Areas: new perspectives from palaeoecological data. *Journal of Applied Ecology*, 36, 719-733.

21. Historical river channel change - Swinhope Burn, Upper Weardale

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Introduction

River channels are one of the most sensitive components of upland landscapes. Widespread evidence from the Northern Pennines suggests that small, gravel-bed streams are sensitive to external forcing by factors such as major flood events, land-use change and sediment supply from historic metal mining. This study uses evidence from Swinhope Burn in upper Weardale, Northern Pennines, to demonstrate that even in catchments not greatly altered by land use, channel change can be significant. The time period over which channel planform change is observed largely determines the apparent sensitivity of a river reach to external influences.

Results

Eight historical maps and one air photograph document change in channel planform over a time period of 180 years. Evidence from a 1.4 km study reach of Swinhope Burn has shown that channel planform has largely remained in a stable, meandering state from 1856 to the present day (Figure 21.1). However, the sensitivity of river response to a change in external factors is demonstrated by a dramatic transformation in channel planform from a meandering channel to a straight, low sinuosity, partly braided channel at some point between 1815 and 1856. The probable cause of the observed channel planform change is identified as an increase in coarse sediment supply generated by a series of large floods in Weardale during the 1820s and upstream metal mining during the period 1823 to 1846. It is likely that three major, regional floods which occurred in February, 1822, October, 1824 and July, 1828 and a highly localised storm which is documented to have been 'most terrific at Swinhope in Weardale' in September, 1824 eroded large quantities of coarse sediment which blocked the channel causing channel avulsion and straightening. Natural sediment sources would have been augmented by inputs of coarse mining waste from Swinhopehead Mine, which ceased production in 1846. By 1856, the channel had reverted back to a meandering pattern, the main elements of which have persisted to the present day.

The reason for the remarkable channel planform stability over a period of almost one and a half centuries relates to the unique geomorphic setting of Swinhope Burn. The presence of the Greenly Hills moraine at the lower end of the basin partially closes the valley system, leading to a local base-level. This has led to the development of a small upstream floodplain, or 'sedimentation zone'. In comparison with other upper Weardale tributary streams, Swinhope Burn has a very distinct long profile with a step in the middle reaches. The low channel gradient (0.012) inhibits coarse bedload transport, and sediment entering the reach either becomes trapped in the channel or migrates downstream at very low rates. In addition, cohesive banks promote lateral channel stability and the wide floodplain (average width 150 m) reduces potential coupling between the channel and valleyside sediment sources. Low channel gradient and highly cohesive banks ensure that when the basin is flooded, very little channel change occurs and the channel rapidly recovers to its pre-flood state.

Observations of contemporary floods that pass through Swinhope Burn show that very little channel change results, with local erosion being the same order of magnitude as local deposition. The channel is highly stable even during overbank flows. Although individual, large floods have affected the study reach over the past 40 years, there is very little evidence of lasting channel planform change. This is in contrast with other streams in the Northern Pennines which show major channel changes in response to flooding. For example, the River Nent, a small, gravel-bed stream 20 km north-west of Swinhope Burn, has shown persistent, major channel planform change in response to inputs of coarse sediment from historic mining activities and major floods over a period of more than 200 years.

Conclusion

These observations illustrate that in the study reach, where lateral channel migration is unconstrained by valley side-slopes, the stream shows a sensitive response to changes in the amount and size of sediment supplied to the channel. Historical map evidence suggests that coarse sediment generated by a series of major flood events and upstream metal mining led to a temporary, but dramatic change in channel planform. However, in the longer-term, the local-base level imposed by the Greenly Hills moraine, a legacy of the Devensian glaciation, has effectively reduced channel gradient and the potential for sensitive channel response to the passage of major flood events through the basin.

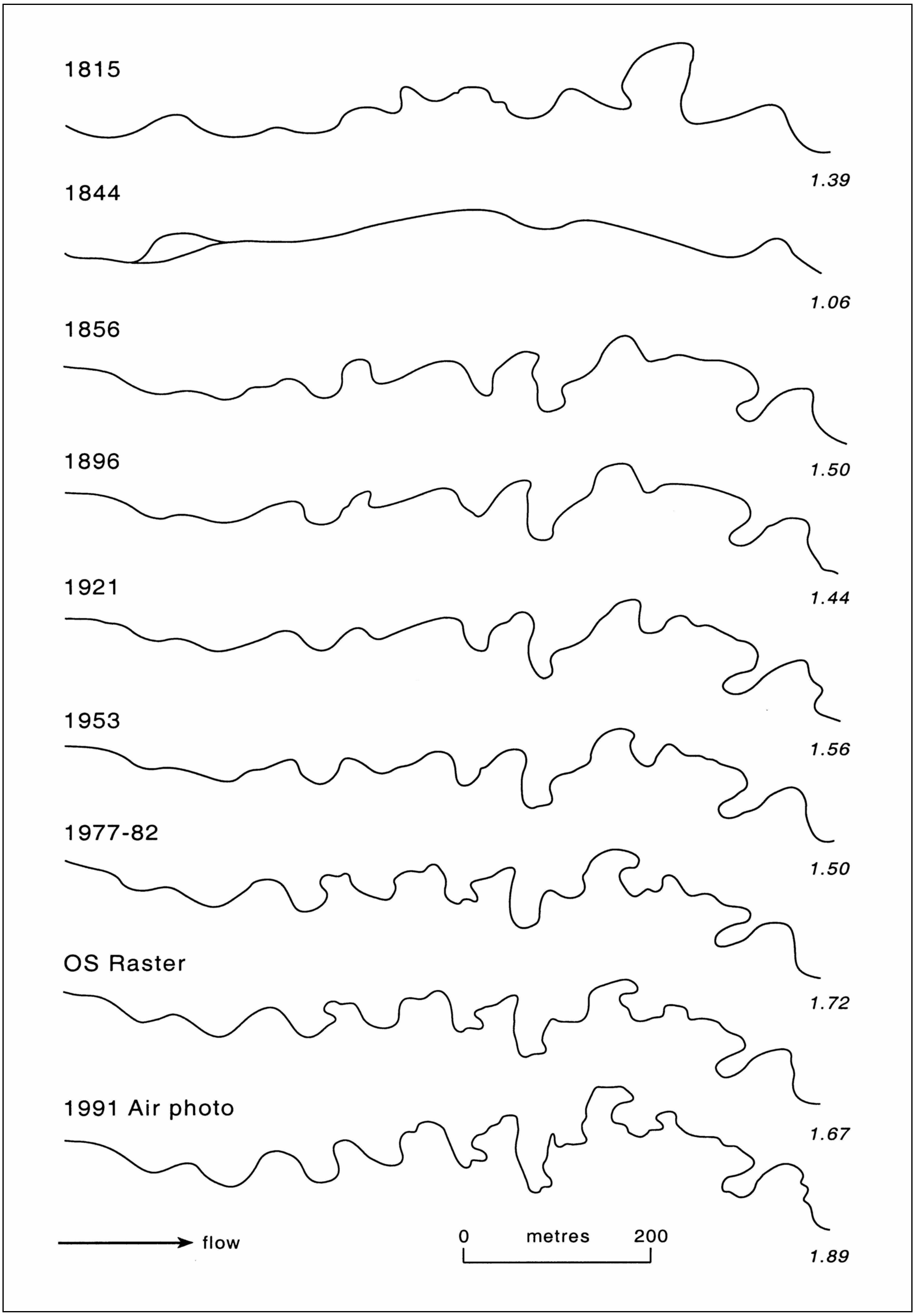

Figure 21.1 Historical evidence of channel planform change, Swinhope Burn, Weardale

22. Soil erosion on the Trotternish Ridge, Isle of Skye; sheep grazing or slope stability?

Alan Frost and Mike O'Sullivan
Soil and Water, Scotland, 4 Bayswell Road, Dunbar, EH42 1AB

Some of the most severe upland soil erosion in Scotland occurs on the eastern scarp slope of the Trotternish ridge in the Isle of Skye. This basalt ridge extends some 21 kilometres north from Portree. Set at an altitude of about 500 metres, the eroding slopes and their herb-rich grassland form part of a candidate Special Area of Conservation. The entire scarp is subject to both sheet and gully erosion resulting in many places in the removal of the entire friable soil (600 – 1000mm deep) and the exposure of the underlying weathered rock.

An earlier study, commissioned by Scottish Natural Heritage with the Scottish Agricultural College, investigated the grazing history of the crofting townships in the area and concluded that, largely due to the change from a system based on cattle and sheep to one based almost entirely on sheep (Figure 22.1), the grazing pressure on the eroding area of herb-rich grassland had increased markedly over the century with stocking density on the scarp reaching the very high level of up to seven ewes per hectare throughout the year, including the winter months (Craigie, Frost and Waterhouse 1995). These findings seemed to confirm the existing suspicion that the erosion was largely the result of overstocking.

However, a new study was commissioned by the Scottish Office Agriculture and Fisheries Department with the Scottish Agricultural College to examine the physical stability of the soils on the scarp which lies at a gradient of between 32 and 36 degrees. Regular measurement of parameters of slope stability have been made since winter 1997. These include soil shear strength, soil moisture content and soil moisture tension throughout the soil profile above the underlying weathered rock. In addition, measurements of soil bulk density, particle size distribution and triaxial testing have been carried out.

The results have demonstrated that the soils are inherently unstable and that a clearly defined shear plane exists at a depth of between 500 and 800mm (Figure 22.2). This shear plane corresponds with a humose horizon within the soil where the organic

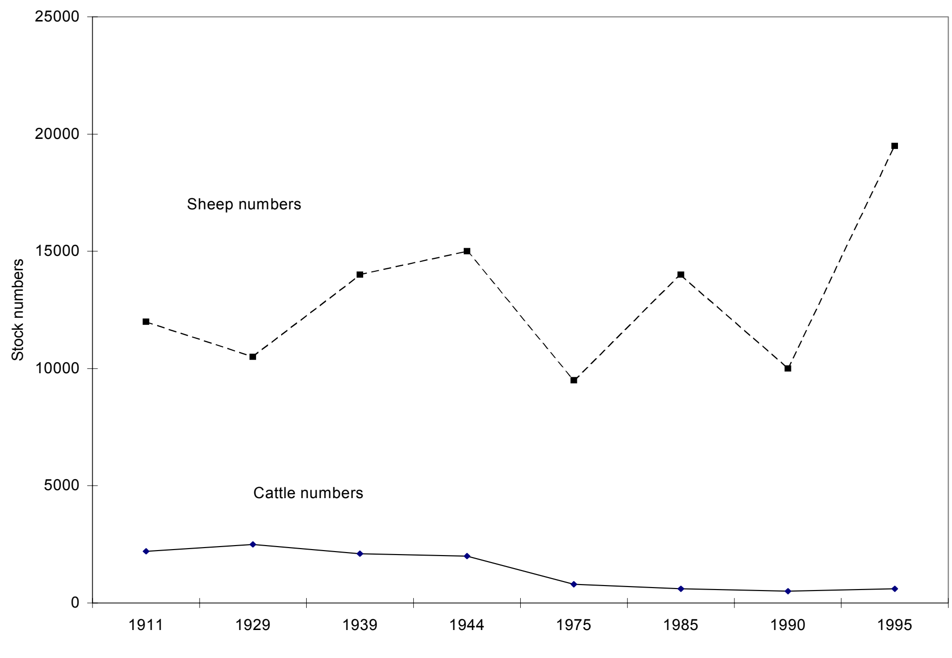

Figure 22.1 Kilmuir parish stock numbers 1911 to 1995

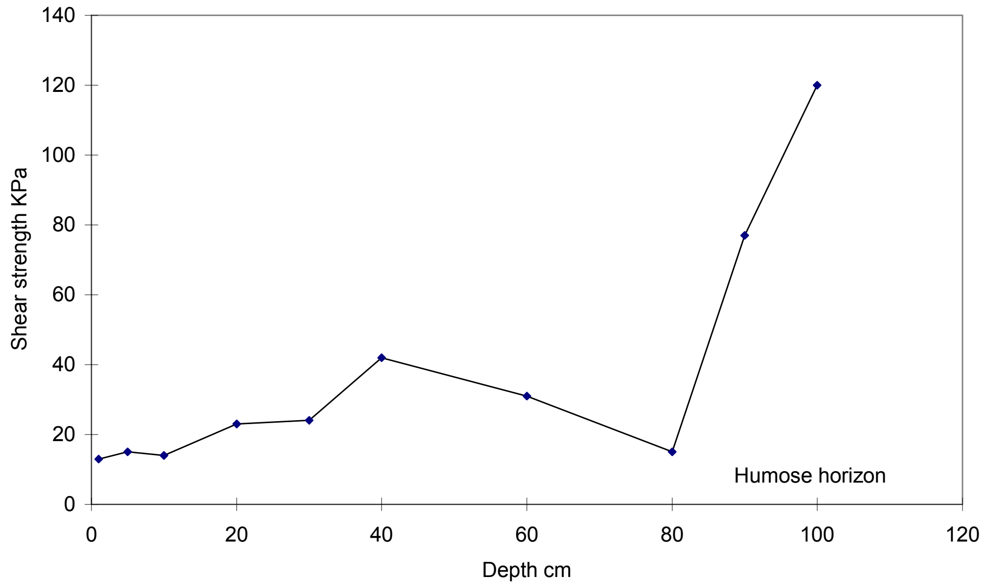

Figure 22.2 Typical depth / strength relationship in the soils

matter content rises to 20 to 30%. The humose horizon, apart from being of low shear strength, is also of markedly lower hydraulic conductivity so that the immediately overlying soil is frequently observed to be saturated.

This plane of instability clearly lies well below any influence of recent changes in grazing pressure. It is probable therefore that in this case, much the observed soil erosion is not the result of overstocking but is an inherent feature of the soil and slope. The investigation illustrates the danger in assuming that erosion of upland grassland is necessarily caused by overgrazing.

