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ECOLOGY IN THE 1980s

II. Report of a discussion in northern England

edited by

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PREFACE

This Research and Development paper contains a summary of the first regional conference by the Institute of Terrestrial Ecology (ITE) on the subject of Ecology in the 1980s. It was concerned with northern England, with particular reference to the uplands, and was designed to develop a dialogue between research ecologists and the users of ecological information. The conference was held at the Cumbria Grand Hotel, Grange-over-Sands, Cumbria, on 13 and 14 April 1981.

The conference was opened by Mr J N R Jeffers (Director, ITE) and Mr J C Dunning (Countryside Commissioner and Farmer). The number of major subject areas were identified and each was introduced by two speakers, one speaker representing the user interests and identified some of the problems which he considered relevant to ecology; the second speaker identified the contribution which can be made by ecological research. These introductory comments were followed by open discussion. The introductory comments and a summary of the discussions constitute the central part of this R & D paper. Mr Jeffers concluded the conference with a summary of ITE's approach to ecological research and Mr Dunning emphasised the importance of integrating our land use policies.

ITE would like to thank the many people who participated so actively in the discussions and the staff who worked so efficiently to ensure the smooth running of the conference.

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ECOLOGY IN THE 1980s

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1 INTRODUCTION

ECOLOGICAL RESEARCH IN THE 1980s

J N R Jeffers

Early in 1980, I posed 4 questions to the staff of ITE:

1. What are the really important ecological issues for the 1980s?
2. How much of ITE's present research is relevant to these issues?
3. What do we need to do to increase the relevance of our research in the 1980s?
4. How can we best work on these issues with other Institutes, with the Universities, and with the organisations and individuals who might use the results of our research?

These questions led to much active discussion in each of ITE's research stations. Some of this discussion was informal, but there were also several more formal workshops arranged to discuss particular issues at greater depth. The results have been brought together in internal papers, and have been summarised for ITE as a whole.

Naturally, our answers to these questions have been those of professional ecologists from a wide range of scientific disciplines. There has been a bias towards applied research, but we have emphasised the importance of a strong investment in fundamental research. Knowledge of the basic ecology of populations and processes is essential if applied research is to have a sure basis from which to start. Our experience of commissioned research has confirmed that solutions to environmental problems can only be derived from long term programmes of fundamental research. When rapid answers to complex questions are needed, it is better to rely on a sound knowledge of processes than on intuition and on short term empirical research.

It was always intended that, when we had cleared our own thoughts on the ecological issues of the 1980s, we would ask the same questions of the wider community of interest in the rural environment. This is the first of 4 symposia on 'Ecology in the 1980s', which will be run by ITE, and it will concentrate mainly on the problems of the uplands of Britain. A further symposium, dealing mainly with the problems of the lowlands, will be run early next year, and the other symposia will be run, one in Scotland and one in Wales, later this year.

In this particular symposium, 6 main themes have been identified as a focus for the discussion, namely:

- Rural land use planning
- Industrial effects on land
- Future forestry practices
- Land-water interactions
- Developments in upland agriculture
- Conservation, recreation and amenity

In addition, however, demonstrations of ITE's research and publications have been arranged, and there will be opportunities for participants to visit the nearby Merlewood Research Station to see some aspects of ecological research which have not been included directly in this symposium, particularly research on chemistry and systems analysis.

THE PROBLEMS OF THE UPLANDS

J C Dunning

1 The uplands (or 'less favoured areas' in EEC jargon) comprise 42% of the agricultural land area of the UK. The way in which the nation utilises this substantial part of its land area is of the utmost significance to both the economy and the life of the nation.

2 The demands which society places on the uplands have broadened and intensified over the past 40 years. There has not been a time when the resources of the uplands were more relevant to the needs of the nation.

3 Agriculture remains the most important land use in the uplands; however, returns from livestock production have become progressively less able to support upland communities and services, and less able to sustain other national purposes which depend on the management of agricultural land - all this in spite of an element of social support in national and community aids to less favoured areas.

4 During the past century, the economy of most upland areas has changed dramatically from an agricultural economy supporting a substantial population which was self-sufficient in most goods and services, to the much reduced population of an extensive agriculture, limited to a narrow range of farm products, buying in most of the goods and services it required. More recently this process has gone much further, but superimposed upon the hill farming economy have emerged many new economic resources such as forestry, tourism and minerals extraction, whilst public demands like water conservation, landscape and wildlife conservation, and public recreation have become the major national concern in large parts of the uplands especially in England and Wales.

5 For historic reasons, the various old and newly emerged roles of the hills have been developed, promoted and administered entirely separately, led by often remote, single purpose government agencies and supported by vociferous pressure groups. The result has, in many cases, been a series of divergent departmental policies which have often resulted in bitter conflict, or unsatisfactory compromise.

6 The UK then has no uplands policy. Each department seeks to protect its interest in the hills either by acquiring land, or by placing a statutory restriction on its use, or by financial inducements, or by paying compensation.

7 These self-defeating conflicts inflict increasing damage on the economy and every other interest as well as increasing the burden on the Treasury. The alternatives are simple, either we must accept a division of land uses, according primary designations, with each interest protecting its patch, and with an increasingly derelict upland economy, or we must integrate our many purposes in the hills and reshape the policies by which our separate purposes are achieved to enable each to prosper by serving its own, and other, purposes simultaneously in the totality of the upland economy.

8 Very little research has been done in this vital field which includes the ecological implications of combining different land uses; the effects of different management systems in facilitating multiple uses; the possibilities for increasing the benefits to several objectives at the same time, by the use of different species or techniques. For example there is need for further research on the interaction of farming with forestry, or the protection of habitats, or landscape conservation, or recreation, or tourism, or small manufacturing or processing enterprises, or indeed any combination of these and other possibilities. New pressures and the changing economic climate now demand that we make full and careful use of our resources in the hills. We still lack the knowledge in many of these interconnected fields which could enable these demands to be answered and reconciled.

2 RURAL LAND USE PLANNING

INTRODUCTORY COMMENTS

J F B Tew

Until the end of World War II, changes of use (or user) in rural areas have, for the most part, taken place in an unplanned manner. It is often said that much of our rural landscape pattern originated during the 18th century enclosures. This is to some extent true as one of the consequences was to reduce the number of trees to provide hundreds of miles of fences within the enclosed land. But it was largely an acceleration of processes in operation for centuries which collectively and gradually changed the balance between man and his environment.

More formal planning processes were developed after 1947 under the auspices of the Ministry of Town and Country Planning. It is generally conceded that the initial concentration was on urban planning, and that the full range of subjects (and even the machinery) to form the basis of rural planning even now requires further debate.

One of the salient features of the period 1955-1980 has been the identification of increasingly severe damage to the countryside and its natural habitats and the extinction or near extinction of species of fauna and flora. Alarm at this situation has resulted in the growth of strong conservation interest and a conservation lobby which seeks a much greater say in how the countryside as a whole is planned. Agriculture is the main user of our rural areas and therefore is held to be the main offender in the damaging changes.

The role of agriculture is clear and has been set in a background which requires increasing productivity from a diminishing area of farmland. The demands for residential and industrial land - often at the expense of high quality agricultural land - have led to further inroads by farmers into the residual uncultivated areas, often rich in important habitats. In the lowlands, this has been at the expense of woodland, raw peat, marshes and the coastal fringe. In the uplands, there have been changes in the moorland fringe, itself a notoriously shifting margin, indicative of economic pressures.

Other pressures, notably those created by forestry, water supply and recreation, have however added to the overall land take. Further major expansion of forestry, both state and private, is envisaged. Much will be in upland areas. Likewise the demand for water will stimulate the need for impounding reservoirs and water catchment areas within the uplands, though the demand for farm reservoirs will be in the lowlands. Recreational needs basically can be satisfied by setting aside certain areas for public access and use, but the impact on habitats should not be overlooked.

We thus see changing pressures on rural areas largely denuded of people but otherwise required for a greater variety of resource allocations. These processes and the changes they initiate, and maybe perpetuate, are largely a step into the unknown. Careful monitoring of cause and effect - and the many inter-relationships - thus becomes essential if we are to plan to best overall effect.

The effects of management practice on moorland insofar as internal and peripheral changes are concerned need careful attention. This raises the question of what happens when moors are reclaimed, and, just as important, what is the sequence of events after reversion. How does afforestation and the management of forests of different species affect adjacent areas? What habitats can be created and how can they be developed? What is the sequence of events in new water catchments where existing uses may be precluded or modified? What are the effects of different - even new - forms of agricultural management on the surrounding land? Does the over-use of recreational areas have a marked and irreversible effect? And are schemes for marshland reclamation really as damaging in the long term as much current opinion alleges? These are just a few of the more general questions it may be pertinent to pose. How the questions should be answered remains.

Those with an interest in agriculture - and the conflicts, real or imagined, with those who seek to conserve - are not unsympathetic to the interests of ecologists, though conservation and ecology are not necessarily synonymous. We feel there is a real need to be better informed on many facets of the inter-relationship. There is a pressing case for what might be termed ecological atlas information; for better documentation of sites which are of interest so that likely conflicts have a sounder basis for debate. Finally, there is a need for long term monitoring of change and the processes of change so that decisions can have a sound factual basis.

INTRODUCTORY COMMENTS

O W Heal

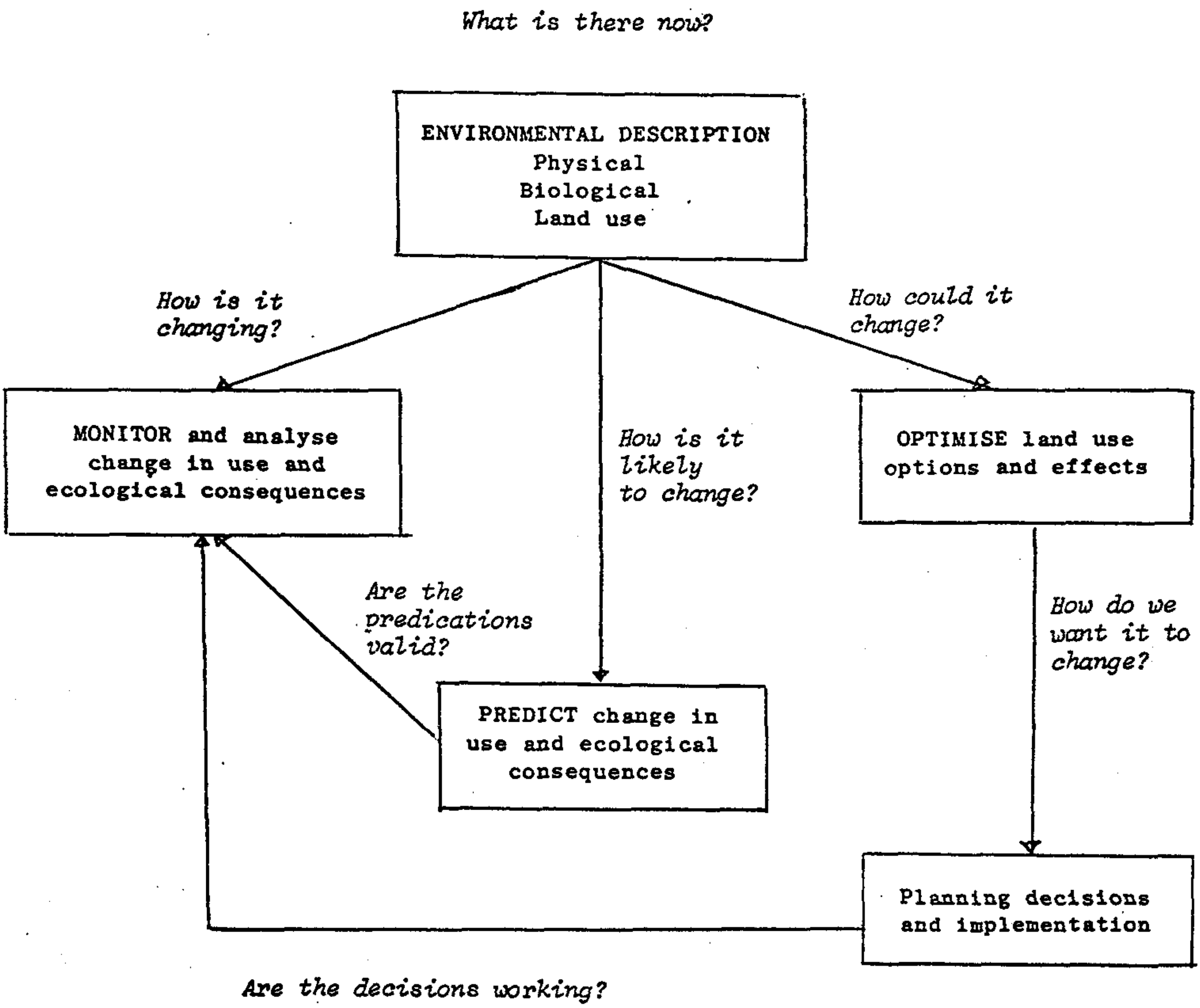
Rural land use is largely outside the formal planning machinery. Nevertheless, plans are developed by individual land owners, commercial organisations and statutory bodies. In some cases these are concerned with increasing production by a change in management or use, others are concerned with the retention or re-establishment of particular wildlife or scenic features. Thus changes in land use and interactions between uses are real issues which are subject to informal planning, public and private debate and pressures.

The key questions, and their inter-relationships, in any area of planning are identified in Figure 1. How can ecological research help in answering these questions?

1 What is there now and how is it changing?

Most user groups have established methods of environmental description, survey and monitoring, designed to provide information for specific limited questions. In contrast, ecological research should focus on providing a common base-line to which the various land uses can be related and on the monitoring of the effects of single and multiple uses.

Figure 1 THE MAIN QUESTIONS AND ACTIVITIES CONCERNED WITH RURAL LAND USE PLANNING



2 How could it change?

Given that most users are concerned with immediate problems with economic return, they have limited opportunity to examine alternative management options, especially those which combine features of interest to other users and compromise their own returns. Ecologists can assist in selection of alternative options especially where these require an understanding of the characteristics of uncultivated plant and animal species and soils.

3 How is it likely to change?

Probably the most important, and most difficult, contribution that ecological research can make is to predict the consequences of current and alternative land use practices to the system (plant, animal and soil) and to adjacent systems. The immediate effects, both in space and time, may be apparent to the user, but long term effects and those resulting from interacting factors are unlikely to be considered by the user and planner. To predict ecological consequences requires understanding of the dynamics of populations and processes. The test of our understanding is whether or not we can predict the effects of management to the level of accuracy required by the users.

SUMMARY OF DISCUSSION

D G Robinson

In introducing his paper, Mr J F B Tew of the Ministry of Agriculture, Fisheries and Food (MAFF) Land Resources Division (representing the user viewpoint), emphasised the importance of investigating the potential for land use change in the uplands. He illustrated the contribution to joint studies of these issues that can be made by an agency with concern for the future of a particular land use by reference to the use of MAFF's Hill and Uplands Survey in two recent studies of areas in the Pennines - the South West Moorlands of the Peak District and the West Pennine Moors, north of Bolton. In such policy studies for upland areas he saw potential for ITE research to contribute valuable knowledge on the ecological inter-relationships between uses and the relationship between management practices in a particular use and the area's natural resource characteristics. In a more general sense he attached considerable importance to ITE's strategic survey work which might provide consistent national 'baseline' data on land use, vegetation and wildlife distribution and the subsequent regular monitoring of change. Disputed, and widely varying, current estimates of loss of mosslands provided a typical illustration of the need for consistent and reliable data on rural land use change. In particular, MAFF hoped that ITE's data bank and monitoring work would go some way towards the compilation of more reliable statistics on rates and types of agricultural land loss.

The paper presented by Dr O W Heal of ITE asked the Group to explore how best ITE's work might contribute to answering 3 questions of major importance in the planning of the uplands:

1 What are the resource and land use characteristics of the uplands and how are they changing?

2 How could the land use change in the future? What are the alternative management and use changes that can be hypothesized from present knowledge and trends?

3 How is it likely to change? Can we predict the long term ecological consequences of current and prospective alternative land use practices and systems and thereby provide guidance on the ways in which land can best be used in order to conserve the natural resources? (Guidance and information that could be set alongside social and economic considerations in future planning.)

In introducing his paper Dr Heal focussed attention on the various levels of ITE's potential contribution. The range began with more basic work such as studies of the long run effects of land uses (in both single- and multiple-use situations) on the ecology of the uplands; and national/regional surveys of land use, vegetation, etc with monitoring of subsequent changes. As mentioned in the paper, however, the range might extend to prediction of the ecological effects of alternative land use futures. Dr Heal was particularly anxious to have the views of the Discussion Group on whether such strategic-level work, which could include attempts to predict the effects of national or regional policies of sectoral agencies and assess their compatibility, was an appropriate area for ITE involvement.

In discussion there was considerable support for the view that the best future for the uplands lay in more integration of the land use activities; with more multiple-use/multiple-enterprise diversification both at farm holding, forest unit, or individual water catchment level and on an upland district basis. In such diversification new enterprises such as energy cropping of bracken could not be discounted. More integration implies more coordination of the planning of sectoral agencies concerned with agriculture, forestry, water, nature conservation, landscape and socio-economic development - influenced by a real acknowledgement of the inter-relationships in resource use. As initiatives for more coordinated planning have not been noticeably effective in the past, the role that dissemination of findings from ITE research might play in influencing 'harmonisation' of policies was much emphasised. In this respect considerable importance was attached to the neutral and objective standing of ITE. As a Natural Environment Research Council (NERC) Institute it is not attached to any particular user interest. Because of its concern with system inter-relationships, ecological information and prediction supplied by ITE research can help to ensure that both sectoral and joint planning for future upland land use takes due account of the need for an integrated approach. It was suggested that consideration should be given to establishing experimental projects which included ITE involvement in a number of selected upland districts. Whilst the Group thus supported the concept of development of ITE work on ecological considerations involved in strategic land use policy, participants were also conscious of the importance of the parallel programme of research on individual organisms and specific ecosystems which supplies knowledge of direct and immediate relevance to detailed land use planning and management. In this connection specific reference was made to 'post-development audits' of new or intensified aspects of rural land use, eg multi-purpose land use areas, intensive recreational sites, etc. This was seen as part of the general need for development of work in the area of Environmental Impact Assessment methodology.

3 INDUSTRIAL EFFECTS ON THE LAND

INTRODUCTORY COMMENTS

T M Roberts

The environmental effects of large-scale industrial development result from direct land loss or indirect effects resulting from increased transportation, emissions to atmosphere and aquatic discharges. Direct land loss (for the development site, increased quarrying and waste disposal sites) will inevitably increase pressures on conservation interests. There will be an increasing need, in these times of cost-benefit analysis, for ecologists to produce computerised data banks on important habitats to help develop objective methods for quantifying the 'conservation value' of threatened sites. For example, in the electricity industry the development of nuclear stations and large barrage schemes will increase the need for pumped storage power stations. These must necessarily be located in mountainous areas so the significance of effects on moorland ecology must be quantified (eg loss of rare species, habitat loss, peat erosion, etc).

For atmospheric emissions, the last decade saw an evolution from concern for localised effects (eg heavy metals around smelters, SO_2 and HF from steelworks, etc) to concern for ecological effects on a regional (acid rain, photochemical smog) or global scale (carbon dioxide). The lesson of the last decade is that environmental problems require inter-disciplinary research. Slow progress in quantifying the effects of acid rain is partly due to the complexity of interactions between terrestrial and aquatic ecosystems and research is likely to continue well into the next decade. Another regional problem is likely to arise from the formation of photochemical smog in Europe. The past two decades have seen an increase in the products of photochemical reactions (aerosol sulphate and nitrate). Although direct measurements of ozone date back only to the early 1970s, it is now clear that emissions of NO_x and hydrocarbons in northern Europe are sufficient to result in photochemical smog formation under suitable climatic conditions (eg the summers of 1975 and 1976). Nevertheless, the frequency and magnitude of episodes are well below those recorded in California and considerable research will be needed to determine the effects on plant growth.

There is likely to be pressure from the EEC in the next decade to modify the 'best practicable means' of pollution control in the UK to incorporate air quality objectives. The EEC directives for lead and sulphur dioxide have already been issued and the NO_x directive is currently under discussion.

The projected expansion of the nuclear industry will focus attention on the ecological significance of released radionuclides and waste disposal. In particular, research effort will focus on the nuclides unique to PWR discharges and not released by the AGRs currently in operation. It is difficult to foresee the ecological consequences of other 'novel' developments. For example, the environmental effects of emissions from coal liquefaction and gasification developments will need some consideration.