Reference

Craigie I, Frost A, and Waterhouse T, 1995. *Trotternish Ridge Land Management Study*, Scottish Natural Heritage report SNH NW/S/029/94, Battelby.

23. Understanding the ecology of dwarf birch: implications for conservation and management of montane scrub

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[2] *Department of Environmental Science, University of Stirling*

Introduction

Montane scrub communities are fragmented and scarce in the UK. They occur in four habitats in the EC Habitats Directive and are a key component of the Montane habitat statement under the UK Biodiversity Action Plan. Dwarf birch (*Betula nana)* is the most abundant of the three UK montane scrub communities, occurring at isolated sites in the Scottish Highlands and northern England. It is almost always found at 250-650 m altitude in blanket bog or wet heath (NVC community M19c *Calluna vulgaris – Eriophorum angustifolium* blanket mire, *Vaccinium vitis-idaea – Hylocomium splendens* sub-community, *B.nana* variant). Little information exists on the ecology of dwarf birch in the UK and its relict distribution has been attributed to burning and grazing. However, the precise habitat requirements of the species are poorly understood and ecological information from Scandinavia and North America may not be applicable as dwarf birch occurs in different communities there. An improved understanding of dwarf birch ecology is essential for informed management of upland ecosystems, and identifying restoration opportunities. Preliminary results are presented below from investigations of the effects of burning, soil moisture and soil water chemistry on *Betula nana* growth and distribution at a site in the Scottish Highlands.

Study site

This study is being carried out at Blargie Craig where Scottish Natural Heritage had erected an exclosure in 1995 within a south-west sloping hollow at 573-622 m elevation. A stand of *B.nana* in the upper part of the exclosure had been accidentally burned during the winter of 1994-1995.

Effects of burning

Non-destructive techniques were used to assess the effects of burning on *B. nana* productivity. As the species exhibits clonal growth an "individual" was defined as a plant emerging from the moss substrate. All individuals in the burnt and unburned stand were sampled and stem diameter, number and length of shoots and number of leaves per shoot were measured in July 1997. The stands were revisited in 1998 and the length and number of leaves on the current shoot growth were recorded as well as the diameter of all individuals in each stand. Table 23.1 indicates that dwarf birch productivity has not been affected by the 1994/1995 burn, in the absence of sheep grazing pressure. Indeed the "plants" in the burnt stand have significantly longer shoots. The increased number of "plants" in the burnt stand in 1998 is due to an increase in plants up to 4.9 mm in diameter as the result of adventitious rooting.

Effects of soil water chemistry and soil moisture

Nine sample sites were established in 1998 within the enclosure: three within and six outside unburned *B. nana* stands. At each site maximum and minimum watertable depths are monitored. Soil water is sampled from dipwells at 10, 20 and 30 cm depths and analysed for pH, soluble reactive phosphate (SRP), ammonium, nitrate, potassium, calcium and magnesium. Soil water chemistry results June-July 1998 showed no significant differences between sites within and outside *B. nana* patches. However there is evidence of

Table 23.1 Productivity in burnt and unburned dwarf birch stands, 1997-1998

	1997 (Total plant productivity)		1998 (Current year's growth)	
	Unburned	Burnt	Unburned	Burnt
Number of "individuals"	31	30	33	92
Min-max stem diameter (mm)	1.1-7.3[1]/ 1.1-6.7[2]	1.4-6.8[1]/ 1.3-6.7[2]	0.6-7.6[1]/ 0.9-8.0[2]	0.2-12.3/ 0.5-11.1[2]
Mean shoot length (mm)	63.3[a]	75.5[a]	18[c]	41[c]
Mean leaves per shoot	17.2	16.4	7[d]	8[d]
Mean leaves per mm shoot length	0.28[b]	0.24[b]	0.46[e]	0.27[e]

[1]diameter 1, [2]diameter 2. Means with same superscript letter are significantly different ($p<0.05$)

nutrient enrichment and a rise in pH immediately upslope of *B. nana* stands (Figure 23.1), suggesting that nutrient movement in soil water could be important for *B. nana* spread. Watertable depth measurements May-November 1998 found less fluctuation beneath *B. nana* stands than outside (Figure 23.2). Although this may be an artefact of sample size, it could indicate that *B. nana* spreads within wetter seepage zones.

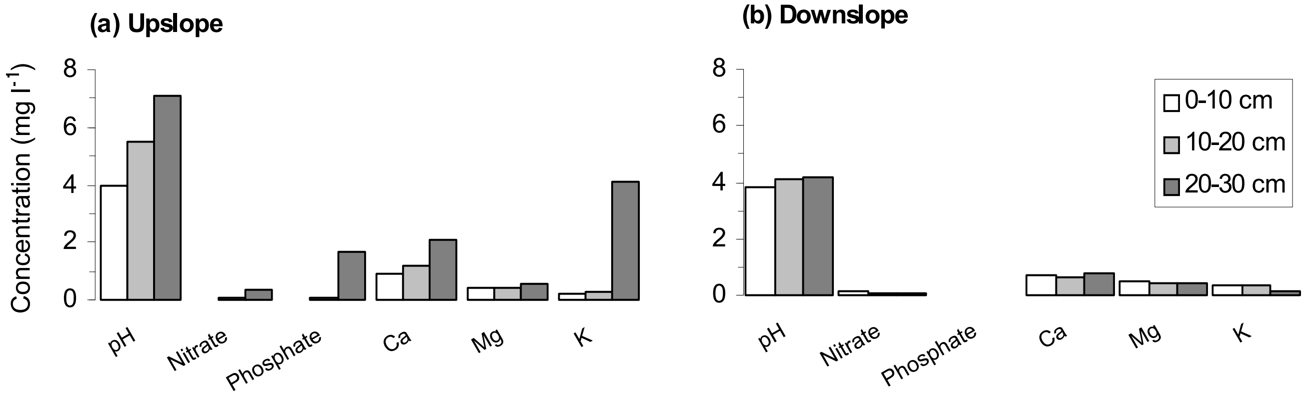

Figure 23.1 Soil water chemistry (a) upslope and (b) downslope of dwarf birch stand, 23/06/98

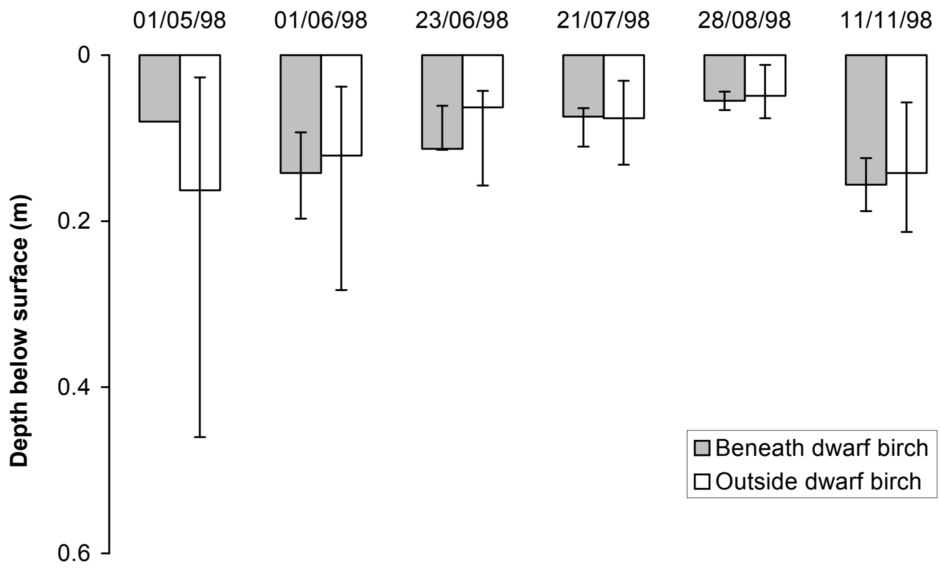

Figure 23.2 Median range of watertable depth beneath and outside dwarf birch stands (Error bars show minimum and maximum ranges)

Management implications

While these are only early results and longer-term monitoring is required there are implications for the management of *B. nana*. Firstly one fire is not necessarily destructive, though as yet nothing is known about the effects of repeated fires or burning in combination with grazing. Secondly they raise the possibility that fire could be used in some situations as a management tool to stimulate regeneration by adventitious rooting. However this is only likely to work if the young shoots can be protected from grazing pressure until they become fully established. Further experimental work is necessary to produce clear guidelines.

Acknowledgements

Mr Donald Wilson and Mr Hugh Morrison permitted site access. Angus Macdonald and David Gowans (Scottish Natural Heritage) provided site information. Part of the research was funded by the University of Stirling Graduates Association.

24. Managing manganese in runoff from upland water supply catchments

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Introduction

The trace metal manganese (Mn) occurs naturally in the environment but Mn concentrations in water supplies can exceed the EC standard (0.05 mg l-1), resulting in pipeline deposition, increased treatment costs for the water industry and customer complaints. 1.03% of drinking water samples in Scotland, and 0.52% of samples in England and Wales, failed the EC standard in 1996 and 1997, respectively. The majority of these failures occur in water supplied from upland catchments. The main source of Mn in upland catchments is weathering of the soil parent material, though mobilisation may be exacerbated by soil acidification. Mn transfer from upland soils into water supplies is governed by its form (Figure 24.1).

The acidic, saturated, organic, and reducing conditions of many upland soils favour the formation of soluble Mn(II), which can run off into water supplies and is difficult to remove by conventional water treatment processes.

Management of upland water supply catchments could be a more cost-effective means of controlling Mn concentrations in runoff rather than upgrading water treatment works, particularly in small water supply zones. To implement catchment management strategies there is a need to understand how Mn is mobilised from soils into runoff. The link between soil hydrology and Mn mobilisation is currently being investigated in the Loch Bradan catchment, Scotland.

Project objectives

- To determine if land use (unimproved moorland and conifer plantations) affects Mn concentrations in soil water.
- To examine if a relationship exists between soil moisture status and Mn concentrations in soil water.
- To model the spatial and temporal variability in Mn mobilisation.

Study site: Loch Bradan

Located 26 km south of Ayr, Loch Bradan is the 6th largest water supply reservoir in Scotland. Operated by West of Scotland Water authority, it supplies 99 Ml water day^{-1} to approximately 180,000 customers. The catchment was selected for this project since Mn concentrations in reservoir water have increased since the early 1970s and regularly exceed the EC standard. Consistent drinking water failures for Mn were one of the main reasons for upgrading the reservoir treatment works in 1995 at a cost of £12 million.

The direct Loch Bradan catchment is owned by the Forestry Commission and has an area of 15.5 km^2, ranging in altitude between 320 and 550 m. Much of the catchment area was planted with conifers in the 1960s, and the remainder is unimproved moorland. Catchment geology consists of greywackes and quartz diorite, overlain in places with a thin veneer of glacial drift and peat deposits. The main soil types are blanket peat, peaty podzols and peaty gleys with some rankers.

Preliminary investigations

Ballochbeatties Burn, a tributary to Loch Bradan, was selected as the focus for research since it contains varied land-uses and soils. Previous sampling had identified elevated Mn concentrations in the stream (up to 0.991 mg l^{-1}). Preliminary

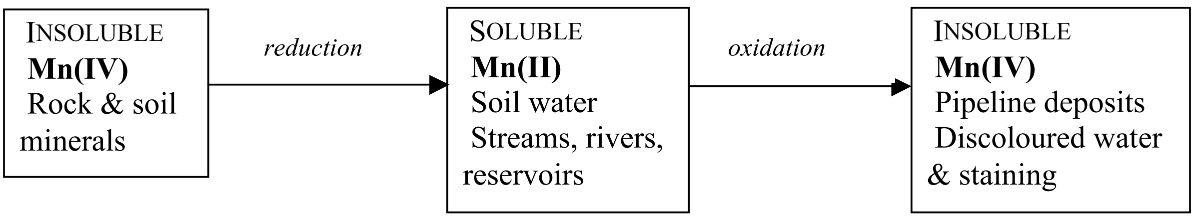

Figure 24.1 Forms and transport of Mn from upland catchments to water supplies

Table 24.1 Water chemistry of Ballochbeatties Burn in moorland and forested land-uses

	December 1998		January 1999	
	Moorland	**Forest**	**Moorland**	**Forest**
Dissolved Mn	0.010-0.020 (4)	0.053-0.084 (4)	0.019-0.022 (4)	0.057-0.144 (7)
Dissolved Fe	0.055-0.087 (4)	0.169-0.320 (4)	0.045-0.063 (4)	0.106-0.212 (7)
Dissolved Al	0.073-0.089 (4)	0.121-0.140 (4)	0.093-0.115 (4)	0.151-0.322 (7)
pH	5.9-6.6 (4)	5.5-5.9 (4)	5.4-5.7 (4)	4.5-5.0 (7)
Colour	16 (4)	22-47 (4)	<1-11 (4)	17-31 (7)

Units mg l^{-1}, apart from pH, and colour (Hazen units). Min - max values, number of samples in brackets.

Table 24.2 Total Mn concentrations in soil samples from the Ballochbeatties catchment

	Moorland	Forest	Clear-felled forest
Total[1] Mn content (μg g^{-1})	13.38-2219	4.00-184.6	161.2-1230
Number of sites sampled	6	4	6

[1] Determined by digestion of ashed samples with nitric and sulphuric acids.

surveys of streamwater chemistry in December 1998 and January 1999 found differences between the upper moorland and lower forested parts of the Ballochbeatties catchment (Table 24.1).

Preliminary soil sampling and analysis in the Ballochbeatties catchment shows no clear relationship between total Mn content and land-use (Table 24.2).