The changing nature of industrial processes will certainly generate some new problems for ecologists involved in reclamation problems. For example, industrial oil-fired furnaces will be replaced by coal-fired fluidised-bed furnaces. The next decade may even see these furnaces introduced into new power stations. This will result in an increase in the volume of wastes and a change in the chemical composition of the fuel ash. With foresight, these waste products may even be used for reinstatement (eg clay workings, etc).

Finally, there are some implications for ecologists in the EEC directive on Environmental Impact Assessment (EIA). Although the member states are to be given considerable flexibility in their approach to EIA, there is certain to be a need for more comprehensive data banks on conservation interests, dose-response relationships for pollutants, etc. Even without legislation, most industries now see adequate consideration of the environmental consequences of large developments as a worth while exercise. In the Central Electricity Generating Board (CEGB), this is largely based on experience with existing developments. There is likely to be greater interest in the next decade in retrospective analysis of the environmental impacts of both local projects and government policies.

INTRODUCTORY COMMENTS

S E Allen

It is only in the last twenty to thirty years that pollution problems have involved the ecologist to any great extent. During this period though interest in the subject has escalated sharply with the growing realisation that there are many forms of pollution which pose a threat to wildlife. So far most of these pollutants have been considered in isolation, but in future more attention will have to be paid to the effects when in combination.

Many of the present pollution problems will stay with us through the 1980s, but the emphasis is bound to change as controls become more effective. This has already happened to some extent with organic pesticides, heavy metals and eutrophication. At present some of the atmospheric pollutants such as sulphur and nitrogen oxides are of particular importance, expecially because of the acid rain problem, but technical developments suggest that more of these contaminants will be reduced at source in a few years' time. Perhaps one of the most important pollutants in the 1980s will be carbon dioxide. Already there is considerable concern about the build-up of this gas in the atmosphere, resulting from the destruction of tropical forests and the ever increasing combustion of fossil fuels. More information is needed about the effects on climate and vegetation cover, not only on a global scale but in individual countries. Some of these effects could be beneficial.

The depletion of oil reserves and the instability of the old producing regimes are already leading to work on coal conversion techniques. If these and similar products develop on a large scale, then both the solid waste and chemical by-product pollution could pose major environmental problems, Already there is much concern about the levels of organic, particularly aromatic, products in the environment.

The need for a dependable energy supply in future is bound to receive the highest priority. In the immediate future we shall have to contend with increased coal working and combustion, and it will be difficult to hold back the nuclear power programme. In connection with the latter, we need to know much more about the likely distribution and the effects of radionuclides in the environment following an accident, and decisions will have to be taken about the disposal of radioactive waste. Even the 'clean' alternative technologies could lead to major pollution and land disturbance.

A further threat to the environment which will need watching could follow from increased agricultural production and marginal land reclamation. Long term effects of using chemical products on the farm such as seed preservatives and herbicides can cause considerable damage. It is now recognised that many of the herbicides can cause long term effects which were previously disregarded, and there is concern about the spread of volatile herbicides to surrounding areas of vegetation. The high levels of fertiliser applications on water quality and soil structure, the extensive stubble and wood burning which is now practised and the disposal of farm slurry are just some examples of agricultural problems which are causing concern.

Disposal of waste in future will need to receive more attention. There is real concern in some parts of the country about the shortage of sites in which to deposit waste, both urban and industrial, including toxic materials. Because of the increased expense of fertilisers, and the state of many of the sewage disposal plants in the country, I would expect to see a move towards the use of partially processed sewage in farming. One of the most likely developments in the uplands in the 1980s will be the increase in giant quarries because of the need to extract low quality ores. The problems of land disturbance and reclamation which could arise would make our present industrial waste problems seem insignificant in comparison.

If we leave aside specific pollutants, perhaps the most important of current developments is the move to tighter pollution controls. The European Commission is introducing much stricter environmental standards and these will call for careful monitoring. One major problem which will be with us much more in the future will be the demand by Third World countries to have their share of pollution-causing 'fruits' of western civilisation. In dealing with all pollution problems at international, national and regional levels there is clearly a need for use of predictive models. Indeed, the move in this direction is already to be seen in the increasing use of environmental appraisals.

SUMMARY OF DISCUSSION

T M Roberts

The scale of industrial development in the uplands through the 1980s will in part be determined by the rate of economic growth for the UK as a whole. Forecasts of economic growth have proven to be grossly inaccurate in the last decade largely because of the unforeseen escalation in oil prices in 1973. Estimates of economic growth (or contraction) for the next 5 years range from +1.5% to -2%. British industry is, therefore, having to come to terms with zero growth and adjustment to an energy-short world but an energy-rich UK.

Nevertheless, within the British economy there are areas of potential growth. In particular, there will be a trend towards increased coal utilisation for electricity production as well as gasification and liquefaction. Oil/gas extraction, biotechnology, special electronics and petrochemicals are all potential growth areas.

The developments with particular relevance to upland areas are likely to be increasing extraction of aggragates and non-ferrous metals. The aggragate industry has been in recession for the past 2 years and this is likely to lead to closure of many small quarrying operations and a concentration in the future on fewer large scale quarries. The next decade may also see large scale opencast extraction of low grade metal ores in upland areas and there is a possibility that deep mining of high grade ores may become economical. There is unlikely to be much large scale reservoir development in the 1980s, but there may be some pumped storage development. All these developments will provide opportunities for ecologists to contribute to the evaluation of environmental effects and the development of techniques for minimising effects or restoration procedures. In some cases, the direct land take by these developments will result in the loss of important conservation sites. An important consideration in these areas is always the 'conservation value' of the threatened areas. Ecologists will need to quantify many of the parameters which make up 'conservation value' if they are to improve an understanding of ecological matters by those involved in the planning and development process.

The uplands are also affected indirectly by air pollution from industrial (and domestic) developments in the lowlands. Upland areas with shallow soils and bedrock resistant to weathering may be susceptible to the effects of acid precipitation. Studies are underway to identify areas where lakes, streams and, to a less extent, soils are susceptible to acidification in upland Great Britain either through acid rain or through afforestation. There is also evidence that sulphur dioxide may have contributed to peat erosion in the Southern Pennines through elimination of the peat-building *Sphagnum* species. Nevertheless, there has been a downward trend in sulphur dioxide concentrations over much of the UK over the last decade, particularly in the most polluted areas, and the projections for emissions over the next decade do not indicate a reversal in the trend.

There is certain to be a growing need in the next decade for ecologists to provide baseline data or predictive models to aid in the environmental impact assessment of major developments. This will also involve a better retrospective analysis of the effects of existing developments.

4 FUTURE FORESTRY PRACTICES

INTRODUCTORY COMMENTS

E J M Davies

The afforestation process has changed greatly over the last 30 years, and attitudes of users of hill land have changed also.

Modern methods involve:

1. Soil and site mapping
2. Fencing
3. Cultivation, drainage and fertilisation according to soil type
4. Planting
5. Weeding
6. (Respacing or pre-thinning)
7. Adoption of fertiliser regime
8. Thinning or not
9. Clear felling
10. Natural regeneration or replanting

Foresters now recognise that they possess huge power to improve sites by cultivation, drainage and fertilisation, and it is now possible to raise fast growing crops of coniferous timber on land that was hitherto considered to be unplantable.

Many problems remain, however, and the most intractable may be the climate, for although the oceanic climate of the UK is admirable for the growth of many species, the remarkably high average wind speeds and the frequency of gales is limiting. Work on Windthrow Hazard Classification is important. Rotations will be shorter than on continental Europe.

The restoration of cover on bare hillsides has given marvellous shelter for deer, and great increases of wild cats, foxes and roe and red deer have been noted in some areas. These pose problems for both farmer and forester.

Another problem relates to the poverty of our native tree flora and the need to use exotics. What risks are involved in the present preeminence of Sitka spruce? Can we diversify further? How much? What with?

Other problems, some well recognised already, will come forward during debate. What changes in present day practice do we foresee?

INTRODUCTORY COMMENTS

F T Last

In considering the research investigations that should be accorded priority in the 1980s, I have attempted to identify (i) those that became of paramount interest in the 1970s and which still need to be followed through, and (ii) those that will, without too much imagination, be newly evolving or gaining momentum in the 1980s.

1 The outstanding and continuing problems of the 1970s

1.1 Windthrow: In the last 10 years, great strides have been made with (i) a more or less universal acceptance of the seriousness of the problem and (ii) a comprehensive analysis of site risks. However, the silvicultural approach to the minimisation of the problem - respacing/no thinning - is still a fertile area for objective experimentation.

1.2 Increasingly, we are learning from field observations that (i) stomatal activity and (ii) fine root growth of Sitka spruce are both exceedingly sensitive to water deficits, which commonly develop in the uplands. Much more needs to be known about the water relations of Sitka spruce and other conifers. Is it feasible to consider the selection of variants with less than average sensitivities to water deficits?

1.3 Acidification of freshwater lochs and streams: Evidence is now emerging from more than one upland site that (i) the acidification of bodies of freshwater and (ii) the concomitant change in populations of fish and invertebrates are associated with the introduction of coniferous plantations. Recognising that the whole of Britain is influenced to a greater or lesser extent by gaseous and particulate atmospheric pollutants, the causes of acidification need to be elucidated, remembering that the pollutants accumulating on trees in dry weather may enter throughfall and stemflow when rain starts to fall.

1.4 The locally intense damage done to lodgepole pine by the pine beauty moth and the widespread havoc wrought by Dutch elm disease highlight the need to consider species diversification, either by selecting a greater range of variants within a species or by considering the appropriateness of 'new' species - a lesson that should have been learnt from agriculture. The search and utilisation of a wider variety of variants, which may be different provenances, will rekindle an earlier debate of 'regional silviculture'.

1.5 Genetic gains: Appreciable advances have been made in the identification of genetic gains likely to accrue from the exploitation of vegetative propagation and the production of rooted cuttings. But how should they be planted and managed - in pure or mixed stands, of what size, remembering their genetic homogeneity?

2 Problems of predictably increasing importance in the 1980s, remembering that areas of clearfelling will increase appreciably and, *ipso facto*, also areas entering a second rotation

2.1 Recognising that appreciable amounts of NO_3 -N have, in a few instances, been released into freshwater following clearfelling, comprehensive attempts to monitor changes at clearfelling must be intensified in the hope of compiling nutrient budgets.

2.2 Are we right to assume that a site at the end of a full forest rotation is as appropriate for provenance 'x' or 'y' of Sitka spruce and lodgepole pine as 50-60 years previously? I think that we should accept that we have a new milieu in which the balance of nutrients, drainage patterns are totally different, possibly favouring different species and provenances. For this reason, I think that comprehensive series of experiments should be arranged investigating, so to speak *de novo*, the nutrient balances, the water budgets, the rates of geochemical cycling of, and in, second rotation forest crops in which we should not rigidly constrain ourselves by experiences gained from first rotations - speculation is required.