Further work

The relationship between soil hydrology and soil water and streamwater chemistry will be assessed in the field from April 1999 to December 2000. Soil moisture content, pressure and soil water chemistry will be monitored at 3 depths and at 3 sites within the moorland and forest land-uses. Soil hydraulic conductivities will also be characterised in the field and laboratory. This information will be used with meteorological data to calibrate a 1-dimensional soil water model to predict the probability of the occurrence of those soil moisture conditions most favourable for Mn mobilisation. The model can also be used to examine the effect of climate change, such as drier summers and wetter winters, on Mn mobilisation in upland catchments. Finally, the findings will be used in conjunction with national soils and climate databases to identify other water supply catchments where Mn mobilisation may occur.

Acknowledgements

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25. GPS: a tool for mapping the uplands

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Introduction

The Global Positioning System (GPS) is a constellation of satellites that transmit precise time and positioning information which can be retrieved using a GPS receiver. The commercial development of GPS receivers has implications for the logistics of gathering positioning information in upland environments. As limitations on the ability to measure a particular variable at an appropriate level of precision can impede the progress of scientific investigation, so the introduction of new techniques can allow fresh insight. In the context of evaluating land degradation, for example, the ability to map relevant features efficiently can enable information to be collected, which was hitherto unavailable.

Background

GPS receivers deduce positioning information through repeated measurements on the travel times of digitally tagged radio signals. Positioning from a single receiver was, until recently, compromised by Selective Availability by the US Department of Defense, such that the receiver's true position is likely to be within 100 m of the displayed co-ordinates. Since May 2000, this has been discontinued. Differential GPS (DGPS) has been developed to resolve positional accuracies by logging positioning data from two receivers simultaneously. One of the receivers is located at a known static control point (base station) while the other (mobile receiver) is moved between survey location points. The measured bias errors at the control point are used to resolve bias errors in the mobile receiver positions and to calculate a vector between the two receivers. Correctable errors include satellite clock, ephemeris data, ionospheric and topospheric interference and Selective Availability. The accuracy of the differentially corrected positioning data depends on the particular type of receiver used and the mode of processing. Dual frequency carrier phase receivers are the most accurate (and most expensive) and are capable of geodetic survey applications. However, the cheaper and more portable hand held code- or single-frequency carrier phase receivers are suitable for many mapping applications where plan form information is more critical that elevation data. In our geomorphological applications we have used a Magellan GPS ProMARK X CP™ system. In carrier phase mode the system is capable of sub-metre accuracy, but requires both receivers to be stationary. In mobile differential mode, the mobile receiver updates every second and collects a string of positions. An attribute function allows individual points within the data stream to be tagged with mapping labels. The accuracy of individual points within the data stream is generally 2 to 3 m.

The ability to collect positioning data by simply walking across features of interest opens up possibility of examining distributions of features which are difficult to recognise from aerial photographs because of size or permanence, or too extensive to measure by conventional survey methods. In illustrating some of the applications to studies of land degradation in upland environments attention is drawn to the potential for examining ephemeral features, geomorphological mapping and establishing spatial distributions.

Ephemera

Much information relating to the impact of hydrological events can be derived from evidence which is ephemeral in nature. One example is the formation of trash marks, following overbank flood events. Conventional survey methods have been used routinely for mapping flood limits but are limited in the spatial scale that can be assessed before the evidence degrades through the effect of wind and rain and by the recovery of floodplain vegetation. Rapid survey by GPS can enable the limits of features on the ground to be traced over a reach scale (e.g. 100 m – 5 km) in a few hours. By conducting surveys as the flood wanes, the relationship between channel morphology and the generation of overbank flow can be explored. The approach can be used for mapping the extent of sediment deposition emanating from hillside instabilities or from fluvial deposition. Similarly, the modelling of runoff generation, and hence sediment transport potential, requires distributed input data. GPS has potential in calibrating hydrological models through the ability to supply information about ground conditions (seepage lines, zones of saturation) over suitable spatial scales.

Geomorphological mapping

Establishing a geomorphological base map is often a preliminary step in an assessment of land degradation or sensitivity. Much information can be obtained through aerial photograph interpretation and the use of base maps, but there are scales of landforms where the resolution obtained from aerial photographs is insufficient and the length of time for conventional survey too demanding. There are also many situations where the availability of recent photography may be problematic or the expense of photography prohibitive. GPS can be used for efficiently generating plan-form maps of boundaries between geomorphological features, which is valuable in situations where suitable aerial photography is not available. For example, mapping of the spatial extent of a large Pennine peatslide was undertaken after the event but has been subsequently covered by a recent flight path. By assigning attributes to points within the data stream it is possible to undertake multi-purpose surveys and extract a variety of positioning information that is relevant to land degradation. For example, in surveying the limits of the peat slide, attribute data included the location of tension cracks, drainage lines, size and angle of peat blocks, distribution of intact blocks deposited between slide and the main valley.

Spatial distributions

Allied closely to geomorphological mapping is the need to obtain information on the spatial distribution of features of interest within an upland catchment. This can provide a basis for calculating the density of features, the degree of clustering and for establishing the connectivity of the system. Sediment supply from upland catchment slopes may be constrained by the linkages between the slope and the channel systems. Slope-channel coupling is an important consideration in modelling geomorphologcal response to climate change scenarios. GPS survey can be used to map the spatial distribution of links between slopes and channels that might be developed as a simple index of sediment yield potential.

Advantages and limitations

The particular GPS system described here has a spatial resolution of approximately 2-3 m which is ideal for rapid mapping but not suitable for detailed topographic survey. GPS receivers require an unobstructed view of satellites and normally search for signals within a 10° mask angle. In steeply dissected terrain the retention of a lock on position may be difficult and prevent full surveys. Geodetic quality GPS has the potential for speeding up the collection of survey data and enabling changes in landform features (such as river cross sections) to be undertaken efficiently. However, portability is another consideration in upland environments. Potential applications in upland catchments should consider the trade-off between speed and accuracy.

26. A comparison of some runoff process regimes in upland blanket peat

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The headwaters of many UK rivers drain areas of upland blanket peat. Nevertheless the details surrounding the spatial and temporal production of runoff within these peatlands remain relatively unknown. Recent studies have demonstrated that blanket peat catchments are extremely productive of runoff and have flashy regimes (e.g. Burt *et al*, 1997; Evans *et al*, 1999). This poster presents a variety of runoff responses from blanket peat sources located in the Moor House NNR, North Pennines (NY 757 328). Plot-scale monitoring allows an insight into the operation of some hydrological processes that contribute to the flashy river flow within blanket peat headwaters.

Table 26.1 gives some indication of the storm response of Trout Beck, a tributary to the Tees with an 11.4 km^2 catchment upstream of the gauging station. Its regime and catchment characteristics are discussed in detail elsewhere (Evans *et al*, 1999). Baseflow is of minimal importance with no delayed flow and rainfall-runoff response is extremely rapid. In a re-instrumentation of one of Conway and Millar's (1960) subcatchments for which they amalgamated an eroded area and a gripped area (contoured ditches of approximately 50 cm depth and spaced at 15 m intervals) the two sections have been monitored separately. Hydrograph analysis shows that both the gripped and the eroded hillsides have quicker rising and falling limbs with the drained catchment flashiest; here 89% of the flow occurs in only 30% of the time. Table 26.2 shows mean rainfall response characteristics for a variety of plot locations.

Table 26.1 Runoff from Trout Beck, a gripped hillslope and an eroded hillslope.

	Time to peak	**Lag**	**Recession time**	**T since rain end**	**70% time**
Trout Beck	6.50	2.80	57.88	56.23	19.15 %
Gripped hill	5.14	1.33	23.31	20.64	10.64 %
Eroded hill	6.94	1.73	29.38	27.25	17.56 %

Note: Time measured in hours, n=40. **Time to peak** = Time since first rainfall to hydrograph peak. **Lag** = Time since maximum fifteen minute rainfall intensity to hydrograph peak. **Recession time** = Time from peak of hydrograph to return to flow below which operates 25% of the time. **T since rain end** = Time since rain end to return to flow below which operates 25% of the time. **70% time** = Proportion of discharge that occurs 70% of the time.

Table 26.2 Mean plot-scale rainfall response characteristics

Location Depth	**Time to peak**	**Lag**	**Recession time**	**T since rain end**	**% Runoff**
Topslope					
Surface	2.46	1.57	5.96	2.93	88.59
5cm	5.071	2.39	7.92	9.42	10.00
50cm	No runoff				
100cm clay interface	8.375	2.125	32.25	25.83	1.41
Footslope					
Surface	6.92	1.69	23.3	10.75	98.08
5cm	7.13	3.45	28.56	18.69	1.73
10cm	No Runoff				
50cm	No Runoff				
120cm clay interface	16.5	6.125	V. slow	V. slow	0.18
Eroded hill gully-head					
Surface	No Runoff				
5cm	5.22	1.28	30.13	24.33	97.49
90cm	8.85	3.6	17.8	14.05	2.51
Gully–head pool	9.68	2.396	54.55	33.05	-----

Notes: Time measured in hours, n=20 (30 for pool flow). Column headings as Table 26.1.
% Runoff = Mean proportion of runoff from each layer for each location

Surface flow (or within 1cm of the surface) is quicker to respond to rainfall events than flow within 5cm of the surface (acrotelm) and significantly dominates runoff volumes except near gully-sides. Surface flow is slightly less frequent and ceases operation sooner than acrotelm flow. Rainfall simulation and tension infiltrometer experiments combined with hillslope storm runoff mapping clearly demonstrates that overland flow is generated through saturation-excess rather than infiltration-excess mechanisms. At footslope locations, surface and near-surface runoff events appear to be prolonged as the upward limit of zones of fully saturated acrotelm move back downslope after rainfall events.

No significantly measurable flow emerges from within the lower layers of peat except from eroded gully sides where water tables have dropped and from macropore outlets and pipe networks. Pipeflow has been measured to contribute typically around 10 % of streamflow volume in these upland blanket peats. Importantly however, flow has been detected at the peat-mineral interface. Flow here is ephemeral, a result of rainfall events and bypassing flow. Although runoff volumes are small, the fact that any flow occurs here at all may have implications for the stability of peat masses and/or the formation of subsurface pipeflow. Both piping and peat mass movements are fairly common within the blanket peat of the North Pennines.

Sphagnum-pool drainage to a gully head via underground channelling is continuous even during dry spells, excepting frozen periods, and during a storm will bring very intense and concentrated flow from a wide source area to the nick point creating suitable conditions for headward extension of the gully. It may be that pools provide the only baseflow component to blanket peat catchments but this would only be where they were linked to drainage lines. Where pools are isolated, any fall in the depth of ponding is evaporatively controlled. The smooth response of pool drainage when compared to other peat runoff processes appears to contribute strongly to the smoother response of the eroded subcatchment hydrograph compared to that of Trout Beck or the gripped catchment.

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27. Environmental management in the uplands: an integrated approach

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The Uplands Experiment on Bodmin Moor and the Forest of Bowland has been set up in recognition of the growing concerns about the upland environment and agricultural economy, expressed through the National Agri-Environment Forum Upland Working Group. The Experiment aims to test whether it is possible to produce a combined package of different grant schemes that address both economic and environmental issues but within the constraints of current funding mechanisms.

The Agenda 2000 proposals envisage the integration of agri-environment and rural development measures. Against this background it is appropriate to consider the implications of this using existing schemes and powers, centred around Objective 5b and the Countryside Stewardship Scheme with the enhanced upland options.

In both of the areas, the respective County Councils took the lead in developing bids for Objective 5b funding and seeking support from partners. By autumn 1998 the projects had been approved and both began operation in January 1999.

The approach in both areas is similar, farmers and land managers can receive a whole farm appraisal examining the environmental, business and human resources and potential opportunities. Through the use of Objective 5b measures, Countryside Stewardship and schemes such as Woodland Grant Scheme, Organic Farming Scheme and other funding from partner organisations, the appropriate mix of grant aid can be tailored to suit the economic needs and environmental features of that particular business. This will be achieved via a single application process.

The grant aid components reflect the difference between the two areas in their local needs and environmental features. However, the overall aim is to enable the communities to develop, promote and market their products using specific environmental criteria as selling points. As a result of increased revenue from these products, businesses can continue to enhance the environment which can be a unique selling point. This will ultimately help to secure the future of the rural communities.

Whilst it is too early to judge the outcome of this approach, the proposals have stimulated considerable interest in both areas. It is hoped that useful lessons will be learned over the 2 year life of the schemes. An evaluation of the experiment will be undertaken during 2001/2. The conference poster illustrated the development of the partnership approach, the range of measures available to applicants and the anticipated outputs of the projects.

28. Torrent erosion in Lake District mountain catchments

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Introduction

Torrent erosion is the erosion, storage and transport of sediment from steep mountain stream systems. The physical processes controlling torrent erosion range from fluvial processes to debris flow mass movements. This range of processes is referred to as the 'sediment water-flow spectrum'. Processes can be classified according to the different mixtures of solids, water and air (Pierson & Costa, 1987; Coussot & Meunier, 1996). In the UK, mountain torrent erosion has been a neglected area of research, despite its significant influence on the geomorphological evolution of upland stream systems, as well as the risk posed to upland communities and infrastructure. For example, the sedimentation caused by the January 1995 flood event at Raise Beck and Dry Gill in the central Lake District covered the A591 leading to its closure. In the Lake District, numerous mountain torrents exist. These are characterised by steep stream channels; abundant sediment supply (from eroding gully heads, side slopes); and basal fan deposits (Newson, 1981; Eisbacher, 1982). A better understanding of sediment-water flows in mountain torrents will allow hazard assessments to be made and appropriate mitigation measures to be proposed.

Present study

The aim of this project is to examine the geomorphological controls on torrent erosion, and investigate the regional hazard posed by this process. A field-based approach has been adopted, comprising of field investigation at two case study torrents and a regional survey of torrent activity. This paper focuses on the case study sites, namely Iron Crag in the Caldbeck Fells and Raise Beck, south-west Helvellyn. Iron Crag is an active torrent, recently dominated by debris flow activity. Raise Beck by contrast is a less active fluvial-dominated system. The different levels of geomorphic activity associated with the torrent systems at each site is reflected in the research design. Raise Beck undergoes significant geomorphological change less frequently, so work here is largely reconstructive and retrospective. Iron Crag is undergoing rapid change, so therefore continuous monitoring is in progress.

Raise Beck contains evidence of recent flood activity. This is demonstrated by in-channel boulder dams; basal fan deposits; a series of recently vegetated in-channel bars; and lateral channel berms. Contemporary deposits are known to relate to a large flood which occurred on 31st January 1995, when 164mm of rainfall fell in 24 hours (recorded at the Nook raingauge-1.5km away). This led to shallow landslides and produced a flood discharge which mobilised debris. The aim of the field reconstruction is to determine the impact of past events; and the triggering and timing of these events.

Iron Crag is being monitored in order to construct a sediment budget, which accounts for the sources and disposition of sediment as it travels from its point of origin to the exit from the catchment. In concert, online monitoring of rainfall; temperature and the initial movement of bedload material is being conducted. The sediment budget and online monitoring have been operational since November 1998, though some elements have been operating since June 1998. The monitoring programme at Iron Crag has been divided into six process zones (Primary source area, Sub-Primary source area, Secondary source area, mid channel bedrock step area, Gully and channel sections, Fan & Pond storage area). In each zone a range of instruments/ surveys provide information on the erosion, storage and deposition of sediment. Adjacent to the primary source area meteorological conditions are monitored. Table 28.1 outlines most of the instruments/ surveys used in each zone and preliminary findings to mid-March 1999. The short report has discussed preliminary findings of the sediment budget and on-line monitoring. Future work will tie together the findings of the case study sites at Iron Crag and Raise Beck, and place these in a wider context of a regional investigation into torrent erosion in Lake District mountain catchments.

Table 28.1 A summary of sediment budget and online monitoring data for Iron Crag (July 1998 to mid March, 1999)

Process zone/ Instrument	Process Rates	
	Mean	Maximum
PRIMARY		
Trough traps	38.60 g d^{-1}	196.72g d^{-1}
Net traps	839.99 g d^{-1}	6955 g d^{-1}
Slope erosion pins	+0.12 mm d^{-1}	-1.97/+2.15 mm d^{-1}
SUB-PRIMARY		
Trough traps	48.28 g d^{-1}	324.01 g d^{-1}
Net traps	119.42 g d^{-1}	916.52 g d^{-1}
Slope erosion pins	-0.02 mm d^{-1}	-3.26/+2.74 mm d^{-1}
CHANNEL		
Scour chains	+1.13 mm d^{-1}	-14.07/+16.39 mm d^{-1}
Bank erosion pins	-0.16 mm d^{-1}	-2.97/+4.13 mm d^{-1}
Bedload tracer (*1)	?	>270m
SECONDARY		
Trough traps	52.44 g d^{-1}	165.09 g d^{-1}
Net traps	657.21 g d^{-1}	5295.81 g d^{-1}
Slope erosion pins	+0.11 mm d^{-1}	-1.57/+1.85 mm d^{-1}
BEDROCK STEP		
Net traps	185.18 g d^{-1}	807.65 g d^{-1}
FAN & POND		
Fan erosion pins	-0.15 mm d^{-1}	-4.26/+1.54 mm d^{-1}
METEORLOGICAL CONDITIONS (June 1998- January 1999)		
Ground surface temperature	6.43 °C	30.31 °C
Rock face temperature	6.11 °C	26.73 °C
Rainfall intensity	1.30 mm hr^{-1} (*2)	11.43 mm hr^{-1}
Rainfall monthly total	224.59 mm	325.374 mm

Note: *1- Approximate distance; *2- On values greater than zero. Negative values indicate erosion of ground surface and positive values deposition on the ground surface. All figures for the trough and net traps are dry mass.

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29. Modelling daily surface air temperature over complex terrain

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Ecological applications of climatic data commonly require the spatial distribution of data to be described on some form of regular grid. Gridding has been achieved by numerical interpolation of station data at larger spatial scales, using long term means (e.g. Hutchinson, 1995), or by modelling climatic elements as a function of surface variables (e.g. Thornton *et al.,* 1997). Small-scale heterogeneity in surface climate is particularly marked in hilly terrain, and the current study therefore models ecologically relevant variables at a 50m grid cell resolution. Data are modelled at a daily timescale in order to capture short-term and temporally autocorrelated events (for example severe frosts or heat waves) which may have a large ecological effect.

The air temperature data are gathered specifically for the study using a network of five *in situ* and five roving automatic weather stations (AWS) within the Moor House National Nature Reserve in the northern Pennine uplands. The sampling strategy is based on protocols developed by the UK Environmental Change Network (ECN) (Sykes and Lane, 1997). The five roving AWS were installed adjacent to the ECN station at Moor House (550m elevation) between 18 September and 22 October 1997. Daily temperature data sampled simultaneously by each roving AWS and the ECN station were compared, and correction factors were calculated by optimising the concordance correlation coefficient (Lin, 1989). These empirical correction factors compensate for small but systematic discrepancies in the response of individual sensors to ambient temperature. Having calculated corrections for the five roving weather stations, their relocation adjacent to *in situ* stations elsewhere in the reserve between 26 November 1997 and 12 January 1998 allowed the correction of data from all AWS within the study area. The correction factors do not exceed ±0.2°C for any station for daily mean, maximum or minimum temperature.

The primary base station at Moor House allows day to day temperature variability to be observed and, in conjunction with a secondary base station on the summit of Great Dun Fell at 845m elevation, allows the calculation of daily lapse rates of mean, maximum and minimum temperature. The linear relationship between temperature and elevation is extrapolated across the study site at a daily time step, using a digital terrain model (DTM) which describes elevation throughout the study area. The resulting temperature surfaces are validated using data from independent AWS located in networks designed to sample a range of topographic variability. The magnitude of the residuals show that the linear lapse rate model performs best for mean temperature, followed by maximum and minimum temperature.

Variables derived from surface topography were calculated using the DTM and the ARC/INFO GIS. Modelled surface variables include topographic shelter and drainage, respectively defined as the elevation difference between each grid cell and the highest and lowest cell within a specified neighbourhood. Each variable was modelled at a range of neighbourhoods, and the most statistically significant neighbourhood was identified empirically. Proximity to the topographic barrier of the Pennines was also modelled, using the inverse of the square of the distance along an axis generated perpendicular to the orientation of the Pennine ridge. Data from an experimental network that operated for 83 days in early 1998 was used in a regression analysis, showing that proximity to the Pennine ridge explains a significant amount of variance in the residuals from the mean temperature lapse rate model (on days when the wind direction at the summit of Great Dun Fell is in the south-easterly quadrant, $t=5.55$ and $R^2=0.84$). This is due to air drying during ascent of the windward slope and warming at a steeper lapse rate as it descends the lee slope. The topographic drainage variable was found to be most significant at a 500m neighbourhood; this variable explains a significant amount of variance in the residuals from the minimum temperature lapse rate model under the shallowest 20% of lapse rates ($t=4.54$ and $R^2=0.77$). This result is consistent with the accumulation of cold air flowing downhill in katabatic density currents. The topography thus determines where cold air accumulates and the distribution of low temperature anomalies.

Inclusion of the effects of topographic variables in the modelling methodology allows the identification of upland areas that meet ecologically relevant climatic criteria. This information is modelled at a daily timescale but can be summed or integrated over longer periods (e.g. degree-days above or below specific physiological thresholds during one or more growing seasons) and used as input for spatially-explicit plant growth or ecosystem dynamics models.

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30. Impacts of environmental change on the vegetation of Widdybank Fell, Upper Teesdale NNR

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Introduction

Widdybank Fell is situated in the northern Pennines and forms part of the Upper Teesdale National Nature Reserve. The fell supports a late-glacial relict flora and among the varied mosaic of plant communities represented are the unique sugar limestone grasslands, in which grow rarities such as the spring gentian (*Gentiana verna).* In 1971 a dam was constructed on the River Tees that flooded the valley west of Widdybank Fell to form Cow Green Reservoir.

The primary objective of this project was to investigate the local climatic impacts of the reservoir upon the vegetation at this internationally important site. This objective was addressed using a vegetation survey and analysis of meteorological records from local stations.

Vegetation survey

An extensive vegetation survey of Widdybank Fell was carried out between 1967 and 1969 (Jones, 1973) using phytosociological techniques. The vegetation was classified into 31 distinct groups or "noda". A resurvey of nine of these noda was carried out in the years 1996-1997, focusing particularly on the vegetation associated with the sugar limestone soils.

Comparison of the two surveys using CANOCO and Monte Carlo simulation showed that species composition had significantly changed in five noda. Mann-Whitney U-tests were used to examine changes in abundance in individual species. The most notable change was seen in *Thymus praecox* sp. *arcticus* which had significantly decreased in abundance in seven noda. The calcicole moss *Ctendidum molluscum* had significantly decreased in two noda and the liverwort *Scapania aspera* had decreased in five noda. In general, there had been no significant changes in abundance of the rare species, including *Gentiana verna*.

Meteorological data

In order to isolate any local climatic effects of the reservoir, meteorological data from stations on Widdybank Fell (513 m) and at the nearby Moor House (560 m) were compared. The two stations are 6.7 km apart and both provided records for the period 1968-1973, covering reservoir construction and filling. Monthly means of daily grass minimum temperatures were compared between the two sites for this period (Figure 30.1). The difference in monthly means between the two sites was greater following reservoir filling (tested using ANOVA, $P<0.01$). There was a consistent moderation of the grass minimum at Widdybank Fell compared to Moor House over this period by c. 0.5 °C.

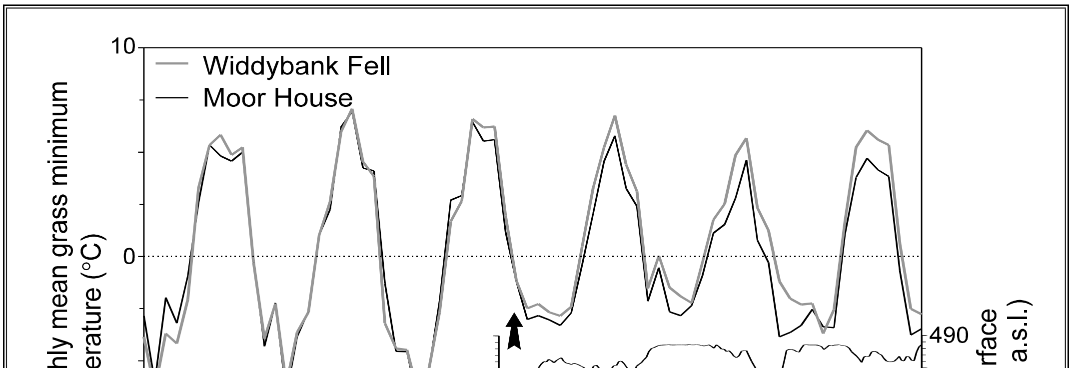

Figure 30.1 Monthly means of daily grass minimum temperatures at Widdybank Fell and Moor House 1968-1973. Inset graph shows reservoir water levels; an arrow marks where the pre- and post- reservoir climate records were divided for the purpose of analysis.

This observed moderation of minima is consistent with the expected local climate effect of the reservoir. In winter, the reservoir water temperature will generally be warner than that of the air and thus will act as a net heat exporter.

Other factors which could account for the changes in the vegetation

A systematic analysis of the ecological and physiological traits of the species which had changed in abundance between the two surveys was carried out. Species which had decreased in abundance or had been lost from the grasslands generally shared two features: they were classified as stress-tolerators *sensu* Grime (1977) and/or they were species which are typically found on calcareous soils.

The loss of stress-tolerators could be accounted for by the amelioration of local climatic conditions, but the loss of calcareous soil-preferring species was more likely to be the effect of acid deposition. Soil analysis from a selection of grasslands at Widdybank showed an average reduction of soil pH of 0.3 units compared to samples analysed by Jones (1973).

Conclusions

Evidence has been presented which illustrates a change in the species composition of some of the vegetation noda on Widdybank Fell in the 25 year period since reservoir construction.

Analysis of meteorological records has demonstrated a local climate impact of the reservoir, which is potentially of significance for plant growth. However, the observed changes in the vegetation may also in part be a result of other environmental factors, such as acid deposition.

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31. Modelling hydroecology in bogs and mire

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The need for accurate predictive models as management tools in complex hydrological and ecological systems is well established. Despite this recognised need, reliable models are not available. This research project aims to develop such a model. The project is based at Centre for Land Use and Water Resources Research, Newcastle University, and is supported by both English Nature and ADAS Redesdale, providing both upland (Trough End Bog, Redesdale, Northumberland) and lowland (Wedholme Flow, Cumbria) field sites. While existing groundwater models, such as Ingram's 'Groundwater Mound Model' (1982), MODFLOW (Harbaugh and McDonald, 1996), and DRAINMOD (Skaggs, 1980), may be used in some cases to describe the groundwater alone, they inherently lack any adequate representation of surface water. A steady state output from Wedholme Flow using MODFLOW was used to illustrate the unsuitability of such a model for mires. In mires with hydraulic regimes characterised by high water tables, high precipitation, low evapotranspiration, peat soils with low saturated hydraulic conductivity and low infiltration rates, the vegetation (bryophytes, ericaceous shrubs, and sedges) plays a leading role in surface flow patterns (MacAlister and Parkin, 1998). Multivariate analysis of vegetation and hydrological data was undertaken in order to investigate relationships between surface water and vegetation assemblages on two mires, one upland valley mire and one lowland raised mire. It is suggested that a representative model must combine surface micro-topography, determined largely by vegetation, with the rapid overland flows of the surface water regime. It is proposed that such a system could be best depicted by a physical model solved numerically. Such models are often difficult to parameterise, requiring large quantities of real data. The monitoring networks established at Wedholme Flow and Trough End Bog for data collection and model validation were outlined. Finally, such a flow domain is illustrated using data from a field plot at Trough End Bog.