2.3 We are already only too well aware of the presence of deer. To ensure that existing and future plantings are safeguarded, increased efforts must be made to characterise the relation between habitat damage (ground vegetation in addition to trees) and population size and composition.

2.4 'Waste not, want not' - even in the uplands, is it possible that the productivity of some of the unproductive, and usually deciduous or mixed, woodlands could be improved without sacrificing amenity and conservation value by planting productive variants of the trees that already exist, if only to produce fuel?

3 General

To this stage, I have assumed that forestry will continue to develop as in the past - to some extent like Topsy. Personally, I would welcome a much more positive attitude to the evolution of a forest policy which, in turn, would demand the development of an integrated land use policy - both policies should have a profound effect on priorities in forestry research. If there were a national land use policy, the impact of afforestation on water conservation, nature conservation, landscape and amenity would, of necessity, be positively considered in advance. Are changes in northern England similar to those in Scotland, where about 40% of the broadleaved woodlands have been lost or converted to conifers during the last 30 years? Do we really know enough about the ecology of predators and their prey to predict the effects of the further fragmentation of sheepwalk, of the ecology of red deer and deer forest fully to understand the magnitude of the problem to be created by more extensive afforestation? Recognising the problems of land tenure and of the economic returns on investments, I still think that positive land use policies are needed. To what extent should we be agriculturally self-sufficient - 50, 60, 70%? How much land, and of what type, should be set aside for water conservation?

In addition to the management of nature reserves, how many parcels of different types of habitat must be sustained to ensure the continuance of our landscape? With these and other constraints, what sort of target should be set for forestry in terms of quality in addition to quantity? To some extent, tropical/semi-tropical forestry may be a far cry from the uplands, but to me they are interrelated. Recognising the limited potential of forestry in the British Isles, to what extent should British investors be encouraged to finance forest plantations elsewhere - to my mind, an important facet of forest policy.

SUMMARY OF DISCUSSION

E J M Davies

1 The importance of economic site potential - where to get the greatest effect in the uplands from a little money.

2 The effect on water supplies of forest fertilisers applied on water catchments.

3 The possibilities of genetic engineering with forest species.

4 The possibility of changing the shape of trees with hormones, particularly after timber height has been achieved.

5 The effect on tree growth of the increasing proportion of CO_2 in the atmosphere.

6 The vulnerability of certain silvicultural systems to biological disaster and the prediction of likelihood.

7 Predator/prey relationships.

8 The possibility of using cheap natural sources of nitrogen in silviculture (eg legumes).

9 A study of the effect of grazing within plantations - soil improvement or deterioration - value of shelter - suitable tree species - a new type of forest grazing integration.

This list is not exhaustive and does not include the enormous problem related to the effect of wind on our tree crops in the uplands generally, but it indicates the key issues requiring research in the 1980s.

5 LAND-WATER INTERACTIONS

INTRODUCTORY COMMENTS

P D Walsh

All forms of life interact with the hydrological cycle - the circulation of water above, on and below the earth's surface. At its least significant the weather is still a topic of conversation for urbanised man, whilst at the other extreme it is both the preserver and, at times of flood or extreme drought, a destroyer of life. Even in a temperate climate, there is a significant interplay between human activities and the hydrological cycle. It is these interactions which are dominant in the conflicts inherent in the land-water interface, since mankind is trying to stabilise to his advantage a natural process or, through ignorance and thoughtlessness, is destroying a natural equilibrium. Many of the conflicts we face are self-induced and ofter occur as a consequence of trying to protect one human activity from another.

The Water Authority role

The North West Water Authority (NWWA) is responsible for all aspects of the water cycle over an area of 14 500 square kilometres. It supplies water directly to and treats the waste water from 7 million domestic and a larger number of industrial consumers. Almost half of its supplies are obtained from lakes and 152 upland reservoirs in Pennine and Lake District hills. The Authority does not have direct control over all its catchments, but it does own and therefore manage 60 000 hectares of catchment; 5 000 hectares of its catchments are afforested, of which 60% is managed directly.

During 1980, 2 460 M l (540 million gallons) of water was treated to a potable standard through over 200 treatment plants. Almost 700 sewage works produce 3¼ million wet tonnes of sludge which has to be disposed of each year.

In addition to these prime functions, the Authority is responsible for:

- Water resource management, including the licensing of abstractions
- Pollution control and issuing of discharge consents
- Land drainage and flood alleviation
- Fisheries management
- Recreation and amenity associated with water

Water resource development

In the early 1970s, it was confidently predicted that demand for water would double by the end of the century. In 1974, the predicted demand for the NWWA area was 3 140 M l/d by 1981, rising to 4 440 M l/d in 2001. In the UK, there is no basic shortage of water; rather, it is available at the wrong time and often in the wrong place. Engineering works are, therefore, needed to store and transport water. In 1977, NWWA initiated a major

Engineering and Environmental Impact Study of 4 major reservoir based schemes - Haweswater, Borrowbeck, Hellefield and Morecambe Bay. As part of this strategic study, which was a corporative effort with the Structure Planning Authorities and involved many other organisations, joint working teams were set up to examine: agriculture, landscape, terrestrial ecology and recreation. Authority staff studied the hydrology and river ecology, whilst the engineering studies and overall management of the study were carried out by consultants.

By late 1978, forecast demand was 2 530 M l/d for 1981, rising by 410 M l/d to 2 920 M l/d in 2001. Currently the available supplies are 2 960 M l/d. Local developments on a small scale will be required, but it is unlikely that a major scheme will be required during the next 20 years, unless a significant upsurge in population or industrial demand were to occur.

Present interactions

Whilst the Environmental Appraisal identified the issues associated with the major developments, the dramatic fall-off in consumption of water means that the topics which should concern us most over the next decade are those associated with the interactions caused by ongoing activities.

All land use whether it be urban development or moorland gripping interacts with the hydrological cycle, and causes a change in the quantity and quality of water discharged to streams or recharged to underlying aquifers. Many of these changes are of themselves small and may take years, even decades, to become apparent.

Increased rates of drainage occur from impermeable urban areas, by improvements to agricultural land, and from pre-afforestation ploughing and moorland gripping. Each of these lead to faster and larger rises in flood runoff with a greater risk of flooding and consequential need for additional flood alleviation works. Protection of one community by enlarging the river channel, as in Kendal, or by the construction of flood embankments prevents the use of the natural storage in the flood plain and, whilst these works may solve one community's problems, they could exacerbate another problem lower down the river system unless designed and constructed with care.

Land treatments lead to other changes often more subtle than those brought about by physical works. Applications of fertilisers can lead to enrichment of waters. Where these are already very productive, the significance may be small. However, the impact of small amounts of phosphate could have major impact on oligotrophic upland reservoirs causing algal blooms and requiring more complex and expensive treatment processes than heretofore. But the fishery of the reservoir might be improved. The weed growth in rivers have effects on land drainage and maintenance costs. In some parts of the country concentrations of nitrate nitrogen are already close to the World Health Organisation (WHO) limit of acceptability for raw waters intended for human consumption. The movement of herbicides and pesticides, etc through the soil and into waters is obviously of vital concern where drinking water supplies are involved.

A complete change of land use such as the afforestation of upland moorlands introduces additional effects. A loss of water by increased interception and transportation losses imposes additional production costs on the Water

Authority, since the loss has to be made good from new sources which usually require expensive pumping and more complex treatment processes. Changes in water temperature and pH can adversely affect the fish populations as can the siltation of gravels used for spawning, this latter occurring as a direct consequence of the pre-planting ploughing which leads to erosion and higher levels of suspended matter, organics and solates in the water. Though siltation is frequently a major factor in the life of reservoirs abroad, it has to date rarely been significant for British reservoirs.

Conclusions

This review of some aspects of land use which interact with Water Authority interests has inevitably been sketchy, but indicates the range of activities that are affected by and affect land use management planning.

INTRODUCTORY COMMENTS

M D Newson

Research requirements and opportunities

Wetness is a major resource in the British uplands; farmers, foresters and tourists fight it, but water supply to Britain's towns and industries depends on it. It is inevitable that modern methods of land improvement interfere with the assumptions about both quantity and quality of upland supplies which were made by reservoir operators in the days of semi-natural 'moorland' catchments. Change of crop height has a hydro-meteorological effect, drainage alters the extremes of flood and drought, nutrients from a bag are poured on and run off, sediments from land disturbed for the first time since the Neolithic times move gradually down river.

The Institute of Hydrology has made the following conclusions based on a 13-year catchment study in mid-Wales and numerous shorter experiments elsewhere in upland Britain:

1. Change from short, wild grass to conifers in a high rainfall area doubles the loss of water via evaporation from intercepted water.

2. Open ditch drainage during ground preparation quadruples (at least) the yield of gravel and can half the time to peak of floods.

3. Mature forest cover leads to cooler and more acid streams with fewer invertebrates and fish.

4. Pasture improvement which employs drainage and application of nitrate fertilisers leads to temporary (seasonal) peaks of nitrate runoff; these are above recognised water quality standards, but recovery occurs to a permissible but higher background.

Research requirements for the 1980s include:

1 The expression of the Institute's results in forms which are more directly useful to water engineers at the river basin scale.

2 Hydrometeorological studies of wild vegetation other than short grass (eg heather, bracken) and of precipitation falling as snow. Both are important for Scotland where the bulk of afforestation before the end of the century will occur.

Research opportunities include:

1 Extension of research, especially on water quality and aquatic life to upland streams which do not enter reservoirs but are of key importance to fisheries or to the use of rivers for nature conservation.

2 During the 1980s, much of Britain's between-the-wars tree plantings are to be harvested; research into the impact of this major change is required on a wide range of site types and harvesting techniques.

Finally, the most intriguing yet least hopeful research avenue would be a multidisciplinary environmental/economic and social investigation of the uplands. No government's attitude has encouraged optimism on this topic; single-agency partisan reactions to the findings of environmental research are likely to continue.

SUMMARY OF DISCUSSION

D J J Kinsman

Pressures on upland areas include particularly afforestation, deforestation and pasture improvement - all predominantly terrestrial developments. However, a major 'harvest' from our uplands is water, in large quantities and generally of a high quality. It should be remembered that nearly all terrestrial activities in uplands will have a 'knock-on' effect on aquatic systems changing quantitative and/or qualitative aspects of the water resource.