Canonical community and environmental variable ordination

Species and environmental data from Wedholme and Trough End were analysed using CANOCO for Windows (ter Braak & Smilauer, 1998). At Trough End there was a clear correlation between the established vegetation and wetness, determined by proximity of groundwater level to surface, and variation of that level (or short term hydrological stability of sites). However Wedholme samples were more difficult to interpret. Examination of species and environmental biplot scores suggest disturbance and proximity to old peat workings likely to assert an extended influence.

Modelling outputs and model development

Steady state MODFLOW outputs from Wedholme Flow illustrate the unsuitability of such a model for peatlands with high water tables and complex physical hydroecological interactions. The predicted hydraulic heads necessary to maintain a realistic site water balance were unrealistically high suggesting that the recharge entering the system must either remain within the system or else must not enter the groundwater. This is corroborated by low recorded infiltration capacity, of the same order as the extremely low recorded saturated hydraulic conductivity. Field observations during storm events at both sites revealed high levels of surface water activity, with the development of micro-catchment systems, within the varied microtopography of the *hummock-hollow* complex (Figure 31.1). These accelerated open-water flow routes provide one explanation for the disparity between high recharge and low groundwater flow rates. They provide a link between vegetation and hydrology, with transient pool and channel network formation around dense mainly bryophytic vegetation and diffuse flow through less dense vascular species. This complex hydro-ecological process is the missing link in the wetland water balance, both lowland and upland, and must be fully understood before any model can be proved valid.

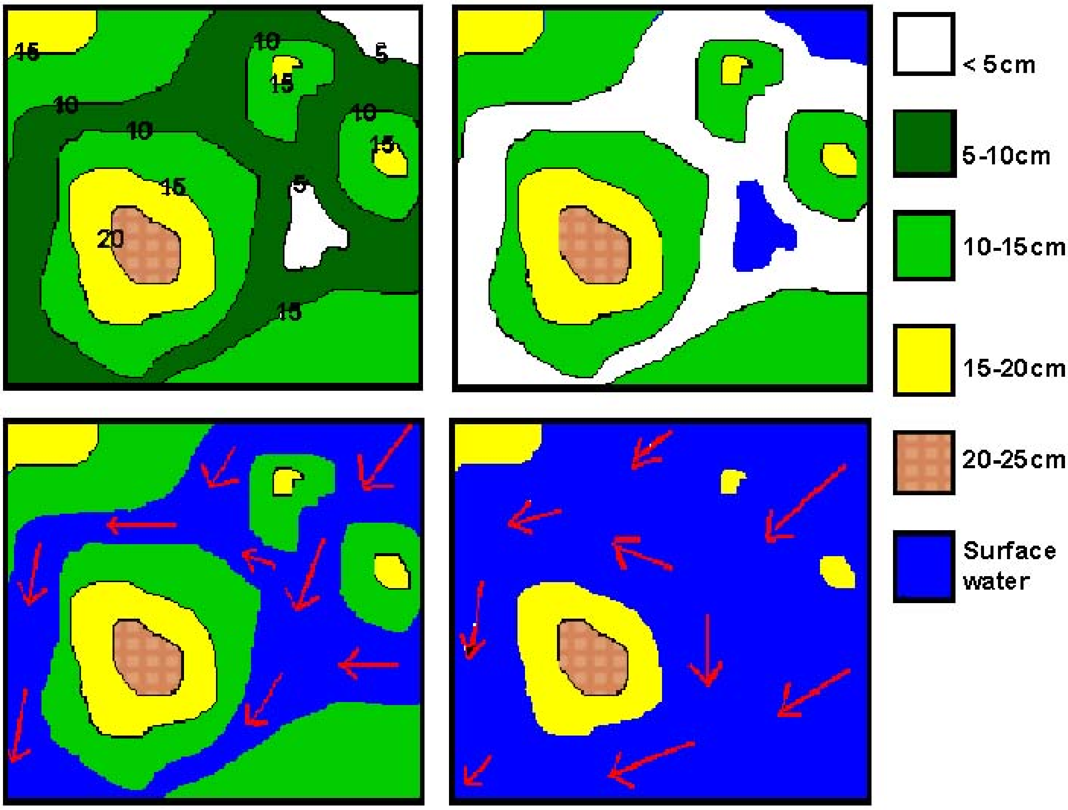

Figure 31.1 Schematic representation of rising surface water levels and surface water flow through a hummock-hollow complex over three time steps **(t_{1-3})**.

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32. Upland soil erosion in England and Wales: the influence of soil

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Introduction

The uplands of England and Wales are internationally important for nature conservation and are prized nationally for their landscape, recreational and cultural value. This report describes SSLRC (Cranfield University) research into the extent, causes and rates of upland soil erosion in England and Wales.

Method

Erosion was investigated at over four hundred objectively selected field sites, located on an orthogonal grid at 5km intersections. Within each 50m-radius site, the dimensions of individual erosion features were recorded. More precise measurements of erosion were made within linear erosion gullies. Environmental attributes, including slope, aspect and altitude, were recorded to establish their effect on erosion whilst sites that were drained, burned or heavily grazed illustrated the effects of management on erosion.

Results

Over 43% of field sites visited in 1997 were eroded. Of these, some 85% (156 sites) contained non-vegetated erosion scars that were still susceptible to further soil loss. In total, over 105,000 m^3 of soil had been lost from field sites.

tatistical analyses indicated that soil type was an important influence on erosion extent and severity (Table 32.1). Although they represented less than a third of all field sites, over 60% of sites on peat soils were eroded to some extent. Calculations from the width, depth and length of eroding features showed that peat soil contributed 67% of the total eroded volume and over half of the entire area of non-vegetated erosion measured within field sites.

The next most erosive soils were the stagnopodzols, of which 37% of sites were eroded. These contributed almost one quarter of the total eroded volume and 28% of the non-vegetated eroded area. In comparison, only one third of stagnogleyic sites and one quarter of lithomorphic sites were eroded and these soils accounted for 13% and 6% of non-vegetated erosion respectively.

The high variability of the survey results is demonstrated by the range of erosion extents recorded and by the differences between mean and median values. The median, or central value of the range, is consistently lower than the mean eroded volume because the large number of sites with little erosion results in a strongly skewed distribution.

Discussion

In spite of the variable extent of erosion measured on different soils, both total eroded area and volume were greatest on peat soils. The nature of peat explains this susceptibility to erosion: it consists of unconsolidated and partially decomposed organic material with very large water content. As surface or near-surface movement is the dominant hydrological pathway, peat is very sensitive to surface disruption by trampling, burning or grazing. In addition, surface peat vegetation is frequently composed almost entirely of *Sphagnum* mosses, which are intolerant of atmospheric pollution.

Table 32.1 Volume and area of erosion measured on field sites in 1997.

	Lithomorphic	**Stagnopodzol**	**Stagnogley**	**Peat**	**Total**
Field sites	115	92	88	131	426
Eroded sites (% of total)	28 (24)	34 (37)	43 (49)	80 (61)	185 (43)
Eroded area (m^2)	20573	20512	8912	68811	118808
Eroded volume (m^3)	8242	23315	3638	69878	105073
Mean (m^3)	294	686	85	874	568
Median (m^3)	9.8	46	13	122	191
Range (m^3/ha)	1 - 6028	1 – 7880	1 – 813	1 - 11750	1 - 11750
Non-vegetated area (m^2)	16417	7602	3711	30681	58411

The next greatest volumes of erosion were recorded on stagnopodzol soils, which also contain large moisture and organic matter contents that may contribute to their erosion vulnerability. Again, surface water movement is a major hydrological route. In contrast the drier lithomorphic and stagnogleyic soils appeared to be more resistant to erosion. Alternatively, these soils, which are more permeable and exist over porous parent material, may avoid the greater erosive pressures that occur on peats and stagnopodzols.

Conclusion

The results confirm that erosion of peat is a serious issue in the uplands. As well as degrading an important natural resource, peat erosion has implications for grazing and water management. By reducing the area of viable grazing ground, eroded peat forces grazing animals to concentrate in smaller areas and thereby promotes further vegetation and soil loss. Eroded peat also causes problems downstream. By remaining suspended, eroded peat reduces water quality, whilst sedimentation of eroded material can severely reduce reservoir capacity: both of these effects represent significant economic costs to water industries. Erosion also has environmental implications as the sedimentation of eroded soils may suffocate fish eggs in riverbeds. There is, therefore, an urgent need to protect peat from further degradation and to reduce the existing area of bare peat.

In addition to assessing erosion on upland soils, this research established the rate of upland soil loss within eroding linear gullies and in the wider upland environment through the interpretation of aerial photographs. This information, in conjunction with the influences of environmental and management factors on erosion, was used to propose effective remedial and preventive actions for erosion in the uplands.

Acknowledgements

The authors gratefully acknowledge the funding of this work by the Ministry of Agriculture, Fisheries and Food (Project SP0402).

33. The problem of water colour in the Pennines: the 1995 drought and the potential impact of climate change

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Since the mid 1980s water colour has been recognised as a problem in the water-gathering grounds of the Yorkshire Pennines. Colour varies seasonally with higher levels experienced in the autumn months as seen in the two examples shown in Figure 33.1. Another feature of the colour series is the enhanced colour levels which, after a lag, follow dry summers such as 1984 in the case of the Nidd intake at Chellow Heights Water Treatment Works (WTW), 1989-1991 at Ewden and, even more marked, the 1995 drought. As an indication of the significance of these years, Figure 33.2 shows the summer rainfall and potential evapotranspiration (PE) anomalies derived from the 30-year mean (1961-1990) for the 40 km square in which Ewden is located. Long-term data for Ewden also show that the pattern of colour response following the 1976 drought was similar to that seen in 1995-1998 (Watts *et al.*, 2001).

Early work suggested that decomposition of the peat is enhanced during hot, dry summers, and that subsequent washout of the stored soluble organic compounds gives rise to increased colour levels. However, the extreme weather conditions experienced between 1989 and 1996 led to both exceptionally low and unprecedented high colour levels. To explain the observed behaviour, it is thought that hydrological pathways through the peat become disrupted following severe drought, and immediate post-drought runoff is not from peat areas, thus resulting in low levels of colour. It takes some time to re-establish drainage from the peat which then yields highly coloured water due to the additional availability of soluble organics.

These hypotheses, partly based on published laboratory and field experiments (Mitchell and McDonald, 1992), have been represented within a numerical model which estimates both the washout of colour and the store of soluble organics within the peat. An outline of the model is shown in Figure 33.3. It is driven by daily time series of rainfall and PE and has been successfully applied to a number of water-supply catchments within the Yorkshire Region.

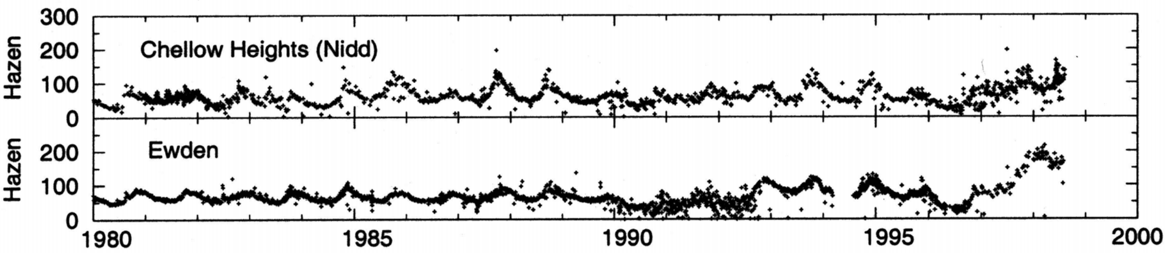

Figure 33.1 Observed water colour at Chellow Heights WTW and Ewden WTW

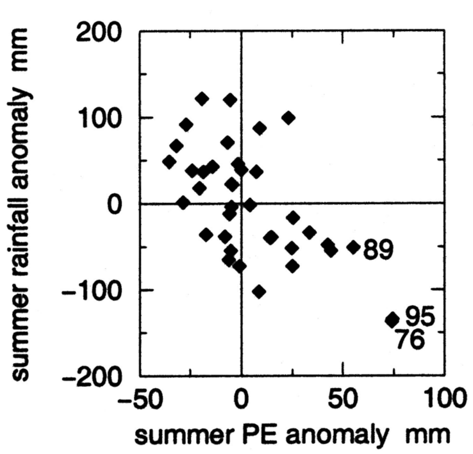

Figure 33.2 Significance of the 1995 drought

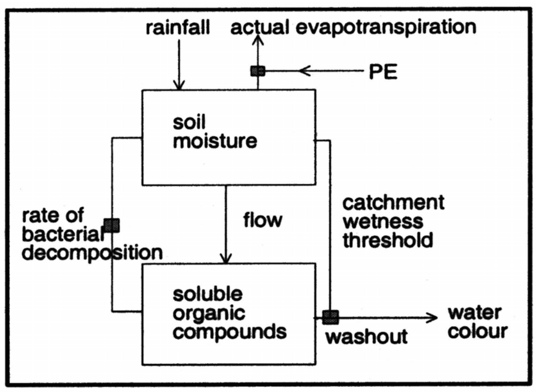

Figure 33.3 Outline of model

The model has also been used to investigate likely future levels of colour in these catchments. One immediate question is how long the enhanced colour levels shown in Figure 33.1 will last. An initial estimate of this has been made by applying the same 1980-1998 sequence of weather but using the final modelled value of the soluble organic store as a starting point. This is shown by the solid line in Figure 33.4; the original simulated series is shown by the dashed line. Different catchments have different behaviour. In the case of Angram, one of the Nidd feeder catchments for Chellow Heights, model results show that the enhanced soluble organics are washed out in 2-3 years. In contrast, enhanced values of modelled colour at Ewden last for about 8-10 years. The actual length of time, over which colour will remain at high levels will, however, depend on the actual future sequence of weather.