We all use water extensively. The 'Water Industry' comprises a variety of organisations, principally in England and Wales, the regional Water Authorities and in Scotland, Regional Councils and the River Purification Boards. The Natural Environment Research Council (NERC), through its component institutes and grant-aided associations, has particular responsibility for research on terrestrial and freshwater environments. The Institute of Terrestrial Ecology (ITE) has especial responsibility for terrestrial research. Freshwater research is carried out by three laboratories - water quantity by the Institute of Hydrology (IH); water quality and biology mainly by the Freshwater Biological Association (FBA), although IH carries out some water quality research and ITE also incorporates a small freshwater research unit. This multi-institute approach has proved valuable as different research skills can be brought to bear on the often broad problems of the freshwater environment. In addition, the Water Research Centre, financed mainly by the Industry, is active in all areas relating to water supply, use and disposal.

Our first speaker was Dr Peter Walsh of the North West Water Authority (NWWA), representing 'user' interests. I have selected a few of his comments below:

1 The Regional Water Authorities are large undertakings, with a broad range of responsibilities; four of the WAs (NWWA, Northumbrian Water Authority, Yorkshire Water Authority and the Welsh Water Authority) have extensive areas of uplands, as do all the Scottish River Purification Boards.

2 Technically, we can do almost anything, but at a cost; for example, we could make watertight tip sites, or distil massive amounts of sea-water, but at a cost that our society would not be prepared to pay.

3 The WAs have a growing problem with the amount of sewage sludge produced; at present some sludge is dumped at sea. Would sludge application be a feasible strategy for upland pasture improvement? What would be the effect on water quality?

4 Treatment costs could rise considerably if upland management activities cause deterioration in water quality of upland waters.

5 Many of the decisions to be made by the WAs require a good 'data-base' and an understanding of the fundamental processes, which are either not available or inadequate.

6 The Victorian water engineers put gravity to work in the design of their water supply systems - good quality upland water was directed to the large cities and waste water flowed from the cities to the estuaries and the sea. More recently we have developed lowland water supplies, which depend on pumping. Energy costs are growing, both for supply and treatment - will these costs drive us back to gravity driven upland water resources in the future?

7 There are obviously competing activities in the uplands and there must be some local and/or national trade-off between these potential developments.

Our second speaker was Dr Malcolm Newson of the NERC Institute of Hydrology, who spoke particularly from his background of many years of research at the Plynlimon experimental catchment in Wales. Here, the IH have instrumented catchments which are forested or grassland and the research has demonstrated the effects of some forest practices on the quality and quantity of water output:

1 The major effect of trees on the water budget is a physical or meteorological effect - the trees intercept precipitation very effectively. The major role of trees is <u>not</u> a physiological one involving increased transpiration losses.

2 The climate of the UK uplands is rather different from that of many temperate forest areas around the world and this limits the value and application of studies carried out elsewhere. The UK upland precipitation is predominantly as drizzle and this is

readily intercepted by the tree canopy. We need comparable research in other climates (eg parts of Scotland where snow is an important precipitation component).

3 At Plylimon the unimproved grassland catchment shows an average evapo-transpiration loss of ~400 mm/yr; adjacent forested catchment has a loss of ~850 mm/yr. Other vegetation types such as heather moor need to be examined.

4 One effect of land drainage in the uplands is to change the shape of the flood hydrograph - the flood peak is enhanced and occurs earlier. Another effect relates to sediment output from catchments - values are increased 4-5 times.

5 Streams in areas of different vegetation may have very different animal populations. A reconnaissance study at Plynlimon showed forested streams to contain very few fish - why is this? Temperature and increased acidity are two possible causes.

Our discussion session aimed at identifying research areas, but we did not make too much progress. In response to the question - 'Do we need more research?' one answer was that communications between the interested parties were not what they might be and should be improved. The role of peat deposits was discussed at some length; it was pointed out that peat hydrology was a neglected research field. As future upland afforestation must include major peat areas we shall surely need to rectify this omission.

In England and Wales reduction of water quantity from the uplands will affect water supplies only. But in Scotland hydro-electric generation will also be affected. The overestimation of population growth and the current economic climate have combined to produce, in general, a situation of adequate supply, both of water and electricity. We should take advantage of this breathing space and not become complacent about future needs.

An important point was raised concerning, specifically, the applicability of the Plynlimon data to other sites. Were these results likely to apply in Scotland, for example? There seemed to be a user group arguing that, to be relevant, research needed to be carried out on the sites of specific interest. There seemed to be misunderstanding of a fundamental tenet of scientific research, ie that research at a particular site should enable us to understand the fundamental processes involved and should enable us to generate a working model; this model will describe things in general terms and should be transferable to other sites where it can be fine-tuned to local vegetational, meteorological and other variables. Problems are rarely, if ever, unique in time and space - your problem could very well be solved by research at Plynlimon, even though you are employed by North West Water Authority!

One questioner asked 'What is at stake?' Should we not attempt to determine the relative values of upland products?' This might be fairly readily done for the tangible products such as trees, lamb cutlets and water, but would be much more difficult for the less tangible products such as amenity and recreation use. However, it would surely be useful for us to pursue a cost-benefit analysis for upland usage.

Considerable discussion centred around siltation in reservoirs marginal to uplands. In general, the low rainfall intensity in the UK uplands leads to low erosion rates. However, upland catchment management practices are likely to be the major control on soil and peat losses.

In conclusion:

1 We probably dwelled on quantity aspects too much in our discussion; water quality effects of upland management practices need more consideration.

2 The spectrum of 'users' of our uplands is broad and an evaluation of cost-benefit ratio of various combinations of use needs to be pursued.

3 We did engage in a debate between users and researchers and this in itself was valuable. I would hope the debate continues beyond this meeting.

4 We did not come up with a priority list of research topics but several can probably be sorted from the debris and flotsam of our discussions:

   i Impact of upland land 'improvements' and applications of fertilisers to forest areas on water supplies and downstream water quality.

   ii Studies of land use change to forestry from vegetation other than grasslands.

   iii Management to control erosion, particularly of peat areas.

   iv Impact of harvesting of forest crops - clear felling - on water quality.

   v Environmental, economic or social issues, including analysis of costs and benefits involved in upland land management.

6 *DEVELOPMENTS IN UPLAND AGRICULTURE*

INTRODUCTORY COMMENTS

M J S Floate

The hill farming industry's position with regard to possible developments in the coming decade is not one that I can claim to represent, but as a member of the Hill Farming Research Organisation I can perhaps offer some suggestions as to what some of the research needs might be in relation to possible agricultural developments. In this context I would point out that much of our work can be regarded as ecological in nature because we are concerned with the inter-relationships between soils, plants and, in our case, production animals: viable agricultural systems must be based on sound ecological principles. There are many topics of ecological interest in upland areas: I intend to deal with some of those which either have a direct bearing upon agriculture, or which arise as a result of agricultural development.

As a matter of definition, I assume that 'upland agriculture' refers to the use of mainly unenclosed and unimproved land for pastoral farming, and the following remarks relate to this form of land use - what I would call 'hill farming' and which is distinct from 'upland farming', which includes the use of much more enclosed and improved land. Upland farming has its own kinds of problems which may be similar to some lowland problems; the problems of hill farming have a larger component arising from the significance of indigenous pasture resources in production systems.

'Ecological' also requires definition - to me it means pertaining to ecology, which is the scientific study of the inter-relations between living organisms and both the physical and biotic factors in their environment. Many of the ecological questions I raise are not new, and are already part of the work of ITE or of HFRO: what I am suggesting is that we should examine their relative importance, and the need to pursue some questions in more detail.

External influences on agricultural development

Both economic and political factors are likely to have a major influence on the direction and extent of change in hill farming in the 1980s. It is impossible for me to attempt to forecast the net results of interactions between the various influences which may include: increasing costs of labour, energy and transport and their relationship to product prices; the changing demand for food commodities within the EEC; political and social decisions which affect the balance of farming, forestry, recreation, water catchment or other forms of land use, and the consequences of political decisions regarding taxation, subsidies, and grant schemes which have a major impact on farmers' and landowners' decisions. Whatever the outcome it seems likely to me that agricultural development may proceed in either of two contrasting directions - intensification of selected areas - or extensification.

Ecological questions relevant to agriculture

The intensification of selected areas only happens as a result of deliberate choice and ecological knowledge could contribute to the choice of the most suitable areas, although a variety of other factors are also important.

Land use capability mapping provides useful information about the permanent, limitation of soils, but does not provide any assessment of their potential or the extent of those temporary limitations due to vegetation, soil acidity or nutrient supply. Information on these limitations should be available and we need more information on the level of nutrition afforded by different communities at various seasons of the year, the response of these communities to known levels of utilization, and how susceptibility varies with season. Information is also needed on the relative responses of different soil and vegetation types to varying degrees of improvement, and on the factors controlling the degree of response.

The following are a few examples of other relevant topics which may be amenable to experimental research:

1 Can we identify the mechanisms which control plant susceptibility to grazing?

2 Is internal re-distribution (cycling) of nutrients an example of such control?

3 What characteristics can be used to predict the capability of soils and plant communities to respond to improvement?

4 What factors control the populations of decomposer organisms in soils?

5 What are the feeding values of different plant communities for deer?

In the wider context of integrating the use of resources into viable systems of agricultural production, Hodgson and Grant (1981) recently summarised the requirements: 'Objective information is still needed on the way in which variation in (a) the relative proportion of different communities and different animal species and (b) the seasonality and efficiency of grazing interact with one another to influence production on a farm scale'.

Ecological questions relevant to 'agro-forestry'

There may be opportunities in some areas for the development of systems which involve the closer integration of farming and forestry. This may take the form of allocation of sheep (or cattle) and trees to separate land areas, or it may involve the mutual sharing of the same land area at stocking densities which would be sub-optimal for sheep or trees separately, but which together could produce an advantageous combined output.

There are many questions of an ecological nature, whose answers might help in the allocation of resources to such schemes of integration, or which could contribute to improved management, through better understanding of interactions.

Examples of such questions might include:

1 What soil and vegetation types are better suited to intermixed trees/grassland, and which types are more appropriate to tree planting alone?

2 What are the effects of shelter - on pasture growth within a wooded area, on pasture growth in the vicinity of a shelter belt, and on animal behaviour?

3 What antagonisms or mutual benefits may arise among mycorrhizal populations appropriate to pastures and forests?

4 Are pasture N-cycles which depend on N-fixation by legume/rhizobia compatible with forest N-cycles?

Ecological consequences of intensification

Intensification could take the form of wider implementation of '2-pasture' systems of farming, or the development of selected areas with consequent abandonment of others, either on a regional or individual farm scale. These developments may have consequences of an ecological nature either for the agriculturalist or for the other kinds of resource users. The following are some examples of ecological questions which may arise from intensification:

1 Land improvements on the better soil types may lead to an exaggeration of the differences between sites of higher and lower output:

  i. What is their ecological importance as habitats for other organisms?

  ii. What natural processes tend to reverse this trend?

2 Pasture improvement should be accompanied by an increase in stock numbers; whilst this may not affect the total number of grazing days on unimproved areas, it will be necessary to determine the ecological consequences of changed seasonal pattern of grazing.

3 What factors control rate of water use by different plant communities, and how does pasture improvement affect soil moisture status?

4 What is the effect of land improvement on populations of worms, moles, etc in soil, and their effect on organic matter turnover rate? What are the indirect effects on other members of the food chain?

5 If more remote areas cease to be used for grazing, what will be the ecological consequences, and what alternative forms of management might be possible?

Ecological consequences of extensification

Extensification could be described as hill-land ranching. It is the consequence of, and the only farming system possible as a result of reducing farm labour, and decreasing the extent of control the farmer has over his grazing animals. Some of the ecological questions which may arise from this process include:

1 Reduced grazing control allows animals to express grazing preferences and hence concentrate on preferred types in a matrix: at what stocking rate do these preferences incur risk of damage or erosion, and how do they relate to the limitations set by animal nutritional requirements?

2 Extensification could lead to pasture 'deterioration' and worsening drainage - what would be the consequence on water yield?

3 There are differences in the nutrient cycles under the low grazing on acid grassland, and under deciduous woodland with its deeper rooting characteristics: what effect does this have on the nutrient balance and stability of such communities?

Questions relating to changing land use

Finally there are a number of questions, whose answers would be of interest to HFRO, related to the consequences of changing land use. Some examples include:

1 What effect does intensification have on rate of nutrient release through weathering in soil?

2 What effect does changing land use have on population of worms, dung beetles and nematodes, and how does this influence nutrient cycling rate?

3 What are the effects of fire on different vegetation communities?

4 What is the relative importance of climatic change, cessation of cutting practices, burning and grazing on bracken distribution?

In conclusion, I hope that some of the topics I have raised will be considered more fully in discussion, and that together we can consider their relative importance in ecological research, and how best to deal with those questions which are amenable to an experimental approach.

INTRODUCTORY COMMENTS

C Milner

'Ecology is now sex, motherhood and goodness but tomorrow the operatic style of our society might turn our paragon into whore or harridan. The issue is brought into sharp focus by the call for an input of ecology into agriculture and farming for if we respond uncritically or unenthusiastically the potential social and scientific significance of our ecology will be lost.' (adapted from Holling 1975)

It is true that as ecologists we have a shared interest with agriculture in organisms and inter-relations in the problems of limits as affecting stability, optimality and production. But have ecologists any predictive powers in these fields (indeed, have agriculturalists!)? We have general qualitative pictures; we have some non-general models of some processes and a very few predictive models. We have, however, very few predictive models which include the important features of system history, which is so vital in the uplands, with the spatial complexities which can so significantly affect the stability properties of a system or indeed with the complexities posed by feedback loops. There is not even general agreement on how we should approach the study of such systems, let alone achieve a predictive ability. Ecologists should, therefore, approach agriculture with an exaggerated sense of ignorance, rather than an overblown view of our knowledge. The implementation of policy and action in this field bankrupts farmers, and one cannot explore abstract niceties that are never put to test. Do ecologists, therefore, want to be involved in upland agriculture?

If ecologists do wish to be involved (as ecologists and not imitation agriculturalists), what strategies do we need to follow? Do we predict changes in agriculture and examine the ecological consequences of that, or do we achieve predictive powers in key ecological processes and use this ability when we know what agricultural changes have occurred? I believe the latter, since not only is this reducing our need for prediction (always welcome!) but there is at least some chance that, with our shared interests in optimality and production, the agricultural scientist can use our models to maximise production. This should be discussed, for it has enormous importance in determining exactly what we do.

Two processes seem paramount in the uplands. Grazing, with its temporal, spatial and ultimately economic effects, and decomposition with its effects on soil development and, through nutrient release processes, on production. It is arguable that all other processes are secondary to these in the uplands, and indeed act through them. Predictive ability and general understanding of these processes should pay enormous dividends.

The grazing process is clearly the key to current land use over most of the uplands, and indeed in the uplands we have a pastoral system in its main ecological features little changed since the iron age. (Should this be so or should attempts to improve the utilisation of the semi-natural pastures be made, rather than attempting to change them into lowlands?) The major feature of the grazing process in this primitive system is of a variety of generalist grazers (2 species usually) selecting within ample, but low quality, food. What determines this selection? What strategy is used? Is there a different process at work at the different scales of selection? Is the process optimised or can we intervene or change the objective function? The Rosetta stone is a general mathematical model of the grazing selection process - will we ever find it?

Although there are some links between the grazing, defaecation process and decomposition (how strong are these links?), it is best to accept them as separate exercises for the not very good reason that they are usually examined by different specialists. The production/decomposition ratio is crucial to the stability and resilience of upland agricultural systems.

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If ecologists do wish to be involved (as ecologists and not imitation agriculturalists), what strategies do we need to follow? Do we predict changes in agriculture and examine the ecological consequences of that, or do we achieve predictive powers in key ecological processes and use this ability when we know what agricultural changes have occurred? I believe the latter, since not only is this reducing our need for prediction (always welcome!) but there is at least some chance that, with our shared interests in optimality and production, the agricultural scientist can use our models to maximise production. This should be discussed, for it has enormous importance in determining exactly what we do.

Two processes seem paramount in the uplands. Grazing, with its temporal, spatial and ultimately economic effects, and decomposition with its effects on soil development and, through nutrient release processes, on production. It is arguable that all other processes are secondary to these in the uplands, and indeed act through them. Predictive ability and general understanding of these processes should pay enormous dividends.

The grazing process is clearly the key to current land use over most of the uplands, and indeed in the uplands we have a pastoral system in its main ecological features little changed since the iron age. (Should this be so or should attempts to improve the utilisation of the semi-natural pastures be made, rather than attempting to change them into lowlands?) The major feature of the grazing process in this primitive system is of a variety of generalist grazers (2 species usually) selecting within ample, but low quality, food. What determines this selection? What strategy is used? Is there a different process at work at the different scales of selection? Is the process optimised or can we intervene or change the objective function? The Rosetta stone is a general mathematical model of the grazing selection process - will we ever find it?

Although there are some links between the grazing, defaecation process and decomposition (how strong are these links?), it is best to accept them as separate exercises for the not very good reason that they are usually examined by different specialists. The production/decomposition ratio is crucial to the stability and resilience of upland agricultural systems.

Is a general model of any subtlety possible? How does it relate to the community of soil organisms? Is this community of organisms an optimal one or can we intervene? What does intervention imply in nutrient terms? Is the supply fixed in the short and medium term, or can it be increased by fixation and release? These questions cannot be answered by me, but it is necessary to know whether they can be reasonably answered by anyone.

There remains the terrible prospect that, in searching for a strategy in this way, we are wasting our time and limited intellectual capability. Questions become more complex as simple ones are answered, and general models have an uncanny habit of failing when most needed. Perhaps the best way for ecologists is indeed to react to short term problems as posed by the agriculturalist. More likely an intelligent flexible generalisation from specific problems will be the answer which requires only current approaches and ideas developed in the 1950s and 1960s. Perhaps there is no ecology of the 80s!

SUMMARY OF DISCUSSION

A B Humphries

1 The creation of either a land use policy or national guidelines would be helpful in identifying priorities in ecological research. Any involvement of ITE in land use policies should be the provision of ecological information on land use options or particular combinations of land uses. Such information would be helpful to those involved in the political area of decision making. This point had been implied by Dr Cedric Milner, who identified the need for ecologists to identify and study key ecological processes so that a fund of information could be built up.

2 A more specific area of study for ITE in respect of land use combinations would be agro-forestry. This seems to be accepted by a large number of 'users' as a possible and desirable development in many ways, which at present is held back not by lack of interest, but by other constraints (eg money, grant schemes, etc).

There seems to be a need for more ecological information, especially where sheep and trees are kept on the same area.

The relationship between sheep/trees, and both with soils needs to be studied. Are the mycorrhizal populations associated with trees and pasture compatible? How will clover perform in open woodland? Perhaps some limited information could be obtained by examining the evidence of past agro-forestry practices?

3 Energy from woodland was discussed and the point was made that farm woodlands should not necessarily be a mirror image of large scale commercial forestry (eg mechanisation).

4 The question was posed - 'Is agriculture an appropriate use of land in the uplands?' This is a relevant question but not necessarily in the context of the meeting. In respect of this question energy inputs and

balances were mentioned on a number of occasions. It should not be forgotten that upland agriculture is a relative low user of fossil fuels. The law of diminishing returns may indeed suggest that inputs into relatively low intensity upland agriculture may produce better responses than further inputs into the already intensified lowland systems.

5 The relevance of deer farming was discussed as a means of diversifying the use of the uplands. Associated research could be useful, although it is doubtful whether large scale deer farming is likely to be important in northern England in the next 10 years, especially when the pattern and size of farms is considered, along with the substantial areas of common land.

6 All developments in land use involve soils to some extent. There remain large gaps in our knowledge of upland soils in respect of how different soils will respond to changes in management and land improvement.

The grazing-decomposition-nutrient cycling in upland soils needs a great deal of further study.

What is the relationship between earthworms and upland soils? What role do earthworms play in phosphate cycling?

In respect of land improvement, we know how much fertiliser will achieve improvement but we are less sure how little is necessary to maintain improvement.

7 Much research has already been done. There is a need to ensure that the information obtained reaches the appropriate user, either directly or through his advisers.

8 Climate was briefly referred to as having an over-riding influence on many uses. There seems to be no clear-cut agreement as to how climate will change. Bearing in mind the effect that such changes would have on agriculture, any research likely to help to identify the direction of such changes could be very important.

9 Two additional points arising from Dr Milner's paper which may be relevant to ITE research were:

i Could reseeds with an 'ecological' mix have a part to play at higher altitudes?

ii Are new plants a possibility (Arctic/Alpine types)?