An initial assessment of the potential impact of climate change has been carried out using the most recent HadCM2 results to perturb the daily rainfall and PE series 1961-1998. This suggests that for the more northern water-gathering grounds, there will be a slight reduction in colour due to higher levels of soil moisture caused by higher rainfall. For the south Yorkshire sites, the climate change scenario used suggests that soil moisture will decrease and, therefore, there will be enhanced generation of soluble organic compounds within the peat. However, these will only be washed out under wetter conditions and, given the dependence of colour levels on the actual sequence of wet and dry years, further work is needed to assess this impact.

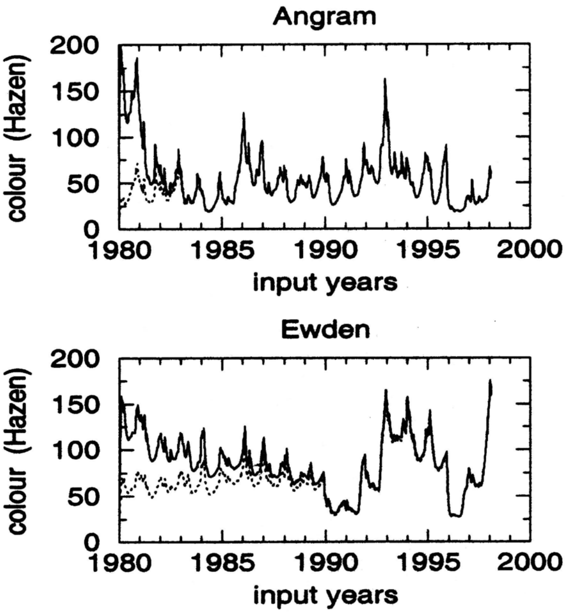

Figure 33.4 Expected duration of high colour

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Acknowledgements

This work was funded by Yorkshire Water and is published with their permission. The use of water colour data from YW, climate change scenarios from the Climatic Research Unit (UEA) and MORECS data from the UK Met. Office is acknowledged.

34. Conserving landscape ecology: the impact of climate change on soil moisture

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In understanding and conserving ecology at the landscape scale, soil moisture is one of the key factors which can be limiting on plant growth or change the competitive advantage between different species. While vegetation has a role in mediating water loss, soil moisture is broadly a result of climate. However, at the local scale, soil type and topography are important influences and, accordingly, a hydrological model has been developed to estimate this fine-scale variation in soil moisture across the landscape. It has been applied to assess the possible impact of climate change on the soil moisture of two upland areas of ecological interest: the Cairngorms (240 km^2) and Moor House in Upper Teesdale (264 km^2).

Fundamental to the model is the concept of a hillslope i.e. a strip of land extending from the catchment divide to a river channel. These hillslopes are defined automatically from a 50m digital terrain model and 1km soil database. These provide the basis for a simple hydrological model which explicitly represents the drainage of sloping land and accumulation of moisture, both downslope and in areas of convergence, such as wetlands, hollows and flushes. Parameters describing the lateral movement of water are calibrated using local catchment data and the model is run using daily rainfall and potential evapotranspiration data. An example of the spatial distribution of the simulated mean soil moisture on a 50m grid for the Cairngorm site in August is shown in Figure 34.1; wetter areas are shown in darker shades. The figure clearly shows the impact of topography, with wetter areas in the valley bottoms; more general darker areas relate to the presence of peat soils.

The model results can also be expressed as boxplots which show both the seasonal variation in soil moisture, expressed in terms of percentage saturation, and its variability across the site. Examples for the dominant soil types within the two sites are given in Figure 34.2. These plots show the median soil moisture (horizontal line), interquartile range (box), and the upper and lower extremes (square brackets). Any outliers are shown by plus signs. The spread of values results from the downslope drainage and different convergence/divergence of flow paths.

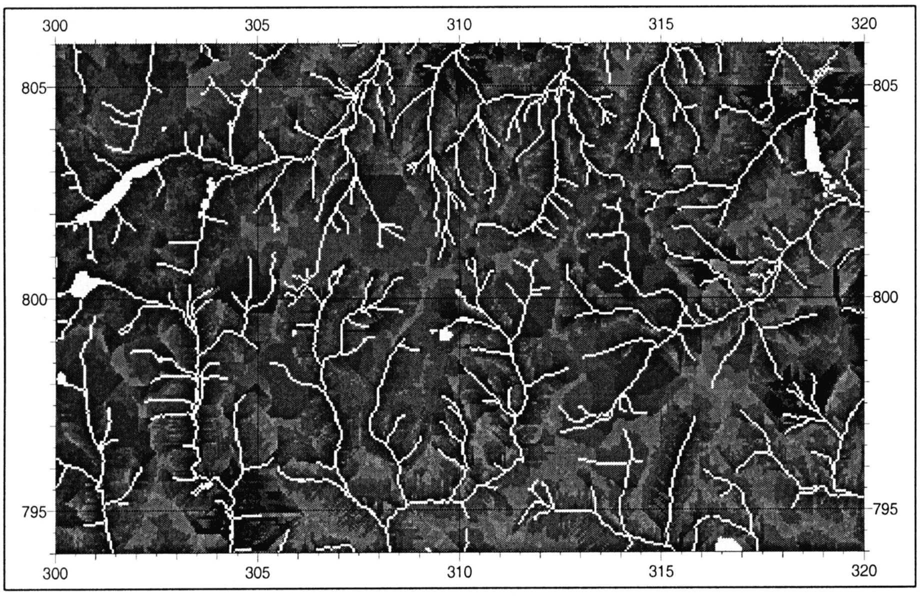

Figure 34.1 Monthly mean soil moisture for the Cairngorm site in August. Wetter areas are shown in darker shades.

The UKTR climate change scenario has been used to perturb the 1961-1995 daily rainfall and potential evapotranspiration series. Example results describing the modelled soil moisture change under this scenario are given in Figure 34.3. In the Cairngorms, these show a general increase in wetness, particularly in the autumn and winter. At Moor House, there is a slight change to drier conditions, especially in late summer and early autumn.

Another way of expressing the results which may be useful to conservationists is in terms of the change in area above, or below, critical thresholds for different plant communities. Thresholds of 90% (solid line) and 98% saturation (dashed line) have been chosen for illustrative purposes in Figure 34.4. The current climate is shown by the thick lines; the results from applying the UKTR climate change scenario are shown by the thin lines. In the Cairngorms, the area above these thresholds shows a marginal increase in the summer and large increases in the winter. At the Moor House site, there is a reduction in the area above these thresholds. These results, therefore, offer an indication of some of the constraints and possibilities for ecological change and conservation at these sites.

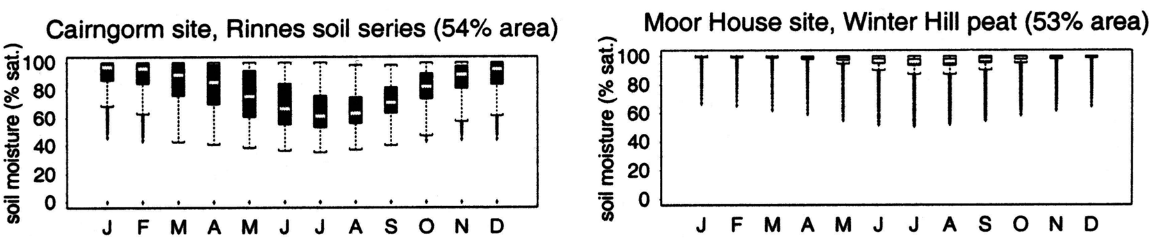

Figure 34.2 Modelled soil moisture distribution under current climate (after Naden *et al.* 2000, Copyright John Wiley and Sons Limited. Reproduced with permission.)

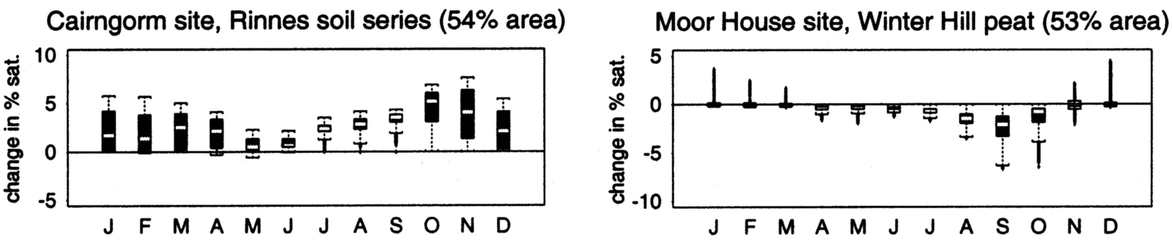

Figure 34.3 Change in modelled soil moisture under the UKTR climate change scenario (after Naden and Watts, 2001, Copyright Kluwer Academic Publishers, reproduced with kind permission from Kluwer Academic Publishers.)

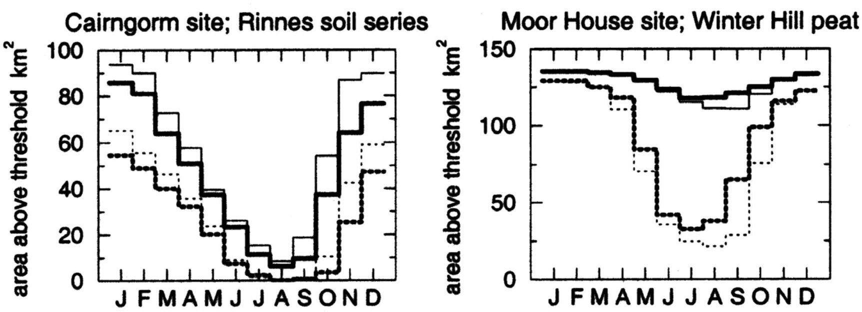

Figure 34.4 Area above 90% and 98% saturation thresholds (after Naden and Watts, 2001, Copyright Kluwer Academic Publishers, reproduced with kind permission from Kluwer Academic Publishers.)

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Acknowledgements

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35. The measurement of utilisation by grazing herbivores and heathland productivity for the Eastern Mournes ASSI

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Aim

The overall aim of the project is to achieve an appropriate stocking density for the Eastern Mournes, Co. Down, Northern Ireland based on sound scientific principles to address the issue of overgrazing. This Area of Special Scientific Interest (ASSI) was declared in 1995 because if its geological and physiographical features as well as its heathland and upland flora and fauna. The main aim will be achieved through the examination of three main objectives: 1) The measurement of heathland biomass and productivity, 2) The measurement of the utilisation of current year's growth of *Calluna vulgaris* by grazing herbivores and 3) The application of the Macaulay Land Use Research Institute (MLURI), Aberdeen Hill Grazing Management Model (HGMM) which can predict the outcome of various grazing management options.

The measurement of heathland biomass and productivity

Exclosure cages were erected in March 1998 across five heathland types: 1) High altitude sites (>550m), 2) Medium altitude sites (550 – 400m), 3) Low altitude sites (400 – 200m), 4) Blanket bog (heather growing in association with *Sphagnum* sp. and *Eriophorum* sp.) (mean alt. 465m) and 5) Climatically suppressed (heather kept short by severe climatic conditions) (mean alt. 660m). There were five sites for each type with two samples being harvested from each site at the end of the growing season from a 50cm x 25cm quadrat. All species were separated and weighed with *Calluna vulgaris* plants being subsampled into the following five fractions: 1) current year's flowers and flower buds, 2) current year's shoots i.e. long shoots and short shoots, 3) previous year's shoots i.e. all other green material, 4) dead material and 5) woody stems. The results for biomass and productivity are shown in Table 35.1.

The biomass values recorded were generally within the range found in the literature, whereas annual shoot production values for *Calluna vulgaris* were above those found in the literature for sites in north-east of Great Britain, but were within the ranges for England and Wales. The breakdown of biomass samples into the five major components allowed the examination of both the total biomass and the production of current year's growth of the heather plant. The relative proportions of wood (63%) and current year's shoots and flowers (16%) show that the majority of the samples taken were from swards dominated by older heather.

The measurement of utilisation current year's growth of *Calluna vulgaris*

The method used for the measurement of biomass utilisation was that devised by Poulton (1990) which allowed the investigation of spatial patterns of utilisation along with relating the levels of utilisation to a number of potentially explanatory environmental and biotic variables. In the field heather stems were sampled every 0.25km^2. At each sample site, heather stems were cut through 3-4 year old wood on the corners of a 1m^2 quadrat.