7 CONSERVATION, RECREATION AND AMENITY

INTRODUCTORY COMMENTS

D C Statham

User interests

There is a broad spectrum of users within this group. The conservation of landscape and wildlife, though closely inter-related, can be regarded as discrete activities with clearly defined objectives. Both are fundamental to the enjoyment of the uplands by those seeking recreation.

Recreationalists range from the lone walker in search of solitude to rally drivers in international car rallies. There is a wide range of specialist activities with varying demands and impacts on the environment. Some, such as car rallying, motor bike scrambling and water skiing, are noisy and intrusive, though no doubt exhilarating for the participant. Others with a more direct man/environment link such as rock climbing, pony trekking, hiking and orienteering have little impact unless concentrated over time and space.

The degree of impact appears to be in more or less direct proportion to the degree of technological sophistication of these activities: the internal combustion engine and the jet at one end of the scale, the rambler at the other.

User demands

With such a wide variety of interests, the resource demands are obviously diverse, but each group clearly seeks an environment optimal to the enjoyment of its activity. Current attitudes assume that recreational pursuits will normally constitute a secondary land using activity and that conservation of both landscape and wildlife will likewise take a subsidiary place to primary economic activities, except over small areas. Thus, current governmental policy is based on the premise that the basic land using activities of agriculture and forestry will largely determine the recreational environment.

However, agriculture is in many respects a marginal activity in the northern uplands and conservation and recreation demands are becoming more dominant. Forestry has expanded and could do so at an increased rate in the next few decades. There have been land management systems dominated by recreation in the past, eg hunting forests in the middle ages, grouse moors more latterly. Is there a case for devoting larger areas primarily to recreation and conservation (= amenity) where agriculture, and perhaps forestry, take ancillary roles? The debate over the Wildlife and Countryside Bill indicates a trend in this direction, especially the amendments regarding the broadening of criteria for MAFF grants.

An economist would probably view the issue rather differently. Is 'conservation' becoming the consumer good in greater demand than food or timber in the uplands? How will this trend express itself on a land management unit such as an owner occupied hill farm?

Ecological issues

Given a scenario of a greater mix of land using activities in the uplands against a background of agriculture perhaps declining and forestry expanding, where should priorities lie?

The general depletion in wildlife resources in the lowlands and the changing trends towards an increased but more diverse use of the uplands present opportunities for diversifying and perhaps generally increasing wildlife in the uplands. There are also opportunities for landscape change. How can the existing habitats of value such as heather moorlands best be managed to satisfy changing needs? What are the ecological implications of agricultural systems where less emphasis is placed on producing maximum numbers of stock as income is derived increasingly from other sources?

Will attempts to fossilize landscape as circumstances change - eg by increasingly expensive management agreements to conserve typical pasture inbye or heather moorland - be justified ecologically? Or are there other management systems which though changing landscape may benefit wildlife?

In a period of change and uncertainty, experimentation is needed on alternative management systems of representative blocks of upland to assess not only the economic alternatives but also the ecological and landscape effects. Experiment on a 'wilderness' area which would involve a cessation of commercial grazing would provide an interesting control against which to compare other management systems, but this is clearly a very long term operation.

INTRODUCTORY COMMENTS

M D Hooper

Upland ecology

Possibly because of my lowland origins, upbringing and experience, I am impressed by the severity of the physical environment of the uplands. I am also impressed by the influence of topography in increasing or ameliorating that severity - the influence of slope aspect and angle upon ground temperature, the length of the growing season, upon the light climate and upon exposure to wind. In addition, I am impressed by the frequency of natural catastrophes, by erosion and by scree slopes.

1 Higher uplands

Hence, I think of the ecology of the higher uplands in terms of open habitats with low levels of biological interaction such as inter- and intra-specific competition. Therefore the main research need is for work on adaptation to the physical environment, especially to fluctuations in that physical environment. It is a need for physiological ecology probably linked with genetics and evolutionary studies.

2 Lower uplands

At lower altitudes we begin to find more closed communities - competition begins to be of significance. But the physical environment is still harsh and with added limitations of soil and water factors. I see the lower uplands as areas dominated by single species - a set of petty kingdoms where bracken, heather, *Sphagnum*, *Molinia*, *Nardus* and cotton-grass rule.

It is in this area that economic exploitation of the land becomes possible in terms of sheep, grouse, deer or trees.

Conservation, recreation and amenity

Here are a set of human desires in conflict with economic exploitation - mainly in the lower uplands. As an ecologist, it is not my place to evaluate human desires. What I can or should be able to evaluate is the impact that management of the land to satisfy any particular desire will have upon the satisfaction of other desires. The role is that of Environmental Impact Assessor. For example, there is the possibility that bracken could be harvested annually or biennially for energy cropping. But what effect will this have on the decomposers? If they too are removed by this treatment, will the soil lose its potential for other uses or indeed the continuation of bracken?

A similar problem concerns newer whole tree harvesting in forests - will the soil become depleted? These are all environmental impact studies. As ecologists, we must be aware of these questions, of their kinds and qualities, of their possible effects on conservation, recreation and amenity. But, as ecologists, we provide answers to questions; we do not evaluate the answers. The evaluation of answers satisfying human desires must be left to political and sociological methodologies.

SUMMARY OF DISCUSSION

H M T Frankland

Discussion was introduced by Mr D C Statham, representing user interests, and Dr M D Hooper, representing the research side. Summaries of their papers are given above and it is only necessary here to highlight their themes.

Mr Statham questioned the assumption that agriculture and/or forestry should be considered the basic land uses of upland. He said that unsubsidised hill farming was not economically viable and that in his view the primary value of upland in the future could well be recreational. He therefore thought we should explore alternative management systems which would provide 'what the tourist wanted' in landscape and facilities; open moorland was the essential feature called for. He would also like to see 'wilderness areas' created experimentally.

Dr Hooper set out the fields in which he thought it proper for the ecologist to contribute to serving the needs of upland user interests. These were to investigate 'what is there, why it is there and what happens if you manipulate the regime'. He considered that the question 'so what?' fell outside the realm of ecological research. He also felt that such research should not be directed towards the solution of specific, local problems, but should rather be concerned with matters of principle of general application. Finally he made a plea for conservationists to move more into the field of active management from that of passive protection.

Disappointingly, but perhaps not surprisingly in view of the broad and rather diffuse nature of the remit of the Group, the discussion which followed these introductions showed a notable absence of specificity in suggestions and recommendations.

The concept of wilderness was explored and it was agreed that British habitats had suffered too much modification for it to be possible to re-create an 'ideal' natural ecosystem and that the furthest we could go would be to remove Man's influence as far as possible; the West Pennine Moors were suggested as a suitable trial area.

As to providing 'what the tourist wants', the Group was not at all sure what people do want, and while it was agreed that objective investigation of this subjective issue was desirable, there was some doubt as to whether people know what they want, and even if they do, whether their preferences will remain constant. It also seemed clear that it might be ecologically impossible to provide an upland countryside tailored to public specification in view of the dynamic and seral nature of most ecosystems.

Attention was therefore turned to the fundamental desirability of basing upland management on sound ecological principles whatever the management objective. In the interests of both landscape and wildlife conservation, comparative ecological evaluation of different habitats was important and, in carrying this out, the significance of habitat interaction and edge effects, ie mosaics, should be stressed. It was further thought desirable that habitat and community re-creation should figure in studies. Finally, the need to monitor management effects and to pass back to land managers the results of such work was emphasised.

Thus, the Group concluded that there is scope for ecological research into ways to maintain and create specific habitats, and that recreational aspirations are worthy objects of study because recreation is an economically viable land use. However, in making recommendations, ecological principles must not be over-ridden. It was felt that we already have sufficient fiscal coercion and incentive to mould the environment as we wish once we know what is wanted, but at present the absence of integrated land use policy obstructs implementation.

8 SUMMARY

ECOLOGICAL RESEARCH

J N R Jeffers

At the beginning of this symposium, I asked for the views of the participants on the research which ITE should do to ensure that the necessary information was available to enable rational policies to be devised for the management of the rural environment in the 1980s and 1990s. In the course of the discussions during the symposium, there have been many valuable suggestions which we will obviously wish to pursue. It is true, of course, that some of these suggestions have already emerged in our own discussions, but it is certainly interesting to have these suggestions confirmed by those who have the more direct responsibility for policies related to the rural environment and to land management. Clearly, we should continue to have discussions of this kind in order to ensure that we have the widest possible basis for our future research policy.

It is also clear, of course, that there is no possibility that ITE could attempt to pursue all of the research ideas which have emerged from this symposium. Even if we trebled the size of the Institute, we still would not have enough resources to undertake all of the research which has been suggested as being relevant to the problems of the 1980s. There must, therefore, be some selection, and ITE must concentrate on those topics of research which are unlikely to be done by other institutes, or by universities and polytechnics. There are, I believe 3 distinct criteria to aid in the selection of the research which should be done by ITE as a positive contribution to the work which must be done by the scientific community as a whole in this important field. These criteria are as follows:

1 ITE should concentrate on long term research, ie research which lasts for more than 3 years, because the shorter term research can, in general, be done more readily by the universities and polytechnics through training for MSc and PhD post-graduate qualifications.

2 ITE should concentrate on research which is essentially multidisciplinary, with staff from many different disciplines working on the same long term project. It is relatively easy for ITE to do research of this kind, and to ensure that the fullest possible range of disciplines is deployed upon the research projects.

3 ITE should undertake research which is geographically widely dispersed. With its wide scatter of research stations, broadly covering every part of Britain, it is possible for ITE to do research of this kind both economically and efficiently.

These 3 criteria will, I believe, effectively help to define the particular topics which are most suitable for concentration by ITE. The criteria will exclude many of the site-specific proposals which have been made at this symposium, and will tend to concentrate ITE's research on broad regional and national problems, on fundamental research and on basic ecological processes.

There are, in addition, 3 ecological criteria to guide the selection of ITE's research activities. I would define these criteria as follows:

1 Research which is concerned with the maintenance of essential ecological processes and life support systems. In the course of this symposium, we have already touched upon many of the processes which are relatively little understood, but which are nevertheless essential if we are to understand the ways in which ecological systems function and the ways in which the systems can be maintained.

2 Research which is concerned with the preservation of genetic diversity. Again, our discussions have emphasised the importance of diversity and variation, and of the maintenance of the genetic resources in ecological systems.

3 Research which emphasises the utilization of species and ecosystems sustainably, as a basis for agriculture and forestry, as well as for wildlife conservation. Basic understanding of the ways in which the population dynamics of species and ecosystems operate in natural, semi-natural and crop ecosystem is an essential criterion for the development of sound policies for the management of ecological systems in the future.