Table 35.1 Results for biomass and productivity

Heather type	Mean biomass of Calluna vulgaris (1998) gm^{-2}	Mean shoot production of Calluna vulgaris (1998) gm^{-2}
Blanket bog	1306 (s.e. 111.7)	188.5 (s.e. 17.1)
Climatically suppressed	698 (s.e. 30.8)	184.7 (s.e. 7.2)
High altitude sites	1301 (s.e. 103.3)	232.7 (s.e. 17.9)
Medium altitude sites	1839 (s.e. 174.8)	343.5 (s.e. 31.4)
Low altitude sites	2417 (s.e. 267.4)	456.9 (s.e. 47.8)
Level of sign. between altitude sites (P values)	P<0.001	P<0.001

In the lab the samples were cut 4cm from the crown to yield a sample of shoots. The shoots were then assessed and counted as grazed, ungrazed or indeterminate. The percentage of shoots grazed was then calculated to give a grazing index. A function was then used which calibrated this index in terms of biomass utilisation (giving a maximum figure of 60%) i.e. the proportion of the annual biomass increment which was lost as a result of sheep grazing. The overall mean utilisation rate of current year's growth of *Calluna vulgaris* for the Eastern Mournes ASSI during 1998 was 21.8% (s.e. 1.2). These utilisation rates could be said to above levels which are seen as appropriate for the long-term survival of heather within the study area, although no direct comparisons can be made with other studies as different techniques were used to measure utilisation. Regression analysis has shown that shorter heather found at lower altitude sites on steeper slopes and within a sward not dominated by *Calluna vulgaris* had a significantly higher utilisation rate than any other heather type. This heather type is the most vulnerable and least responsive to grazing.

Application of MLURI HGMM

The model has two main elements. The first element predicts the annual monthly dry matter production of a range of hill vegetation types at any altitude and latitude. The second predicts on a daily basis how sheep divide their time between vegetation types each month and how much dry matter the flock will eat from each vegetation type. The model predicts vegetation production across the UK using temperature zones based on mean July isotherms as potential growth indicators. Using a higher temperature zone than recommended in order to run the model (due to the higher productivity rates than recorded at sites of similar temperature ranges), the HGMM predicted that higher stocking densities and winter grazing produced the highest biomass utilisation rates. The outcome suggested that a site specific grazing regime is required in order arrive at an appropriate biomass utilisation rate of heather which should avoid conversion of heather dominated swards to grassland dominated swards for any one grazing area. If a grazing regime with specific stocking densities (e.g. 2 sheep ha^{-1} on dry heath as for agri-environmental schemes) is implemented to maintain heathland for conservation purposes, then it is strongly recommended that it be closely monitored to determine the impact of this regime on the flora and fauna of the study area.

Conclusions

Shoot production of *Calluna vulgaris* was generally noted to be above the values recorded for sites in north-east of Great Britain, but within the range for England and Wales. The average biomass utilisation of current year's growth of *Calluna vulgaris* was 21.8% and the use of HGMM predicted the greater impact of higher stocking densities and winter grazing. It also noted that a site specific grazing regime was required in order to arrive at an appropriate biomass utilisation rate of heather which would avoid conversion of heather dominated swards to grassland dominated swards for any one grazing area.

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36. The use of invertebrates as early warning indicators of land use changes

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Using invertebrates as biological indicators of change

Invertebrates are ideal biological indicators of land management change. There is a wide diversity and abundance of species in almost all habitats, their relatively sedentary habit allows the presence of most taxa to be related directly to environmental conditions at their place of capture, and qualitative sampling is easy and inexpensive (Furse *et al.* 1987).

The aim of the Habitat Characteristics Database is to characterise the faunas of the major upland vegetation types in Britain. The invertebrate groups chosen must, therefore, meet the objectives of the project in the following ways: 1) they must be sensitive to land management change 2) they have been widely monitored over upland areas in the past, and 3) data must have been collected in a standardised way.

Choice of invertebrate group

A basic level of skill is required to identify most invertebrate groups satisfactorily to species and this often proves costly in time and financial terms. Rather than sampling all invertebrates present in a habitat, a representative group can be chosen to meet the objectives of the survey in question (Lott and Eyre 1996). The target group chosen should be taxonomically stable, easily sampled, their distribution and ecology well documented and enough species to allow for discrimination between different forms of environmental change (Lott and Eyre 1996).

Ground beetles and spiders have been used extensively in the past, and large amounts of biogeographical and ecological information have been collected from Scotland, England and Wales.

Standardised invertebrate sampling method

Sampling methods must be standardised where possible if data is to be comparable. Spider species assemblage show extreme differences depending on the sampling method used (Børgesen 1984, in Clausen 1986), as do the ground beetles (Andersen 1995).

Pitfall traps are widely used to sample invertebrates. Their advantages are that they are time and cost-effective, training is not required to use them, and they can produce an impressive amount of data (Southwood 1978). They give estimates of relative mobility; can be used for qualitative assessment of different epigeal faunas, especially those which are restricted to one particular habitat, and they can provide information on the frequency of the species (Greenslade 1964).

It is the presence or absence of particular species that provides the pertinent information for the indication of land management changes (Luff 1996). Pitfall traps can, therefore, provide valuable information provided proper attention is paid to potential sources of variation.

Using invertebrates as early warning indicators of land use changes

The data accumulated in the Habitat Characteristics Database will be used to characterise the ground beetle and spider faunas of the upland vegetation types in Britain. To achieve this aim, the project will use a Discriminant Analysis Approach. This is achieved by; 1) deriving a species-by-site matrix e.g. using presence/absence data for ground beetle and spider species (Rushton *et al.* 1994), 2) classifying upland sites on the basis of their invertebrate assemblages using Two-Way Indicator Species Analysis (TWINSPAN) (Hill 1979), and 3) identifying the key environmental variables determining the classification between the groups of sites using multiple discriminant analysis (MDA) (Furse *et al.* 1987).

The Habitat Characteristics Database: a management tool

Often in environmental monitoring and conservation assessment, vegetation is one of the main criteria used to assess site quality or to indicate change. Habitats assigned on the basis of their invertebrate assemblages, however, can highlight less apparent differences between sites that are similar botanically. The Habitat Characteristics Database has the potential to become an important management tool for upland sites, a fundamental part of assessing upland site quality and an early warning indicator of land use changes.

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SECTION 5

Land management issues

Section 5 is a continuation of the collection of shorter articles originally presented as posters at the conference.

Papers in this section focus on issues related to management of the uplands. Edwards *et al* provide an interesting summary of the uptake of Environmentally Sensitive Area (ESA) scheme incentives. They show that around 60% of eligible land was under ESA agreement (indeed, this figure has risen to 69% by 2000). MacFarlane provides a case study from the Lake District ESA. This shows the challenges of managing a landscape which straddles many ownership areas. Gough summarises the Countryside Stewardship scheme, announced in 1999. Importantly, this has paved the way for unifying incentive measures outwith ESAs. It will soon be timely to review the success of this. Two other papers look at quite different facets of management in the uplands. Mills *et al* describe the formation of what should be a fascinating information base – The Peat Mass Movement Database. Many geographers, ecologists, naturalists, and indeed farmers and hillwalkers, have noticed peat landslides for these can be striking to the eye. The global database described by Mills *et al* should help us understand the cause of these landslides, and should shed light on some common elements of these across the world. Finally, Good *et al* report on work they were commissioned to undertake on the potential for woodland expansion in the uplands of England and Wales. Again presented in summary form, this paper suggests that there is potential for a three-fold expansion of woodland in Wales, and for 4% - 34% expansion in England, (depending on which region one considered). A particular challenge in these two countries, however, is that around 60% of the potential area for woodlands is designated as SSSI, based primarily on open features of the land. Taken together, these papers nicely touch on some of the more policy-driven or natural process driven aspects of management in the uplands.

37. Operation and uptake of upland ESAs in England

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Introduction

The Environmentally Sensitive Area (ESA) scheme was introduced by MAFF[10] in 1987 in five designated areas of England. Since then, a further 17 areas have been designated. Altogether, they cover about 10% of the agricultural land. Under the scheme, incentives are provided to landowners and farmers in these areas to manage their land in ways which conserve wildlife, landscape and historic features. The nine upland ESAs target heather and associated moorland habitats as well as the diverse landscapes of the hills, and valleys with their meadows, pastures, woodlands and wetlands.

Designation

The criteria for designating each area were as follows:

- the area must be of national significance;
- it must be a distinct area of environmental interest;
- conservation of the area must depend on adopting, maintaining or extending particular farming practices;
- farming practices in the area must have changed, or must be likely to do so, in ways that pose a threat to the environment.

Operation

The ESA Scheme is voluntary. Farmers who wish to participate agree to enter into a 10-year management agreement with MAFF. They are paid according to the amount and type of land they enter into the Scheme. Since no two ESAs are the same, the land management practices which farmers in the Scheme must follow are tailored to suit the needs of each particular ESA.

Most upland ESAs have two levels or tiers of entry:

Tier 1 - the guidelines for land management aim to protect and maintain the landscape, wildlife and historic features.

Tier 2 - the guidelines aim to achieve greater environmental benefits

MAFF considers the suitability of land entered into tier 2. If it is accepted, farmers receive increased payments for following the guidelines which impose stricter management conditions.

Supplementary payments are available for rebuilding walls, improving hedges and allowing new public access through pastoral land. In addition, ESA agreement holders may apply for grants towards the cost of environmental enhancement projects under Conservation Plans. These are aimed at improving particularly valuable features and may include, for example, the planting of new hedges, renovation of traditional farm buildings and restoration of ponds.

The entry of commons (shared grazing land) is encouraged, provided that agreement is reached by all those who have an active interest in the use of the land. In some ESAs, the areas are substantial and account for a high proportion of moorland. As the level of stocking on upland common land tends to be high, it is often difficult for the graziers to reach an agreement on reducing sheep numbers to meet prescribed limits.

The Scheme is administered by MAFF Regional Service Centres. FRCA (MAFF agency) Project Officers, supported by landscape and ecology specialists, survey the land entered into the Scheme, prepare the agreements and assist with the application and processing of Conservation Plans. MAFF and FRCA liaise with statutory agencies and other bodies which have an interest in conserving the environment.

[10] The former Ministry of Agriculture, Fisheries and Food, all functions of which are now being carried out by the newly-formed Department for Environment, Food and Rural Affairs (DEFRA).

Table 37.1 Uptake of ESA Schemes

Total eligible area (approx):	565,000ha
Total area under agreement (approx)	340,000ha
Proportion of land under agreement:	60%
Range between ESAs	30-80%
Proportion of area under tier 2 management	5%
Number of holdings under agreement:	4970
Proportion of holdings under agreement (approx):	65%
Range between ESAs	60-80%

Uptake

The general level of uptake is such that the ESA scheme is making a significant impact on maintaining and enhancing the environment in most of the designated areas. The lowest uptake is achieved where there is a high proportion of common land and it has proved difficult for the graziers to reach an agreement and be in a position to make an application to enter the land into the scheme.

The scheme can make a valuable contribution to the UK biodiversity action plans for upland habitats and helps maintain traditional agricultural systems and skills. Through Conservation Plan grants, income is channelled into the rural economy. In this way, rural employment is both supported and created.

38. The potential for woodland expansion in the uplands of England and Wales

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In the 1995 White Paper, *Rural England*, the Government set a target for the doubling of woodland in England by 2050. A similar target was set for Wales in the 1995 report of the working group on forestry, *The Way Ahead for Welsh Forestry*. Both these policy documents called for sustainable new forests and woodlands that would provide multiple benefits, including improved landscapes, wildlife conservation, recreation and amenity, as well as timber production. Both documents acknowledged that achieving such a substantial increase in woodland cover would hinge on improvements in the relative economic benefits to farmers and landowners from forestry as compared with agriculture. This would depend, at least in part, on reform of the European Union Common Agricultural Policy.

In response to these initiatives we were contracted in 1995-96 by the Countryside Council for Wales to determine the potential for woodland expansion in the Welsh uplands, taking account of impacts on farming operations and farm incomes, landscape and ecology. Subsequently English Nature contracted one of us (CEH Bangor) to carry out a similar study, but including only outline consideration of the agri-economic dimension, in the upland National Parks in England.

Both studies involved a two-stage approach. First, we carried out office-based assessments of potential areas suitable for woodland expansion above the 250m contour. This was done by mapping (in a GIS) the characteristics (geology, soils, elevation, slope, aspect) of land with woodland cover and identifying similar areas which are not currently wooded. We also canvassed both expert and lay opinion on the desirability of woodland expansion, possible constraints and the likelihood of achieving a substantial increase. The methods which could be used to assess the ecological costs and benefits of new planting in particular areas, and the most appropriate forestry procedures for establishing and maintaining the new woods were also described. In the second phase we did detailed assessments of existing woodland cover and identified potential new woodland areas and types in a range of contrasting study areas. These studies involved site visits and, especially in the Welsh study, pooling of landscape, forestry, agri-economic and ecological expertise through discussion and the development of an integrated GIS-based approach. This allowed the development of agreed planting proposals for each study area, which took account of a range of potential constraints. The conference poster gave an example, with colour maps, which could not be reproduced here.

Table 38.1 Distribution of major vegetation types

Vegetation type (ITE land cover class)	Potential area for woodland expansion in hectares (%)
Managed grass (6)	245923 (43)
Heath/moor (10 and 11)	89926 (16)
Montane/unimproved grass	61948 (11)
Bracken (12)	33282 (6)
Other	144659 (25)
Total	575738 (100)

Note: Vegetation types are as defined by the ITE Land Cover Map, in the areas currently unplanted above 250m elevation in Wales but which have similar characteristics to land currently carrying woodland, and which are considered potentially suitable for woodland expansion.

The assessments of potential areas for woodland expansion showed that in the absence of imposed land use constraints there was no shortage of suitable land in upland Wales or in the English National Parks. In Wales there was room for a threefold expansion, almost half onto managed grassland which was considered to be of low conservation value (Table 38.1). The 6% of land identified as being bracken infested (>60% cover) was highlighted as being particularly appropriate for woodland planting in *The Way Ahead for Welsh Forestry* and has subsequently been the subject of a targeted Forestry Commission Challenge Fund initiative.