I emphasised, at the beginning of this symposium, that one essential component of any applied research programme is the feasibility of particular types of research. This feasibility determines the opportunities which exist in the development of research techniques. At this point in the discussion, therefore, it may be helpful if I outline my own view of where research strategies can best be developed and deployed to meet the kinds of problems which have been outlined in this symposium. In talking about research strategies in this way, I will necessarily adopt a somewhat olympian view of both research and ecology. There are, in essence, 3 main strategies which, either singly or in combination, can be adopted by research scientists. The first of these strategies is that of survey, whereby the existing variation is explored by modern sampling and survey techniques. It should perhaps be emphasised here that there has been an enormous and largely unexploited development of survey techniques, both in terms of sampling theory and in terms of instrumentation and equipment, including that of remote sensing by satellites or aerial photography. Survey is, therefore, one of the most important scientific developments which is ripe for exploitation in the 1980s.

The second strategy is that of experimentation, whereby some of the variation is controlled in order to obtain more precise information about some remaining part of the variability of ecological systems. Again, there have been striking developments of experimental theory, and of our ability to analyse the results of experiments in order to achieve an understanding of the underlying processes in ecological systems.

Finally, there is the strategy of simulation, whereby mathematical models are used to synthesise the variation which is observed in the field and in experiments so as to obtain a conceptual understanding of the underlying processes. This is yet another of the important scientific advances by which we are able to use both computers and the new kinds of mathematics made possible by computers in order to develop mathematical models of ecological systems. I realise, of course, that this is an extremely unpopular subject with most, if not all, of the participants in this symposium, but I have to say to you that this is perhaps the most important field of development for the future. Modern mathematics, linked to the awesome power of the computer, and particularly of the microcomputer, has given us the possibility of scientific developments in the whole field of ecology of which we could only dream even a few short years ago. Of all the fields ripe for development, this is perhaps the most potent, and, somehow, resource managers, administrators and politicians must lose their fear of mathematics and of computer models.

There are a number of direct applications of the 3 basic strategies which I have outlined above. For survey, for example, the exploration of soils, vegetation, fauna, habitats and land use, and the mapping of all of these factors is perhaps the most obvious. We sometimes assume that, because Britain is a relatively small group of islands, we already know all that we need to know about the rural environment. Nothing, however, could be further from the truth. Almost all of the ecological research in Britain has been done on about 15% of the total area of Britain, concentrating on those places which are ecologically interesting, ie the places where ecologists spend their holidays, or the places to which parties of students are taken for their basic field work. The rest of Britain, because it is ecologically untidy, heterogeneous and apparently 'uninteresting, has been largely neglected. The first priority, therefore, must be to survey and map the remaining parts of the country, to obtain a clear indication of what is there and of the kind of changes which are taking place in the ecological systems. Much of the emphasis, initially, will be on the production of maps, but, increasingly, the information derived from surveys will be held in computerised data banks from which it is possible to construct classifications and models of the ecology of the country as a basis for future policies. Some work has already been done along these lines, and will surely be extended in the immediate future.

Experimental ecology may be expected to expand greatly in the fields of genetics and physiology, including many of the problems which were touched upon in our discussions of forestry, agriculture and pollution, and will also be greatly extended into the whole field of nutrient cycling and decomposition. While our ecological text books are full of attractive diagrams showing the carbon, nitrogen, phosphorus, etc cycles, we need to be aware that most of these diagrams are pure fiction, and that we still have very little understanding of the cycling and decomposition of nutrients. Still less do we have sufficient information about the actual rates of the movement of these elements through ecological systems, and the extent to which the rates can be changed by management practices. All of these topics will provide ample work for experimental ecologists in the coming 10 to 20 years.

In simulation, the principal ecological processes will provide many of the opportunities for the application of mathematical modelling, as we seek for a better understanding of the ways in which these processes function, and the way in which the processes can be modified or developed to meet man's changing requirements in the rural environment.

By the combination of any 2 of the basic strategies, however, we can embrace a wider range of ecological research. Thus, by combining survey and experimentation, research on vegetation change, and the monitoring of actual change in the rural environment, can be incorporated into our research programme. Similarly, by combining simulation and survey, the research on land use modelling, and on the effects of pollution, can be effectively pursued. Finally, by combining simulation and experimentation, the important study of population dynamics of organisms, and of plant and animal communities, will help to provide much needed answers for the management of semi-natural and crop ecosystems, and the various wildlife organisms which are dependent upon such systems. Figure 1, therefore, provides a simple classification of the main research activities which are likely to form a basis for ITE's attack upon the problems of ecology in the 80s.

As we draw to the conclusion of this symposium, it is perhaps relevant for me to discuss, briefly, where we go from here. It seems clear to me that there should be continued discussion with the users of ecological research following this symposium, in addition to the 3 other regional symposia which have already been planned. I envisage, therefore, a series of workshops to follow up the discussions of this symposium, probably in rather smaller groups. At these workshops, the users of ecological research can discuss the results of research directly with the research scientists, preferably in relation to some of our models or simulations of the ecological systems themselves. Much will, of course, depend upon the willingness of the participants to continue the discussion in this way, but I very much hope that at least some of you will feel encouraged and motivated to discuss research problems and our suggested solutions to these problems in this way.

In addition, however, it is clear that there is further discussion that still needs to take place on the relative contributions of ITE, the other research institutes of NERC, and the universities and polytechnics. I propose, therefore, to hold a meeting some time later this year at which we discuss with other research scientists the best way to ensure that we work together on these problems rather than in competition. It seems likely that we could find a way of ensuring that each of the research institutes and each of the university departments concentrates on the particular problems which are most appropriate to the available resources so as to make the best use of the scarce resource of scientific expertise, capital equipment and facilities. I will, therefore, be writing to the university participants at this symposium to suggest a meeting some time later this year.

LAND USE

J C Dunning

In closing I would like to re-emphasise the deepening problems of our upland areas and to point towards the ways in which ITE could best help. Perhaps the greatest need is to find ways of enabling different interests to co-exist in the uplands in a manner which could lend strength to each interest rather than weaken it, as happens so often at present. These interests include farming, forestry, public recreation, landscape conservation, wildlife conservation and the social and economic interests of upland communities. It is upon our ability as a nation to integrate these many purposes that the

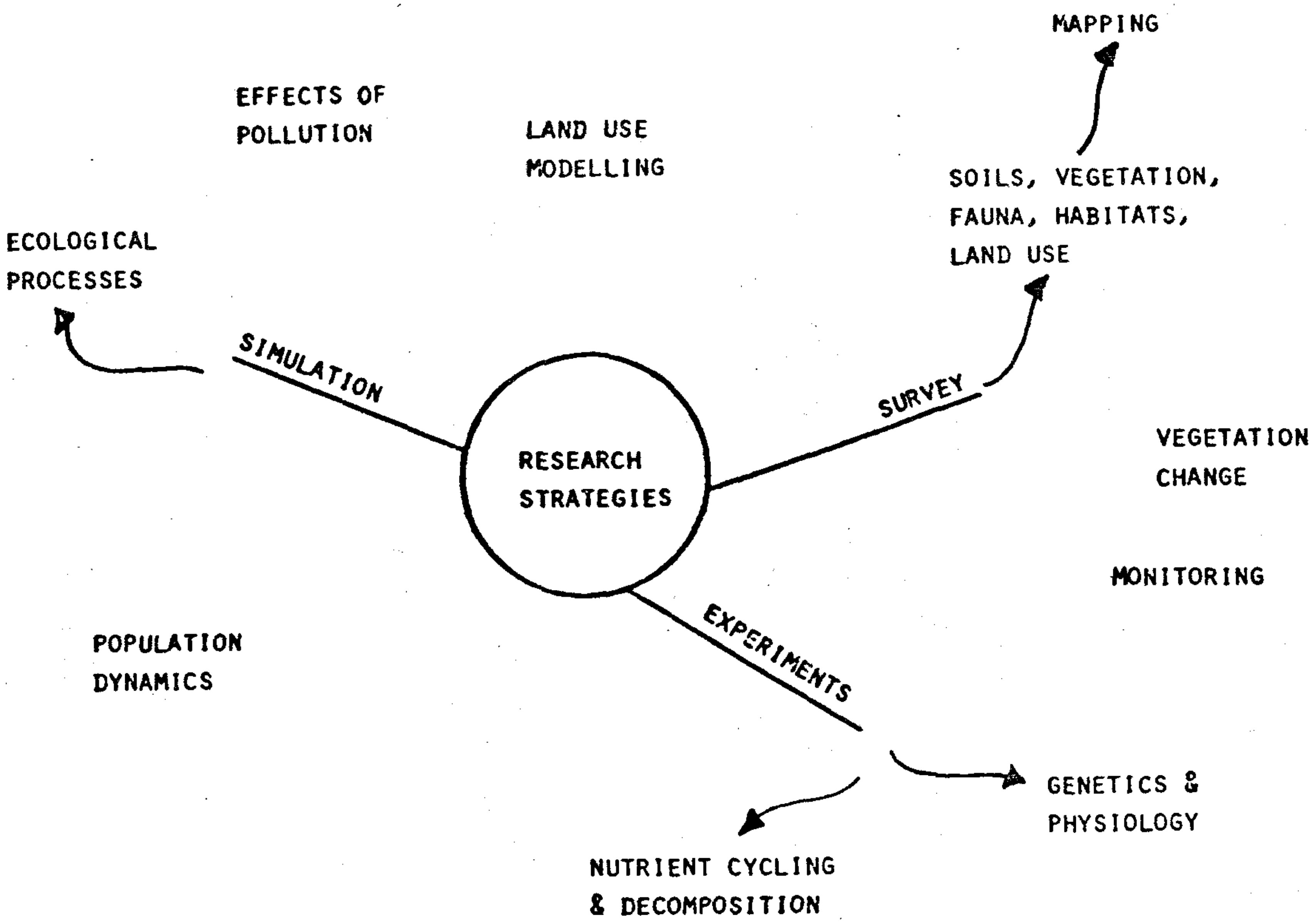

Figure 1 A simple classification of main research activities in relation to the research strategies of survey, experimentation and simulation

future well-being of our upland areas depends. The ways of achieving this integration will often involve a fundamental re-examination of our land use policies, for it has already been demonstrated, in many imaginative projects, that a variety of national purposes in the uplands can be reconciled through the careful reshaping of policies to meet a set of defined objectives.

It is in this complex field that I believe ITE could have an important role to play and I very much hope this interest, so well begun, will be sustained.