In the study areas within the English National Parks the areas potentially available for woodland expansion varied from as little as 4% in Northumberland to 34% on Dartmoor. However, when landscape, ecological, agri-economic, and especially archaeological constraints were taken into account on Dartmoor, it became clear that the proportion of the land area likely to become available for woodland expansion was considerably less than 34% and probably less than in Northumberland. Similarly, in Wales we found that the study area with the least extant woodland cover and the largest area of unplanted land suitable for woodland expansion was that most hedged around by landscape, agri-economic and ecological restrictions. Economic analysis showed that the whole of this study area was within a Severely Disadvantaged Area, which ensured the highest levels of CAP livestock headage payments to farmers. Loss of open areas to forestry would, in many instances, have reduced the area of land and hence the number of grazing animals on which headage payments could be claimed. Current grant schemes for woodland establishment and management could not in most cases make up the balance, resulting in a net loss of income when converting land to forestry. In addition, >60% of the study area was affected by national (SSSI) and/or international (Special Protection Area for birds, nominated Special Area for Conservation) nature conservation designations based primarily on the openness of the site. It was considered unlikely that woodland expansion on anything more than a trivial scale would be acceptable while retaining these designations. In contrast we found, paradoxically, that in the richer, more wooded countryside of the Welsh/English border, where subsidy payments are a less important component of farm incomes, and landscape and nature conservation guidelines favour woodland maintenance and expansion, there are better opportunities for achieving substantial new woodlands.

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39. Countryside stewardship 1999: a comprehensive new approach for the uplands

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MAFF[11] were committed to reviewing the Moorland Scheme before the end of its five-year pilot phase and incorporating the lessons learned into the Countryside Stewardship (CS) scheme. As a result of the review MAFF has revised the CS scheme to incorporate a range of new items that are designed to replace the Moorland Scheme and help protect and enhance the wildlife, landscape history and amenity on upland farms.

The Moorland Scheme aimed to improve and conserve heather moor through payments for grazing fewer sheep. The scheme was considered unsuccessful due to its limited uptake and has been closed to new applications.

CS does not require the removal of stock from the farm business in the same way as the Moorland Scheme. However, a key feature of the new package is the requirement for applicants to submit a survey describing all the environmental features on the holding. This will enable applicants and project officers to consider the most appropriate elements to be included in the agreement and ensure that changes in the management of one area do not result in damage elsewhere on the holding.

Under CS not all land has to be brought under agreement. Areas that have lower environmental potential may continue to be managed more intensively which gives the farmer flexibility of management and ensures that the schemes resources are targeted on features that offer greatest environmental value for money.

The 1999 enhancements to the CS scheme provide, for the first time outside ESAs, a comprehensive range of upland measures within one agri-environment scheme. The popularity and effectiveness of the CS upland menu and approach will need to be considered in the light of experience.

The conference poster illustrated the latest developments in agri-environment measures for the English uplands outside ESAs.

[11] The former Ministry of Agriculture, Fisheries and Food, all functions of which are now being carried out by the newly-formed Department for Environment, Food and Rural Affairs (DEFRA).

40. Principles of landscape ecology and management of the conservation estate: a case study from the Lake District Environmentally Sensitive Area

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One of the most significant shifts of recent years in thinking about conservation has been the reorientation of focus to the landscape scale. This, in turn, has been associated with the growth of interest in landscape ecology, with a research agenda that is characterised by multi-disciplinarity, a regional scale approach and a central interest in connectivity and coherence, both ecological and aesthetic. However, in spite of advances in understanding in both the social and physical sciences, there is a significant disjunction between the largely scientific research into the ecology of landscapes and regions and the contribution from the social sciences. Landscape ecology has an explicit concern with geography; the spatial arrangement and interaction of landscape components over space. If these components are defined as including the socio-economic fabric of the landscape and the cultural legacy of socio-economic structures through history, in addition to the physical landscape and ecological mosaics, then it must be acknowledged that landscape ecology is significant as a framework or forum for increasing communication and collaboration between researchers and practitioners with a shared concern for rural environmental sustainability.

Landscape ecology focuses on the spatial configuration of elements in the landscape, but most of the social science research into the conservation behaviour of farmers and land enrolment in Agri-Environmental Policy (AEP) schemes has overlooked the significance of this spatial configuration: the patch-corridor-mosaic model. What this research evaluates is the degree to which the principles of landscape ecology may be considered as a framework for the spatial organisation of AEP management agreements and management prescriptions. Applications of Geographical Information Systems (GIS), remote sensing and aerial photography are important tools in landscape ecology and have been used to identify and map patches, corridors and other characteristics of the landscape mosaic. These features may be nature reserves, other designated sites or features of conservation interest in the wider countryside, but all the features are contained within, or distributed across, farms or other land management units. It becomes important, therefore, to understand how farmers' conservation behaviour over space maps out relative to these features of conservation significance.

The paper builds on previous arguments that certain localities or features of conservation significance are best managed not in isolation from the surrounding landscape, but explicitly in the context of the wider landscape (MacFarlane, 1998). This will require, for many localities, a way round 'the problem' of landownership, whereby neighbouring land managers are pursuing different strategies and practices on their land which may be either insensitive or actually damaging to the prospects of obtaining either ecological or aesthetic objectives for particular landscape elements or the wider matrix that makes up the visible landscape. Landscape ecology is concerned with the ecological functionality and aesthetic valuation of landscapes, and the derived landscape management principles are multi-scaled in so far as they prescribe management requirements for patch and linear features, but with always with an eye to the overall matrix that is the landscape. It could be argued that these principles presuppose the control and authority to implement management at the landscape scale. In the context of North America, where National Parks are state owned, this may be an acceptable assumption and managing authorities have the geographical scope to manage the land and conservation resource with a very broad overview. In the UK context, land holding is far more fragmented, only a very small minority of protected areas are state owned and few of these are of a significant size. One of the major obstacles to the utilisation of the theoretical principles of landscape ecology as a framework for planning and management of large areas is obtaining the co-operation of landowners, for many landscape and ecological features, such as riparian corridors, may span a number of different landholdings, and management practices are often inconsistent across those boundaries.

Although the design principles for sustainable landscape management have been established, or at least drafted out, the control necessary to implement those designs is difficult to attain. In spite of the difficulties presented by fragmented land ownership and differing perspectives and practices relating to conservation, this research challenges the assumption that present patterns of farming and landholding are incompatible with the attainment of landscape scale conservation management.

The poster presented the results of a study which has evaluated the scope for multiple-farm collaboration over conservation management planning within the context of the uplands of the Lake District Environmentally Sensitive Area (ESA), using a range of spatial datasets, integrated using the ArcView GIS. Within the Lake District ESA enrolment of land into the scheme has been high, but the structure of the enrolment, management and monitoring methodologies place no emphasis on the pattern of agreements, or how synergies may be attained through an attention to the specific landscape-ecological context of the farm; although the conservation significance of particular sites can be ensured through sensitive management of patches within the landscape, horizontal coherence is often left to the accidental or fortunate synergies arising from neighbouring land managers' activities and strategies (MacFarlane, 2000a, b). It is rare, outwith areas of large scale landownership, that parcels of land owned by various people are managed in a way that encourages these synergies; conversely the scope for the development of intrusive human artefacts, the destruction of semi-natural or other valued features and fragmentation of linear features such as stone walls or riparian corridors is often high. The poster presented the preliminary results of further analysis into the habitat requirements of selected species of conservation significance, and their spatial configuration relative to the pattern of farm boundaries, across which collaborative management agreements could be negotiated.

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41. Peat mass movements: a world and regional database

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Peat landslides represent a relatively understudied form of rapid mass movement common in blanket peat areas of the UK, Ireland and abroad (including Australia, the Falkland Isles and Canada). Carling (1986) following Bower (1959) classifies peat mass movements as slides and flows on the basis of form and process. In most of the reported cases, peat failure is ascribed to rainfall induced instability over a mineral soil or alternative substrate. Figure 41.1 shows all the documented mass movement sites recorded in the UK (excluding Northern Ireland), and demonstrates that their distribution in time and space is widespread.

In the North Pennines, 18 individual peat mass movement sites have been identified. Some are clustered in close proximity (e.g. on Noon Hill, Carling 1986; Stainmore, Huddleston 1930 and Crisp *et al*. 1964), while others exist in apparent isolation (Feldon Burn Head, Johnson 1992; Hart Hope, Warburton and Higgitt 1998). Similarities in local geomorphic conditions within clustered sites, and the variability between sites suggest a regional approach to the study of peat mass movements, through the comparison of geomorphic, geotechnic and peat blanket properties. Such an approach is being applied to the problem of peat slide initiation, the mechanisms by which they develop during the sliding process, and their recovery subsequent to failure.

Peat mass movement initiation and movement mechanisms may be examined in part through the use of analytical databases, whose components represent quantitative and qualitative assessments of spatial and temporal form and process. Such an approach allows the cross-examination of sets of related (and seemingly disparate) variables, as well as a quick and easy to read summary of key aspects of geomorphological, contextual and bibliographic data. The large and detailed datasets for the North Pennine examples lend themselves particularly well to analysis incorporating such databases.

This work demonstrates the application of a database approach to peat mass movements in the North Pennines in the context of a global set of peat mass movement studies.

The Peat Mass Movement Database is divided into several themed sections:

- *General Description* incorporating information about location and references to each slide and the antecedent conditions;
- *Morphological Characteristics* describing the presence or absence of key peat slide features such as levées, blocks, tension cracking and pipes, as well as the geomorphological classification of the event and its links to other geomorphic systems;
- *Material Properties* quantifying a range of basic geotechnical properties commonly used in slope studies, and a set of material descriptions pertaining to the failed material, the material beneath it and the failure/shear plane that divides the two material bodies;
- *Morphometric Characteristics* examining basic geometric properties of slide sites including length, width, depth and volume excavated and slope angle and form.
- *Recovery Characteristics* used to quantify post-failure landscape change within the areas affected by peat landslides.

Over 60 variables can be examined, or used in combination in the study of peat mass movements. A further development of the database is to construct a peat slide susceptibility algorithm, incorporating weighted controlling factors (determined by analysis of database variables).

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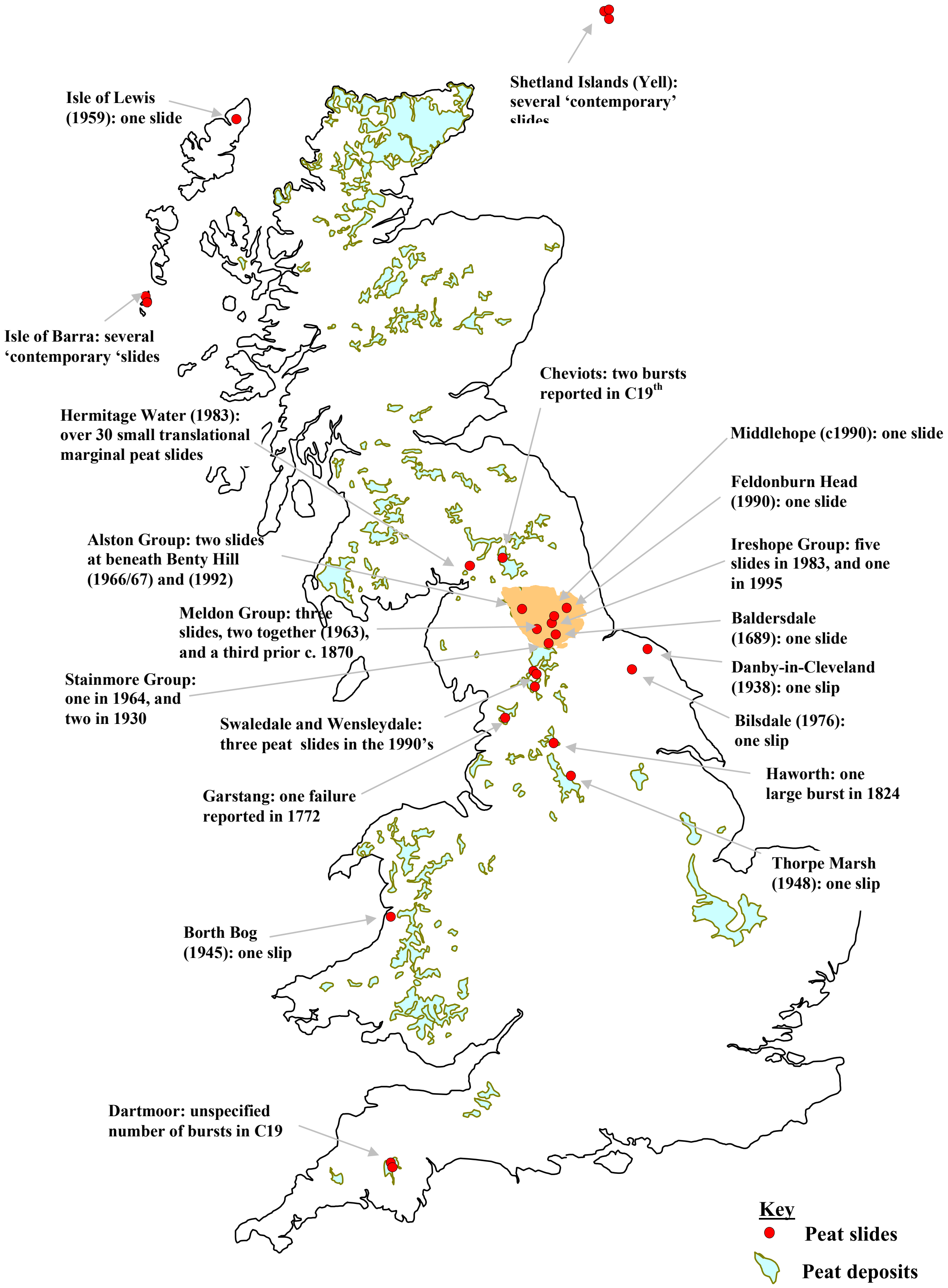

Figure 41.1 Peat resource and peat mass-movements in England, Scotland and Wales (after Taylor, 1977; does not include shallow peats)